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REPORT OF REVIEW THE SSL, MSE Plus® MECHANICALLY STABILIZED EARTH WITH PRECAST CONCRETE FACING PANELS AND INEXTENSIBLE SOIL REINFORCEMENTS

October 2023

HIGHWAY INNOVATIONS, DEVELOPMENTS, ENHANCEMENTS AND ADVANCEMENTS (IDEA)

The SSL, MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System has been evaluated in accordance with the IDEA protocol. Key information regarding this system is presented in this section of this final report of review. Important details of the system's components, design, construction and quality control measures are presented in the attached final submittal. Design parameters defined within the submittal are summarized in the table located at the end of this IDEA report.

Applicant Information

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Review Summary

Following its initial review of the MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System submittal, the IDEA review team provided the applicant with a series of comments and requests for clarification and the need for additional connection testing and analysis. The applicant has been thorough in its responses and the review team finds that there are no outstanding issues that should be brought to the attention of the transportation agencies. Rather, the agencies are encouraged to rely upon the MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System submittal for projects where the MSE Plus® Retaining Wall System is proposed.

Submittal Checklist

The checklist used from the IDEA protocol for this evaluation is C4 – Initial Technical Evaluation Checklist for Concrete Panel Paired with Inextensible Reinforcement. This is the second evaluation of the MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System by the IDEA evaluation program. This evaluation was performed at SSL's request review new testing of the connection between the soil reinforcement and the concrete face panels. The system was originally evaluated by the HITEC evaluation program in 1999.

Confidential Information

The applicant has the option to omit information from the version of its submittal that is attached to the final report if it believes that such information is confidential. In such instances, the applicant will notify the review team. However, for the SSL MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System no information has been designated by the applicant as confidential.

System Description

Components
The major components of the MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System are precast concrete facing panels, inextensible steel soil reinforcements, connection system and select granular backfill. The facing system is a precast concrete panel. The inextensible soil reinforcing consists of a grid type welded wire mesh. The other components that are used with the MSE system include, and are not limited to a concrete leveling pad, coping or barriers, bearing pads and joint filter fabric for soil retention.

The MSE Plus system offers four distinct standard size precast facia wall panels. They are 5' x 5', 5' x 6', 5' x 10', and 5' x 12' system. Each of the facing panels are 6-inches in thickness with a standard concrete strength of 4,000 PSI. The SSL MSE Plus system does not incorporate the use shear pins or alignment devices for wall construction. The system does use two bearing pads at the top of each 5' or 6' wide standard size panel to control the horizontal panel joint width. Larger 10' and 12' width panels will use 3 or 4 bearing pads per panel joint. The SSL MSE Plus retaining wall system utilizes three longitudinal wire sizes, W11, W20, and W24 with W11 transverse wires spaced at 0.5, 1.0, 1,5 2.0 ft, 2.5, and 3.0 spacing.

The connection system is comprised of three components. The first is a pair of wire loops are cast into the panel to form a clevis, the second component is the one end of the soil reinforcement that is bent 90 degrees to form a 90-degree loop. The looped end of the soil reinforcement is inserted in between the two loops cast into the panel which forms the clevis. The third component is a pin that is inserted into the soil reinforcement loop and clevis to complete the connection of the soil reinforcement to the panel. The MSE Plus system uses only one type of connection device paired to up to 6 connectors per layer. The connection system is fabricated in accordance with ASTM A 1064. The embed loops are fabricated with material with a minimum yield strength of 75,000 PSI.

System History
SSL's MSE Plus® system was developed in 1997 and SSL received its first approval in California by The California Department of Transportation. With the completion of our HITEC evaluation in 1999 SSL received approvals by most state departments of transportation agencies. The connection system evaluated in the 1999 HITEC reports was for an "internal" connection. In 2003 SSL revised their connection system to a more conventional external system using clevis embed connectors cast into the concrete panel by then joining the 90-degree loop in soil reinforcement to the clevis using a connection pin. Testing requirements were modified for LRFD designs. Testing was performed in December of 2012 and SSL received approval of their LRFD design shortly thereafter.

Three of the oldest structures using this new connection system are in California. The projects are the SR 22 Project in Orange County, SR 101 Ralston in San Mateo County and Route 116 /101 in San Ramon. All these projects were for Caltrans. Two of the tallest structures using the connection system are in California. The tallest structure was of the SR 91 Widening Project in Corona California. Wall 115C was 52 feet tall with 115B in similar height. The third tallest structure was a project for the Nevada Department of Transportation on the I 580 Realignment Project constructed south of Reno, Nevada. One of the MSE walls on this project was 65.0 feet tall.

System Properties

The following properties are reported by the applicant for MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System.

Soil Reinforcement

Depending on the specific wall design parameters and loading requirements conditions the soil reinforcement mesh sheet can be 2 wires up to a 6-wire mesh sheet. MSE Plus retaining walls system utilizes weld wire reinforcement manufactured in conformance with ASTM A1064 utilizing wire with a minimum yield strength of 75,000 PSI. Longitudinal wire sizes vary from a diameter of W8 (0.08 in2) up to a maximum diameter wire size of W24 (0.24 in2). The reinforcing mesh sheets are fabricated using welds, which are then evaluated in accordance with ASTM A1064. The crossbar spacing of the mesh sheets varies from 6 inches up to 30 inches. The length of each sheet is based upon a minimum of 8 feet or 70% of the design height of the wall.

For the welded wire soil reinforcement, the corrosion measure is hot dipped galvanizing which applied in accordance with ASTM A123. The minimum galvanized coating thickness should be no less than 3.4 mills or 2-ounces per square foot of the reinforcement surface area. The zinc coating provides a sacrificial anode that corrodes while protecting the base metal. Galvanization also assists in preventing the formation of pits in the base metal during the first years of aggressive corrosion.

Soil Reinforcement-Facing Panel Connection Capacity

SSL conducted a supplemental connection test program in July 2023 and testing was witnessed by Twining Labs. This test focused on the strength of the panel connectors embedded into the precast panel with respect to tensile capacity. The test was conducted on a full-scale standard production "Y" panel designed for use with a 6 wire W24 mesh soil reinforcement sheet. Two loads were applied TL1 and TL2. The test loads were determined as follows: 1) One W24 wire = 0.24 in^2 x 75,000 psi = 18,000 lbs. An unfactored load for a 6-wire sheet would be 108,000 lbs. TL1 uses the AASHTO resistance factor of 0.65 for a nominal TL1 load of 70,200 lbs. and TL2 used a provisional loading factor of 0.70 for a test load 75,600 lbs.

The testing was successful with both applied loads with the panel and connectors showing no deformations or cracking. The test load applied to this panel would equate to a wall design height of approximately of 75 feet with a 5' x 5' panel.

AASHTO Section 11.10.6.2.2 Reinforcement Loads at the Connection to Wall Face states: "The nominal tensile load applied to the soil reinforcement connection at the wall face, T_O, shall be equal to the nominal reinforcement tension, T_{max}, for all wall systems regardless of facing and reinforcement type." The appropriate resistance factor must be applied to the connection capacity per AASHTO Table 11.5.7.1 for inextensible grid systems (i.e., the SSL MSE Plus system) the resistance factor is 0.65 when using the coherent gravity method of analysis.

The current connection design by SSL is based on a laboratory connection testing program discussed above. This testing program was recommended by the IDEA review team during their preliminary evaluation of the MSE Plus retaining wall system. The IDEA review Team aided SSL regarding details of connection laboratory testing program. The test program details and results are included as an appendix of the MSE Plus IDEA evaluation submittal.

Soil Reinforcement Design Tensile Strength
The design tensile strength of the reinforcement is controlled by the tensile strength of the reinforcement. MSE Plus retaining walls system utilizes weld wire reinforcement manufactured in conformance with ASTM A1064 utilizing wire with a minimum yield strength of 75,000 PSI. The connection between the reinforcement and facing panel is designed as discussed above.

Pullout Design Parameters

Based on the data available for AASHTO specified backfill gradations, SSL recommends the following relationship for determining f* for SSL welled wire mesh for granular backfills meeting AASHTO requirements for gradation, shear strength and durability:

F* = 20 (t/St) at the top of structure

F* = 10 (t/St) at a depth of 20'

Where: t = the thickness of the transverse bar and St = transverse bar spacing

Retaining Wall Design
The SSL MSE wall system is designed in accordance with AASHTO and National Highway Institute (NHI) documents and follows conventional design practices of inextensible reinforcement systems and does not include any design innovations.

The design methodology of a MSE Plus wall considers both the external and internal stability of the structure. The design uses a bi-lineal failure plane to design the soil reinforcement. Depending on the transportation agency SSL designs the MSE Plus structure using either the coherent gravity method or the simplified method to determine the vertical internal pressures at each reinforcement layer to determine the reinforcement stresses at each layer. In almost all design conditions SSL uses the industry standard software MSEW+. Information with respect to MSEW+ is available at https://geoprograms.com/msew/.

The internal and external stability design methodology also includes a seismic analysis, if required. SSL follows Section 11.10 of AASHTO.

The design examples in this submittal were performed using MSEW+. Agencies may check designs with a commercial program, with the design properties listed in the table attached to this review report.

System Innovations
The IDEA evaluation concurs with SSL that the MSE Plus® retaining wall system does not contain any innovations.

Reviewer Comments

Following its initial review of the SSL MSE Plus Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System submittal, the review team provided the applicant with several comments and requests for clarification. The applicant has been thorough in its responses and the review team finds that there are no outstanding issues that should be brought to the attention of the transportation agencies. Rather, the agencies are encouraged to rely upon the final SSL MSE Plus Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System submittal for projects where the MSE Plus System is proposed.

Closing

An update technical evaluation should be performed for the SSL MSE Plus Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System in five years (i.e., October 2028) or upon notice that a significant modification of the system has been made. For details regarding update technical evaluations and other guidance for the use of technical evaluations by transportation agencies, go to https://www.geoinstitute.org/special-projects/idea.

Summary Table MSEW+ Input Parameters for MSE Plus® Precast Concrete Facing and Inextensible Reinforcement Retaining Wall System

Inextensible Soil Reinforcement:											
Data\Type		3W11 x 0.5W11	4W11 x 1.0W11	5W11 x 1.5W11	6W11 x 2.0W11	4W20 x 2.5W11	5W20 x 3.0W11	6W20 x 3.0W11	6W24 x 3.0W11	7W24 x 3.0W11	8W24 x 3.0W11
$T_{long\text{-}term}$ (lb) (F_y*A_c) (75 years)		17,925	23,903	29,873	35,850	47,475	59,348	71,213	87,315	101,865	116,423
$T_{long\text{-}term}$ (lb) (F_y*A_c) (100 years)		15,368	20,490	25,605	30,728	42,608	53,265	63,915	79,215	92,415	105,615
Coverage Ratio (R_c)		0.27	0.40	0.53	0.67	0.40	0.53	0.67	0.67	0.80	0.93
Reinforcement width (b, in)		16	24	32	40	24	32	40	40	48	56
$T_{long\text{-}term\ per\ unit\ length\ of\ wall}$ (lb/ft) [(F_y*A_c)*R_c/b] (75 years)		3,585	4,781	5,975	7,170	9,495	11,870	14,243	17,463	20,373	23,285
$T_{long\text{-}termper\ unit\ length\ of\ wall}$ (lb/ft) [(F_y*A_c)*R_c/b] (100 years)		3,074	4,098	5,121	6,146	8,522	10,653	12,783	15,843	18,483	21,123
Pullout resistance factor, F*	Top of Wall	1.06	0.53	0.35	0.27	0.21	0.18	0.18	0.18	0.18	0.18
	Depth of 20 ft below top of wall	0.53	0.27	0.18	0.13	0.11	0.09	0.09	0.09	0.09	0.09
Friction Angle along reinforcement-soil interface ρ	Top of Wall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Depth of 20 ft below top of wall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scale-effect correction factor, α		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Connection Strengths:	a[a] (lb/ft²)	CRcr[b] = F_{yc}/F_y)									
		3W11 x 0.5W11	4W11 x 1.0W11	5W11 x 1.5W11	6W11 x 2.0W11	4W20 x 2.5W11	5W20 x 3.0W11	6W20 x 3.0W11	6W24 x 3.0W11	7W24 x 3.0W11	8W24 x 3.0W11
		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
F_y = Yield strength of reinforcement											
F_{yc} = Yield strength of connection between reinforcement and precast panel											
A_c = Area of reinforcement at the design service life (i.e., 75 or 100 years)											
[a] Normal pressure (lb/ft²); [b] MSEW program term											

IDEA

HIGHWAY INNOVATIONS, DEVELOPMENTS, ENHANCEMENTS AND ADVANCEMENTS

MECHANICALLY STABILIZED EARTH WALL - MSE Plus^{TM}

February 2022

INNOVATIVE CONSTRUCTION PRODUCTS

MSE Plus™ Wall SYSTEM

IDEA

HIGHWAY INNOVATIONS, DEVELOPMENTS,ENHANCEMENTS AND ADVANCEMENTS

MECHANICALLY STABILIZED EARTHWALL SYSTEM

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Table of Contents

INTRODUCTION

This evaluation document has been organized to follow the IDEA Checklist C4 – "Precast Panel Paired with Inextensible Reinforcement". The submittal is organized into two sections.

IDEA ERS Submittal Checklist Response

IDEA ERS Section 1 through 5 Appendixes

The submittal package addresses each of the items contained in the Checklist C4. If an item from Checklist C4 is not applicable to the submittal it is noted with then a response will be provided as not applicable. If additional supporting documents are required for our response that information will be included in the Appendix using the same checklist numbering format. The Appendix contains all the sections in Checklist C4.

1.0 ERS COMPONENTS

The primary components for the SSL, MSE Plus™ retaining wall system consist of a facing unit, connection system and inextensible soil reinforcing. The facing unit is segmental concrete panel. The inextensible soil reinforcing consists of a grid type welded wire mesh. The other components that are used with the MSE system include, and are not limited to, compacted select backfill, coping or barriers, bearing pads and joint filter fabric for soil retention.

1.1 FACING UNITS

1.1.1 The MSE Plus retaining wall system does not claim any innovations to the facing system.

1.1.2 The MSE Plus system offers four distinct standard size facia wall panels. They are 5' x 5', 5' x 6', 5' x 10', and 5' x 12' system. The panel sizes vary to the requirements of each agency. The system also includes standard half size panels for the bottom of the wall. For the top of the wall extended sloped top panels are fabricated to match the roadway grade and can be up to 7.5' in height.

1.1.3 Each of the facings listed in Section 1.1.2 are 6-inches in thickness with a standard concrete strength of 4,000 PSI without air entrainment. Of the four size types noted in Section 1.1.2 the panels are designed and fabricated in three structural types - Type A, X and Y. The determination on the panel type chosen for the MSE structure is a function of the wall design height, top of wall geometric configuration and applied loading.

1.1.4 The standard panel design, dimensions, tolerances, and typical steel reinforcement schedule for each type of panel discussed in Sections 1.1.2 and 1.1.3 are provided in Appendix 1.1.4.

1.1.5 The 28-day standard target strength for MSE facia wall panels is 4,000 PSI. The panels in some instances are fabricated to higher strengths depending on the DOT agency. The MSE wall facia panels are also fabricated using higher concrete strengths when exceptionally tall walls are designed or when the facing panels are subject to extreme impact loading.

1.1.6 The target percentage of air content for the concrete is specified by the DOT agency and the amount of air content can vary from state to state.

1.1.7 The mix design of the MSE fascia panels varies from state to state. Some agencies require a higher minimum 28-day concrete compressive strength, the use of fly ash, to include slag or air entrainment. SSL uses a different producer for each state and each local producer is familiar with their agency's respective mix design requirements.

1.1.8 The SSL MSE Plus system does not incorporate the use shear pins or alignment devices for wall construction. The system does use two bearing pads at the top of each 5' or 6' wide standard size panel to control the horizontal panel joint width. Larger 10' and 12' width panels will use 3 or 4 bearing pads per panel joint. The bearing pads are fabricated using an injection molded polypropylene copolymer. See Appendix 1.1.8 for bearing pad details.

1.1.9 All panel joints are covered using a minimum 1-foot wide filter cloth to prevent the migration of the select fill material through the panel joints. SSL specifies a Mirafi FW 402 or equal type geotextile, which is a woven high tenacity monofilament yarn. See Appendix 1.1.9 for the filter cloth specifications.

1.1.10 Many aesthetic possibilities are available. From fractured fin, seashells, rock etc. Examples of the various finishes are provided in Appendix 1.1.10.

1.1.11 Facing units using a 5 and 6 foot standard width and a ¾" panel joints are limited to a 50 foot inside radius.

1.2 INEXTENSIBLE REINFORCEMENT

1.2.1 The MSE Plus system does not use soil reinforcement that would be considered innovative.

1.2.2 The SSL MSE Plus retaining wall system utilizes only one type of welded wire mesh soil reinforcement. Depending on the specific wall design parameters and loading requirements conditions the soil reinforcement mesh sheet can be 2 wires up to a 6 wire mesh sheet. The crossbar spacing of the mesh sheets varies from 6 inches up to 30 inches. The length of each sheet is based upon a minimum of 8 feet or 70% of the design height of the wall as defined by AASHTO.

1.2.3 The SSL MSE Plus retaining walls system utilizes weld wire reinforcement manufactured in conformance with ASTM A1064 utilizing wire with a minimum yield strength of 75,000 PSI. Longitudinal wire sizes vary from a diameter of W8 (0.08 in^2) up to a maximum diameter wire size of W24 (0.24 in^2). The reinforcing mesh sheets are fabricated using welds, which are then evaluated in accordance with ASTM A1064. A copy of the ASTM specification is included in Appendix 1.2.3.

1.2.4 For the welded wire soil reinforcement as described in Section 1.2.3 the corrosion measure is hot dipped galvanizing which applied in accordance with ASTM A123. The minimum galvanized coating thickness should be no less than 3.4 mills or 2-ounces per square foot of the reinforcement surface area. The zinc coating provides a sacrificial anode that corrodes while protecting the base metal. Galvanization also assists in preventing the formation of pits in the base metal during the first years of aggressive corrosion.

1.2.5 The sacrificial steel thickness for the weld wire mesh reinforcement is determined as follows for W11 and W24 wire sizes.

75 Year Design Life Corrosion Reduction Analysis

Galvanizing coverage ASTM A123 = 2 ounces per square foot

Rate of corrosion for zinc = 15_{um} per year – first 2 years

4_{um} per year – thereafter

For residual carbon steel = 12_{um} per year

Galvanizing thickness = (2 oz x (1728 /16))/(440 x 144) = 0.00341 inches = 3.41 mils = 86.59_{um}

First 2 years = 2 x 15_{um} = 30_{um} per year

Number of years of galvanized coating = 2 + ((86.59 – $30)_{um}$)/ 4_{um} = 16.15 years

Steel loss = (75 – 16.14) years x 12_{um} / year = 706.32_{um} = 0.0278 inches

W11 wire diameter = 0.374 inches

W11 effective wire diameter = (0.374 – (2 x 0.0278) = 0.318 in^2

W24 wire diameter = 0.553 inches

W24 effective wire diameter = (0.553 – (2 x 0.0278) = 0.497 in^2

100 Year Design Life Corrosion Reduction Analysis

Steel loss = (100 – 16.14) years x 12_{um} / year = $1{,}002.32_{um}$ = 0.0396 inches

W11 effective diameter = 0.374 – (2 x 0.0396) = 0.295 in^2

W24 effective diameter = (0.553 – (2 x 0.0396) = 0.474 in^2

1.2.6 Corrosion testing has been performed by others which is well documented in past publications. SSL follows the requirements for galvanized coating and sacrificial steel rates provided and recommended in AASHTO and FHWA NHI 10-024.

1.2.7 The SSL MSE Plus system utilizes weld wire mesh fabricated in accordance with the tolerances outlined in ASTM A1064. Drawings for reinforcement types with tolerances are available in Appendix 1.1.4.

1.2.8 The connection system is comprised of three components. The first is a pair of wire loops are cast into the panel to form a clevis, the second is where one end of the soil reinforcement is bent 90 degrees to form a 90 degree loop. The looped end of the soil reinforcement is inserted in between the two loops cast into the panel which forms the clevis. The third is a pin is inserted into the soil reinforcement loop and clevis to complete the connection of the soil reinforcement to the panel. Complete details are shown in Appendix 1.2.8.

1.2.9 The MSE Plus system uses only one type of connection device paired to up to 6 connectors per layer. That connection system is described in Section 1.2.8.

1.2.10 The connection system is fabricated in accordance with ASTM A 1064. The embed loops are fabricated with material with a minimum yield strength of 75,000 PSI.

1.2.11 The connection system components are galvanized in accordance with NHI 10-024 with a minimum coating thickness of 3.4 mils. The coating is applied in accordance with ASTM A123.

1.2.12 The sacrificial steel thickness is determined as follows for both 75 and 100 years for the connection device is as follows.

75 Year Design Life Corrosion Reduction Analysis

Galvanizing coverage ASTM A123 = 2 ounces per square foot

Rate of corrosion for zinc = 15_{um} per year – first 2 years

4_{um} per year – thereafter

For residual carbon steel = 12_{um} per year

Galvanizing thickness = (2 oz x (1728 /16))/(440 x 144) = 0.00341 inches = 3.41 mils = 86.59_{um}

First 2 years = 2 x 15_{um} = 30_{um} per year

Number of years of galvanized coating = 2 + ((86.59 – $30)_{um}$)/ 4_{um} = 16.15 years

Steel loss = (75 – 16.14) years x 12_{um} / year = 706.32_{um} = 0.0278 inches

W11 wire diameter = 0.374 inches

Effective area for connection = (0.374 – (2 x 0.0278) = ((0.318/2)^2 x 3.14) = 0.080" x 4 = 0.318 in^2

W24 wire diameter = 0.553 inches

W24 effective area = (0.553 – (2 x 0.02780) = (0.497/2)^2 x 3.14) = 0.194 in^2

Connection area vs. wire Area = 0.318 in^2/0.194 in^2 = 1.64. Panel connector area greater than W24 wire.

100 Year Design Life Corrosion Reduction Analysis

Steel loss = (100 – 16.14) years x 12_{um} / year = $1{,}002.32_{um}$ = 0.0396 inches

W11 effective area for connection = 0.374" – (2 x 0.0396) = ((0.295/2)2 x 3.14) x 4 = 0.275 in^2

W24 effective area = (0.553 – (2 x 0.0396) = (0.474/2)^2 x 3.14) = 0.176 in^2

Connection area vs. wire area = 0.275 in^2 / 0.176 in^2 = 1.56. Panel connector area greater than W24 wire.

1.2.13 Corrosion tests have not been performed on this connection system by SSL. The performance

of the system is based upon corrosion rates recommended in AASHTO and NHI 10 - 024.

1.2.14 See Appendix 1.2.8 and 1.2.14 for drawings with the dimensional tolerances for the soil reinforcement and panel connector, respectively.

1.2.15 SSL developed a panel connection system for MSE retaining walls, which uses welded wire soil reinforcement with precast concrete fascia panels. Connection testing was performed by SSL in November 2013, and this testing focused on the capacity of the connection bends in the individual wires to ensure loading of 100% of yield strength of the wire could be achieved.

SSL conducted a supplemental connection test program in July 2023, and testing was witnessed by Twining Labs. This test focused on the strength of the panel connectors embedded into the precast panel with respect to tensile capacity. The test was conducted on a full-scale standard production “Y” panel designed for use with a 6 wire W24 mesh soil reinforcement sheet. Two loads were applied TL1 and TL2. The test loads were determined as follows: 1) One W24 wire = 0.24 in2 x 75,000 psi = 18,000 lbs. An unfactored load for a 6-wire sheet would be 108,000 lbs. TL1 uses the AASHTO resistance factor of 0.65 for a nominal TL1 load of 70,200 lbs. and TL2 used a provisional loading factor of 0.70 for a test load 75,600 lbs.

The testing was successful with both applied loads with the panel and connectors showing no deformations or cracking. The test load applied to this panel would equate to a wall design height of approximately of 75 feet with a 5’ x 5’ panel.

AASHTO Section 11.10.6.2.2 Reinforcement Loads at the Connection to Wall Face states: “The nominal tensile load applied to the soil reinforcement connection at the wall face, TO, shall be equal to the nominal reinforcement tension, Tmax, for all wall systems regardless of facing and reinforcement type.” The appropriate resistance factor must be applied to the connection capacity per AASHTO Table 11.5.7.1 for inextensible grid systems (i.e., the SSL MSE Plus system) the resistance factor is 0.65 when using the coherent gravity method of analysis.

1.2.16 SSL has not performed pullout tests and uses the default values provided in NHI-10-024.

1.2.17 This section only applies for geosynthetic reinforcement and inextensible systems.

1.3 OTHER COMPONENTS

1.3.1 The wall system does not contain an innovation with respect to any wall components.

1.3.2 This section does not apply to our MSE system.

1.3.3 Our MSE Plus system utilizes drainage methods such as underdrains or drainage structures at the roadway surface to collect and distribute runoff away from the MSE structure. In the majority of the MSE wall projects the transportation agency specifies their drainage system or systems designed by the agencies drainage engineers. Please see Appendix 1.3.3 for a standard drainage structure used at the roadway surface and a standard underdrain system.

1.3.4 Our system uses both precast and cast in place styles of coping. Our precast coping comes in 10' and 12' lengths and are usually 24 inches tall using a panel embedment of 12 inches. The cast in place coping is usually installed in continuous lengths with a crack control joints at 30' intervals. The overall dimensions can be the same as precast coping. Both precast and cast in place copings can vary for each agency. Typical coping details can be found in Appendix 1.3.4.

1.3.5 Most transportation agencies integrate the cast in place traffic barrier with a moment slab for roadway conditions. Please see Appendix 1.3.5 for a typical standard example. Each agency will have a slight variation of what is presented in this Appendix.

1.3.6 The slip joint is a "T" shaped panel in cross section with wide flanges for the standard panels to slip in behind the flanges. The wide flanges allows standard panel to move freely within the joint in the event differential settlement exceeds 1/100. The height of the slip joint panels is in the same increments as the standard MSE wall panels. Please see Appendix 1.3.6 for additional details and dimensions.

2.1 ERS DESIGN

2.1.1 The SSL MSE wall system is designed in accordance with AASHTO and NHI documents and follows conventional design practices of inextensible reinforcement systems and does not include any design innovations.

2.1.2 The internal and external stability design methodology also includes a seismic analysis, if required, for the MSE structures. SSL follows Section 11.10 of AASHTO as well as Chapter 4

Section 4.4.7 of NHI-10-024 for the design of internal and external stability. Since SSL utilizes an inextensible metallic mesh style reinforcement, we recognize the design must incorporate a bi-lineal failure plane to design the soil reinforcement. Depending on the transportation agency we design the MSE structure using either the coherent gravity method or the simplified method to determine the vertical internal pressures at each reinforcement layer to determine the reinforcement stresses at each layer. In almost all design conditions SSL uses the industry standard software MSEW+. Information with respect to MSEW+ is available at https://geoprograms.com/msew/.

2.1.3 For vertical obstructions in the MSE reinforced zone SSL follows the recommendation provided in NHI-10-024 Section 5.4.2. by either shifting or offsetting the reinforcement to ends of the panel so a reinforcement sheet is on each side of the vertical obstruction as recommended in Alternative 1. In the event the detail shown in Alternative 1 and not feasible we follow the guidance recommended shown in Alternative 2 by using narrow reinforcements in conjunction with an angle frame. In both instances the obstruction is centered over a panel joint such as a drainage structure. For situations where the vertical obstruction is large such as a cast in place bridge column SSL incorporates a structural frame as recommended in Alternative 3. The photograph shown in NHI documents of Figure 5-19(a) is a SSL design detail utilizing a structural frame. For horizontal obstructions in the MSE reinforced zone SSL follows the recommendation in NHI-10-024 Section 5.4.3 whereby SSL deviates the reinforcement no more than 15 degrees either above or below the obstruction as shown in Figure 5-21. SSL will also recommend to the Owner to move the obstruction outside the reinforce zone, if possible, to ease construction and to facilitate future maintenance for the utilities if necessary. Plan details for vertical and horizontal obstructions are provided in Appendix 2.1.3.

2.2 DESIGN EXAMPLE

2.2.1 We have included three design examples which are for a MSE roadway MSE wall with 250 PSF live load, a MSE wall with a 2:1 infinite slope and a pile supported bridge MSE abutment structure. The MSEW+ calculations for all three design examples are included in Appendix 2.2.1.

3.1 CONSTRUCTION PROCEDURES

3.1.1 The SSL MSE Plus does contain an innovative construction procedure. Our MSE walls system follows conventional construction procedures for inextensible structures.

3.1.2 The SSL MSE Plus Installation Manual is included in Appendix 3.1.2.

3.1.3 For inside curves in our wall system, the curves are developed by a series of panel chords, which are 5' foot in width. Based upon a ¾" panel joint we recommend a 50 foot minimum radius. For outside curves in our wall system, we recommend a 50 foot minimum radius and special consideration to protect the filter cloth from UV exposure is a major consideration.

3.1.4 Since metallic systems designs do not consider coverage ratios for the design for internal stability overlapping of reinforcement is typically not a design issue. The SSL MSE Plus wall system utilizes a bar mat system whereby the pullout capacity of the mat is developed using the interaction between the soil and the bar mats crossbars to develop the passive resistance. Since bar mat systems do not rely on frictional resistance to develop pullout capacity, vertical separation between layers in overlapping situations should not be required.

3.1.5 The procedures to maintain the vertical and horizontal alignment of our system are described in detail in our Installation Manual in Appendix 3.1.2 beginning on page 17.

3.1.6 The procedures to install soil in the reinforced zone of our system are described in detail in our Installation Manual in Appendix 3.1.2 beginning on page 17.

3.1.7 During construction we recommend that after the end of each working day the grade of the backfill at the top of the wall be sloped downward away from the back of the wall panels to allow drainage of any water away from the wall to prevent erosion. For the front face of the wall, we recommend finished grade is sloped away from the front face to prevent erosion and the collection of water.

3.1.8 The experience and qualifications of the MSE wall contractor is a requirement usually specified by the transportation agency. Some agencies' specifications require little or no experience. But most agencies do request that the MSE wall manufacturer provide jobsite assistance for varying lengths of time. Some states such as Arizona stipulate specific experience requirements from management as well as the jobsite personnel and labor staff.

3.1.9 The procedure to install the MSE select fill in the reinforced zone is described in our Installation Manual in Appendix 3.1.2 beginning on page 17.

4.1 MANUFACTURING

4.1.1 The precast concrete fascia panels are manufactured following the precast concrete manufacturer's Quality Control Plan for each state agency. An example of a Precast Quality Control Plan also known as a PCQCP is presented in Appendix 4.1.1. This PCQCP is from Precast Solutions Incorporate for the INDOT and is prepared with respect to the requirements of the National Precast Concrete Association also known as NPCA. Other agencies require similar plans for approvals for each precaster by each agency, the NPCA or both.

4.1.2 The weld wire mesh soil reinforcements are manufactured following SSL's Quality Control Manual. This manual is available in Appendix 4.1.2.

4.1.3 SSL MSE Plus system does not utilize shear or alignment devices. The bearing pads used at the horizontal panel joints are tested with the results evaluated for each batch of pads manufactured. Bearing pads are evaluated under an incremental compressive load up to 40,000 pounds. During the compressive loading, the vertical displacement is recorded to develop a load vs. displacement curve. Upon completion of the compressive testing the bearing pad is measured for dimensional changes and photographed. Please see Appendix 4.1.3 for a sample test report. The connection devices are manufactured in accordance with the Quality Control Manual in Appendix 4.1.2.

4.2 CONSTRUCTION

4.2.1 The quality control measures are not described in the construction manual with respect to assembling the MSE structure. On page 36 of the Construction Manual in Appendix 4.1.2 SSL provides a checklist of items that should be addressed during wall construction. The backfill and the preparation of the MSE structure foundation are performed in accordance with the transportation agency recommendation and their specifications. The contractor's work is inspected by the transportation agency or the Engineer of Record for the project.

5.1 PERFORMANCE HISTORY

5.1.1 Our MSE Plus^{TM} system was developed in 1997 and SSL received our first approval in California by The California Department of Transportation or Caltrans. With the completion of our HITEC evaluation in 1999 SSL received approvals by most state departments of transportation agencies. The connection system evaluated in the 1999 HITEC reports was for our internal connection. In 2003 SSL revised the internal connection system to a more conventional external system using clevis embed connectors cast into the concrete panel by then joining the 90 degree loop in soil reinforcement to the clevis using a connection pin. This connection was approved by Caltrans in 2003 and once again in 2012 as their connection testing requirements were modified for their LRFD approval. Testing was performed for Caltrans in December 2012 SSL received LRFD approval shortly thereafter.

5.1.2 Three of the oldest structures using this new connection system are in California. The projects are the SR 22 Project in Orange County, SR 101 Ralston in San Mateo County and Route 116 / 101 in San Ramon. All these projects were for Caltrans.

5.1.3 Two of the tallest structures using the connection system are in California. The tallest structure was of the SR 91 Widening Project in Corona California. Wall 115C was 52 feet tall with 115B in similar height. The third tallest structure was a project for the Nevada Department of Transportation on the I 580 Realignment Project constructed south of Reno, Nevada. One of the MSE walls was on this project was 65.0 feet tall.

5.1.4 Provide a list of private and public sector users who have approved the use of the system. Also provide contact information for a person at the user agency who may be contacted regarding the wall system's performance. Please see Appendix 5.1.4 for a list of users for the SSL MSE Plus retaining wall system.

6.0 OTHER INFORMATION –

No additional information is provided for Section 6.

Appendix

IDEA
HIGHWAY INNOVATIONS, DEVELOPMENTS, ENHANCEMENTS AND ADVANCEMENTS

MSE Plus^{TM} Wall System

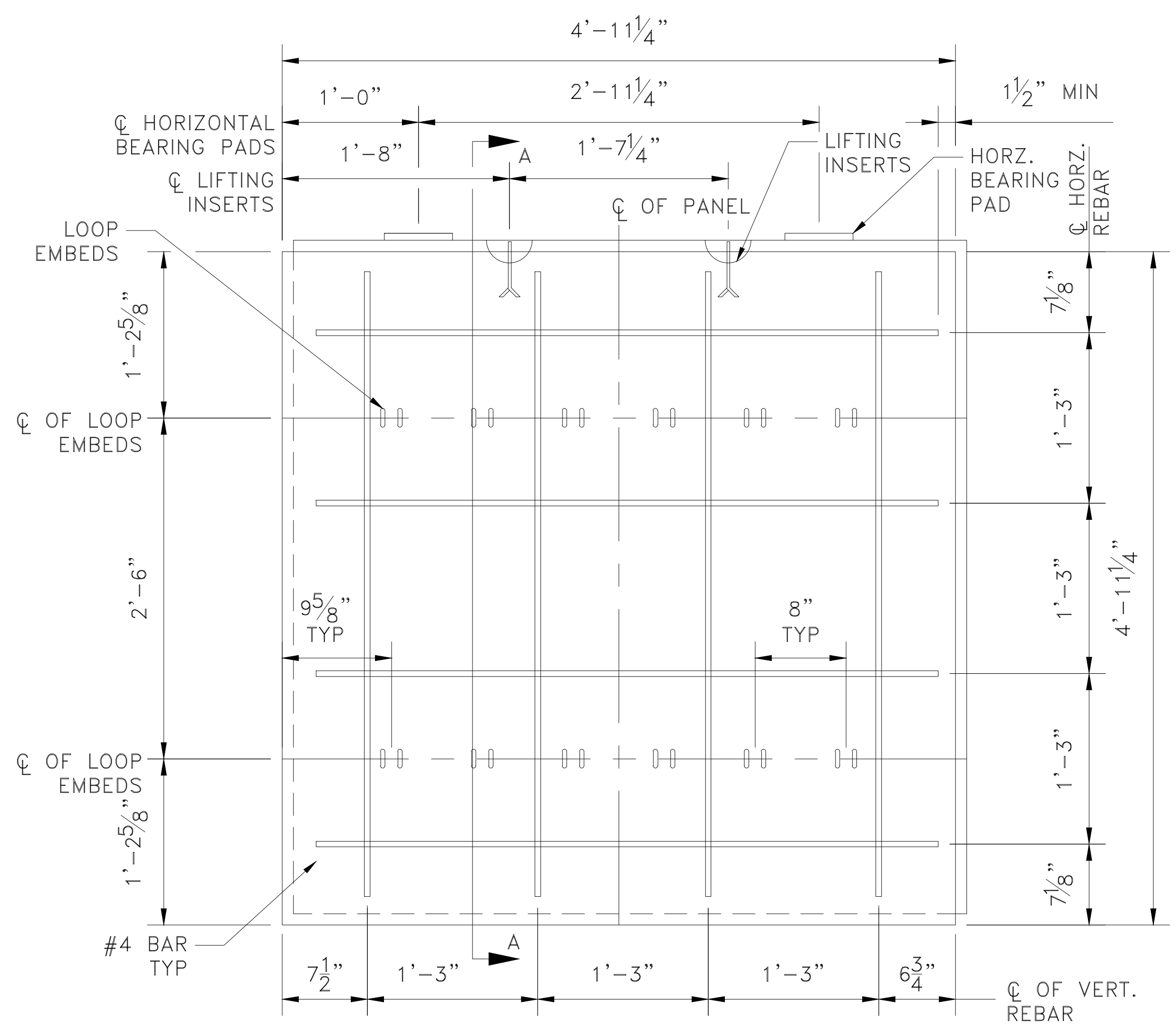
Table of Contents

Section 1: ERS Components

1.1
Facing Units

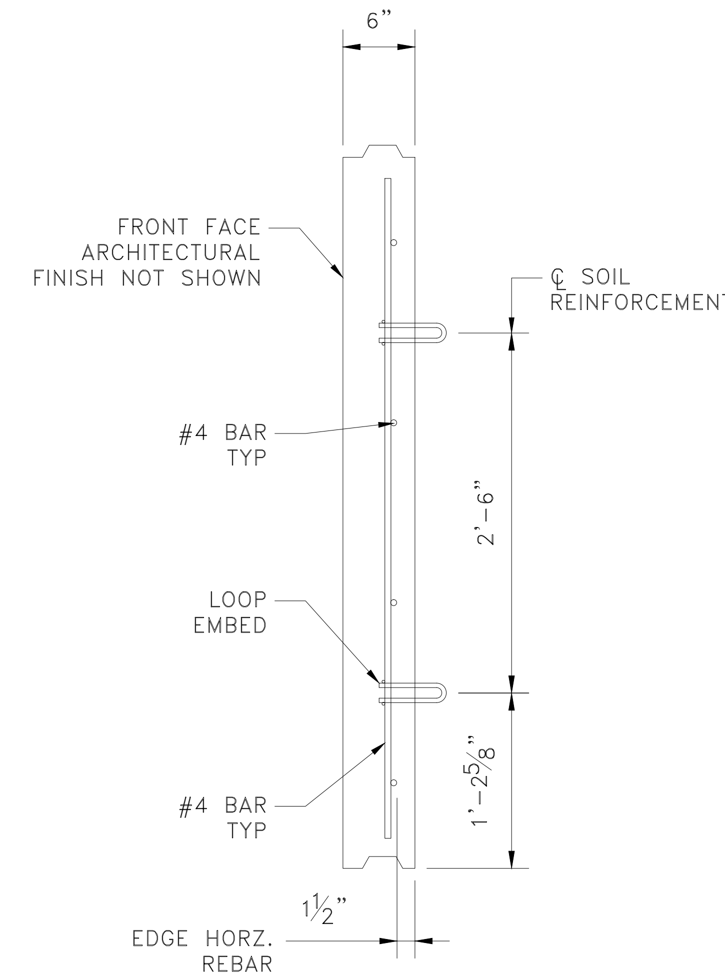
1.1.4 Facing Unit Dimensions

5’ x 5’ STANDARD PANELS



STANDARD "A" PANEL

SHOWN FROM BACK FACE



SECTION A-A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

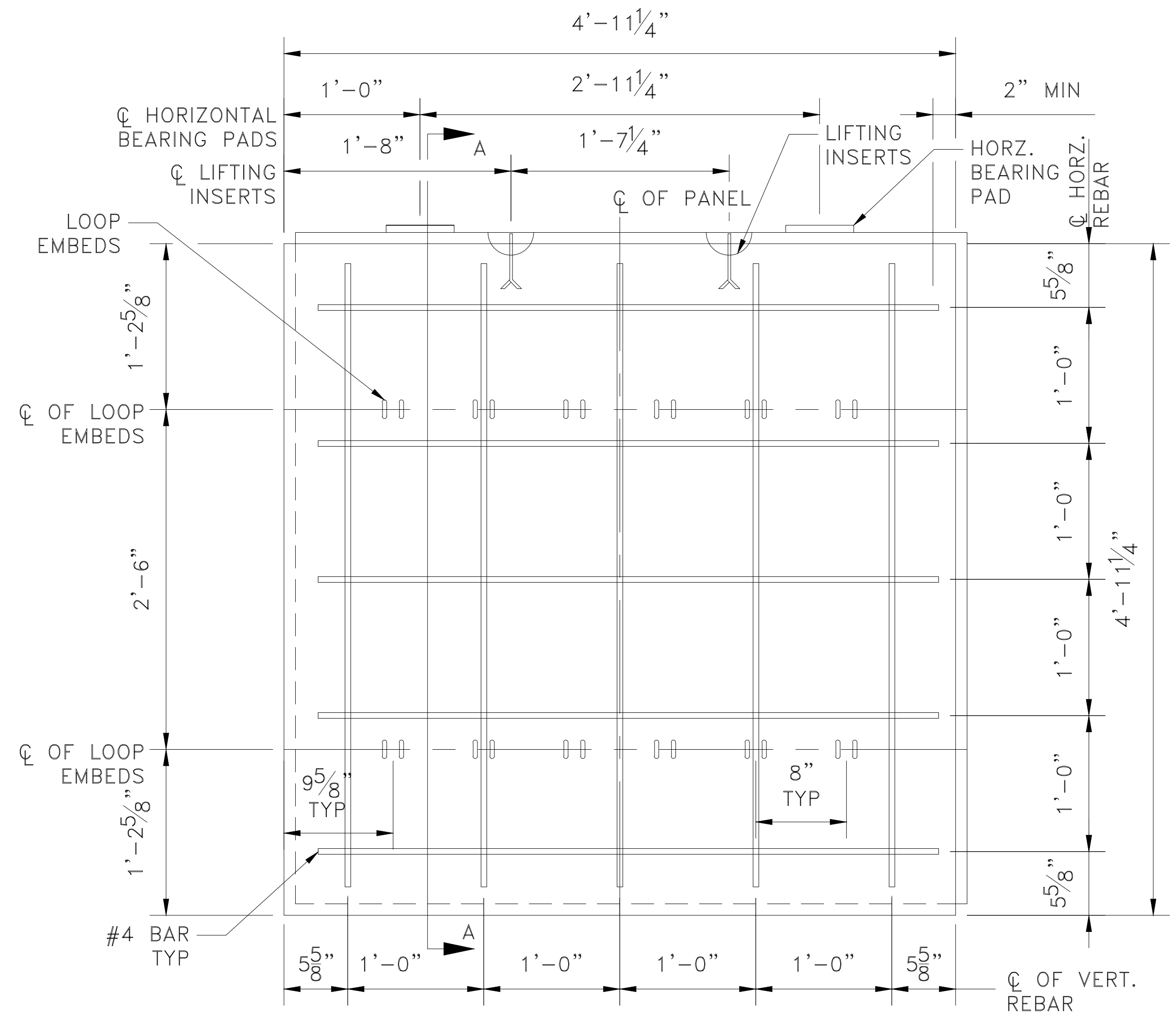
THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X5' PANEL DETAILS

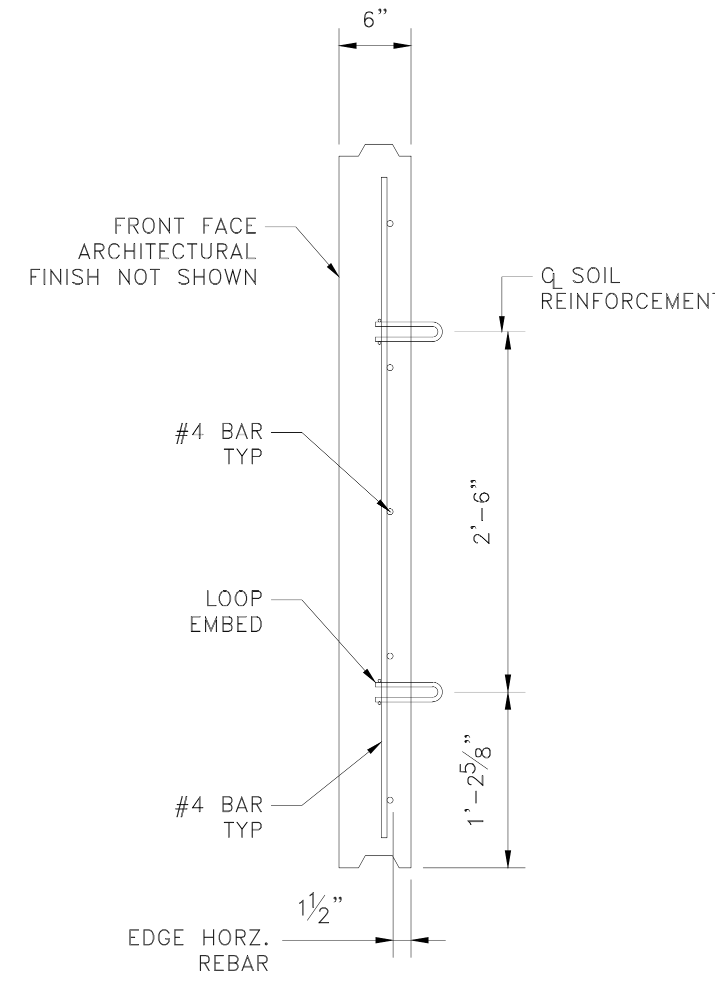
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

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IDEA EVALUATION

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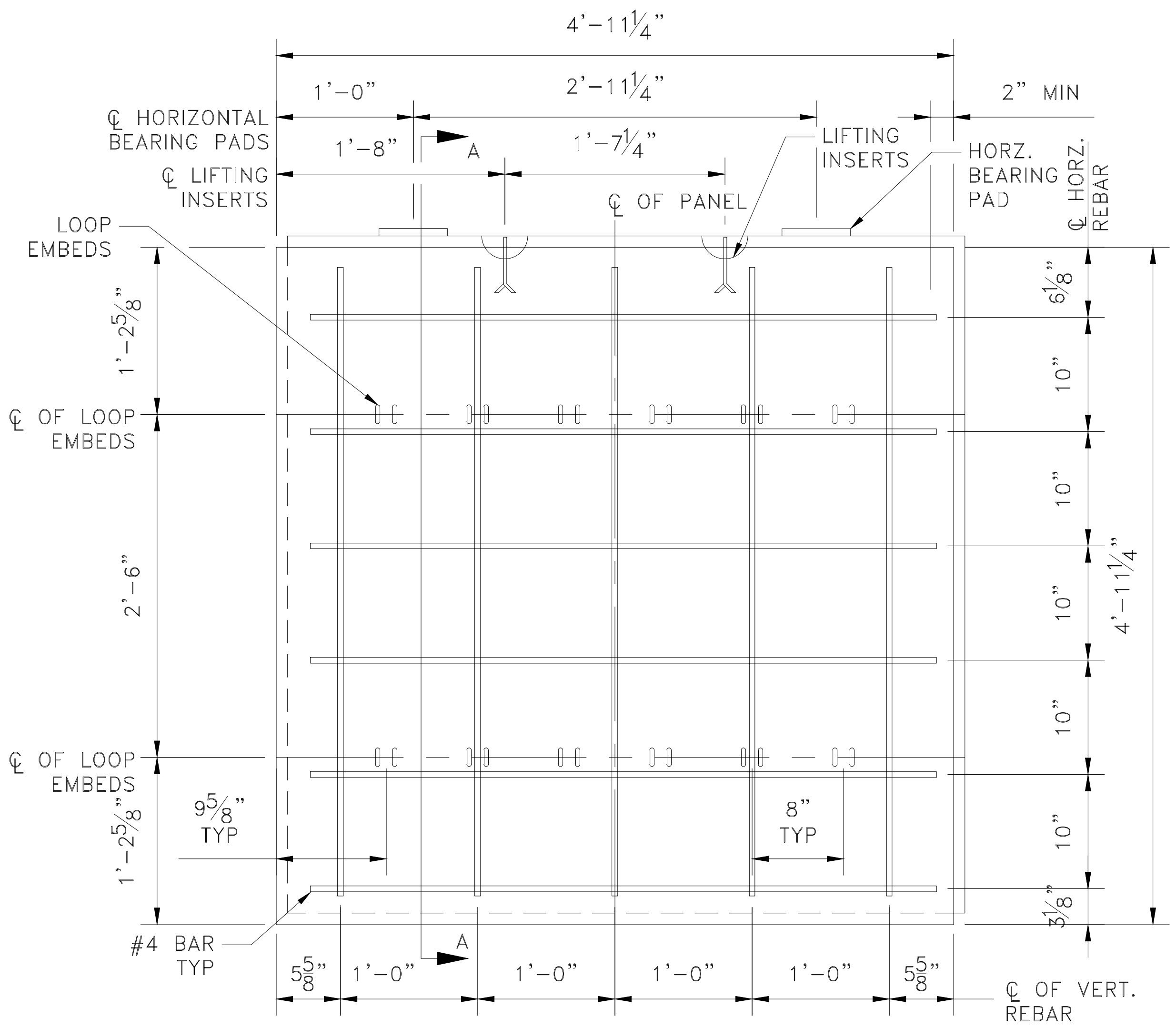
Job:
Sheet:
Sheet of



STANDARD "Y" PANEL

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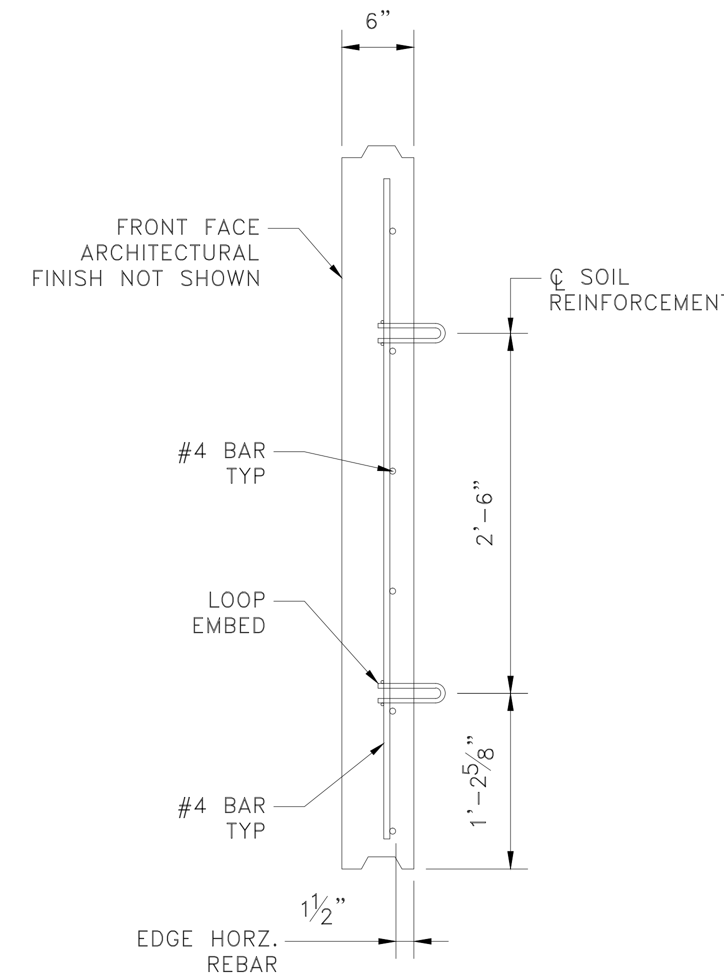

SECTION A-A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X5' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

TOC – Appendix

	Area	Diameter
16	Galvanize Life Coating	
12	Corrosion Rate Carbon Steel (in microns)	
75	Design Life	

Wire	Area sqin	Diameter in	Diameter microns	Diameter after microns	Diameter after in	% effective	Area after sqin					6	7	8
W5	0.05	0.252	6408.757	4992.757	0.1966	0.6069	0.0303	2	3	4	5	0.1821	0.2124	0.2428
W8	0.08	0.319	8106.507	6690.507	0.2634	0.6812	0.0545	0.1090	0.1635	0.2180	0.2725	0.3270	0.3815	0.4359
W11	0.11	0.374	9505.722	8089.722	0.3185	0.7243	0.0797	0.1593	0.2390	0.3187	0.3983	0.4780	0.5577	0.6374
W15	0.15	0.437	11100.292	9684.292	0.3813	0.7611	0.1142	0.2283	0.3425	0.4567	0.5709	0.6850	0.7992	0.9134
W20	0.20	0.505	12817.513	11401.513	0.4489	0.7913	0.1583	0.3165	0.4748	0.6330	0.7913	0.9495	1.1078	1.2660
W24	0.24	0.553	14040.882	12624.882	0.4970	0.8085	0.1940	0.3881	0.5821	0.7761	0.9702	1.1642	1.3582	1.5523
W30	0.30	0.618	15698.184	14282.184	0.5623	0.8277	0.2483							

SPRING CONSTANT

Modulus of Sub-Grade Reaction and Spring Constant Check

From Principles of Foundation Engineering; Braja M. Das 8th Edition:

Table 8.2 Typical Subgrade Reaction Values, $k_{0.3}(k_1)$

Soil type	$k_{0.3}(k_1)$ MN/m^3	$k_{0.3}(k_1)$ lb/in.^{3}
Dry or moist sand:		
Loose	8–25	30–90
Medium	25–125	90–450
Dense	125–375	450–1350
Saturated sand:		
Loose	10–15	35–55
Medium	35–40	125–145
Dense	130–150	475–550
Clay:		
Stiff	10–25	40–90
Very stiff	25–50	90–185
Hard	>50	>185

$K_{0.3}$ (k_1) = 1350 lb/in^3 (is selected)

(dense Sand, value is conservative considering no reinforcement is included)

Adjust to panel 5' x 10' (1.5m x 3m)

Foundations on Sandy Soils

For foundations on sandy soils,

$$k = k_{0.3}\left(\frac{B+0.3}{2B}\right)^2 \tag{8.45}$$

where $k_{0.3}$ and k = coefficients of subgrade reaction of foundations measuring 0.3 m × 0.3 m and B(m) × B(m), respectively (unit is kN/m^3).

In English units, Eq. (8.45) may be expressed as

$$k = k_1\left(\frac{B+1}{2B}\right)^2 \tag{8.46}$$

where k_1 and k = coefficients of subgrade reaction of foundations measuring 1 ft × 1 ft and B(ft) × B(ft), respectively (unit is lb/in^3).

$$k_{1.5} = k_{0.3} \cdot \left(\frac{B+0.3}{2B}\right)^2$$

$$k_{1.5} = 1350\,x \left(\frac{1.5+0.3}{2\,x\,1.5}\right)^2$$

$k_{1.5}$ = 486 lb/in^3

$$k_{1.5x3.0} = k_{1.5} \cdot \left(\frac{1+\frac{1.5}{3.0}}{1.5}\right)^2$$

$k_{1.5x3.0}$ = 486 lb/in^3

$k_{1.5x3.0}$ = 839.755 kip/ft^3

From Foundation Analysis And Design; Joseph E. Bowles, RE., S.E. 5th Edition:

10-5 MODULUS OF SUBGRADE REACTION k_s FOR MATS AND PLATES

All three discrete element methods given in this chapter for mats/plates use the modulus of subgrade reaction k_s to support the plate. The modulus k_s is used to compute node springs based on the contributing plan area of an element to any node as in Fig. 10-5. From the figure we see the following:

Node	Contributing area
1 (corner)	$\frac{1}{4}$ of rectangle *abde*
2 (side)	$\frac{1}{4}$ of *abde* + $\frac{1}{4}$ of *bcef*
3 (interior)	$\frac{1}{4}$ of each rectangle framing to a common node (as node 3)

For a triangle one should arbitrarily use one-third of the triangle area to any corner node. For these area contributions the fraction of k_s node resistance from any element is

$$K_i = k_s,\ \text{kN/m}^3, \times \text{Area},\ \text{m}^2 = \text{units of kN/m (or kips/ft in Fps)}$$

Since this computation gives units of a "spring" it is common to call the effect a *node spring*.

In this form the springs are independent of each other, the system of springs supporting the plate is termed a "Winkler" foundation, and the springs are uncoupled. Uncoupling means that the deflection of any spring is not influenced by adjacent springs.

<u>Spring Constant</u>

Note Spacing: 1ft x 1ft

Tributary Area: 1' x 1' = 1SF

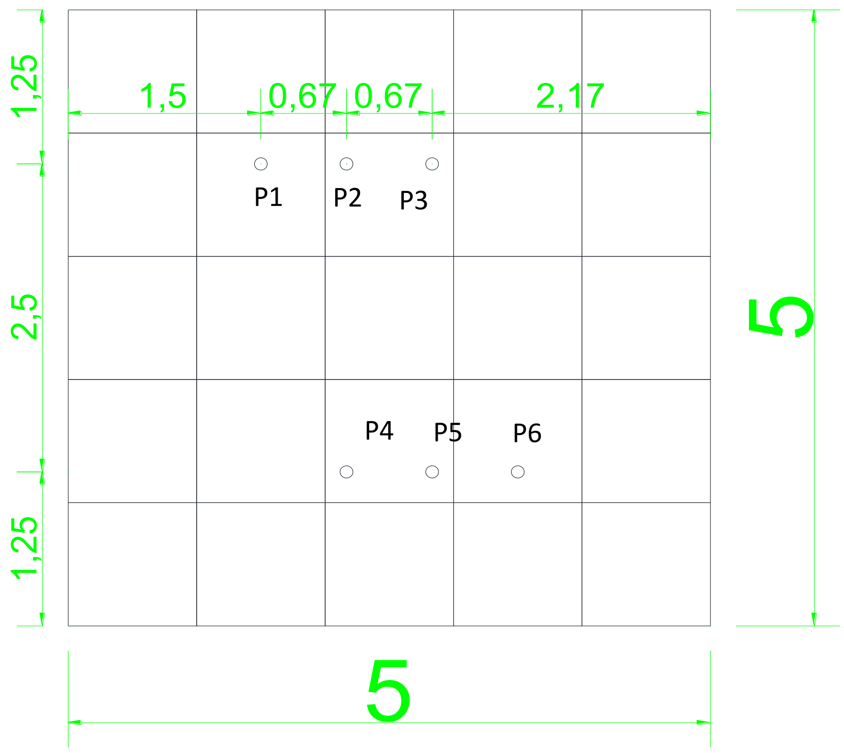
Ka = k x a

Ka = 839.755 kip/ft (Input to Staad Pro)

MAXIMUM BENDING MOMENT AND SHEAR

Typical Panel Type (mesh 3W11), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input

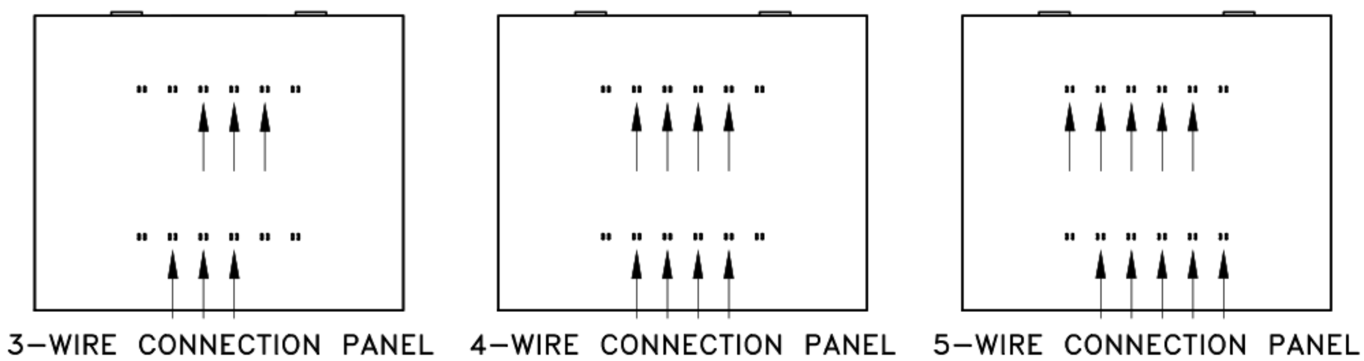


Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0	0.25
P2	-0.33	0.25
P3	0.33	0.25
P4	-0.33	-0.25
P5	0.33	-0.25
P6	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

A	=	0.0797	in^2
Fy	=	75	ksi
P	=	0.65 x A x Fy	
	=	3.885	Kips (per wire point)



ATTACHMENT BY No. WIRES
(STANDARD PANELS ONLY)

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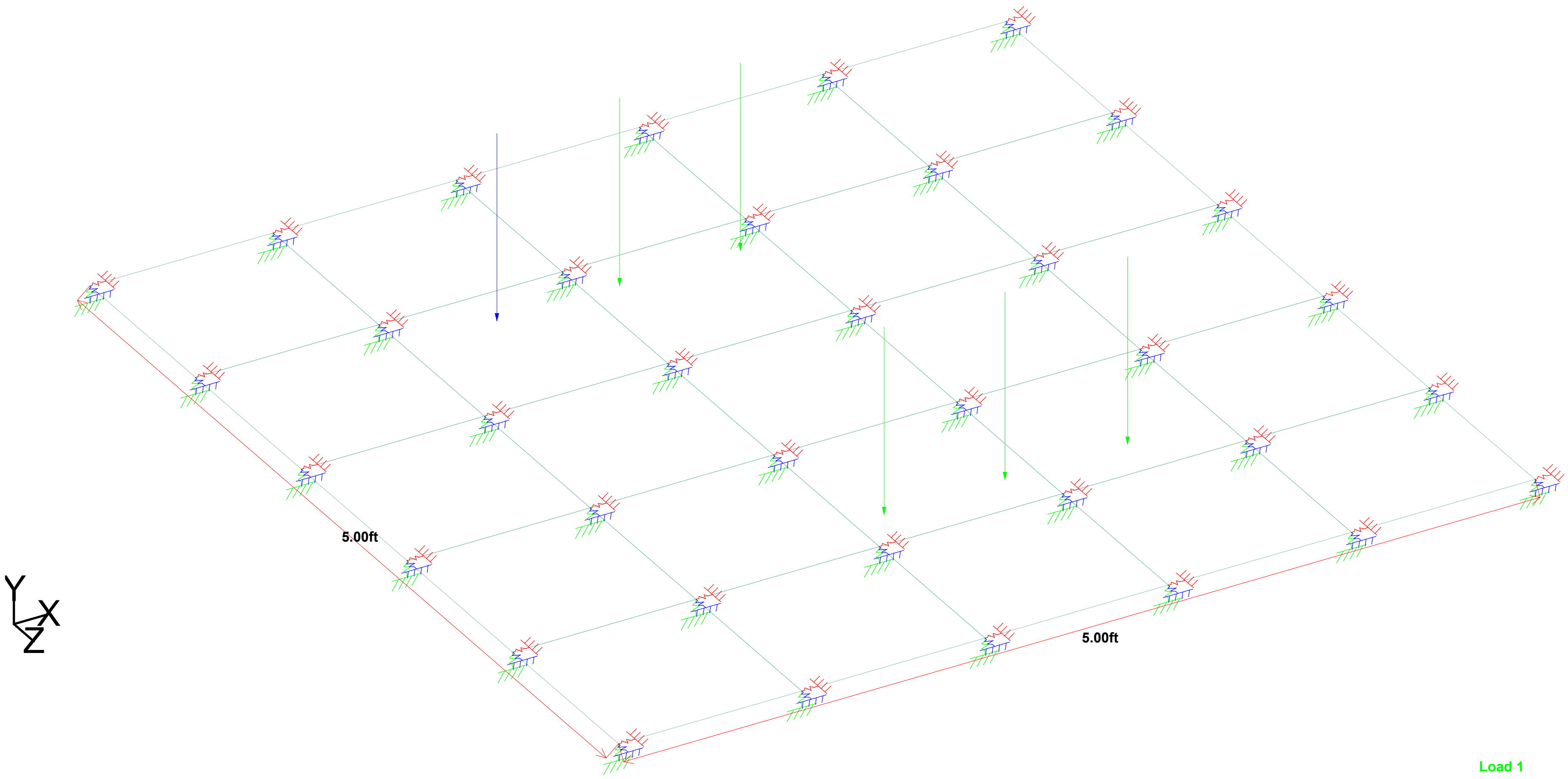
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 05:22	



TOC – Appendix

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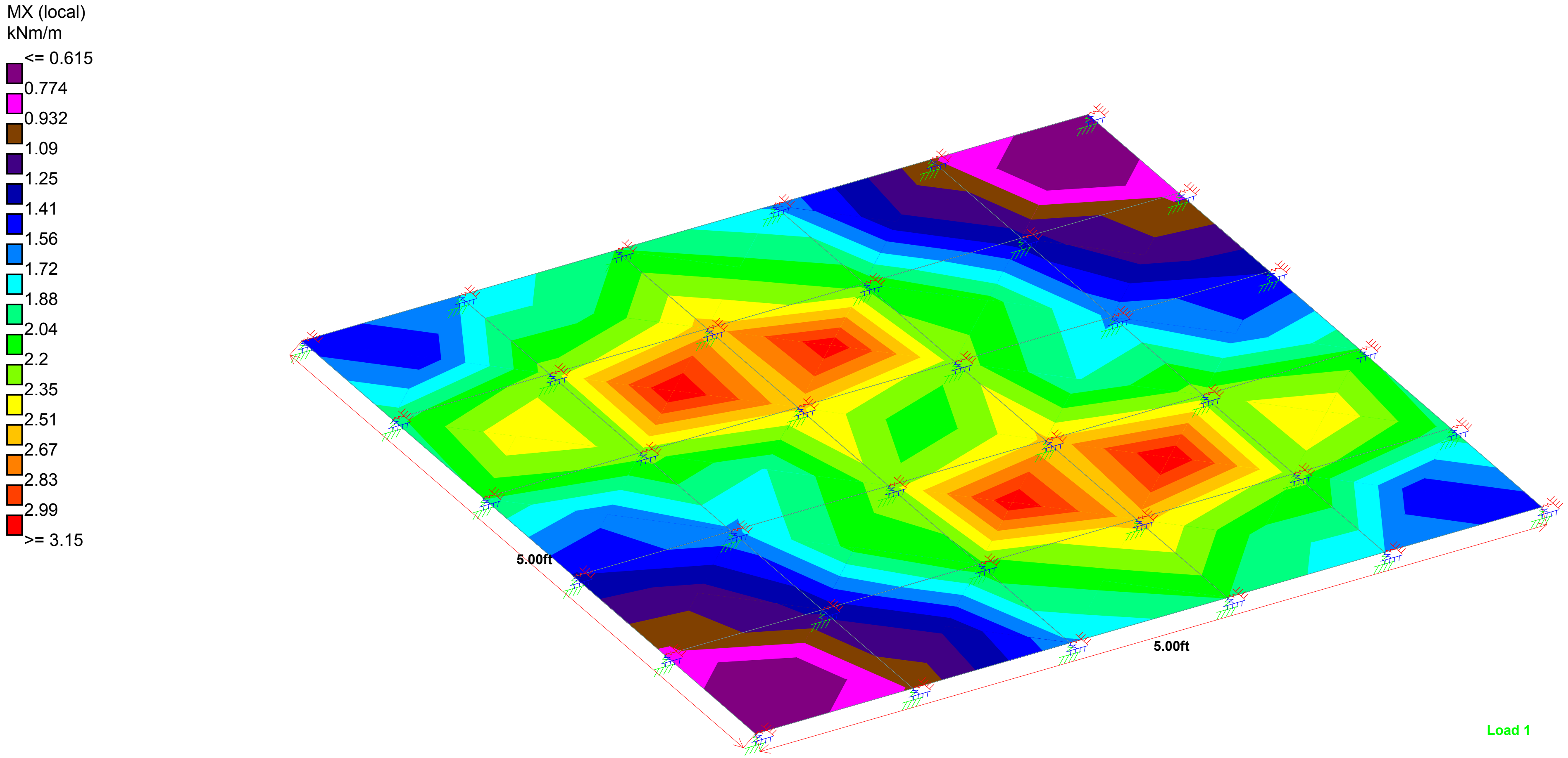

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
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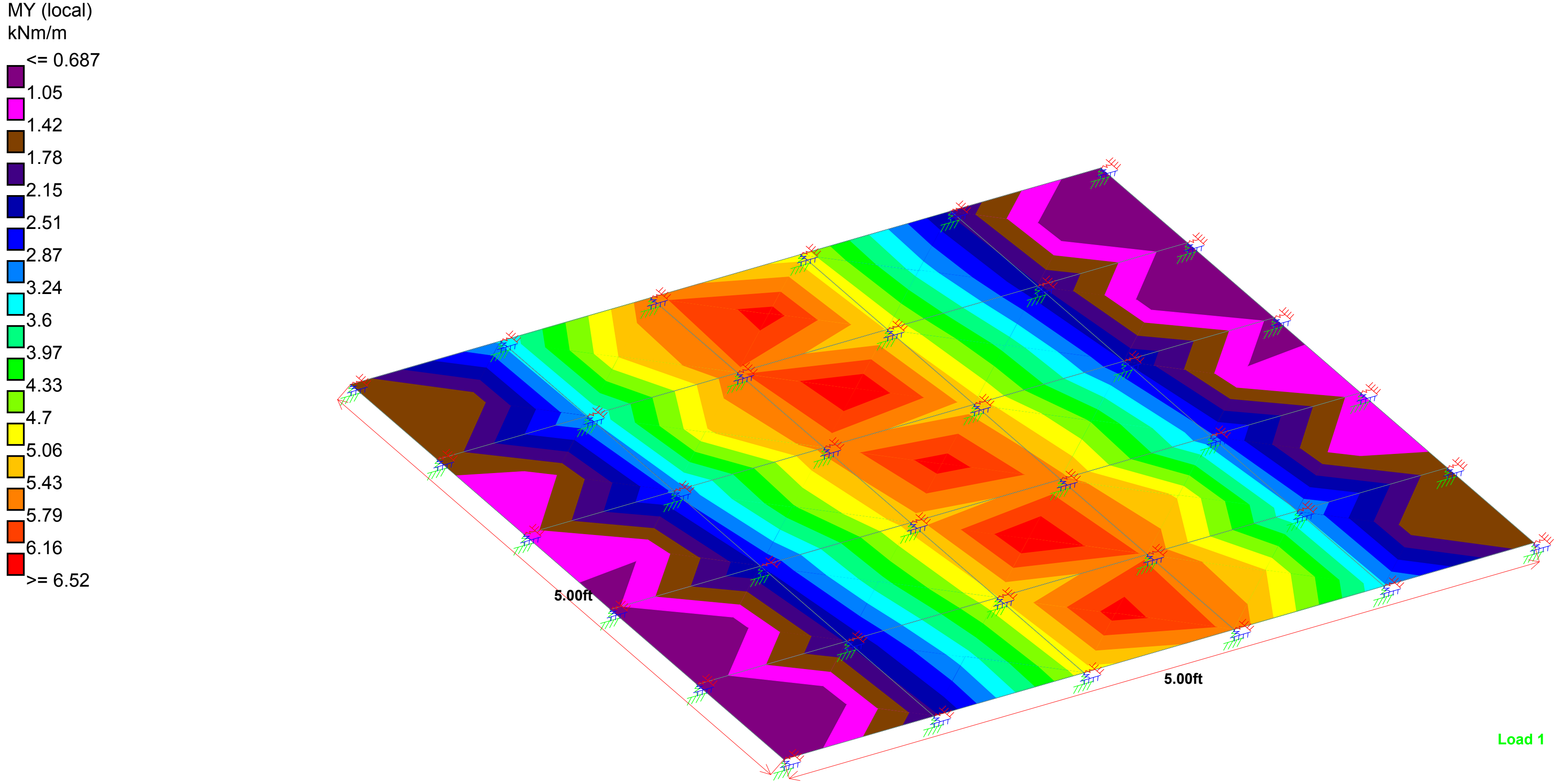
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 05:32	



TOC – Appendix

Job No		Sheet No 1		Rev
Part				
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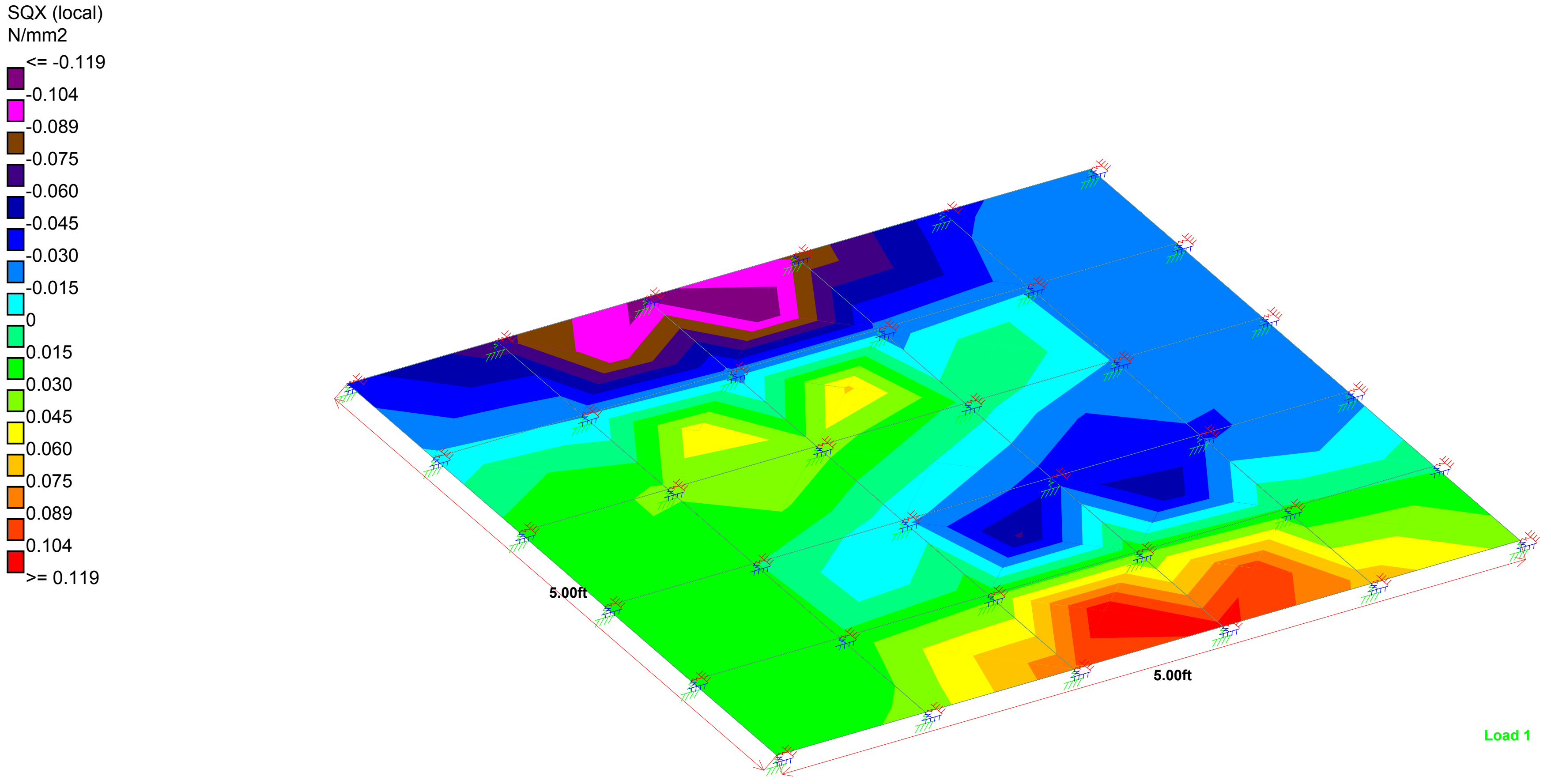
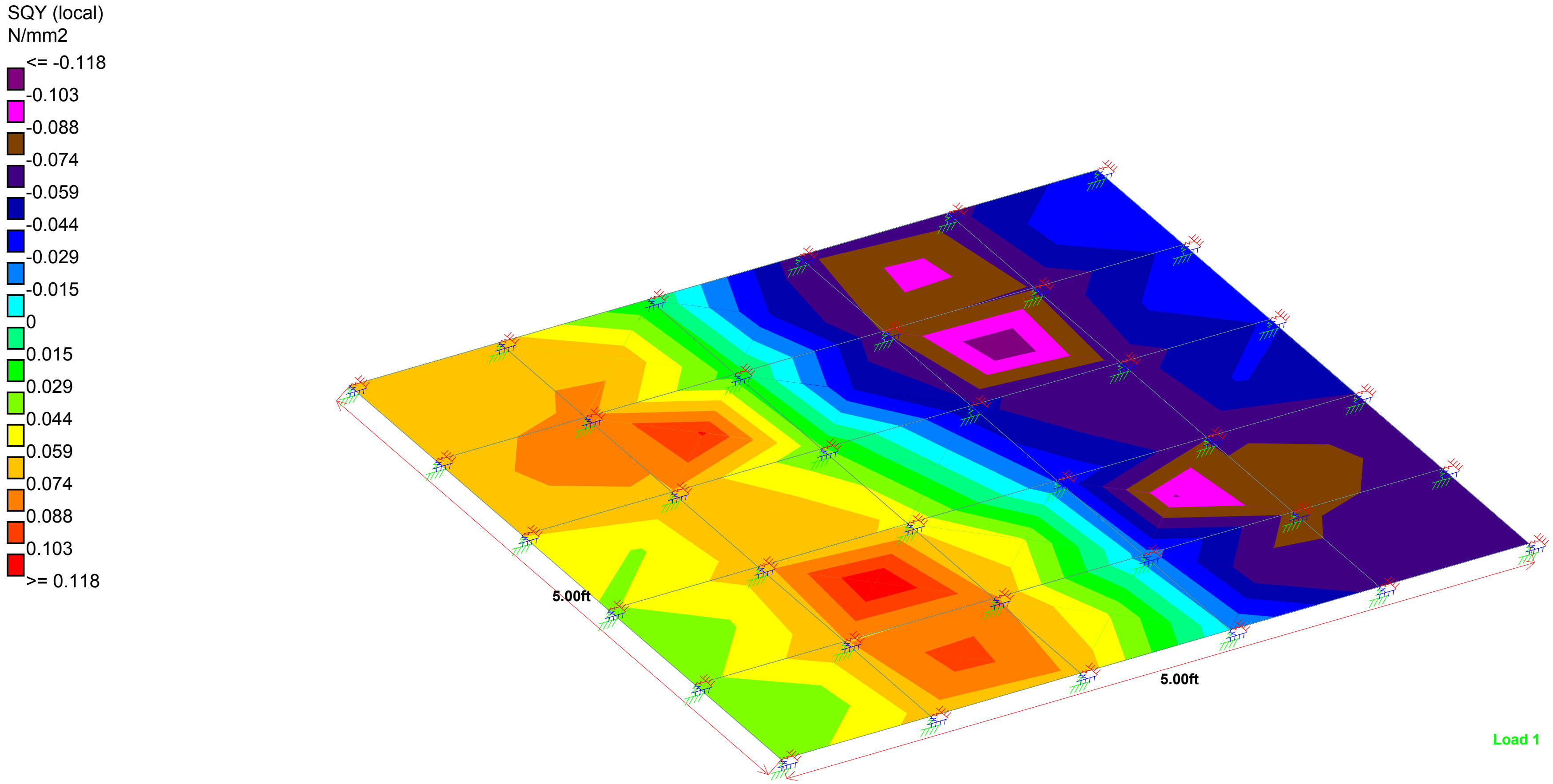


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 05:32	



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 *           Version  2007    Build 04              *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR  6, 2021                  *
 *           Time=     5:32:12                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
 ****************************************************


     1. STAAD SPACE
INPUT FILE: Panel Check - 5x5 type A (3W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 32 PR GY -3.885 0.25 0
    40. 33 PR GY -3.885 0.25 -0.33
```



```
    41. 33 PR GY -3.885 0.25 0.33
    42. 8 PR GY -3.885 -0.25 -0.33
    43. 8 PR GY -3.885 -0.25 0.33
    44. 11 PR GY -3.885 -0.25 0
    45. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

        SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

  ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
  TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
  SIZE OF STIFFNESS MATRIX =        11 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.2/ 263455.4 MB


    46. FINISH
```

Typical Panel Type (mesh 4W11), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0	0.25
P2	-0.33	0.25
P3	0.33	0.25
P4	0	0.25
P5	0	-0.25
P6	-0.33	-0.25
P7	0.33	-0.25
P8	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

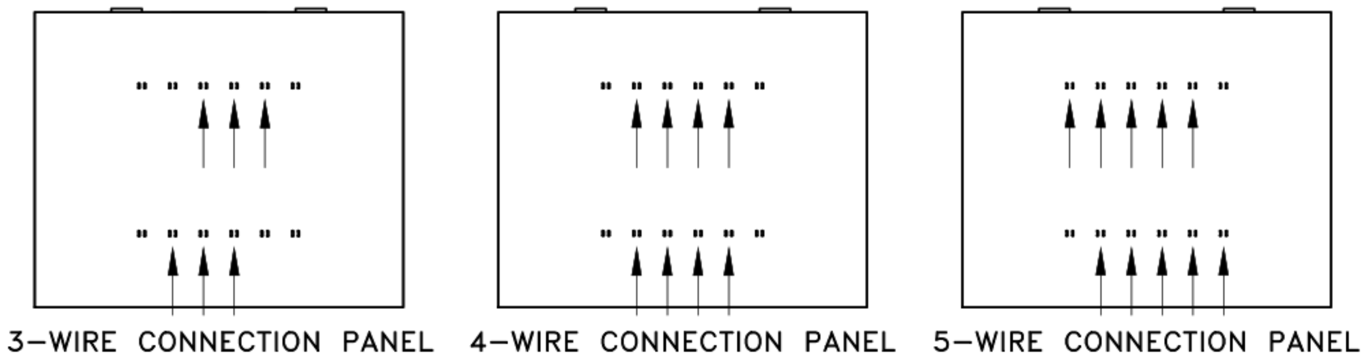
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

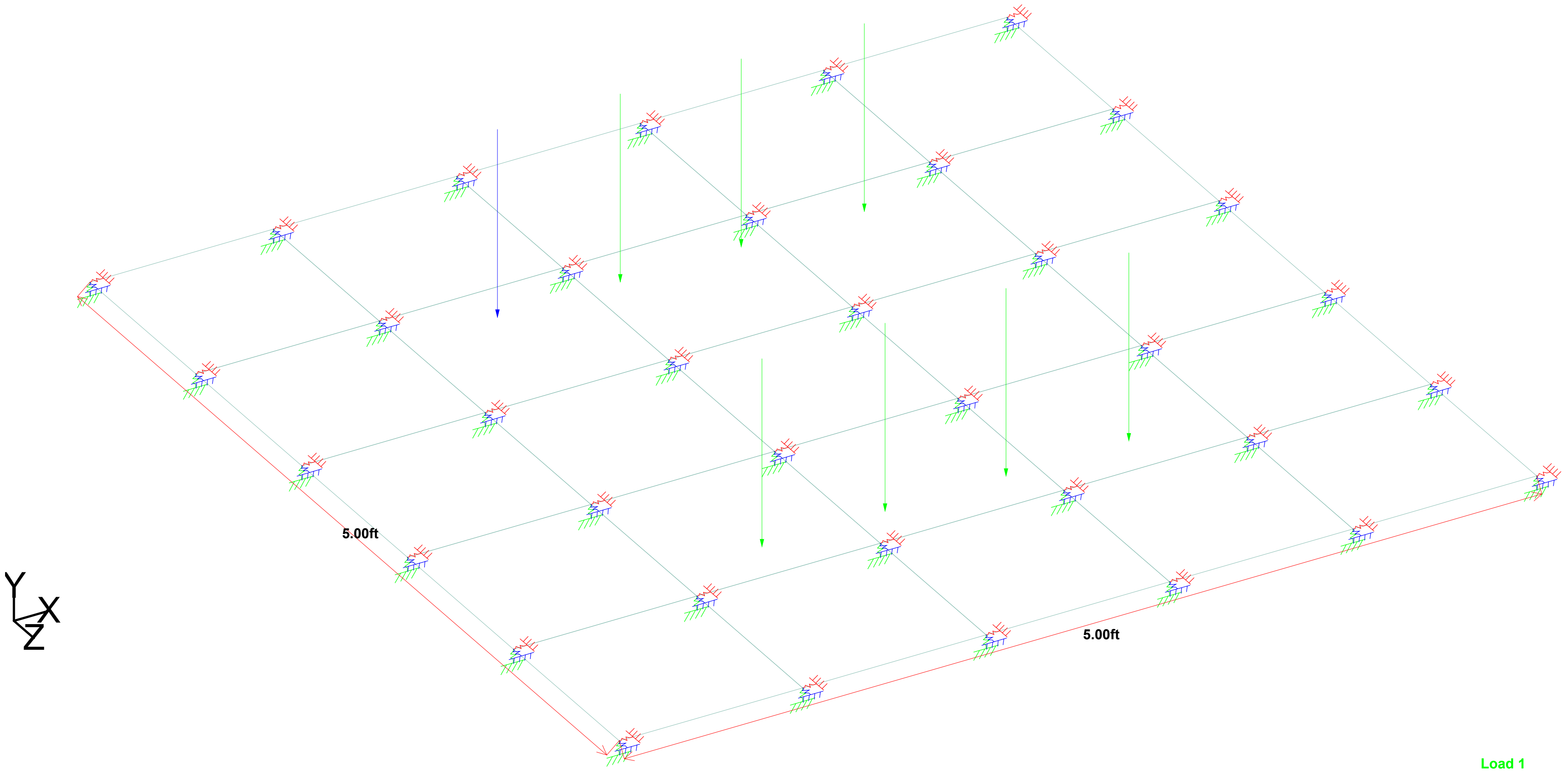
= 3.885 Kips (per wire point)



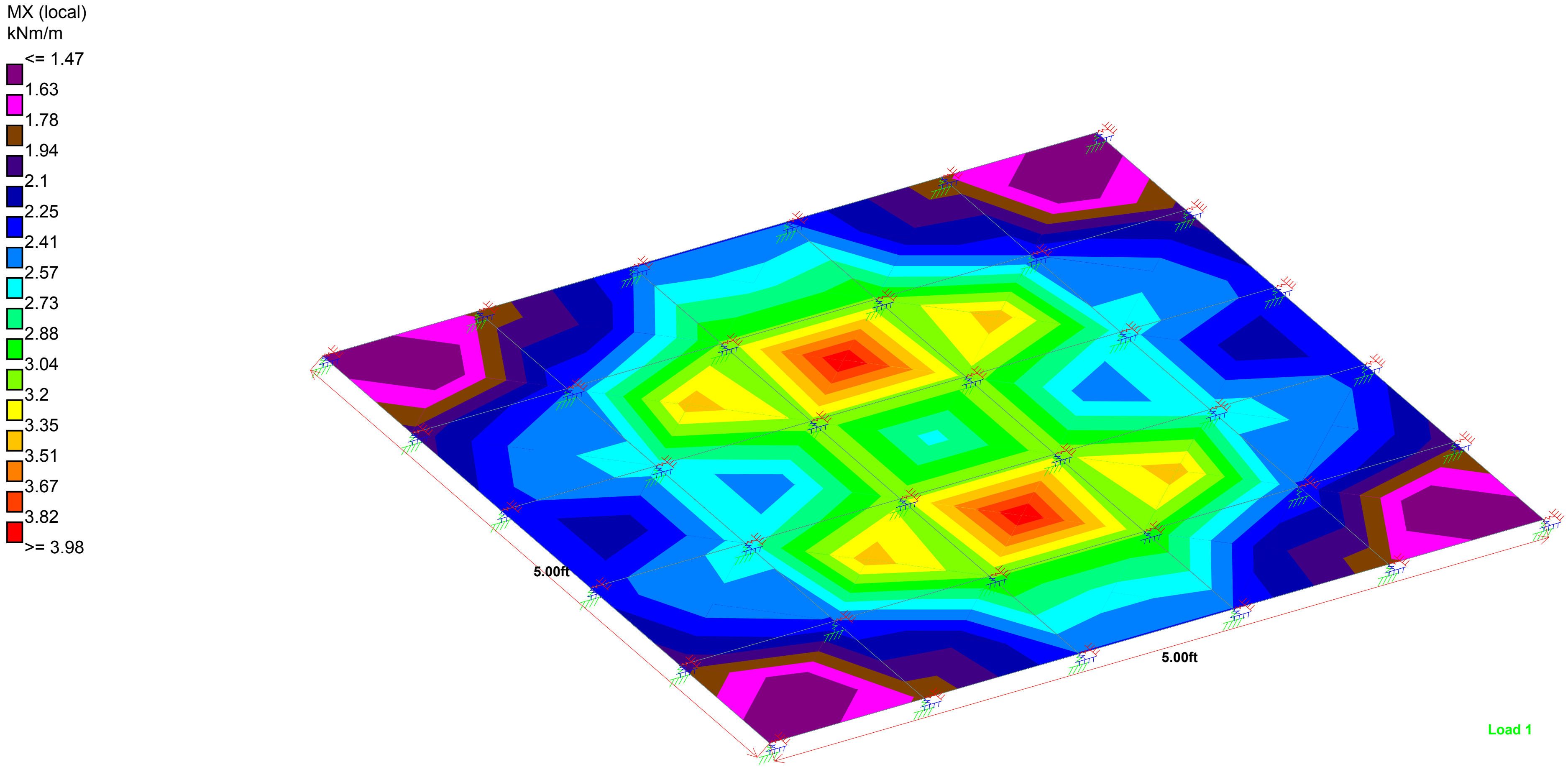
ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

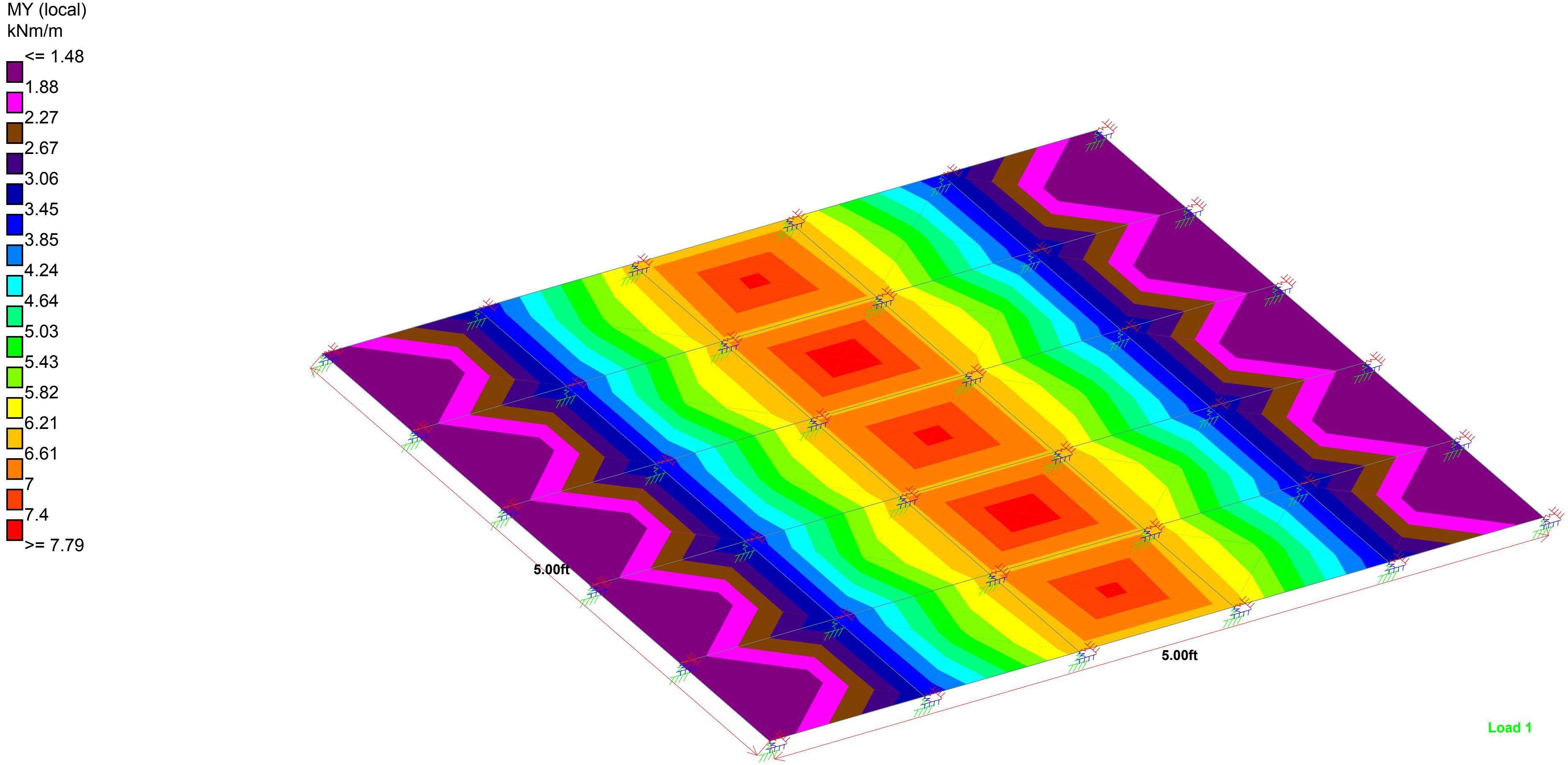
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 06:54	



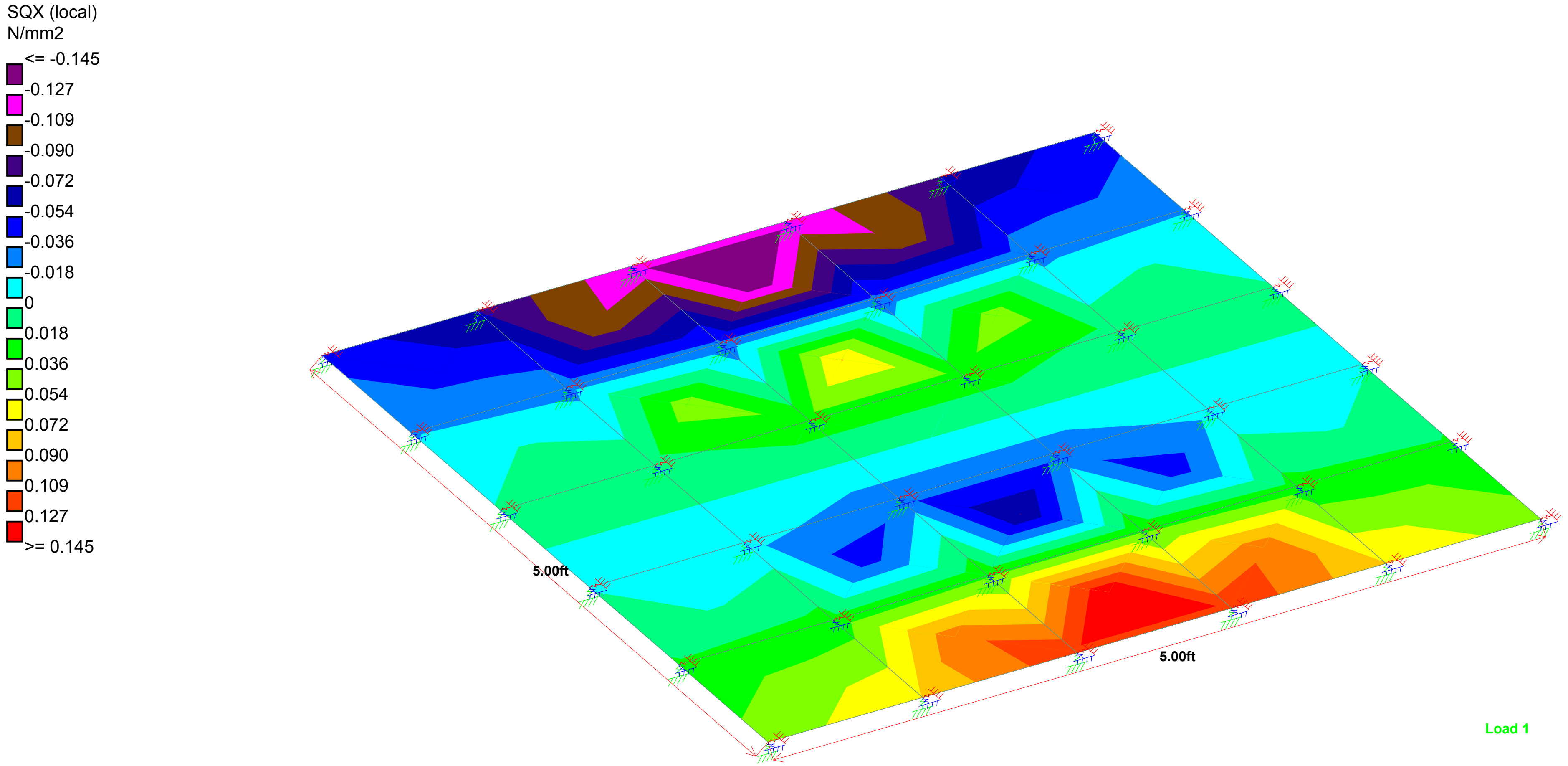
Software licensed to Optimal Engineering Support	Job No	Sheet No 1		Rev
	Part			
Job Title	Ref Panel Check			
	By CH	Date 04-Mar-21		Chd
Client SSL	File Panel Check - 5x5 type A		Date/Time 06-Mar-2021 06:54	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 06:54	

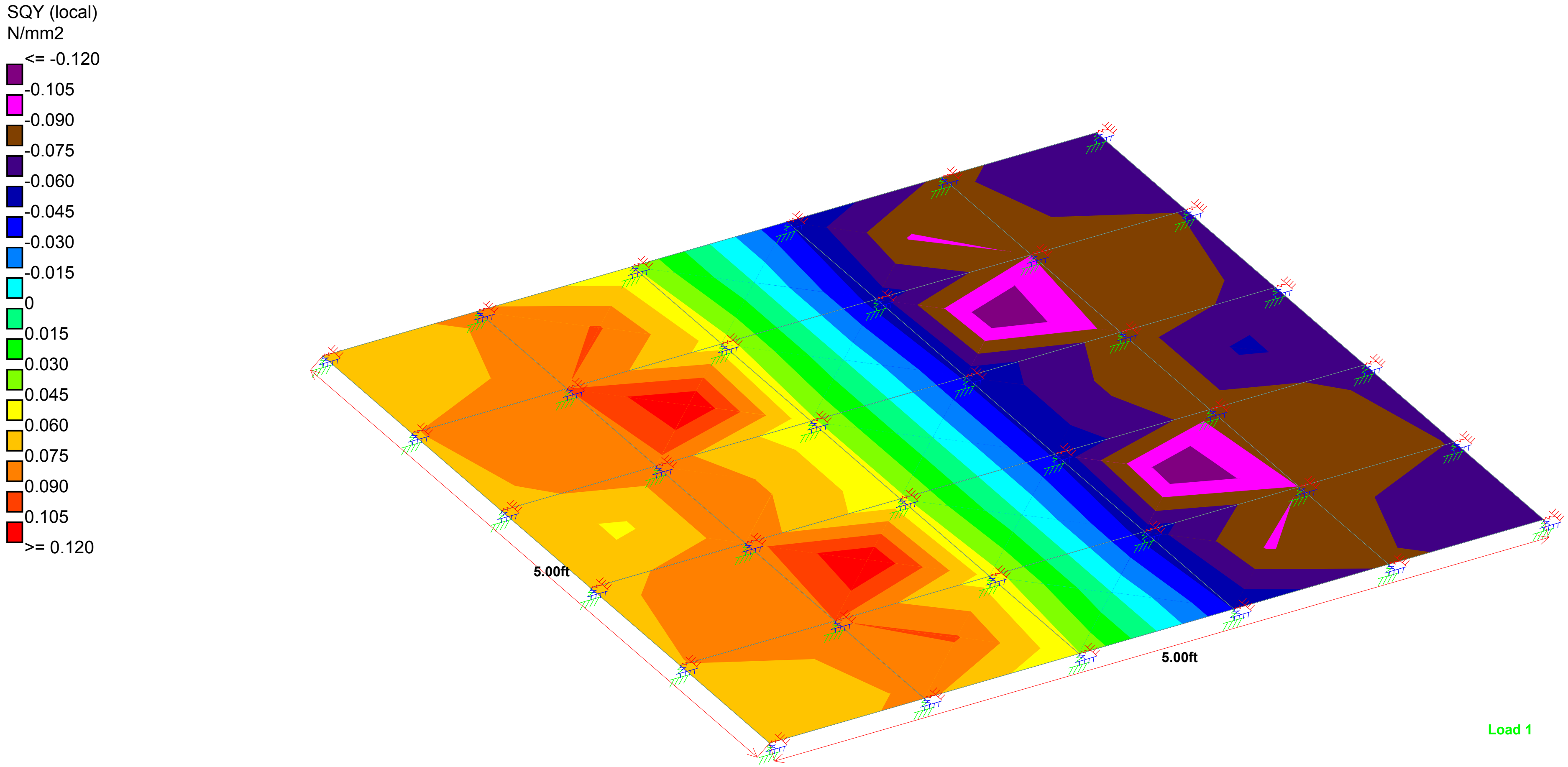


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 06:54	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 06:54	



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 *           Version  2007    Build 04              *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR  6, 2021                  *
 *           Time=      6:54:34                     *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
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     1. STAAD SPACE
INPUT FILE: Panel Check - 5x5 type A (4W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 32 PR GY -3.885 0.25 0
    40. 33 PR GY -3.885 0.25 -0.33
```



```
    41. 33 PR GY -3.885 0.25 0.33
    42. 34 PR GY -3.885 0.25 0
    43. 5 PR GY -3.885 -0.25 0
    44. 8 PR GY -3.885 -0.25 -0.33
    45. 8 PR GY -3.885 -0.25 0.33
    46. 11 PR GY -3.885 -0.25 0
    47. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

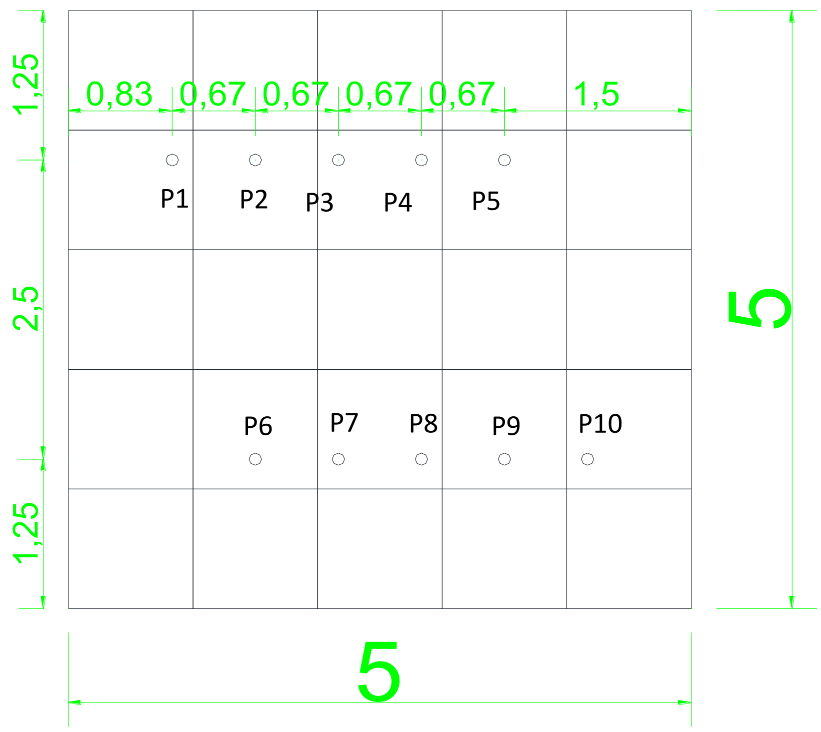
        SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

  ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
  TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
  SIZE OF STIFFNESS MATRIX =       11 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.2/ 263451.6 MB


    48. FINISH
```

Typical Panel Type (mesh 5W11), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	0	-0.25
P7	-0.33	-0.25
P8	0.33	-0.25
P9	0	-0.25
P10	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

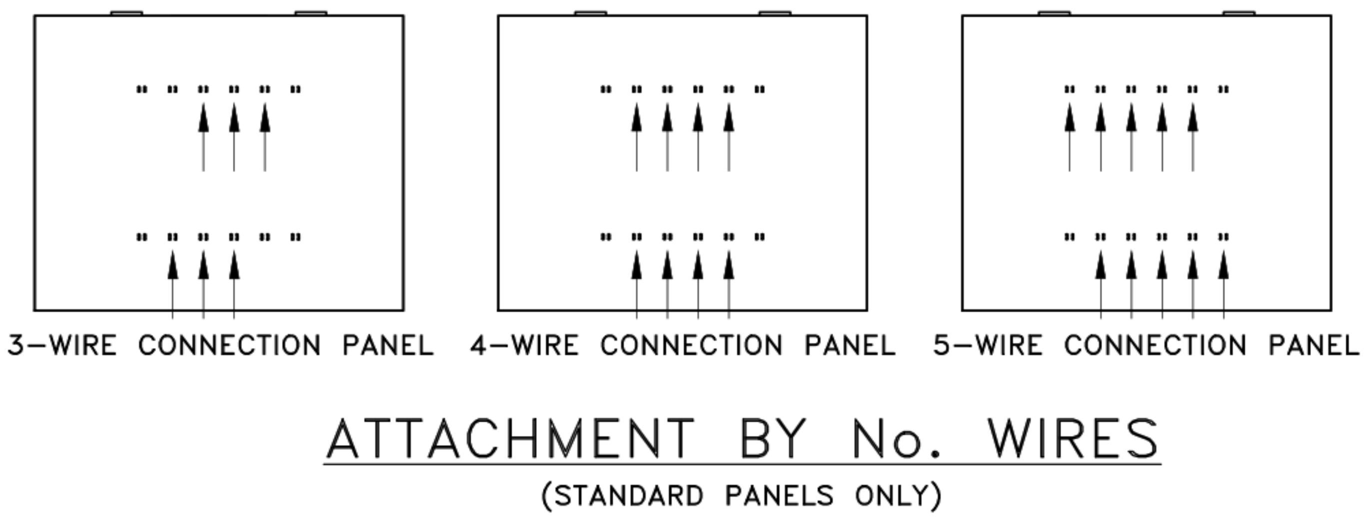
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

= 3.885 Kips (per wire point)



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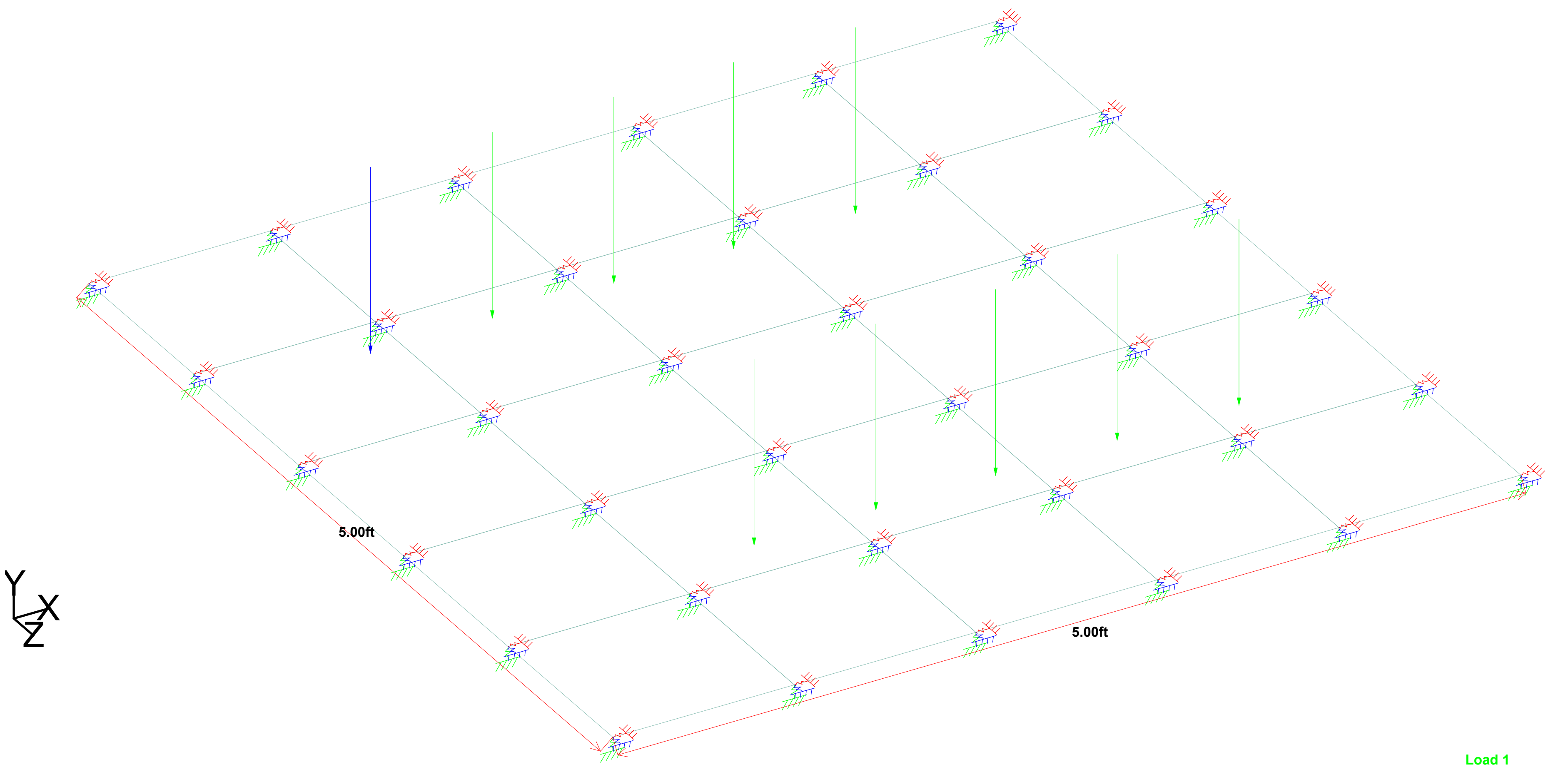
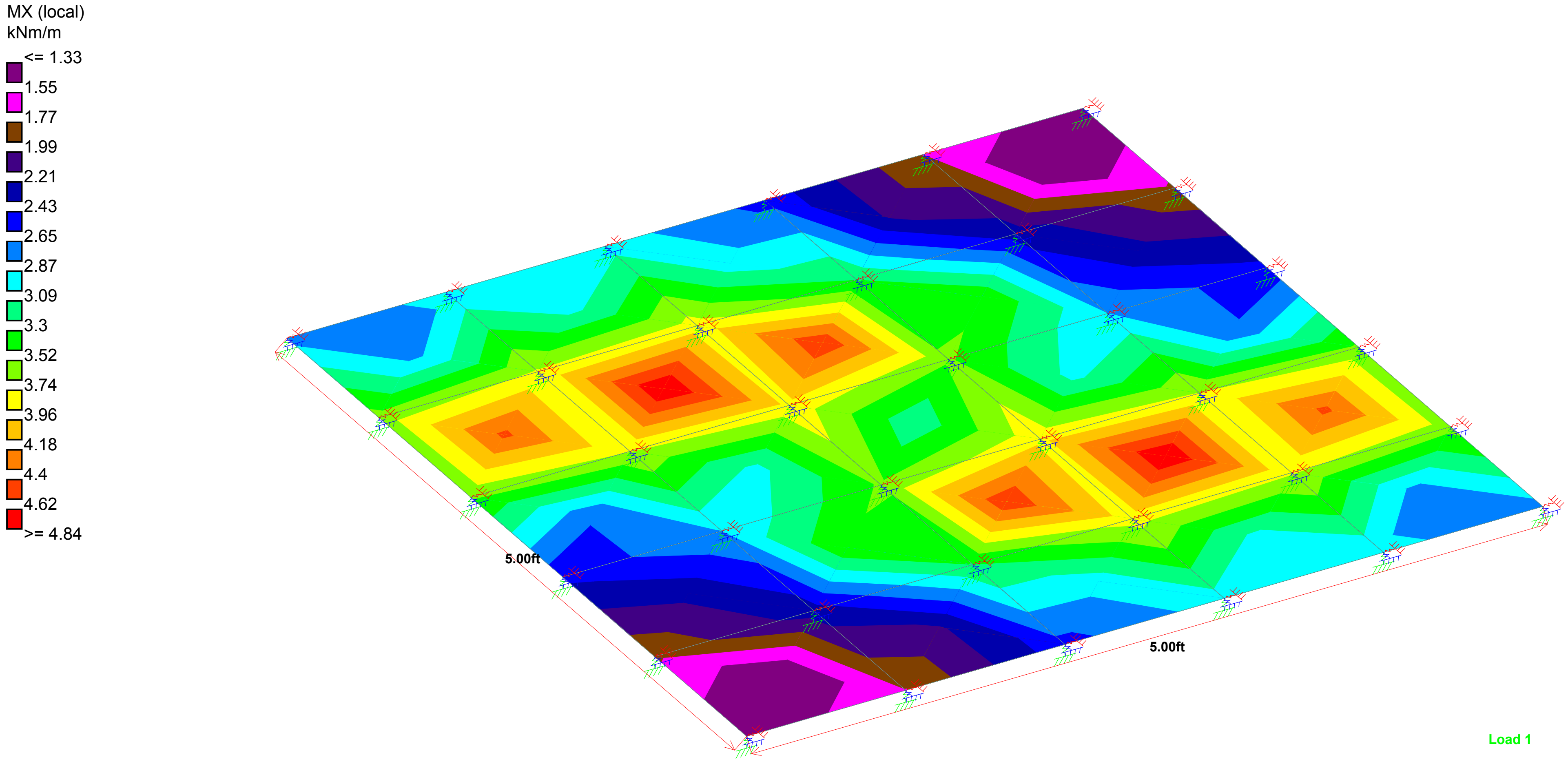
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 11:24	

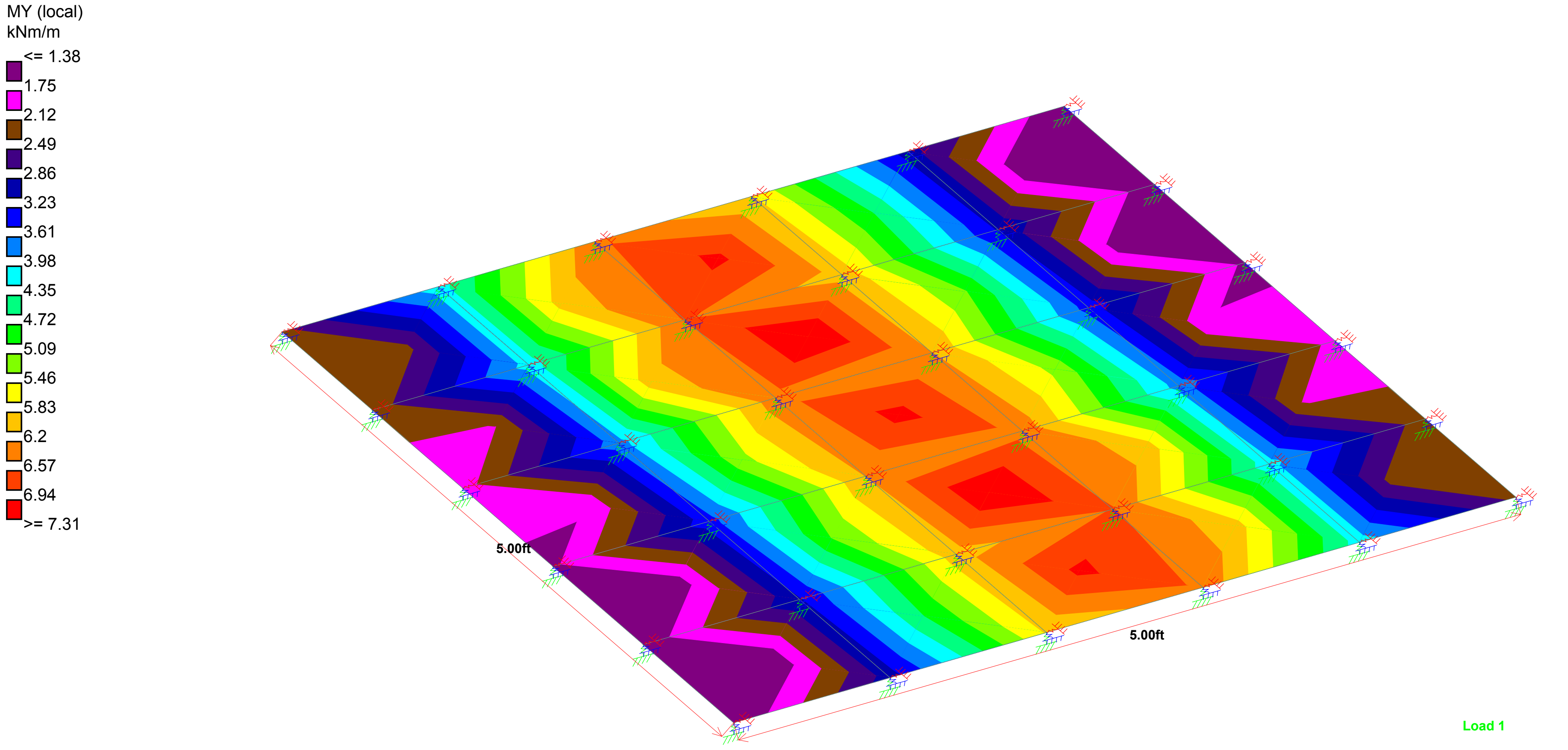


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 11:24	

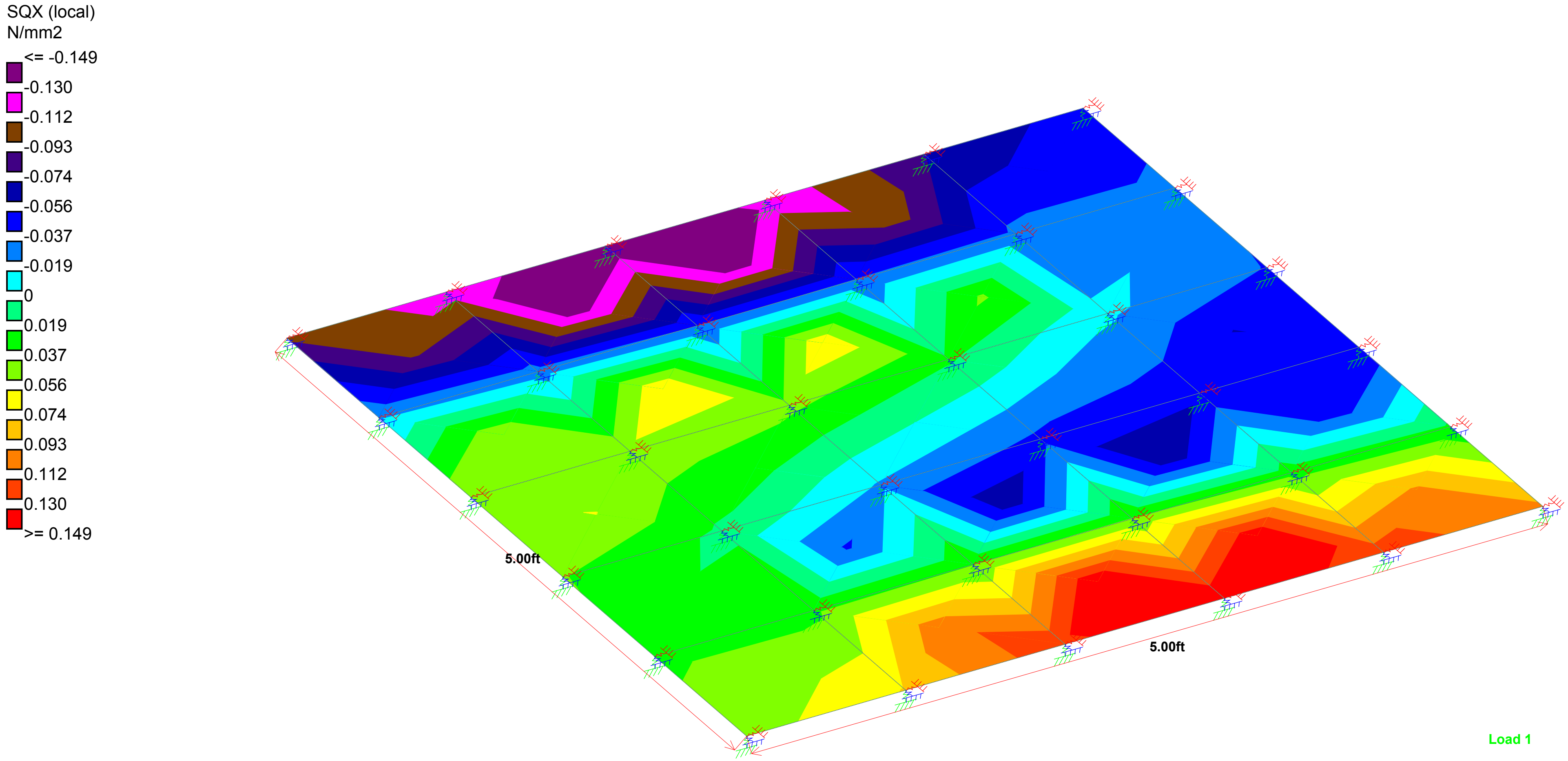


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 11:24	

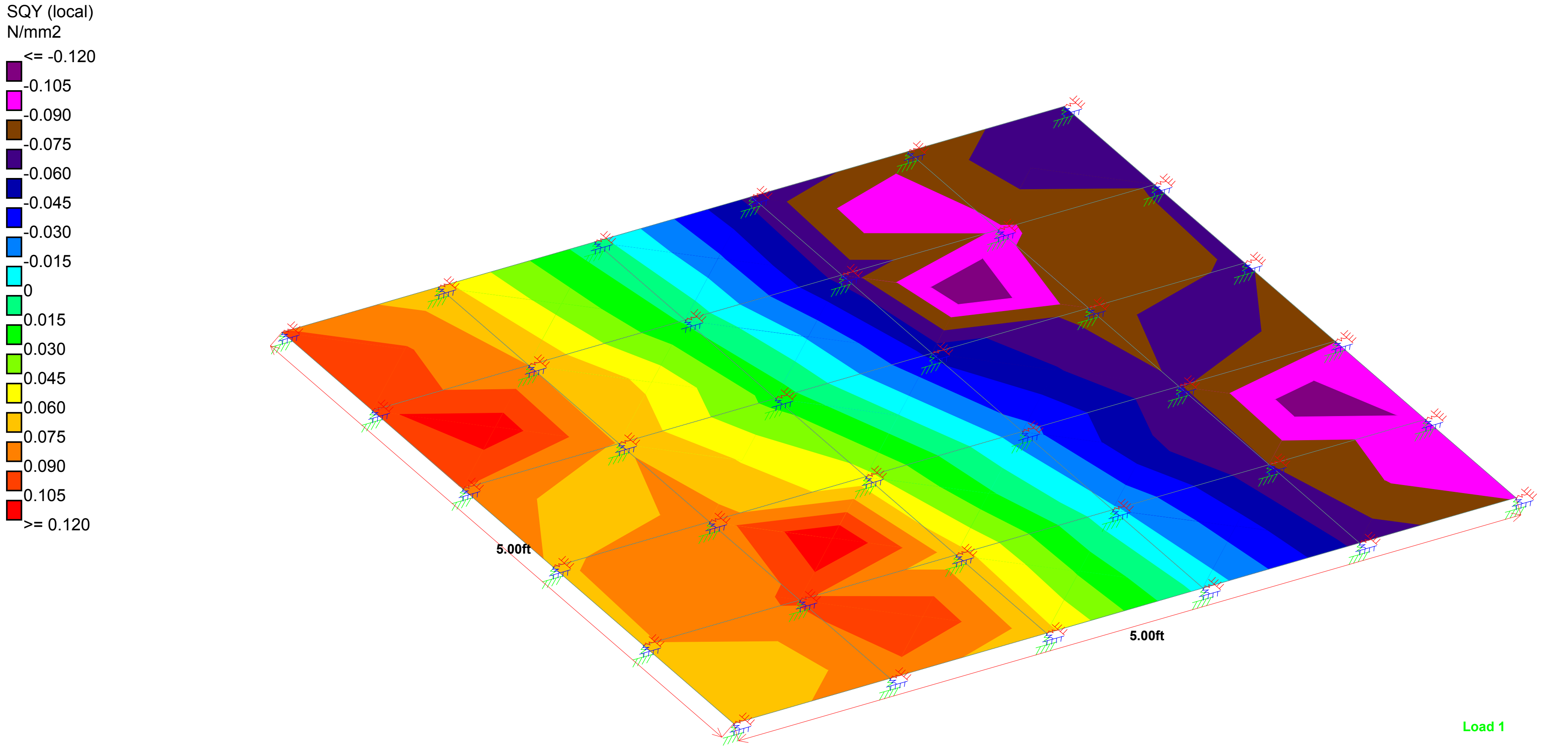


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 11:24	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 11:24	



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 *           Research Engineers,  Intl.             *
 *           Date=    MAR  6, 2021                  *
 *           Time=    11:24:17                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
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INPUT FILE: Panel Check - 5x5 type A (5W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 31 PR GY -3.885 0.25 0.33
    40. 32 PR GY -3.885 0.25 0
```



```
    41. 33 PR GY -3.885 0.25 -0.33
    42. 33 PR GY -3.885 0.25 0.33
    43. 34 PR GY -3.885 0.25 0
    44. 5 PR GY -3.885 -0.25 0
    45. 8 PR GY -3.885 -0.25 -0.33
    46. 8 PR GY -3.885 -0.25 0.33
    47. 11 PR GY -3.885 -0.25 0
    48. 14 PR GY -3.885 -0.25 -0.33
    49. PERFORM ANALYSIS


          P R O B L E M   S T A T I S T I C S
          -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

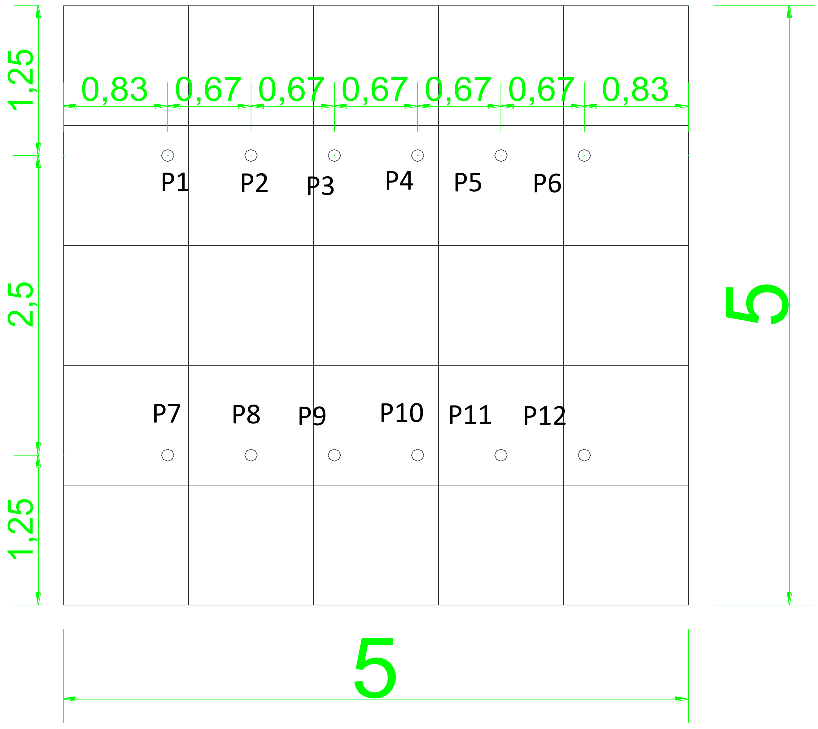
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
 SIZE OF STIFFNESS MATRIX =       11 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.2/ 263449.2 MB


    50. FINISH
```

Typical Panel Type (mesh 6W11), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	-0.33	0.25
P7	0.33	-0.25
P8	0	-0.25
P9	-0.33	-0.25
P10	0.33	-0.25
P11	0	-0.25
P12	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

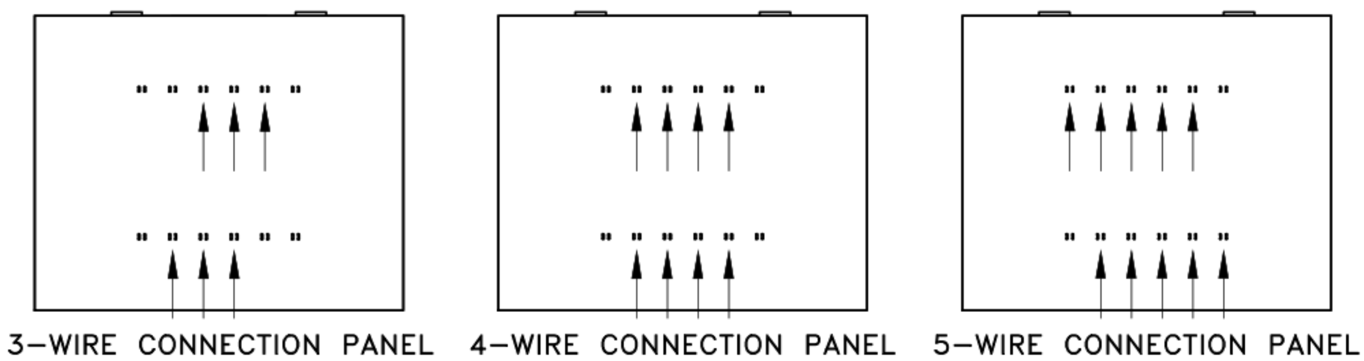
W11 - 75 Years

$A = 0.0797 \text{ in}^2$

$F_y = 75 \text{ ksi}$

$P = 0.65 \times A \times F_y$

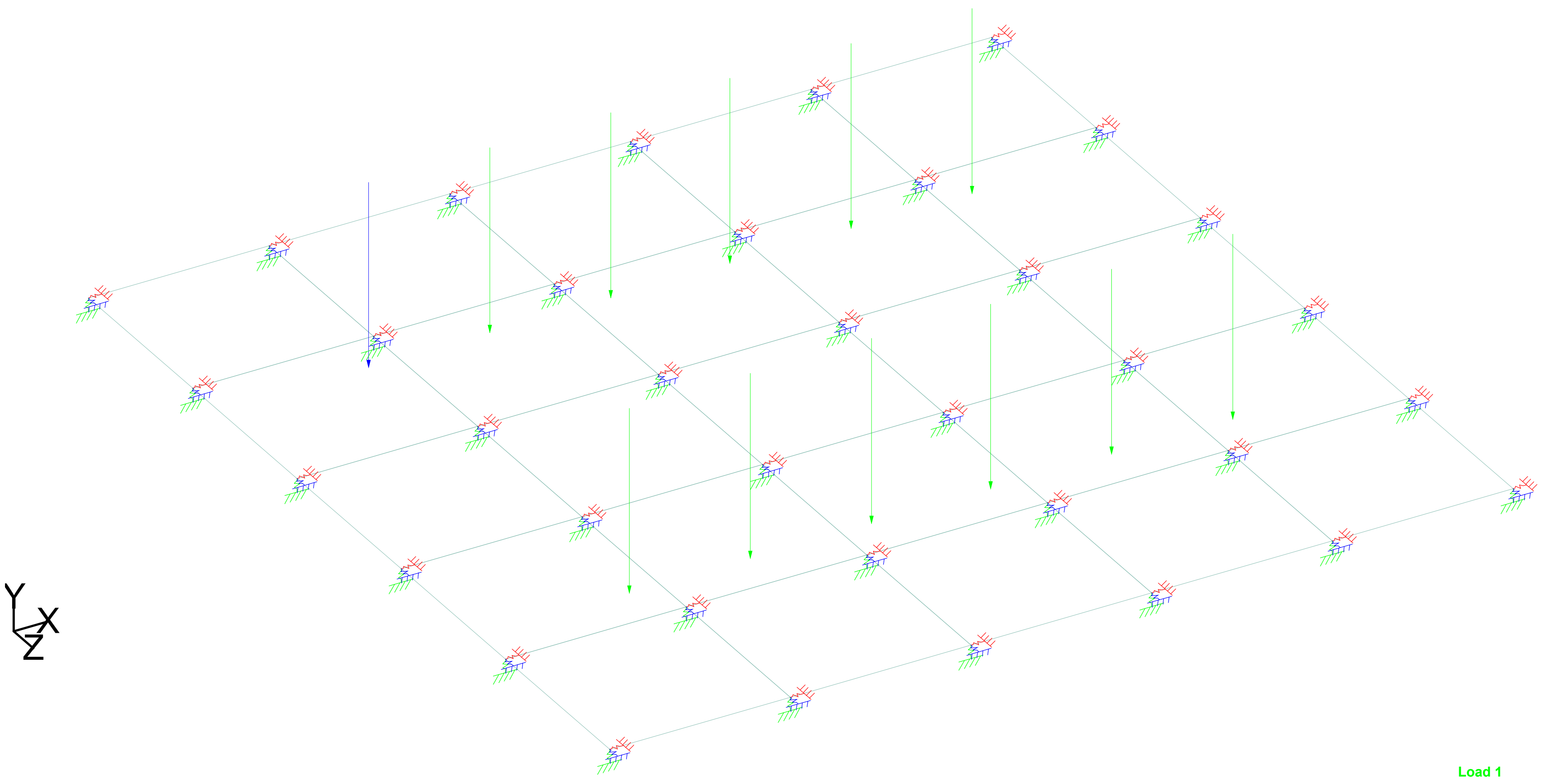
$= 3.885$ Kips (per wire point)



ATTACHMENT BY No. WIRES

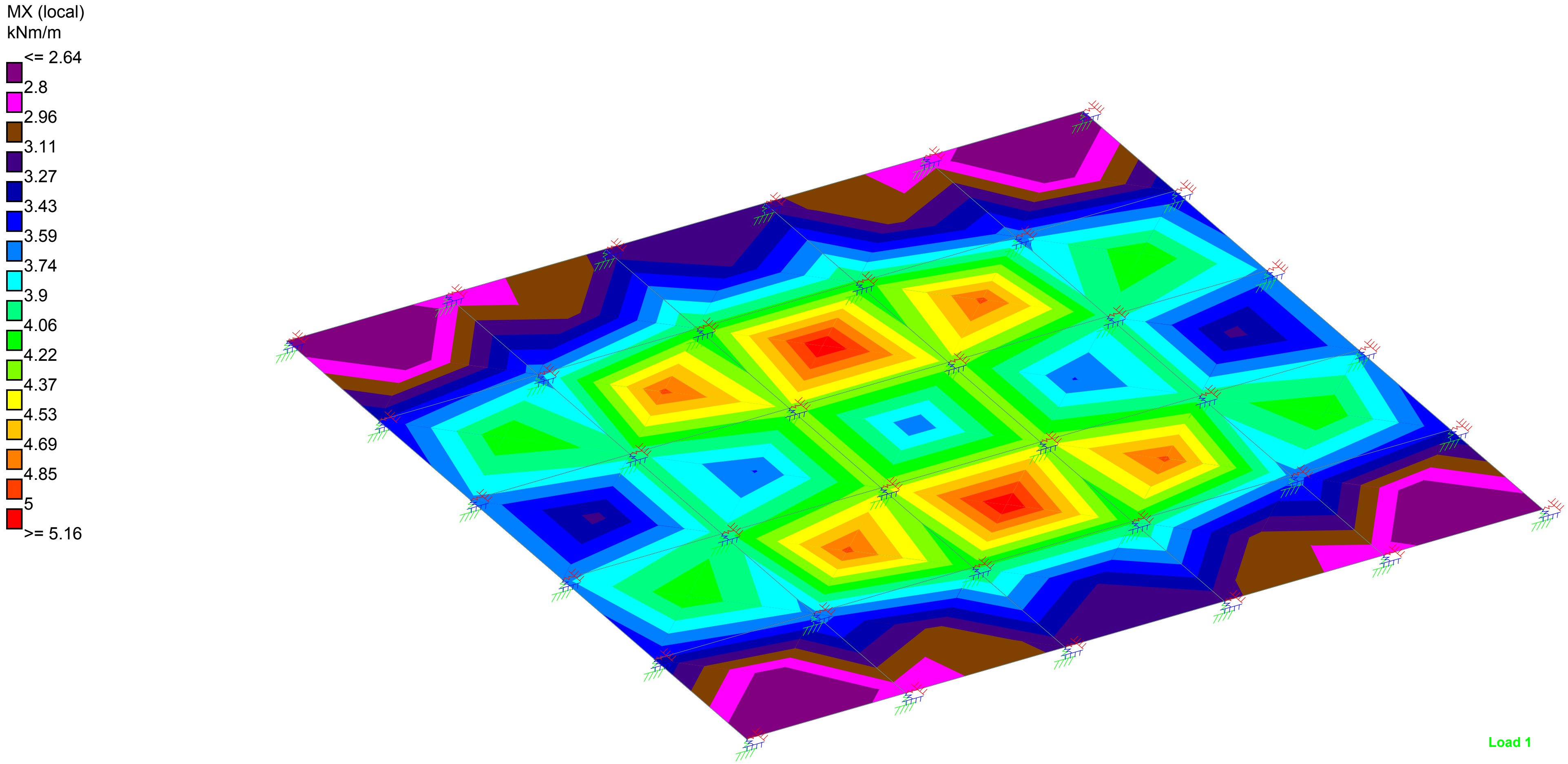
(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 12:43	



TOC – Appendix

	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 12:43	



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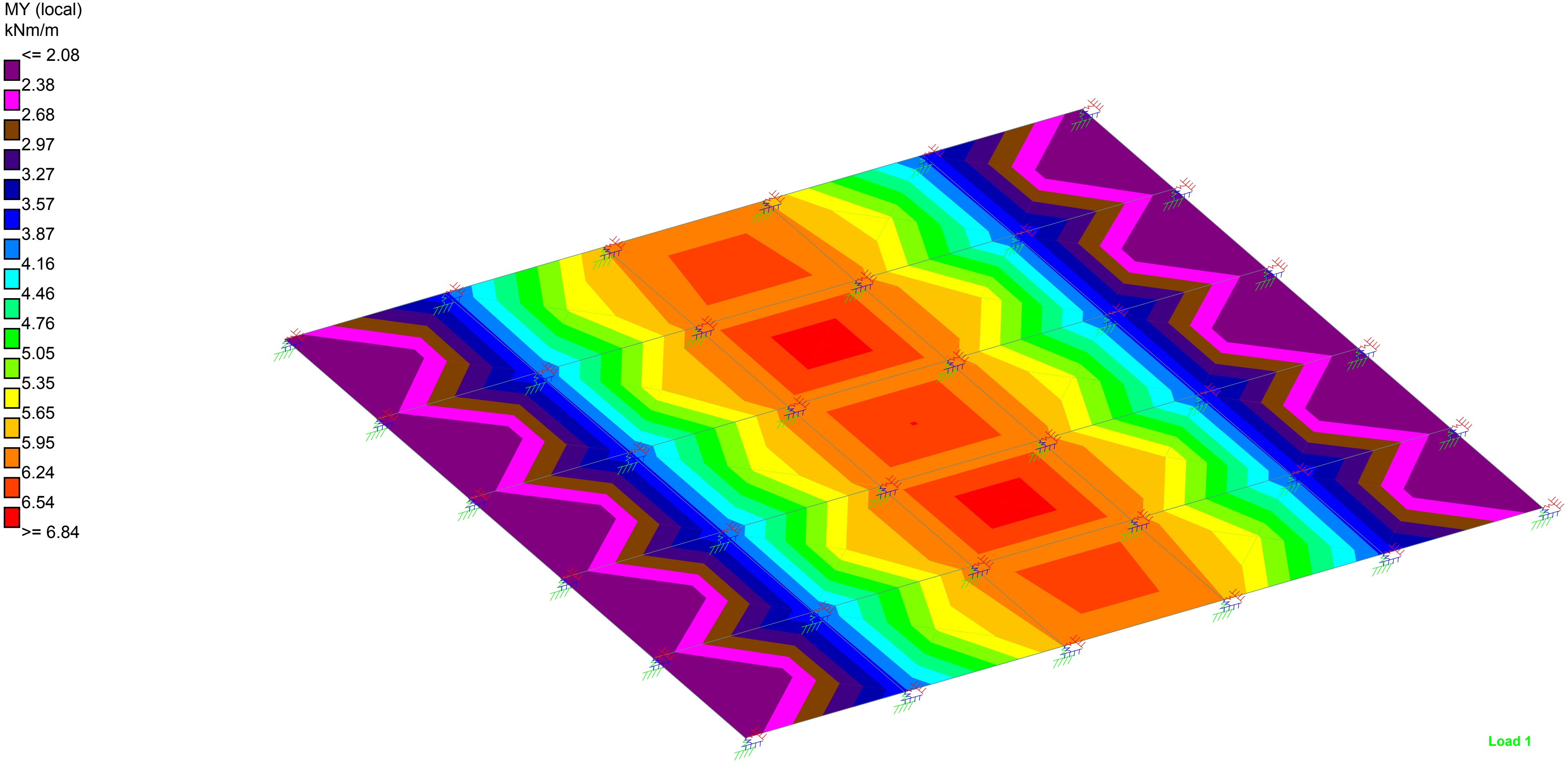
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 12:43	



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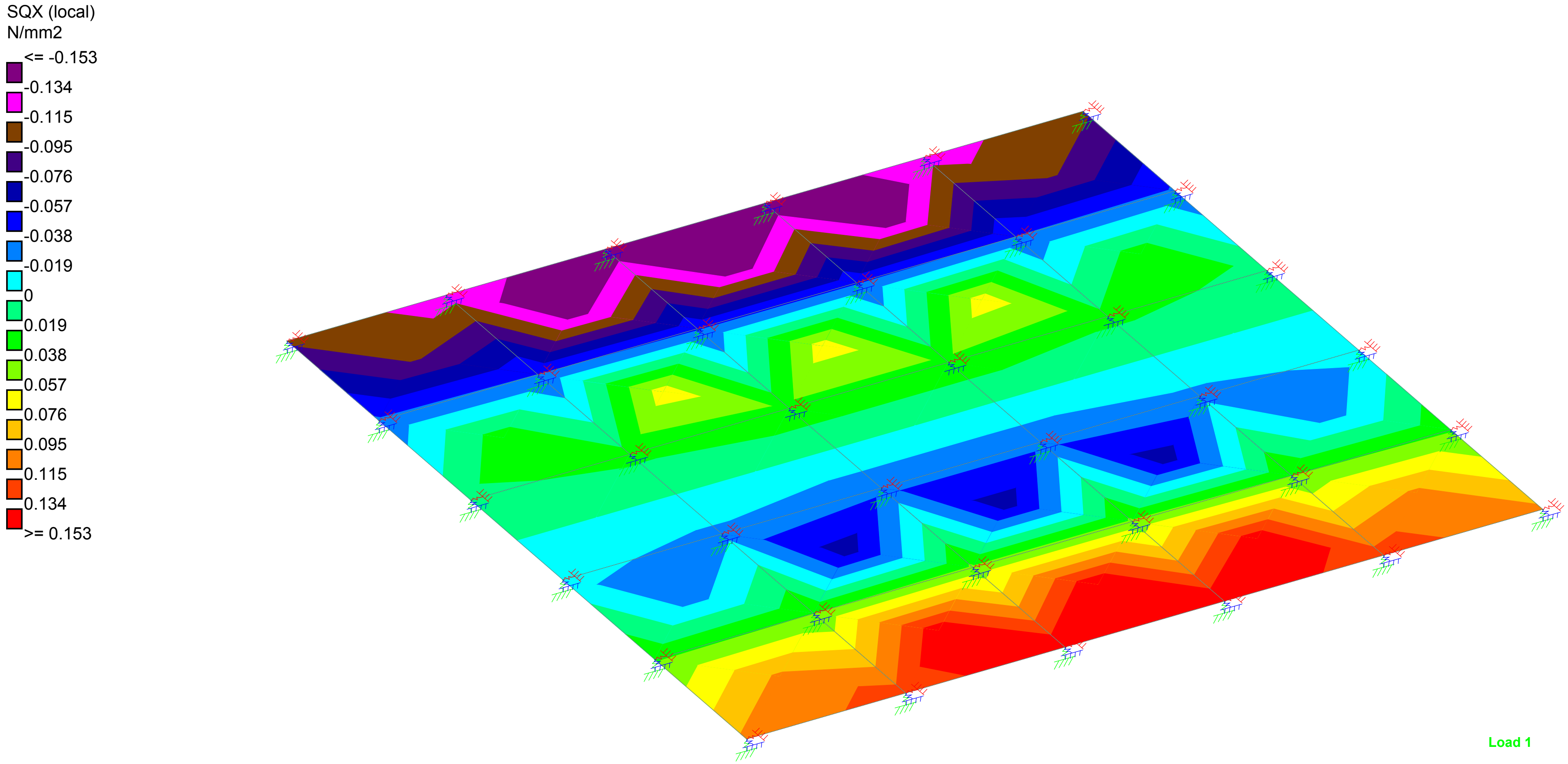
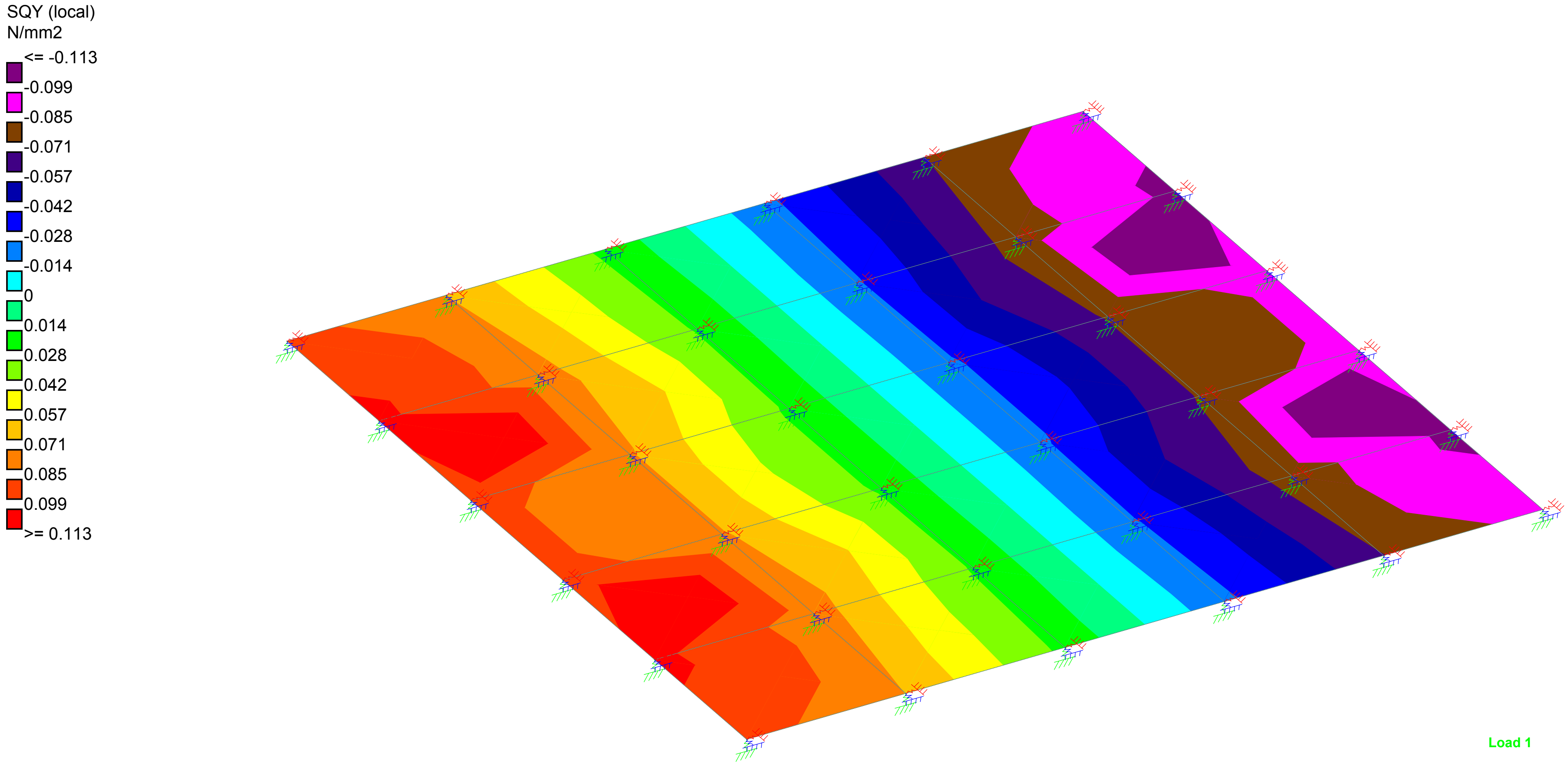
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 12:43	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 12:43	



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 *           Version  2007    Build 04              *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR  6, 2021                  *
 *           Time=    12:43:13                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
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INPUT FILE: Panel Check - 5x5 type A (6W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 31 PR GY -3.885 0.25 0.33
    40. 32 PR GY -3.885 0.25 0
```



```
    41. 33 PR GY -3.885 0.25 -0.33
    42. 33 PR GY -3.885 0.25 0.33
    43. 34 PR GY -3.885 0.25 0
    44. 35 PR GY -3.885 0.25 -0.33
    45. 2 PR GY -3.885 -0.25 0.33
    46. 5 PR GY -3.885 -0.25 0
    47. 8 PR GY -3.885 -0.25 -0.33
    48. 8 PR GY -3.885 -0.25 0.33
    49. 11 PR GY -3.885 -0.25 0
    50. 14 PR GY -3.885 -0.25 -0.33
    51. PERFORM ANALYSIS


         P R O B L E M   S T A T I S T I C S
         -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     36/    25/    36

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=      7/      7/     48 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
 SIZE OF STIFFNESS MATRIX =        11 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.2/ 263446.3 MB



    52. FINISH
```

Typical Panel Type (mesh 4W20), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0	0.25
P2	-0.33	0.25
P3	0.33	0.25
P4	0	0.25
P5	0	-0.25
P6	-0.33	-0.25
P7	0.33	-0.25
P8	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

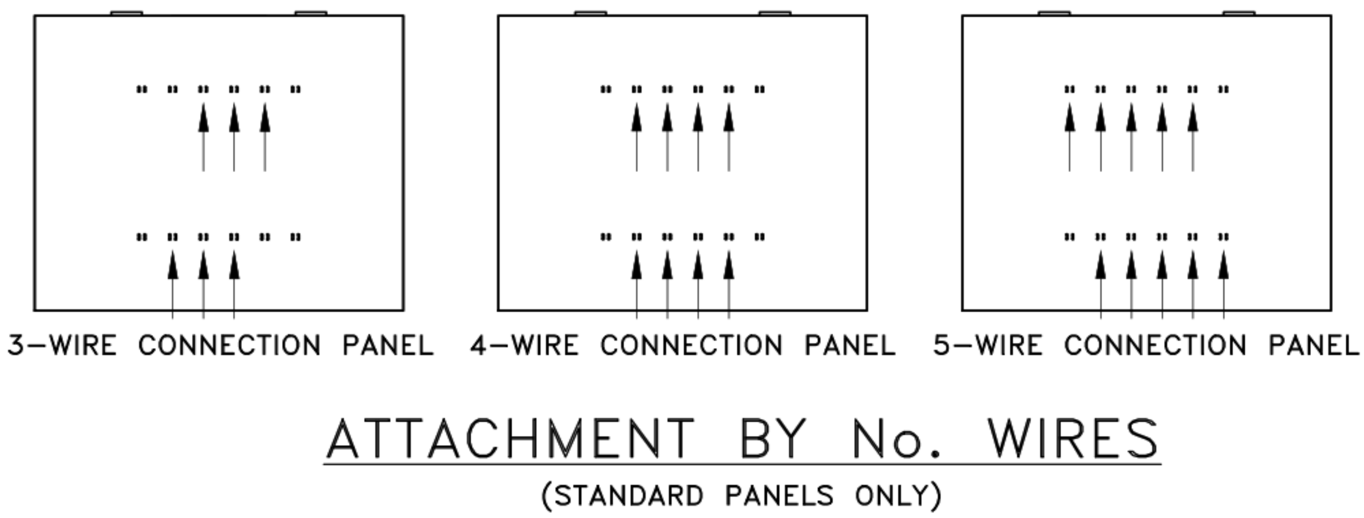
W20 - 75 Years

A = 0.1583 in^2

Fy = 75 ksi

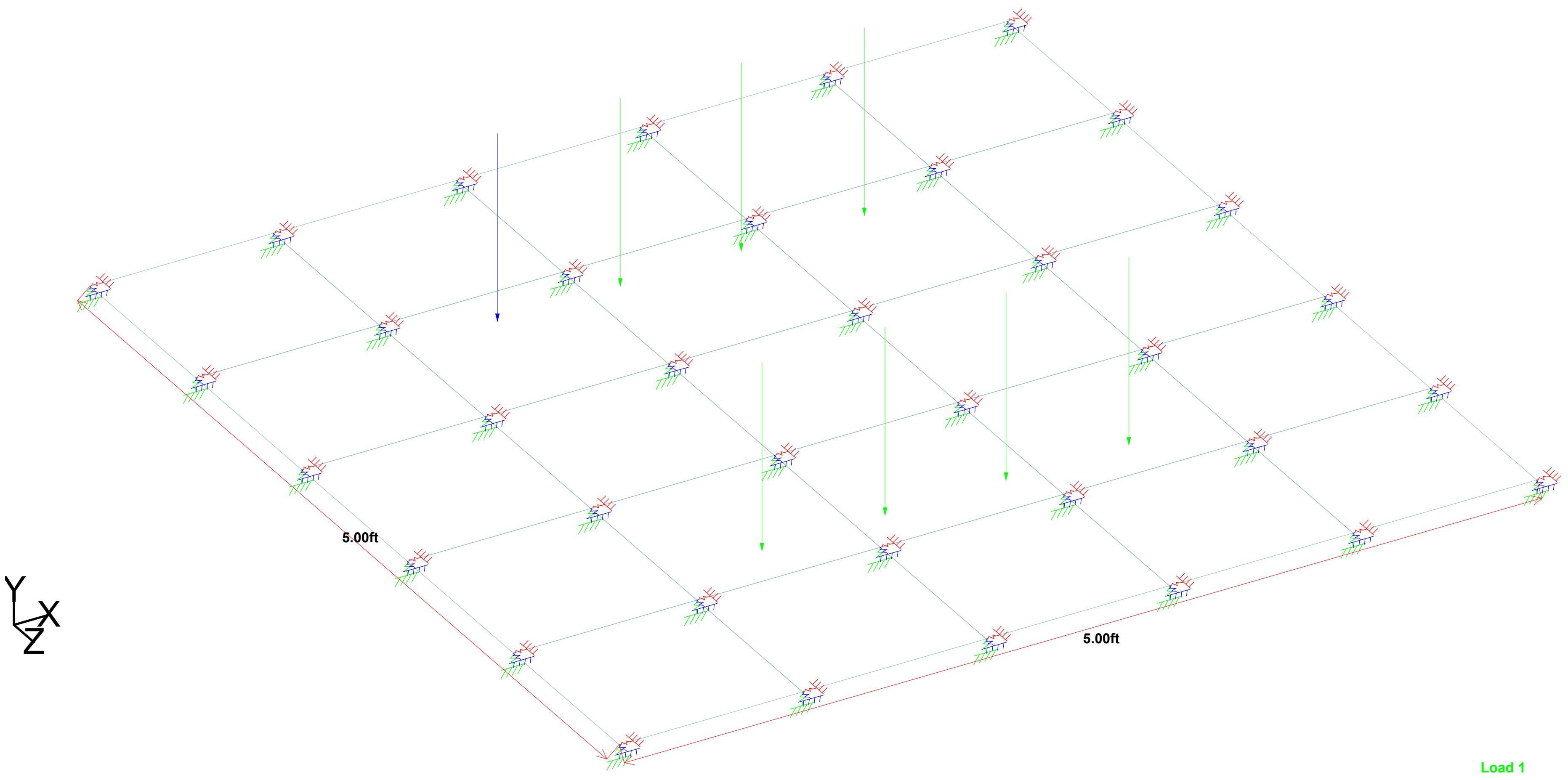
P = 0.65 x A x Fy

= 7.717 Kips (per wire point)



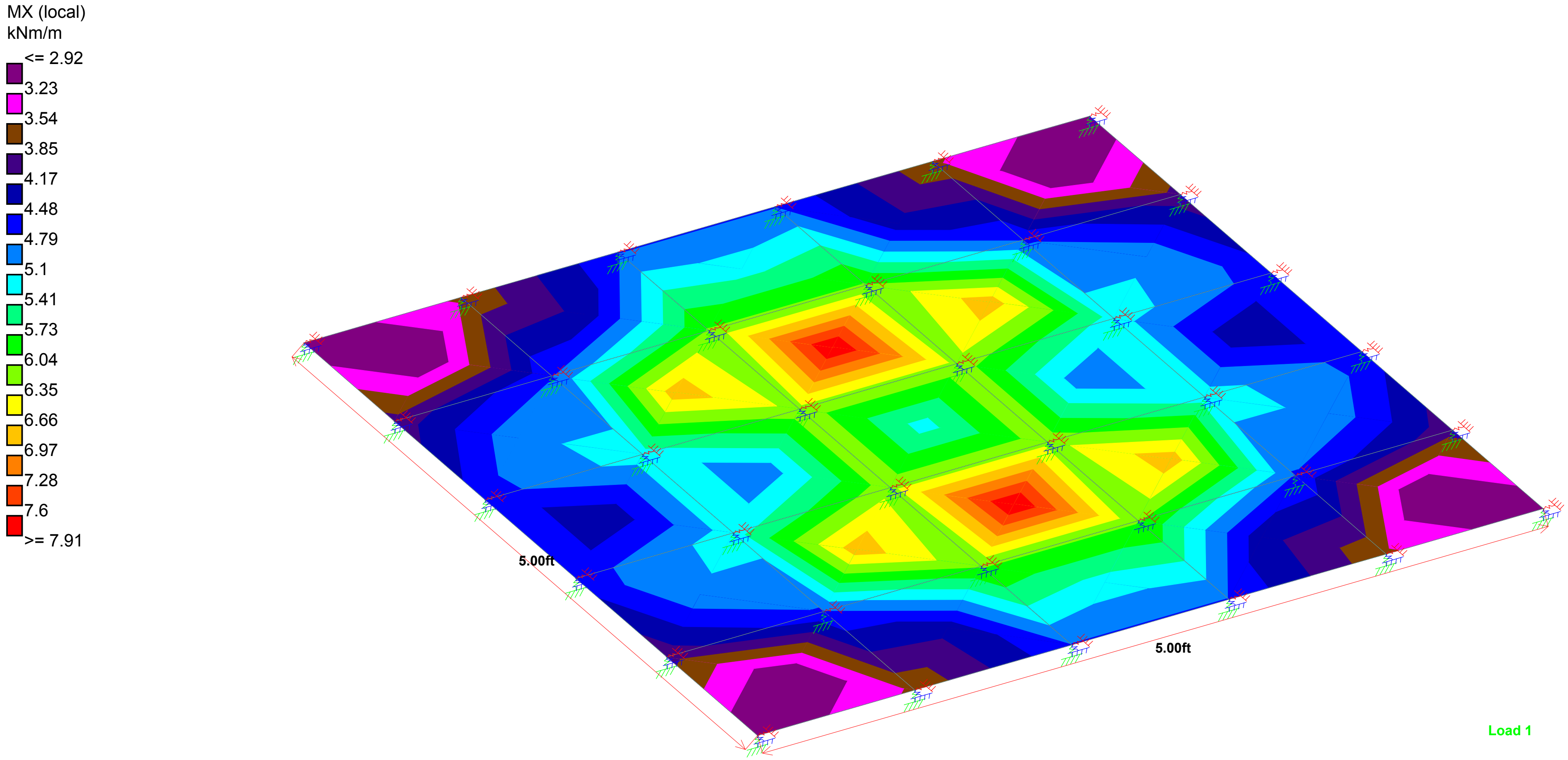
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 06-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 23:25	

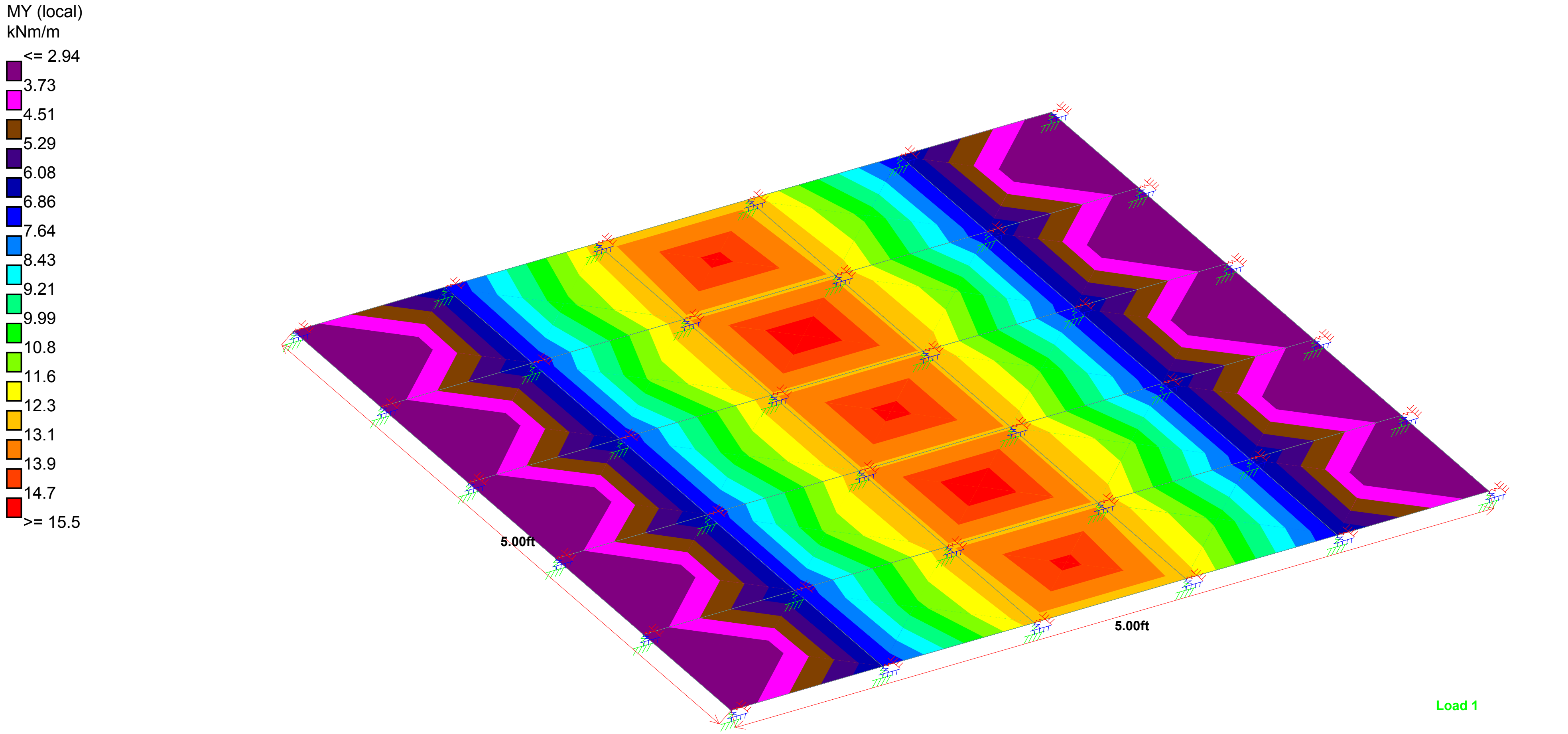


Software licensed to Optimal Engineering Support

Job No	Sheet No 1	Rev	
Part			
Job Title	Ref Panel Check		
	By CH	Date 06-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 23:25	

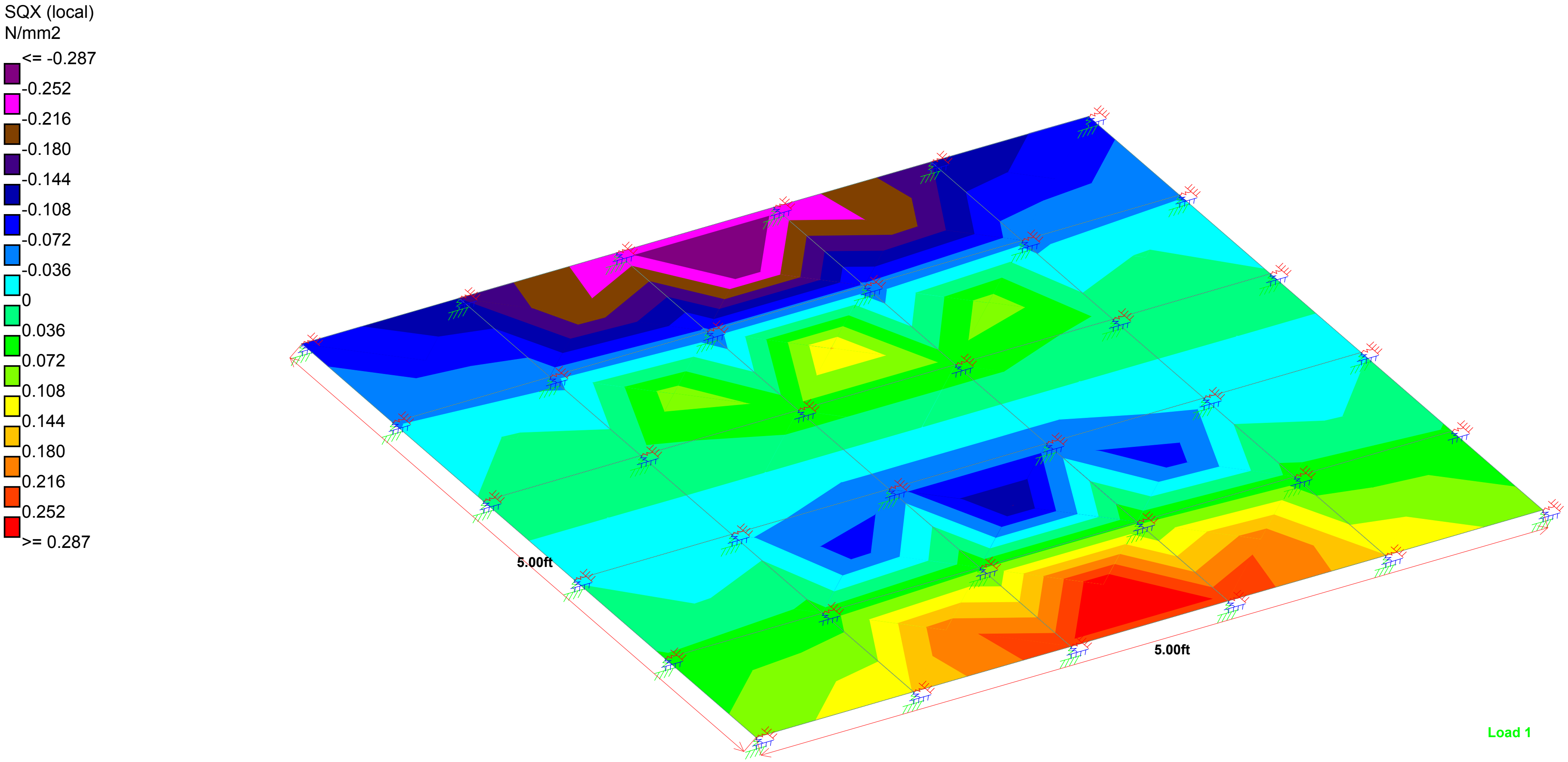


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 06-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 23:25	



TOC – Appendix

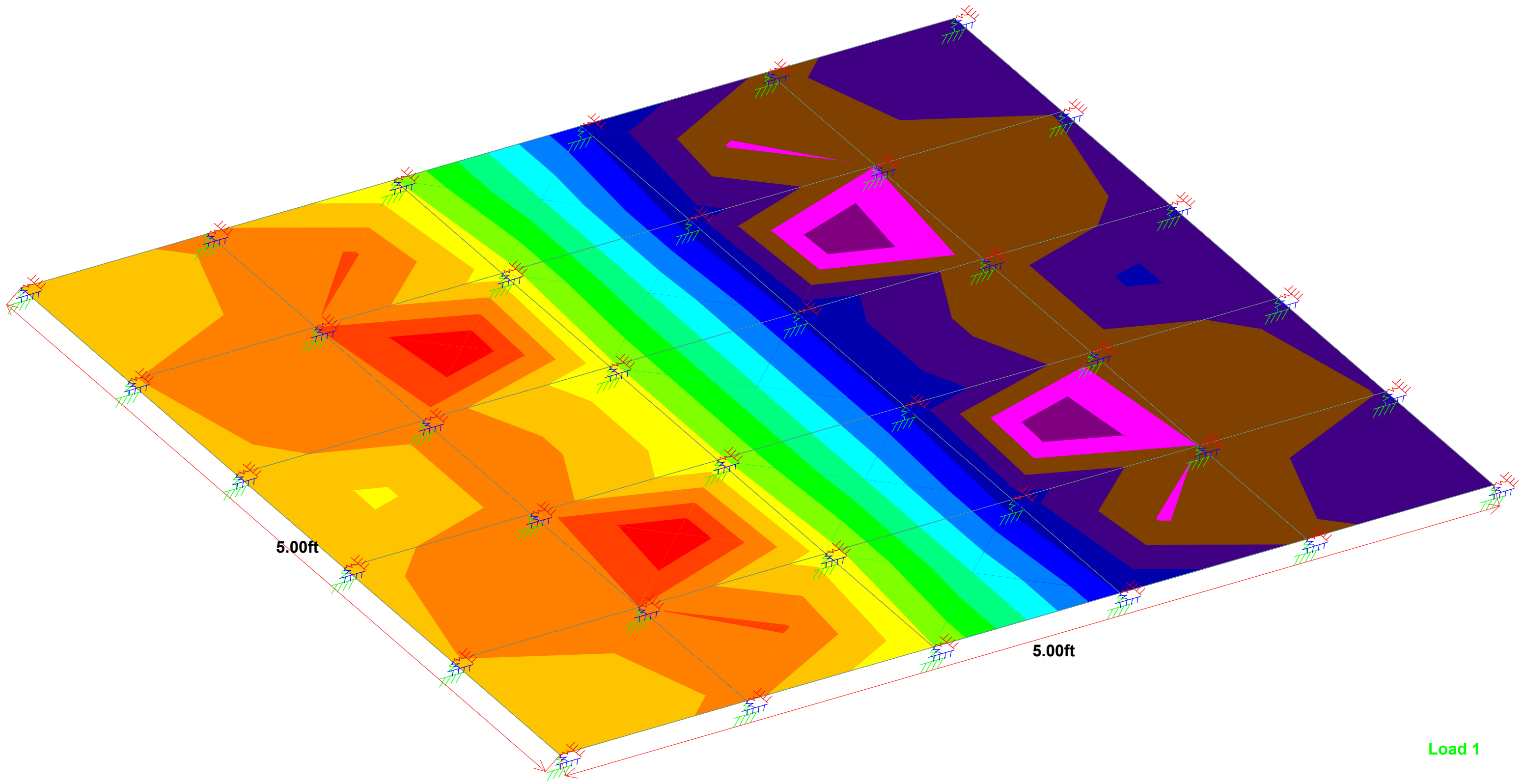
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 06-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 23:25	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 06-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 06-Mar-2021 23:25	

SQY (local)
N/mm2
<= -0.238
-0.208
-0.179
-0.149
-0.119
-0.089
-0.060
-0.030
0
0.030
0.060
0.089
0.119
0.149
0.179
0.208
>= 0.238



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*****************************************************
*                                                   *
*           STAAD.Pro                               *
*           Version  2007    Build 04               *
*           Proprietary Program of                  *
*           Research Engineers,  Intl.              *
*           Date=    MAR  6, 2021                   *
*           Time=    23:35:43                       *
*                                                   *
*      USER ID: Optimal Engineering Support         *
*****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x5 type A (4W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 06-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 32 PR GY -7.717 0.25 0
    40. 33 PR GY -7.717 0.25 -0.33
```



```
    41. 33 PR GY -7.717 0.25 0.33
    42. 34 PR GY -7.717 0.25 0
    43. 5 PR GY -7.717 -0.25 0
    44. 8 PR GY -7.717 -0.25 -0.33
    45. 8 PR GY -7.717 -0.25 0.33
    46. 11 PR GY -7.717 -0.25 0
    47. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

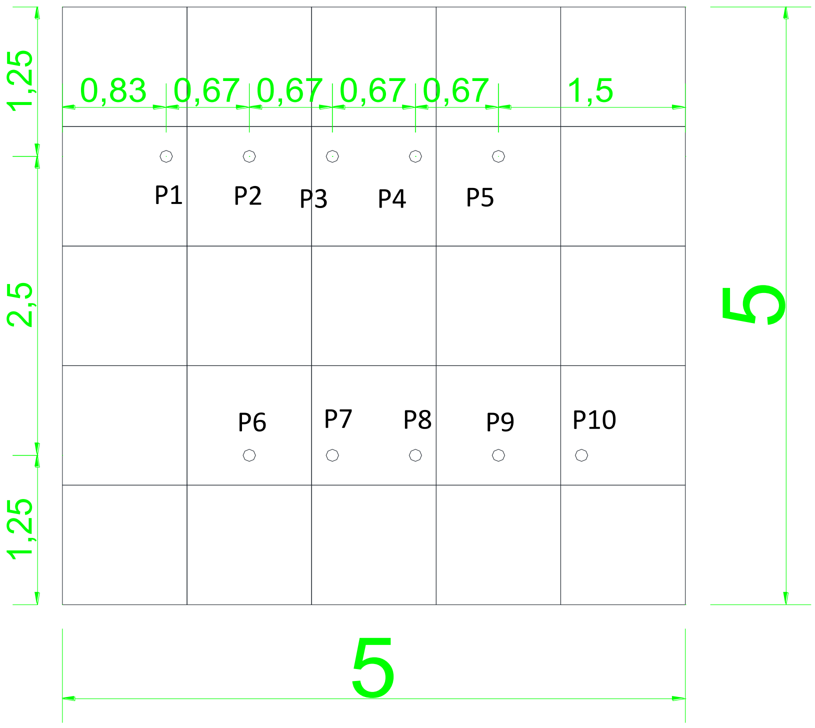
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
 SIZE OF STIFFNESS MATRIX =       11 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.2/ 263435.0 MB
```

```
    48. FINISH
```

Typical Panel Type (mesh 5W20), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	0	-0.25
P7	-0.33	-0.25
P8	0.33	-0.25
P9	0	-0.25
P10	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

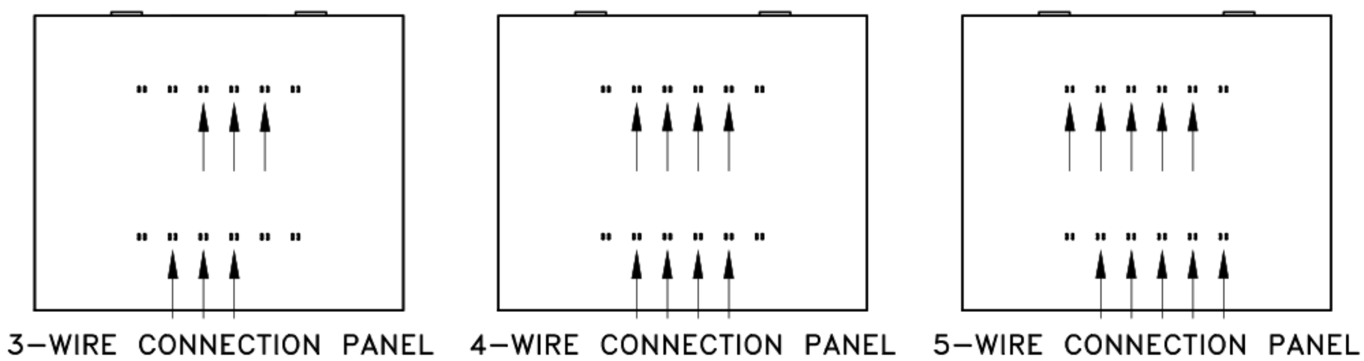
W11 - 75 Years

$A = 0.1583 \text{ in}^2$

$Fy = 75 \text{ ksi}$

$P = 0.65 \times A \times Fy$

$= 7.717$ Kips (per wire point)

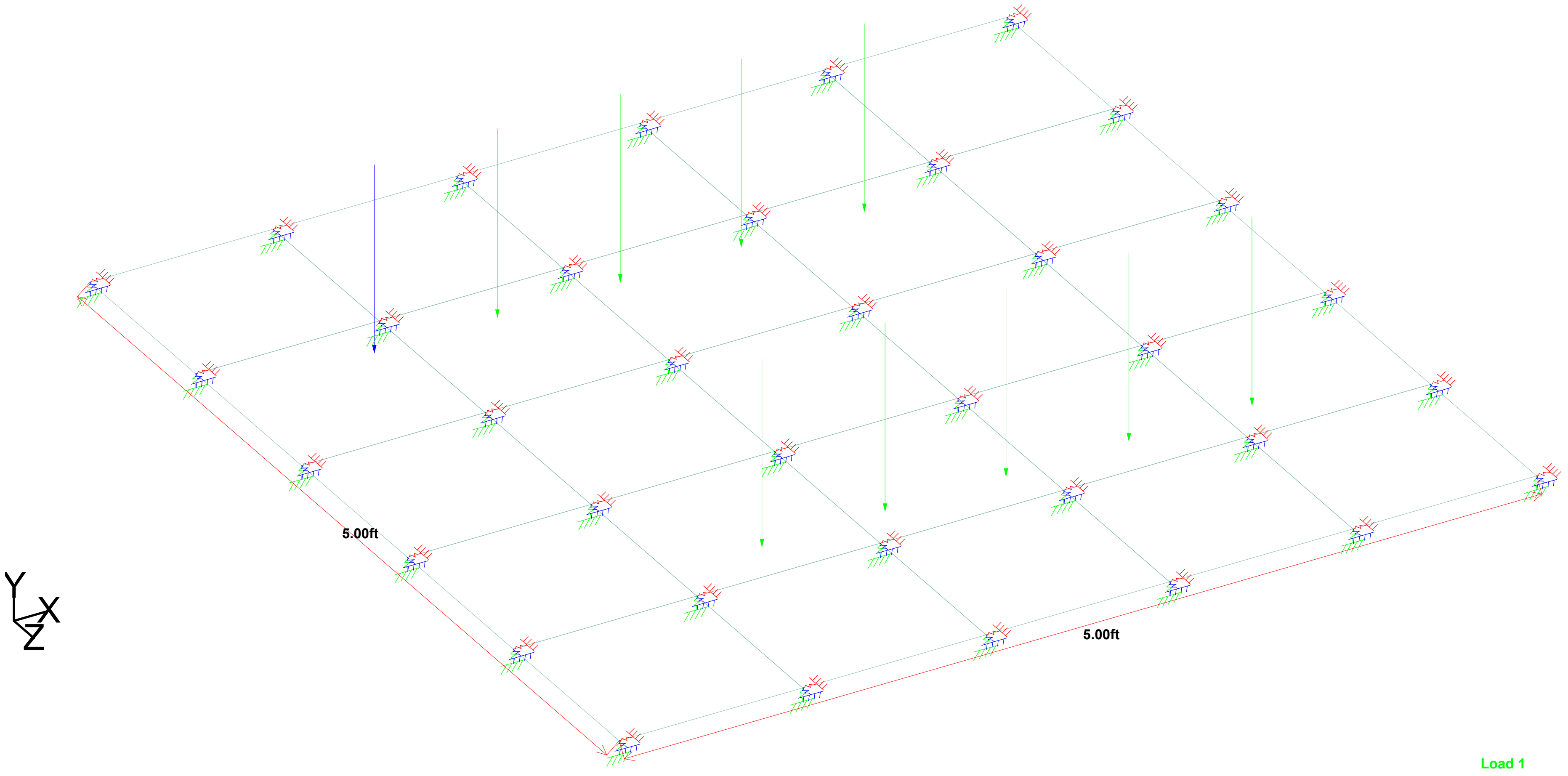


ATTACHMENT BY No. WIRES

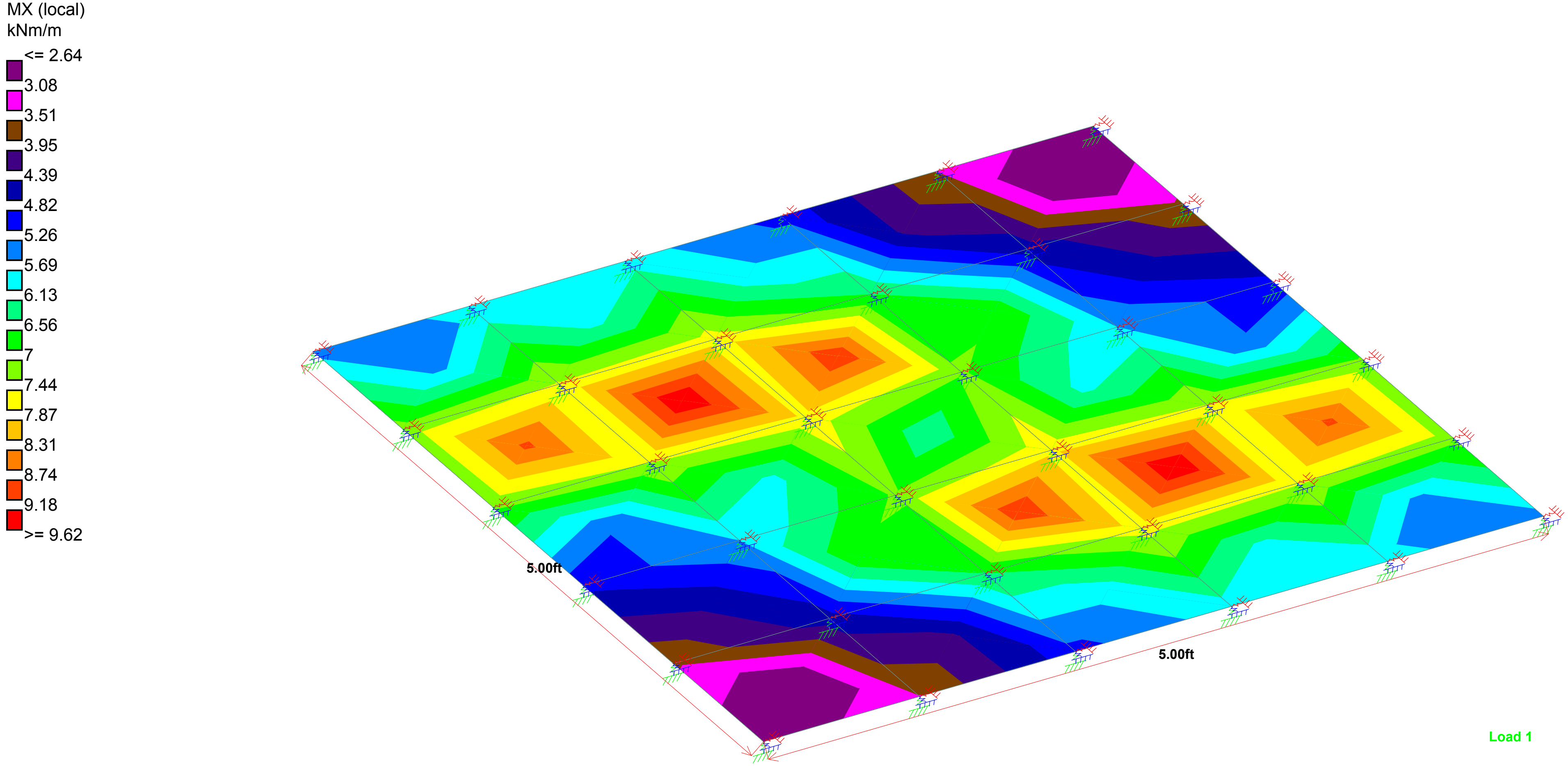
(STANDARD PANELS ONLY)

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 01:49	

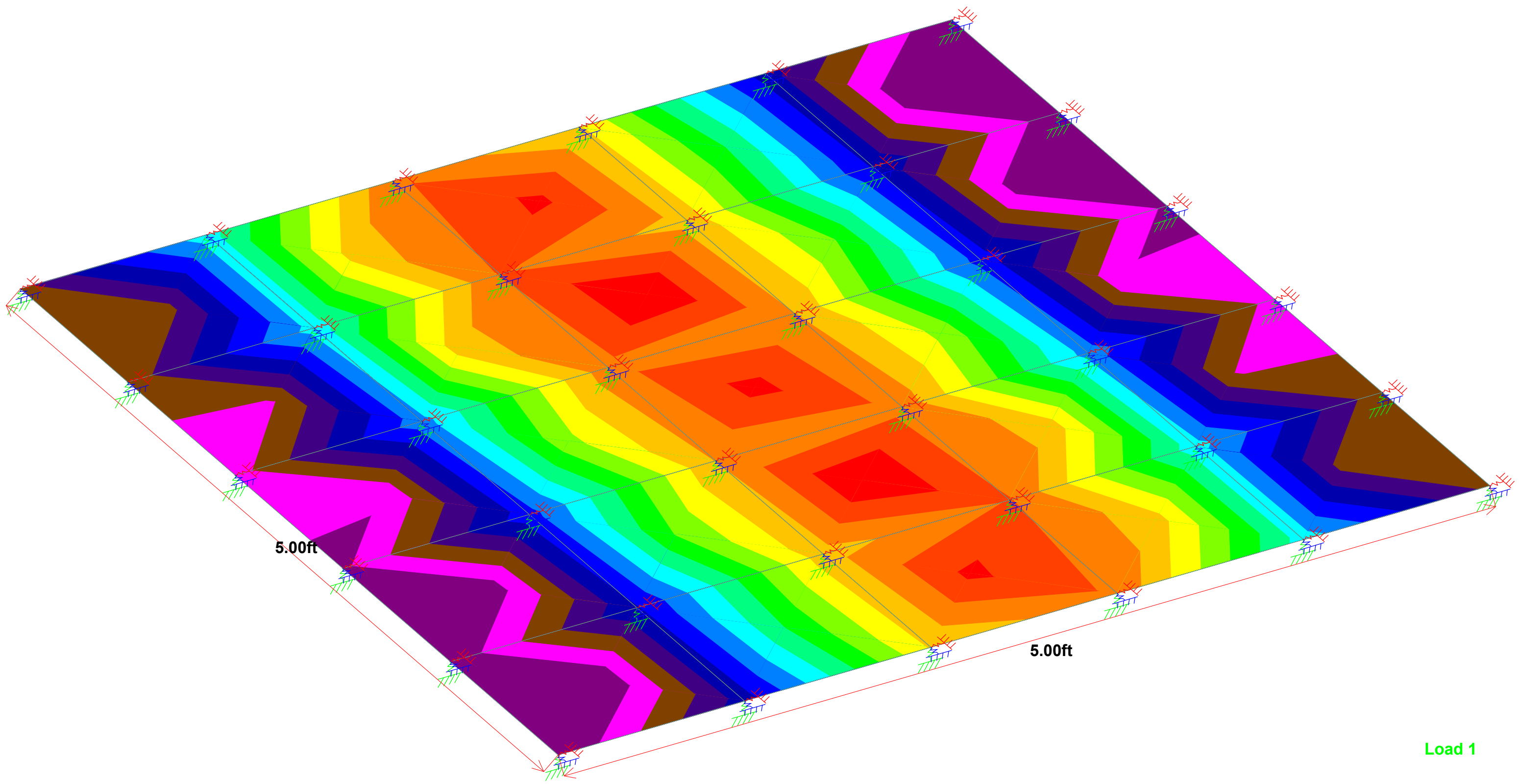


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 01:49	



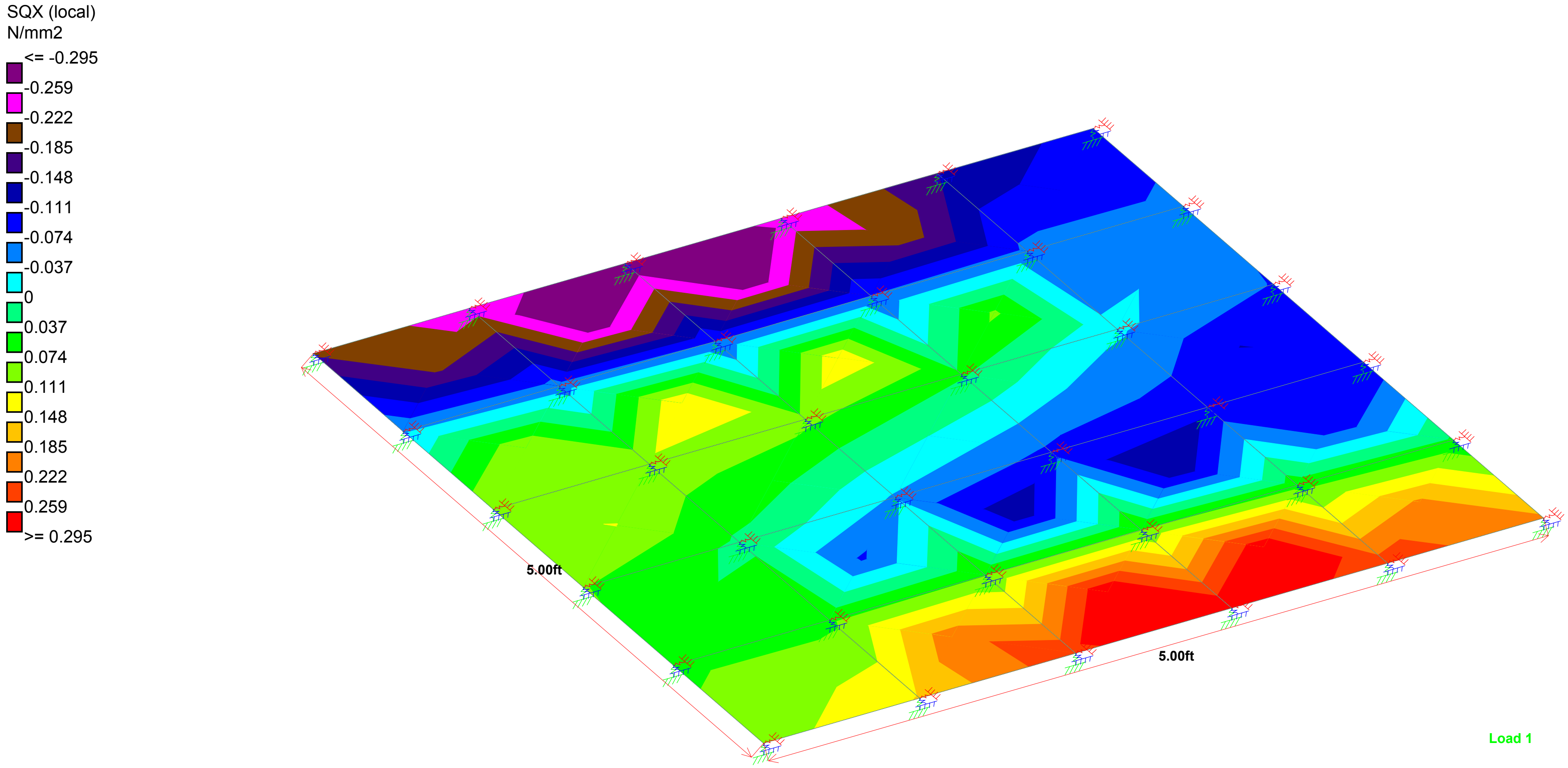
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 01:49	

MY (local)
kNm/m
<= 2.74
3.48
4.21
4.95
5.69
6.42
7.16
7.9
8.64
9.37
10.1
10.8
11.6
12.3
13.1
13.8
>= 14.5



Software licensed to Optimal Engineering Support

	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 01:49	



Software licensed to Optimal Engineering Support

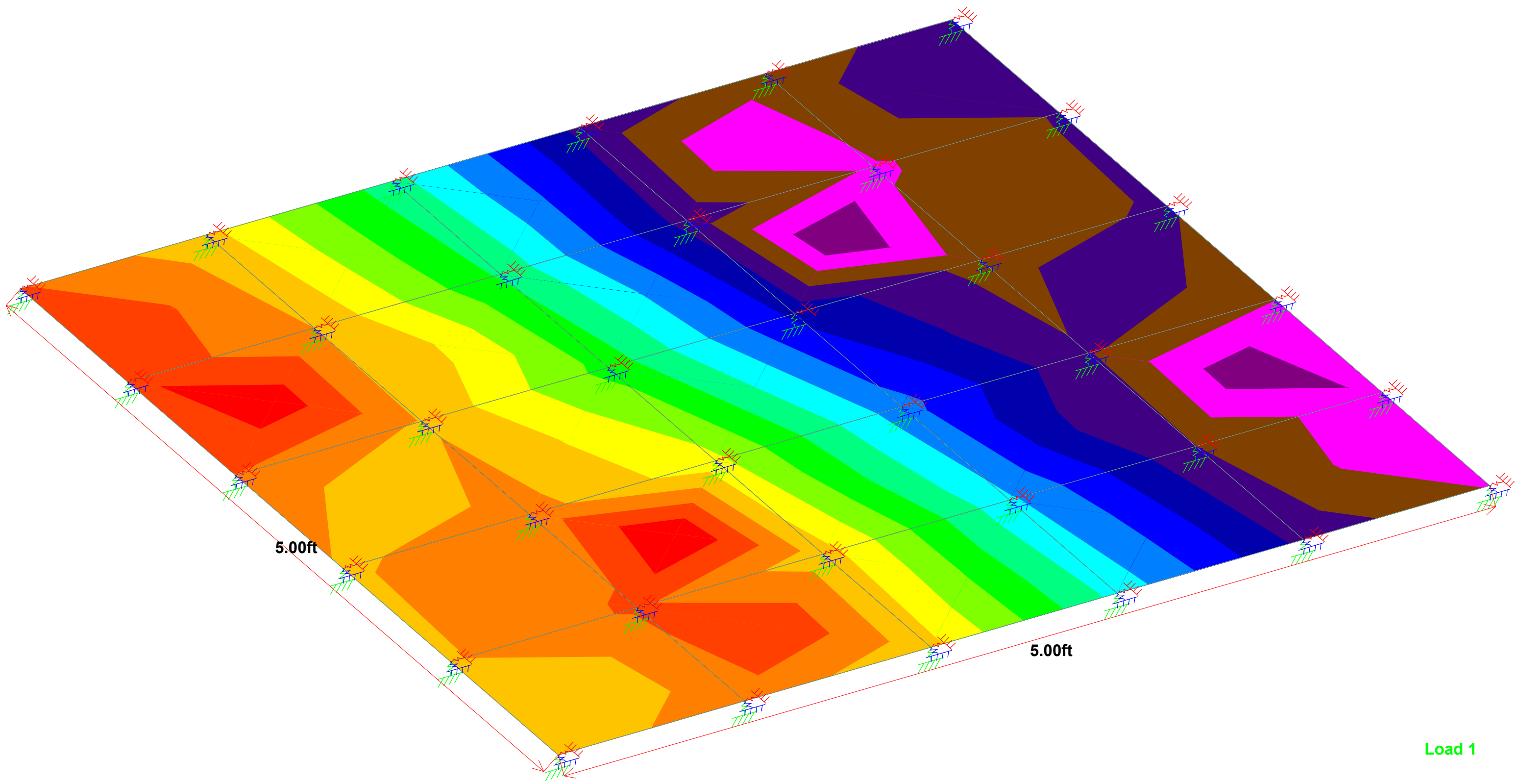
Job No	Sheet No 1		Rev
Part			
Ref Panel Check			
By CH	Date 04-Mar-21	Chd	
File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 01:49		

Job Title

Client SSL

SQY (local)
N/mm2

<= -0.239
-0.209
-0.179
-0.149
-0.119
-0.089
-0.060
-0.030
0
0.030
0.060
0.089
0.119
0.149
0.179
0.209
>= 0.239



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 *           STAAD.Pro                              *
 *           Version  2007    Build 04              *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR  7, 2021                  *
 *           Time=     1:50: 7                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
 ****************************************************
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```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x5 type A (5W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 31 PR GY -7.717 0.25 0.33
    40. 32 PR GY -7.717 0.25 0
```



```
    41. 33 PR GY -7.717 0.25 -0.33
    42. 33 PR GY -7.717 0.25 0.33
    43. 34 PR GY -7.717 0.25 0
    44. 5 PR GY -7.717 -0.25 0
    45. 8 PR GY -7.717 -0.25 -0.33
    46. 8 PR GY -7.717 -0.25 0.33
    47. 11 PR GY -7.717 -0.25 0
    48. 14 PR GY -7.717 -0.25 -0.33
    49. PERFORM ANALYSIS
```

```
         P R O B L E M   S T A T I S T I C S
         -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

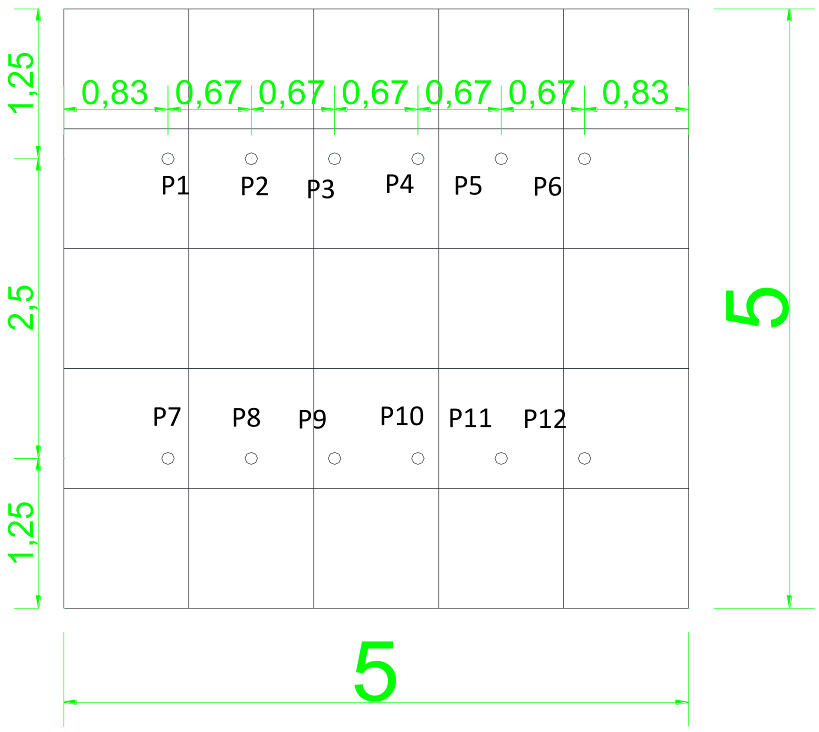
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
 SIZE OF STIFFNESS MATRIX =        11 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.2/ 263432.0 MB
```

```
    50. FINISH
```

Typical Panel Type (mesh 6W20), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	-0.33	0.25
P7	0.33	-0.25
P8	0	-0.25
P9	-0.33	-0.25
P10	0.33	-0.25
P11	0	-0.25
P12	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

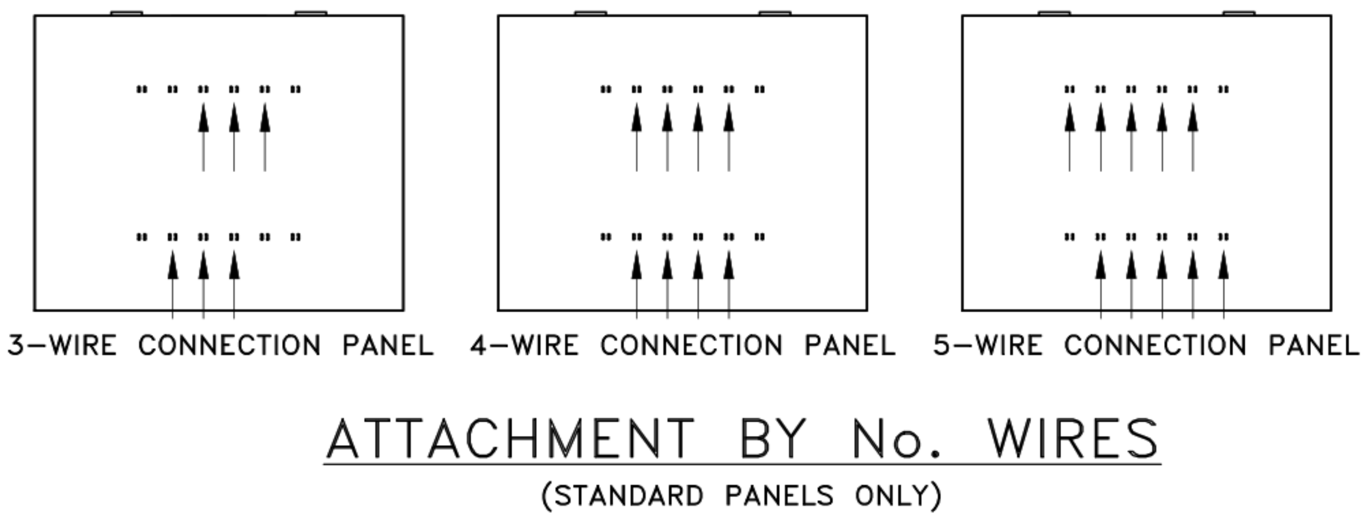
W11 - 75 Years

A = 0.1583 in^2

Fy = 75 ksi

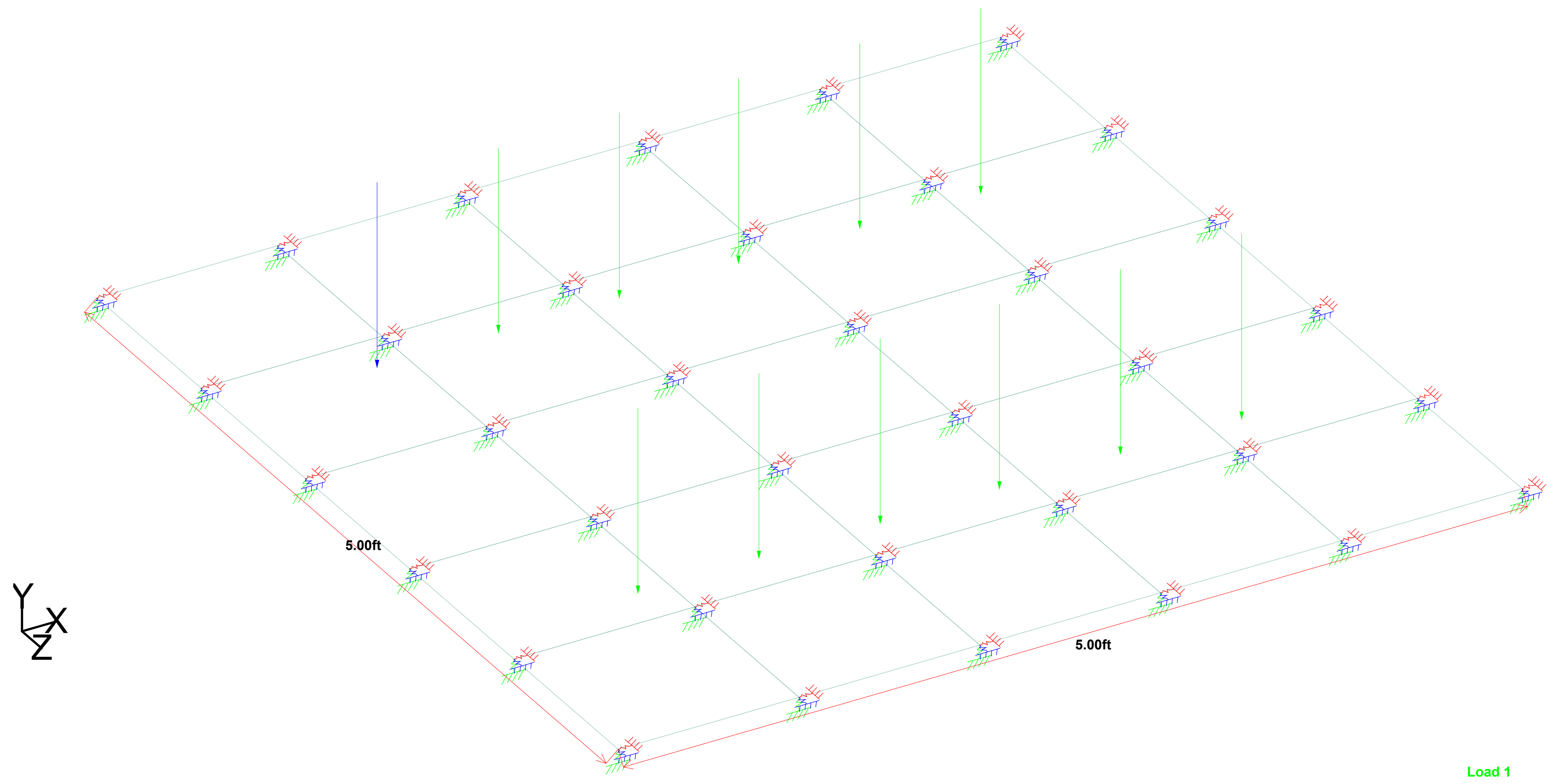
P = 0.65 x A x Fy

= 7.717 Kips (per wire point)



Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
	Part		
	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 02:29	



Software licensed to Optimal Engineering Support

Job No	Sheet No	Rev
	1	

Part

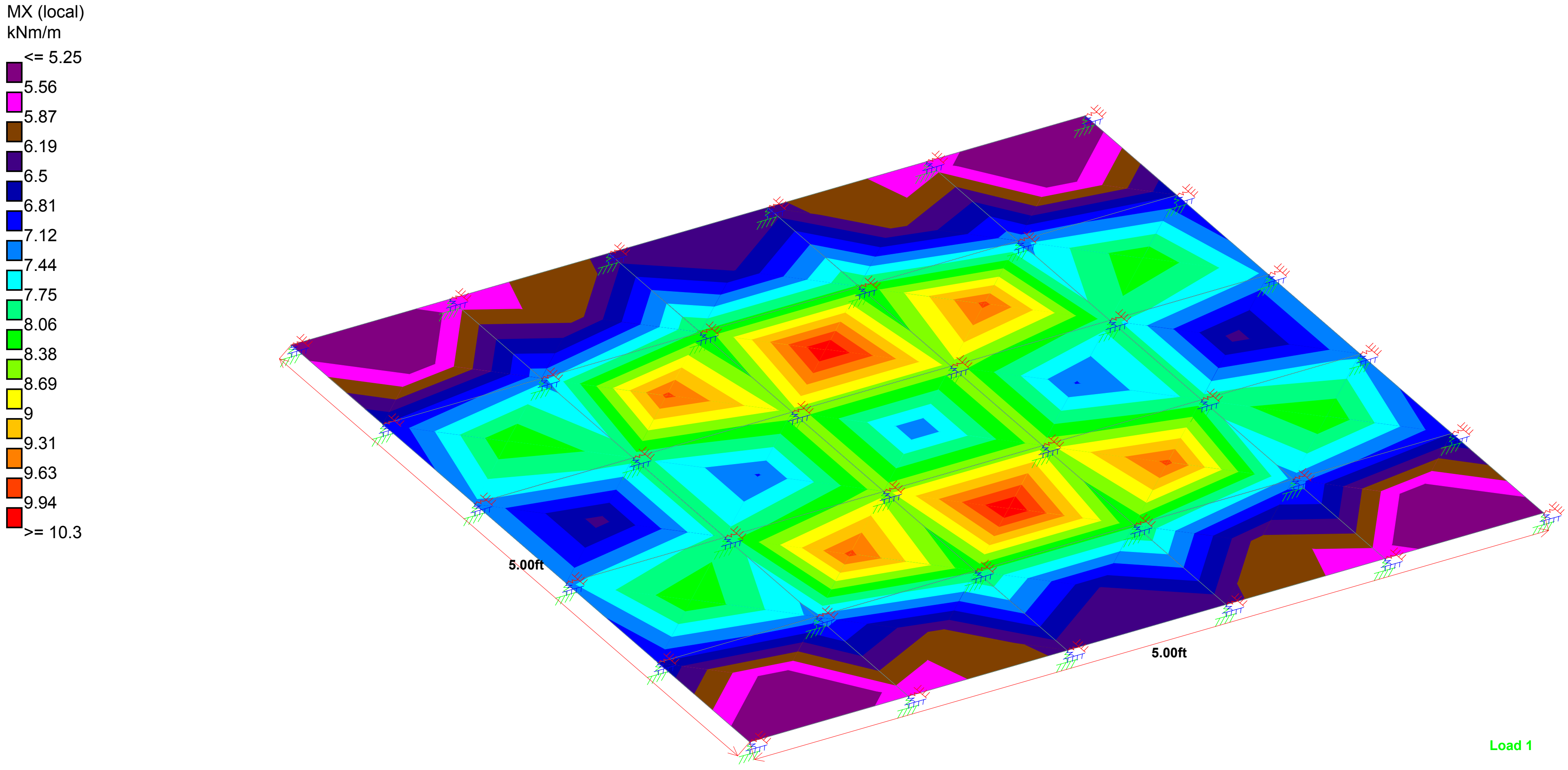
Job Title

Ref Panel Check

By CH | Date 04-Mar-21 | Chd

Client SSL

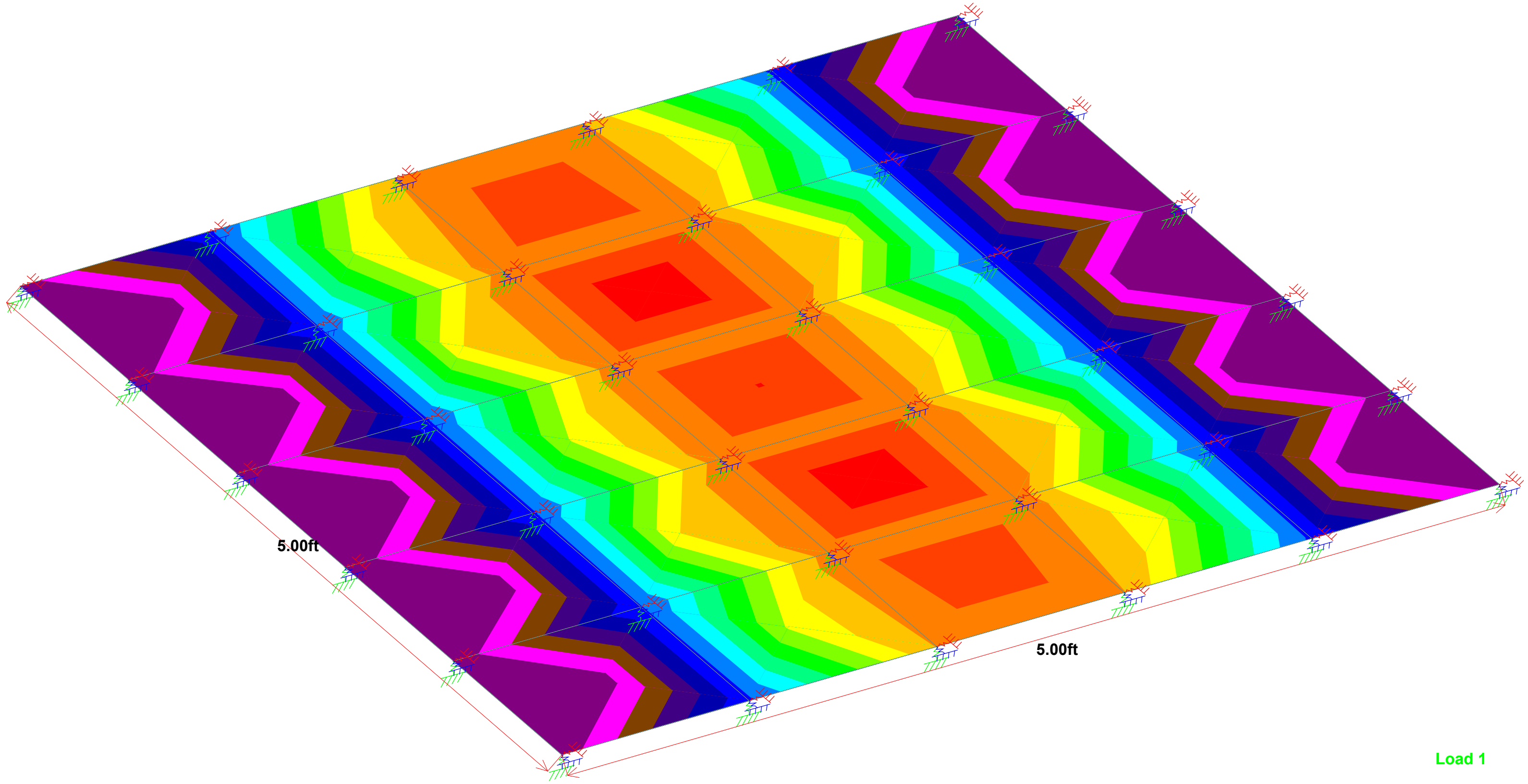
File Panel Check - 5x5 type A | Date/Time 07-Mar-2021 02:29



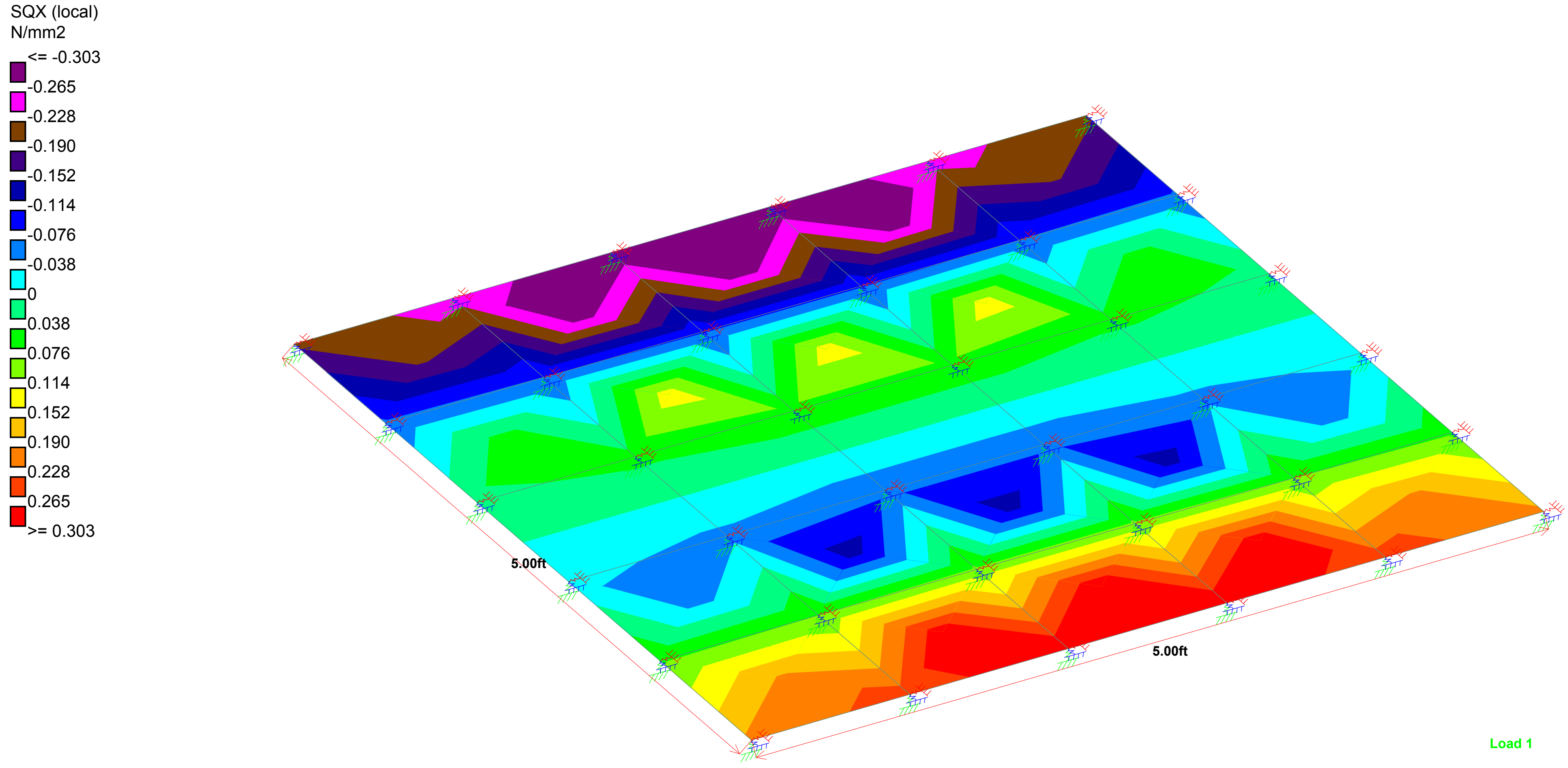
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 02:29	

MY (local)
kNm/m
<= 4.14
4.73
5.32
5.91
6.5
7.09
7.68
8.27
8.86
9.45
10
10.6
11.2
11.8
12.4
13
>= 13.6

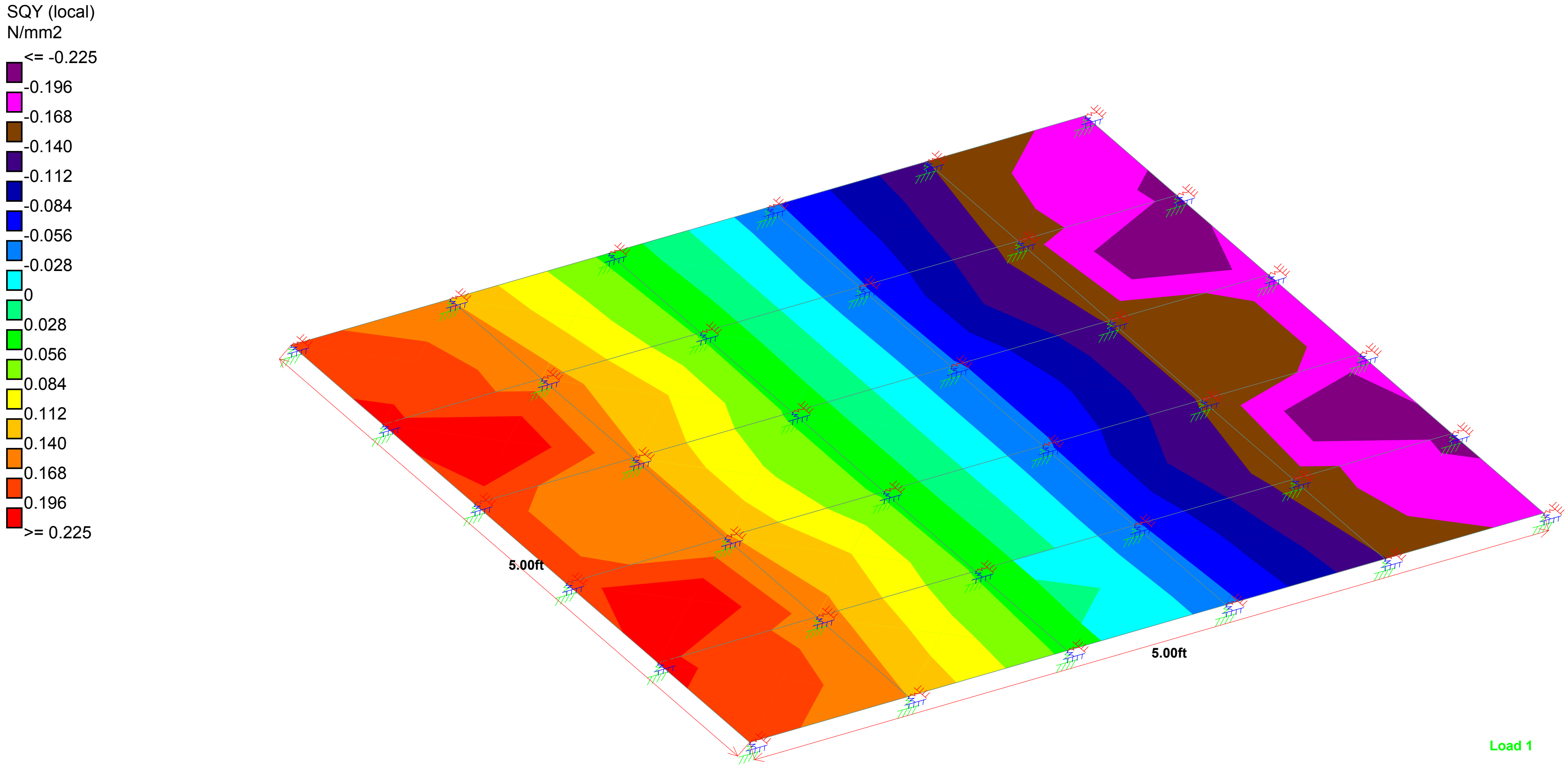


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 02:29	



Software licensed to Optimal Engineering Support

Job No	Sheet No 1		Rev
Part			
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 02:29	



```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR  7, 2021                  *
*           Time=     2:42:41                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
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```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x5 type A (6W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 31 PR GY -7.717 0.25 0.33
    40. 32 PR GY -7.717 0.25 0
```



```
    41. 33 PR GY -7.717 0.25 -0.33
    42. 33 PR GY -7.717 0.25 0.33
    43. 34 PR GY -7.717 0.25 0
    44. 35 PR GY -7.717 0.25 -0.33
    45. 2 PR GY -7.717 -0.25 0.33
    46. 5 PR GY -7.717 -0.25 0
    47. 8 PR GY -7.717 -0.25 -0.33
    48. 8 PR GY -7.717 -0.25 0.33
    49. 11 PR GY -7.717 -0.25 0
    50. 14 PR GY -7.717 -0.25 -0.33
    51. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

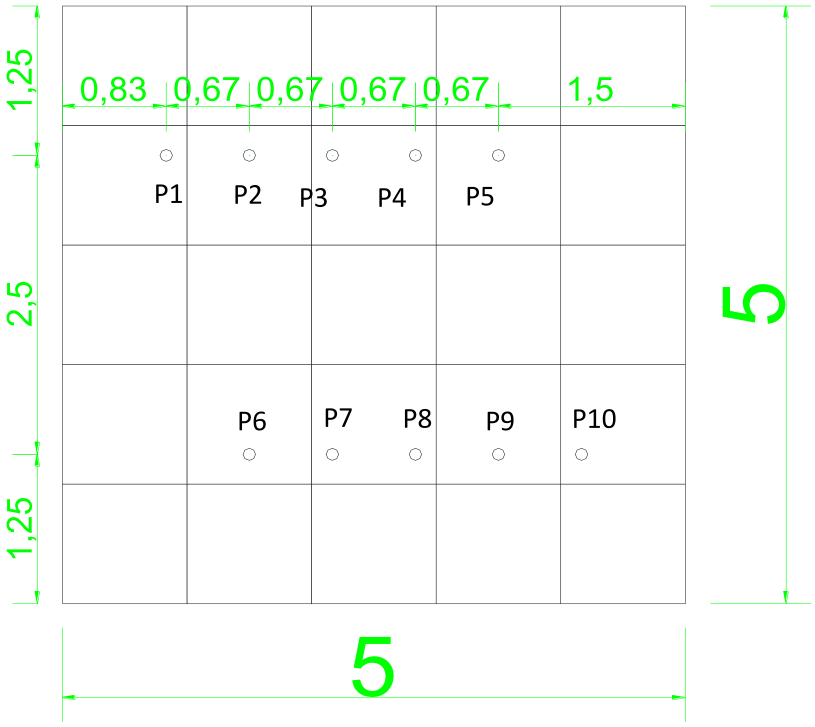
      SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    216
SIZE OF STIFFNESS MATRIX =       11 DOUBLE  KILO-WORDS
REQRD/AVAIL. DISK SPACE  =     12.2/ 263430.2 MB
```

```
    52. FINISH
```

Typical Panel Type (mesh 5W24), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	0	-0.25
P7	-0.33	-0.25
P8	0.33	-0.25
P9	0	-0.25
P10	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

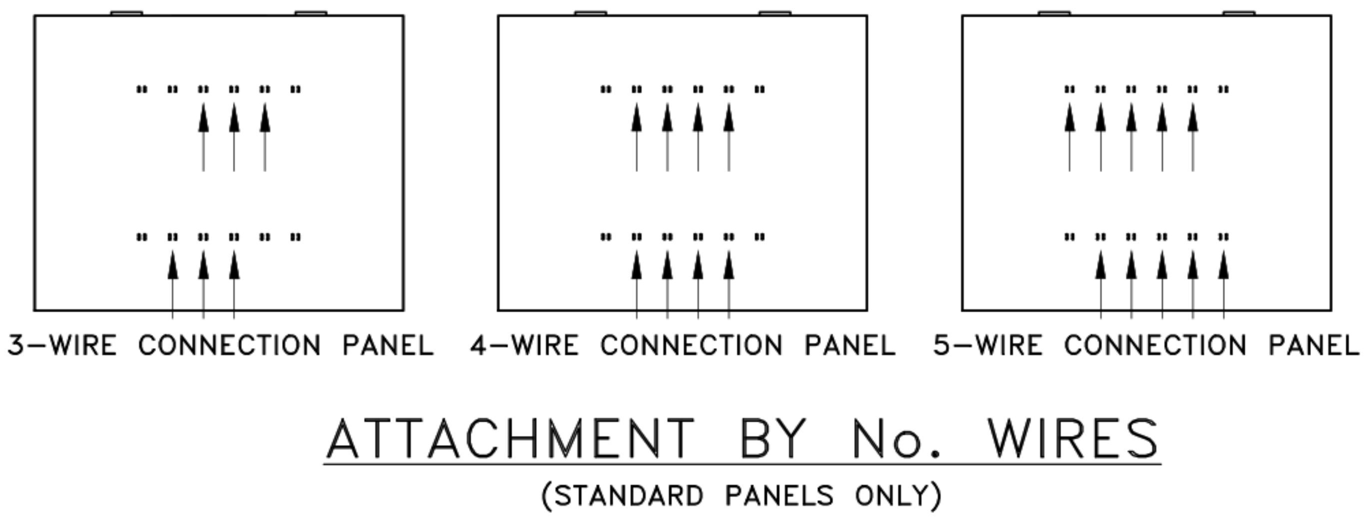
W11 - 75 Years

$A = 0.194 \text{ in}^2$

$F_y = 75 \text{ ksi}$

$P = 0.65 \times A \times F_y$

$= 9.458$ Kips (per wire point)



TOC – Appendix

Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
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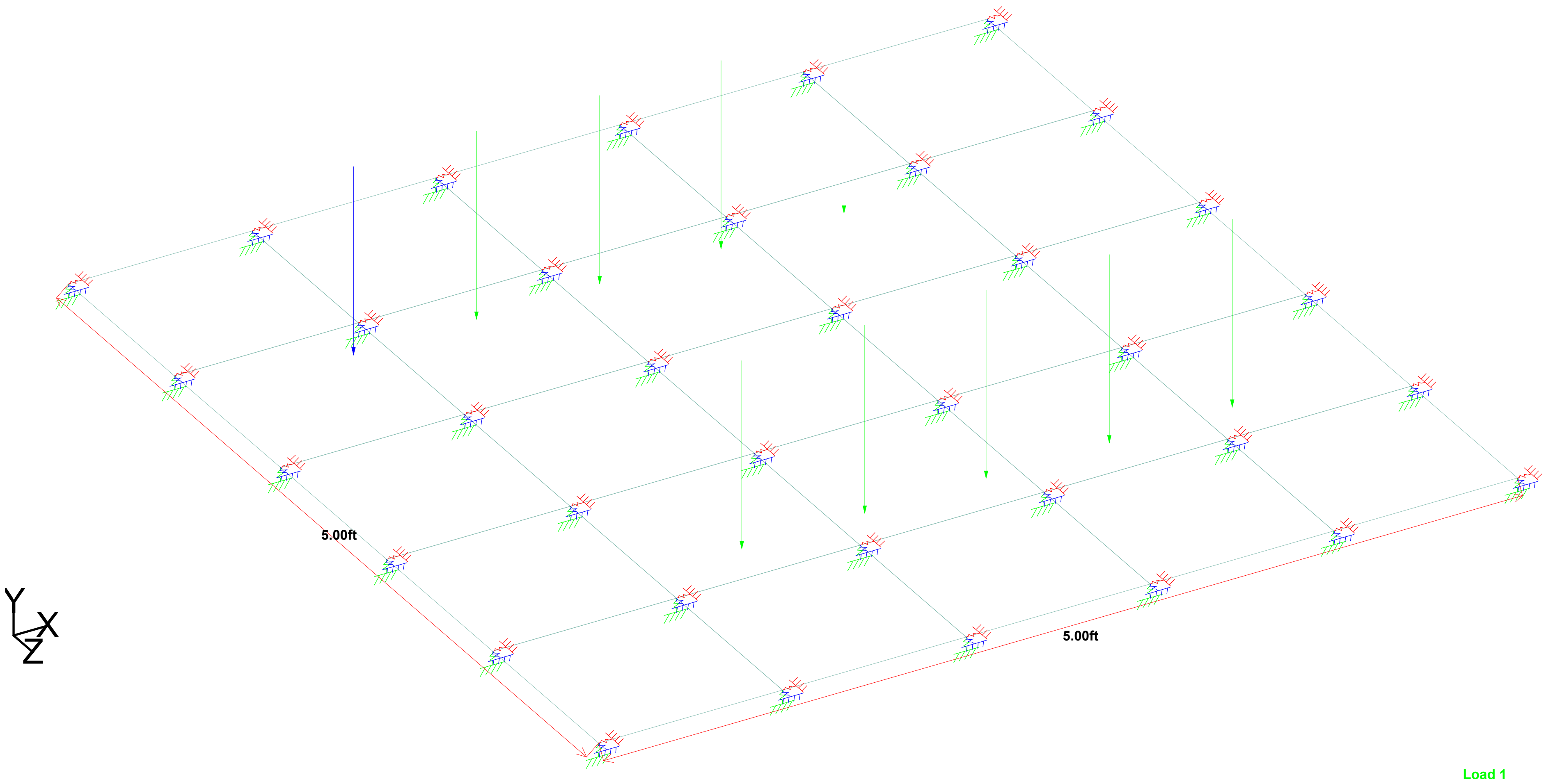
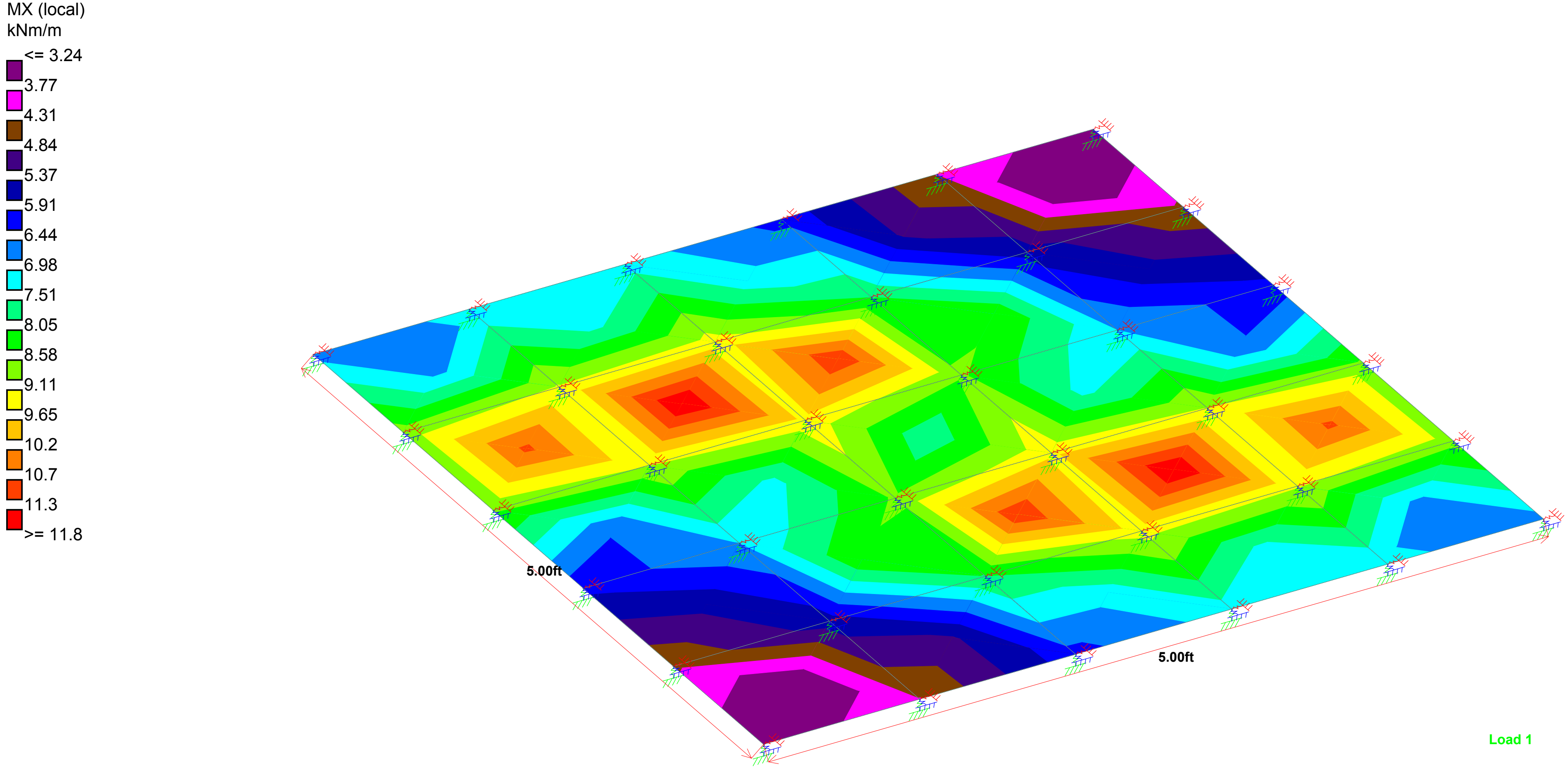
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 13:19	



Software licensed to Optimal Engineering Support

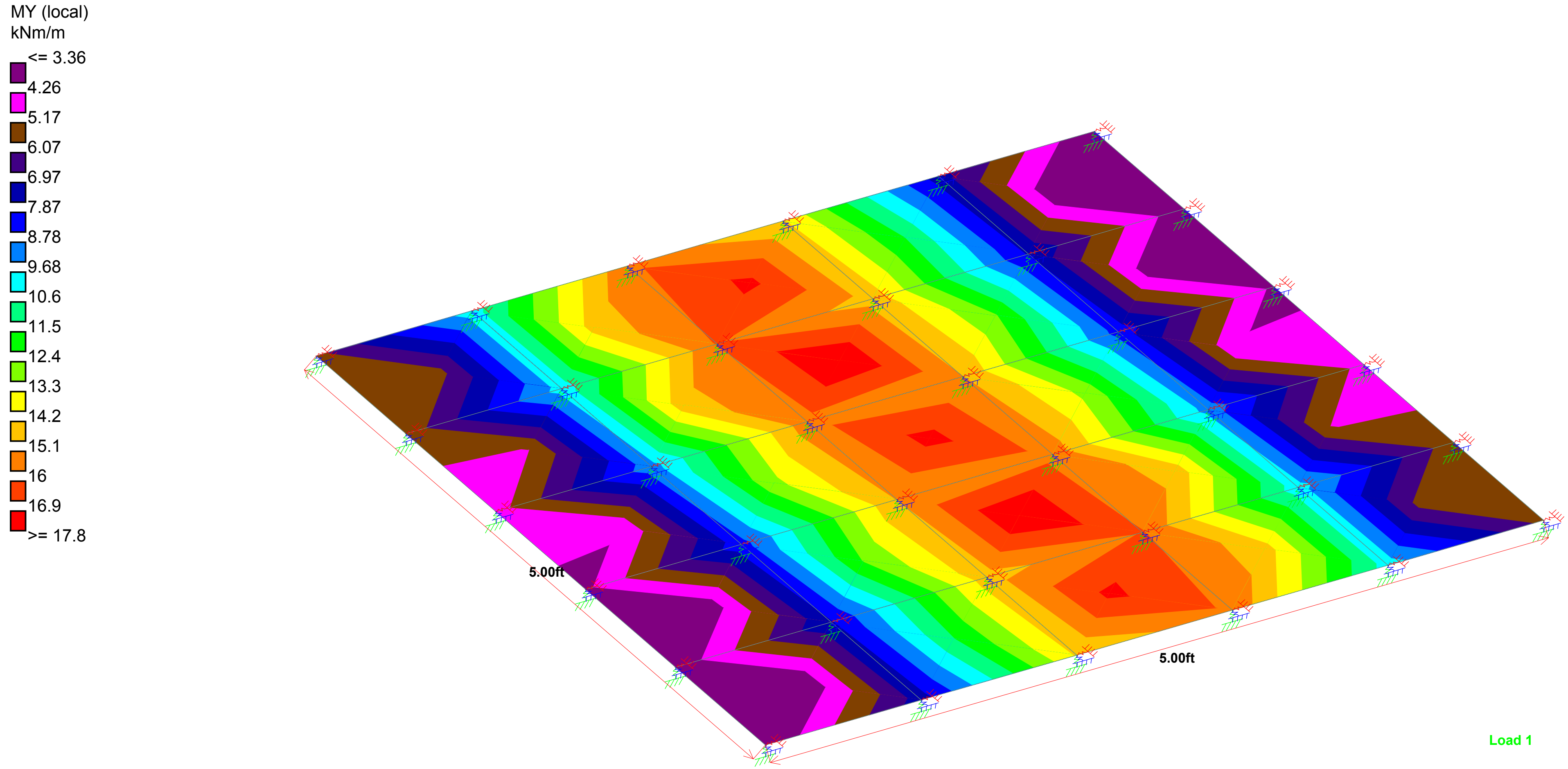
Job No	Sheet No	Rev
	1	

Part	
Ref	Panel Check
By	CH
Date	04-Mar-21
Chd	
Job Title	
Client	SSL
File	Panel Check - 5x5 type A
Date/Time	07-Mar-2021 13:19



Software licensed to Optimal Engineering Support

Job No		Sheet No 1		Rev
Part				
Job Title	Ref Panel Check			
	By CH	Date 04-Mar-21		Chd
Client SSL	File Panel Check - 5x5 type A		Date/Time 07-Mar-2021 13:19	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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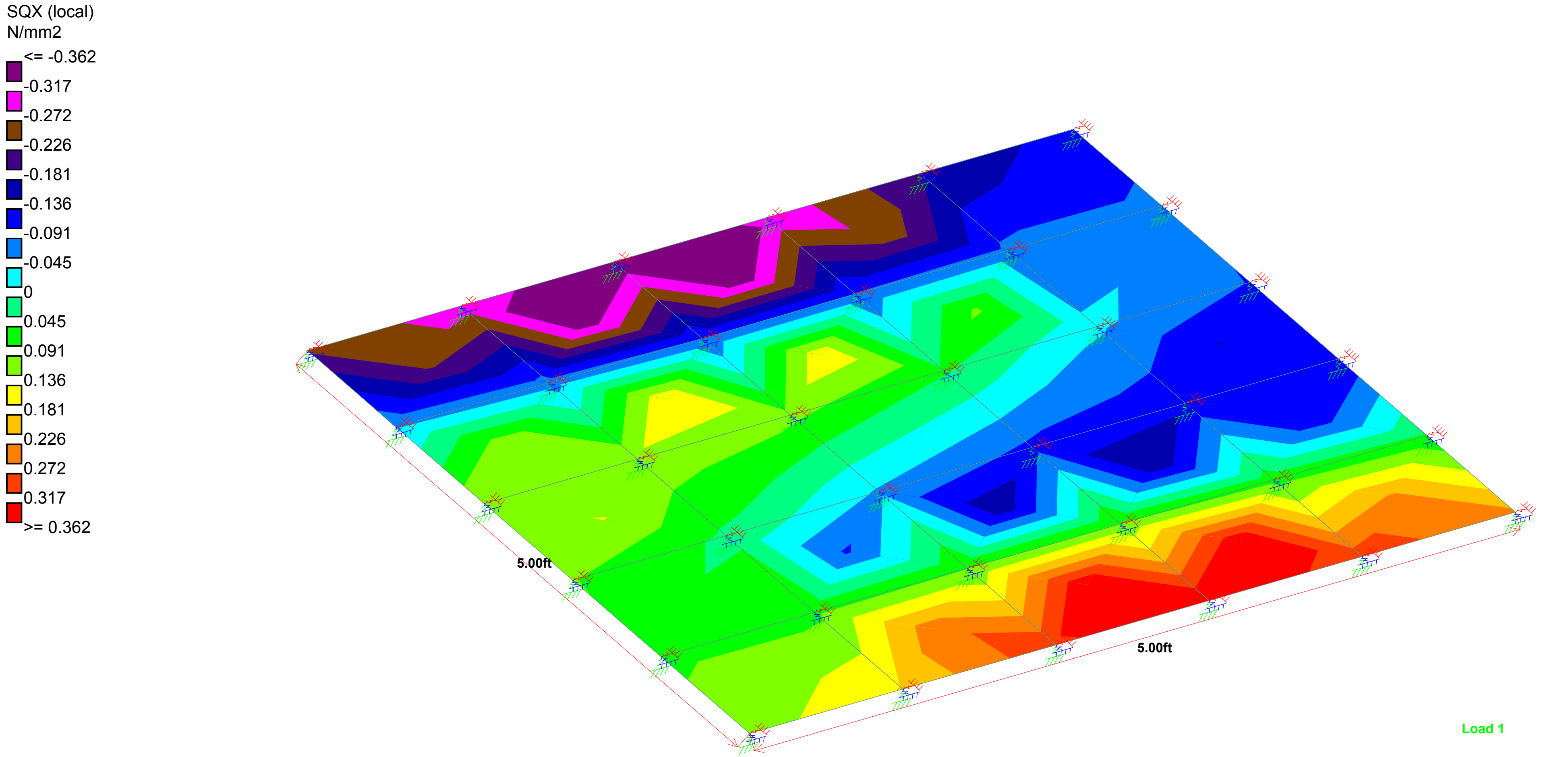
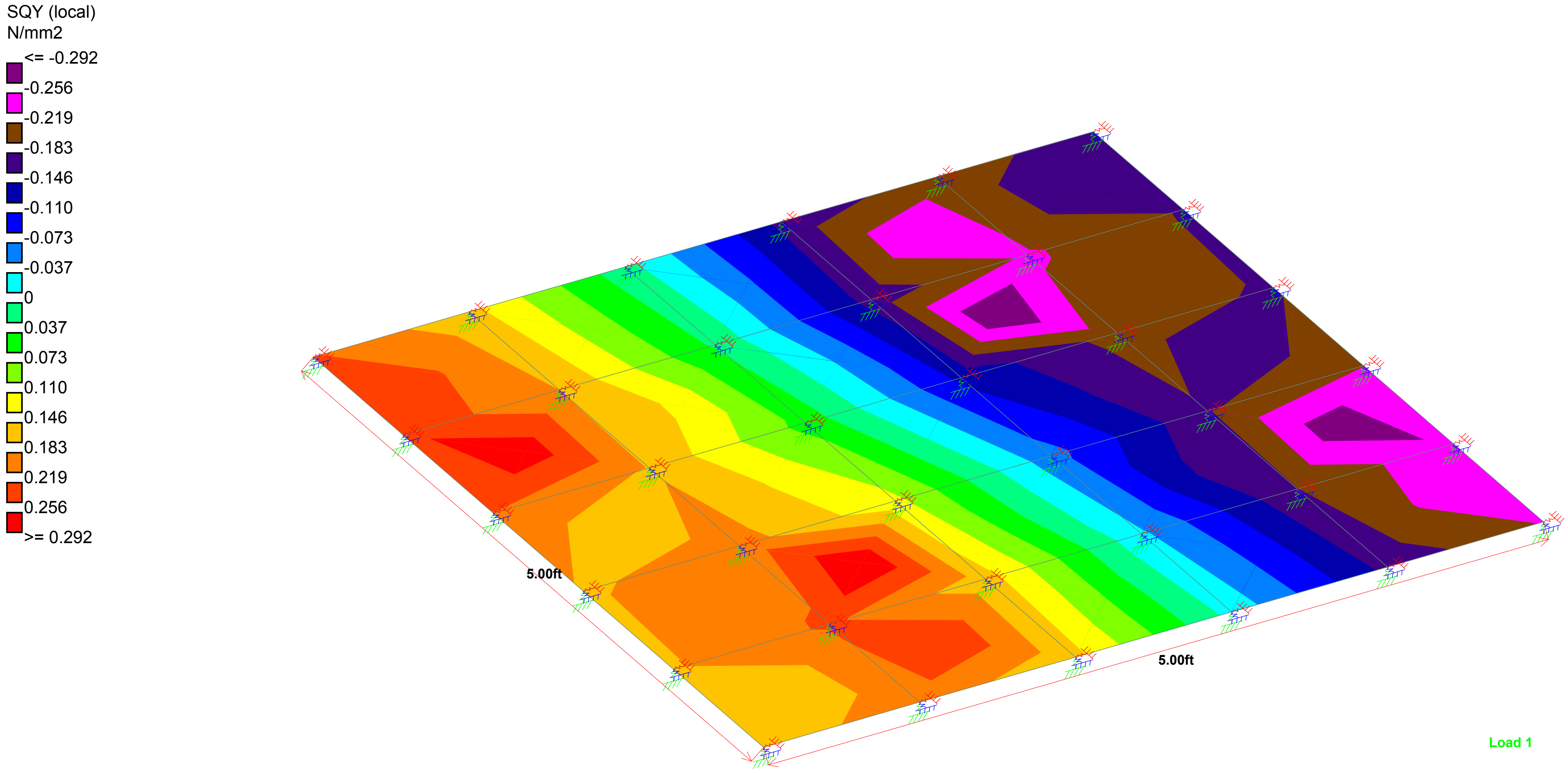
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 13:19	



Software licensed to Optimal Engineering Support

	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 13:19	



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     *           Research Engineers,  Intl.             *
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     *           Time=    13:20:27                      *
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     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
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     9. UNIT FEET KIP
    10. JOINT COORDINATES
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    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. ELEMENT INCIDENCES SHELL
    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    18. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    19. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    20. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    21. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    22. ELEMENT PROPERTY
    23. 1 TO 15 31 TO 35 41 TO 45 THICKNESS 0.5
    24. DEFINE MATERIAL START
    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 31 PR GY -9.458 0.25 0.33
    40. 32 PR GY -9.458 0.25 0
```



```
    41. 33 PR GY -9.458 0.25 -0.33
    42. 33 PR GY -9.458 0.25 0.33
    43. 34 PR GY -9.458 0.25 0
    44. 5 PR GY -9.458 -0.25 0
    45. 8 PR GY -9.458 -0.25 -0.33
    46. 8 PR GY -9.458 -0.25 0.33
    47. 11 PR GY -9.458 -0.25 0
    48. 14 PR GY -9.458 -0.25 -0.33
    49. PERFORM ANALYSIS


          P R O B L E M   S T A T I S T I C S
          -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

        SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

  ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
  TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
  SIZE OF STIFFNESS MATRIX =       11 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.2/ 263428.4 MB


    50. FINISH
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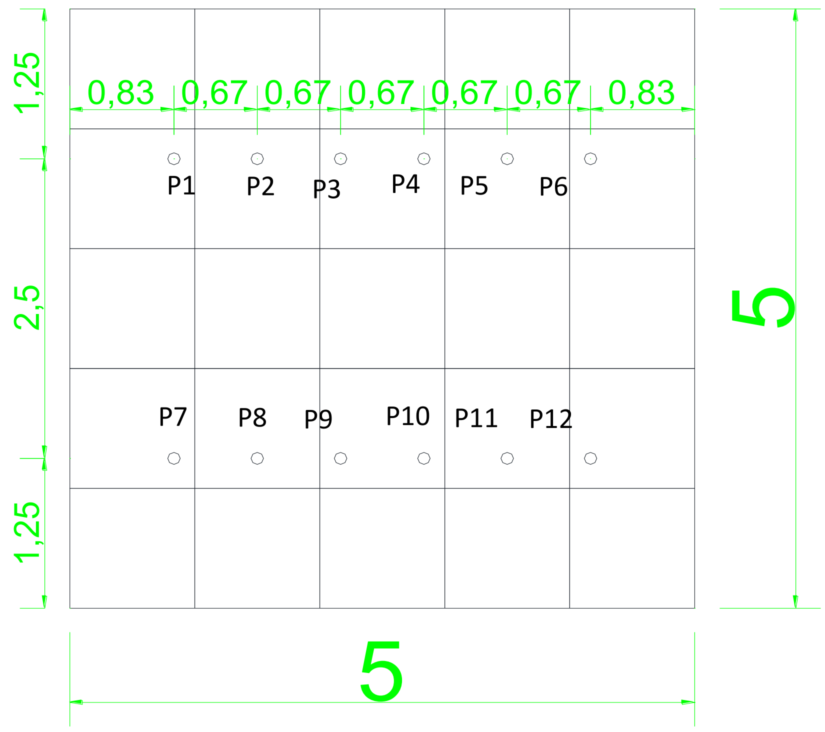
Typical Panel Type (mesh 6W24), Panel Thickness 6", 5'x5'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	-0.33	0.25
P7	0.33	-0.25
P8	0	-0.25
P9	-0.33	-0.25
P10	0.33	-0.25
P11	0	-0.25
P12	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

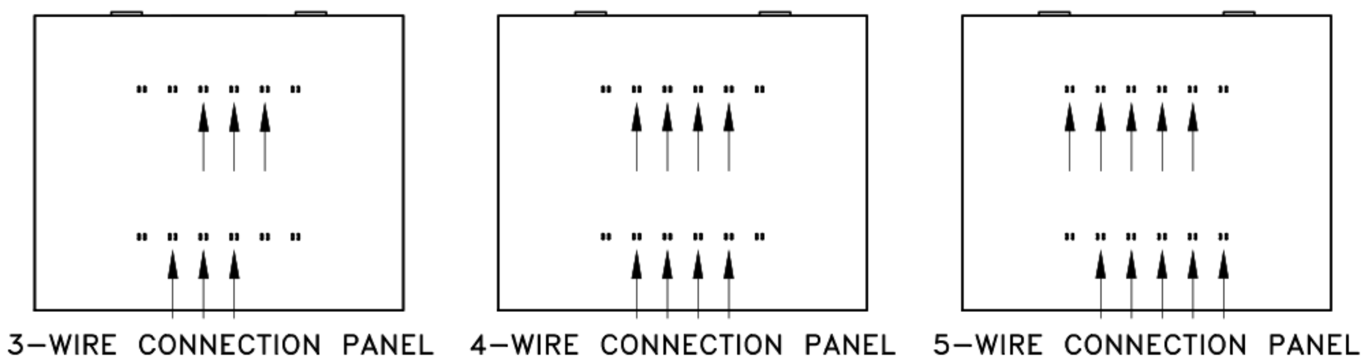
W11 - 75 Years

A = 0.194 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

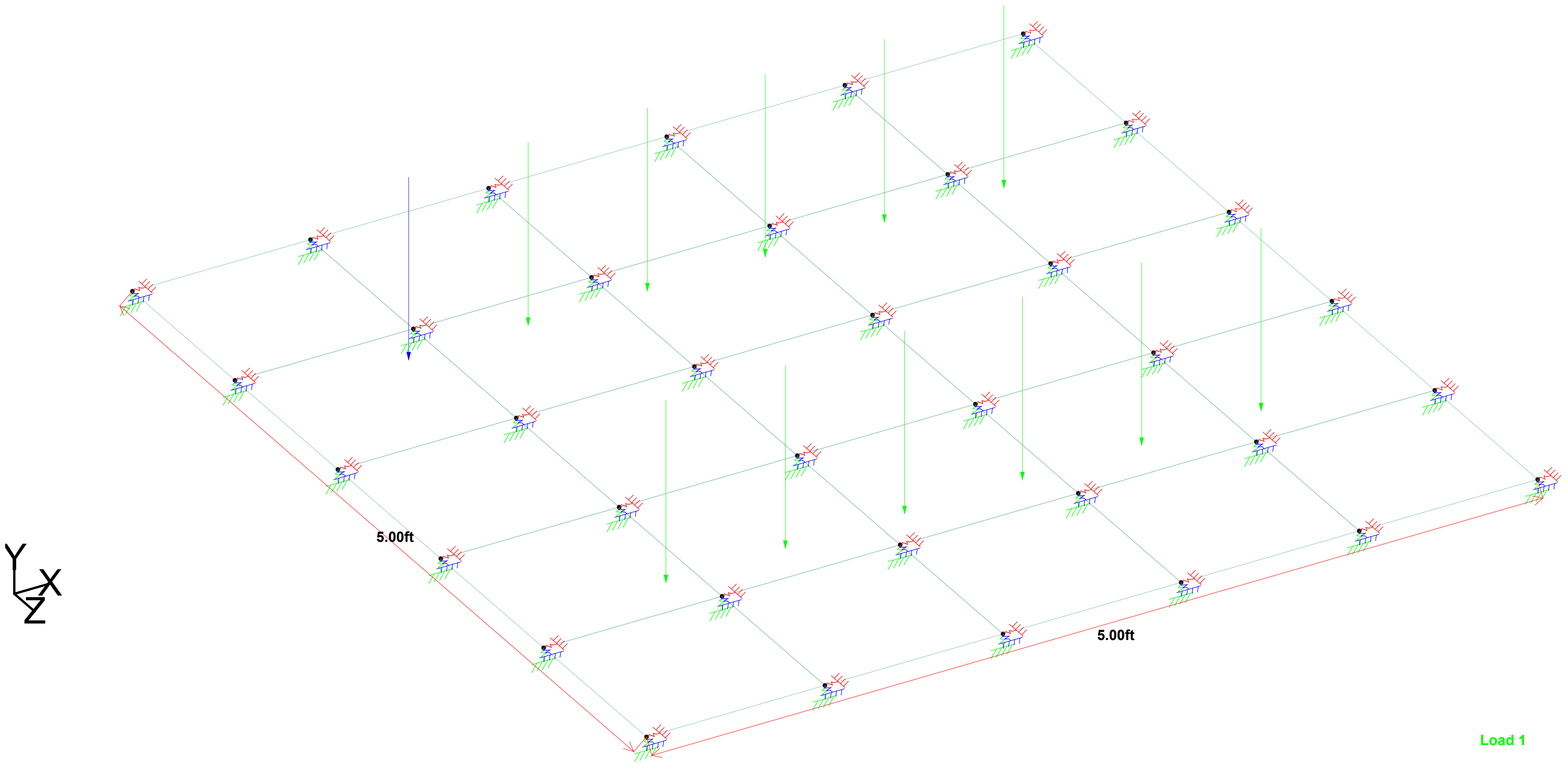
= 9.458 Kips (per wire point)



ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

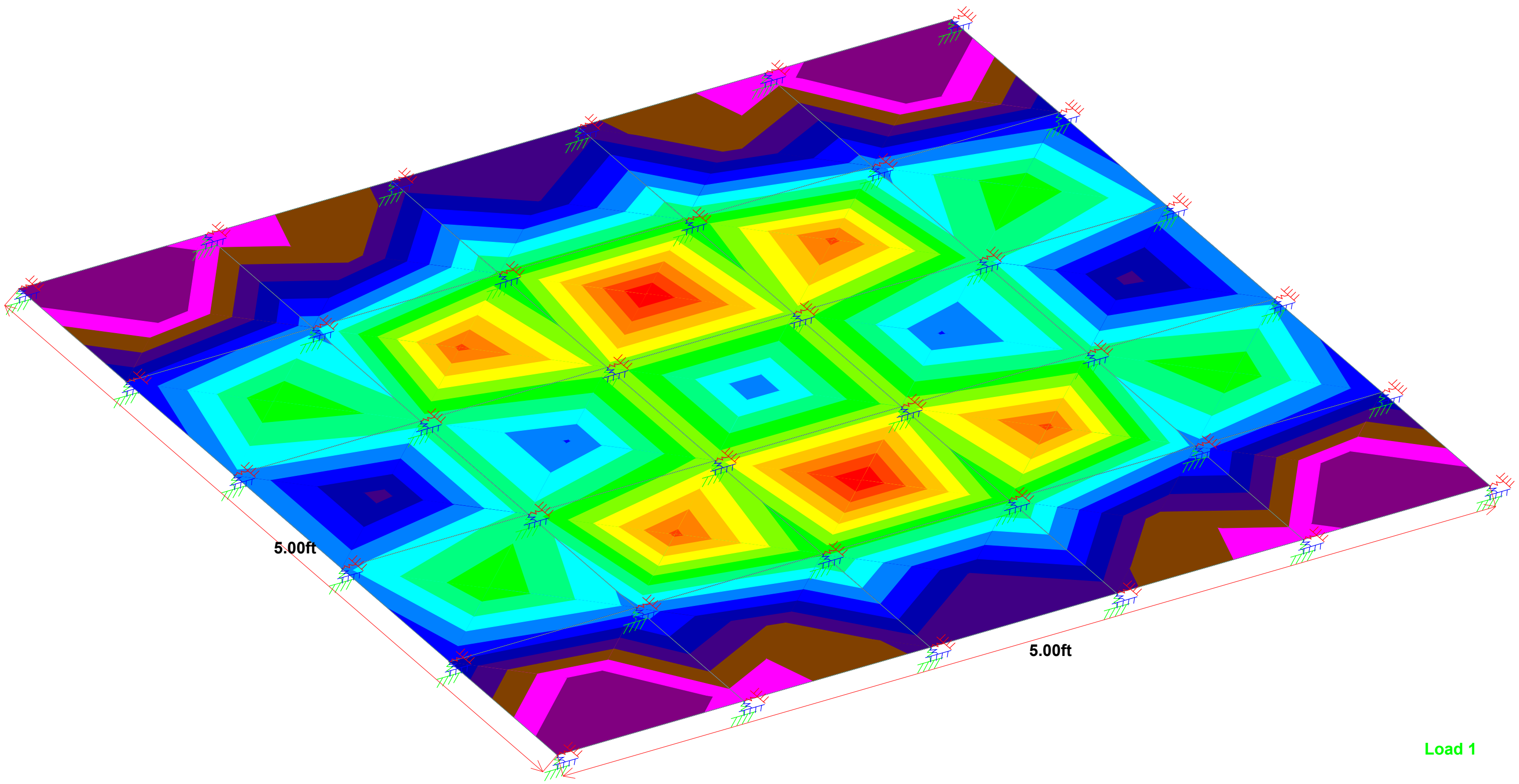
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 14:51	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 14:51	

MX (local)
kNm/m

<= 6.43
6.82
7.2
7.58
7.97
8.35
8.73
9.12
9.5
9.88
10.3
10.6
11
11.4
11.8
12.2
>= 12.6



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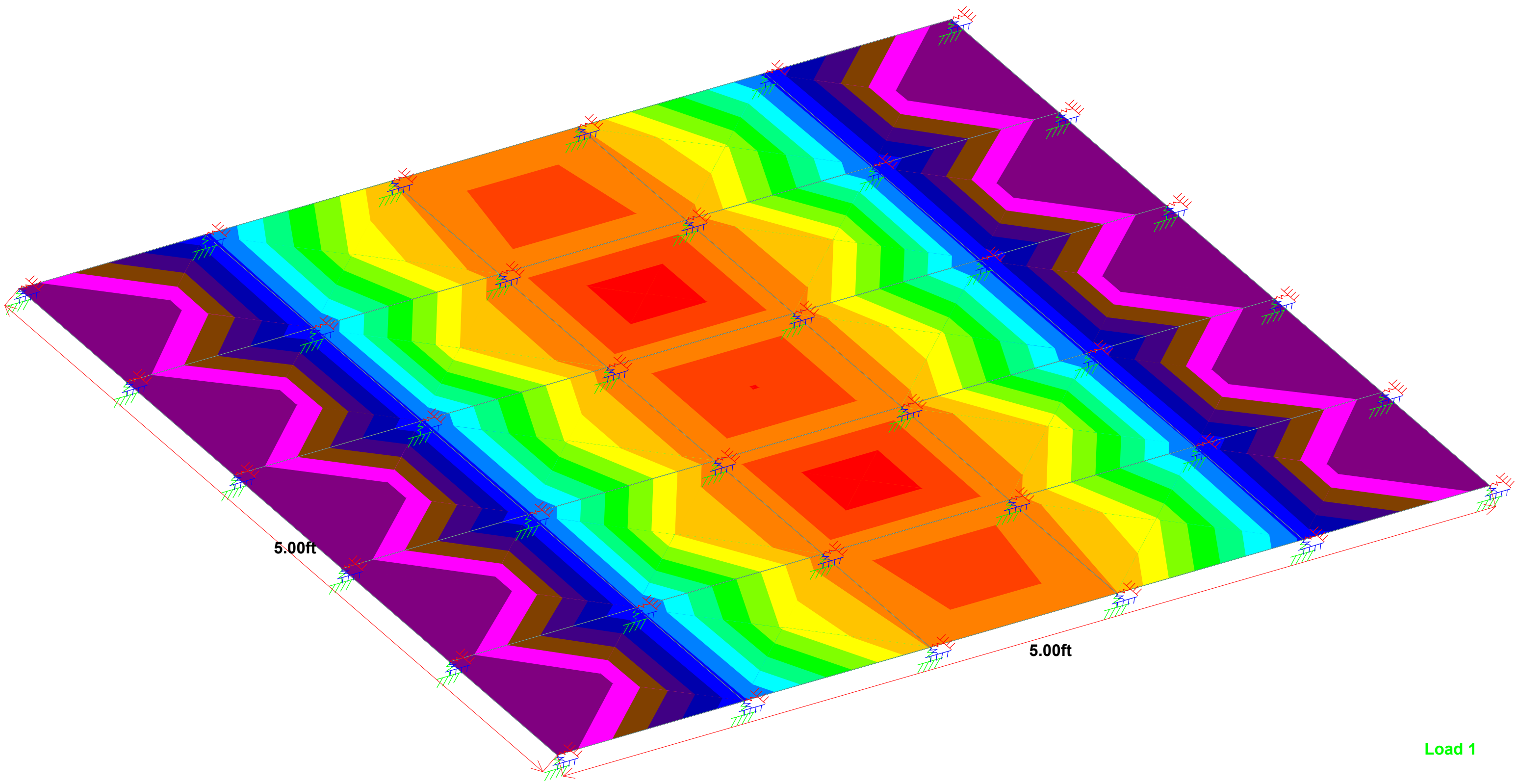
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x5 type A	Date/Time 07-Mar-2021 14:51	

MY (local)
kNm/m
<= 5.07
5.8
6.52
7.24
7.97
8.69
9.41
10.1
10.9
11.6
12.3
13
13.8
14.5
15.2
15.9
>= 16.6



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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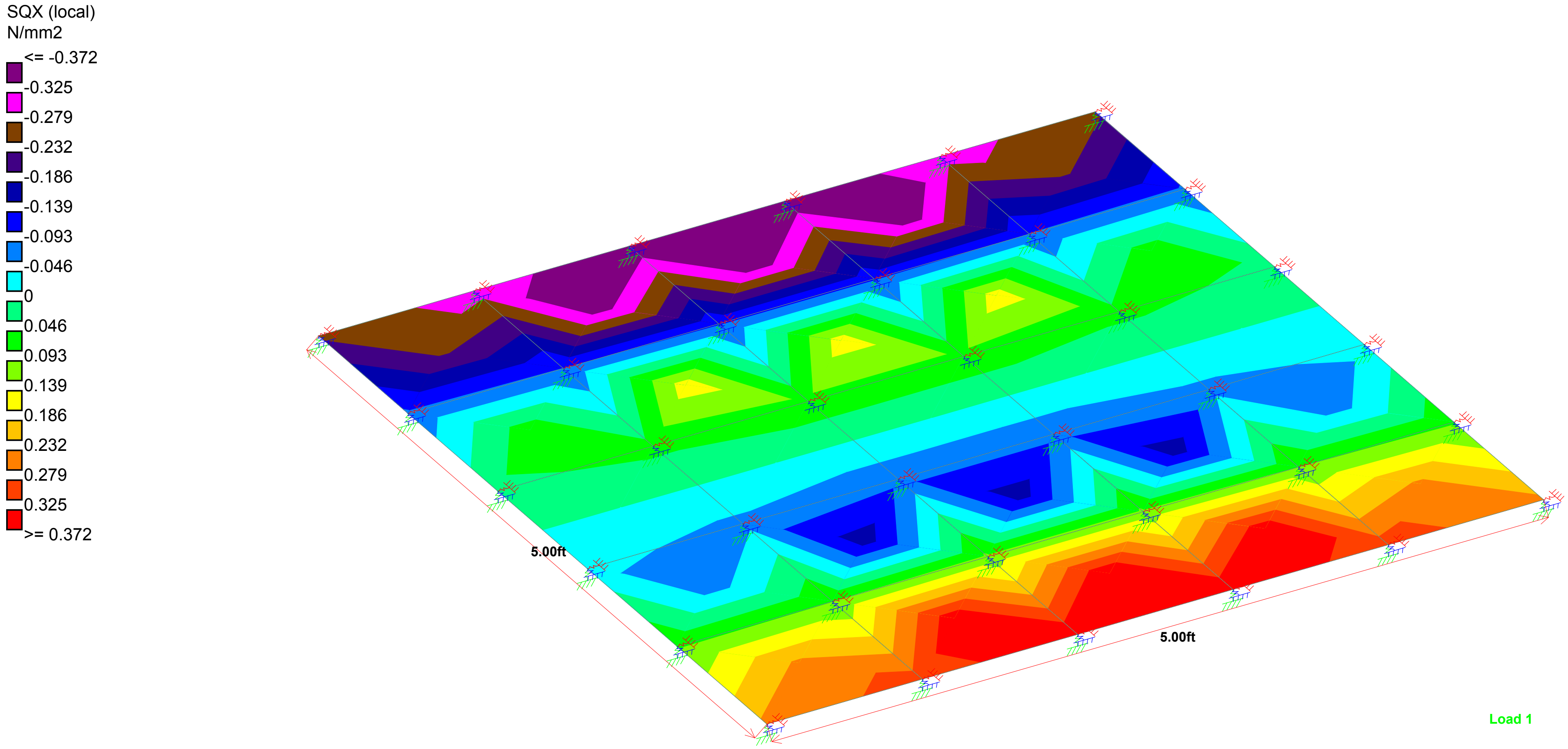

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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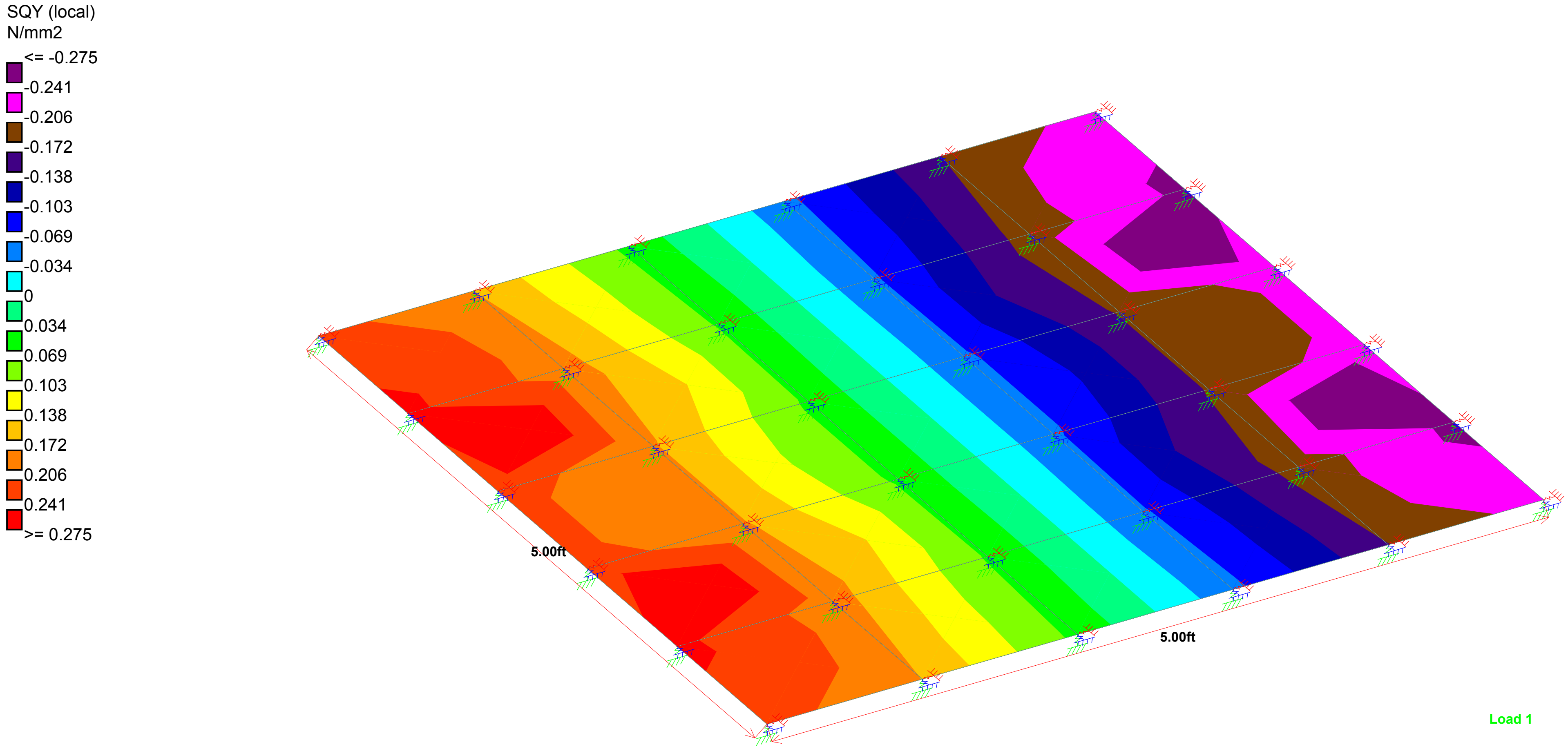

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 *           Research Engineers,  Intl.             *
 *           Date=    MAR  7, 2021                  *
 *           Time=    18: 3:41                      *
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 *      USER ID: Optimal Engineering Support        *
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     2. START JOB INFORMATION
     3. ENGINEER DATE 07-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
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    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
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    17. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
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    25. ISOTROPIC CONCRETE
    26. E 614304
    27. POISSON 0.17
    28. DENSITY 0.15
    29. ALPHA 1E-005
    30. DAMP 0.05
    31. END DEFINE MATERIAL
    32. CONSTANTS
    33. MATERIAL CONCRETE ALL
    34. SUPPORTS
    35. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 60 -
    36. 61 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    37. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    38. ELEMENT LOAD
    39. 31 PR GY -9.458 0.25 0.33
    40. 32 PR GY -9.458 0.25 0
```



```
    41. 33 PR GY -9.458 0.25 -0.33
    42. 33 PR GY -9.458 0.25 0.33
    43. 34 PR GY -9.458 0.25 0
    44. 35 PR GY -9.458 0.25 -0.33
    45. 2 PR GY -9.458 -0.25 0.33
    46. 5 PR GY -9.458 -0.25 0
    47. 8 PR GY -9.458 -0.25 -0.33
    48. 8 PR GY -9.458 -0.25 0.33
    49. 11 PR GY -9.458 -0.25 0
    50. 14 PR GY -9.458 -0.25 -0.33
    51. PERFORM ANALYSIS


          P R O B L E M   S T A T I S T I C S
          -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    25/    36

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     7/     7/     48 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    216
 SIZE OF STIFFNESS MATRIX =       11 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.2/ 263425.6 MB


    52. FINISH
```

Summary Result From Staad Pro Analysis Output

Standard Panel Size	Bar Mat Type	Panel Type	Horz Rebar	Vert Rebar	Staad Pro Output				Data for AASHTO LRFD Design Check			
					Mx (kNm/m)	My (kNm/m)	SQx (N/mm^2)	SQy (N/mm^2)	Mx (Kips-ft/ft)	My (Kips-ft/ft)	SQx (lbs/in^2)	SQy (lbs/in^2)
5'x5'	3W11	A	4 #4	4 #4	3.150	6.520	0.119	0.118	0.708	1.466	17.260	17.114
	4W11				3.980	**7.790**	0.145	**0.120**	0.895	**1.751**	21.031	17.405
	5W11				4.840	7.310	0.149	0.120	1.088	1.643	21.611	**17.405**
	6W11				**5.160**	6.840	**0.153**	0.113	**1.160**	1.538	**22.191**	16.389
	4W20	X	5 #4	5 #4	7.910	**15.500**	0.287	0.238	1.778	**3.484**	41.626	34.519
	5W20				9.620	14.500	0.295	**0.239**	2.163	3.260	42.786	**34.664**
	6W20				**10.300**	13.600	**0.303**	0.225	**2.315**	3.057	**43.947**	32.634
	5W24	Y	6 #4	5 #4	11.800	**17.800**	0.362	**0.292**	2.653	**4.001**	52.504	**42.351**
	6W24				**12.600**	16.600	**0.372**	0.275	**2.832**	3.732	**53.954**	39.885

* Maximum bending moment and shear for each panel type shown in **red bold** font

5’ x 5’ STANDARD

A PANEL

Typical Panel Type A, Panel Thickness 6", 5'x5', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\,\pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\,d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.75	kip-ft	$+M_{u\_service}$	=	1.30	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.447 kip-ft

Check $+\varphi M_n > +M_u$ 2.447 > 1.75 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 0.974 kip-ft

Check $-\varphi M_n > -M_u$ 0.974 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	2.33	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	2.33	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 2.447 > 2.33 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 0.974 > 0.00 **OK**

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x5', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \cdot f_s}{\alpha_1 \cdot f_c{}' \cdot \beta_1 \cdot b}$	c	=	0.226	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.137	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \cdot \beta \cdot \alpha \cdot \sqrt{f_c{}'} \cdot b_v \cdot d_v$	Vc	=	6.275	Kips
$V_s = \frac{A_v \cdot f_y \cdot d_v \cdot (\cot\theta + \cot\alpha) \cdot \sin\alpha}{s}$	Vs	=	2.708	Kips
	(1) Vn	=	8.982	Kips
(2) $V_n = 0.25 \cdot f_c' \cdot b_v \cdot d_v$	(2) Vn	=	49.641	Kips
From (1) and (2) Vn should be:	Vn	=	8.982	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	8.084	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.12	N/mm^2		
	=	17.40	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1253.13	lbs		
	=	1.253	Kips	OK, Vmax less than Vn	

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x5', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1\!/_4\,\pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1\!/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.16	kip-ft	$+M_{u\_service}$	=	0.86	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.152 kip-ft

Check $+\varphi M_n > +M_u$ 2.152 > 1.16 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.269 kip-ft

Check $-\varphi M_n > -M_u$ 1.269 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:
1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \dfrac{b\,h^2}{6} = \dfrac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	1.54	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	1.54	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 2.152 > 1.54 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.269 > 0.00 **OK**

Typical Panel Type A, Panel Thickness 6", 5'x5', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s . f_s}{\alpha_1 . f_c{}' . \beta_1 . b}$	c	=	0.226	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.137	in	

AASHTO 5.7.3.3

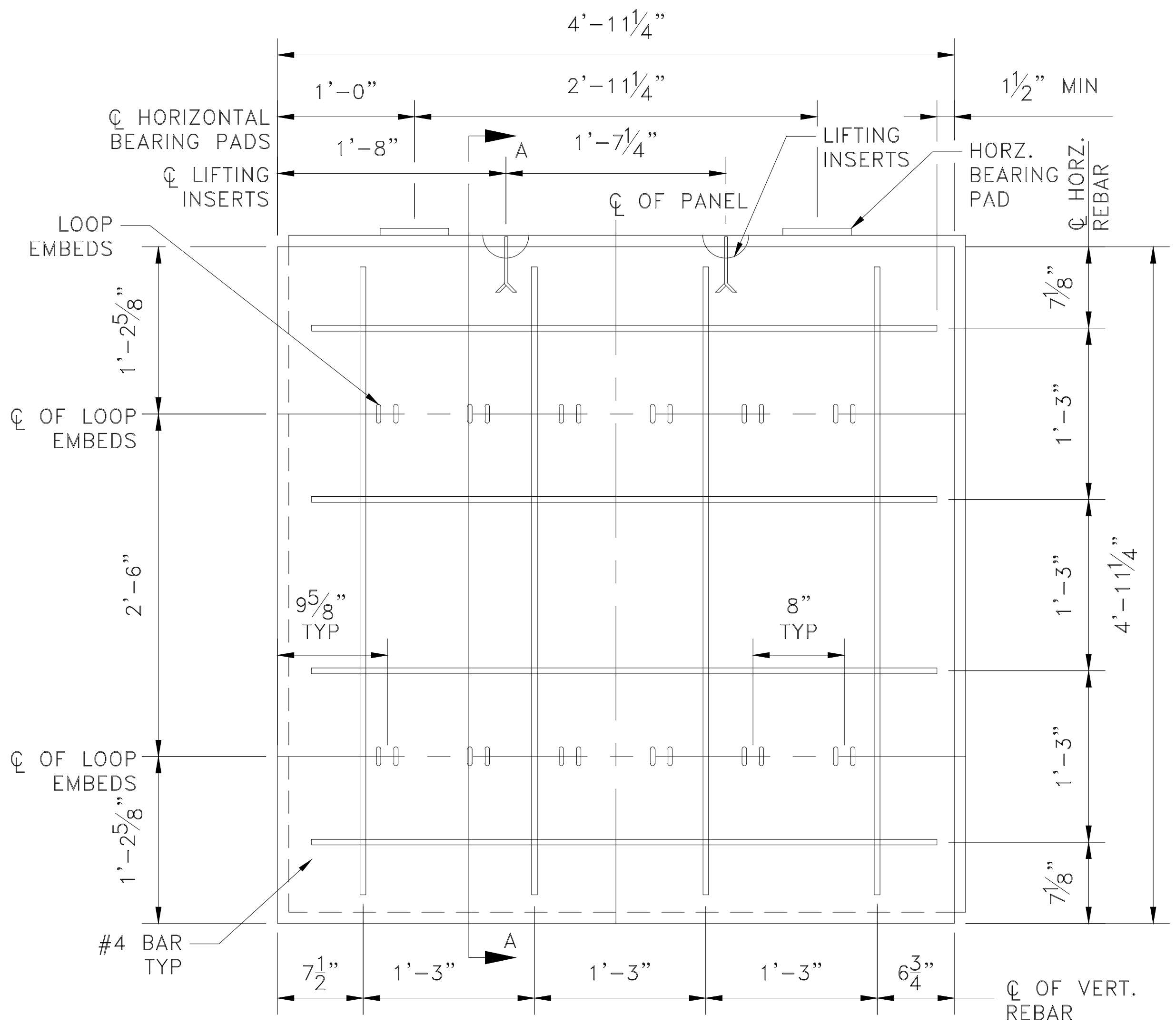
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 . \beta . \alpha . \sqrt{f_c{}'} . b_v . d_v$	Vc	=	4.758	Kips
$V_s = \frac{A_v . f_y . d_v . (\cot\theta + \cot\alpha) . \sin\alpha}{s}$	Vs	=	2.053	Kips
	(1) Vn	=	6.811	Kips
(2) $V_n = 0.25 . f_c' . b_v . d_v$	(2) Vn	=	37.641	Kips
From (1) and (2) Vn should be:	Vn	=	6.811	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.130	Kips

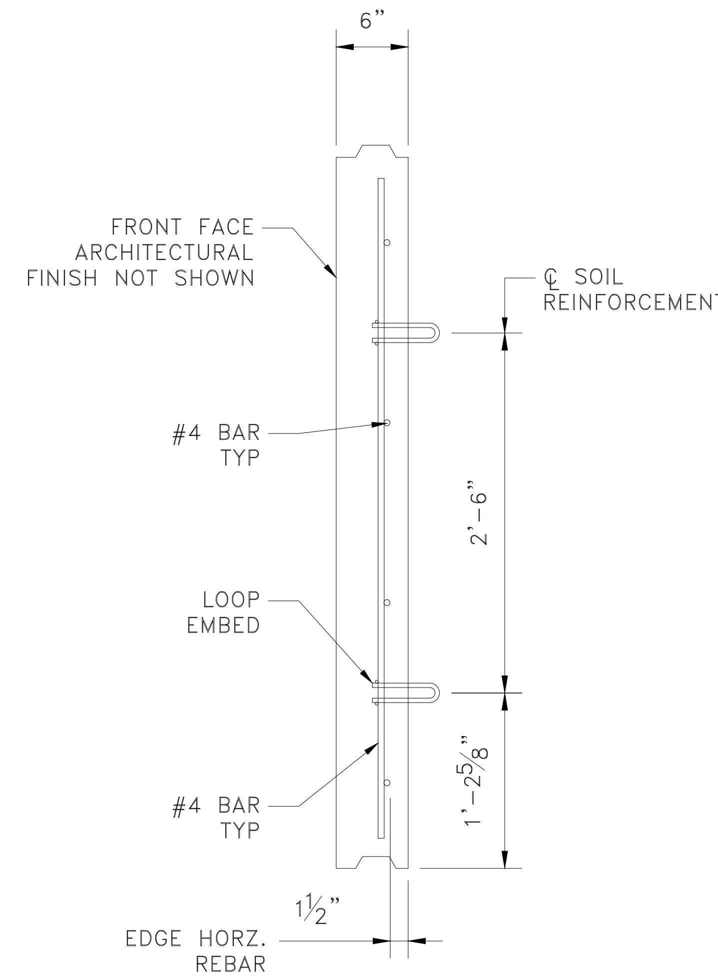
Shear Force:

From Staad Pro Result Vmax	=	0.153	N/mm^2		
	=	22.19	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1597.74	lbs		
	=	1.598	Kips	**OK, Vmax less than Vn**	



STANDARD "A" PANEL

SHOWN FROM BACK FACE



SECTION A-A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X5' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5' x 5' STANDARD

X PANEL

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x5', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	3.48	kip-ft	$+M_{u\_service}$	=	2.58	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.628 kip-ft

Check $+\varphi M_n > +M_u$ 3.628 > 3.48 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.419 kip-ft

Check $-\varphi M_n > -M_u$ 1.419 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:
1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	4.63	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 3.628 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.419 > 0.00 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x5', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\,\pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s\,.\,f_s}{\alpha_1.\,f_c{}'.\,\beta_1\,.\,b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.080	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316\,.\,\beta\,.\,\alpha\,.\sqrt{f_c{}'}\,.\,b_v\,.\,d_v$	Vc	=	6.189	Kips
$V_s = \frac{A_v\,.\,f_y\,.\,d_v\,.\,(\cot\theta + \cot\alpha)\,.\,\sin\alpha}{s}$	Vs	=	4.006	Kips
	(1) Vn	=	10.194	Kips
(2) $V_n = 0.25\,.\,f_c'.\,b_v\,.\,d_v$	(2) Vn	=	48.962	Kips
From (1) and (2) Vn should be:	Vn	=	10.194	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	9.175	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.239	N/mm^2		
	=	34.66	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	2495.81	lbs		
	=	2.496	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x5', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.32	kip-ft	$+M_{u\_service}$	=	1.71	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.186 kip-ft

Check $+\varphi M_n > +M_u$ 3.186 > 2.32 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.860 kip-ft

Check $-\varphi M_n > -M_u$ 1.860 > 0.00 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	3.08	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.08	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 3.186 > 3.08 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.860 > 0.00 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x5', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s . f_s}{\alpha_1 . f_c' . \beta_1 . b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

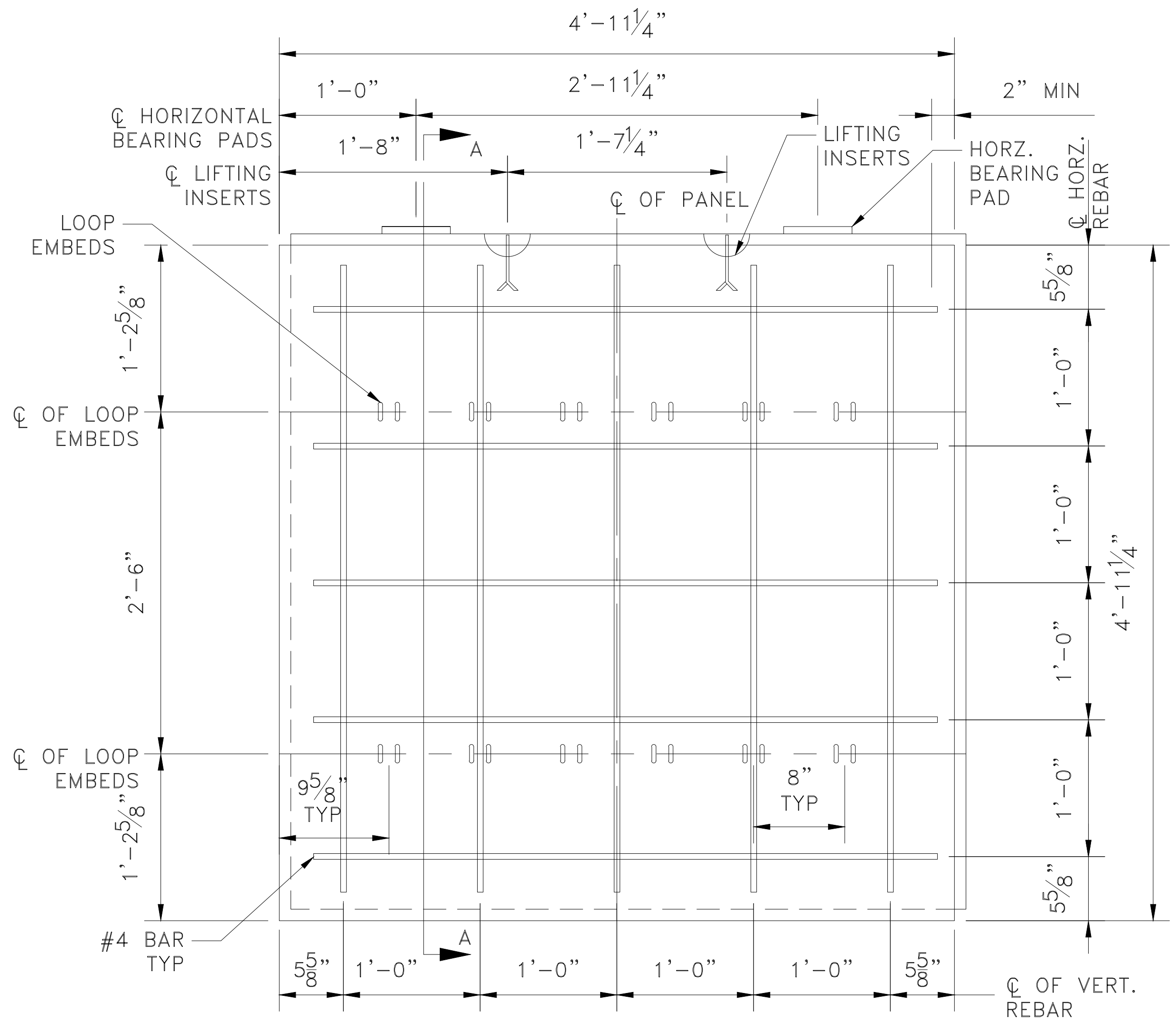
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 . \beta . \alpha . \sqrt{f_c'} . b_v . d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v . f_y . d_v . (\cot\theta + \cot\alpha) . \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 . f_c' . b_v . d_v$	(2) Vn	=	36.962	Kips
From (1) and (2) Vn should be:	Vn	=	7.696	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.926	Kips

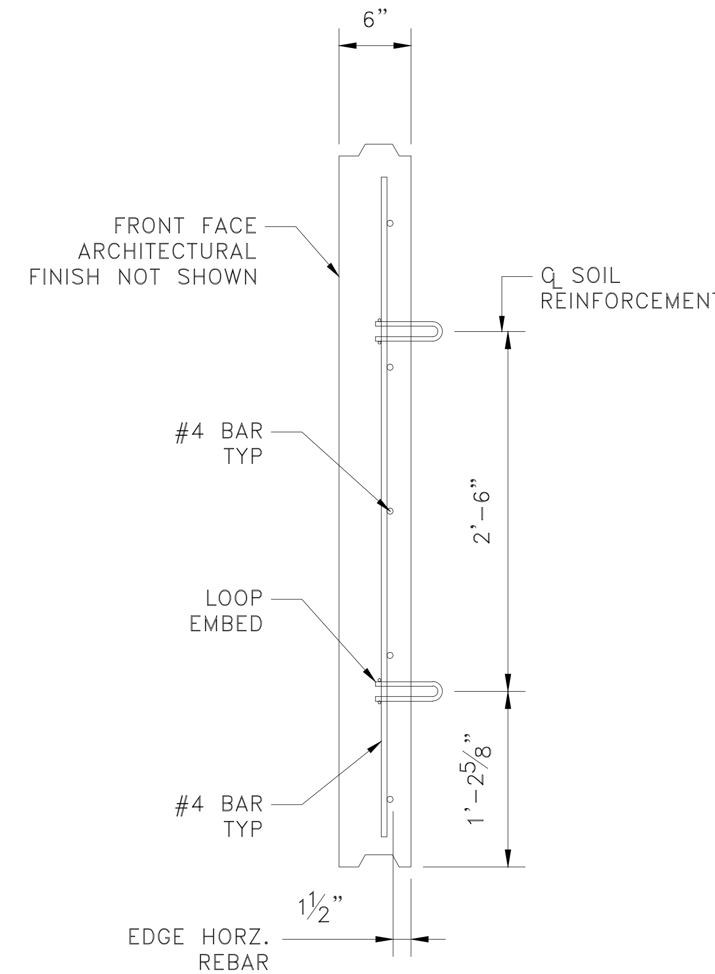
Shear Force:

From Staad Pro Result Vmax	=	0.303	N/mm^2		
	=	43.95	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3164.15	lbs		
	=	3.164	Kips	**OK, Vmax less than Vn**	



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
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CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'X' 5'X5' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 5’ STANDARD

Y PANEL

Typical Panel Type Y, Panel Thickness 6", 5'x5', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\,\pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	4.00	kip-ft	$+M_{u\_service}$	=	2.96	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \frac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \frac{a}{2}\right)$ = 4.323 kip-ft

Check $+\varphi M_n > +M_u$ 4.323 > 4.00 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \frac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \frac{a}{2}\right)$ = 1.672 kip-ft

Check $-\varphi M_n > -M_u$ 1.672 > 0.00 **OK**

Typical Panel Type Y, Panel Thickness 6", 5'x5', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1\!/_4\, \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \, . \, f_s}{\alpha_1 . \, f_c{}' . \, \beta_1 \, . \, b}$	c	=	0.408	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.046	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \, . \, \beta \, . \, \alpha \, . \sqrt{f_c{}'} \, . \, b_v \, . \, d_v$	Vc	=	6.137	Kips
$V_s = \frac{A_v \, . \, f_y \, . \, d_v \, . \, (\cot\theta + \cot\alpha) \, . \sin\alpha}{s}$	Vs	=	4.767	Kips
	(1) Vn	=	10.904	Kips
(2) $V_n = 0.25 \, . \, f_c' . \, b_v \, . \, d_v$	(2) Vn	=	48.554	Kips
From (1) and (2) Vn should be:	Vn	=	10.904	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	9.814	Kips

Shear Force:

From Staad Pro Result Vmax	=	4.001	N/mm^2		
	=	580.30	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	41781.39	lbs		
	=	41.781	Kips	**not ok**	

Typical Panel Type Y, Panel Thickness 6", 5'x5', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	3.73	kip-ft	$+M_{u\_service}$	=	2.76	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.792 kip-ft

Check $+\varphi M_n > +M_u$ 3.792 > 3.73 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 2.202 kip-ft

Check $-\varphi M_n > -M_u$ 2.202 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	4.96	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored +M_u and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 3.792 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored -M_u and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 2.202 > 0.00 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \dfrac{b\,h^2}{6} = \dfrac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	5.32	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 4.323 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.672 > 0.00 **OK**

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x5', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \cdot f_s}{\alpha_1 . f_c{}' . \beta_1 . b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

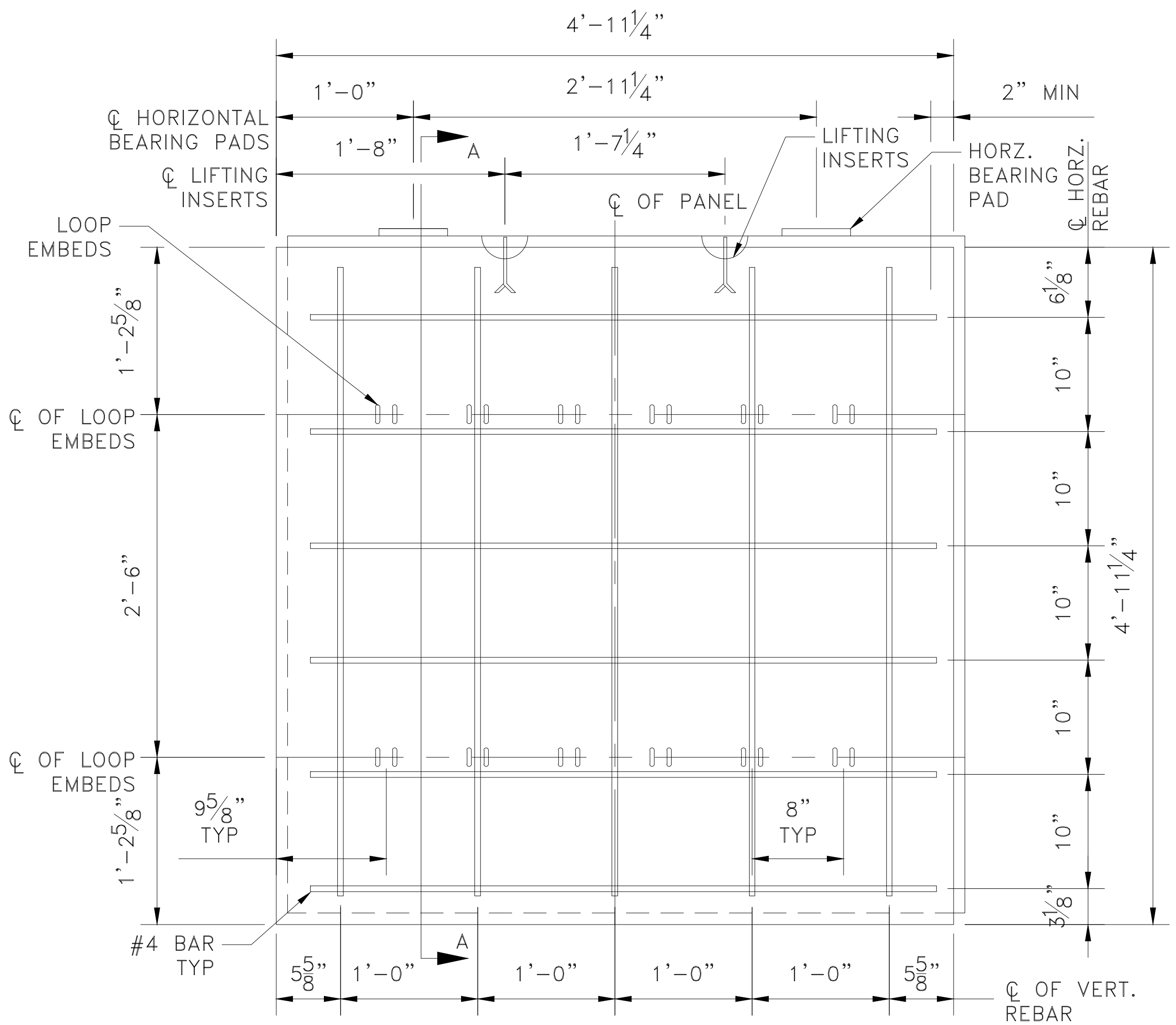
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 . \beta . \alpha . \sqrt{f_c{}'} . b_v . d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v . f_y . d_v . (\cot\theta + \cot\alpha) . \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 . f_c' . b_v . d_v$	(2) Vn	=	36.962	Kips
From (1) and (2) Vn should be:	Vn	=	7.696	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.926	Kips

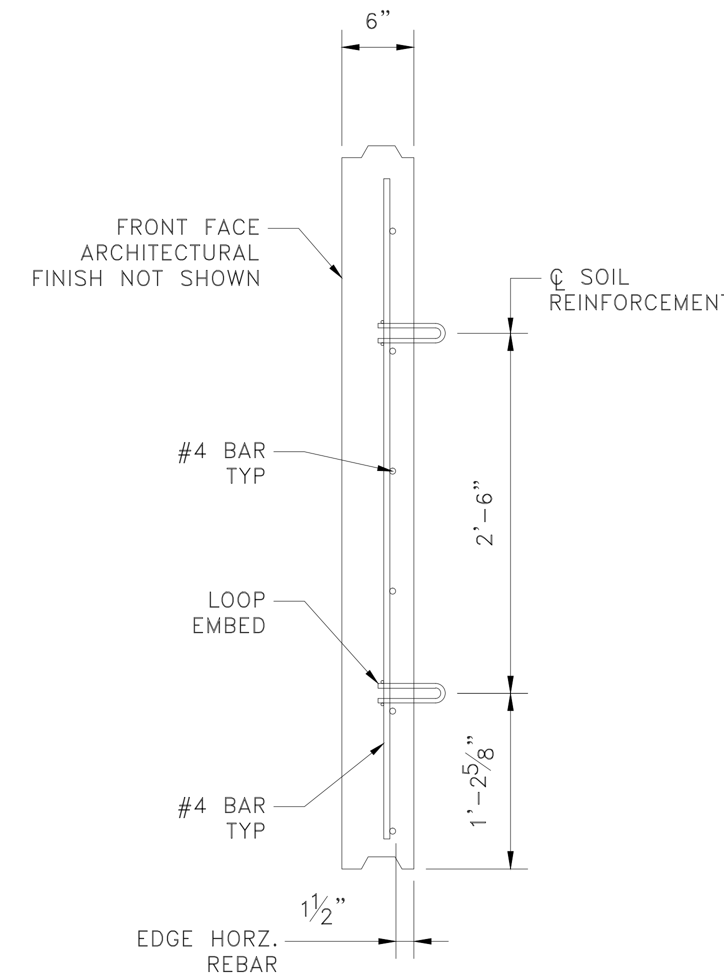
Shear Force:

From Staad Pro Result Vmax	=	0.372	N/mm^2		
	=	53.95	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3884.70	lbs		
	=	3.885	Kips	**OK, Vmax less than Vn**	



STANDARD "Y" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
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CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

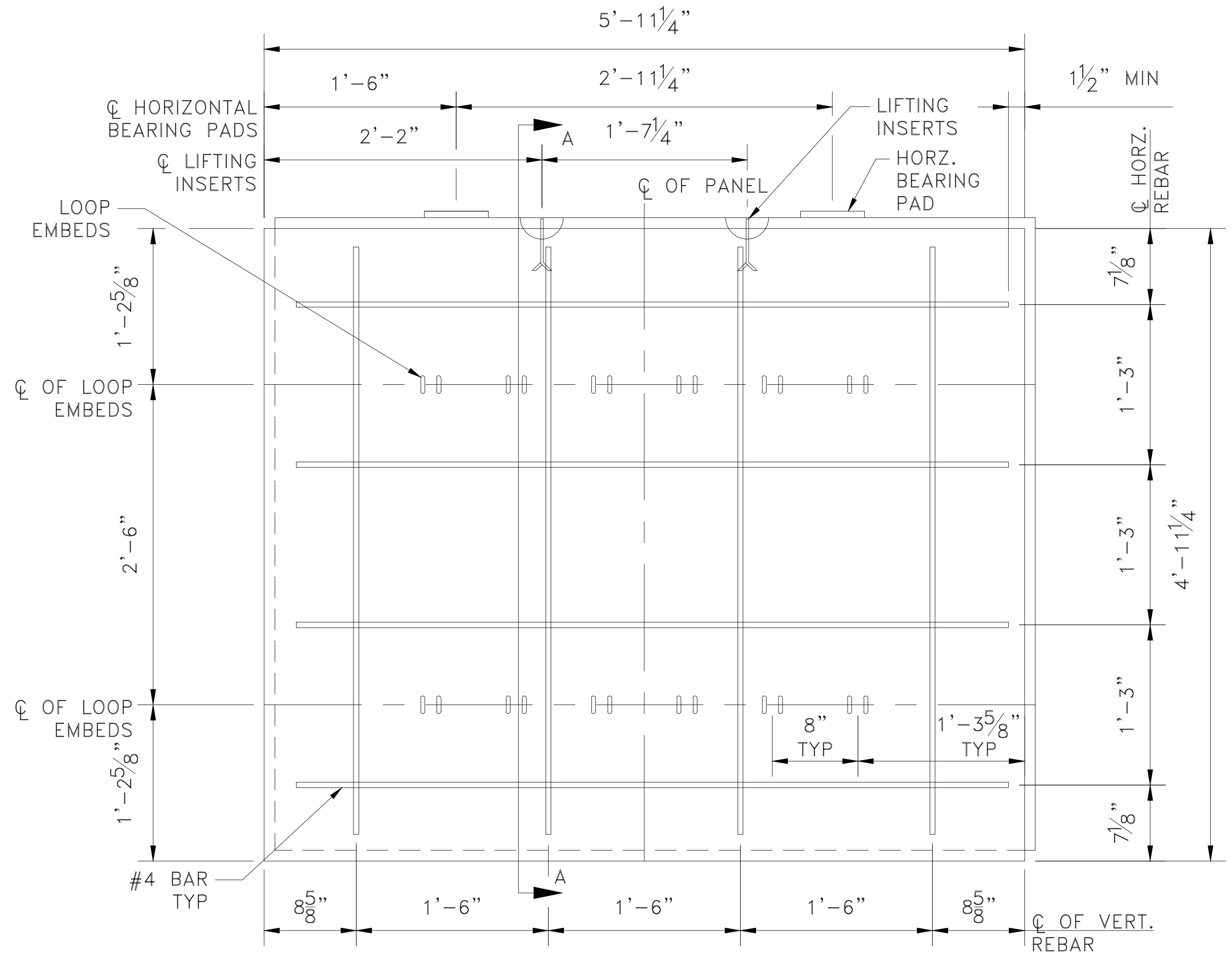
NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X5' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

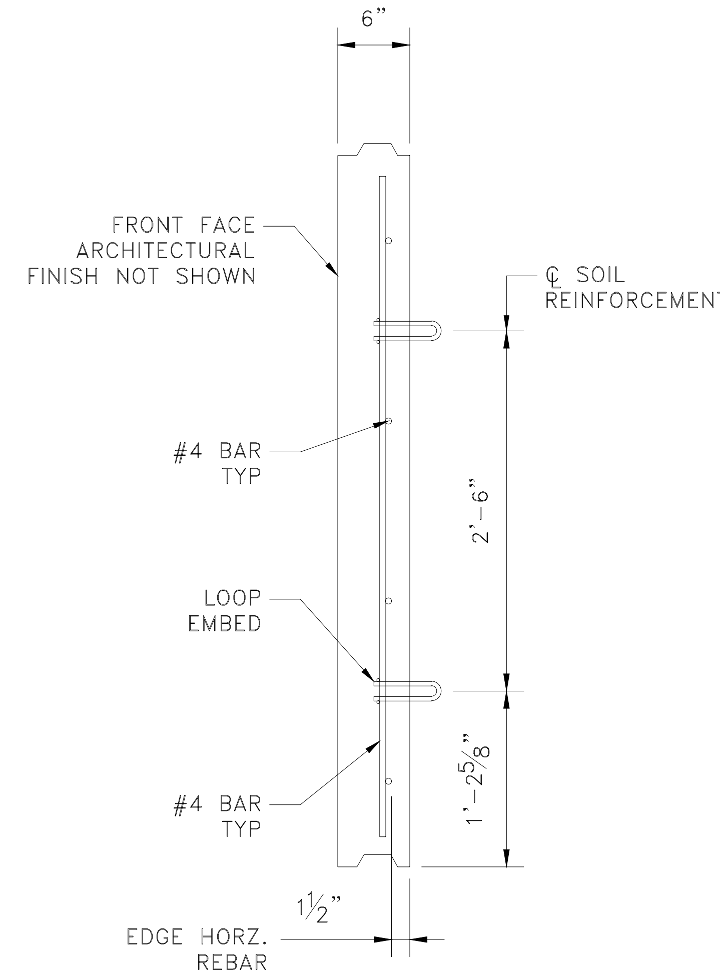
Scale: NTS
Job:
Sheet:
Sheet of

5’ x 6’ STANDARD PANELS



STANDARD "A" PANEL

SHOWN FROM BACK FACE



SECTION A-A

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DESIGN BY: FSH	01/24/22			
CHECK BY: SR	01/24/22			
PROJ. ENGR: FSH	NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X6' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
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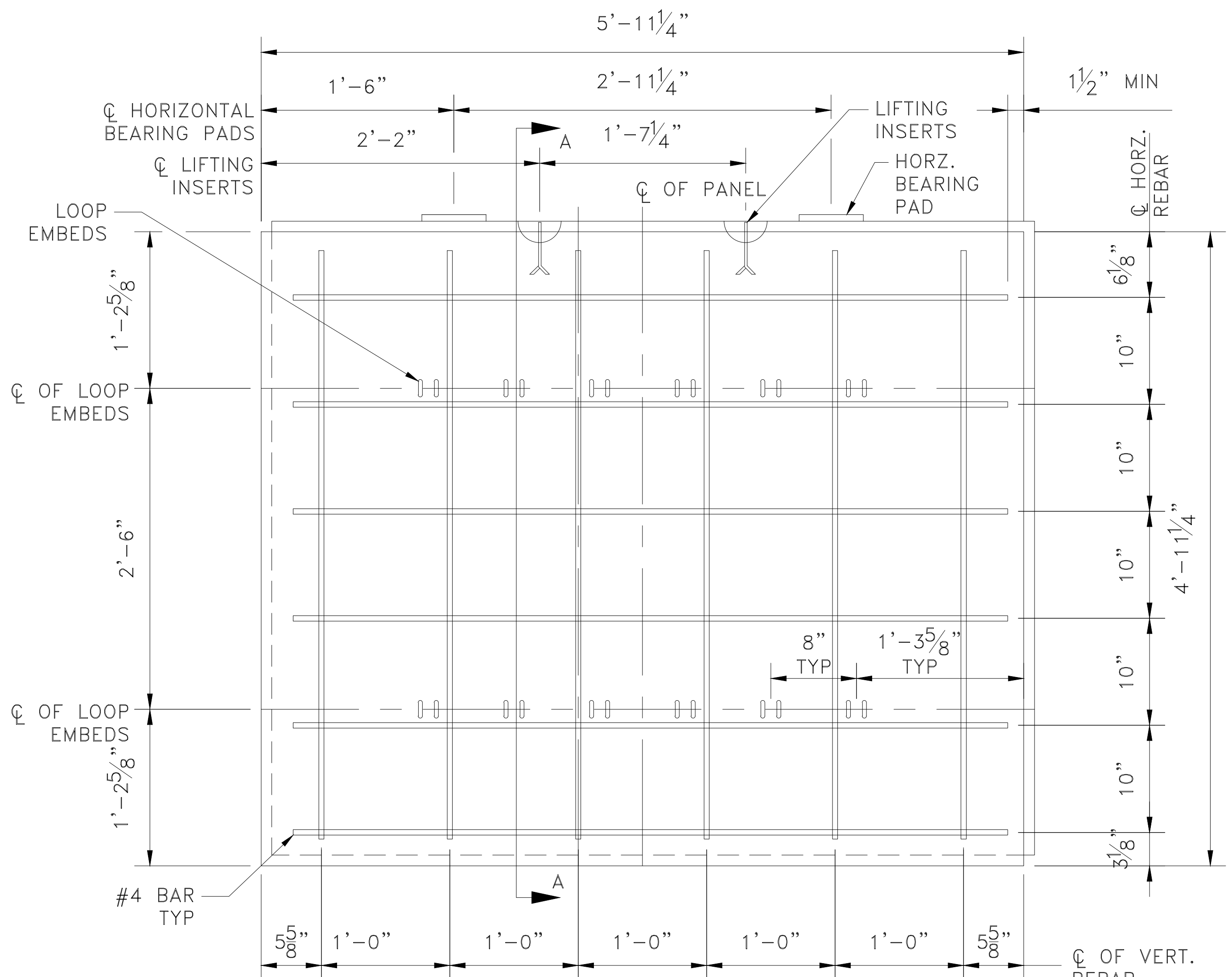
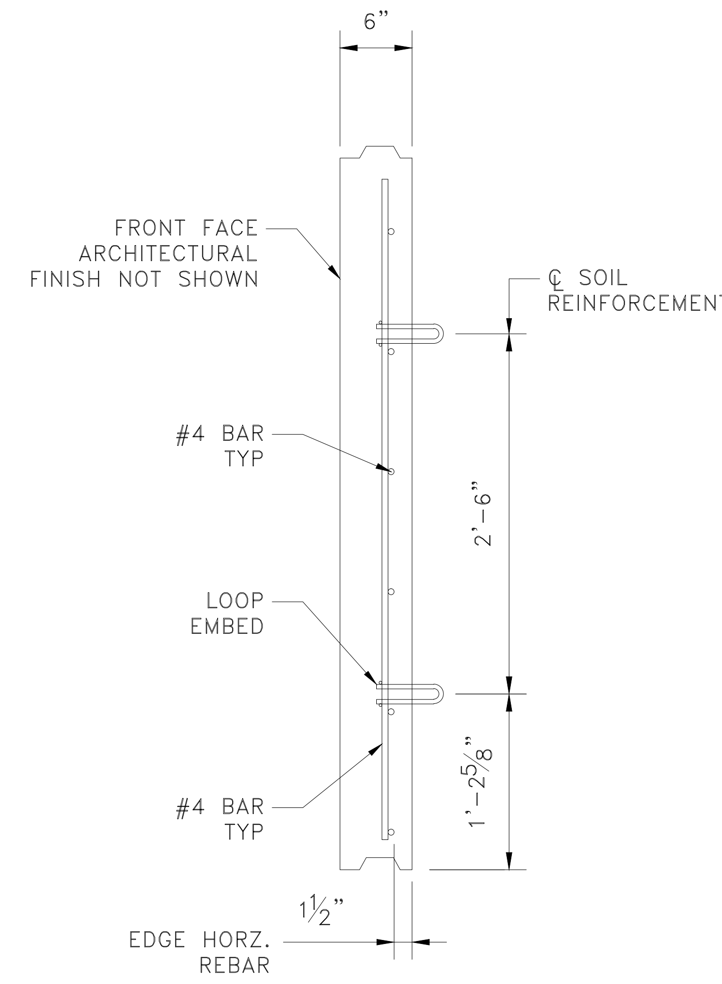
Sheet of



STANDARD "X" PANEL

SHOWN FROM BACK FACE



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CHECK BY: SR	01/24/22
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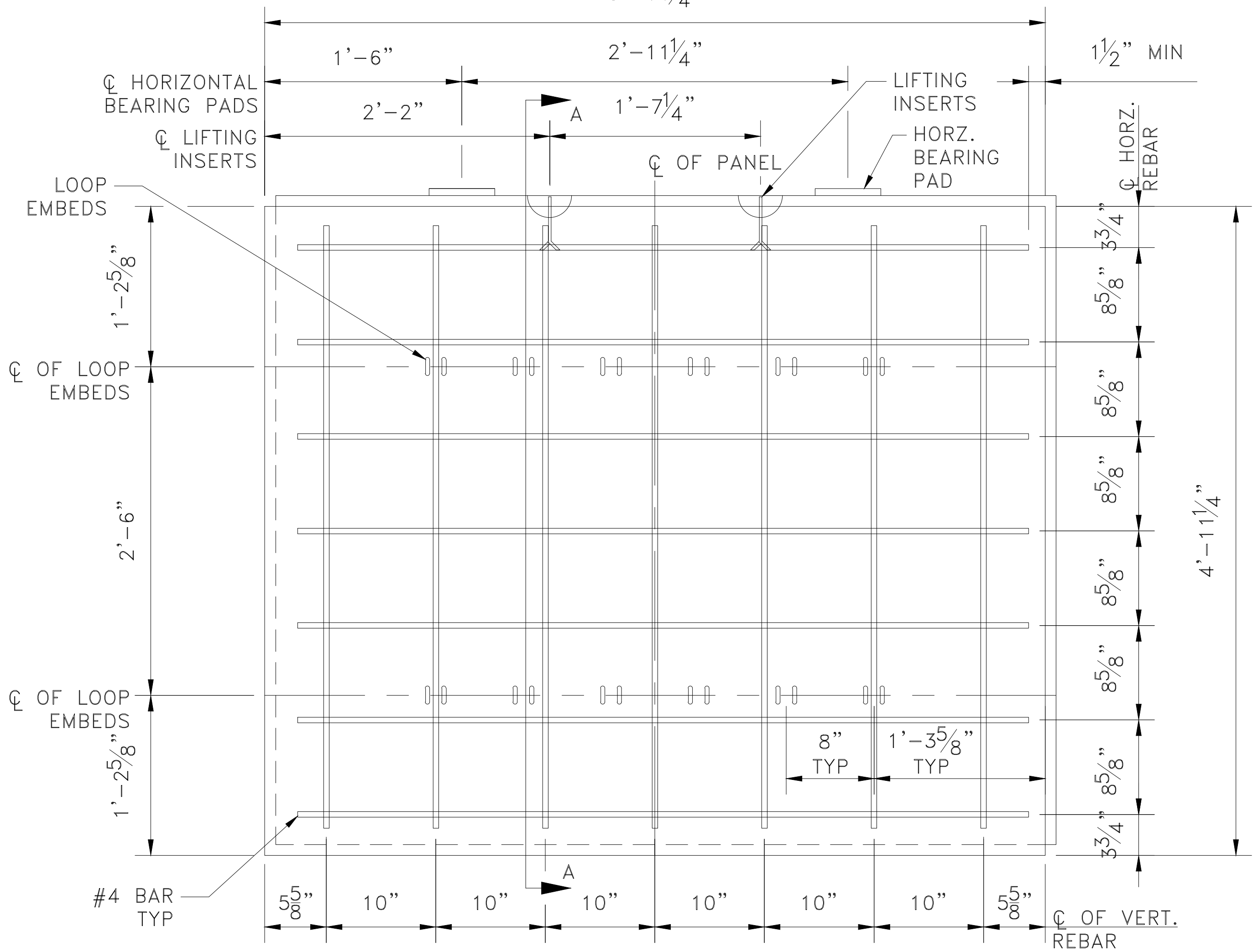
TYPE 'X' 5'X6' PANEL DETAILS

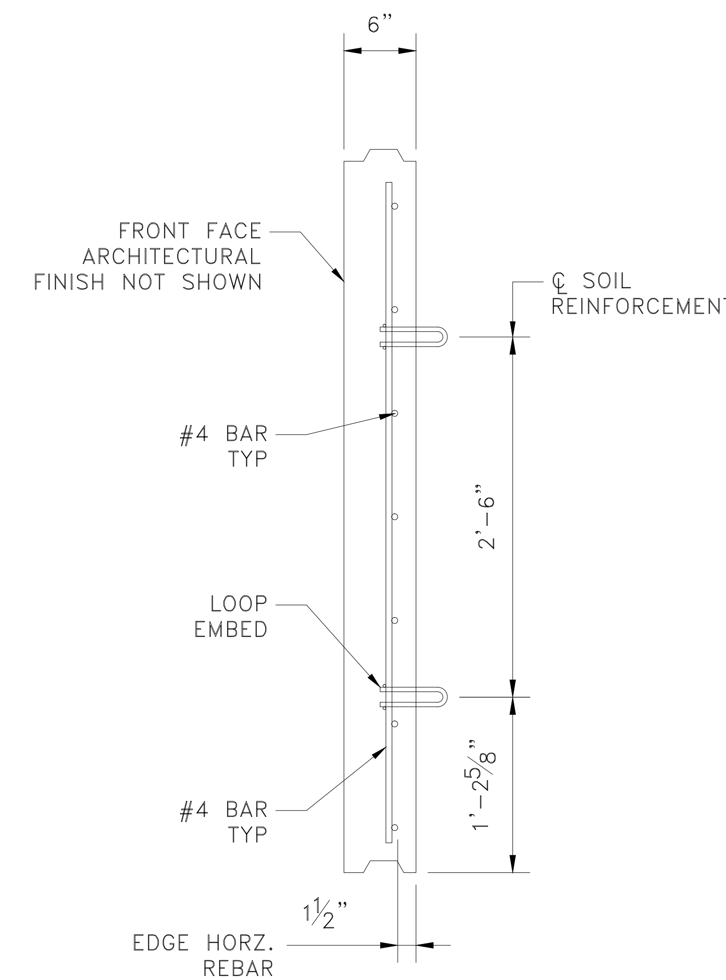
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of



STANDARD "Y" PANEL

SHOWN FROM BACK FACE



SECTION A–A

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NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X6' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

TOC – Appendix

	Area	Diameter
16	Galvanize Life Coating	
12	Corrosion Rate Carbon Steel (in microns)	
75	Design Life	

Wire	Area sqin	Diameter in	Diameter microns	Diameter after microns	Diameter after in	% effective	Area after sqin					6	7	8
W5	0.05	0.252	6408.757	4992.757	0.1966	0.6069	0.0303	2	3	4	5	0.1821	0.2124	0.2428
W8	0.08	0.319	8106.507	6690.507	0.2634	0.6812	0.0545	0.1090	0.1635	0.2180	0.2725	0.3270	0.3815	0.4359
W11	0.11	0.374	9505.722	8089.722	0.3185	0.7243	0.0797	0.1593	0.2390	0.3187	0.3983	0.4780	0.5577	0.6374
W15	0.15	0.437	11100.292	9684.292	0.3813	0.7611	0.1142	0.2283	0.3425	0.4567	0.5709	0.6850	0.7992	0.9134
W20	0.20	0.505	12817.513	11401.513	0.4489	0.7913	0.1583	0.3165	0.4748	0.6330	0.7913	0.9495	1.1078	1.2660
W24	0.24	0.553	14040.882	12624.882	0.4970	0.8085	0.1940	0.3881	0.5821	0.7761	0.9702	1.1642	1.3582	1.5523
W30	0.30	0.618	15698.184	14282.184	0.5623	0.8277	0.2483							

SPRING CONSTANT

Modulus of Sub-Grade Reaction and Spring Constant Check

From Principles of Foundation Engineering; Braja M. Das 8th Edition:

Table 8.2 Typical Subgrade Reaction Values, $k_{0.3}(k_1)$

Soil type	$k_{0.3}(k_1)$ MN/m³	$k_{0.3}(k_1)$ lb/in.³
Dry or moist sand:		
Loose	8–25	30–90
Medium	25–125	90–450
Dense	125–375	450–1350
Saturated sand:		
Loose	10–15	35–55
Medium	35–40	125–145
Dense	130–150	475–550
Clay:		
Stiff	10–25	40–90
Very stiff	25–50	90–185
Hard	>50	>185

$K_{0.3}$ (k_1) = 1350 lb/in^3 (is selected)

(dense Sand, value is conservative considering no reinforcement is included)

Adjust to panel 5' x 10' (1.5m x 3m)

Foundations on Sandy Soils

For foundations on sandy soils,

$$k = k_{0.3}\left(\frac{B+0.3}{2B}\right)^2 \tag{8.45}$$

where $k_{0.3}$ and k = coefficients of subgrade reaction of foundations measuring 0.3 m × 0.3 m and B(m) × B(m), respectively (unit is kN/m³).

In English units, Eq. (8.45) may be expressed as

$$k = k_1\left(\frac{B+1}{2B}\right)^2 \tag{8.46}$$

where k_1 and k = coefficients of subgrade reaction of foundations measuring 1 ft × 1 ft and B(ft) × B(ft), respectively (unit is lb/in³).

$$k_{1.5} = k_{0.3} \cdot \left(\frac{B+0.3}{2B}\right)^2$$

$$k_{1.5} = 1350\ x \left(\frac{1.5+0.3}{2\ x\ 1.5}\right)^2$$

$k_{1.5}$ = 486 lb/in^3

$$k_{1.5x3.0} = k_{1.5} \cdot \left(\frac{1+\frac{1.5}{3.0}}{1.5}\right)^2$$

$k_{1.5x3.0}$ = 486 lb/in^3

$k_{1.5x3.0}$ = 839.755 kip/ft^3

From Foundation Analysis And Design; Joseph E. Bowles, RE., S.E. 5th Edition:

10-5 MODULUS OF SUBGRADE REACTION k_s FOR MATS AND PLATES

All three discrete element methods given in this chapter for mats/plates use the modulus of subgrade reaction k_s to support the plate. The modulus k_s is used to compute node springs based on the contributing plan area of an element to any node as in Fig. 10-5. From the figure we see the following:

Node	Contributing area
1 (corner)	$\frac{1}{4}$ of rectangle *abde*
2 (side)	$\frac{1}{4}$ of *abde* + $\frac{1}{4}$ of *bcef*
3 (interior)	$\frac{1}{4}$ of each rectangle framing to a common node (as node 3)

For a triangle one should arbitrarily use one-third of the triangle area to any corner node. For these area contributions the fraction of k_s node resistance from any element is

$$K_i = k_s,\ \text{kN/m}^3, \times \text{Area},\ \text{m}^2 = \text{units of kN/m (or kips/ft in Fps)}$$

Since this computation gives units of a "spring" it is common to call the effect a *node spring*.

In this form the springs are independent of each other, the system of springs supporting the plate is termed a "Winkler" foundation, and the springs are uncoupled. Uncoupling means that the deflection of any spring is not influenced by adjacent springs.

Spring Constant

Note Spacing: 1ft x 1ft

Tributary Area: 1' x 1' = 1SF

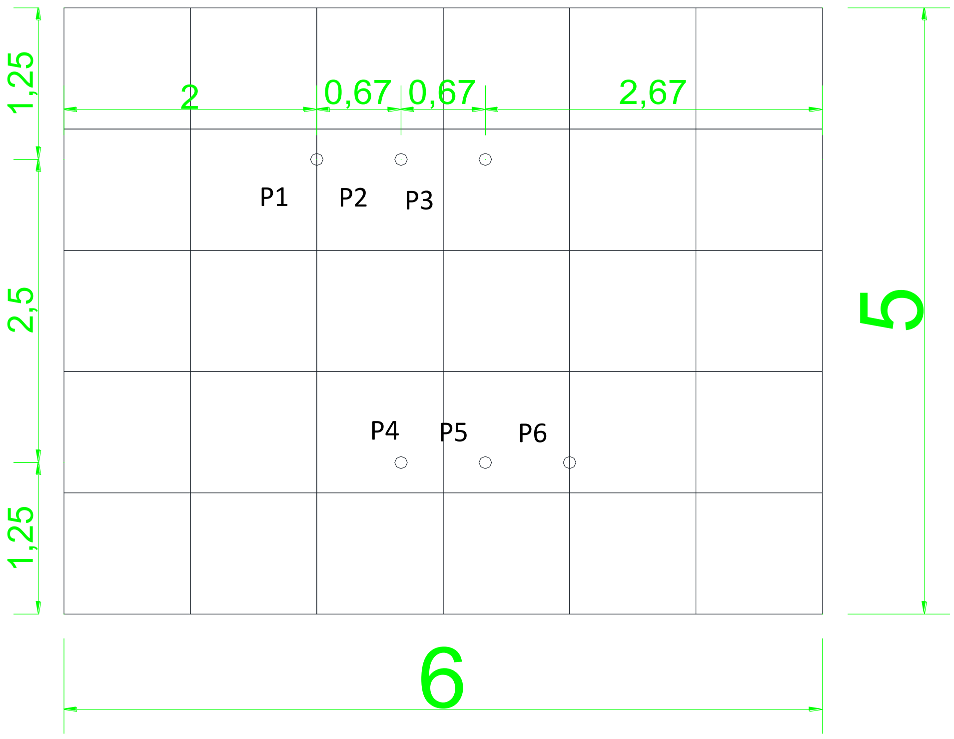
Ka = k x a

Ka = 839.755 kip/ft (Input to Staad Pro)

MAXIMUM BENDING MOMENT AND SHEAR

Typical Panel Type (mesh 3W11), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.5	0.25
P2	0.1667	0.25
P3	-0.1667	0.25
P4	0.1667	-0.25
P5	-0.1667	-0.25
P6	0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

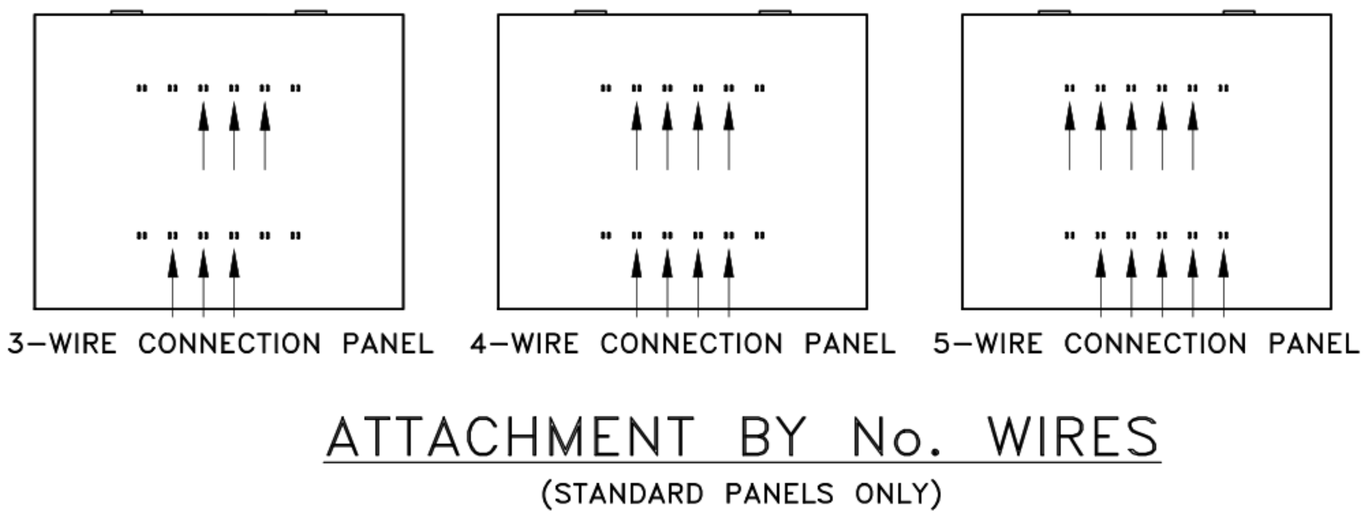
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

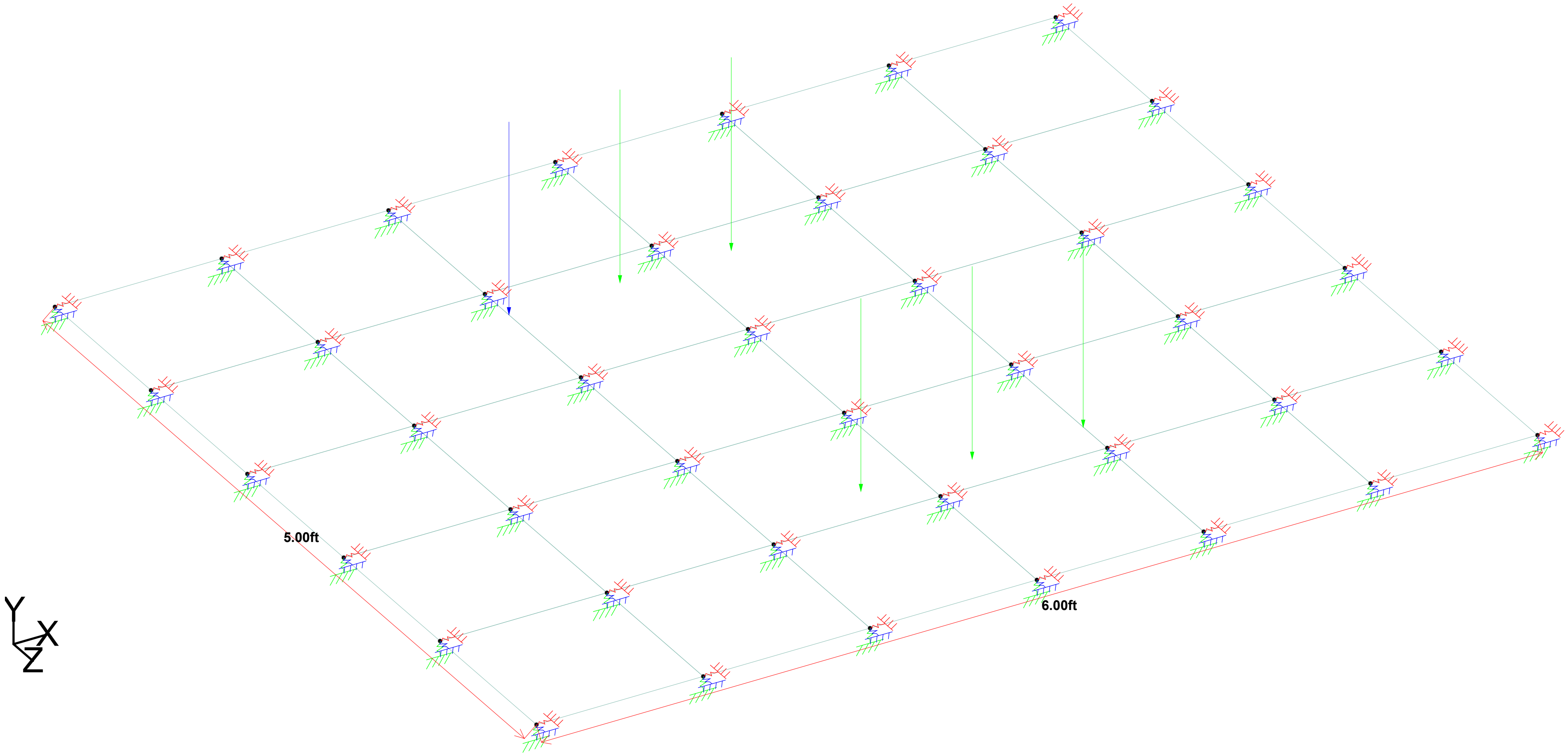
P = 0.65 x A x Fy

= 3.885 Kips (per wire point)



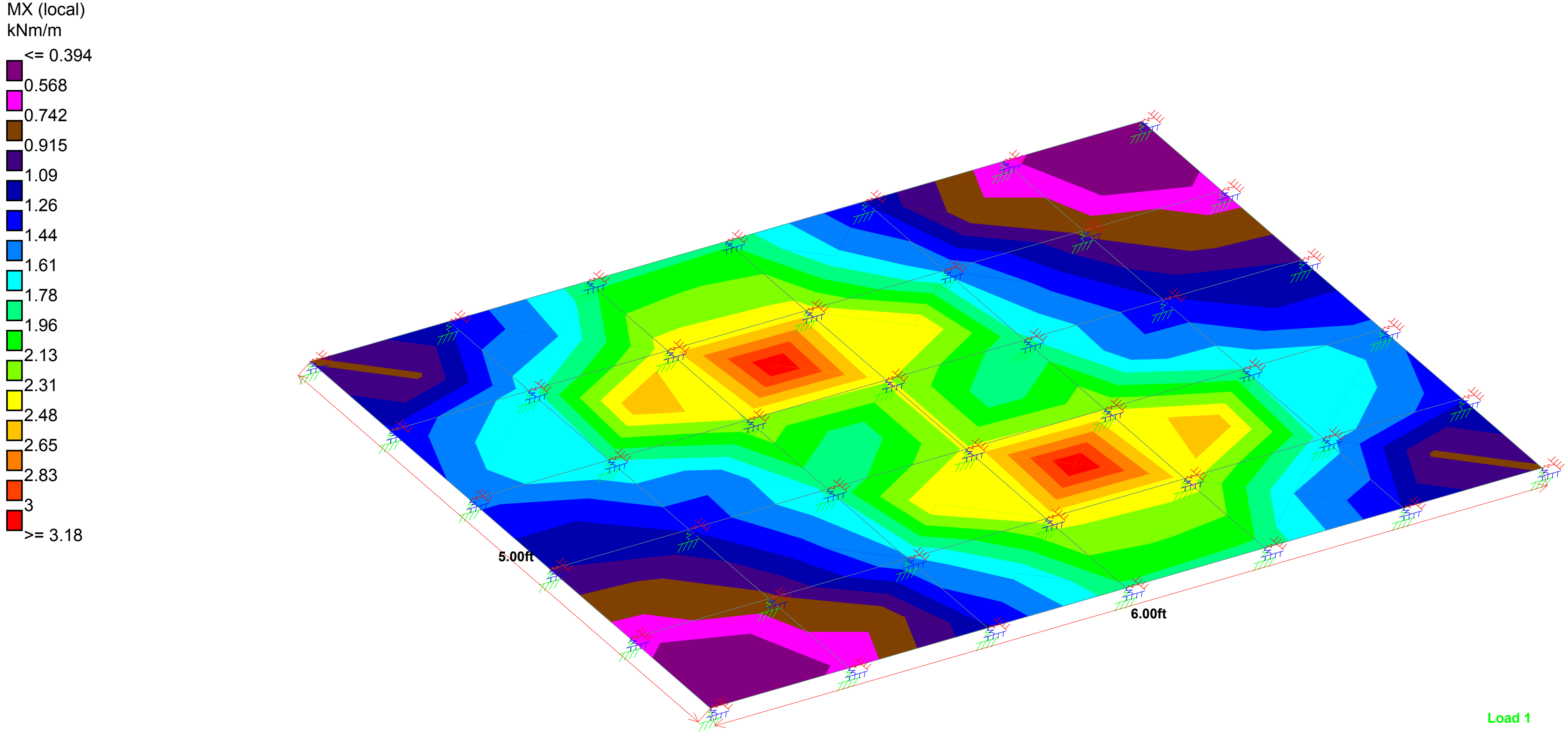
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 17:19	



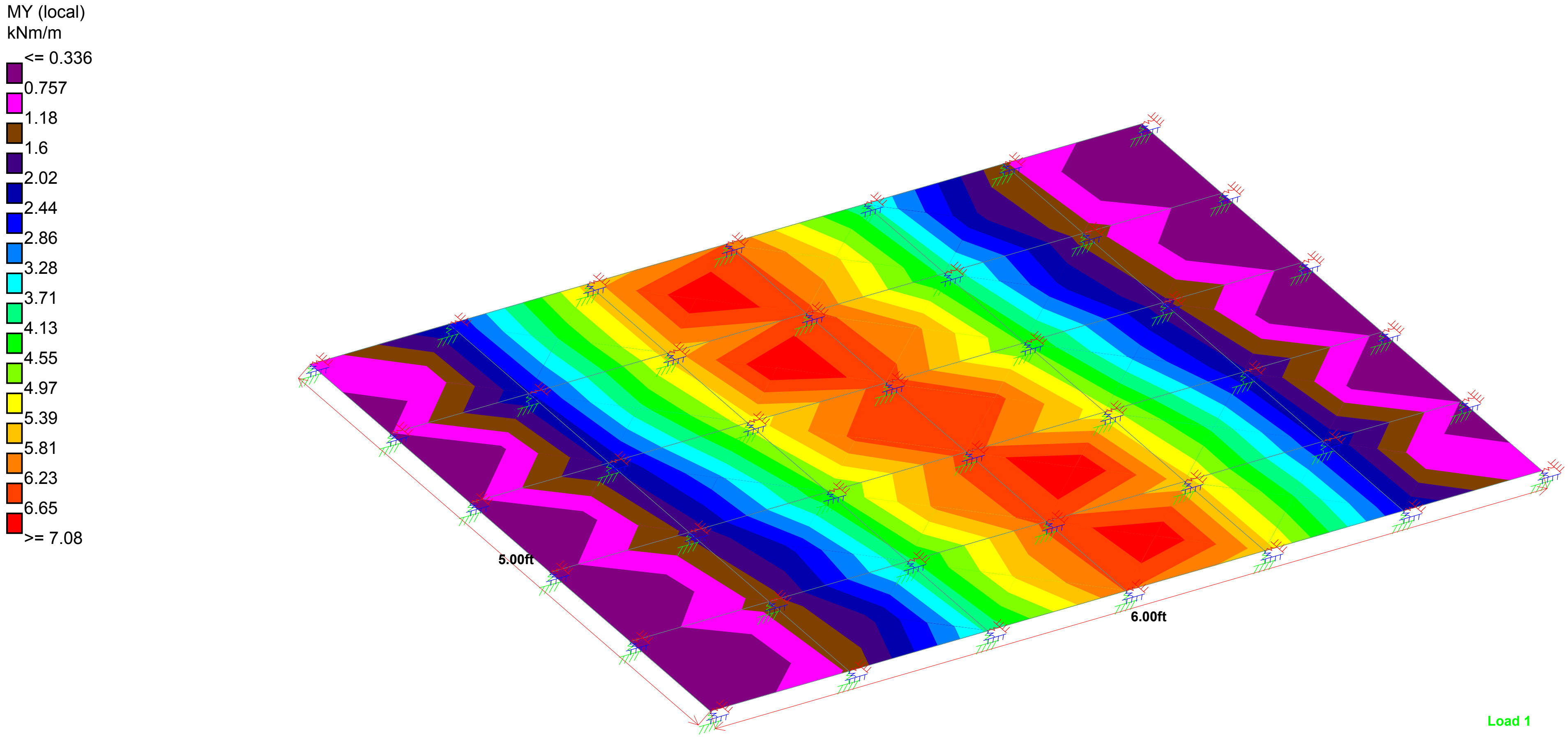
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 17:19	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 17:19	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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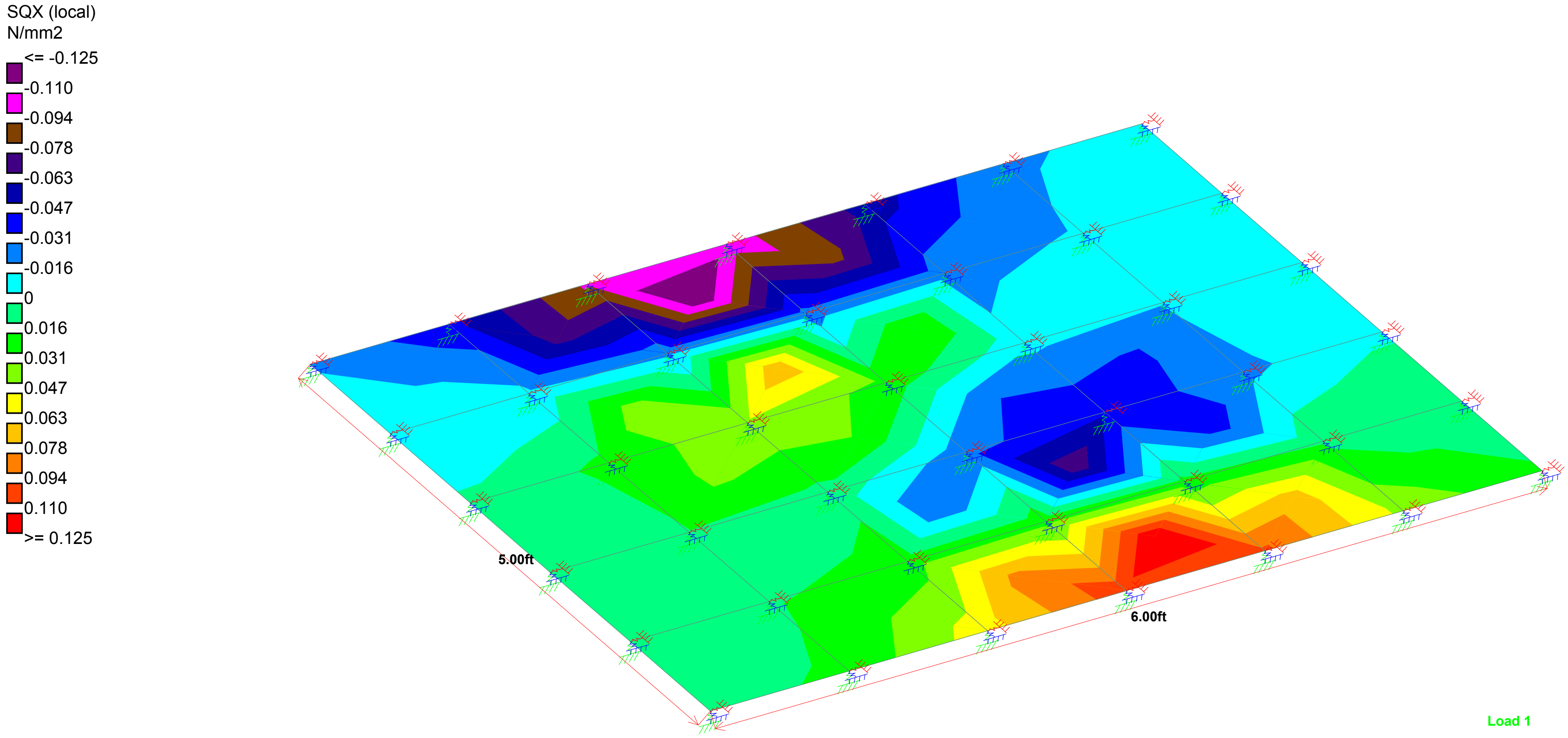
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 17:19	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1		Rev
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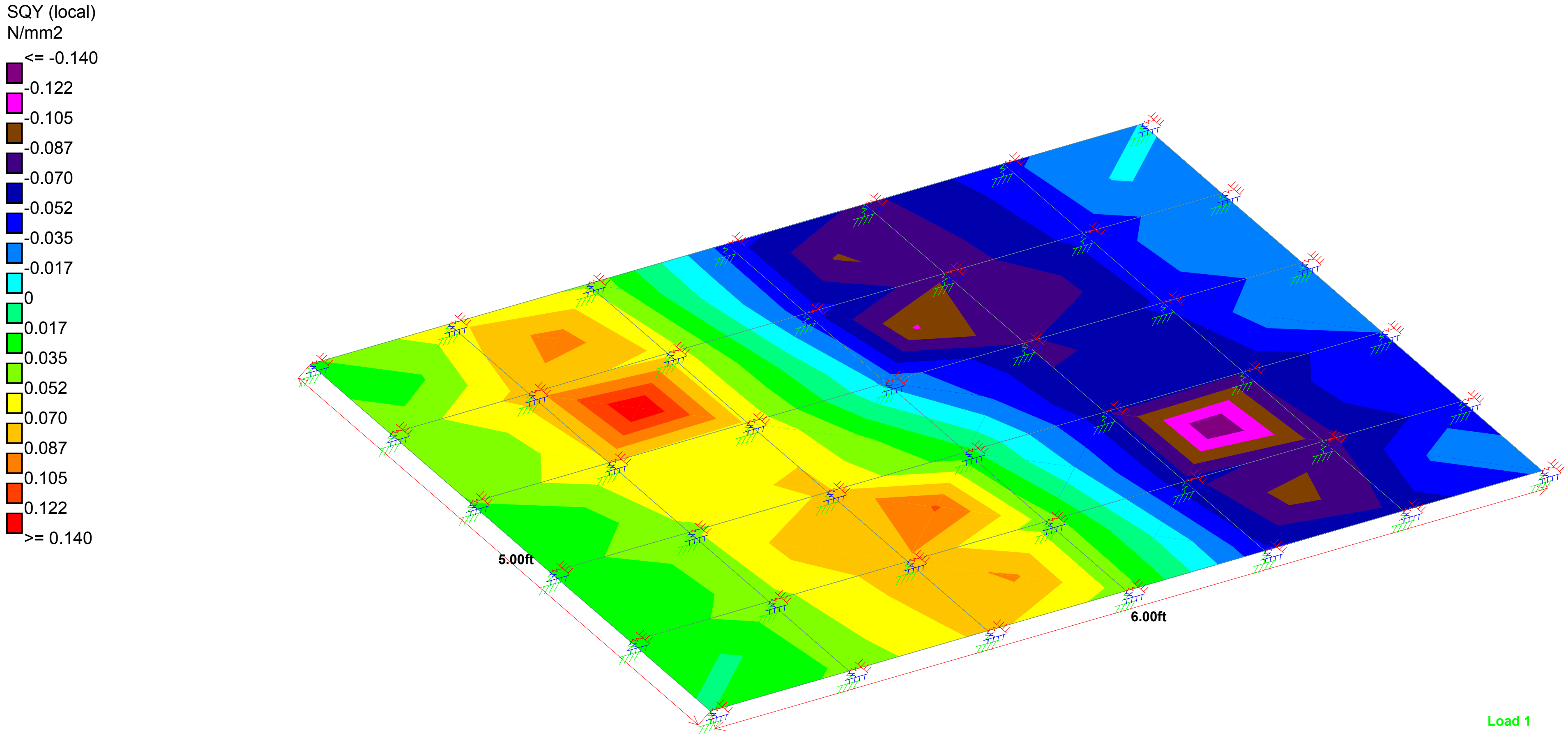
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 17:19		



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 *           Research Engineers,  Intl.             *
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     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
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    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
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    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
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    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -3.885 0.25 0.5
    42. 33 PR GY -3.885 0.25 0.1667
    43. 34 PR GY -3.885 0.25 -0.1667
    44. 8 PR GY -3.885 -0.25 0.1667
    45. 11 PR GY -3.885 -0.25 -0.1667
    46. 11 PR GY -3.885 -0.25 0.5
    47. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    252
 SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.3/ 263443.7 MB
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    48. FINISH
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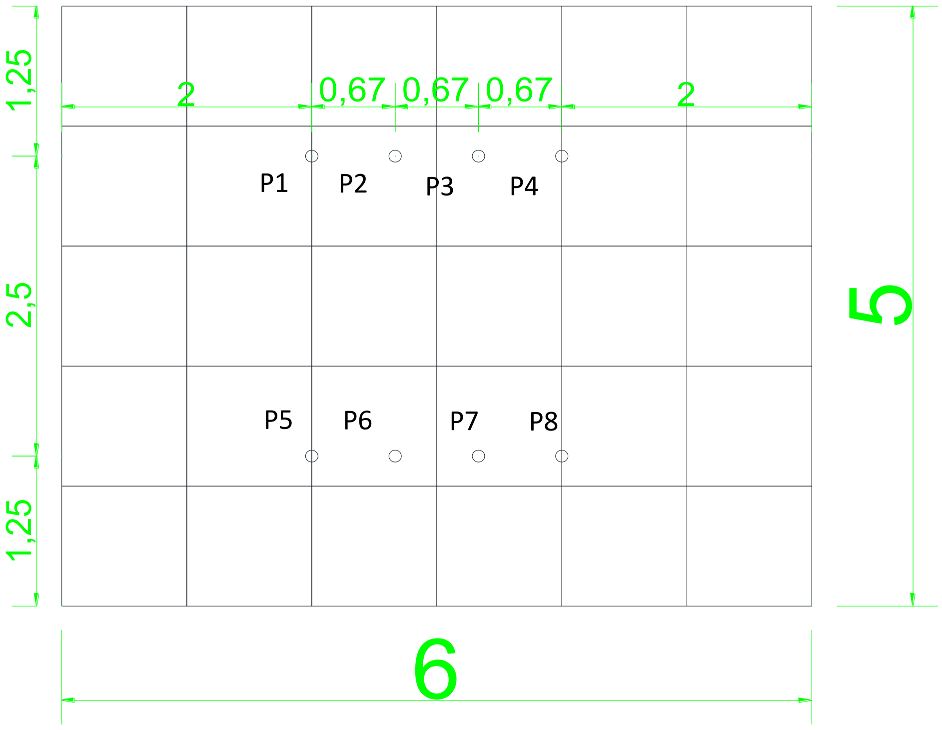
Typical Panel Type (mesh 4W11), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.5	0.25
P2	0.1667	0.25
P3	-0.1667	0.25
P4	0.5	0.25
P5	0.5	-0.25
P6	0.1667	-0.25
P7	-0.1667	-0.25
P8	0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

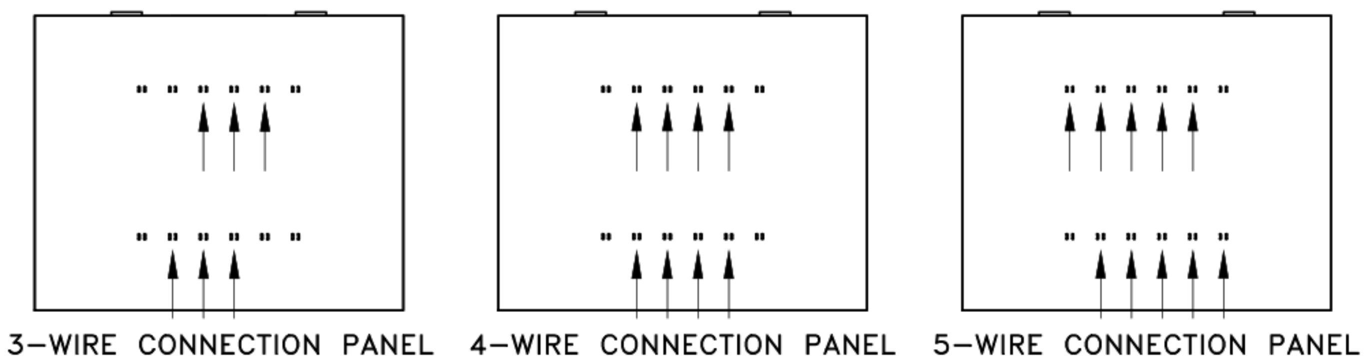
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

= 3.885 Kips (per wire point)



ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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	By CH	Date 04-Mar-21	Chd
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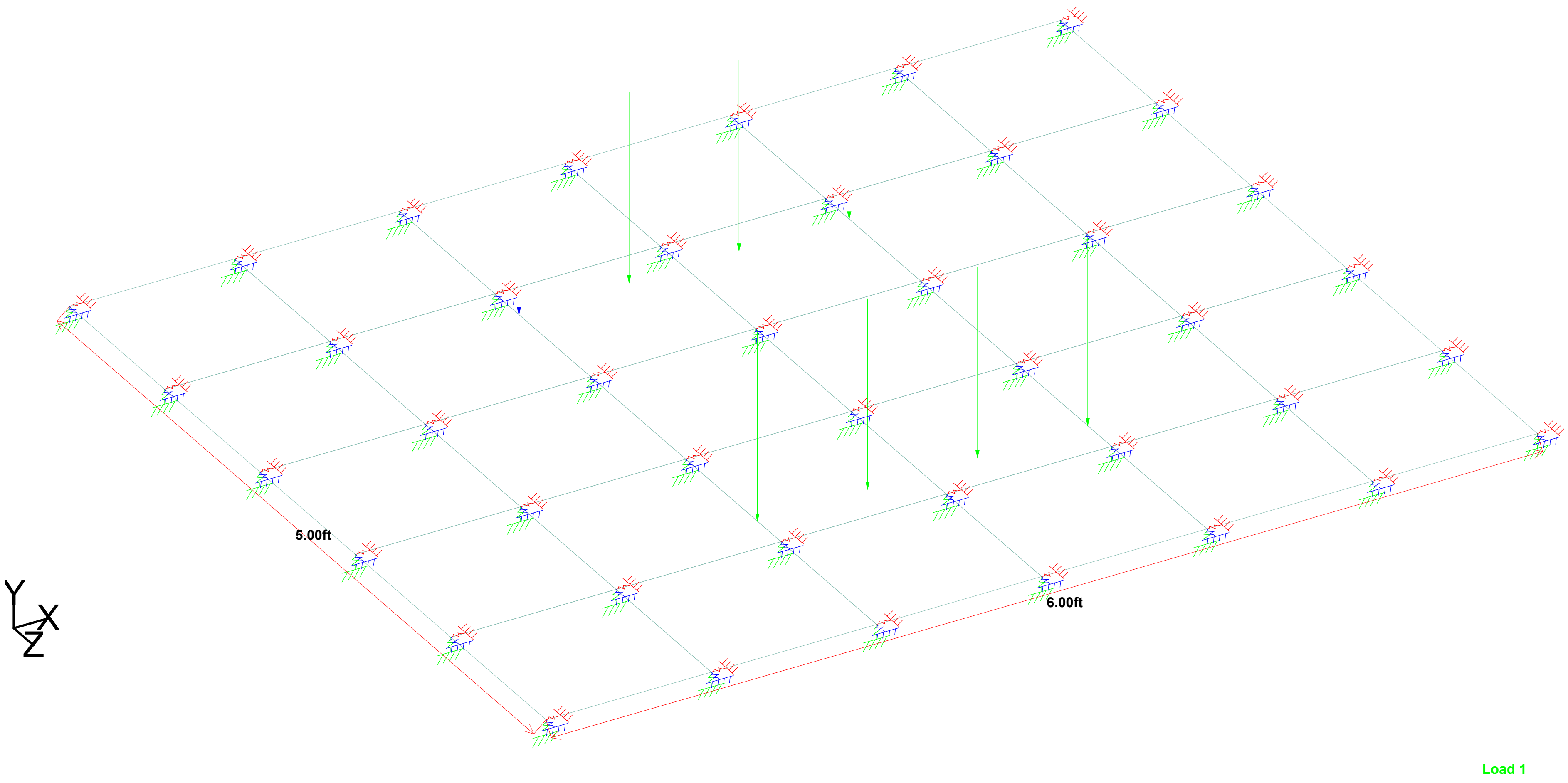

Software licensed to Optimal Engineering Support

Job No	Sheet No 1		Rev
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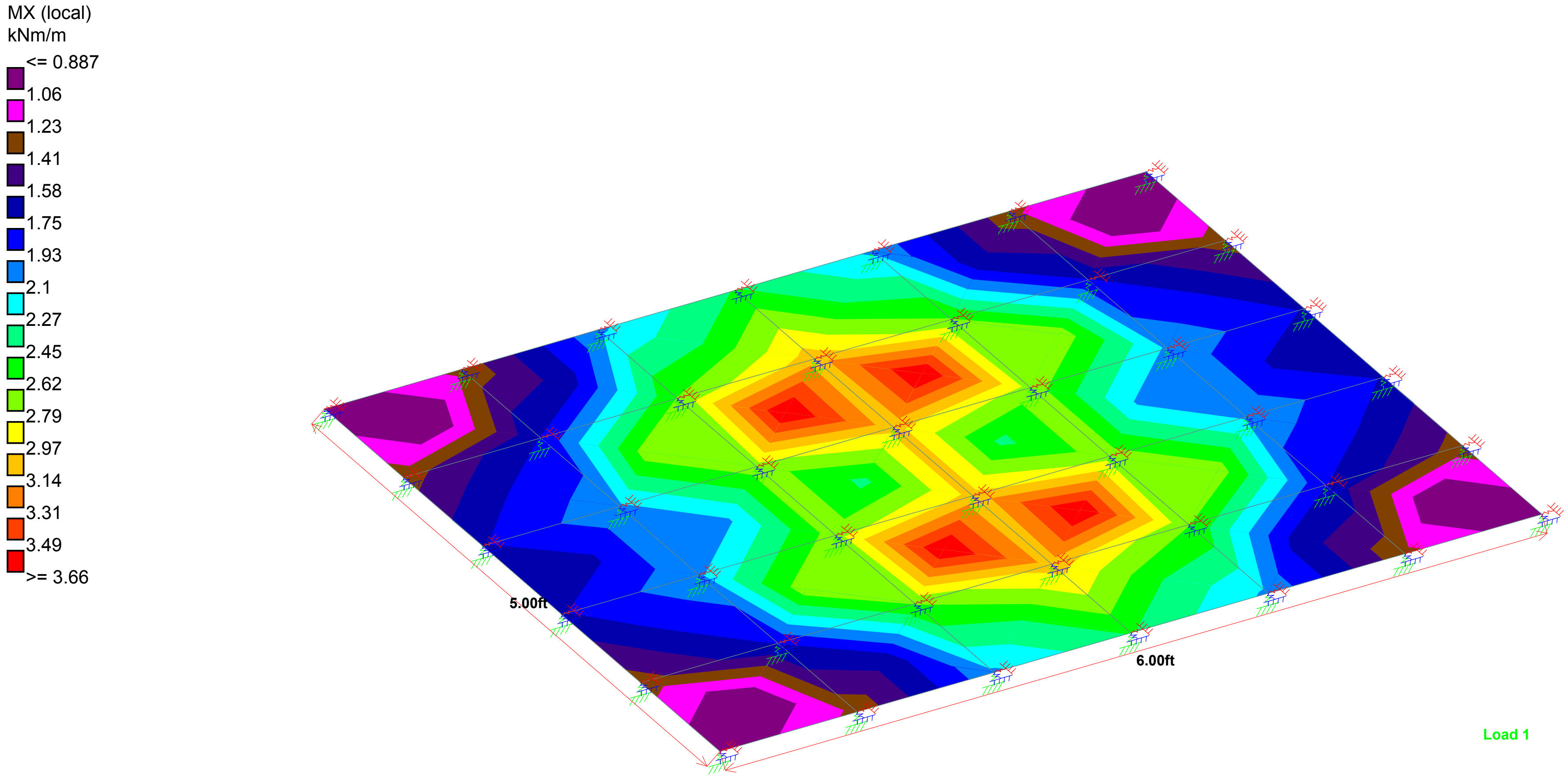

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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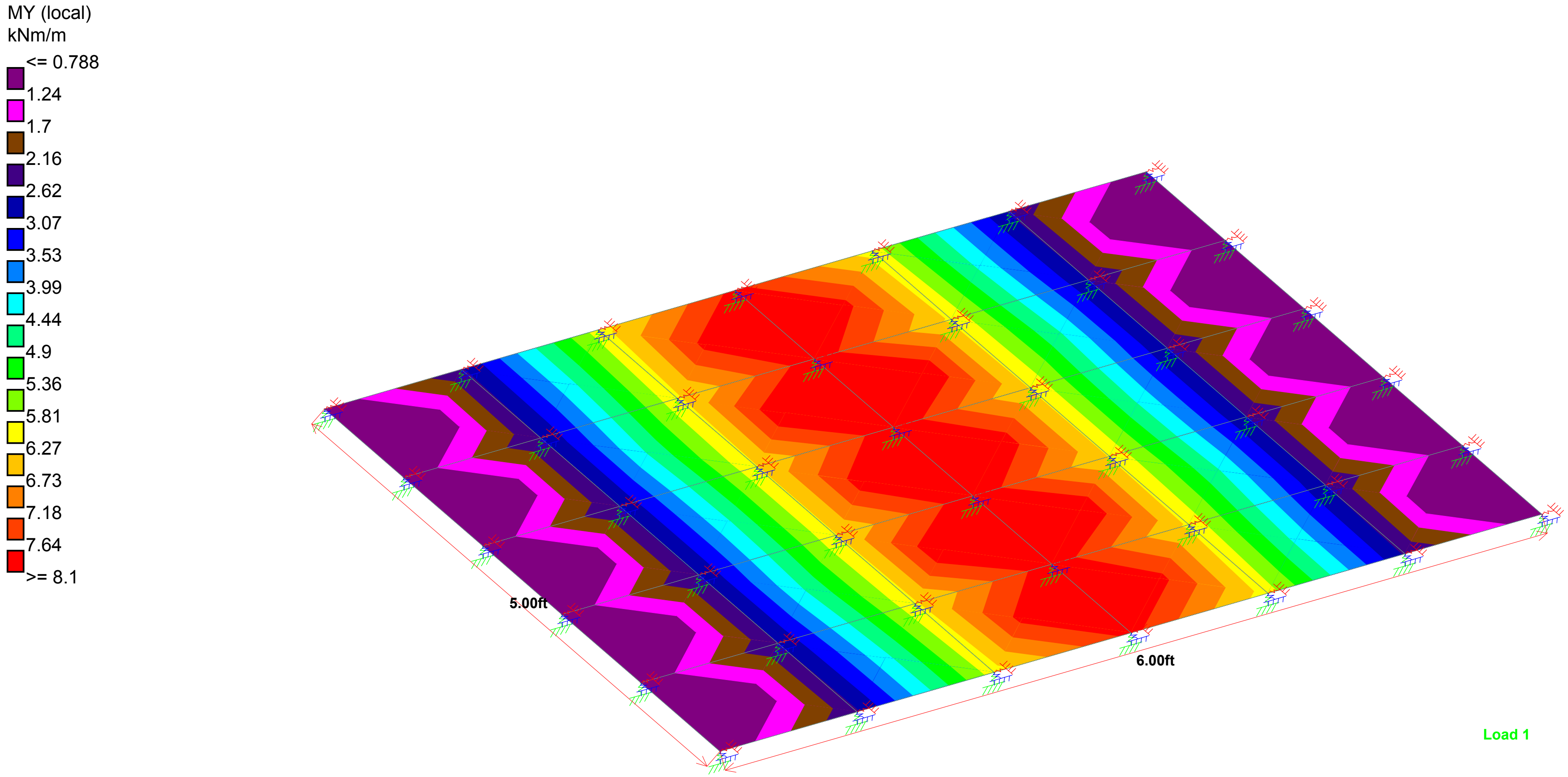

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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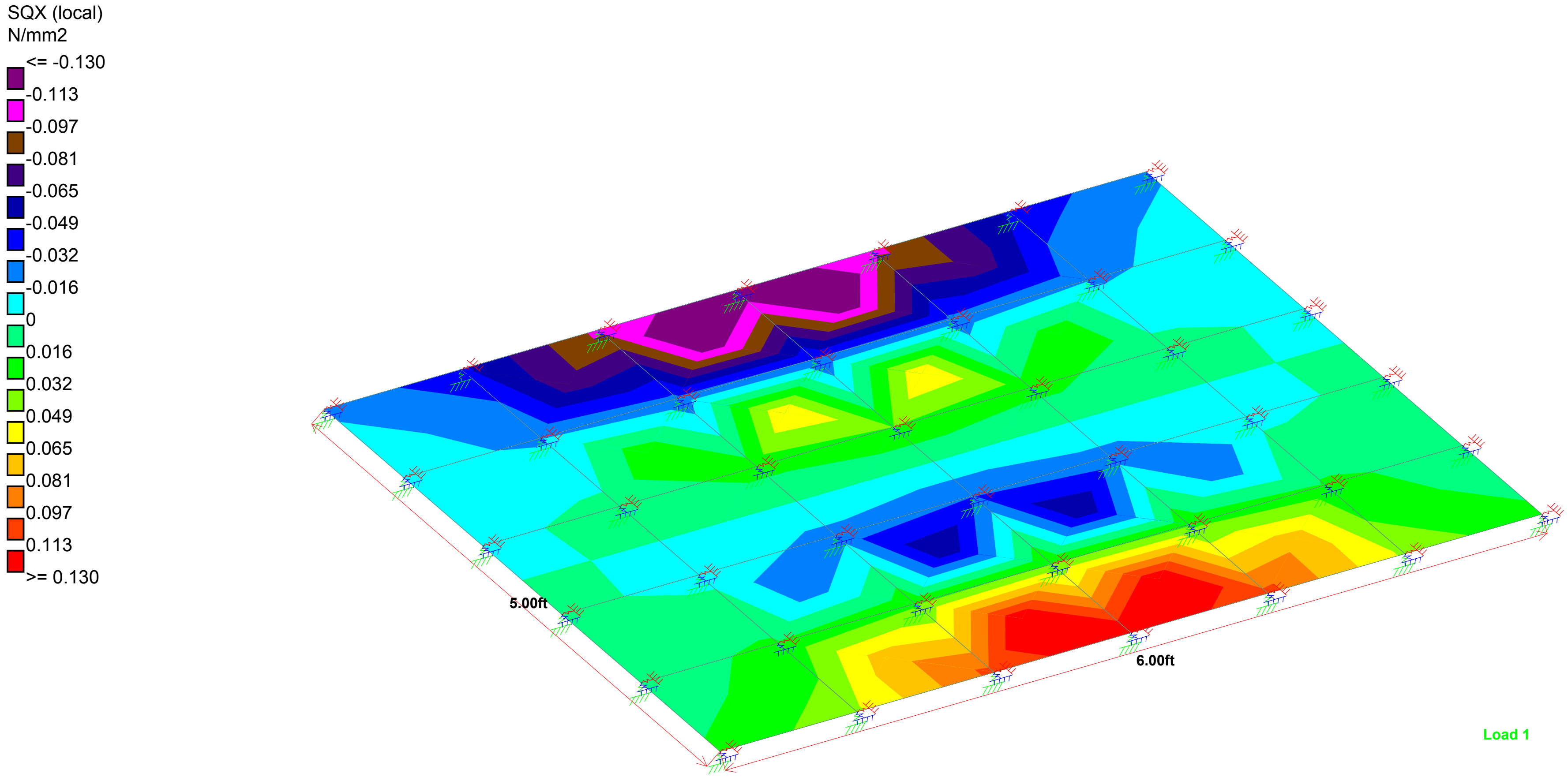

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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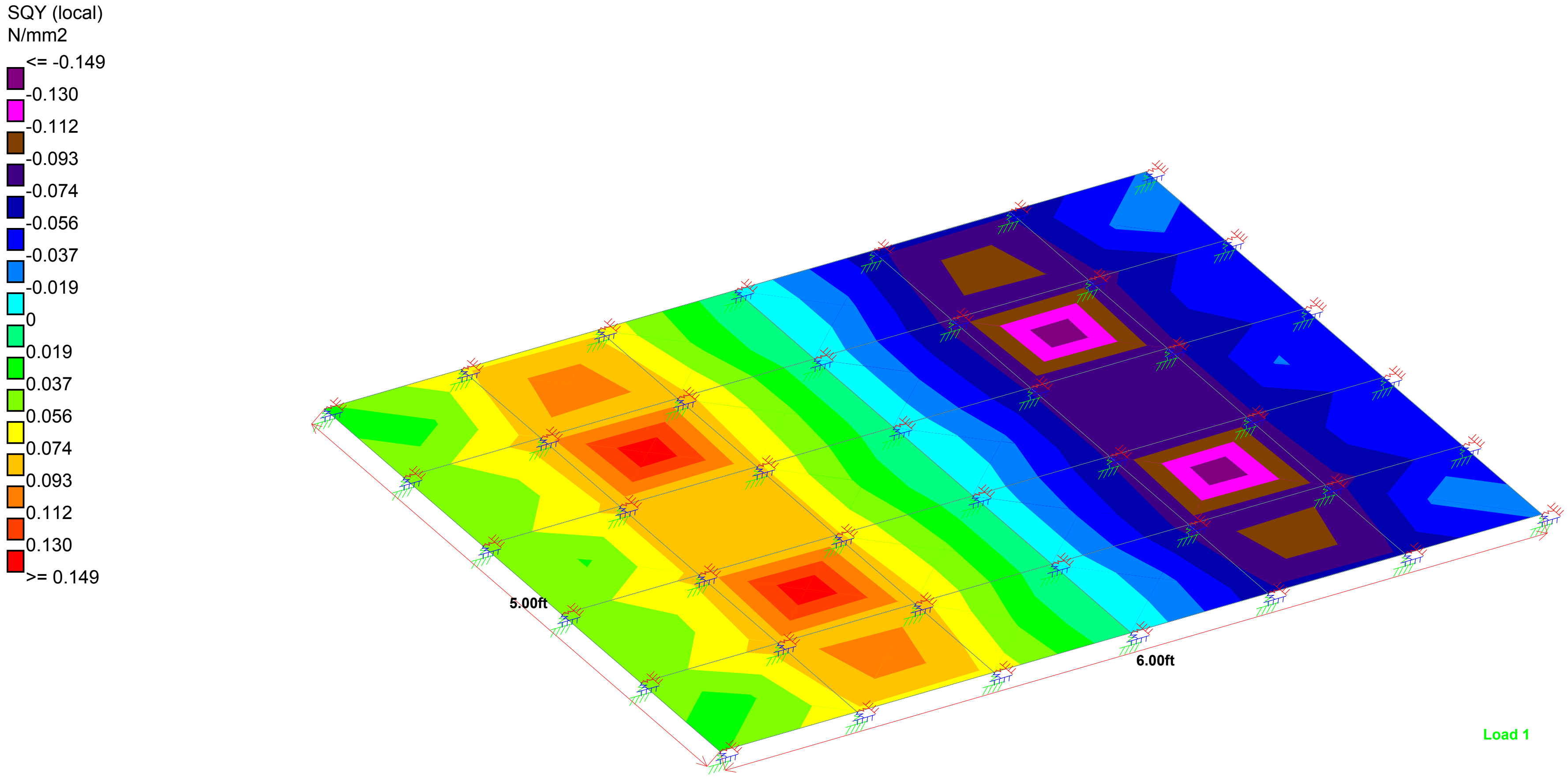

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    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
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    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
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    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
41. 32 PR GY -3.885 0.25 0.5
42. 33 PR GY -3.885 0.25 0.1667
43. 34 PR GY -3.885 0.25 -0.1667
44. 34 PR GY -3.885 0.25 0.5
45. 5 PR GY -3.885 -0.25 0.5
46. 8 PR GY -3.885 -0.25 0.1667
47. 11 PR GY -3.885 -0.25 -0.1667
48. 11 PR GY -3.885 -0.25 0.5
49. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

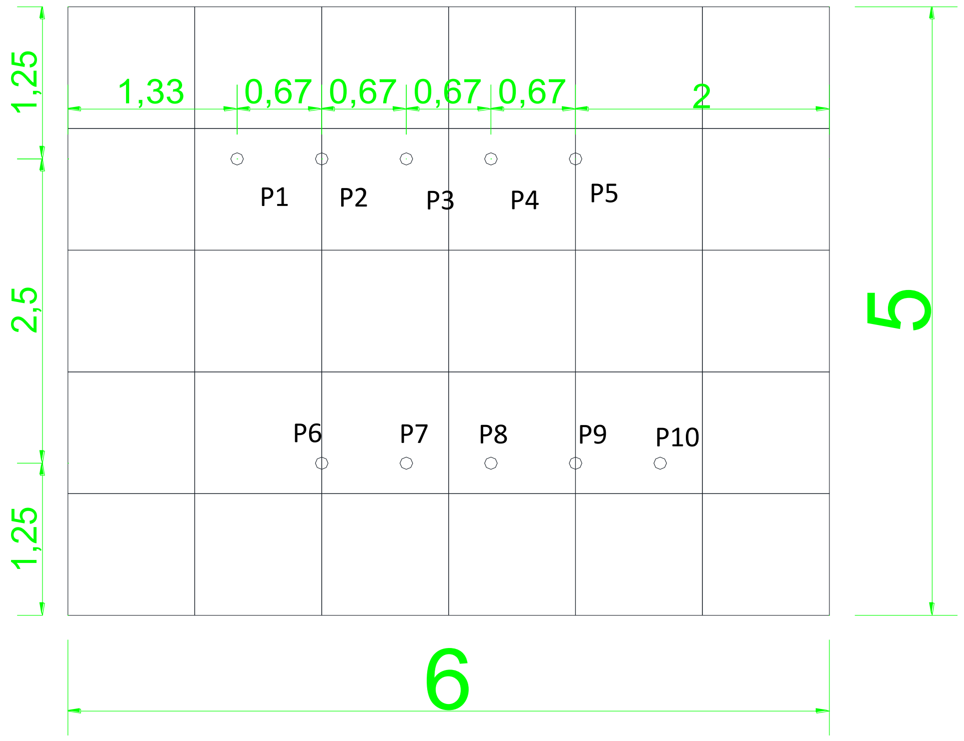
      SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    252
SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
REQRD/AVAIL. DISK SPACE  =     12.3/ 263441.7 MB
```

```
50. FINISH
```

Typical Panel Type (mesh 5W11), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.1667	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.1667	0.25
P5	0.5	0.25
P6	0.5	-0.25
P7	0.1667	-0.25
P8	-0.1667	-0.25
P9	0.5	-0.25
P10	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

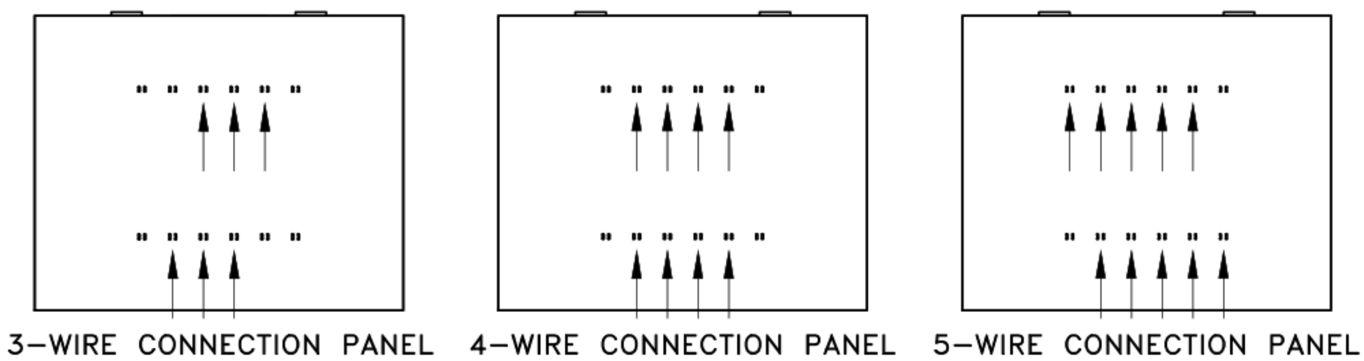
W11 - 75 Years

$A = 0.0797$ in^2

$Fy = 75$ ksi

$P = 0.65 \times A \times Fy$

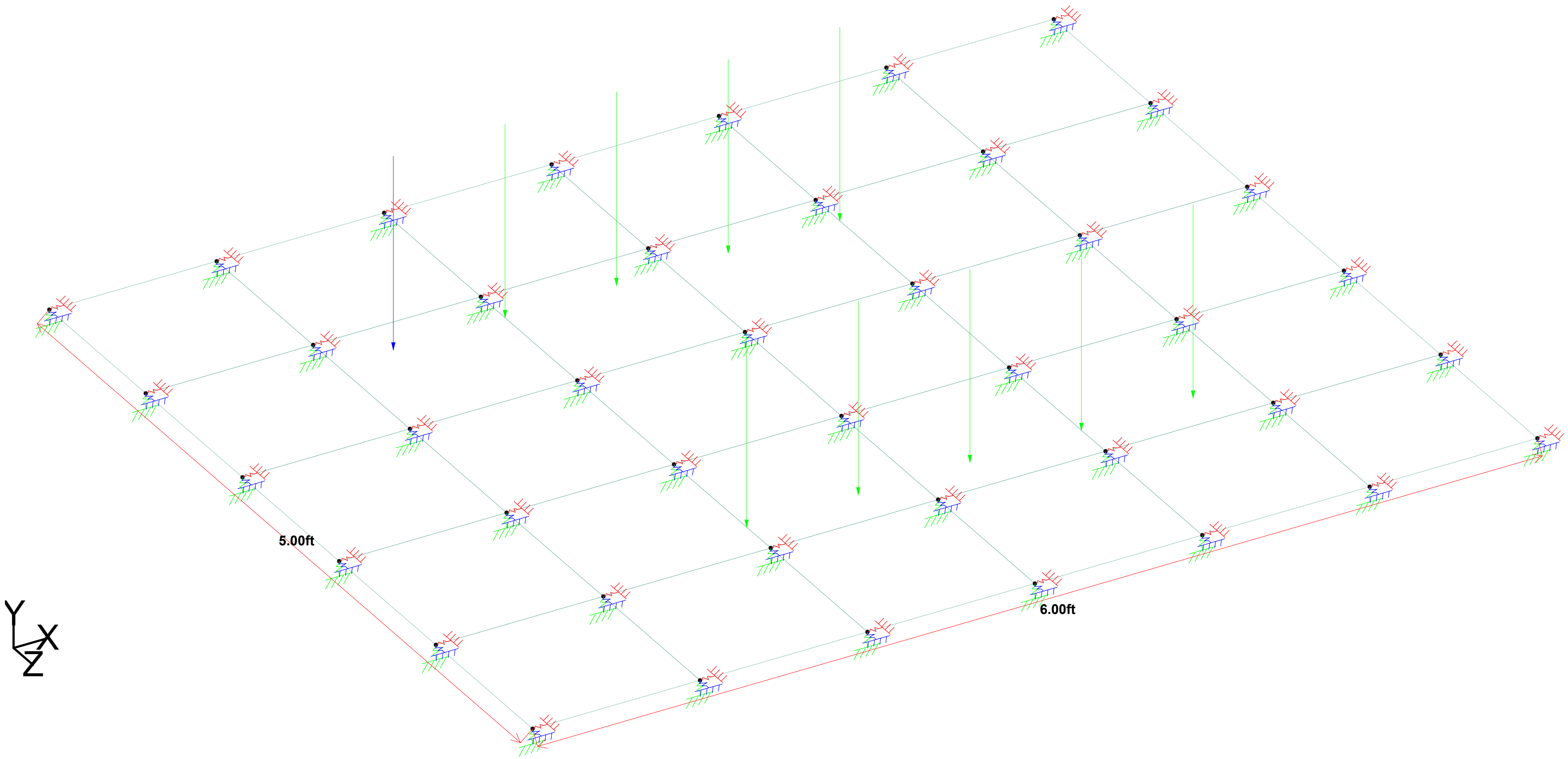
$= 3.885$ Kips (per wire point)



ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 21:36	



Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
	Part		
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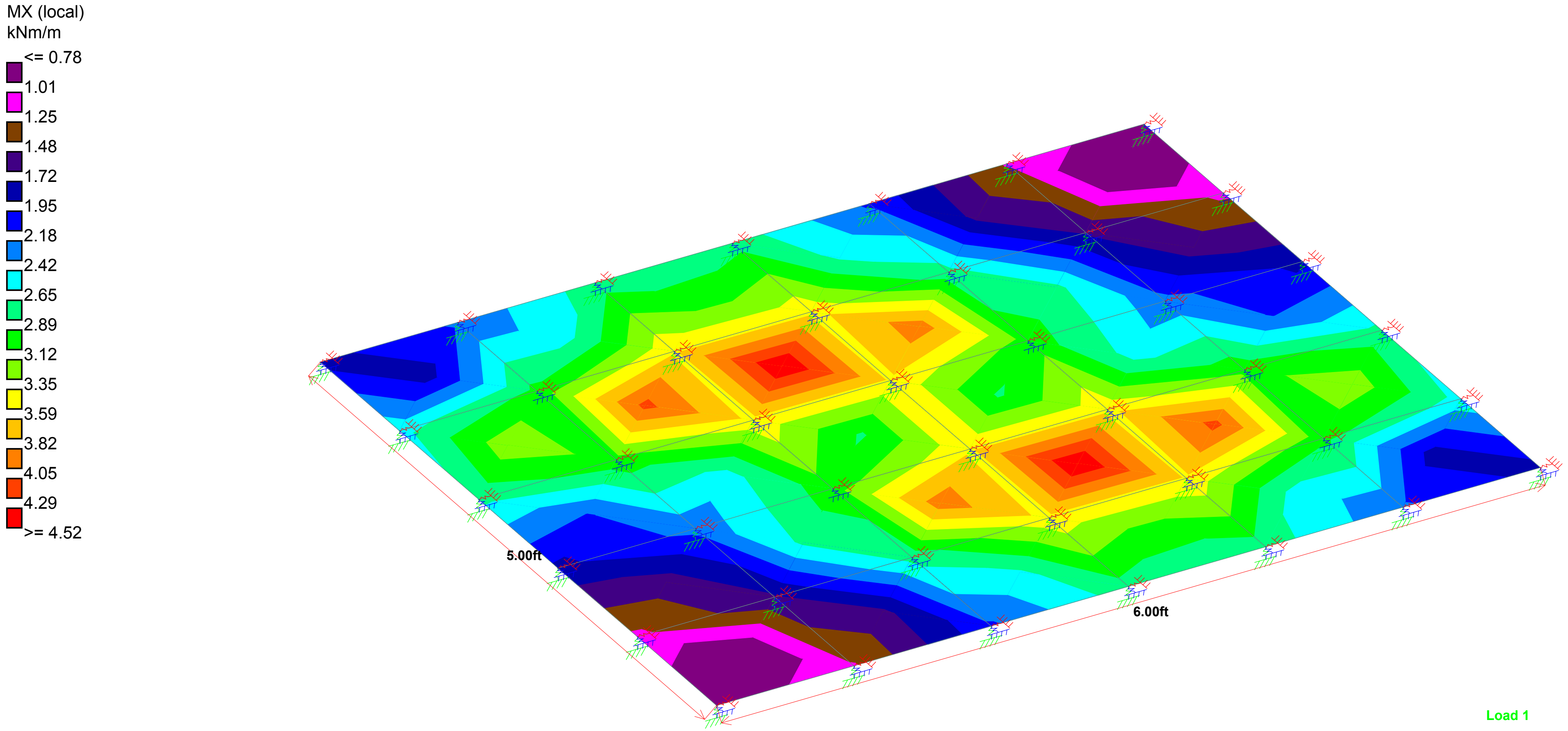
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 21:36	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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	By CH	Date 04-Mar-21	Chd
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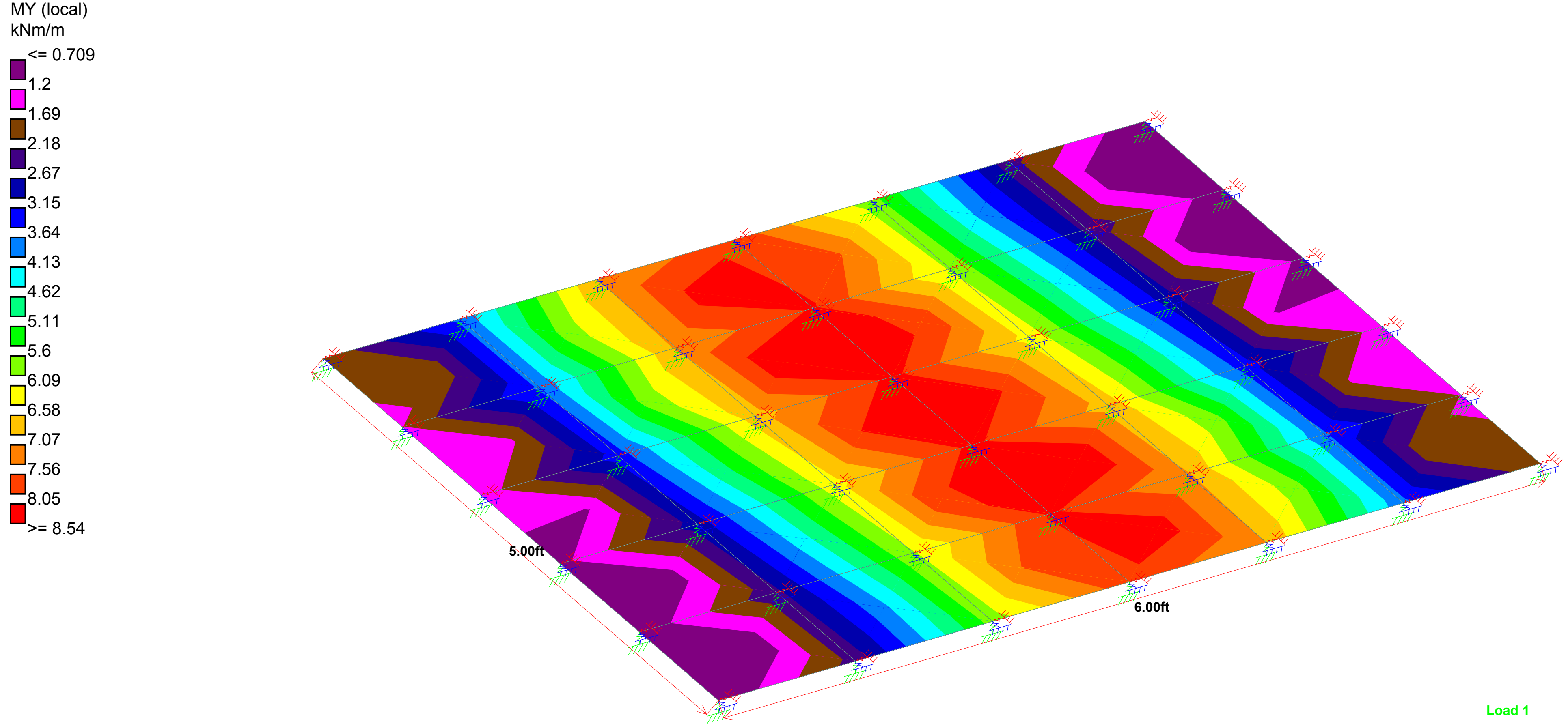
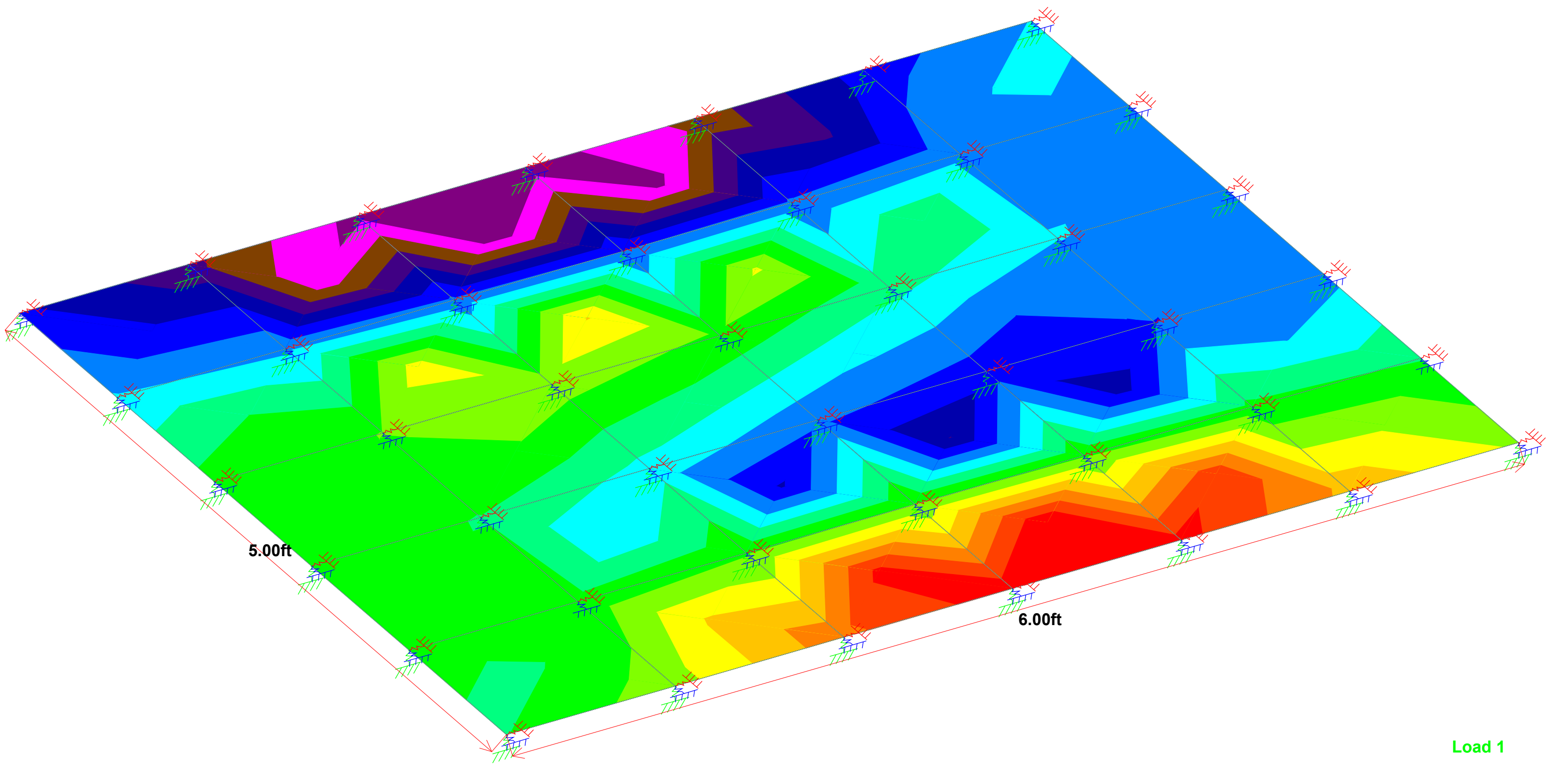


Software licensed to Optimal Engineering Support

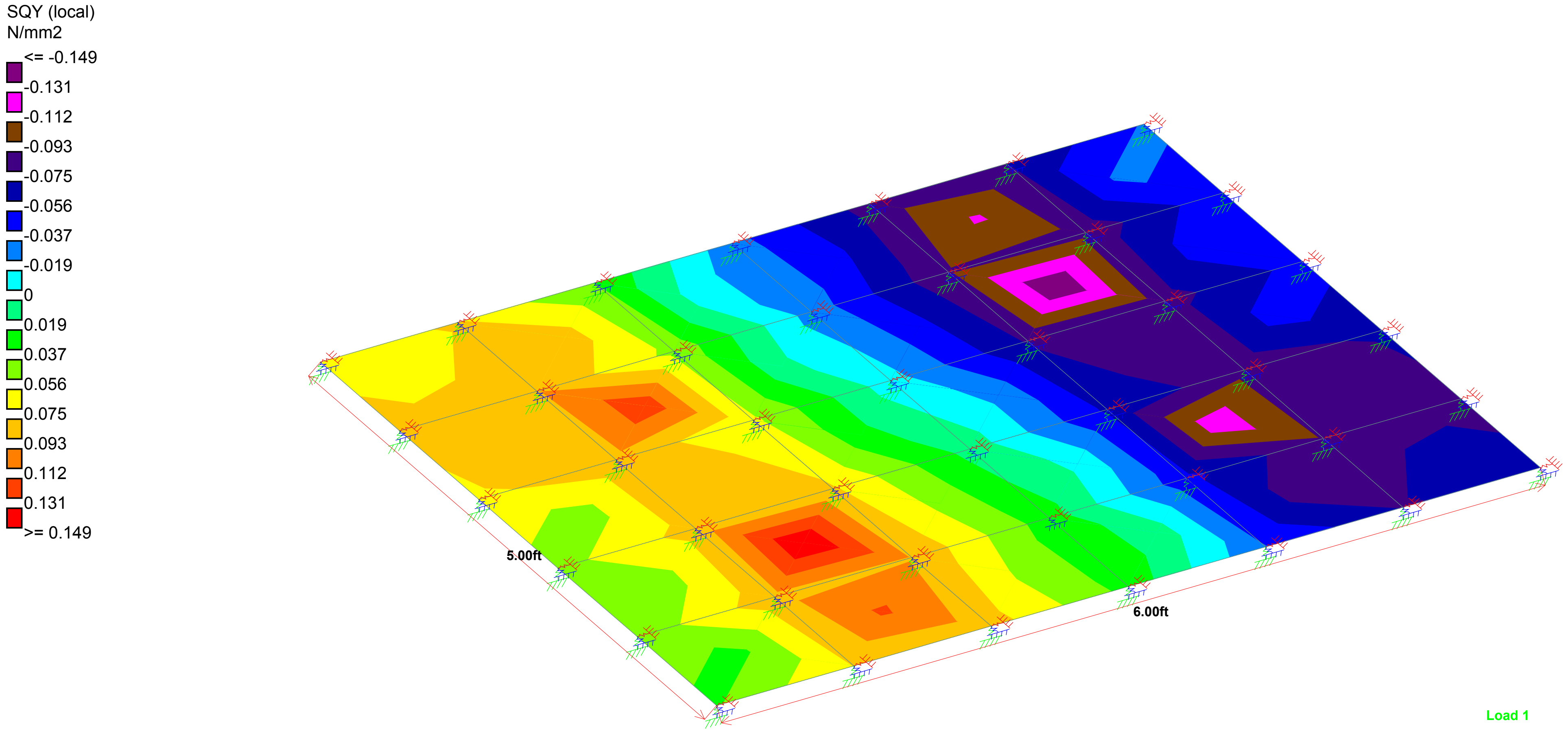
Job Title	Job No	Sheet No 1	Rev
	Part		
	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 21:36	

SQX (local)
N/mm2

- <= -0.147
- -0.129
- -0.110
- -0.092
- -0.074
- -0.055
- -0.037
- -0.018
- 0
- 0.018
- 0.037
- 0.055
- 0.074
- 0.092
- 0.110
- 0.129
- >= 0.147



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 21:36	



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*                                                  *
*          STAAD.Pro                               *
*          Version  2007    Build 04               *
*          Proprietary Program of                  *
*          Research Engineers,  Intl.              *
*          Date=    MAR  6, 2021                   *
*          Time=    21:36:18                       *
*                                                  *
*      USER ID: Optimal Engineering Support        *
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```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x6 type A (5W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    20. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -3.885 0.25 -0.1667
    42. 32 PR GY -3.885 0.25 0.5
    43. 33 PR GY -3.885 0.25 0.1667
    44. 34 PR GY -3.885 0.25 -0.1667
    45. 34 PR GY -3.885 0.25 0.5
    46. 5 PR GY -3.885 -0.25 0.5
    47. 8 PR GY -3.885 -0.25 0.1667
    48. 11 PR GY -3.885 -0.25 -0.1667
    49. 11 PR GY -3.885 -0.25 0.5
    50. 14 PR GY -3.885 -0.25 0.1667
    51. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

      SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    252
SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
REQRD/AVAIL. DISK SPACE  =     12.3/ 263438.8 MB
```

```
    52. FINISH
```

Typical Panel Type (mesh 6W11), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.1667	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.1667	0.25
P5	0.5	0.25
P6	0.1667	0.25
P7	-0.1667	-0.25
P8	0.5	-0.25
P9	0.1667	-0.25
P10	-0.1667	-0.25
P11	0.5	-0.25
P12	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

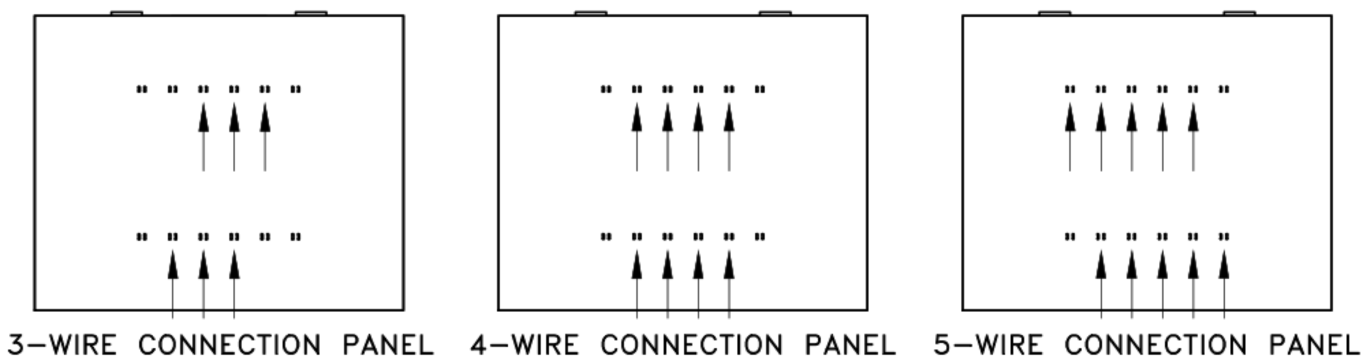
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

= 3.885 Kips (per wire point)

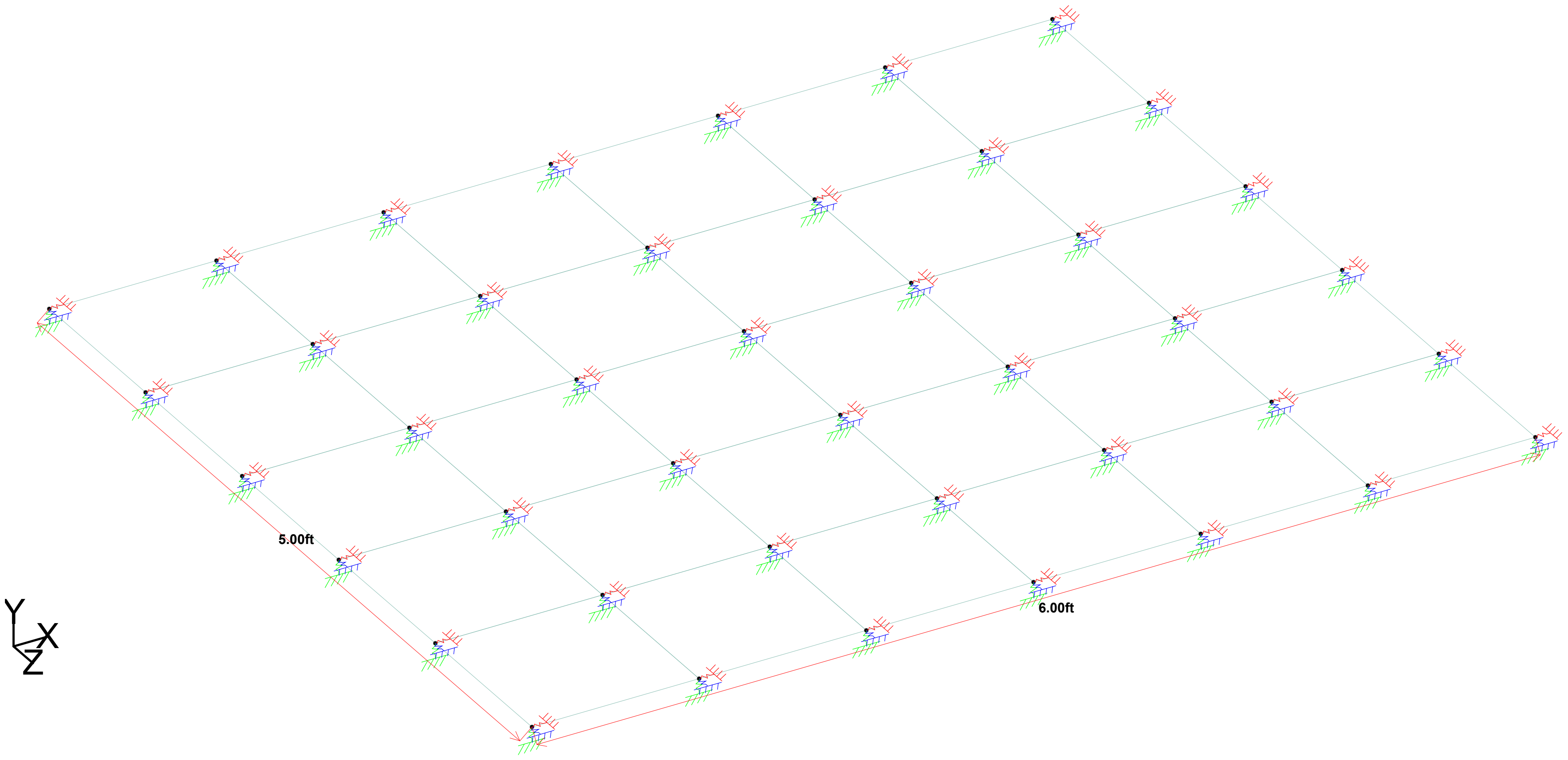


ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

TOC – Appendix

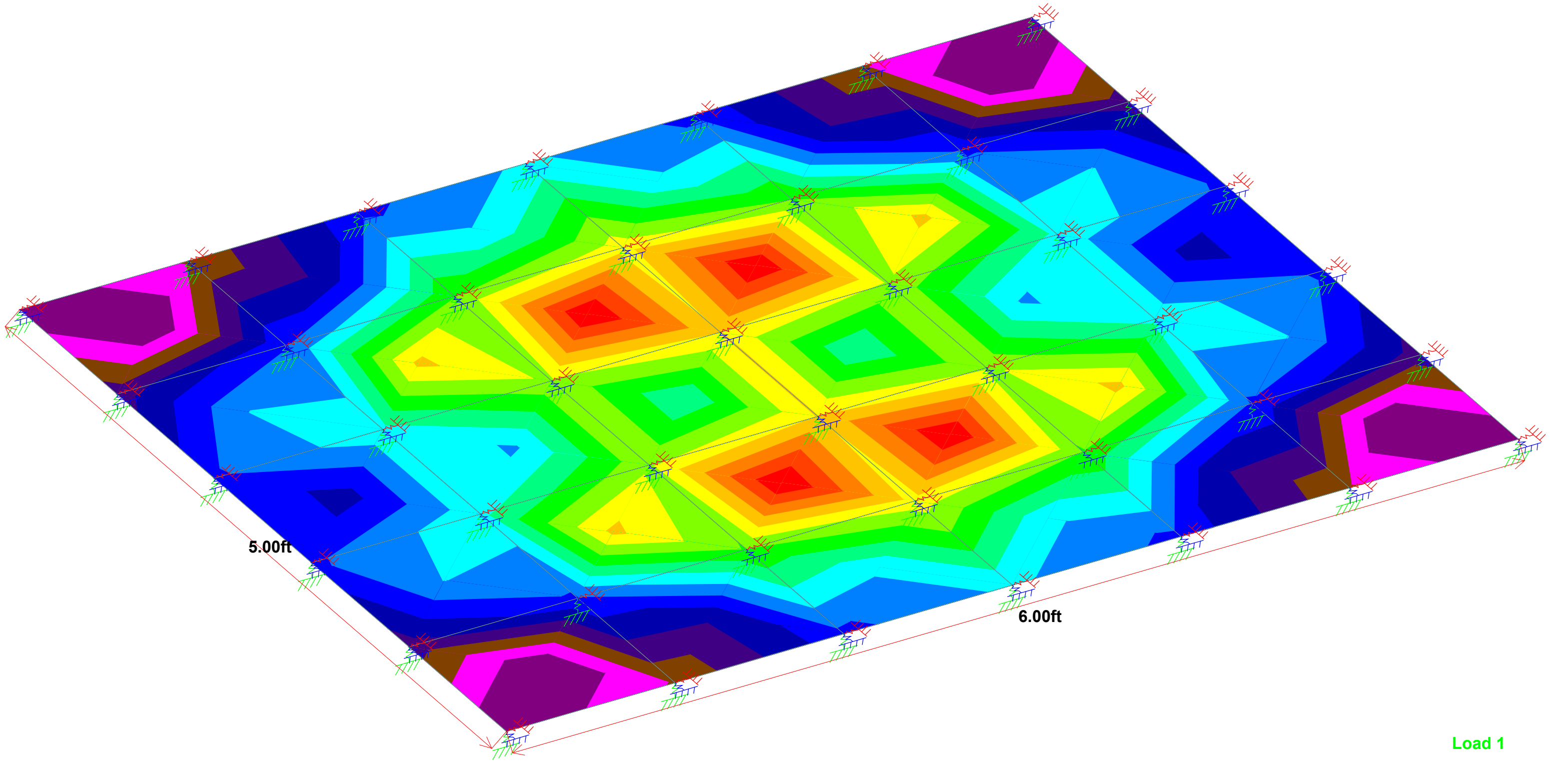
Software licensed to Optimal Engineering Support	Job No	Sheet No **1**	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 22:30	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 22:30	

MX (local)
kNm/m

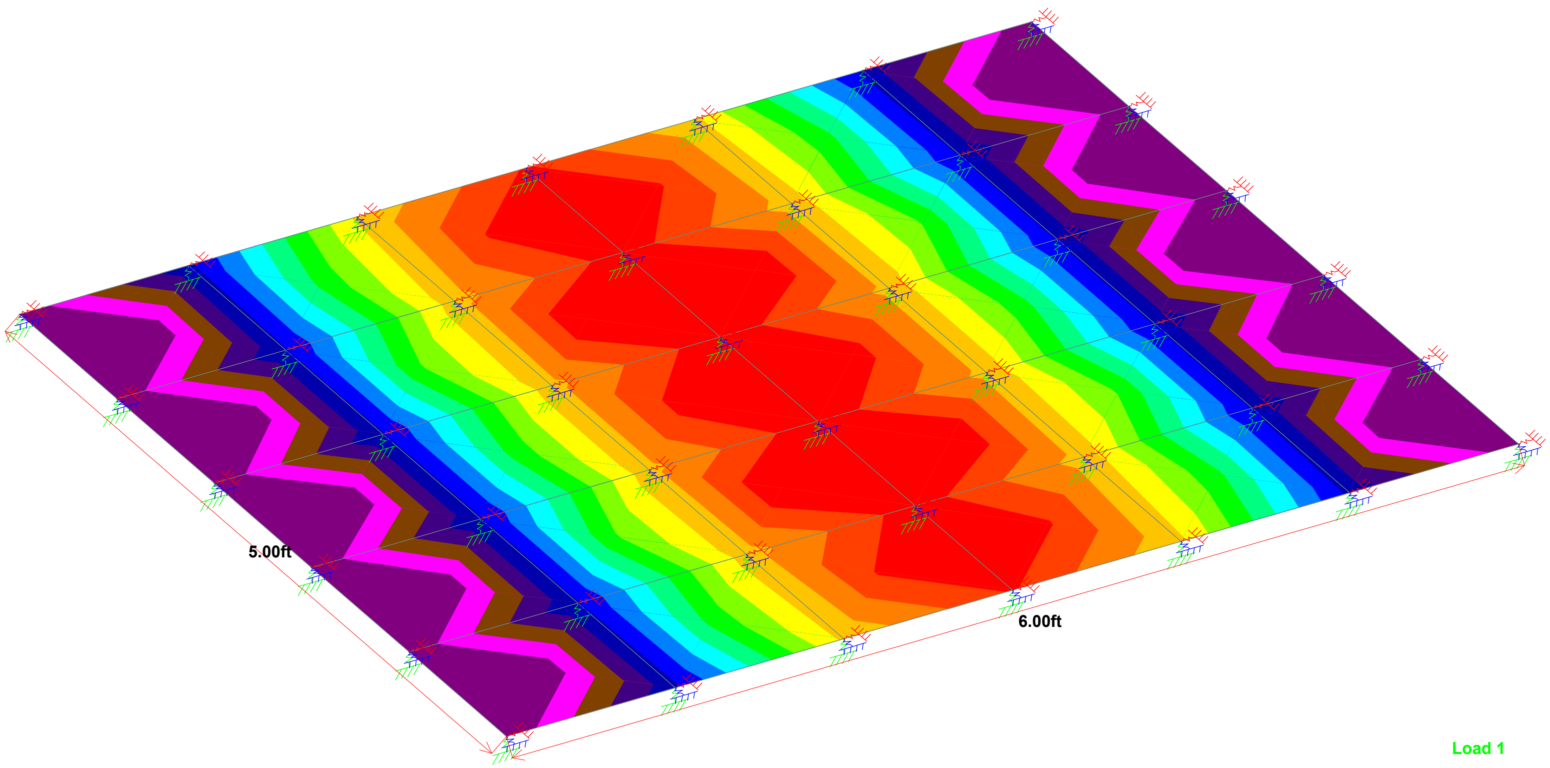
<= 1.76
1.95
2.14
2.33
2.52
2.71
2.9
3.09
3.28
3.47
3.66
3.85
4.04
4.24
4.43
4.62
>= 4.81



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 22:30	

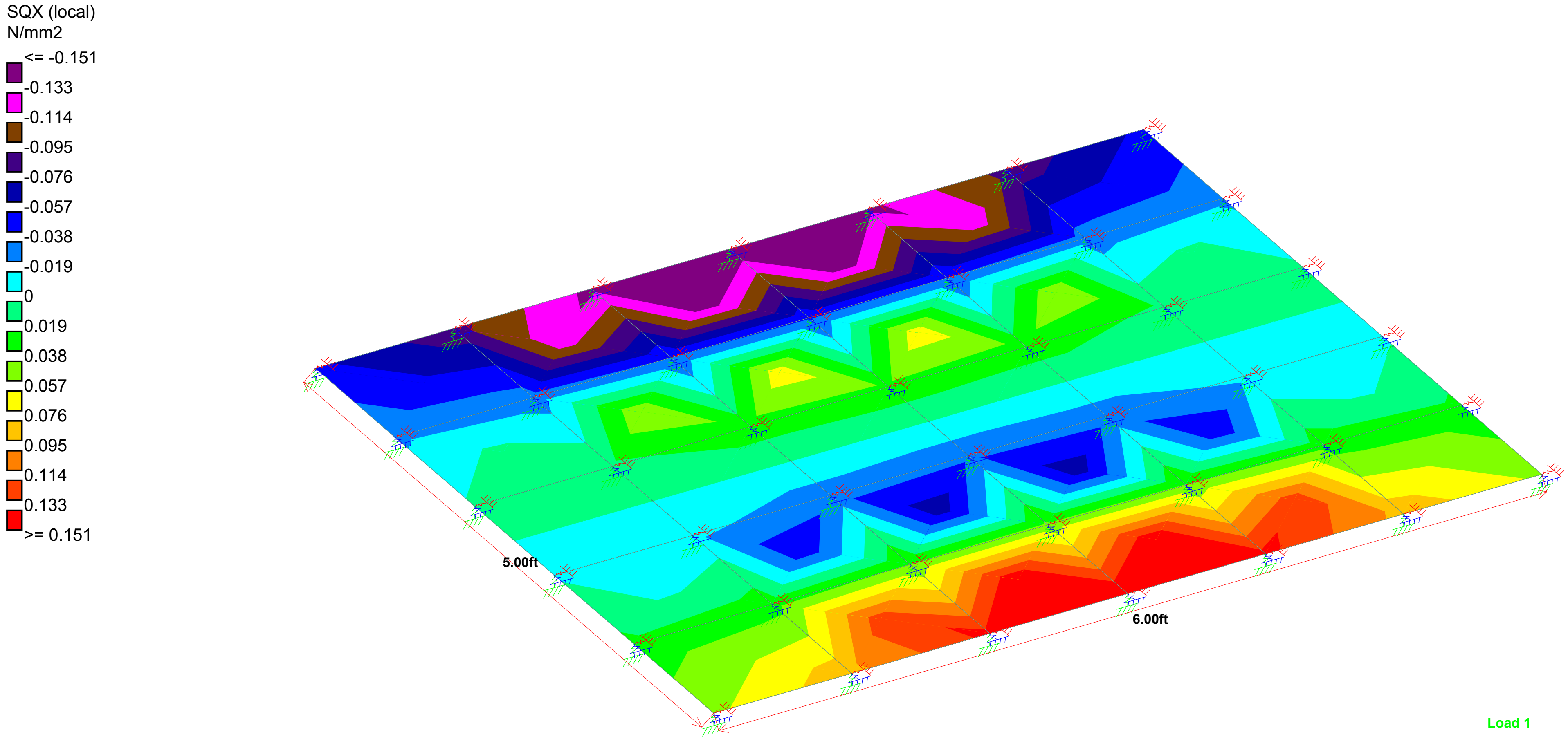
MY (local)
kNm/m

<= 1.57	
2	
2.43	
2.86	
3.29	
3.72	
4.15	
4.58	
5.01	
5.44	
5.87	
6.3	
6.73	
7.16	
7.59	
8.02	
>= 8.45	



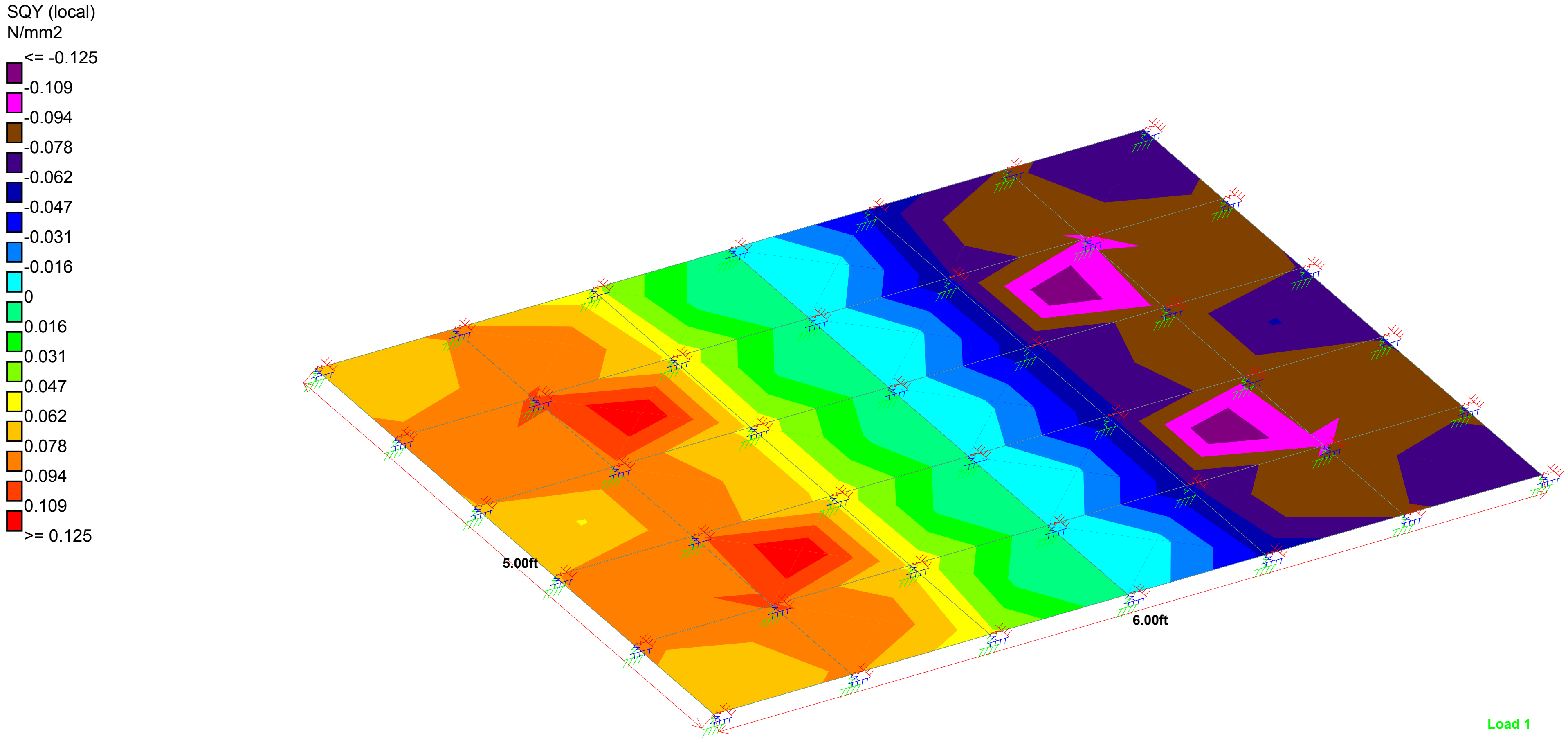
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 22:30	

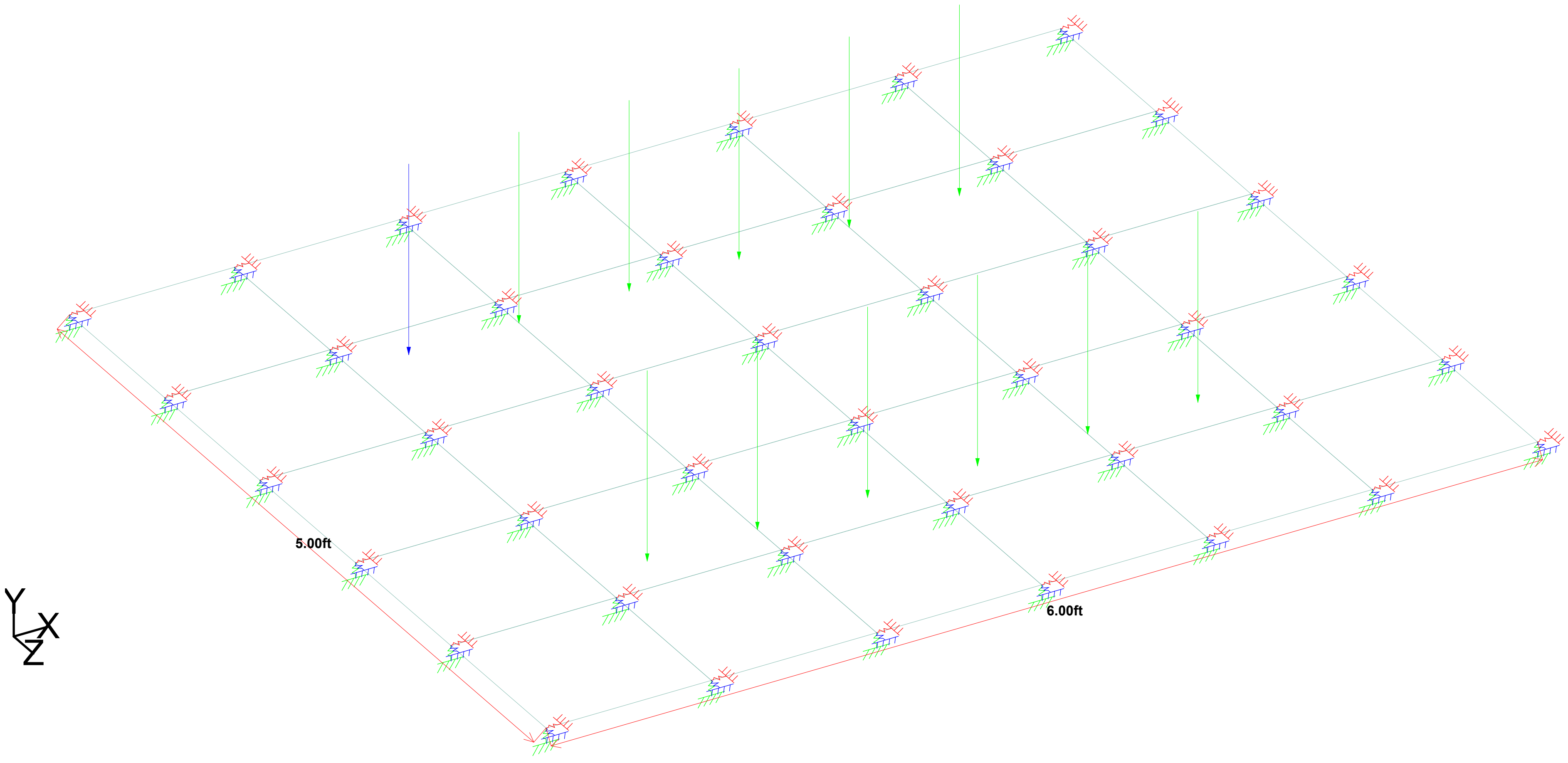


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 22:30	

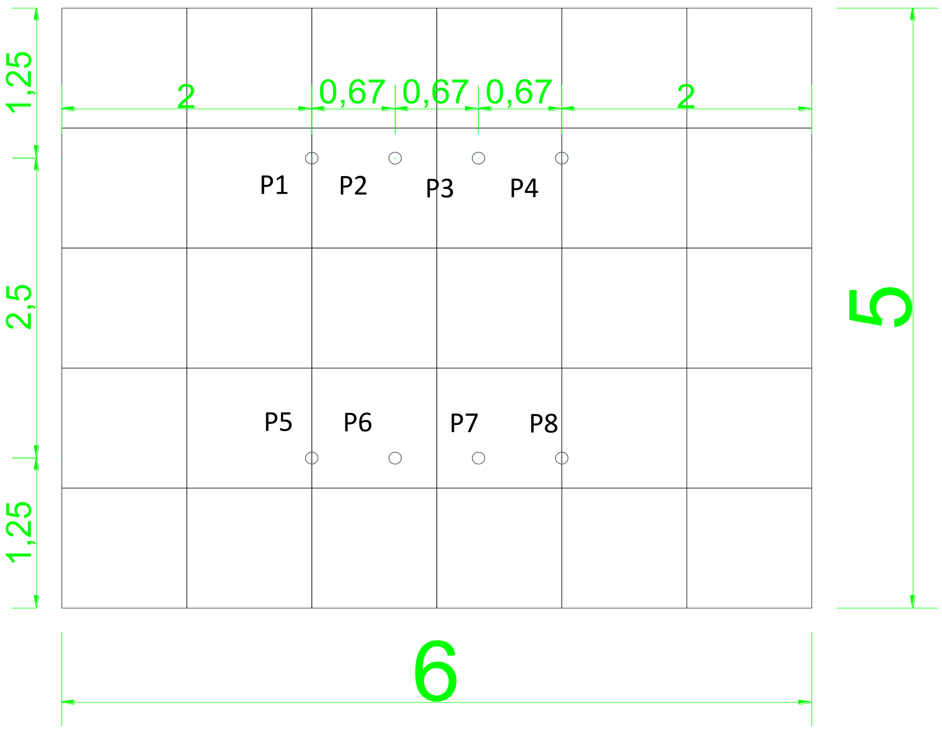


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 06-Mar-2021 22:30	



Typical Panel Type (mesh 4W20), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input



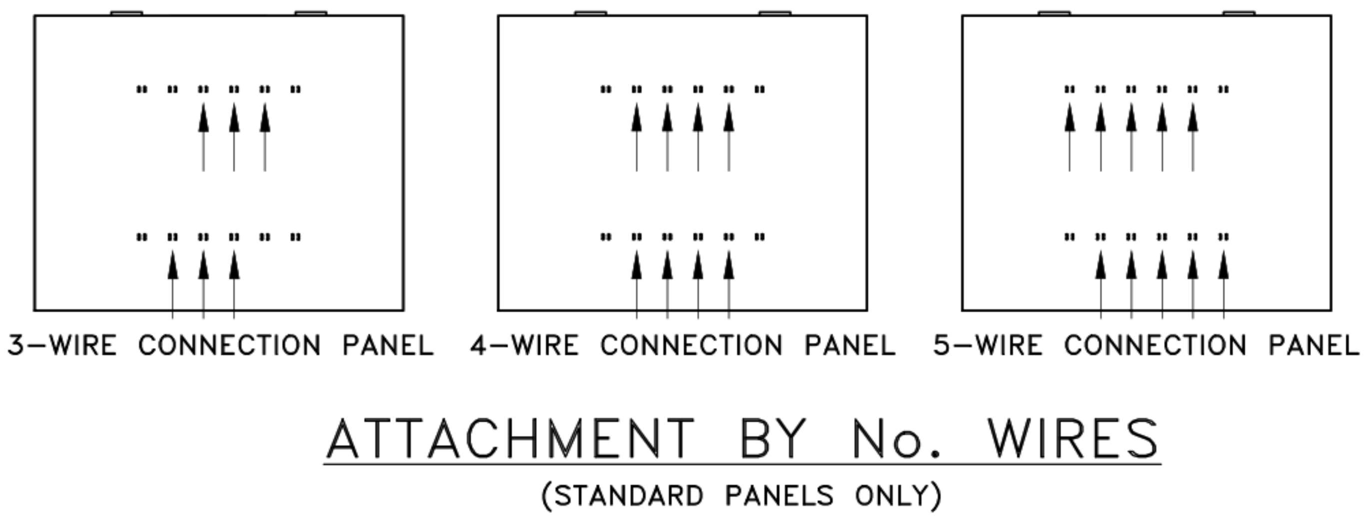
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.5	0.25
P2	0.1667	0.25
P3	-0.1667	0.25
P4	0.5	0.25
P5	0.5	-0.25
P6	0.1667	-0.25
P7	-0.1667	-0.25
P8	0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

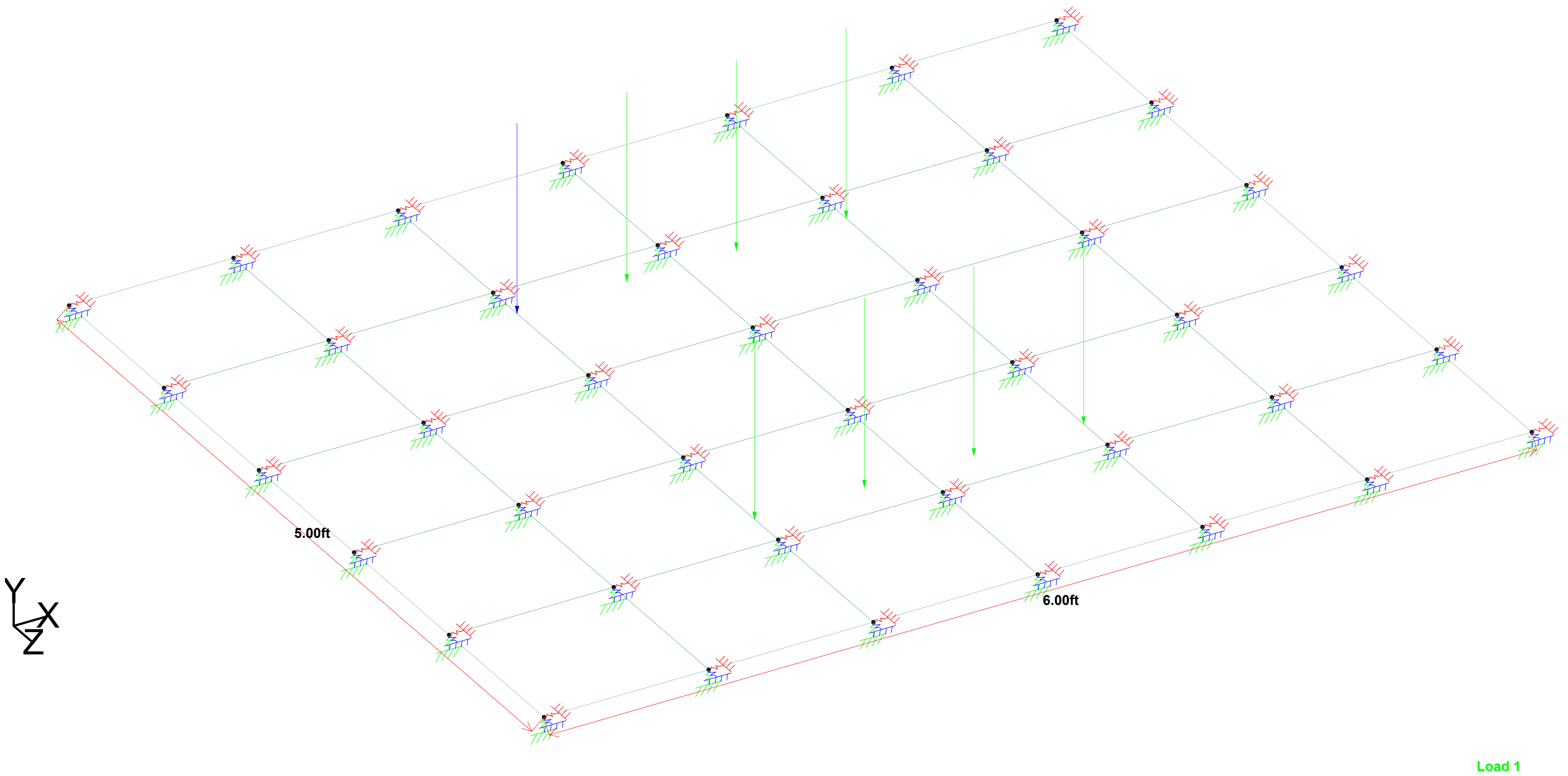
Bar Mat Used:
W11 - 75 Years

A = 0.1583 in^2
Fy = 75 ksi

P = 0.65 x A x Fy
= 7.717 Kips (per wire point)

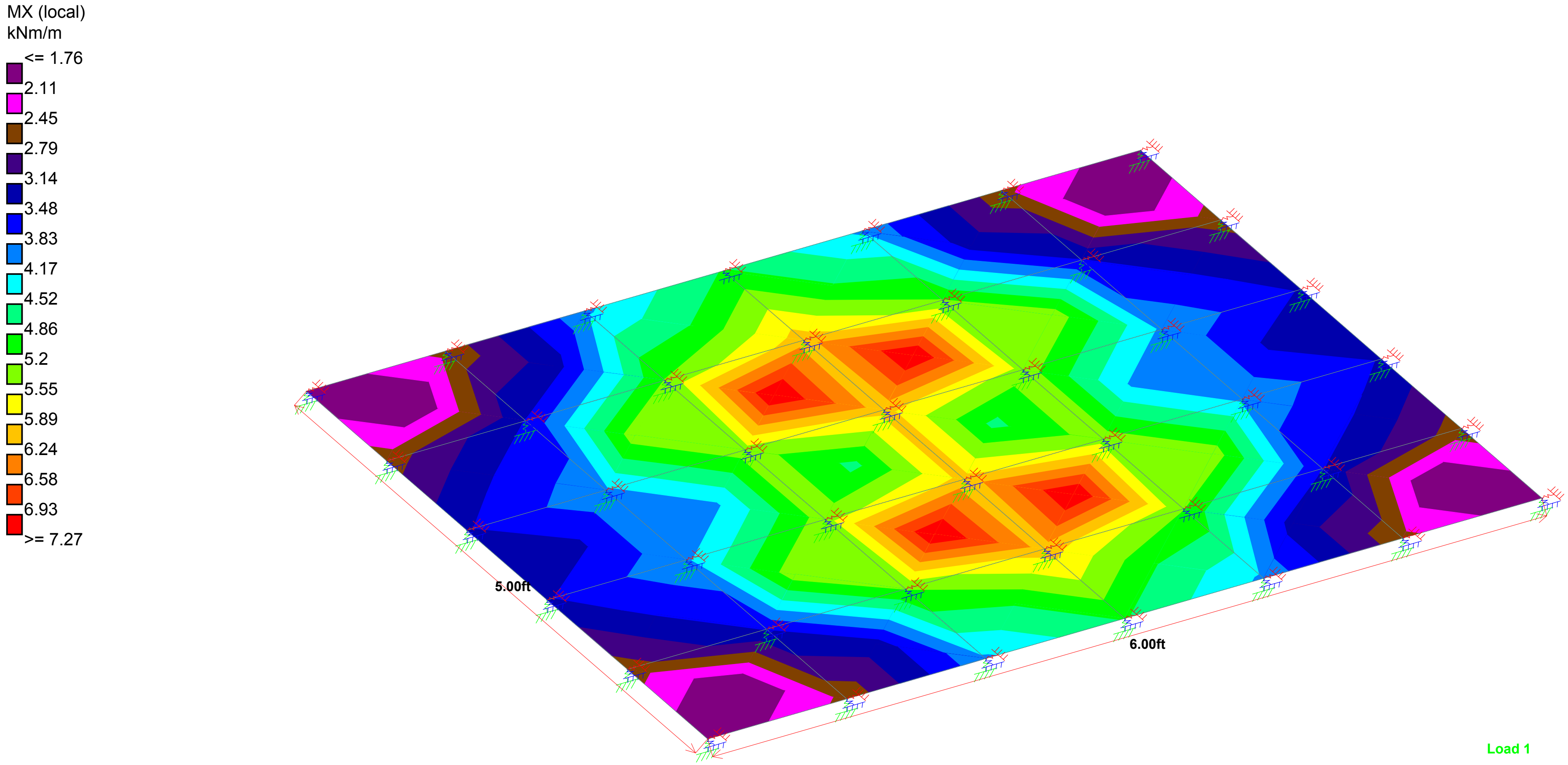


Software licensed to Optimal Engineering Support	Job No		Sheet No 1	Rev
	Part			
Job Title	Ref Panel Check			
	By CH		Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A		Date/Time 07-Mar-2021 21:15	



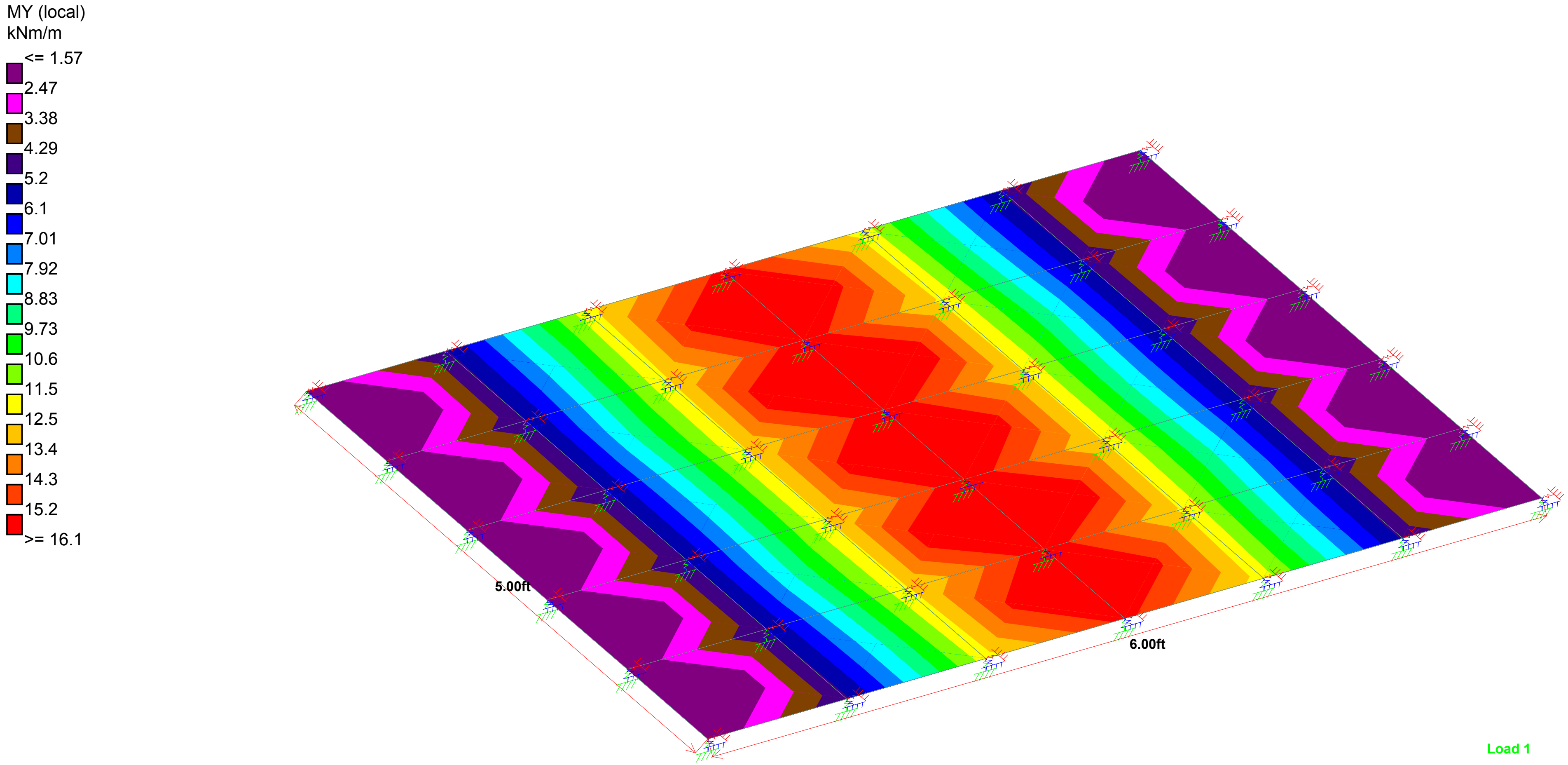
Software licensed to Optimal Engineering Support

Job Title		Job No	Sheet No 1	Rev
		Part		
		Ref Panel Check		
		By CH	Date 07-Mar-21	Chd
Client SSL		File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 21:15	

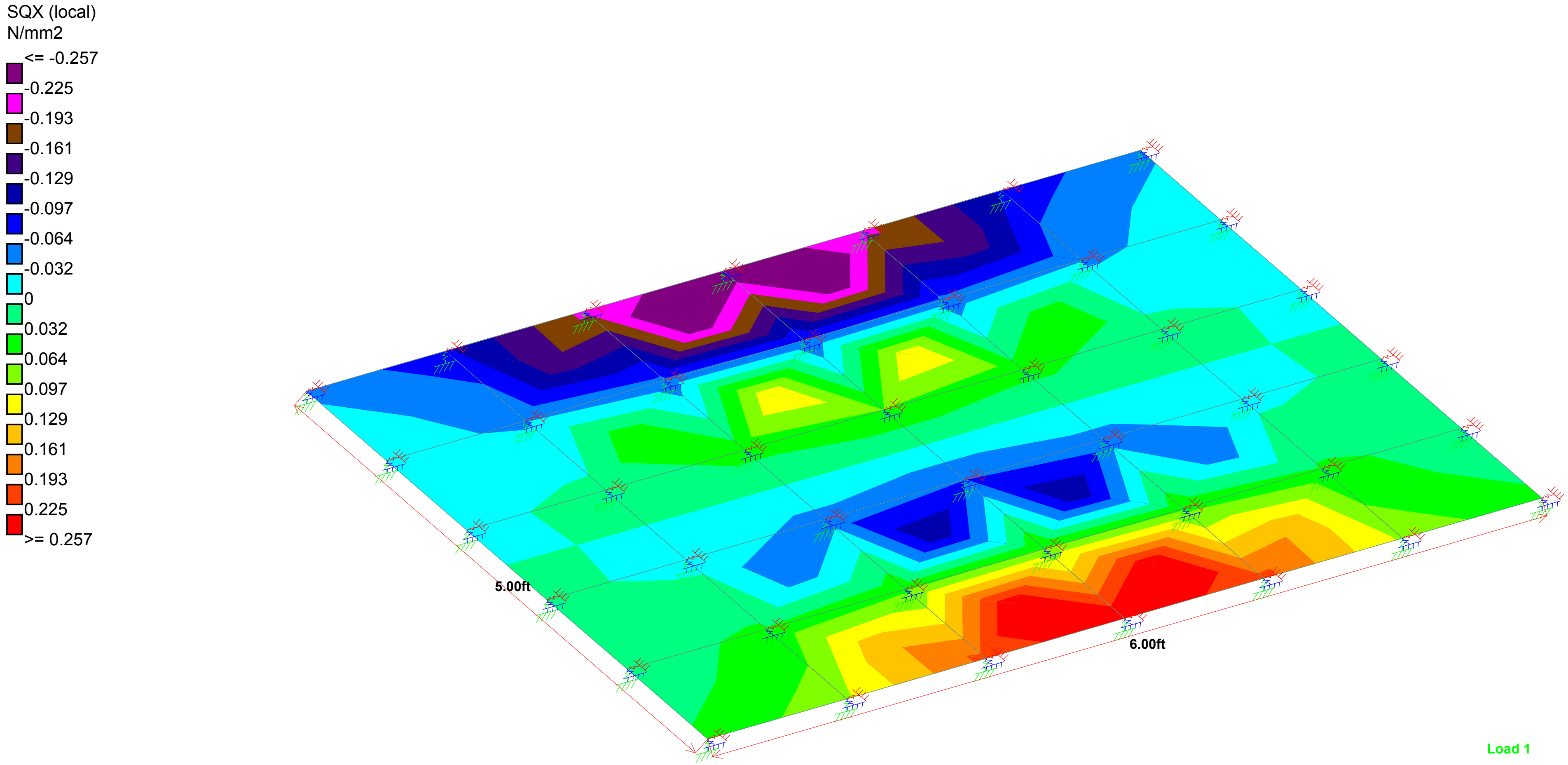


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 21:15	

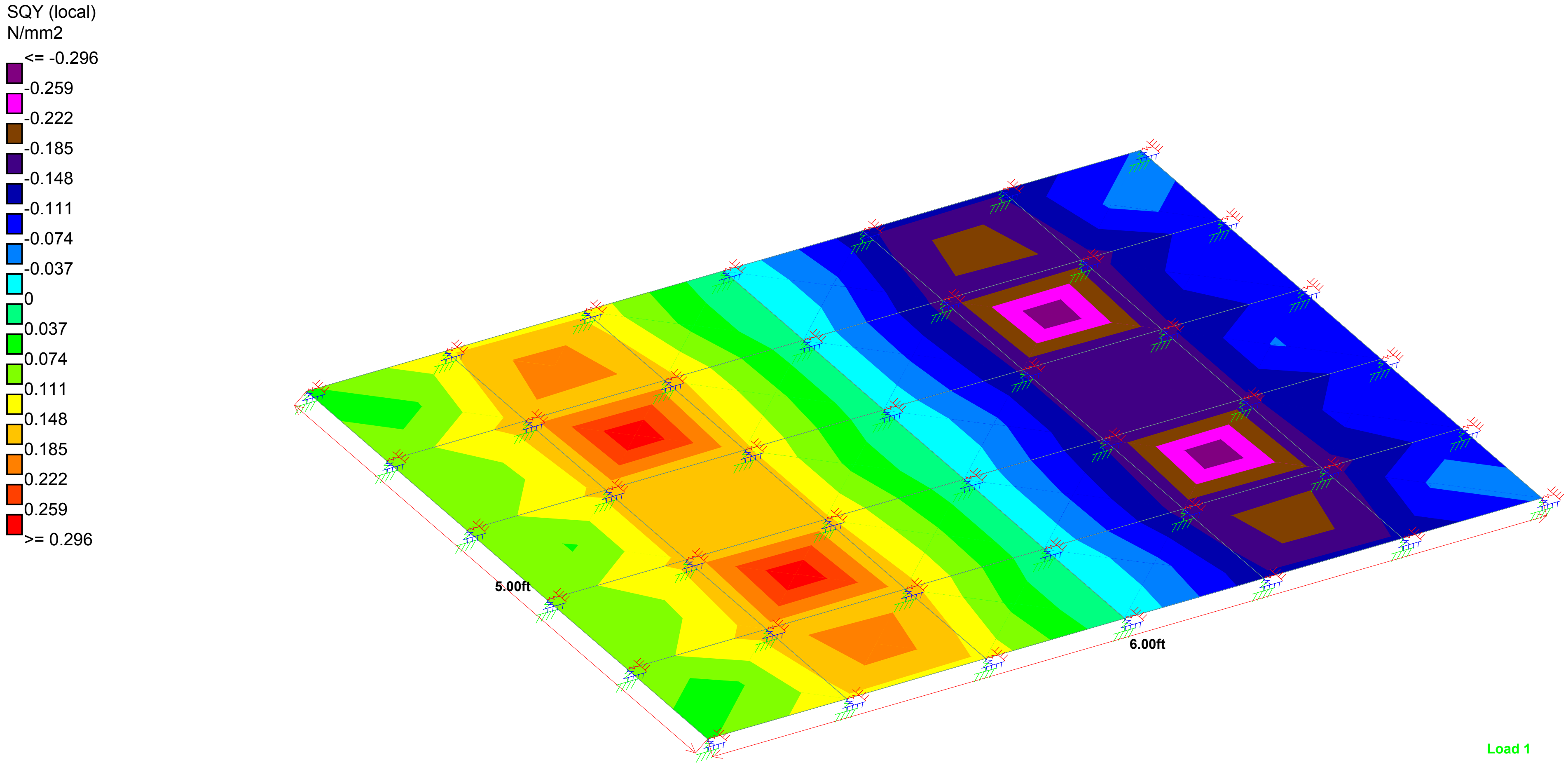


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 21:15	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 21:15	



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 *           Version  2007    Build 04              *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR  7, 2021                  *
 *           Time=    21:19:52                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
 ****************************************************
```

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     1. STAAD SPACE
INPUT FILE: Panel Check - 5x6 type A (4W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 07-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    20. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -7.717 0.25 0.5
    42. 33 PR GY -7.717 0.25 0.1667
    43. 34 PR GY -7.717 0.25 -0.1667
    44. 34 PR GY -7.717 0.25 0.5
    45. 5 PR GY -7.717 -0.25 0.5
    46. 8 PR GY -7.717 -0.25 0.1667
    47. 11 PR GY -7.717 -0.25 -0.1667
    48. 11 PR GY -7.717 -0.25 0.5
    49. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

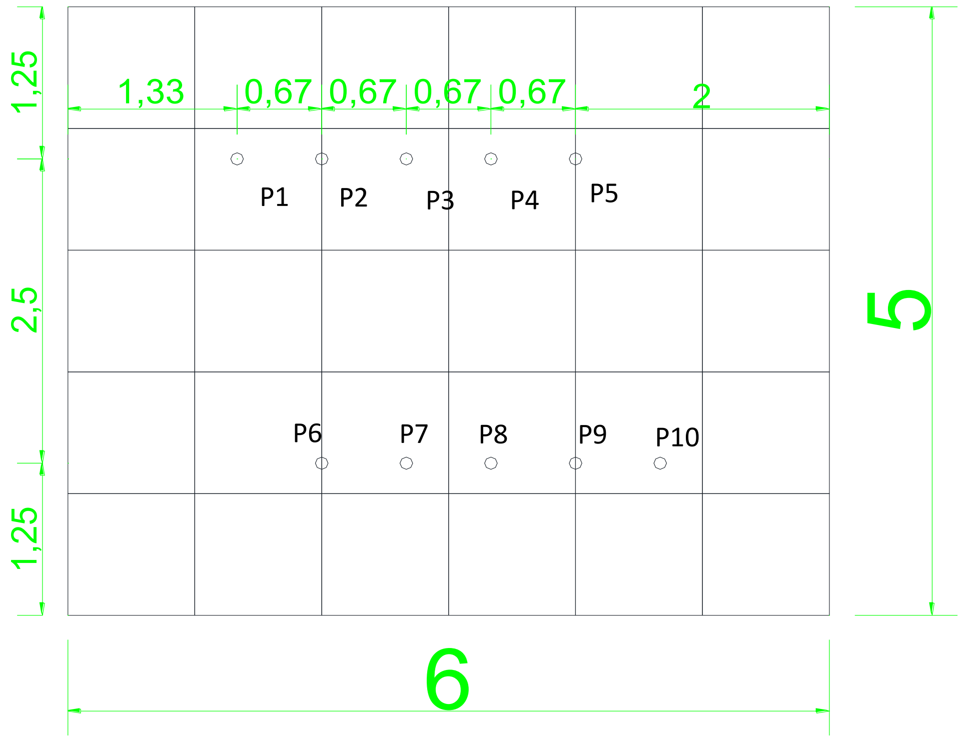
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
 TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    252
 SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.3/ 263423.7 MB


    50. FINISH
```

Typical Panel Type (mesh 5W20), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input



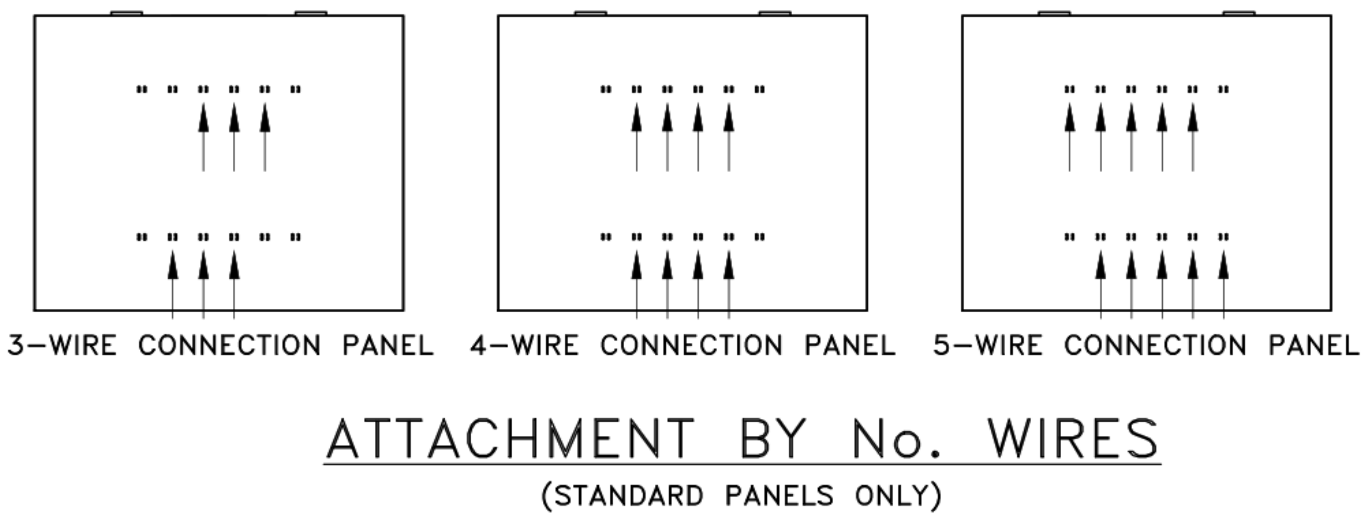
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.1667	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.1667	0.25
P5	0.5	0.25
P6	0.5	-0.25
P7	0.1667	-0.25
P8	-0.1667	-0.25
P9	0.5	-0.25
P10	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

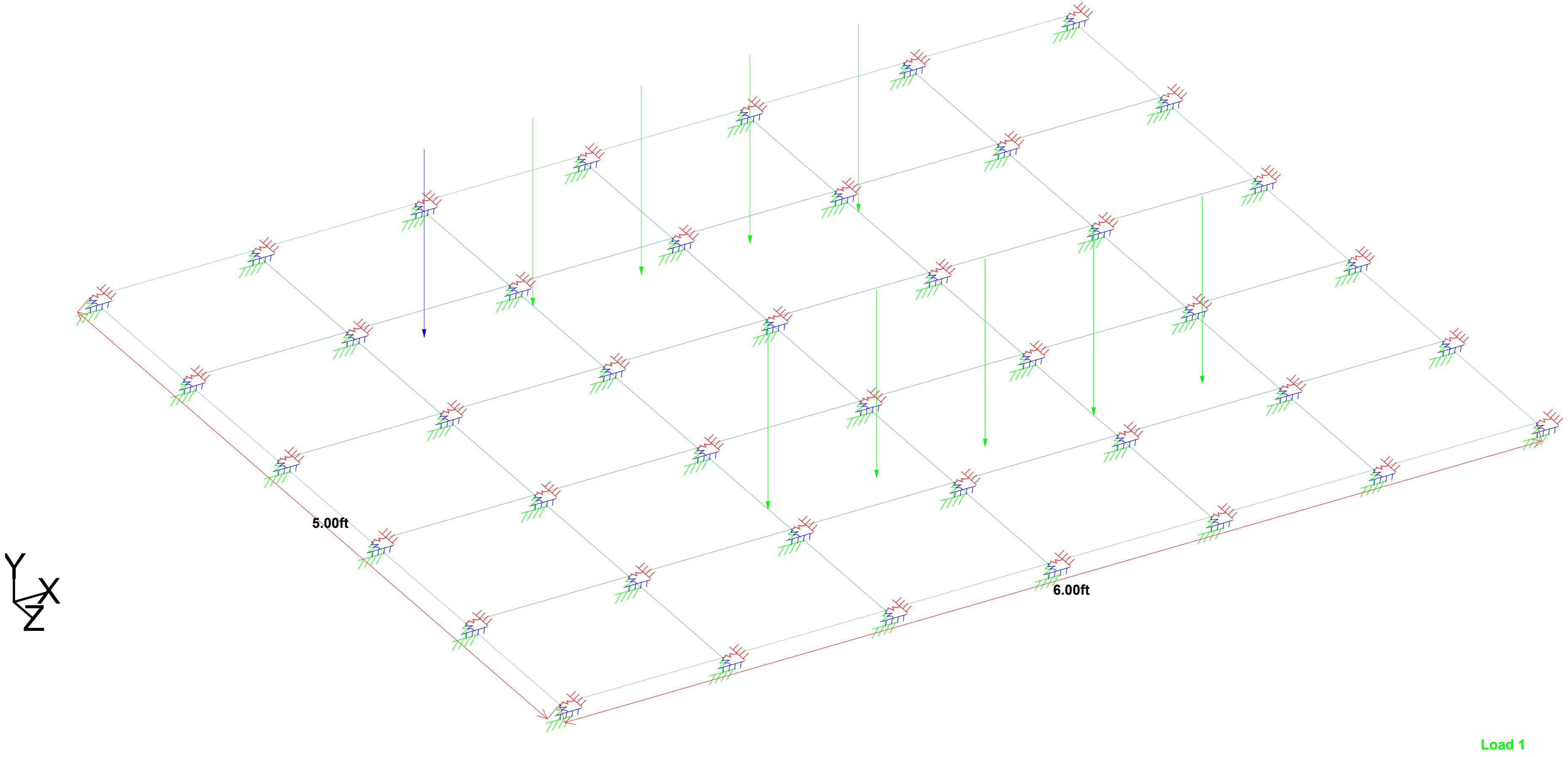
Bar Mat Used:

W11 - 75 Years

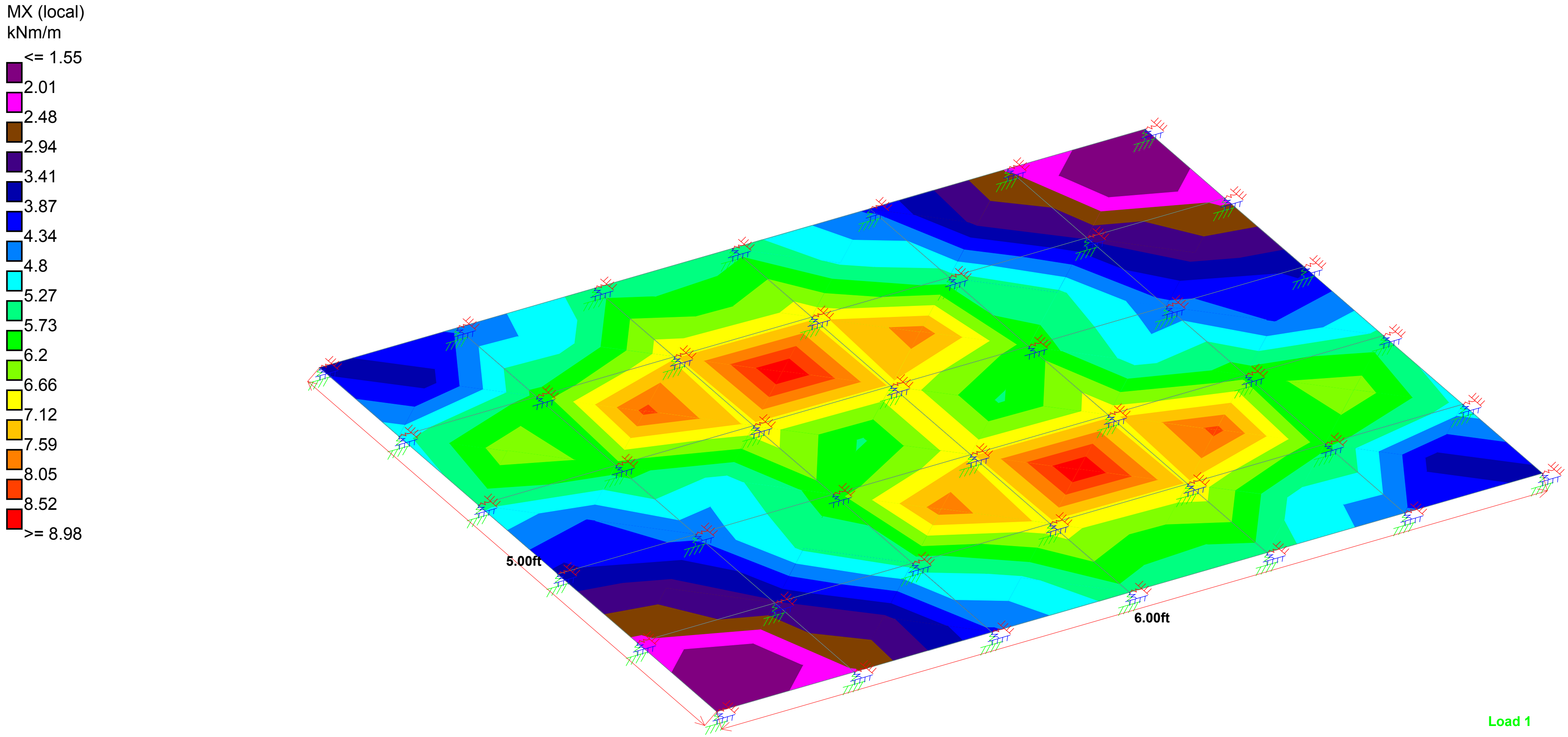
A	=	0.1583	in^2
Fy	=	75	ksi
P	=	0.65 x A x Fy	
	=	7.717	Kips (per wire point)



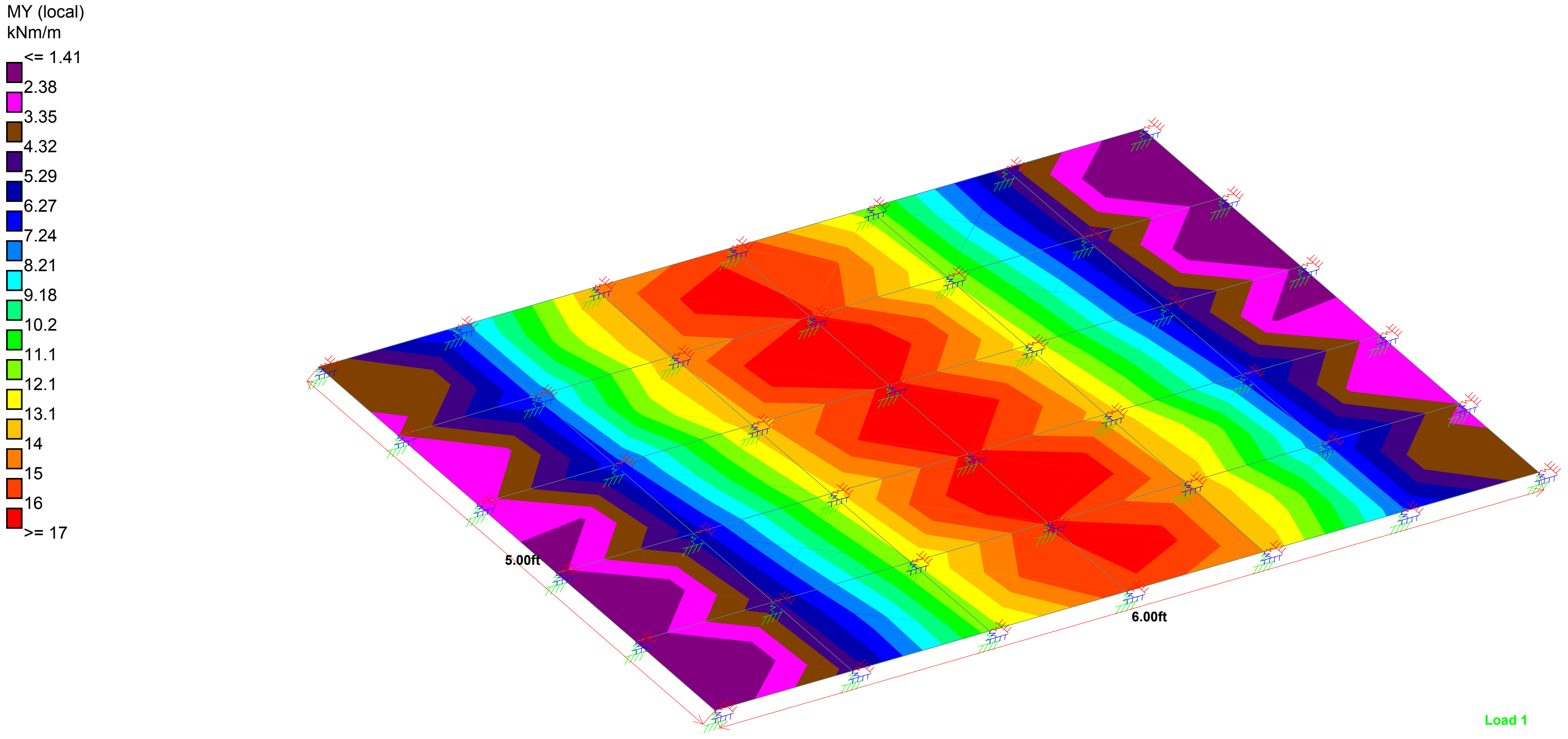
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 22:57	



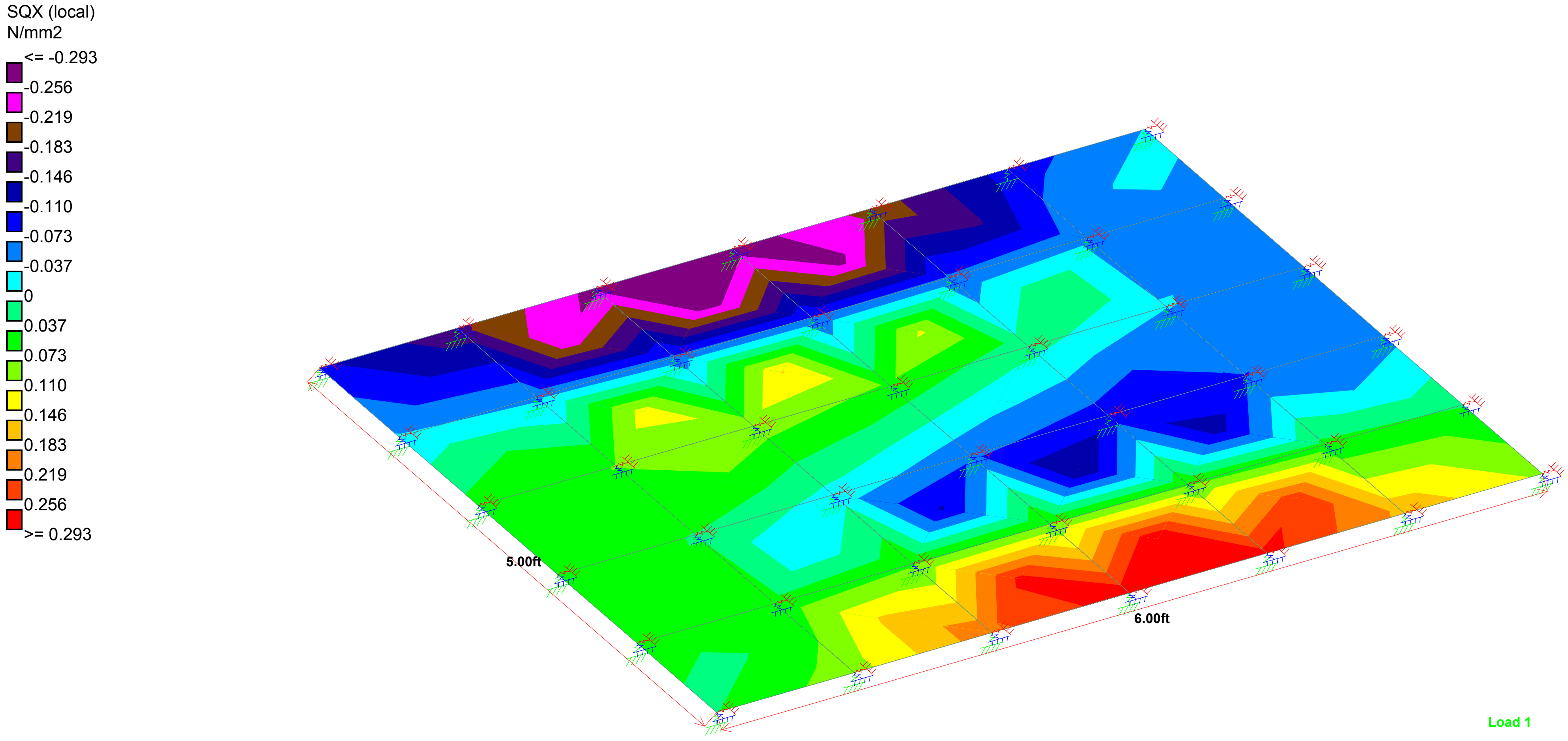
Software licensed to Optimal Engineering Support	Job No	Sheet No 1		Rev
	Part			
Job Title	Ref Panel Check			
	By CH	Date 07-Mar-21		Chd
Client SSL	File Panel Check - 5x6 type A		Date/Time 07-Mar-2021 22:57	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 22:57	

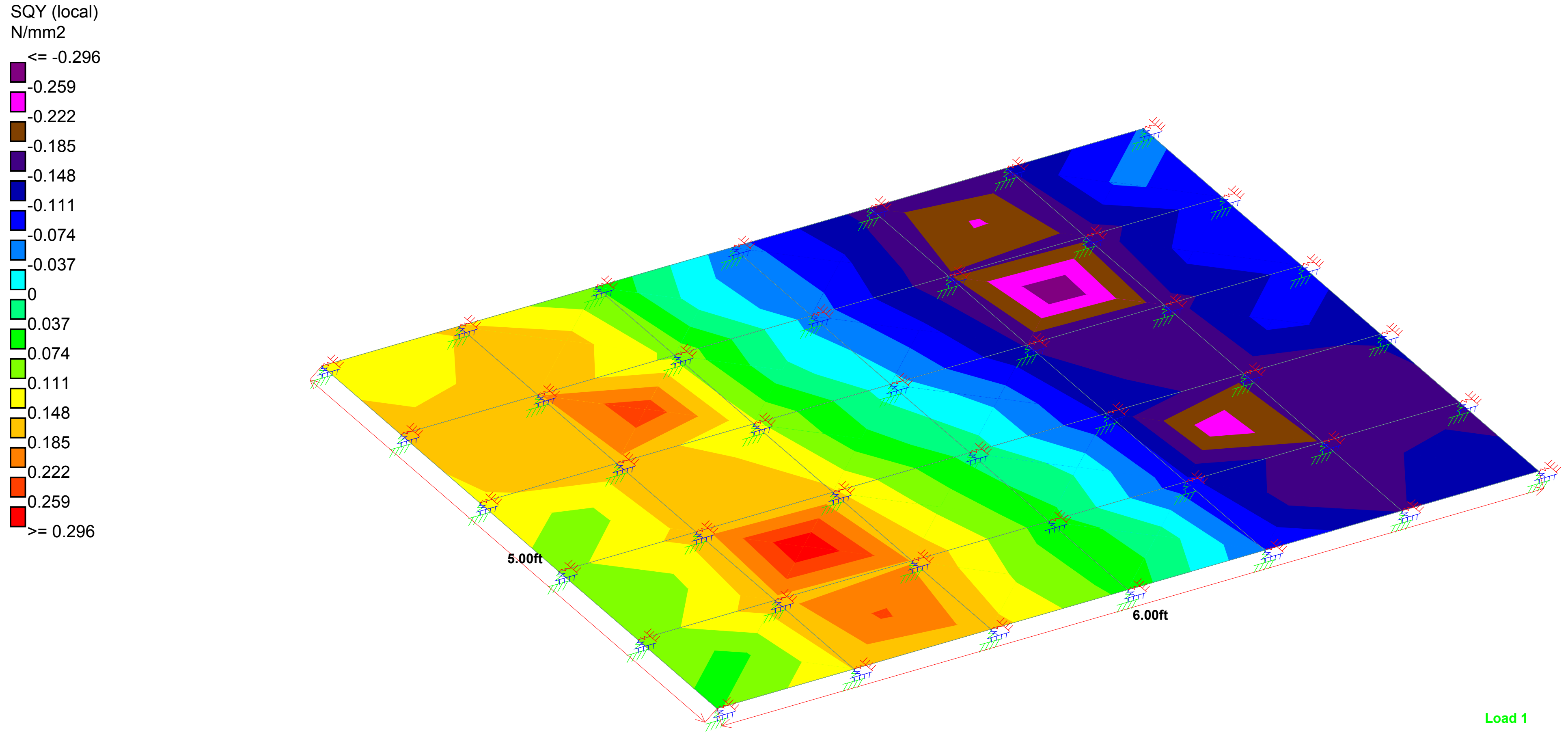


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 22:57	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 22:57	



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*          STAAD.Pro                               *
*          Version  2007    Build 04               *
*          Proprietary Program of                  *
*          Research Engineers,  Intl.              *
*          Date=    MAR  7, 2021                   *
*          Time=    22:58:19                       *
*                                                  *
*      USER ID: Optimal Engineering Support        *
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     1. STAAD SPACE
INPUT FILE: Panel Check - 5x6 type A (5W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 07-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
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    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    20. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -7.717 0.25 -0.1667
    42. 32 PR GY -7.717 0.25 0.5
    43. 33 PR GY -7.717 0.25 0.1667
    44. 34 PR GY -7.717 0.25 -0.1667
    45. 34 PR GY -7.717 0.25 0.5
    46. 5 PR GY -7.717 -0.25 0.5
    47. 8 PR GY -7.717 -0.25 0.1667
    48. 11 PR GY -7.717 -0.25 -0.1667
    49. 11 PR GY -7.717 -0.25 0.5
    50. 14 PR GY -7.717 -0.25 0.1667
    51. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    252
 SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.3/ 263422.0 MB
```

```
    52. FINISH
```

Typical Panel Type (mesh 6W20), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input

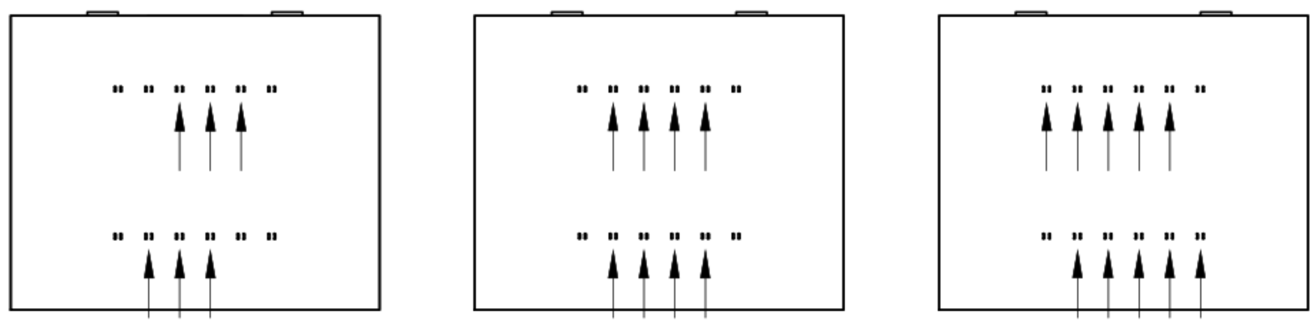
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.1667	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.1667	0.25
P5	0.5	0.25
P6	0.1667	0.25
P7	-0.1667	-0.25
P8	0.5	-0.25
P9	0.1667	-0.25
P10	-0.1667	-0.25
P11	0.5	-0.25
P12	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

A = 0.1583 in^2
Fy = 75 ksi

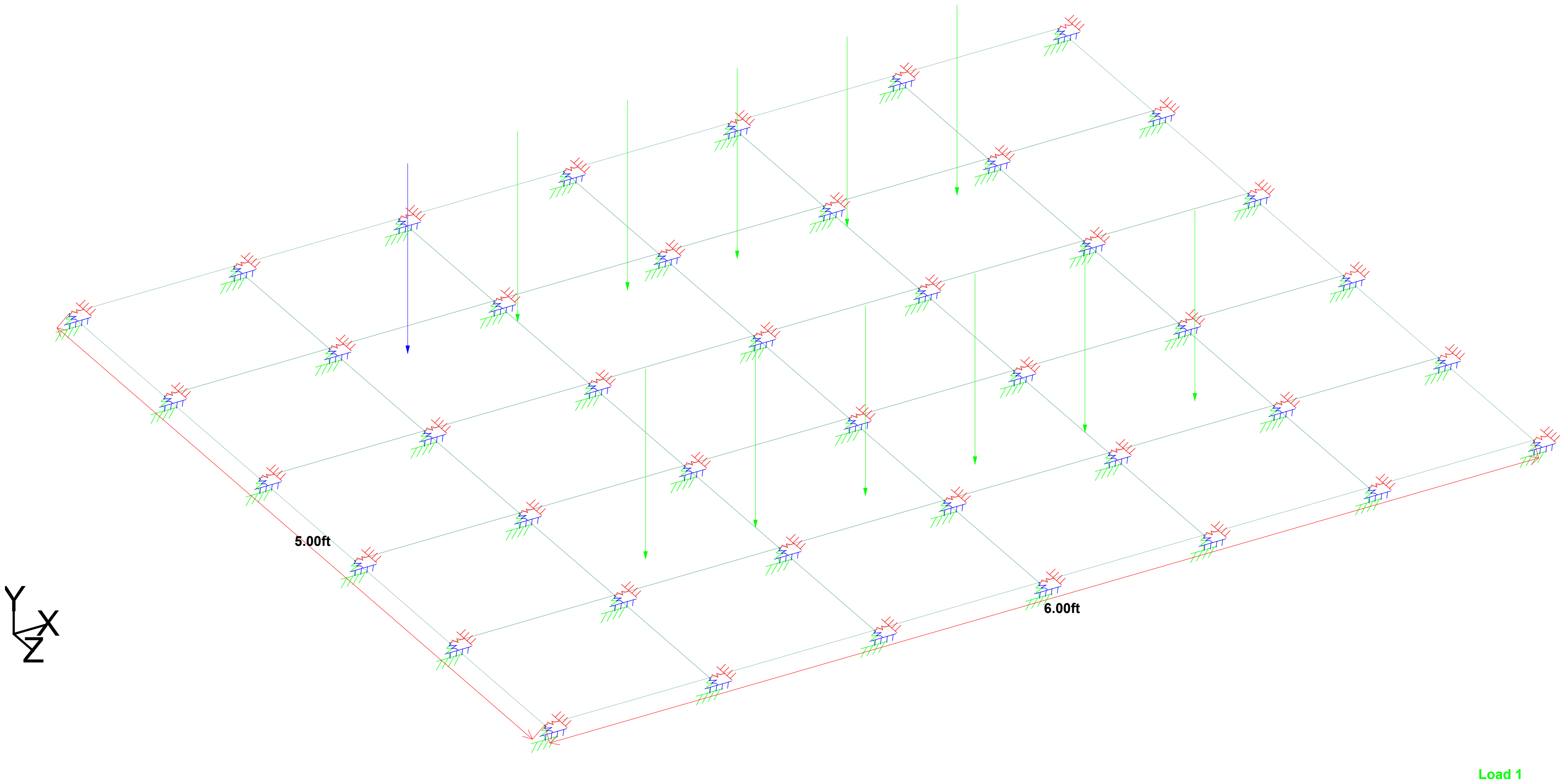
P = 0.65 x A x Fy
= 7.717 Kips (per wire point)



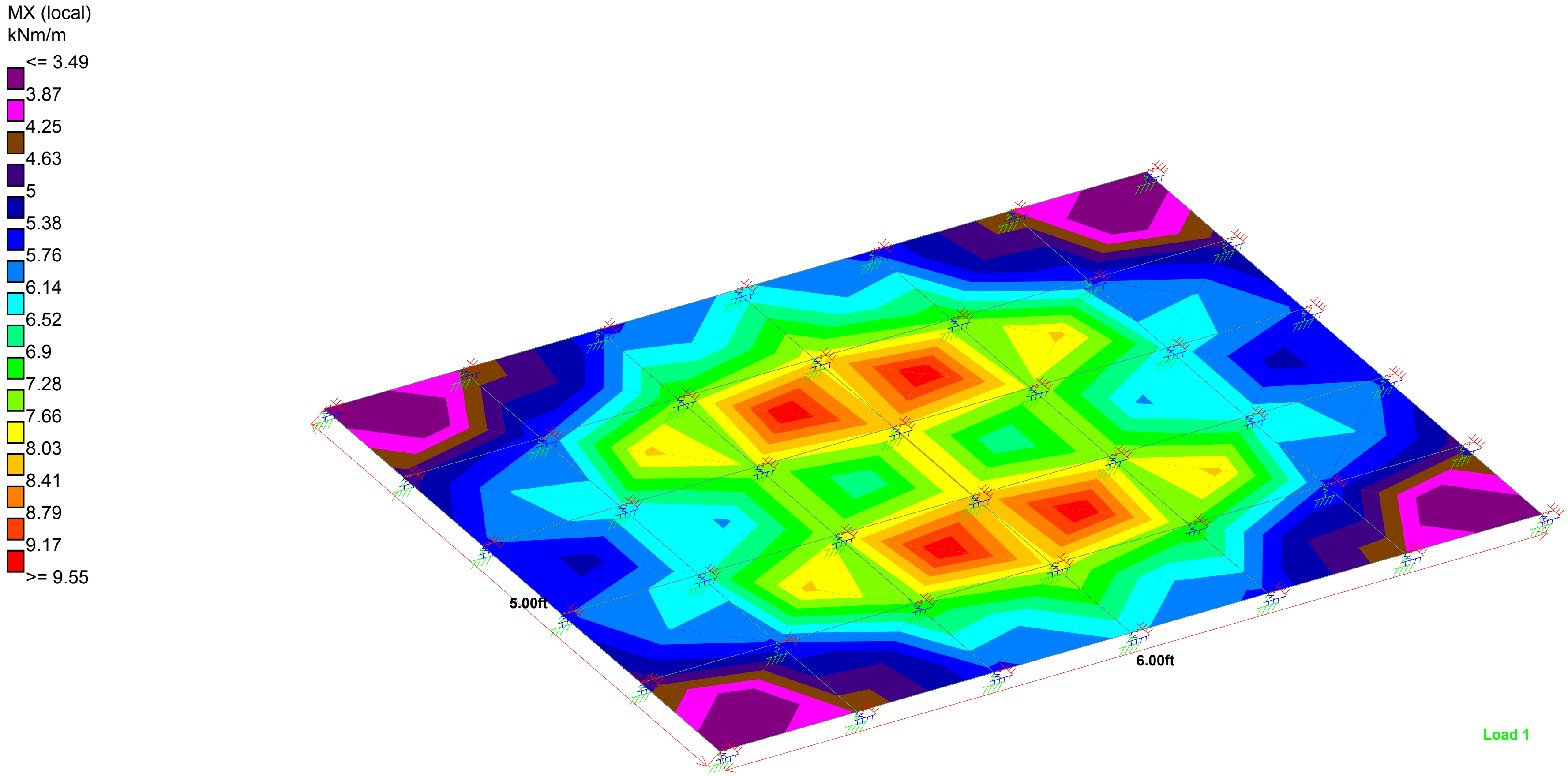
3–WIRE CONNECTION PANEL   4–WIRE CONNECTION PANEL   5–WIRE CONNECTION PANEL

ATTACHMENT BY No. WIRES
(STANDARD PANELS ONLY)

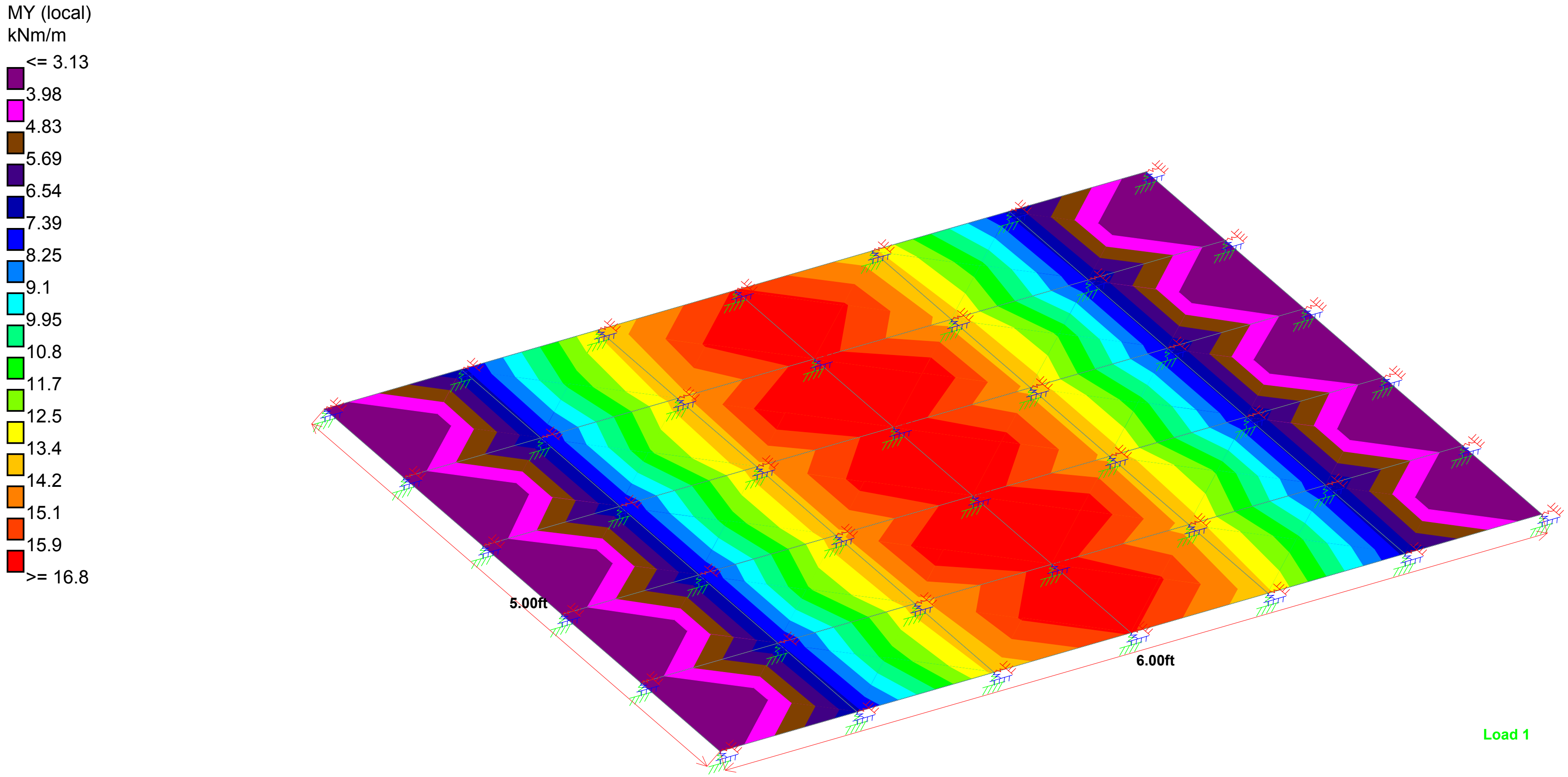
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 23:34	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 23:34	

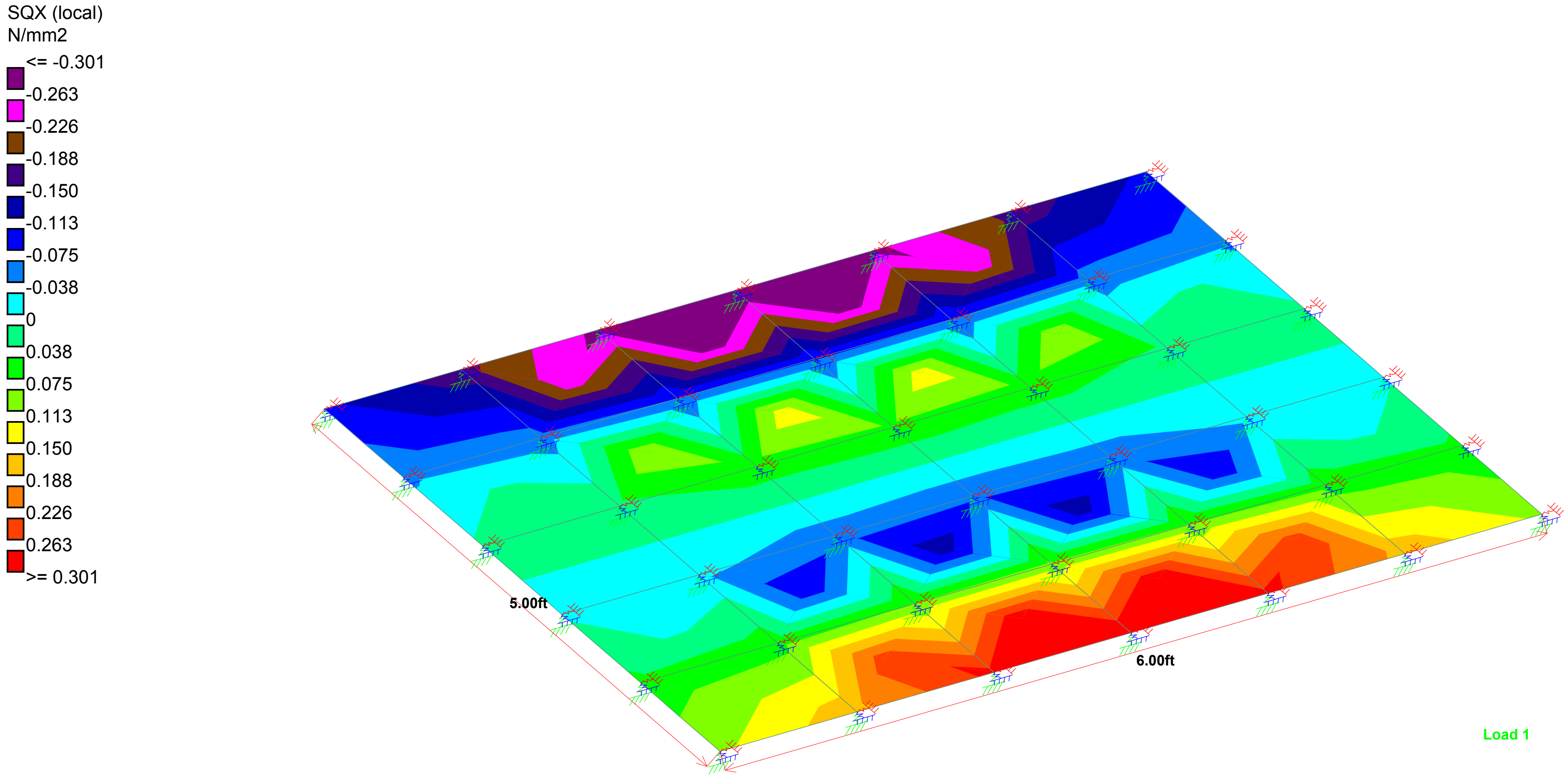


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 23:34	

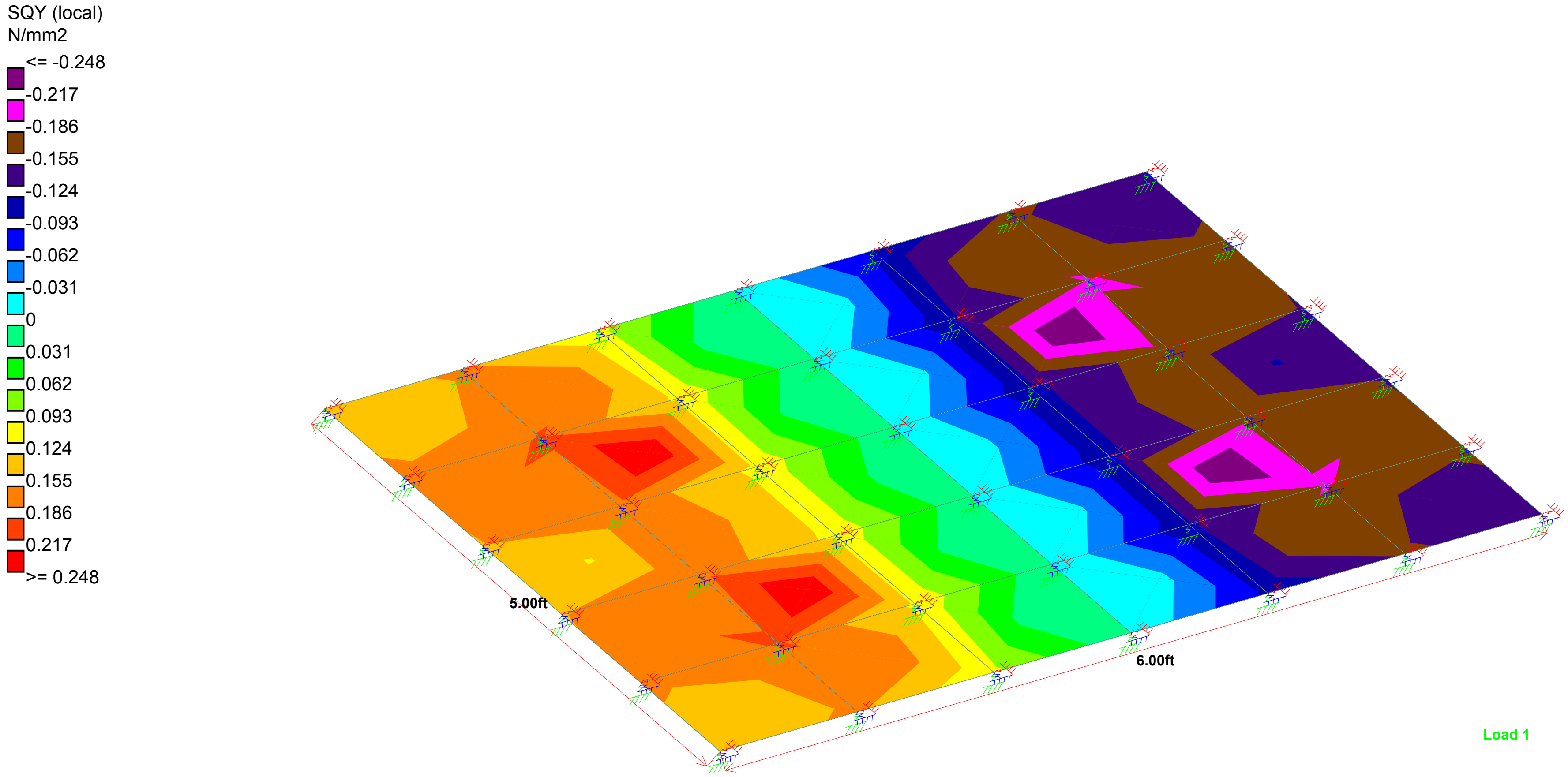


Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
	Part		
	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 23:34	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 07-Mar-2021 23:34	



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*          STAAD.Pro                               *
*          Version  2007    Build 04               *
*          Proprietary Program of                  *
*          Research Engineers,  Intl.              *
*          Date=    MAR  7, 2021                   *
*          Time=    23:34:31                       *
*                                                  *
*      USER ID: Optimal Engineering Support        *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x6 type A (6W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 07-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    20. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -7.717 0.25 -0.1667
    42. 32 PR GY -7.717 0.25 0.5
    43. 33 PR GY -7.717 0.25 0.1667
    44. 34 PR GY -7.717 0.25 -0.1667
    45. 34 PR GY -7.717 0.25 0.5
    46. 35 PR GY -7.717 0.25 0.1667
    47. 5 PR GY -7.717 -0.25 -0.1667
    48. 5 PR GY -7.717 -0.25 0.5
    49. 8 PR GY -7.717 -0.25 0.1667
    50. 11 PR GY -7.717 -0.25 -0.1667
    51. 11 PR GY -7.717 -0.25 0.5
    52. 14 PR GY -7.717 -0.25 0.1667
    53. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

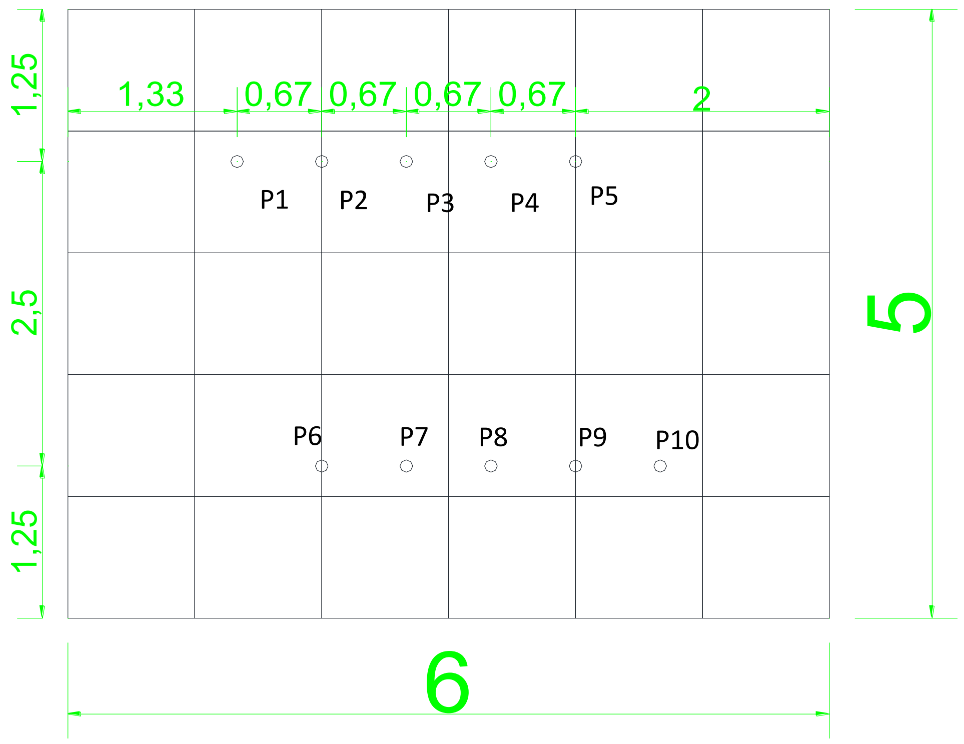
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
 TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    252
 SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.3/ 263420.3 MB
```

```
    54. FINISH
```

Typical Panel Type (mesh 5W24), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.1667	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.1667	0.25
P5	0.5	0.25
P6	0.5	-0.25
P7	0.1667	-0.25
P8	-0.1667	-0.25
P9	0.5	-0.25
P10	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

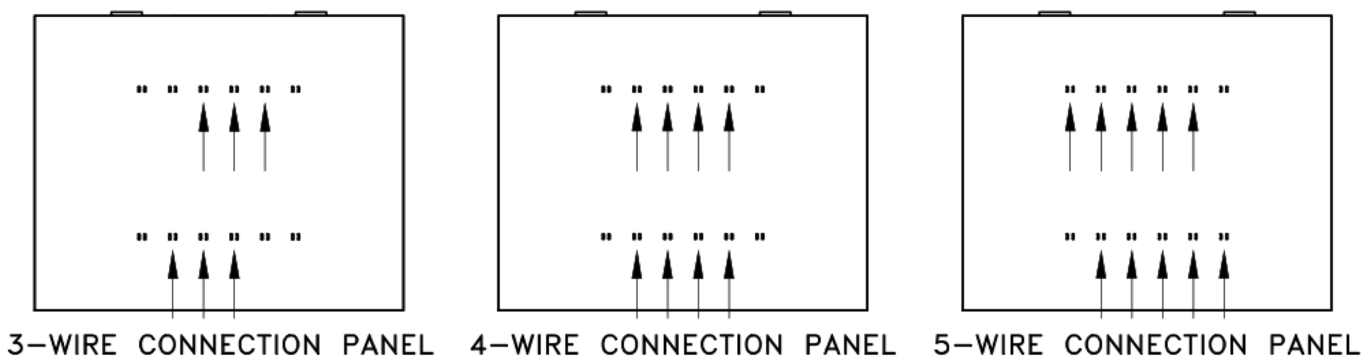
W11 - 75 Years

A = 0.194 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

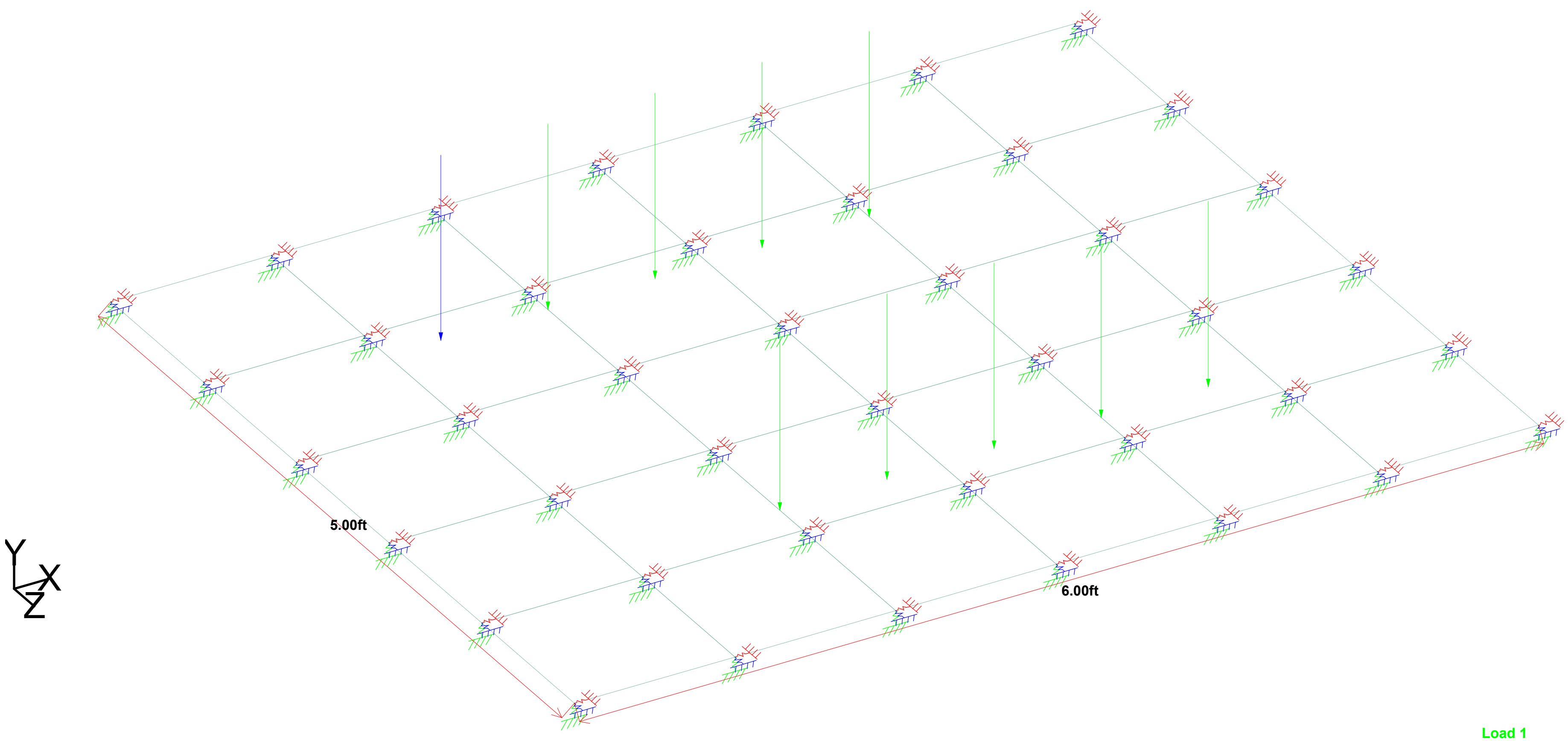
= 9.458 Kips (per wire point)



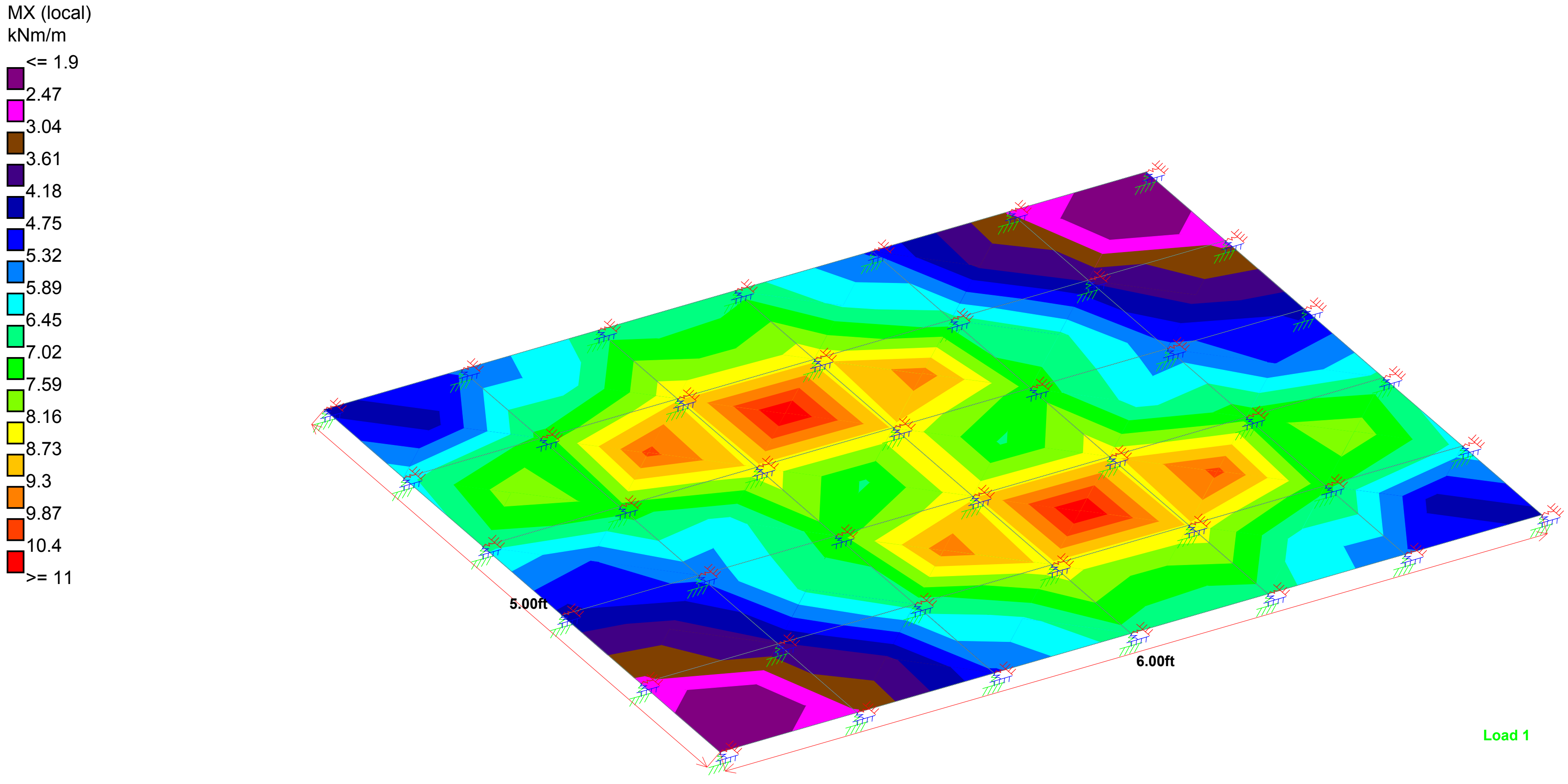
ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 00:08	

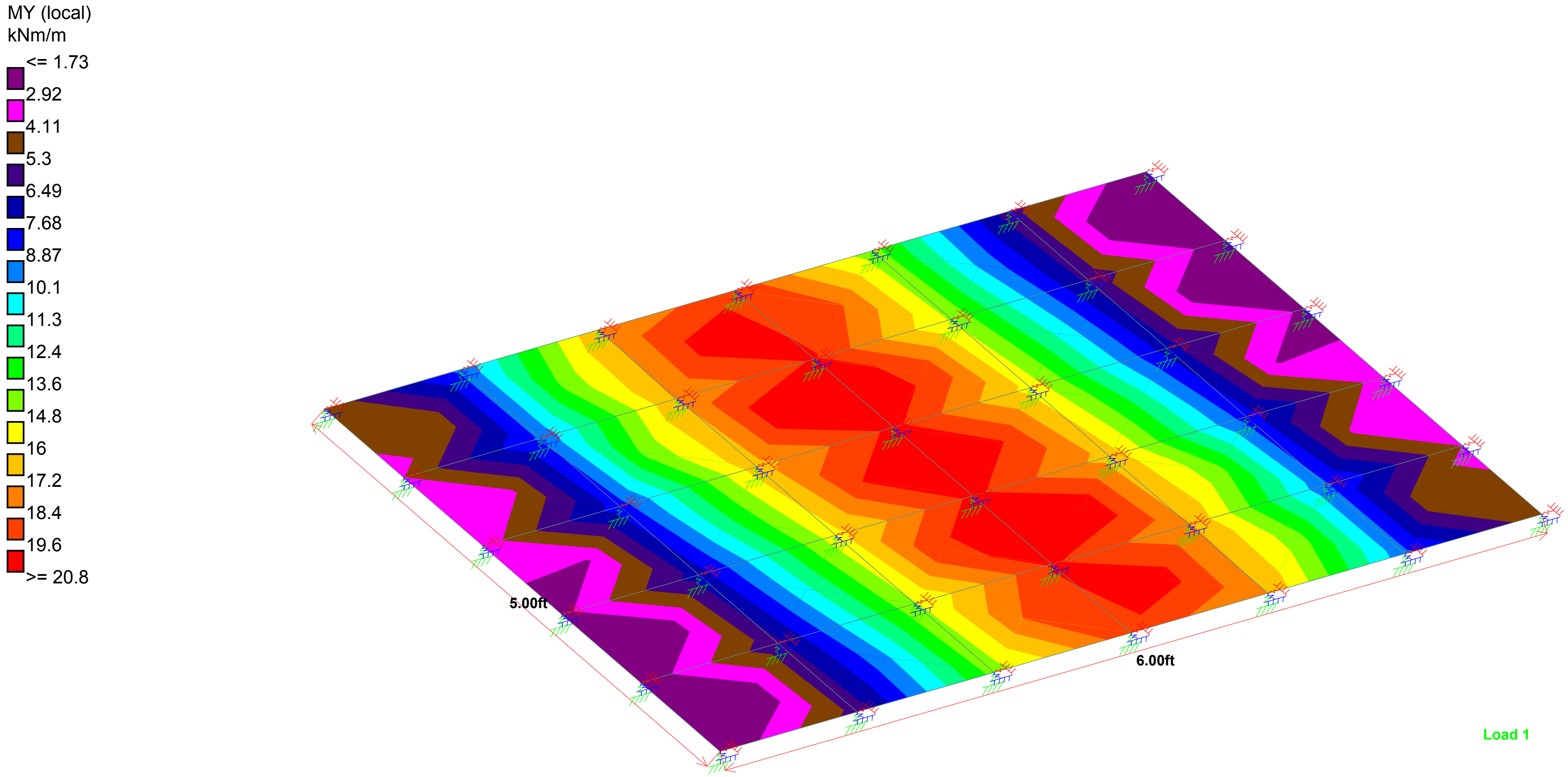


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 00:08	



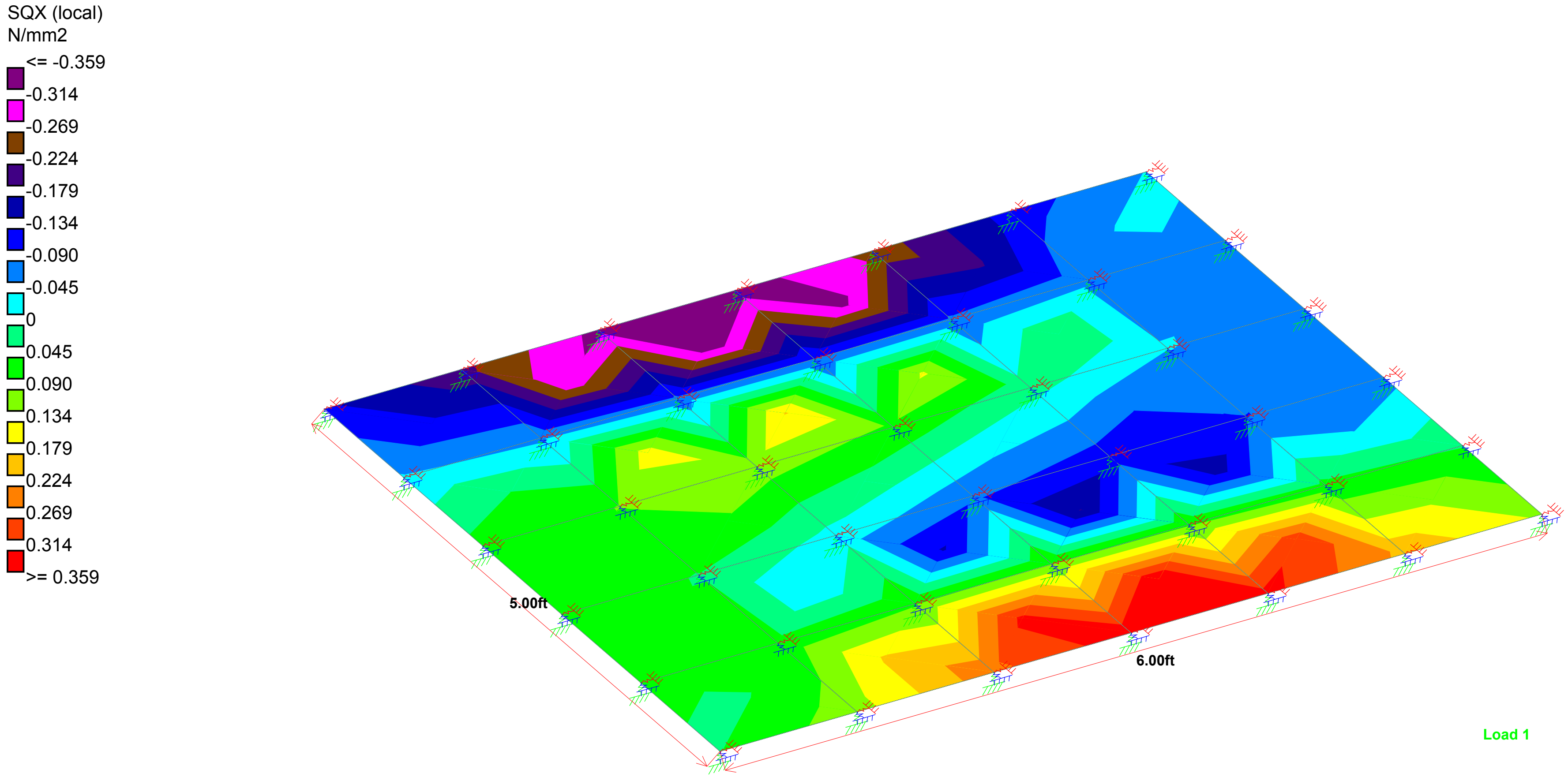
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 00:08	

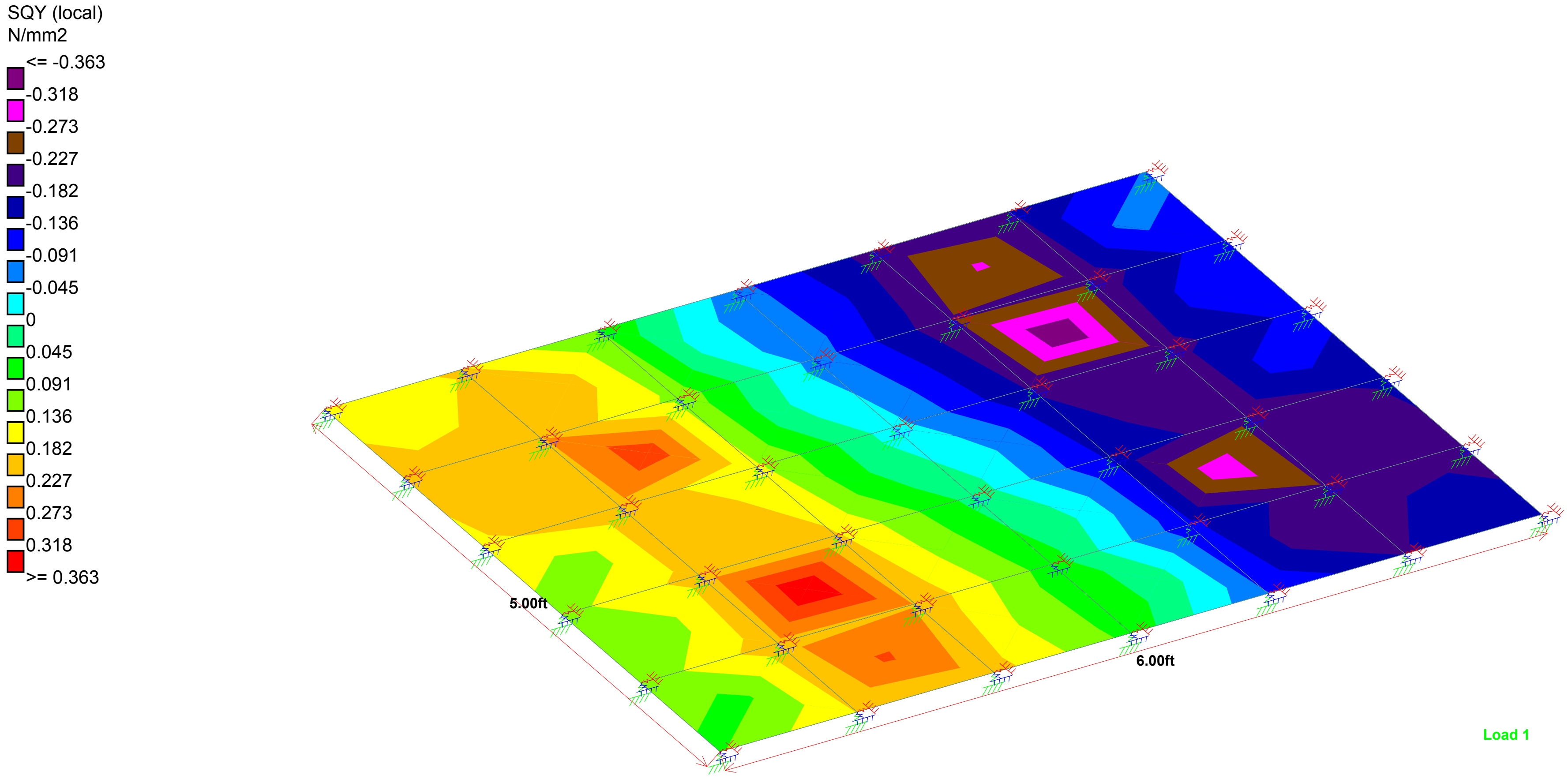


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 00:08	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 00:08	



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 *           STAAD.Pro                                 *
 *           Version  2007    Build 04                 *
 *           Proprietary Program of                    *
 *           Research Engineers,  Intl.                *
 *           Date=    MAR  8, 2021                     *
 *           Time=     0:11: 4                         *
 *                                                     *
 *      USER ID: Optimal Engineering Support           *
 *******************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x6 type A (5W24).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 07-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    20. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -9.458 0.25 -0.1667
    42. 32 PR GY -9.458 0.25 0.5
    43. 33 PR GY -9.458 0.25 0.1667
    44. 34 PR GY -9.458 0.25 -0.1667
    45. 34 PR GY -9.458 0.25 0.5
    46. 5 PR GY -9.458 -0.25 0.5
    47. 8 PR GY -9.458 -0.25 0.1667
    48. 11 PR GY -9.458 -0.25 -0.1667
    49. 11 PR GY -9.458 -0.25 0.5
    50. 14 PR GY -9.458 -0.25 0.1667
    51. PERFORM ANALYSIS
```

```
        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    252
 SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.3/ 263418.5 MB
```

```
    52. FINISH
```

Typical Panel Type (mesh 6W20), Panel Thickness 6", 5'x6'

Point load Input Force in panel for Staad Pro input

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.1667	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.1667	0.25
P5	0.5	0.25
P6	0.1667	0.25
P7	-0.1667	-0.25
P8	0.5	-0.25
P9	0.1667	-0.25
P10	-0.1667	-0.25
P11	0.5	-0.25
P12	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

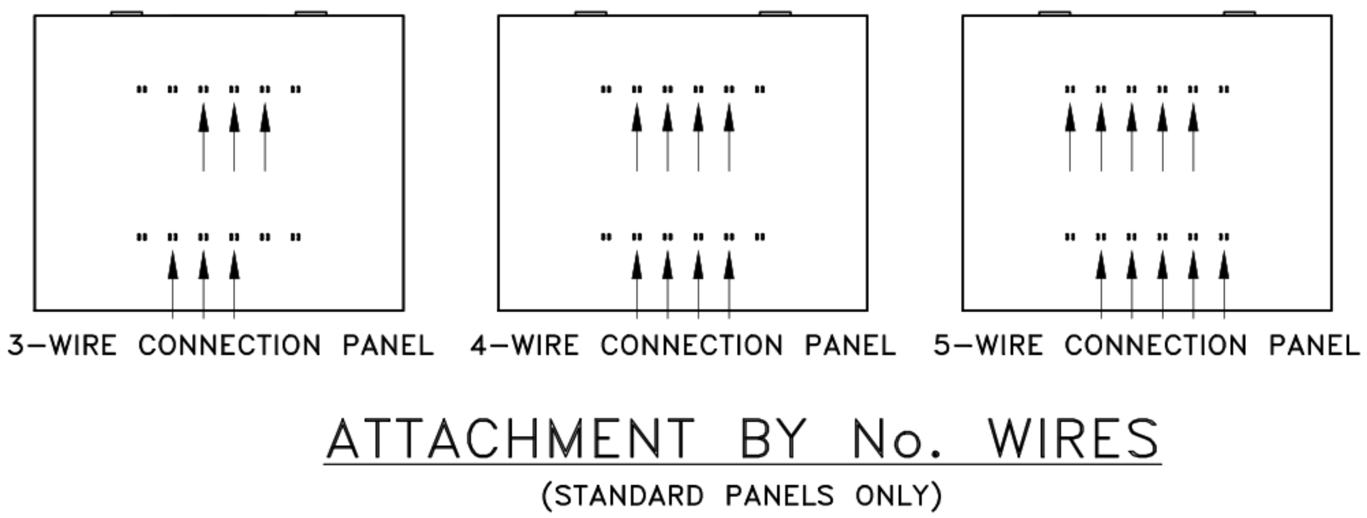
Bar Mat Used:
W11 - 75 Years

$A = 0.194 \text{ in}^2$

$F_y = 75 \text{ ksi}$

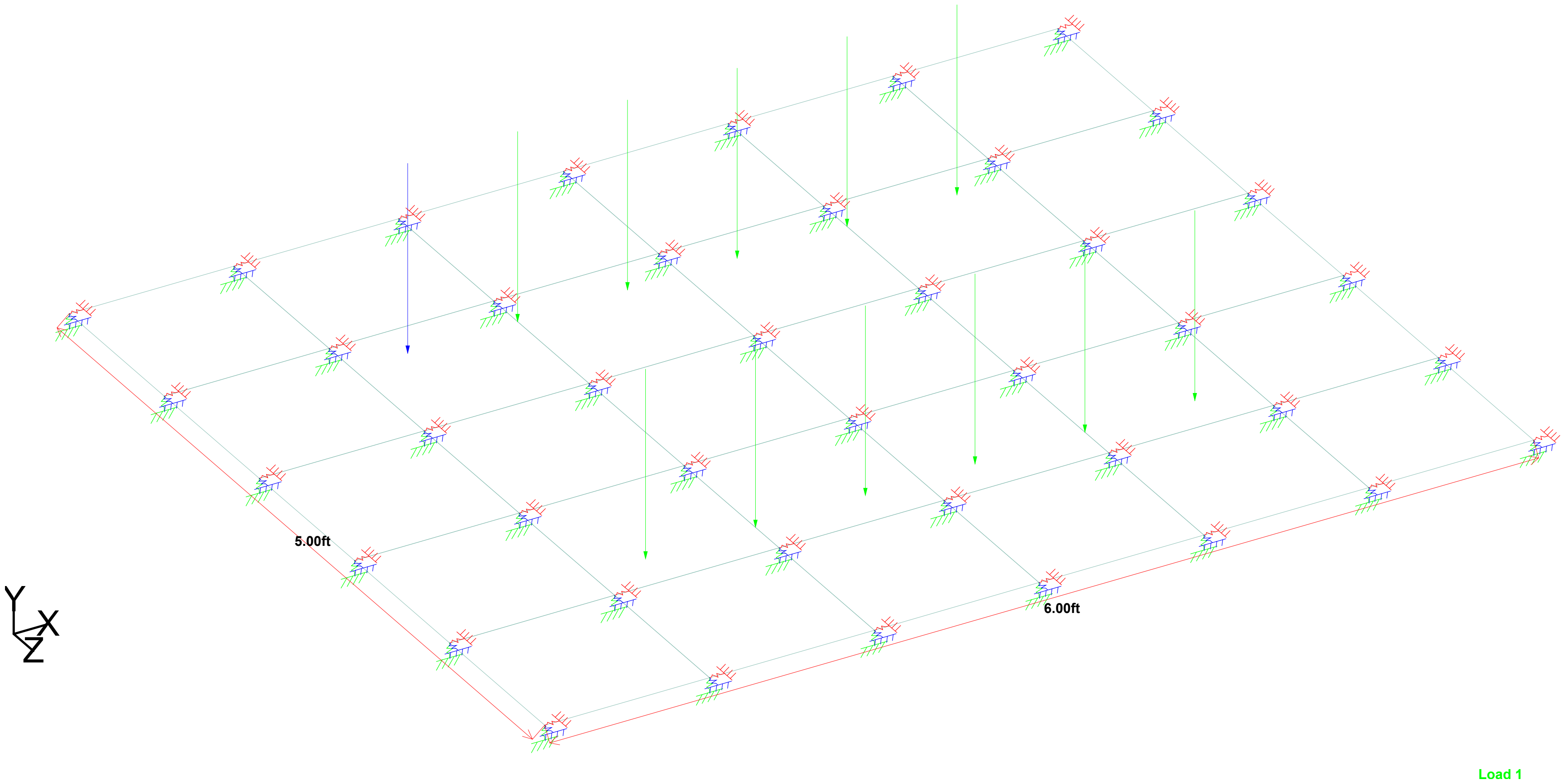
$P = 0.65 \times A \times F_y$

$= 9.458$ Kips (per wire point)



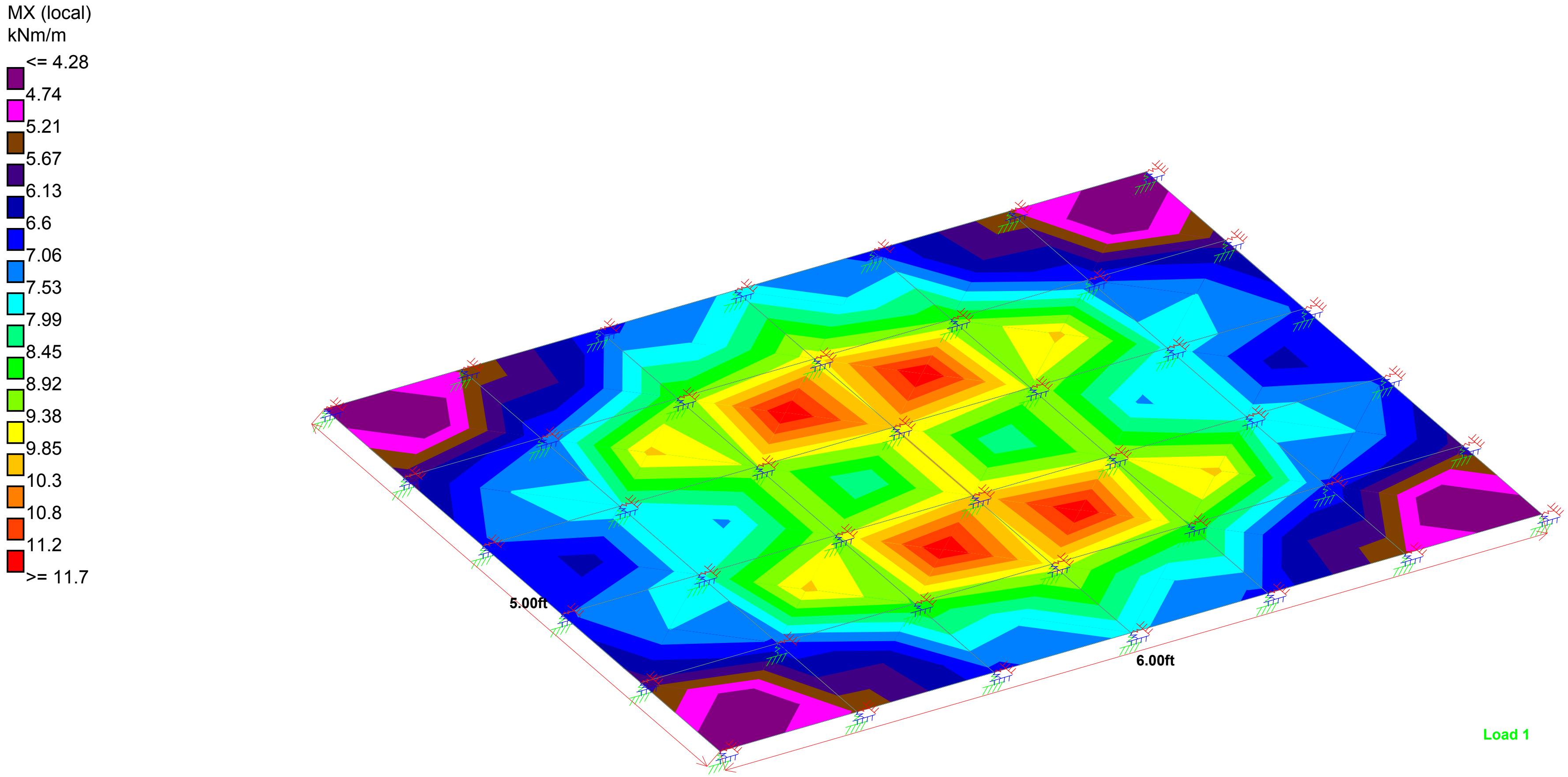
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 01:09	

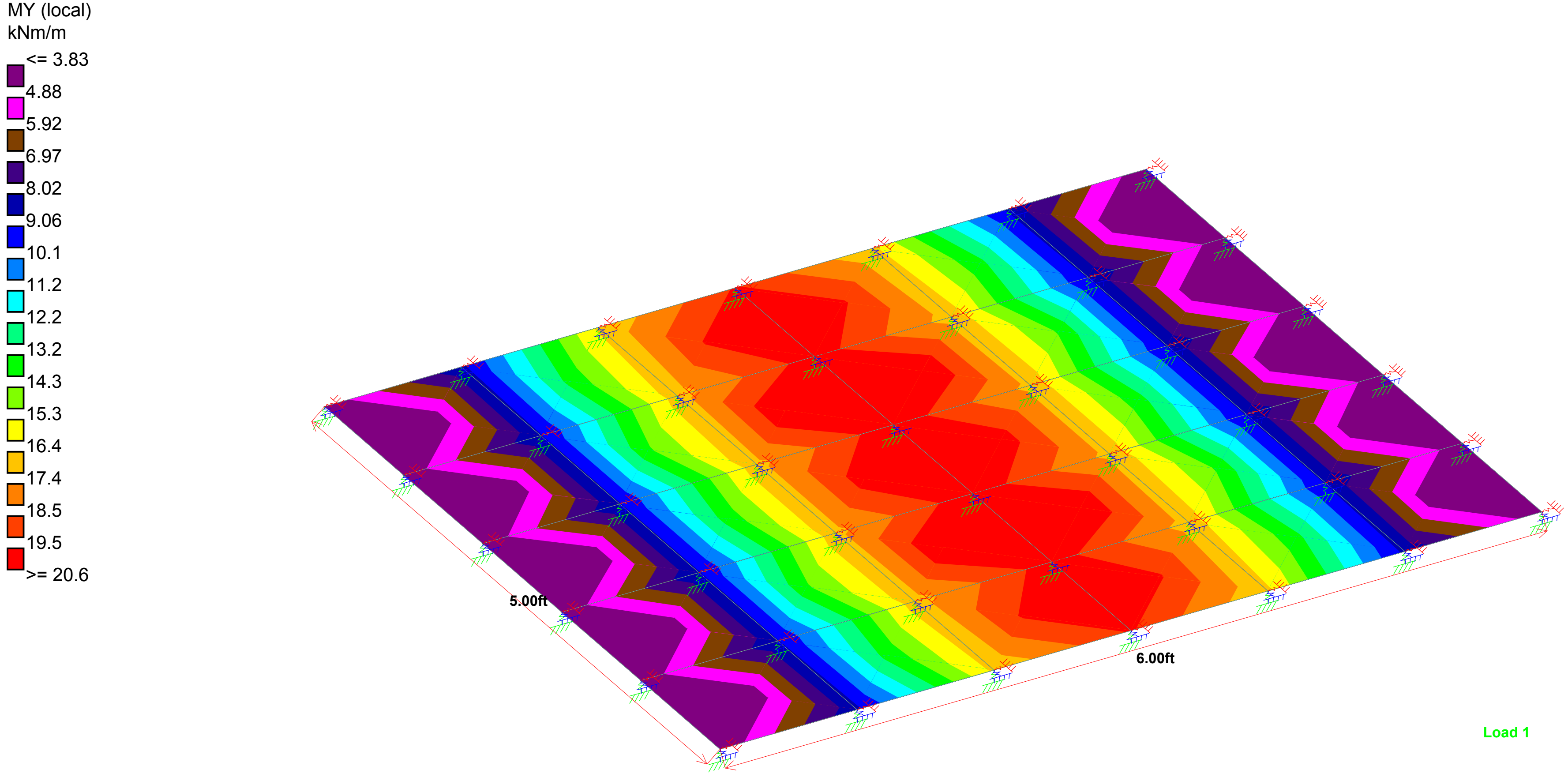


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 01:09	

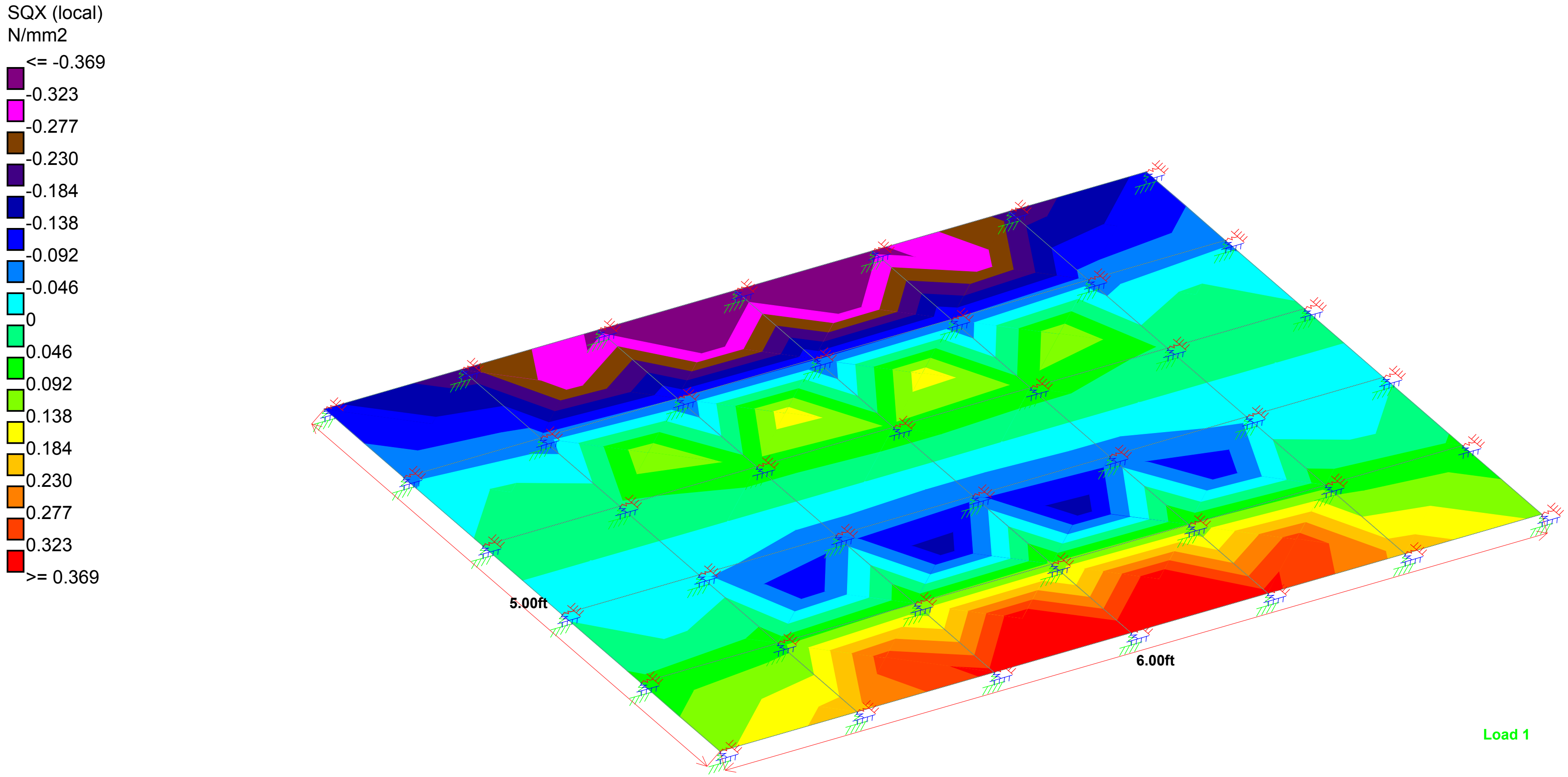


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 01:09	



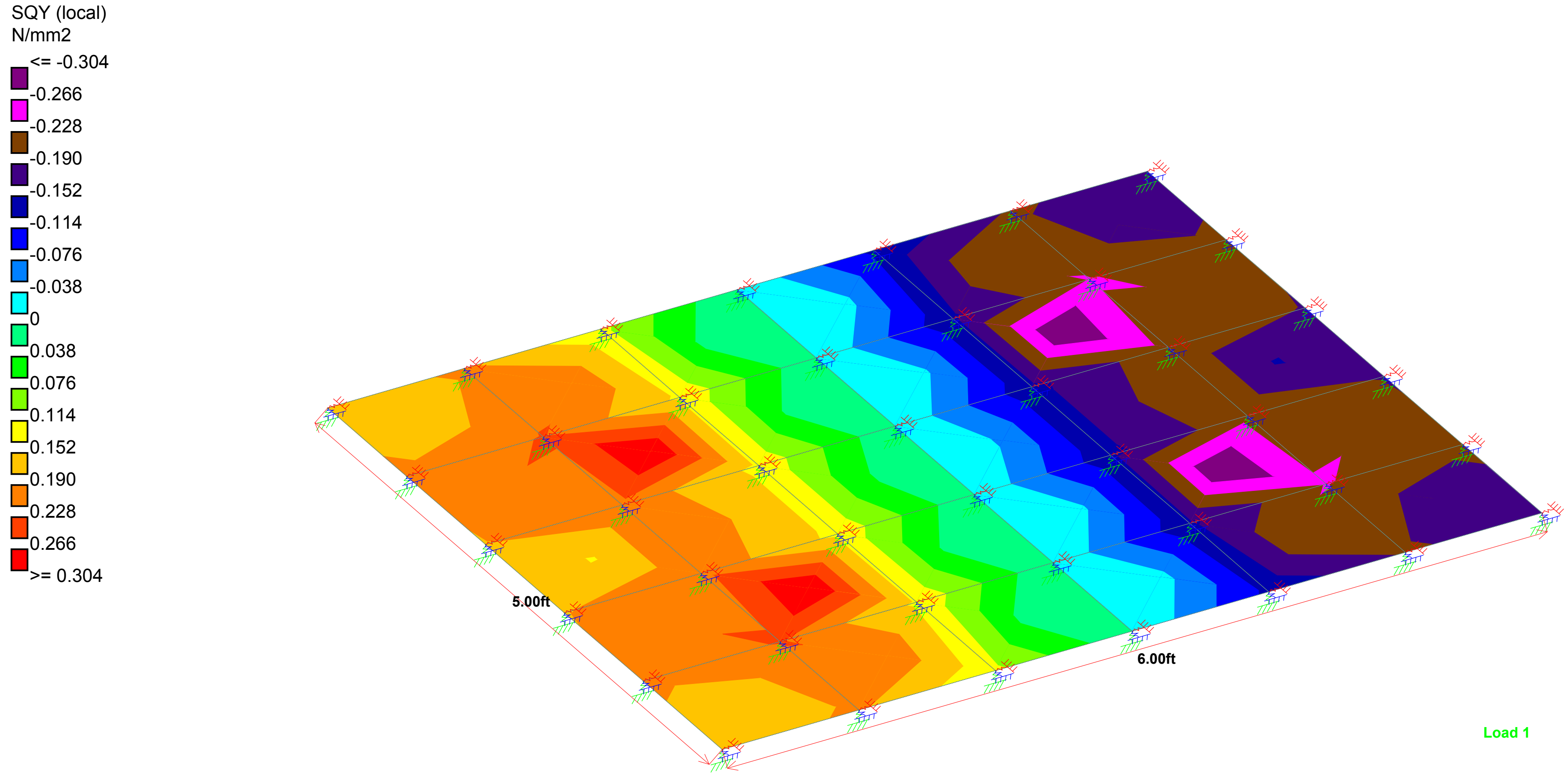
Software licensed to Optimal Engineering Support

Job No	Sheet No 1		Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 01:09	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 07-Mar-21	Chd
Client SSL	File Panel Check - 5x6 type A	Date/Time 08-Mar-2021 01:09	



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*                                                  *
*          STAAD.Pro                               *
*          Version  2007    Build 04               *
*          Proprietary Program of                  *
*          Research Engineers,  Intl.              *
*          Date=    MAR  8, 2021                   *
*          Time=     1:17:38                       *
*                                                  *
*      USER ID: Optimal Engineering Support        *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x6 type A (6W24).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 07-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5
    17. ELEMENT INCIDENCES SHELL
    18. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    19. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    20. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    21. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    22. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    23. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    24. ELEMENT PROPERTY
    25. 1 TO 18 31 TO 36 41 TO 46 THICKNESS 0.5
    26. DEFINE MATERIAL START
    27. ISOTROPIC CONCRETE
    28. E 614304
    29. POISSON 0.17
    30. DENSITY 0.15
    31. ALPHA 1E-005
    32. DAMP 0.05
    33. END DEFINE MATERIAL
    34. CONSTANTS
    35. MATERIAL CONCRETE ALL
    36. SUPPORTS
    37. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 61 -
    38. 62 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    39. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    40. ELEMENT LOAD
```



```
    41. 32 PR GY -9.458 0.25 -0.1667
    42. 32 PR GY -9.458 0.25 0.5
    43. 33 PR GY -9.458 0.25 0.1667
    44. 34 PR GY -9.458 0.25 -0.1667
    45. 34 PR GY -9.458 0.25 0.5
    46. 35 PR GY -9.458 0.25 0.1667
    47. 5 PR GY -9.458 -0.25 -0.1667
    48. 5 PR GY -9.458 -0.25 0.5
    49. 8 PR GY -9.458 -0.25 0.1667
    50. 11 PR GY -9.458 -0.25 -0.1667
    51. 11 PR GY -9.458 -0.25 0.5
    52. 14 PR GY -9.458 -0.25 0.1667
    53. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    42/    30/    42

      SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
 TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    252
 SIZE OF STIFFNESS MATRIX =       14 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.3/ 263416.8 MB
```

```
    54. FINISH
```

Summary Result From Staad Pro Analysis Output

Standard Panel Size	Barmat Type	Panel Type	Horz Rebar	Vert Rebar	Staad Pro Output				Data for AASHTO LRFD Design Check			
					Mx (kNm/m)	My (kNm/m)	SQx (N/mm^2)	SQy (N/mm^2)	Mx (Kips-ft/ft)	My (Kips-ft/ft)	SQx (lbs/in^2)	SQy (lbs/in^2)
5'x6'	3W11	A	4 #4	4 #4	3.180	7.080	0.125	0.140	0.715	1.592	18.130	20.305
	4W11				3.660	8.100	0.130	0.149	0.823	1.821	18.855	21.611
	5W11				4.520	**8.540**	0.147	**0.149**	1.016	**1.920**	21.321	**21.611**
	6W11				**4.810**	8.450	**0.151**	0.125	**1.081**	1.900	**21.901**	18.130
	4W20	X	6 #4	5 #4	7.270	16.100	0.257	0.296	1.634	3.619	37.275	42.931
	5W20				8.980	**17.000**	0.293	**0.296**	2.019	**3.822**	42.496	**42.931**
	6W20				**9.550**	16.800	**0.301**	0.248	**2.147**	3.777	**43.656**	35.969
	5W24	Y	7 #4	7 #4	11.000	**20.800**	0.359	**0.363**	2.473	**4.676**	52.069	**52.649**
	6W24				**11.700**	20.600	**0.369**	0.304	**2.630**	4.631	**53.519**	44.092

* Maximum bending moment and shear for each standard panel size shown in **red bold** font

5’ x 6’ STANDARD

A PANEL

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x6', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	15	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2 d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.157	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.92	kip-ft	$+M_{u\_service}$	=	1.42	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.231 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.923 kip-ft

Check $+\varphi M_n > +M_u$ 2.923 > 1.92 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.231 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.155 kip-ft

Check $-\varphi M_n > -M_u$ 1.155 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	2.55	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	2.55	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 2.923 > 2.55 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 1.155 > 0.00 **OK**

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x6', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\,\pi {d_b}^2$
Rebar spacing	s	=	15	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.157	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s\,.\,f_s}{\alpha_1.\,f_c{}'.\,\beta_1\,.\,b}$	c	=	0.272	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.114	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316\,.\,\beta\,.\,\alpha\,.\sqrt{f_c{}'}\,.\,b_v\,.\,d_v$	Vc	=	6.240	Kips
$V_s = \frac{A_v\,.\,f_y\,.\,d_v\,.\,(\cot\theta + \cot\alpha)\,.\,\sin\alpha}{s}$	Vs	=	3.231	Kips
	(1) Vn	=	9.472	Kips
(2) $V_n = 0.25\,.\,f_c'.\,b_v\,.\,d_v$	(2) Vn	=	49.369	Kips
From (1) and (2) Vn should be:	Vn	=	9.472	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	8.524	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.149	N/mm^2		
	=	21.61	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1555.97	lbs		
	=	1.556	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x6', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1\!/_4 \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1\!/_2 d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.08	kip-ft	$+M_{u\_service}$	=	0.80	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.152 kip-ft

Check $+\varphi M_n > +M_u$ 2.152 > 1.08 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.269 kip-ft

Check $-\varphi M_n > -M_u$ 1.269 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:
1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	1.44	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	1.44	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 2.152 > 1.44 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 1.269 > 0.00 **OK**

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x6', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \cdot f_s}{\alpha_1 \cdot f_c{}' \cdot \beta_1 \cdot b}$	c	=	0.226	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.137	in	

AASHTO 5.7.3.3

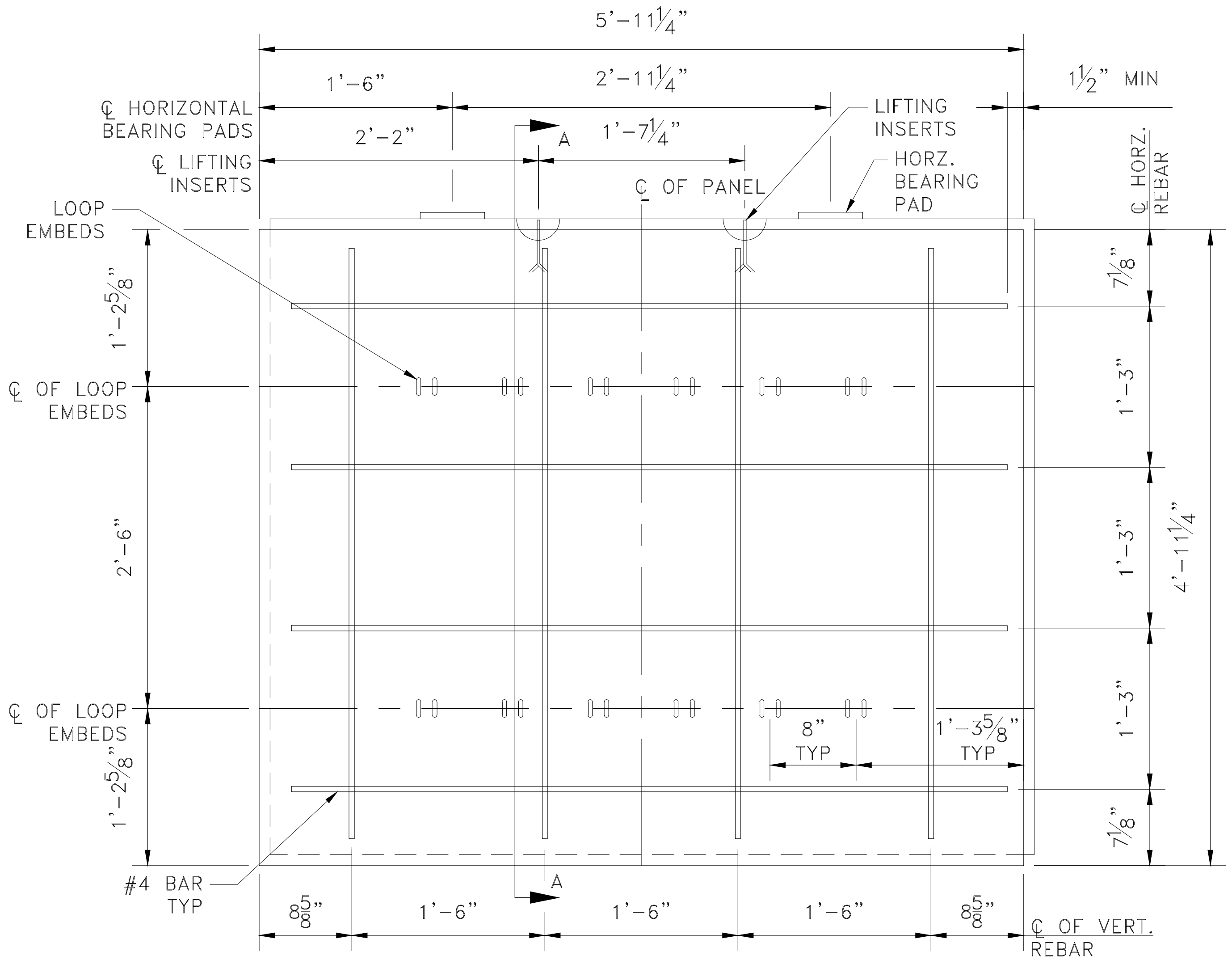
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \cdot \beta \cdot \alpha \cdot \sqrt{f_c{}'} \cdot b_v \cdot d_v$	Vc	=	4.758	Kips
$V_s = \frac{A_v \cdot f_y \cdot d_v \cdot (\cot\theta + \cot\alpha) \cdot \sin\alpha}{s}$	Vs	=	2.053	Kips
	(1) Vn	=	6.811	Kips
(2) $V_n = 0.25 \cdot f_c' \cdot b_v \cdot d_v$	(2) Vn	=	37.641	Kips
From (1) and (2) Vn should be:	Vn	=	6.811	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.130	Kips

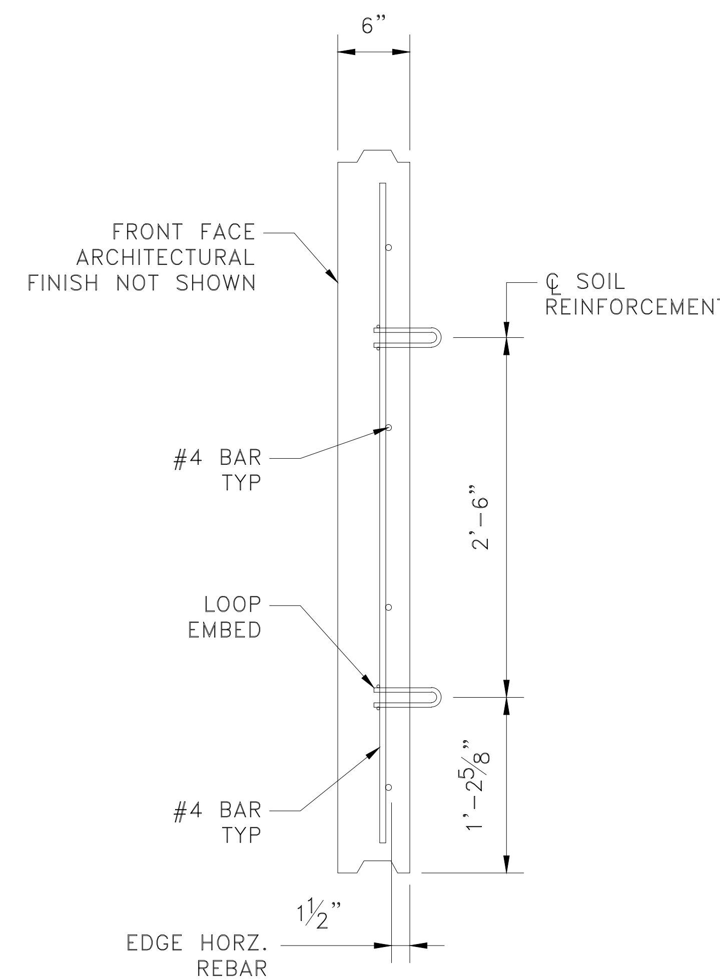
Shear Force:

From Staad Pro Result Vmax	=	0.151	N/mm^2		
	=	21.90	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1576.85	lbs		
	=	1.577	Kips	**OK, Vmax less than Vn**	



STANDARD "A" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY:	WM	01/24/22
CHECK BY:	FSH	01/24/22
DESIGN BY:	FSH	01/24/22
CHECK BY:	SR	01/24/22
PROJ. ENGR:	FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X6' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 6’ STANDARD

X PANEL

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x6', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per

AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.

This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	3.82	kip-ft	$+M_{u\_service}$	=	2.83	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \frac{a}{2}\right)$ = 4.323 kip-ft

Check $+\varphi M_n > +M_u$ 4.323 > 3.82 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \frac{a}{2}\right)$ = 1.672 kip-ft

Check $-\varphi M_n > -M_u$ 1.672 > 0.00 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:
1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor	γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength	γ_3	=	0.67		(A615 steel)
concrete density modification factor	λ	=	1.00		AASHTO 5.4.2.8

modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	5.08	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 4.323 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 1.672 > 0.00 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x6', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c{}' . \beta_1 \,.\, b}$	c	=	0.408	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.046	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316\,.\,\beta\,.\,\alpha\,.\,\sqrt{f_c{}'}\,.\,b_v\,.\,d_v$	Vc	=	6.137	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\,(\cot\theta + \cot\alpha)\,.\,\sin\alpha}{s}$	Vs	=	4.767	Kips
	(1) Vn	=	10.904	Kips
(2) $V_n = 0.25\,.\,f_c'.\,b_v\,.\,d_v$	(2) Vn	=	48.554	Kips
From (1) and (2) Vn should be:	Vn	=	10.904	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	9.814	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.296	N/mm^2		
	=	42.93	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3091.05	lbs		
	=	3.091	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x6', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 {W_c}^2 {f'_c}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.15	kip-ft	$+M_{u\_service}$	=	1.59	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.186 kip-ft

Check $+\varphi M_n > +M_u$ 3.186 > 2.15 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.860 kip-ft

Check $-\varphi M_n > -M_u$ 1.860 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor	γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength	γ_3	=	0.67		(A615 steel)
concrete density modification factor	λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture $f_r = 0.24\lambda\sqrt{f'_c}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section $S_c = \frac{b\,h^2}{6} = \frac{b t_{panel}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment $M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment		=	2.86	kip-ft
Cracking moment		=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})		=	2.86	kip-ft
Check: $+\varphi M_n > \min(+M_u, M_{cr})$	3.186	>	2.86	**OK**

check negative moment reinforcement:

1.33 x factored ultimate moment		=	0.00	kip-ft
Cracking moment		=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})		=	0.00	kip-ft
Check: $-\varphi M_n > \min(-M_u, M_{cr})$	1.860	>	0.00	**OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x6', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c{}' . \beta_1 \,.\, b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

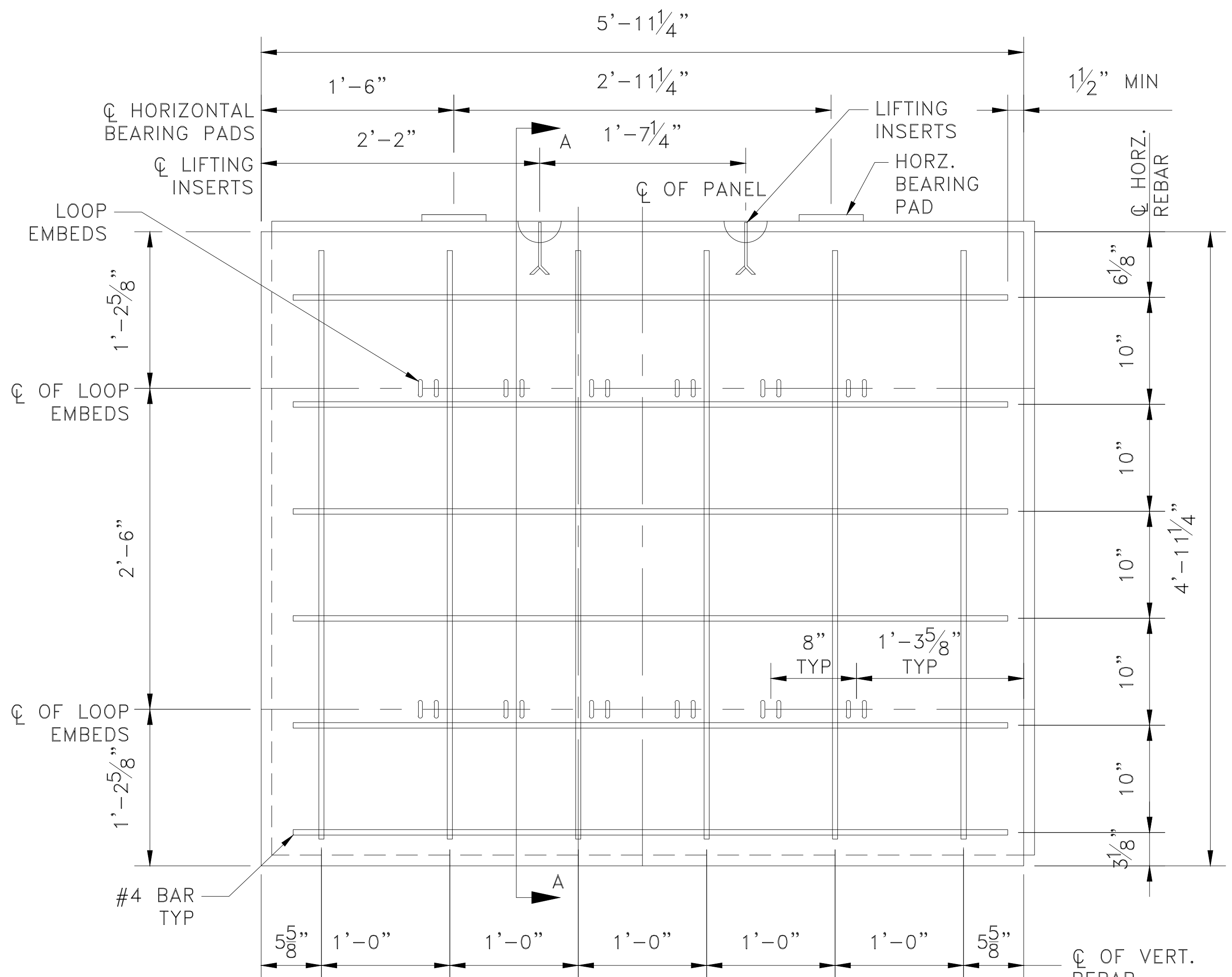
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c{}'} \,.\, b_v \,.\, d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 \,.\, f_c' . b_v \,.\, d_v$	(2) Vn	=	36.962	Kips
From (1) and (2) Vn should be:	Vn	=	7.696	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.926	Kips

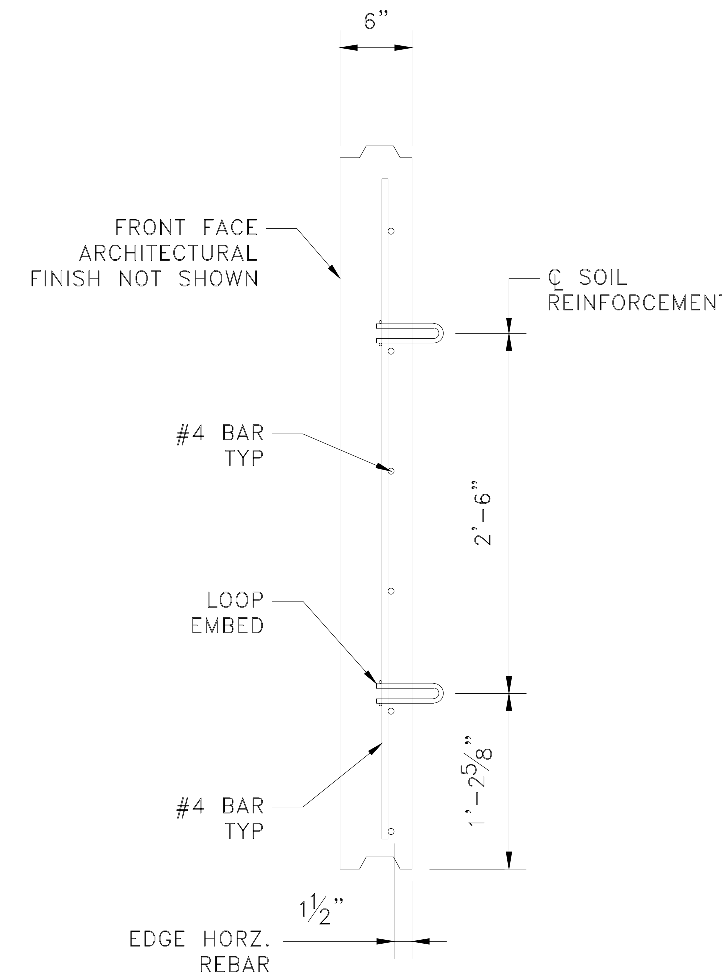
Shear Force:

From Staad Pro Result Vmax	=	0.301	N/mm^2	
	=	43.66	lbs/in^2	
Shear Section Area	=	b	x	tpanel
	=	12	x	6
Vmax	=	3143.26	lbs	
	=	3.143	Kips	**OK, Vmax less than Vn**



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'X' 5'X6' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 6’ STANDARD

Y PANEL

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x6', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per

AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.

This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	8.57	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2 d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.275	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	4.68	kip-ft	$+M_{u\_service}$	=	3.46	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.404 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \frac{a}{2}\right)$ = 5.008 kip-ft

Check $+\varphi M_n > +M_u$ 5.008 > 4.68 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.404 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \frac{a}{2}\right)$ = 1.915 kip-ft

Check $-\varphi M_n > -M_u$ 1.915 > 0.00 **OK**

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Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	6.22	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 5.008 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.915 > 0.00 **OK**

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x6', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	9	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.275	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \, . f_s}{\alpha_1 . f_c{}' . \beta_1 \, . b}$	c	=	0.476	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.012	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \, . \beta \, . \alpha \, . \sqrt{f_c{}'} \, . \, b_v \, . d_v$	Vc	=	6.086	Kips
$V_s = \frac{A_v \, . f_y \, . d_v \, . (\cot\theta + \cot\alpha) \, . \sin\alpha}{s}$	Vs	=	5.515	Kips
	(1) Vn	=	11.601	Kips
(2) $V_n = 0.25 \, . f_c' . b_v \, . d_v$	(2) Vn	=	48.146	Kips
From (1) and (2) Vn should be:	Vn	=	11.601	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	10.441	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.363	N/mm^2		
	=	52.65	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3790.71	lbs		
	=	3.791	Kips	**OK, Vmax less than Vn**	

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Typical Panel Type Y, Panel Thickness 6", 5'x6', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per

AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.

This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	10.28	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.229	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.63	kip-ft	$+M_{u\_service}$	=	1.95	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.337 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.694 kip-ft

Check $+\varphi M_n > +M_u$ 3.694 > 2.63 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.337 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 2.147 kip-ft

Check $-\varphi M_n > -M_u$ 2.147 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3\gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment		=	3.50	kip-ft
Cracking moment		=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})		=	3.09	kip-ft
Check: $+\varphi M_n > \min(+M_u, M_{cr})$	3.694	>	3.09	**OK**

check negative moment reinforcement:

1.33 x factored ultimate moment		=	0.00	kip-ft
Cracking moment		=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})		=	0.00	kip-ft
Check: $-\varphi M_n > \min(-M_u, M_{cr})$	2.147	>	0.00	**OK**

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Typical Panel Type Y, Panel Thickness 6", 5'x6', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1\!/_4\, \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.229	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c{}' . \beta_1 \,.\, b}$	c	=	0.397	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.052	in	

AASHTO 5.7.3.3

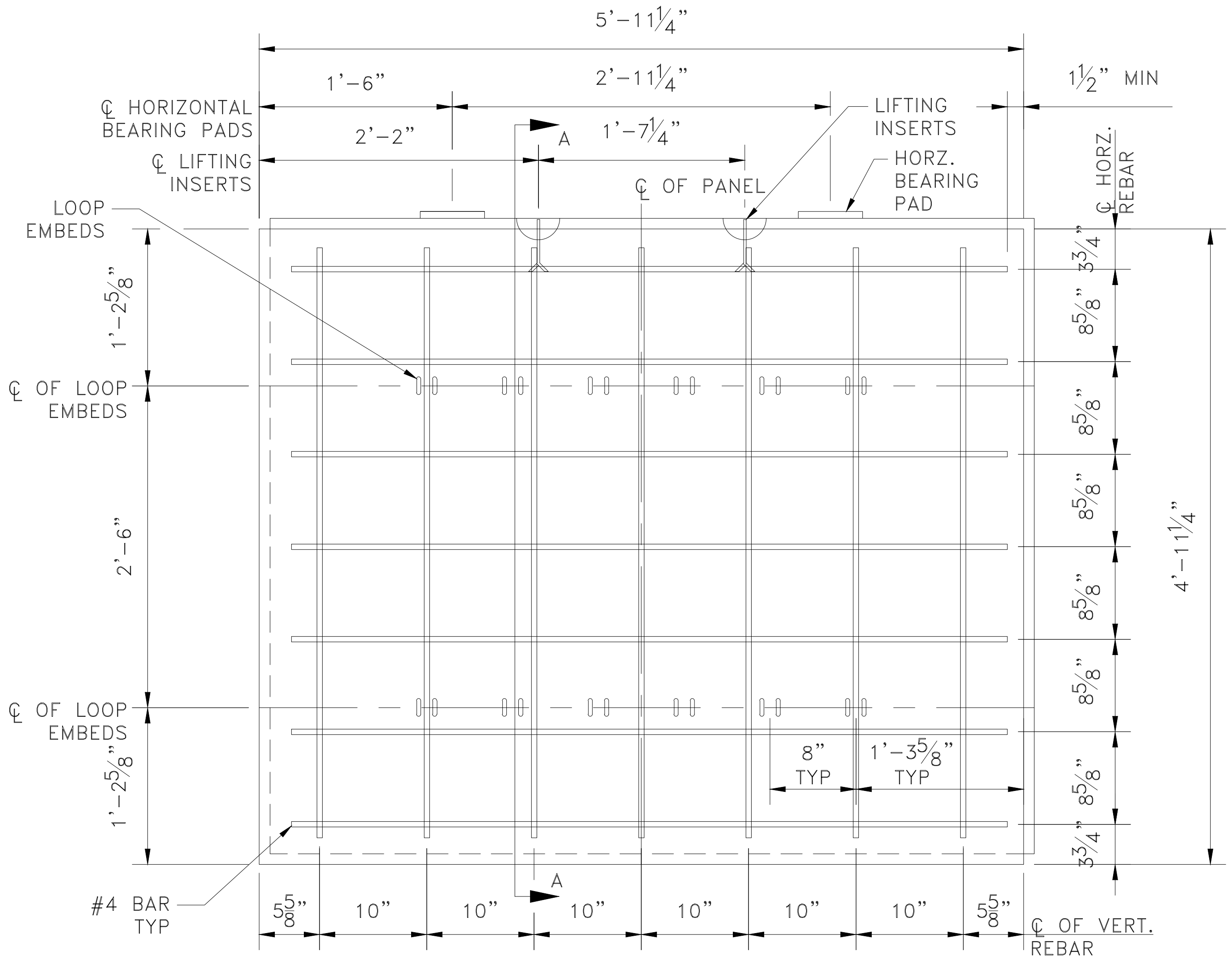
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c{}'} \,.\, b_v \,.\, d_v$	Vc	=	4.629	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	3.497	Kips
	(1) Vn	=	8.126	Kips
(2) $V_n = 0.25 \,.\, f_c' . b_v \,.\, d_v$	(2) Vn	=	36.621	Kips
From (1) and (2) Vn should be:	Vn	=	8.126	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	7.314	Kips

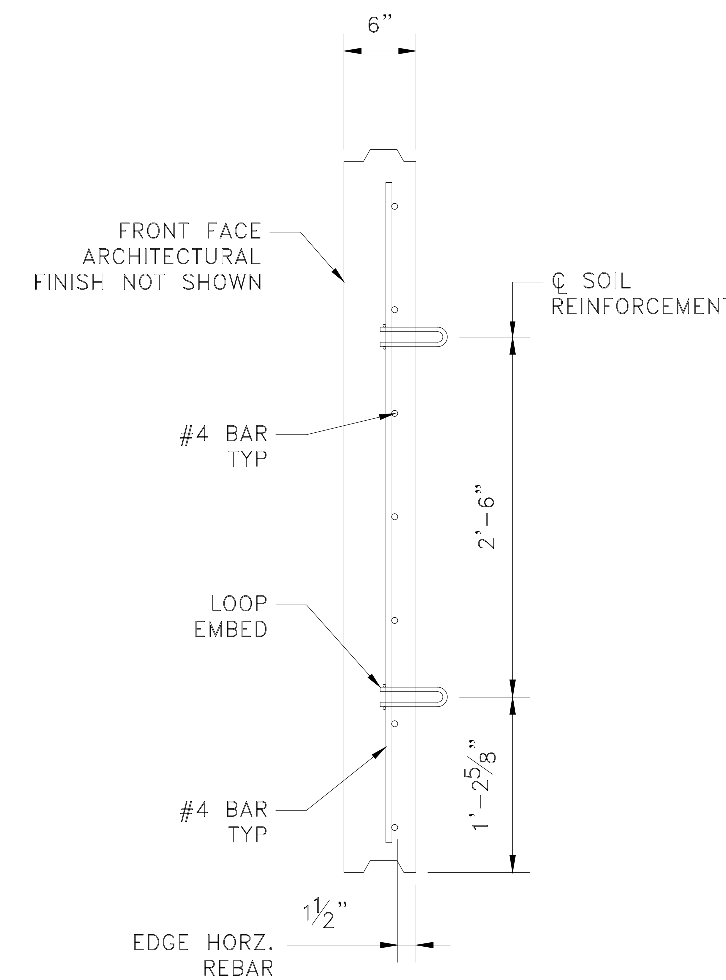
Shear Force:

From Staad Pro Result Vmax	=	0.369	N/mm^2		
	=	53.52	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3853.37	lbs		
	=	3.853	Kips	**OK, Vmax less than Vn**	



STANDARD "Y" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

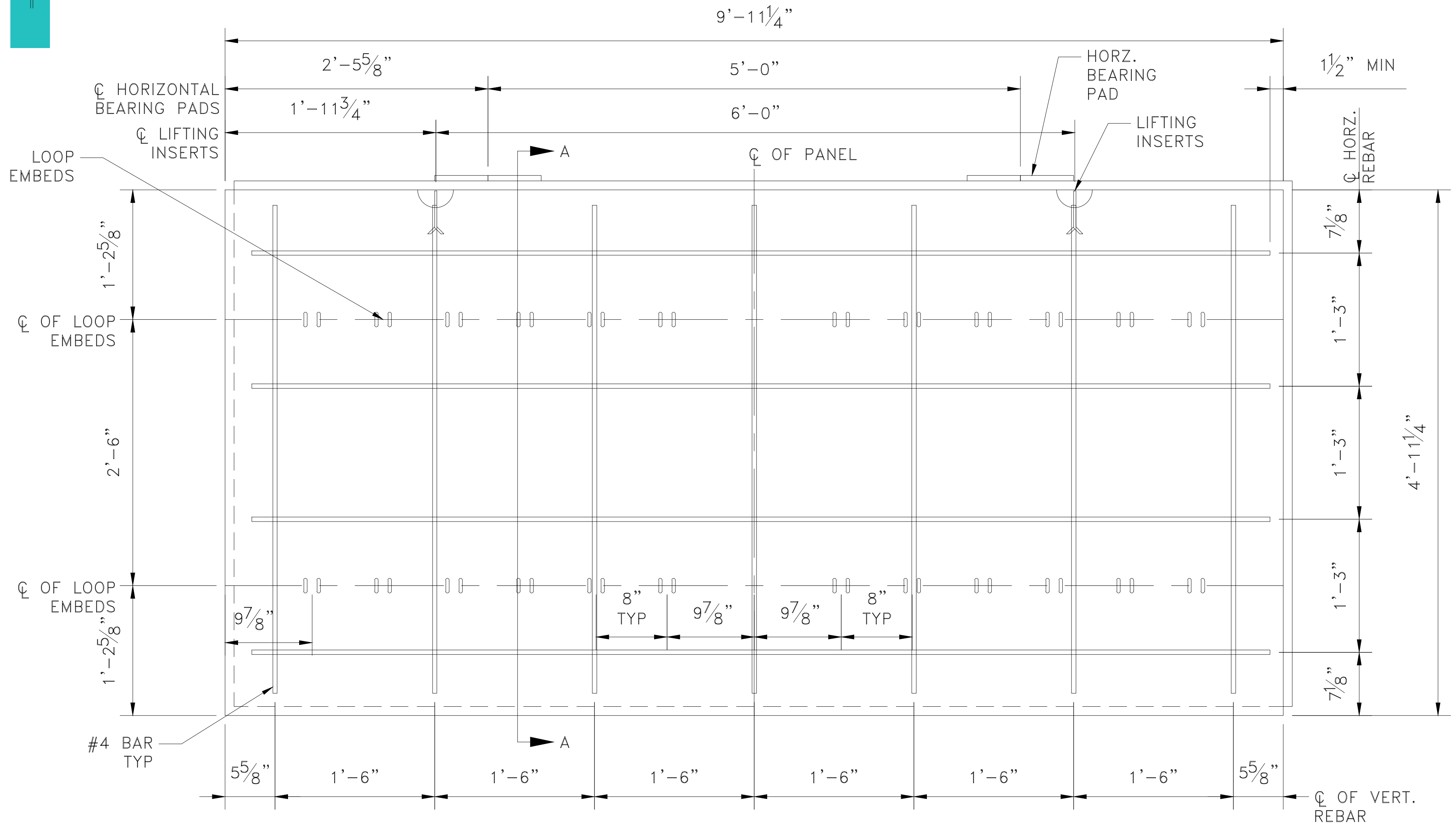
TYPE 'Y' 5'X6' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

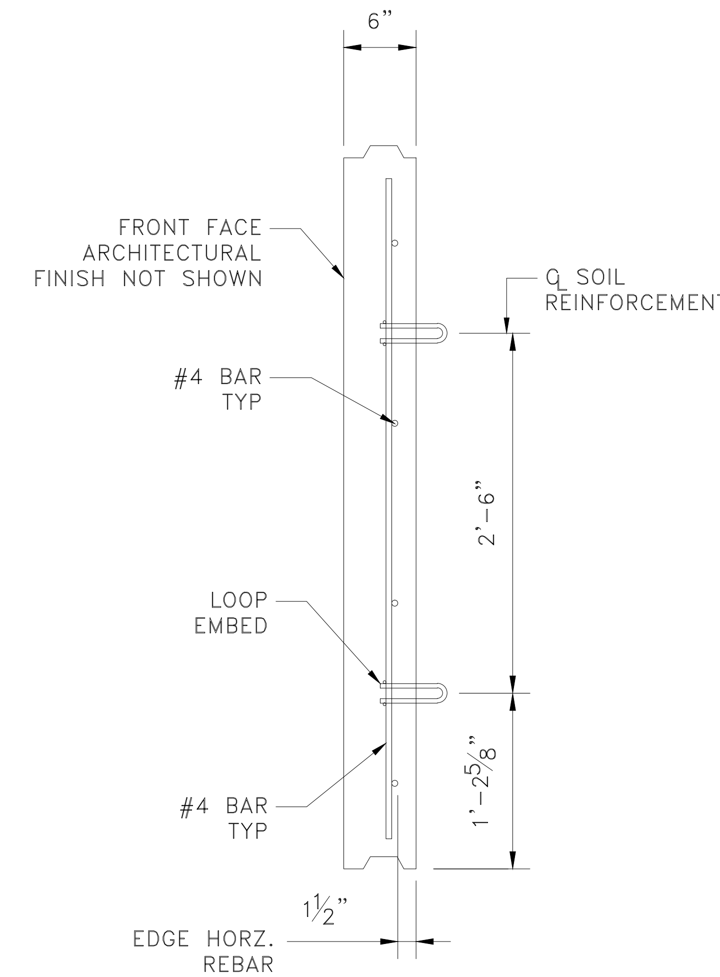
TOC – Appendix

5’ x 10’ STANDARD PANELS



STANDARD "A" PANEL

SHOWN FROM BACK FACE



SECTION A–A

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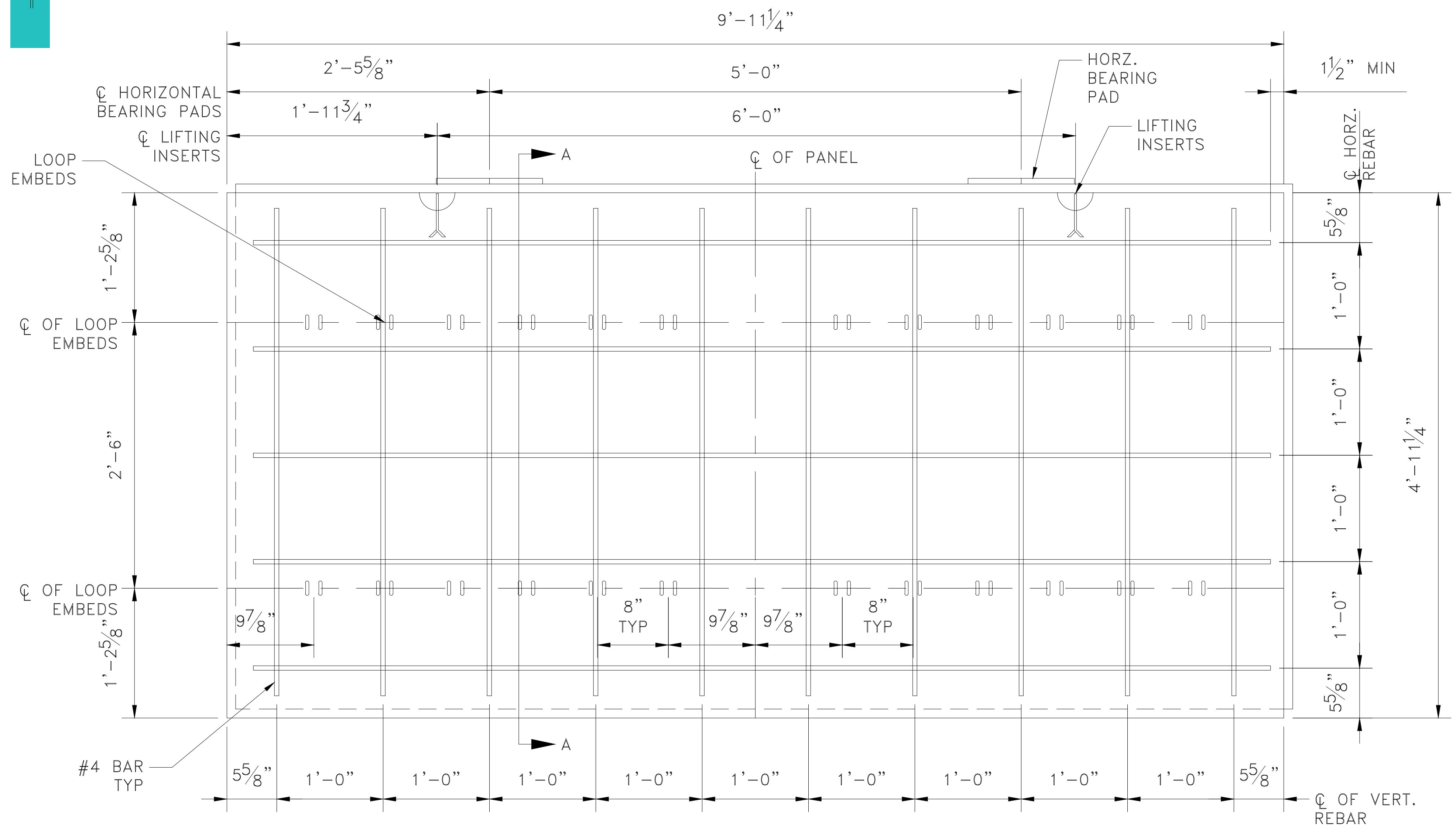
DRAWN BY:	WM	01/24/22
CHECK BY:	FSH	01/24/22
DESIGN BY:	FSH	01/24/22
CHECK BY:	SR	01/24/22
PROJ. ENGR:	FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X10' PANEL DETAILS

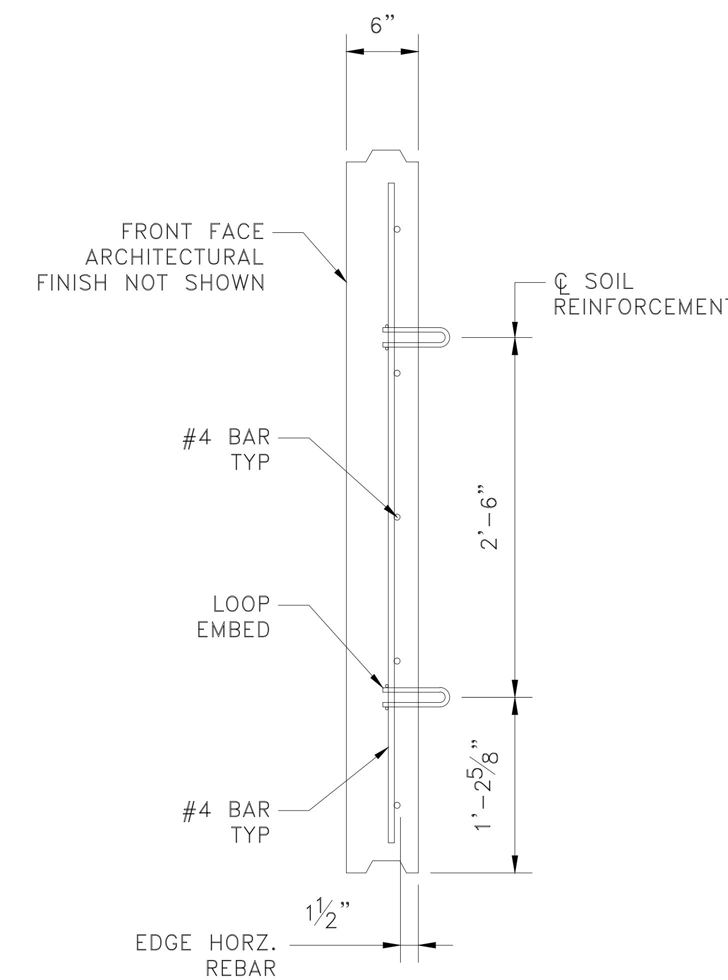
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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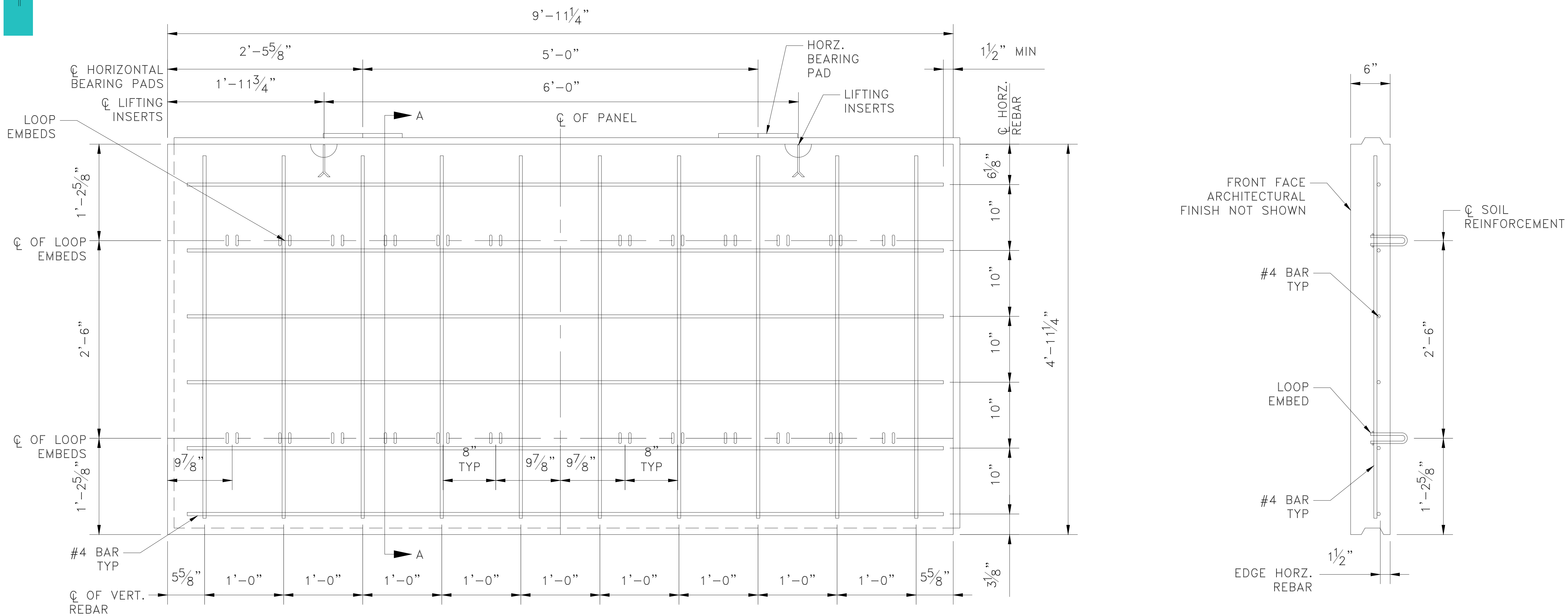
DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'X' 5'X10' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of



STANDARD "Y" PANEL

SHOWN FROM BACK FACE

SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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4740 SCOTTS VALLEY DRIVE, SUITE E
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PHONE: (831) 430-9300 FAX: (831) 430-9340

DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X10' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

TOC – Appendix

	Area	Diameter
16	Galvanize Life Coating	
12	Corrosion Rate Carbon Steel (in microns)	
75	Design Life	

Wire	Area sqin	Diameter in	Diameter microns	Diameter after microns	Diameter after in	% effective	Area after sqin					6	7	8
W5	0.05	0.252	6408.757	4992.757	0.1966	0.6069	0.0303	2	3	4	5	0.1821	0.2124	0.2428
W8	0.08	0.319	8106.507	6690.507	0.2634	0.6812	0.0545	0.1090	0.1635	0.2180	0.2725	0.3270	0.3815	0.4359
W11	0.11	0.374	9505.722	8089.722	0.3185	0.7243	0.0797	0.1593	0.2390	0.3187	0.3983	0.4780	0.5577	0.6374
W15	0.15	0.437	11100.292	9684.292	0.3813	0.7611	0.1142	0.2283	0.3425	0.4567	0.5709	0.6850	0.7992	0.9134
W20	0.20	0.505	12817.513	11401.513	0.4489	0.7913	0.1583	0.3165	0.4748	0.6330	0.7913	0.9495	1.1078	1.2660
W24	0.24	0.553	14040.882	12624.882	0.4970	0.8085	0.1940	0.3881	0.5821	0.7761	0.9702	1.1642	1.3582	1.5523
W30	0.30	0.618	15698.184	14282.184	0.5623	0.8277	0.2483							

SPRING CONSTANT

Modulus of Sub-Grade Reaction and Spring Constant Check

From Principles of Foundation Engineering; Braja M. Das 8th Edition:

Table 8.2 Typical Subgrade Reaction Values, $k_{0.3}(k_1)$

Soil type	$k_{0.3}(k_1)$ MN/m³	$k_{0.3}(k_1)$ lb/in.³
Dry or moist sand:		
Loose	8–25	30–90
Medium	25–125	90–450
Dense	125–375	450–1350
Saturated sand:		
Loose	10–15	35–55
Medium	35–40	125–145
Dense	130–150	475–550
Clay:		
Stiff	10–25	40–90
Very stiff	25–50	90–185
Hard	>50	>185

$K_{0.3}$ (k_1) = 1350 lb/in³ (is selected)

(dense Sand, value is conservative considering no reinforcement is included)

Adjust to panel 5' x 10' (1.5m x 3m)

Foundations on Sandy Soils

For foundations on sandy soils,

$$k = k_{0.3}\left(\frac{B + 0.3}{2B}\right)^2 \tag{8.45}$$

where $k_{0.3}$ and k = coefficients of subgrade reaction of foundations measuring 0.3 m × 0.3 m and B(m) × B(m), respectively (unit is kN/m³).

In English units, Eq. (8.45) may be expressed as

$$k = k_1\left(\frac{B + 1}{2B}\right)^2 \tag{8.46}$$

where k_1 and k = coefficients of subgrade reaction of foundations measuring 1 ft × 1 ft and B(ft) × B(ft), respectively (unit is lb/in³).

$$k_{1.5} = k_{0.3} \cdot \left(\frac{B + 0.3}{2B}\right)^2$$

$$k_{1.5} = 1350\ x \left(\frac{1.5 + 0.3}{2\ x\ 1.5}\right)^2$$

$k_{1.5}$ = 486 lb/in³

$$k_{1.5x3.0} = k_{1.5} \cdot \left(\frac{1 + \frac{1.5}{3.0}}{1.5}\right)^2$$

$k_{1.5x3.0}$ = 486 lb/in³

$k_{1.5x3.0}$ = 839.755 kip/ft³

From Foundation Analysis And Design; Joseph E. Bowles, RE., S.E. 5th Edition:

10-5 MODULUS OF SUBGRADE REACTION k_s FOR MATS AND PLATES

All three discrete element methods given in this chapter for mats/plates use the modulus of subgrade reaction k_s to support the plate. The modulus k_s is used to compute node springs based on the contributing plan area of an element to any node as in Fig. 10-5. From the figure we see the following:

Node	Contributing area
1 (corner)	$\frac{1}{4}$ of rectangle *abde*
2 (side)	$\frac{1}{4}$ of *abde* + $\frac{1}{4}$ of *bcef*
3 (interior)	$\frac{1}{4}$ of each rectangle framing to a common node (as node 3)

For a triangle one should arbitrarily use one-third of the triangle area to any corner node. For these area contributions the fraction of k_s node resistance from any element is

$$K_i = k_s,\ \text{kN/m}^3, \times\text{Area},\ \text{m}^2 = \text{units of kN/m (or kips/ft in Fps)}$$

Since this computation gives units of a "spring" it is common to call the effect a *node spring*.

In this form the springs are independent of each other, the system of springs supporting the plate is termed a "Winkler" foundation, and the springs are uncoupled. Uncoupling means that the deflection of any spring is not influenced by adjacent springs.

Spring Constant

Note Spacing: 1ft x 1ft

Tributary Area: 1' x 1' = 1SF

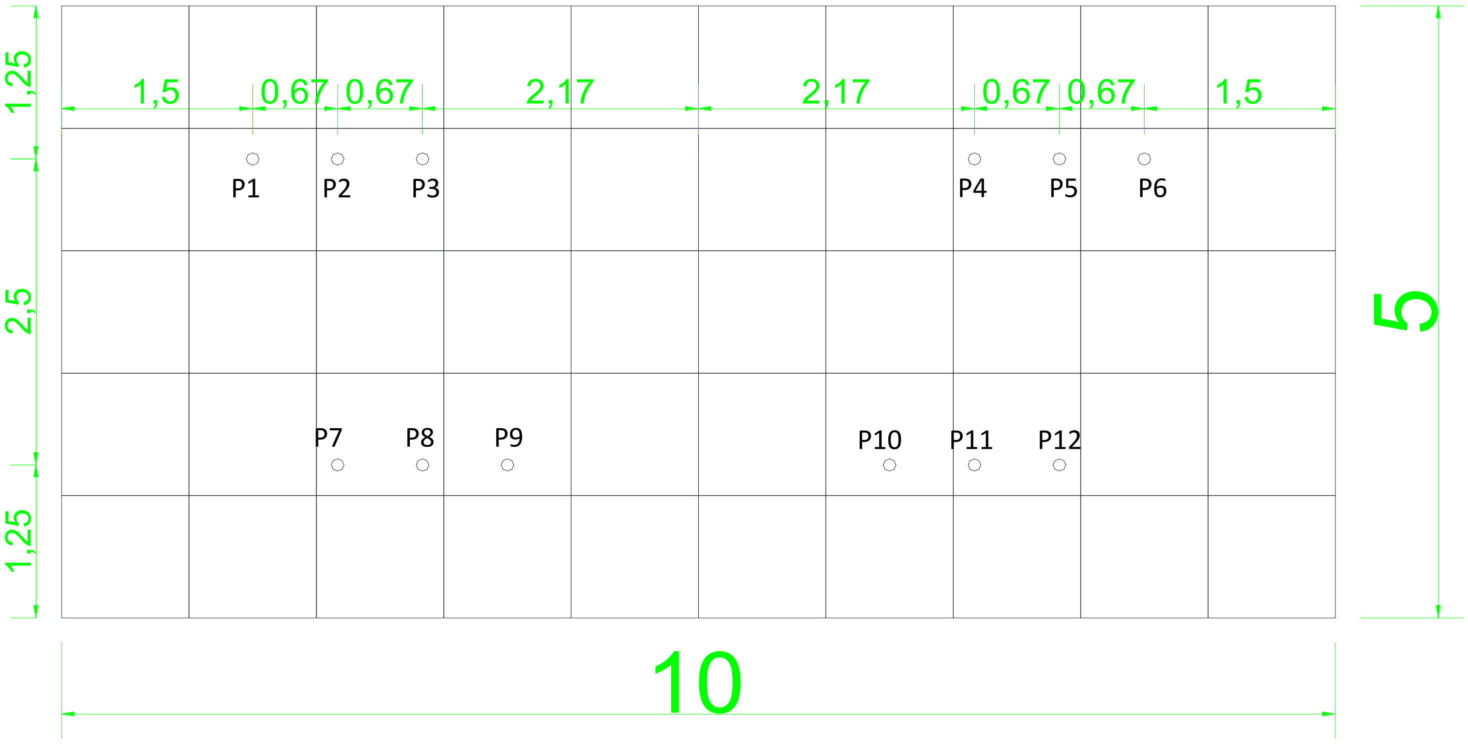
Ka = k x a

Ka = 839.755 kip/ft (Input to Staad Pro)

MAXIMUM BENDING MOMENT AND SHEAR

Typical Panel Type (mesh 3W11), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0	0.25
P2	-0.33	0.25
P3	0.33	0.25
P4	-0.33	0.25
P5	0.33	0.25
P6	0	0.25

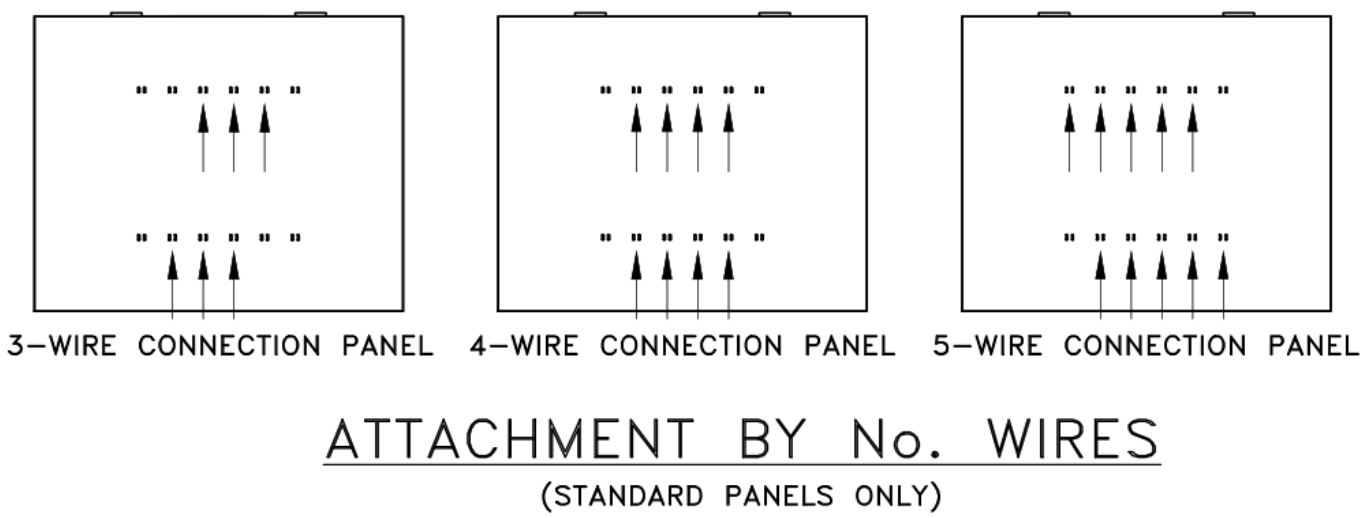
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.33	-0.25
P8	0.33	-0.25
P9	0	-0.25
P10	0	-0.25
P11	-0.33	-0.25
P12	0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

A = 0.0797 in^2
Fy = 75 ksi

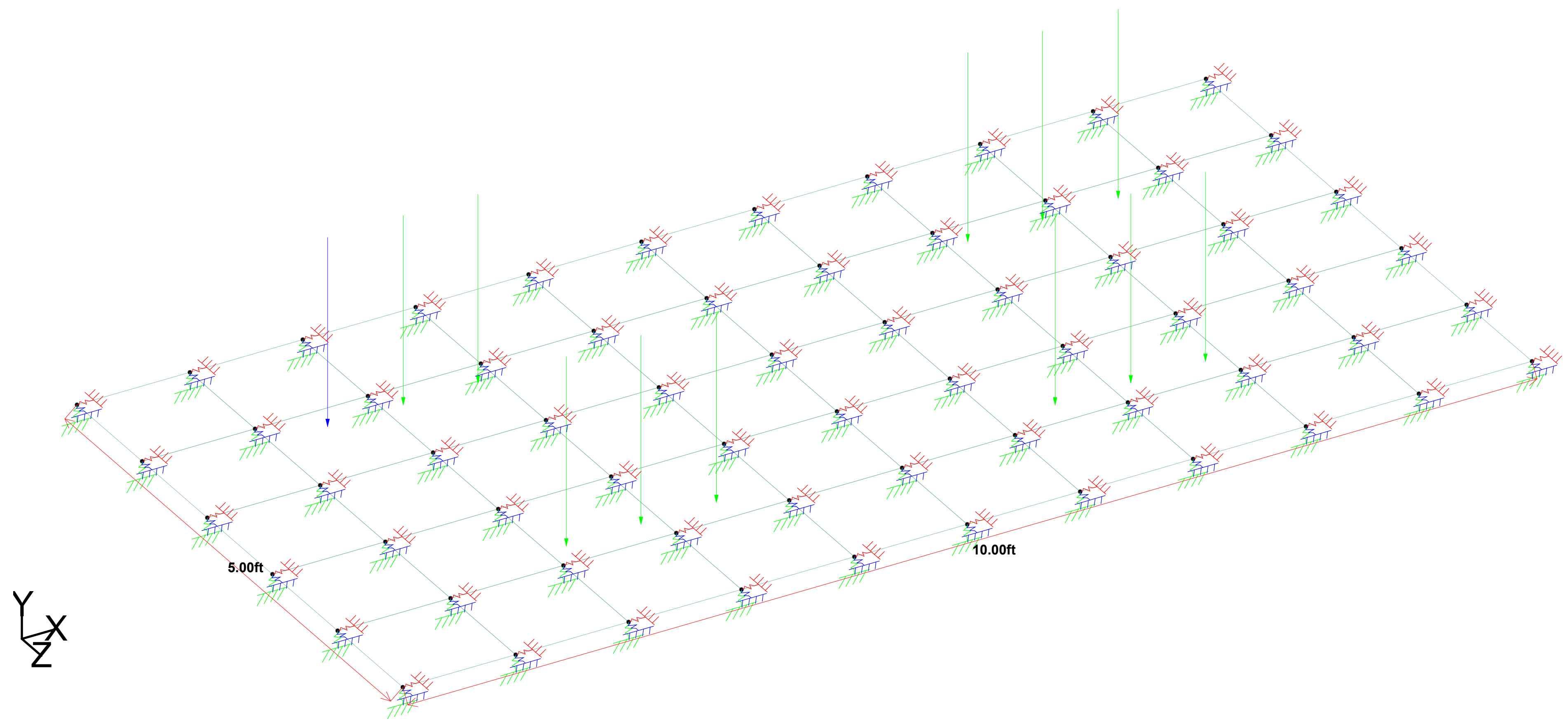
P = 0.65 x A x Fy
= 3.885 Kips (per wire point)



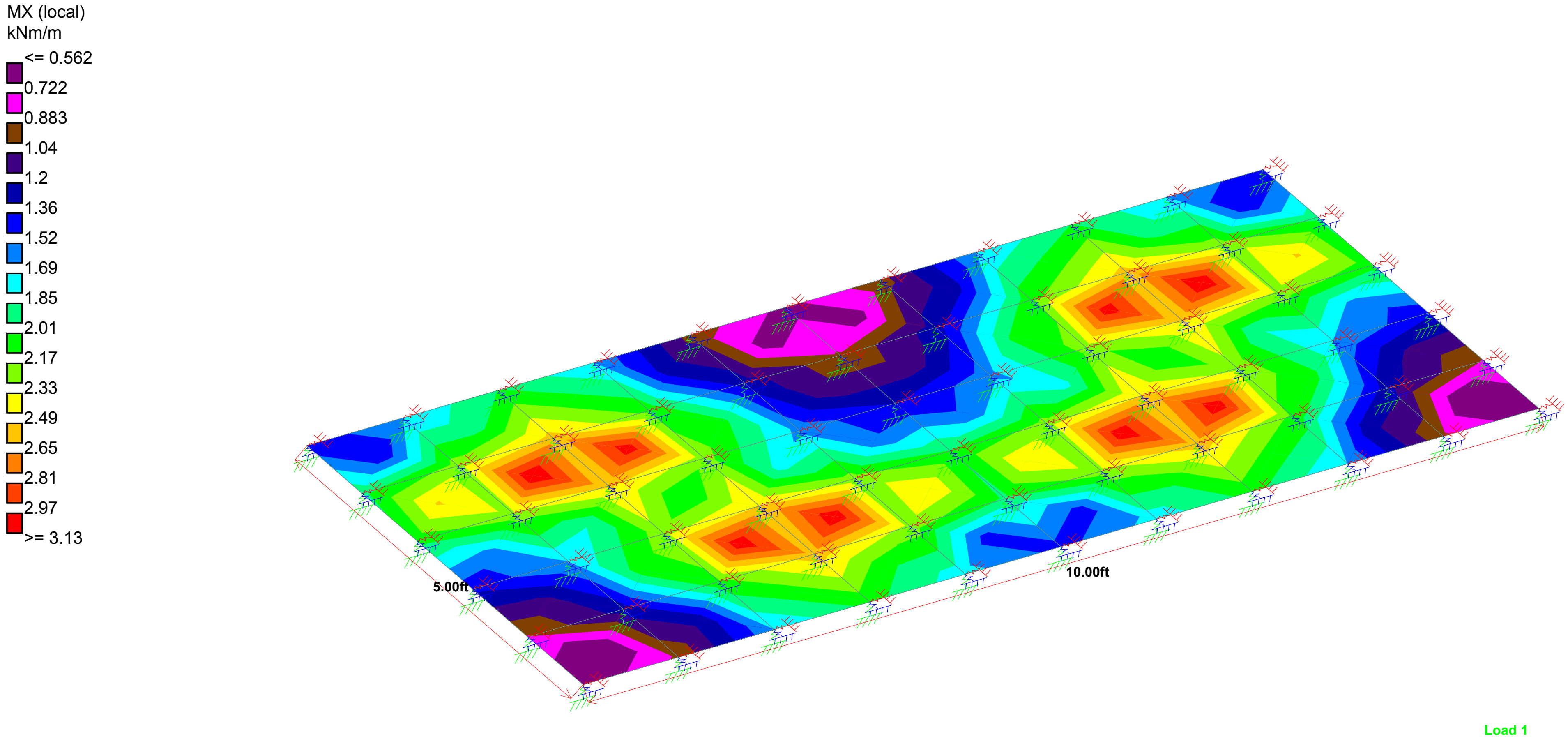
TOC – Appendix

Software licensed to Optimal Engineering Support

	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:08	

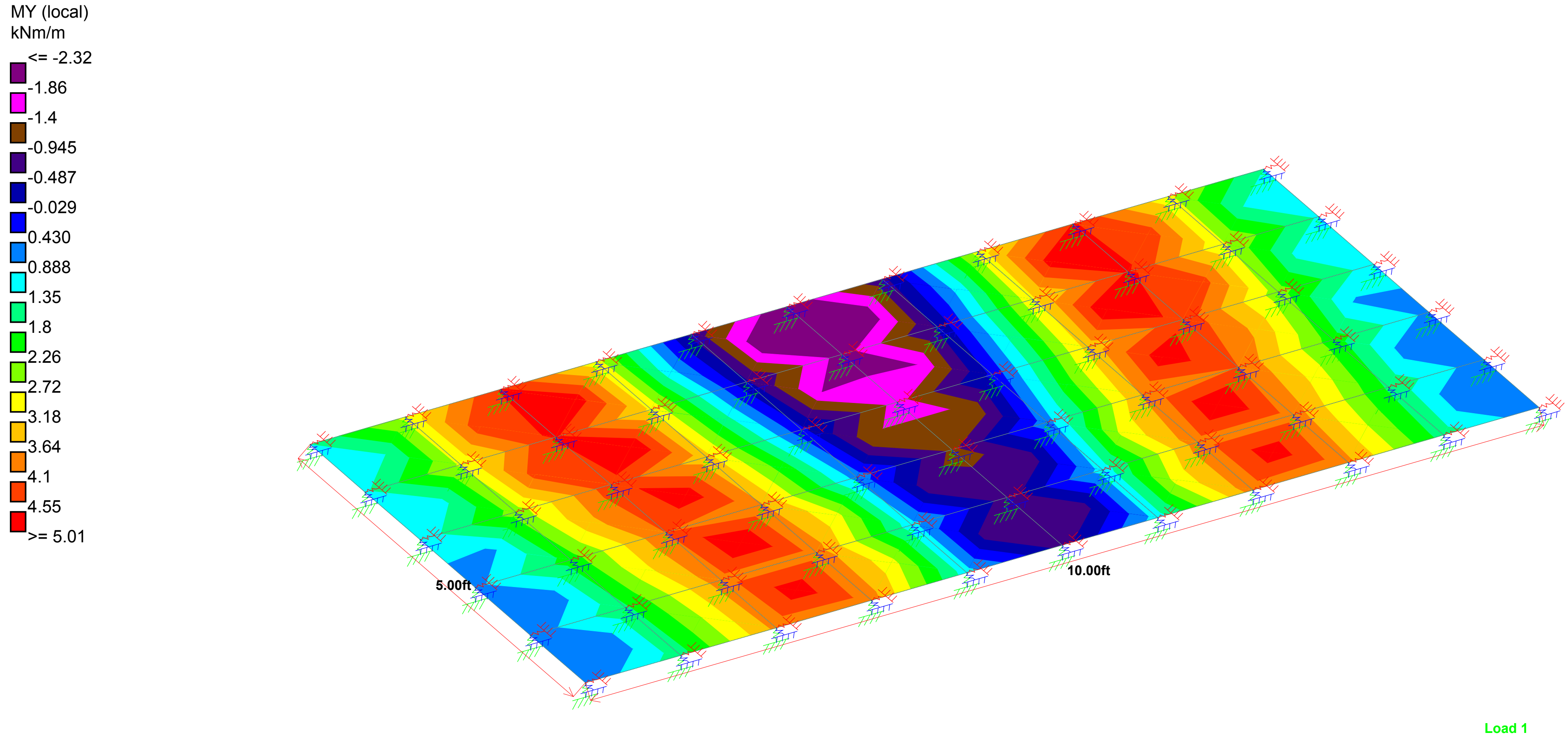


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:08	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:08	

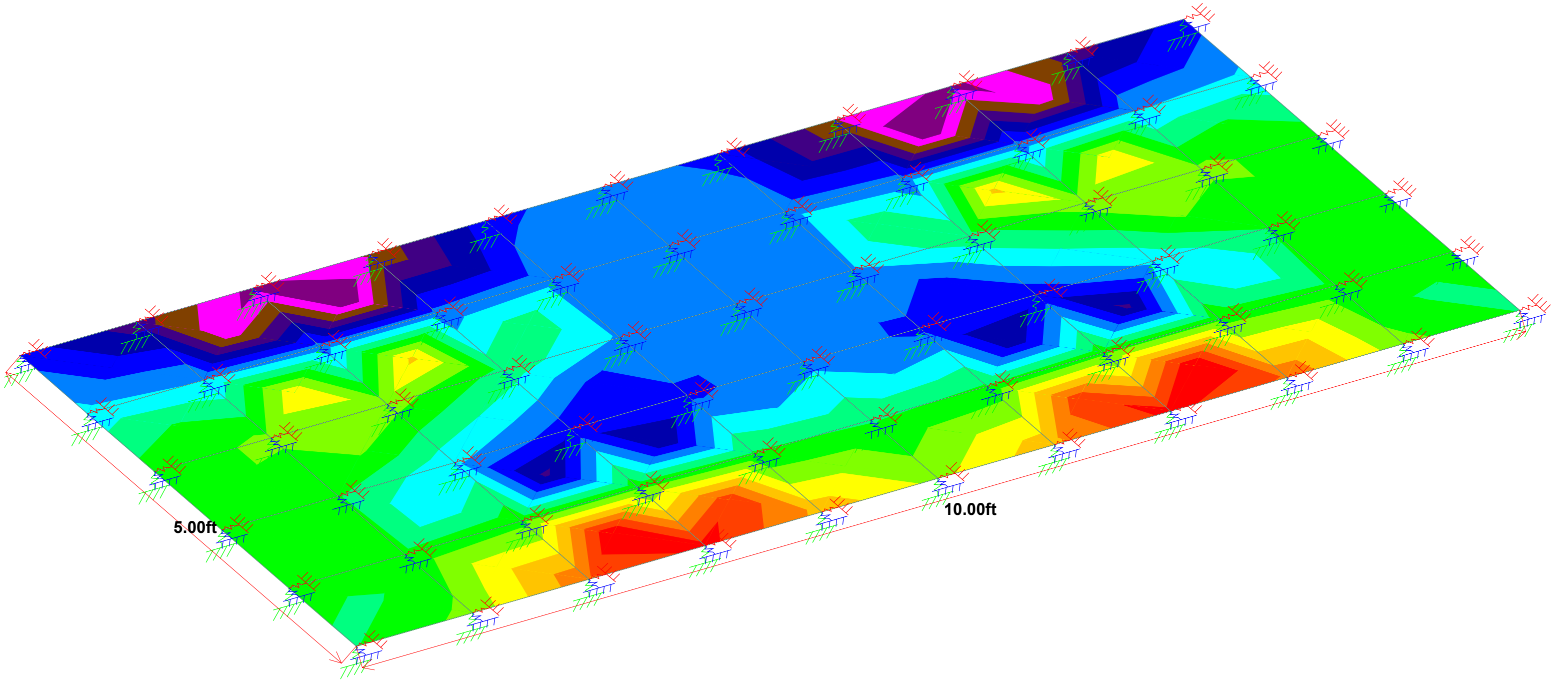


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:08	

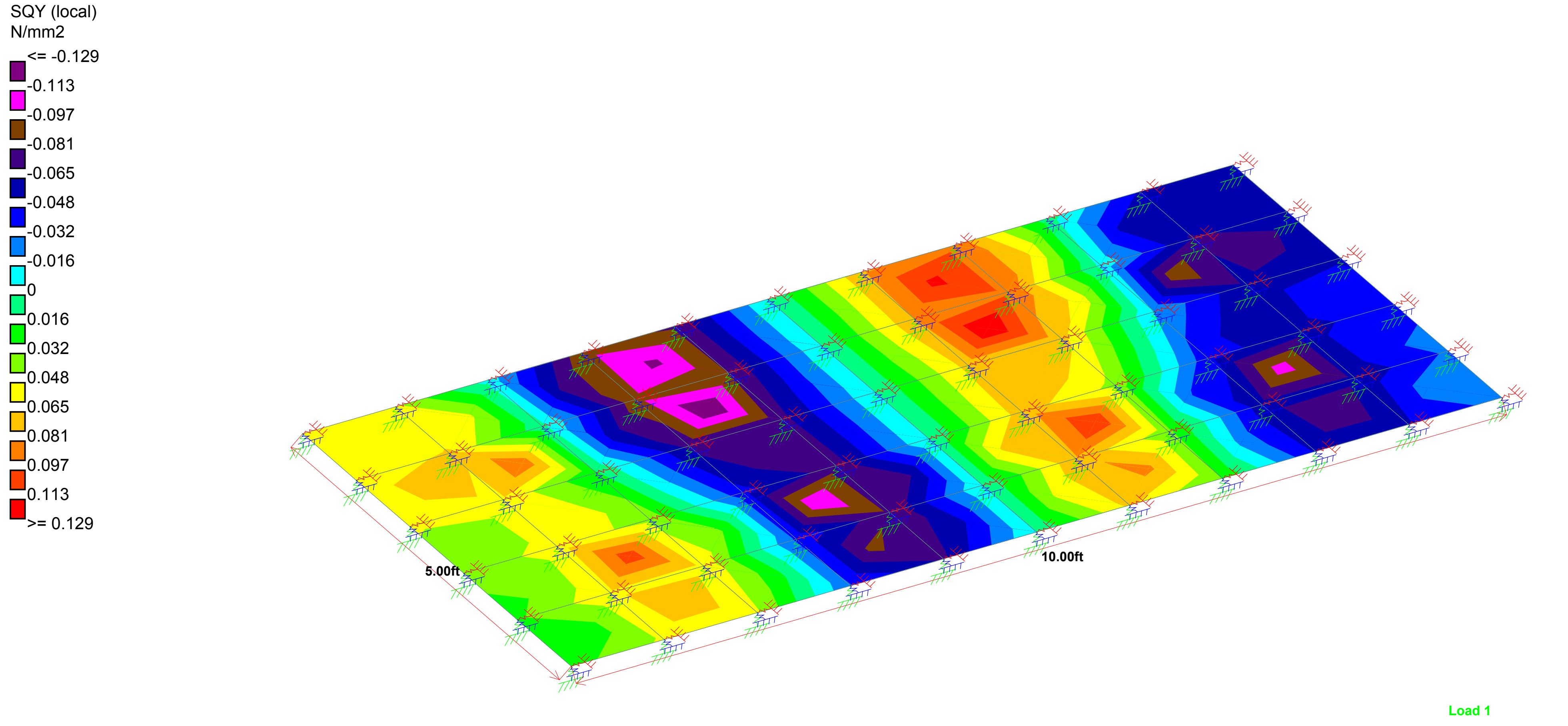
SQX (local)
N/mm2

- <= -0.118
- -0.103
- -0.089
- -0.074
- -0.059
- -0.044
- -0.029
- -0.015
- 0
- 0.015
- 0.030
- 0.045
- 0.060
- 0.074
- 0.089
- 0.104
- >= 0.119



Load 1

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:08	



```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR 10, 2021                  *
*           Time=     2:11:15                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x10 type A (3W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 32 PR GY -3.885 0.25 0
    50. 33 PR GY -3.885 0.25 -0.33
    51. 33 PR GY -3.885 0.25 0.33
    52. 63 PR GY -3.885 0.25 -0.33
    53. 63 PR GY -3.885 0.25 0.33
    54. 64 PR GY -3.885 0.25 0
    55. 8 PR GY -3.885 -0.25 -0.33
    56. 8 PR GY -3.885 -0.25 0.33
    57. 11 PR GY -3.885 -0.25 0
    58. 50 PR GY -3.885 -0.25 0
    59. 53 PR GY -3.885 -0.25 -0.33
    60. 53 PR GY -3.885 -0.25 0.33
    61. PERFORM ANALYSIS
```

```
         P R O B L E M   S T A T I S T I C S
         -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    66/    50/    66

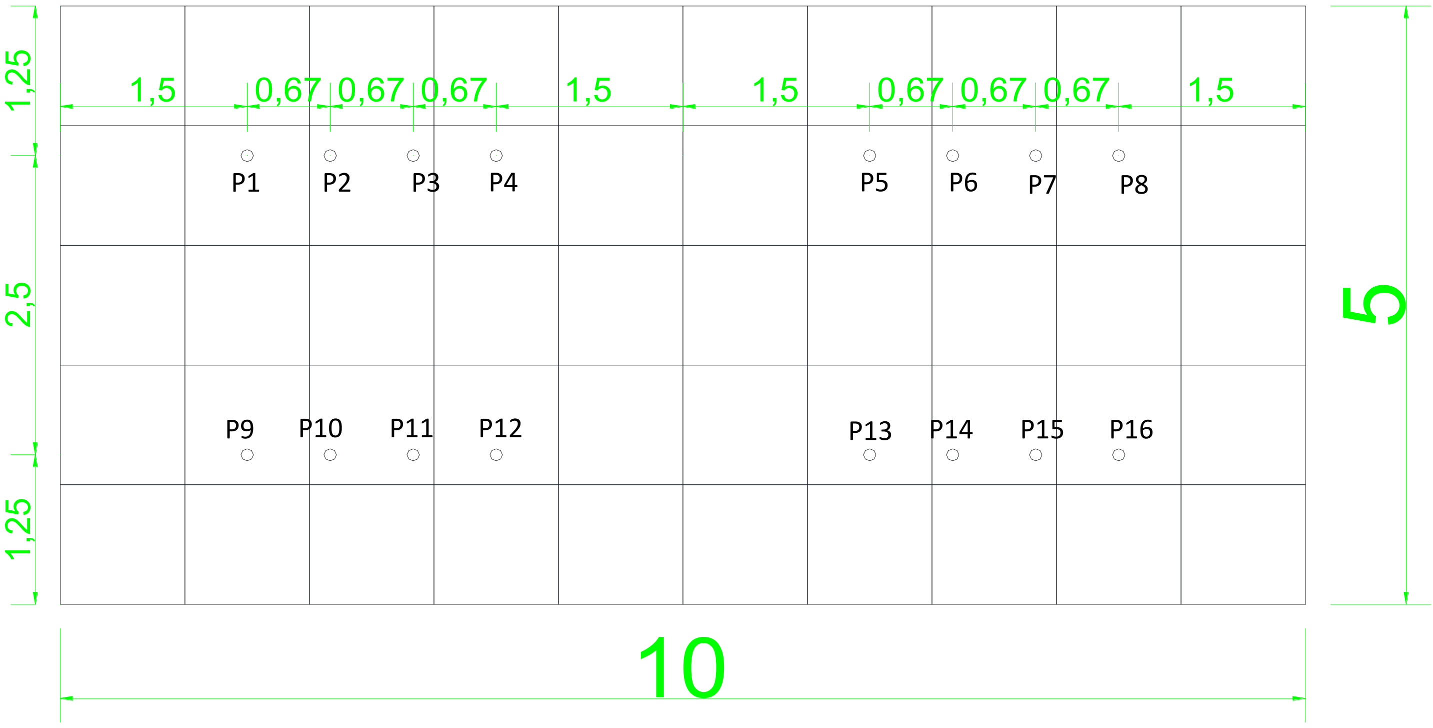
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263354.2 MB
```

```
    62. FINISH
```

Typical Panel Type (mesh 4W11), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0	0.25
P2	-0.33	0.25
P3	0.33	0.25
P4	0	0.25
P5	0	0.25
P6	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.33	0.25
P8	0	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P9	0	-0.25
P10	-0.33	-0.25
P11	0.33	-0.25
P12	0	-0.25
P13	0	-0.25
P14	-0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P15	0.33	-0.25
P16	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

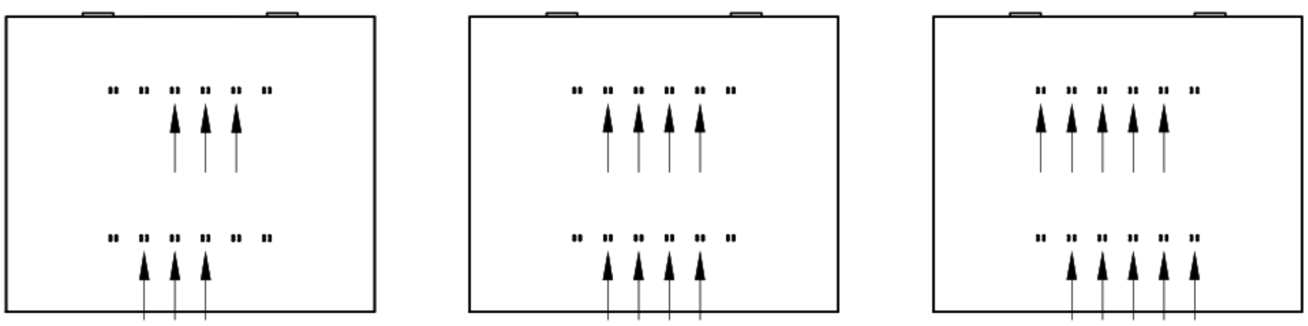
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

= 3.885 Kips (per wire point)

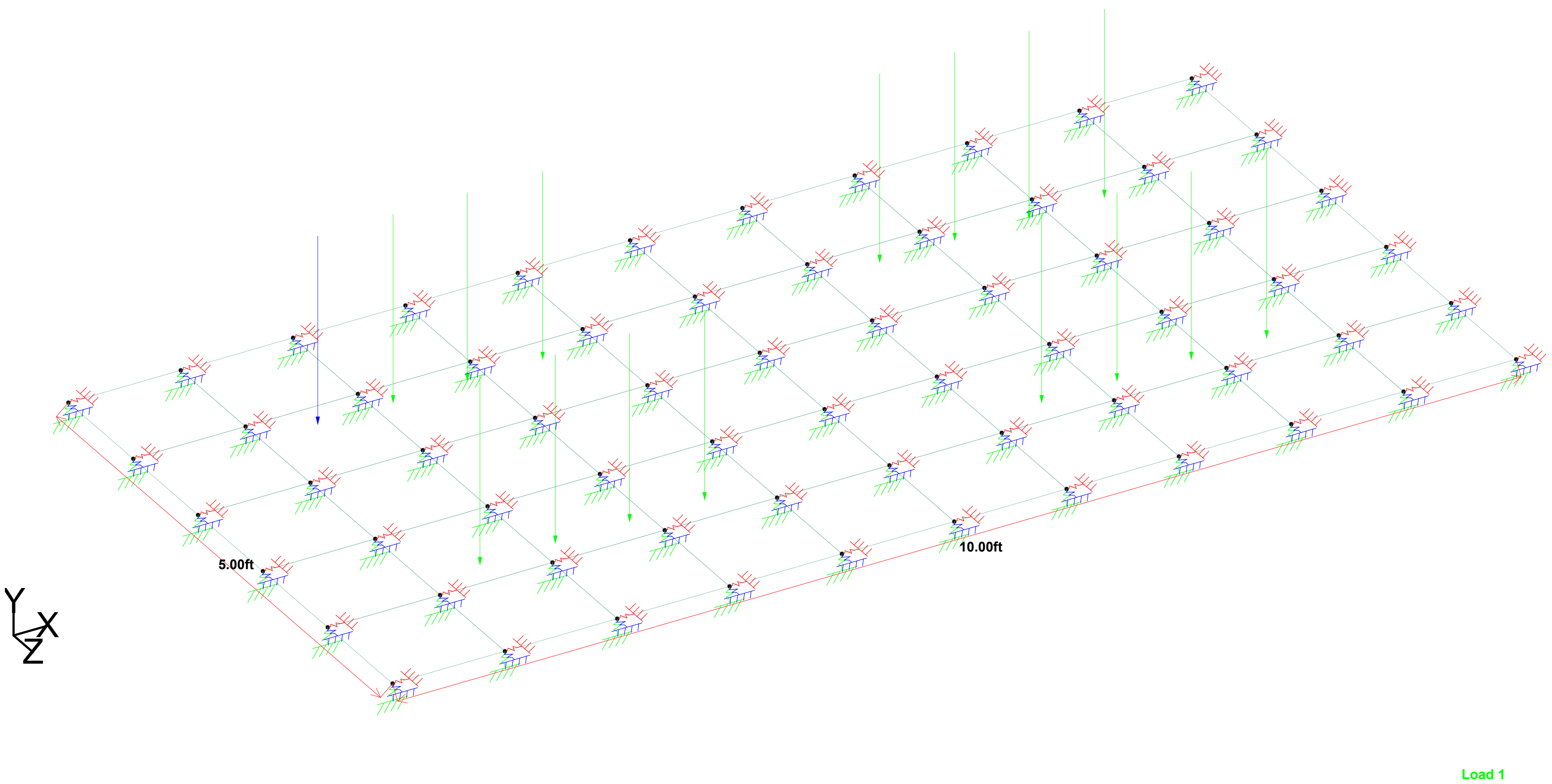


ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:59	



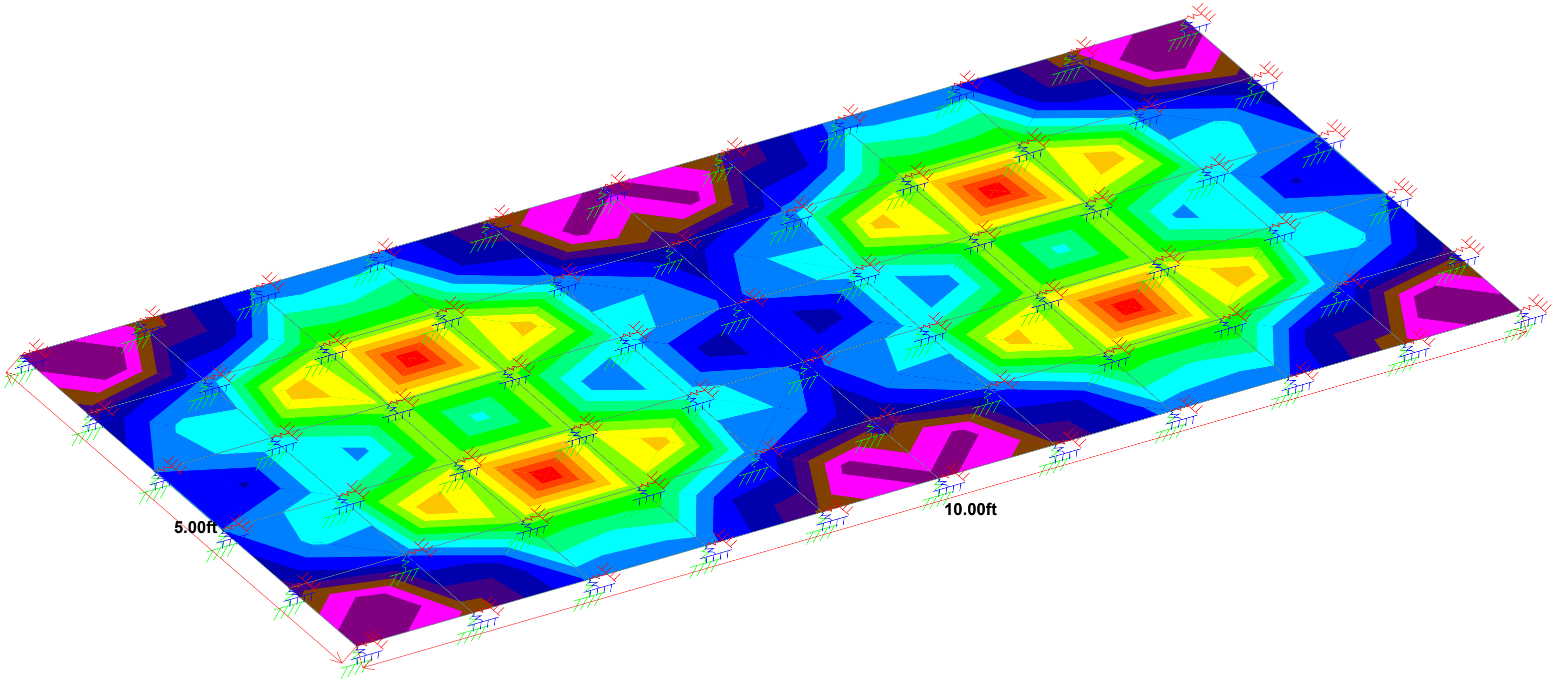
Print Time/Date: 10/03/2021 03:01

STAAD.Pro for Windows 20.07.04.12

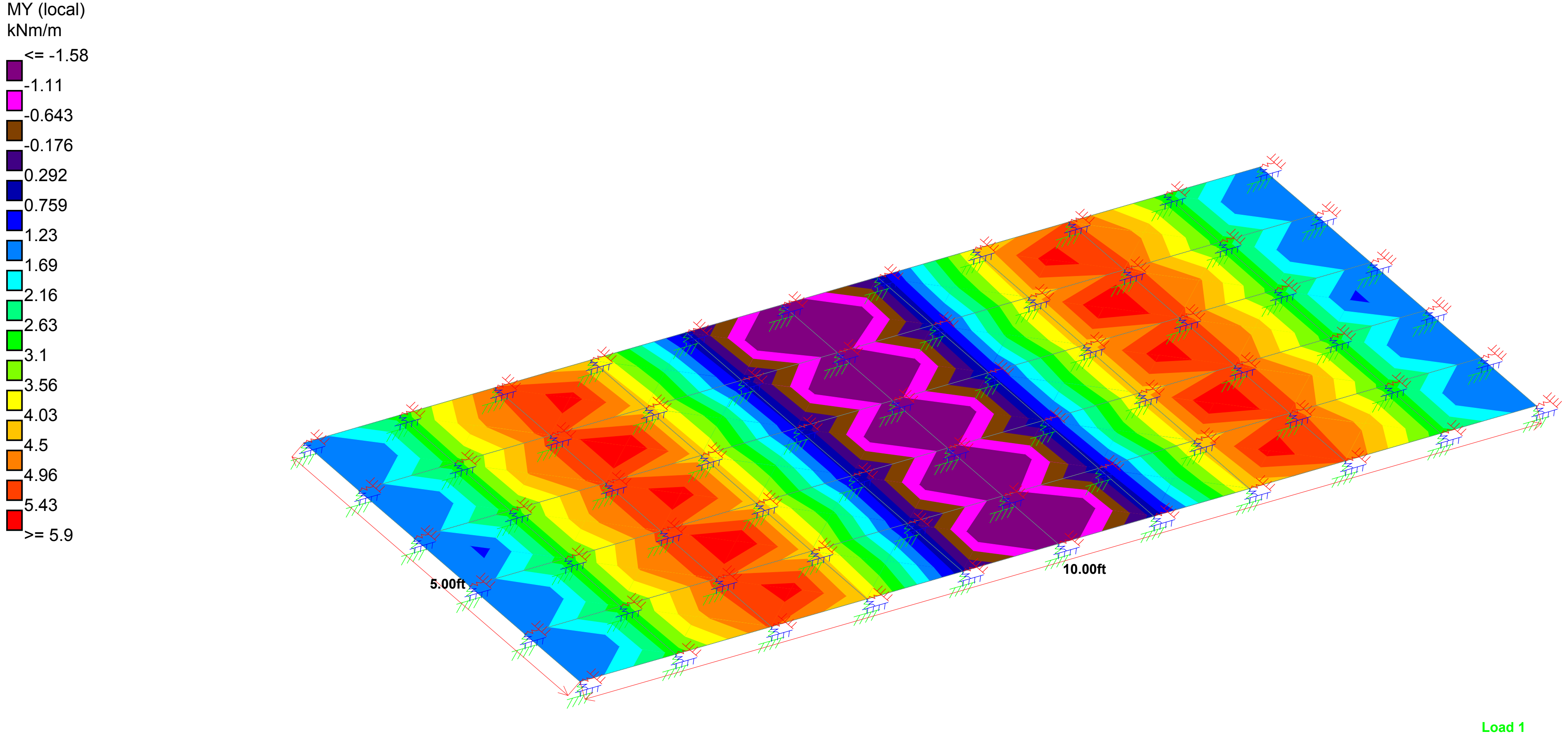
Print Run 1 of 1

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:59	

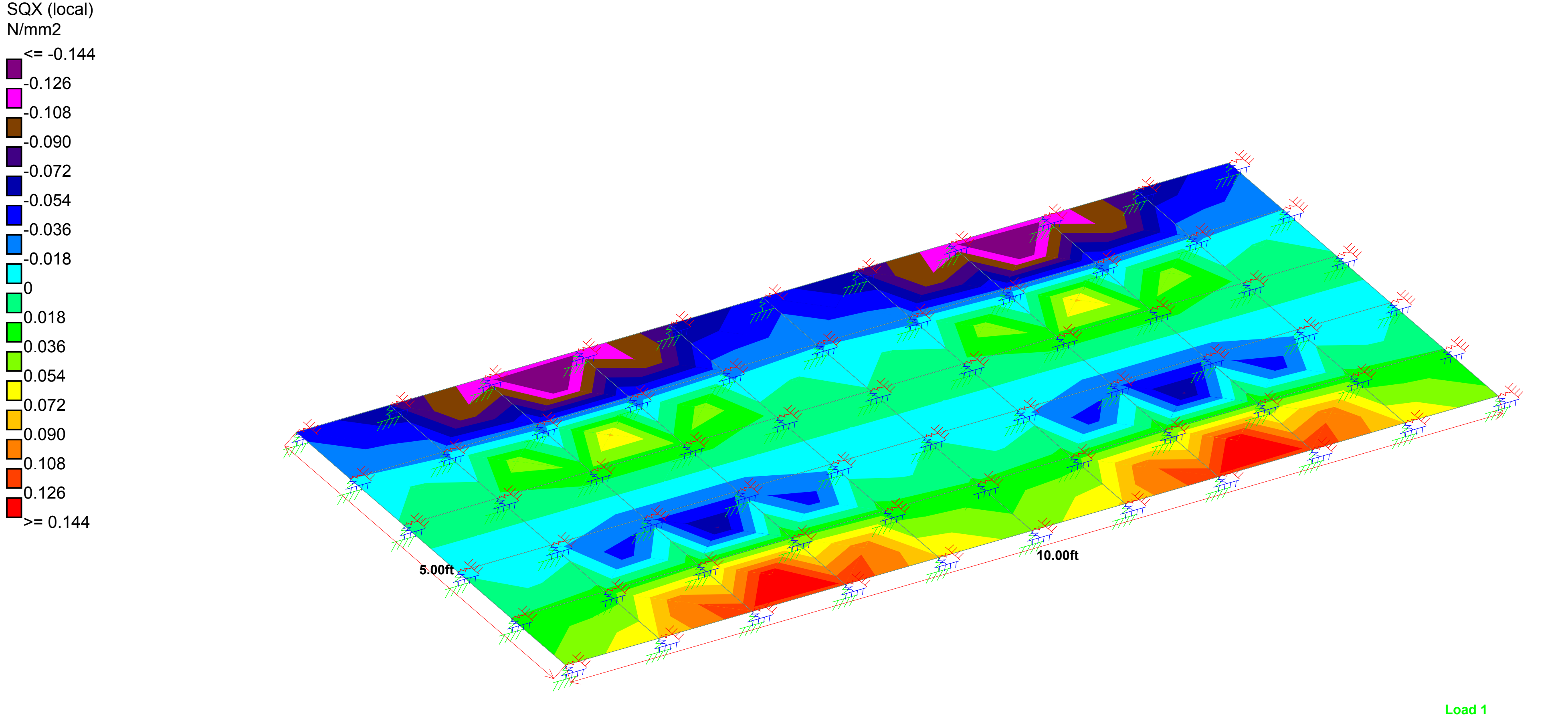
MX (local)
kNm/m
<= 1.4
1.56
1.72
1.88
2.04
2.2
2.35
2.51
2.67
2.83
2.99
3.15
3.31
3.47
3.63
3.79
>= 3.95



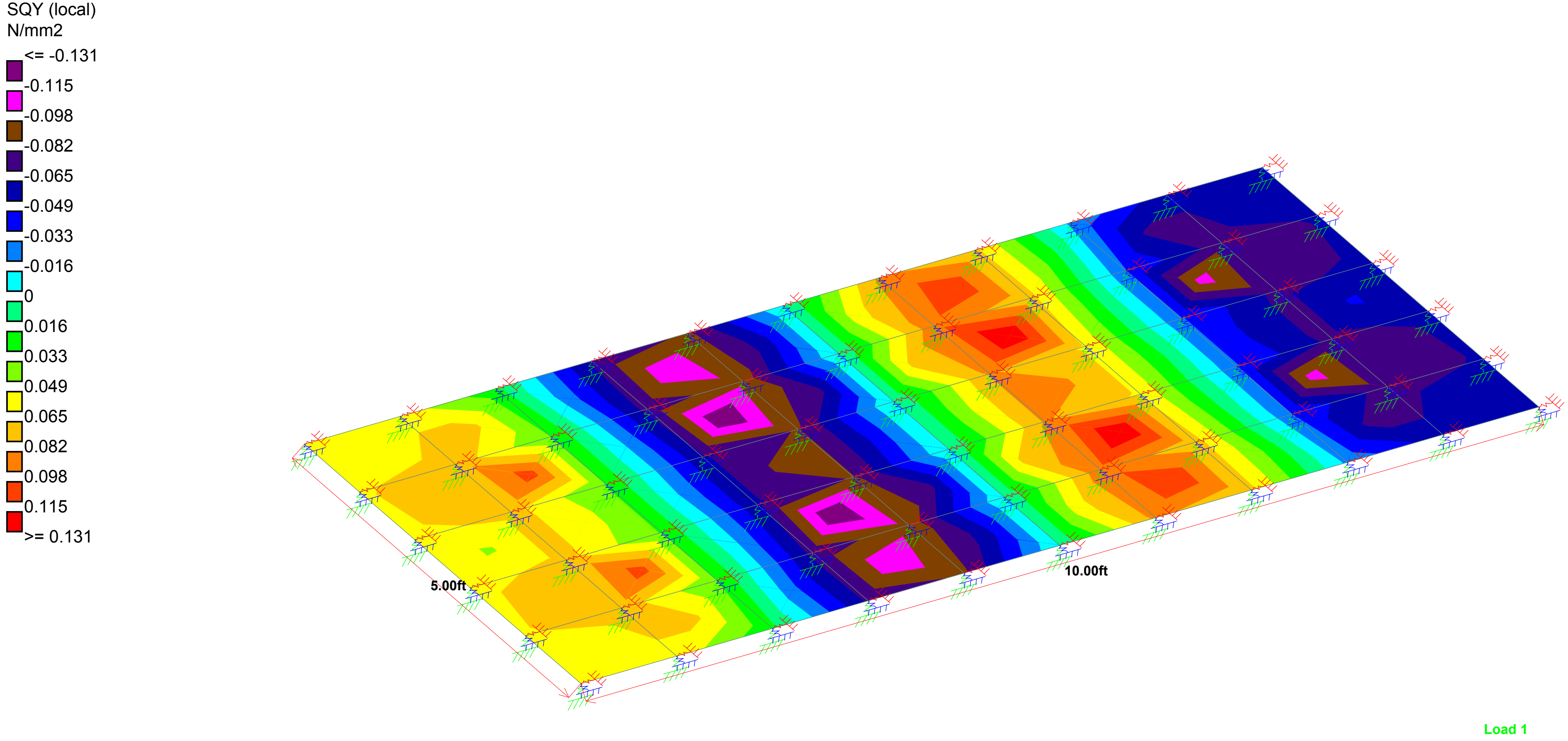
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:59	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:59	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 04-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 02:59	



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*           STAAD.Pro                              *
*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR 10, 2021                  *
*           Time=     3: 0:16                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
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INPUT FILE: Panel Check - 5x10 type A (4W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 04-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 32 PR GY -3.885 0.25 0
    50. 33 PR GY -3.885 0.25 -0.33
    51. 33 PR GY -3.885 0.25 0.33
    52. 34 PR GY -3.885 0.25 0
    53. 62 PR GY -3.885 0.25 0
    54. 63 PR GY -3.885 0.25 -0.33
    55. 63 PR GY -3.885 0.25 0.33
    56. 64 PR GY -3.885 0.25 0
    57. 5 PR GY -3.885 -0.25 0
    58. 8 PR GY -3.885 -0.25 -0.33
    59. 8 PR GY -3.885 -0.25 0.33
    60. 11 PR GY -3.885 -0.25 0
    61. 50 PR GY -3.885 -0.25 0
    62. 53 PR GY -3.885 -0.25 -0.33
    63. 53 PR GY -3.885 -0.25 0.33
    64. 56 PR GY -3.885 -0.25 0
    65. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     66/    50/    66

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263352.2 MB
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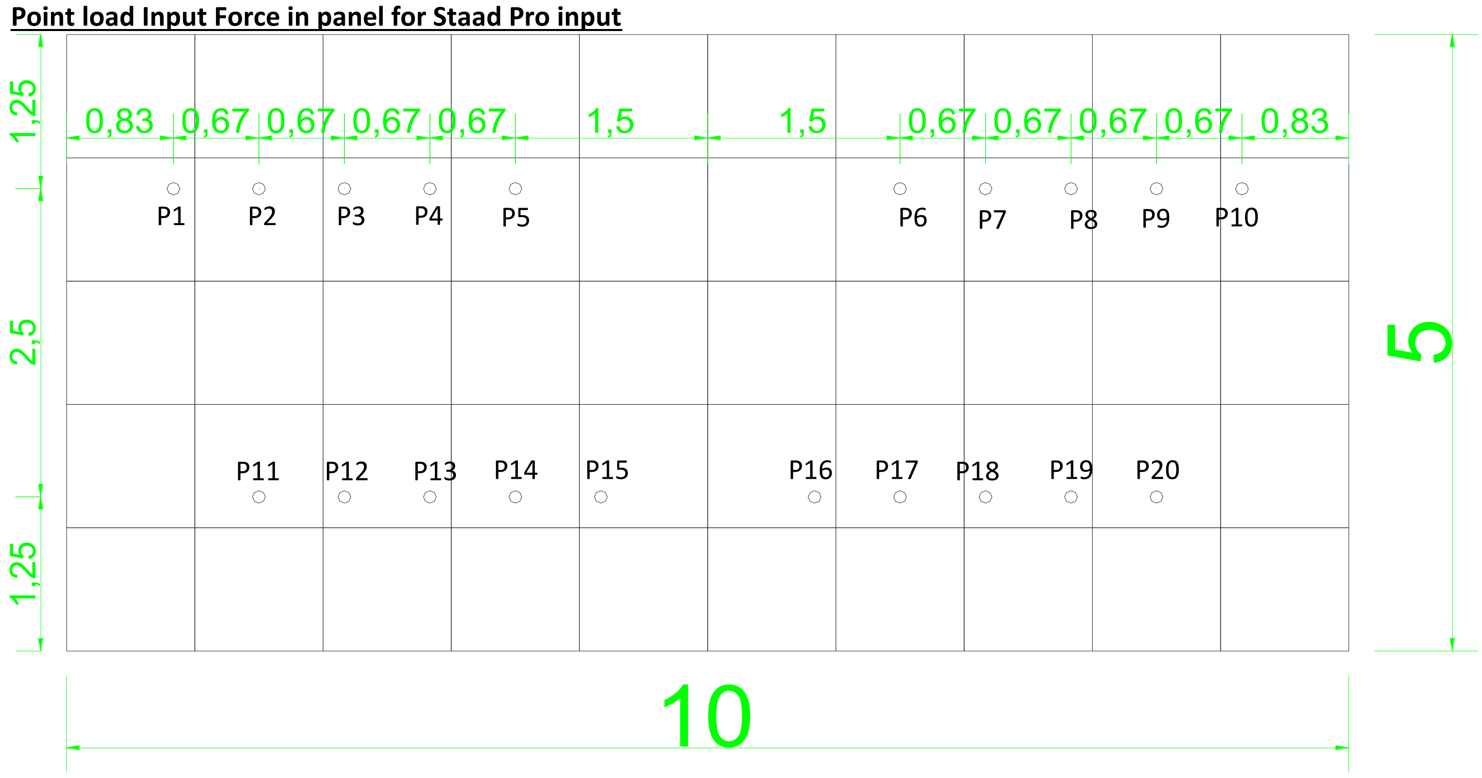
```
    66. FINISH
```

Typical Panel Type (mesh 5W11), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	0	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.33	0.25
P8	0.33	0.25
P9	0	0.25
P10	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P11	0	-0.25
P12	-0.33	-0.25
P13	0.33	-0.25
P14	0	-0.25
P15	-0.33	-0.25
P16	0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P17	0	-0.25
P18	-0.33	-0.25
P19	0.33	-0.25
P20	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

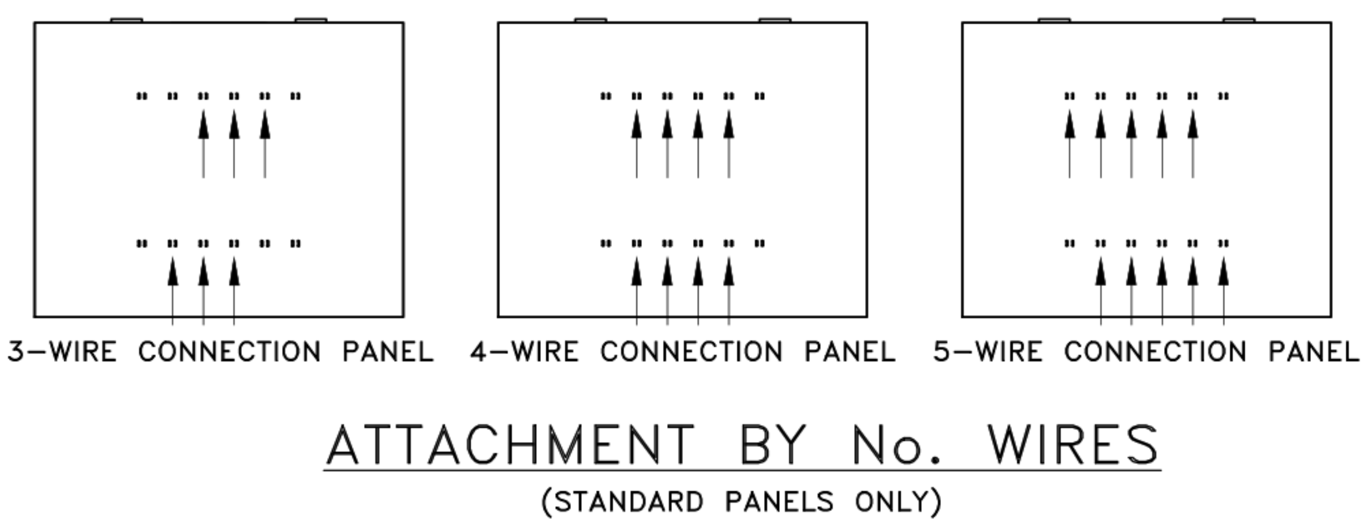
W11 - 75 Years

A = 0.0797 in^2

Fy = 75 ksi

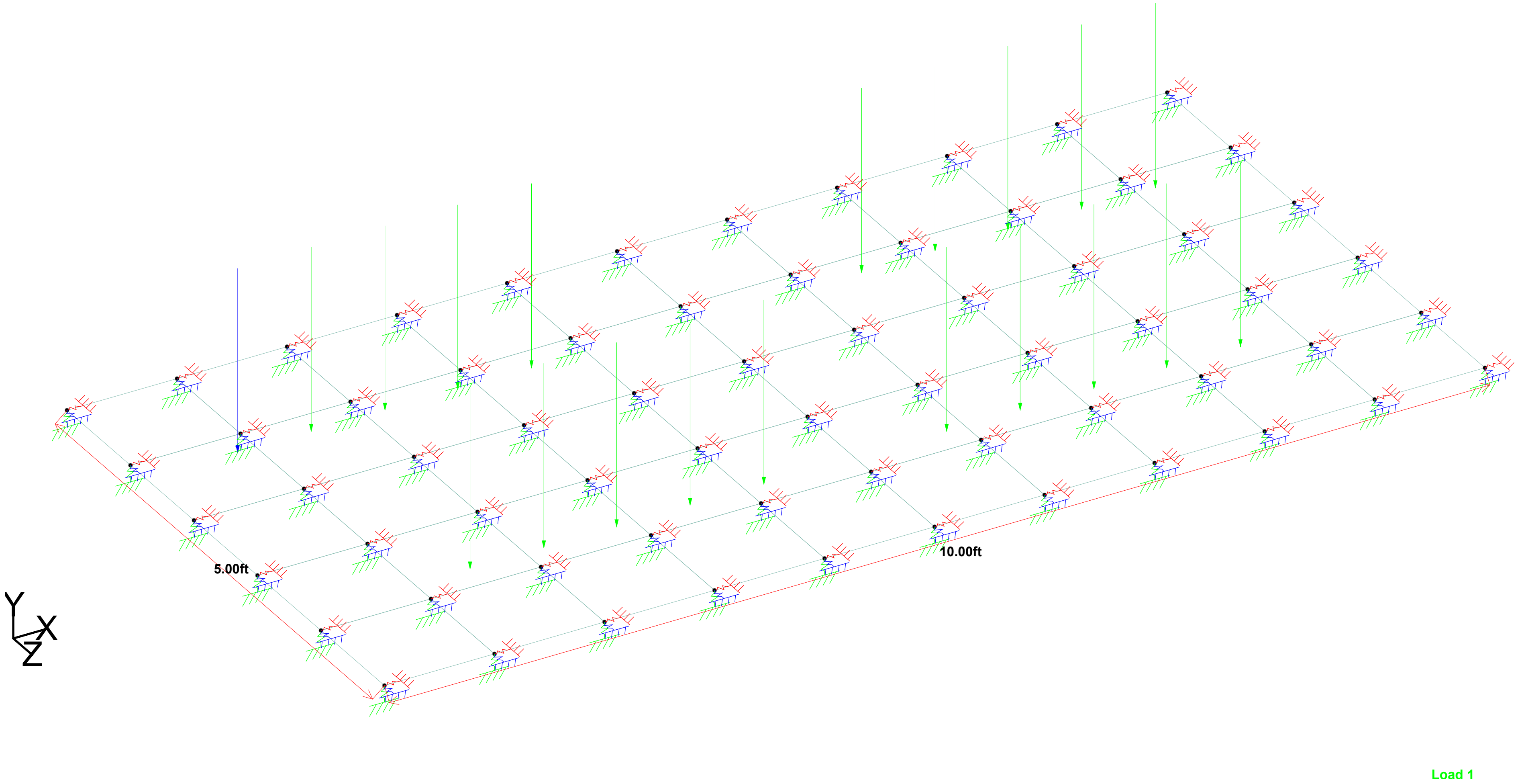
P = 0.65 x A x Fy

= 3.885 Kips (per wire point)

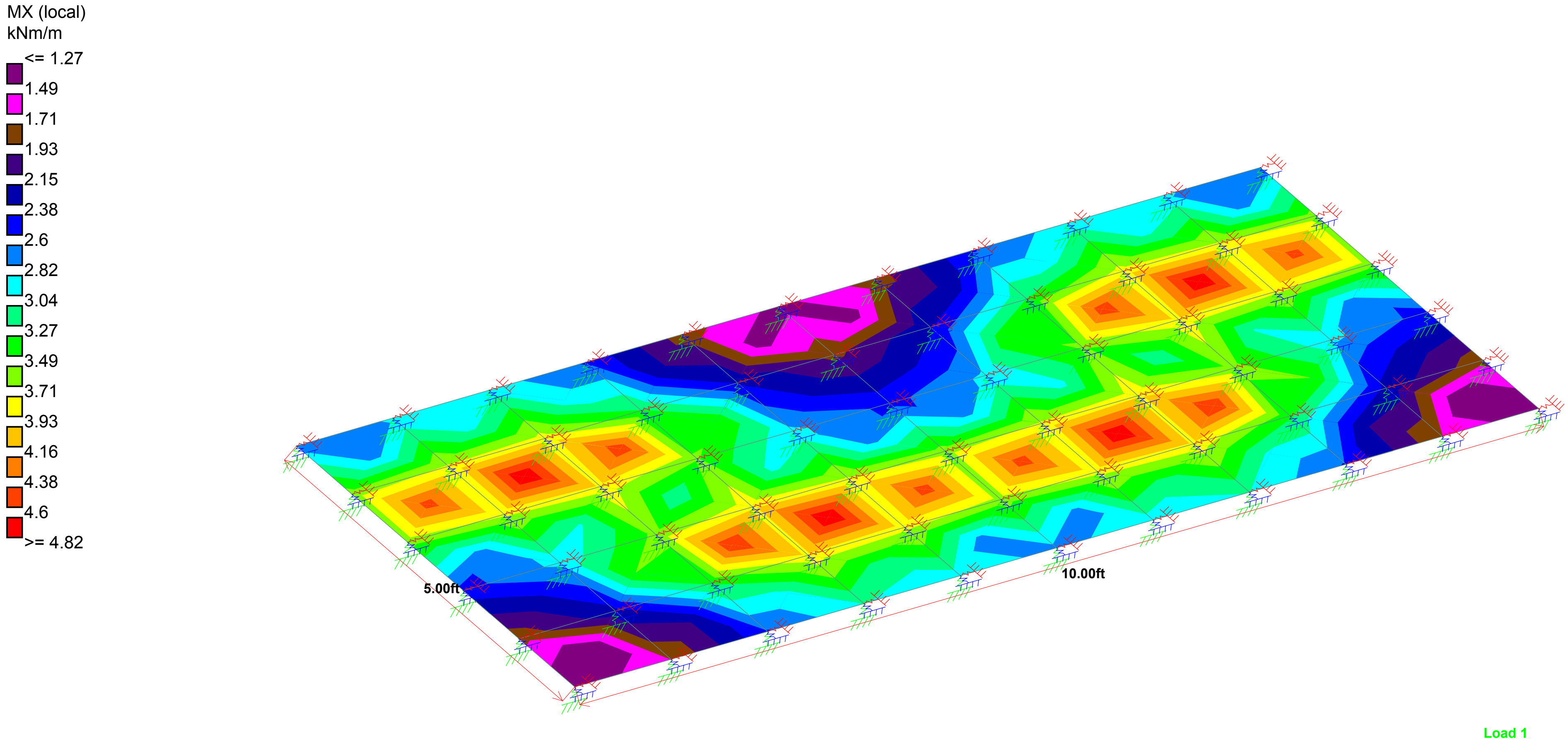


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 04:42	



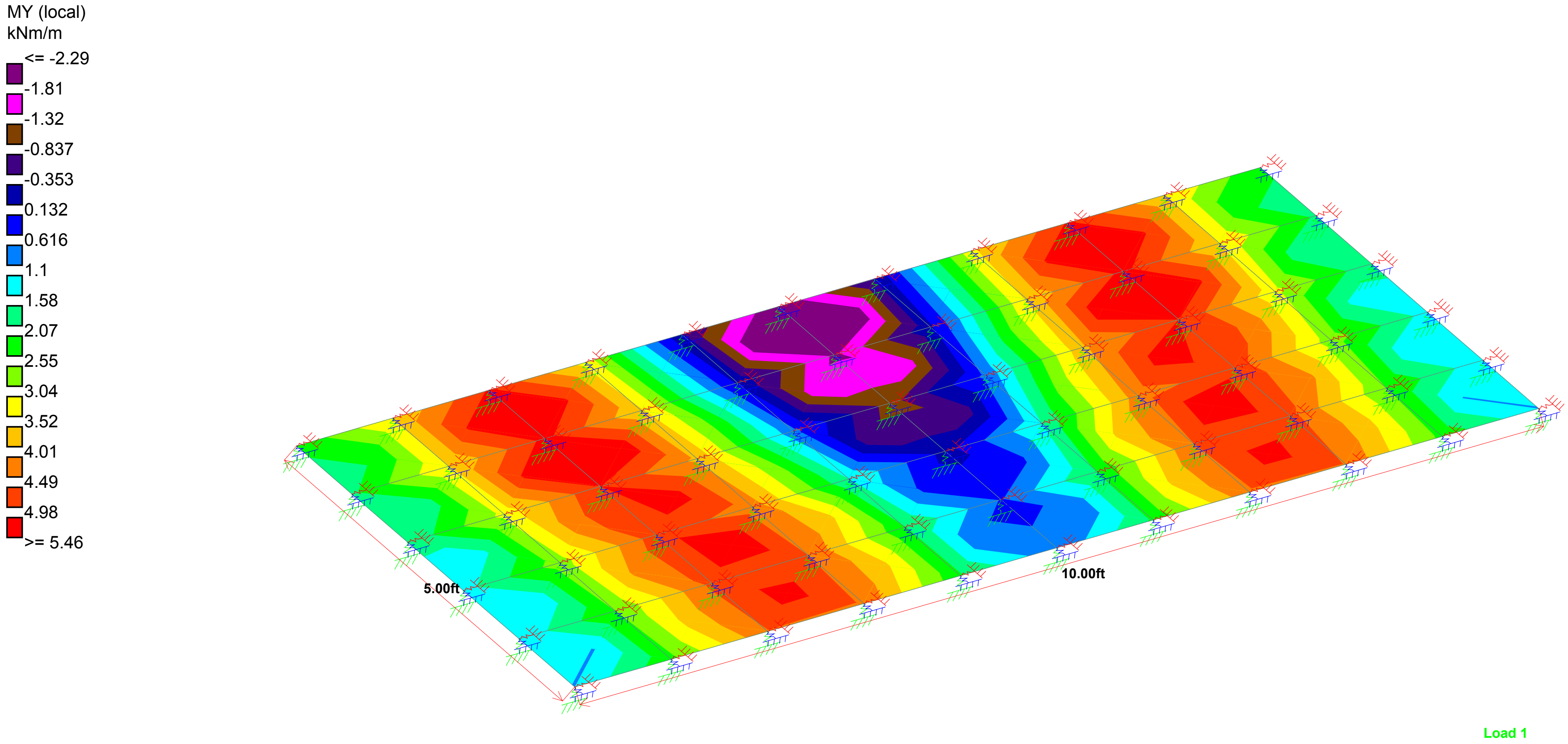
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 04:42	



TOC – Appendix

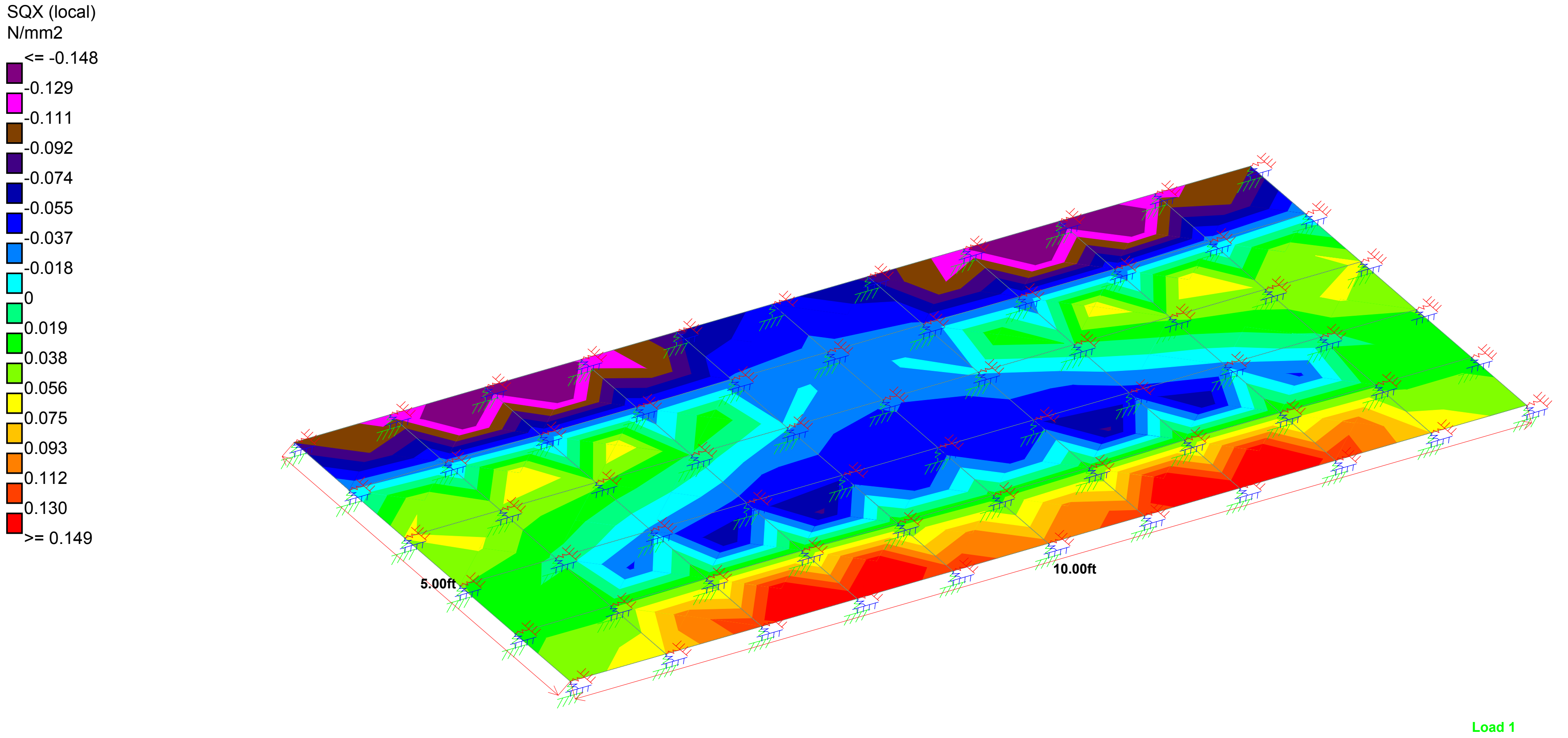
Software licensed to Optimal Engineering Support

Job No		Sheet No 1		Rev
Part				
Job Title	Ref Panel Check			
	By CH	Date 09-Mar-21	Chd	
Client SSL	File Panel Check - 5x10 type /		Date/Time 10-Mar-2021 04:42	

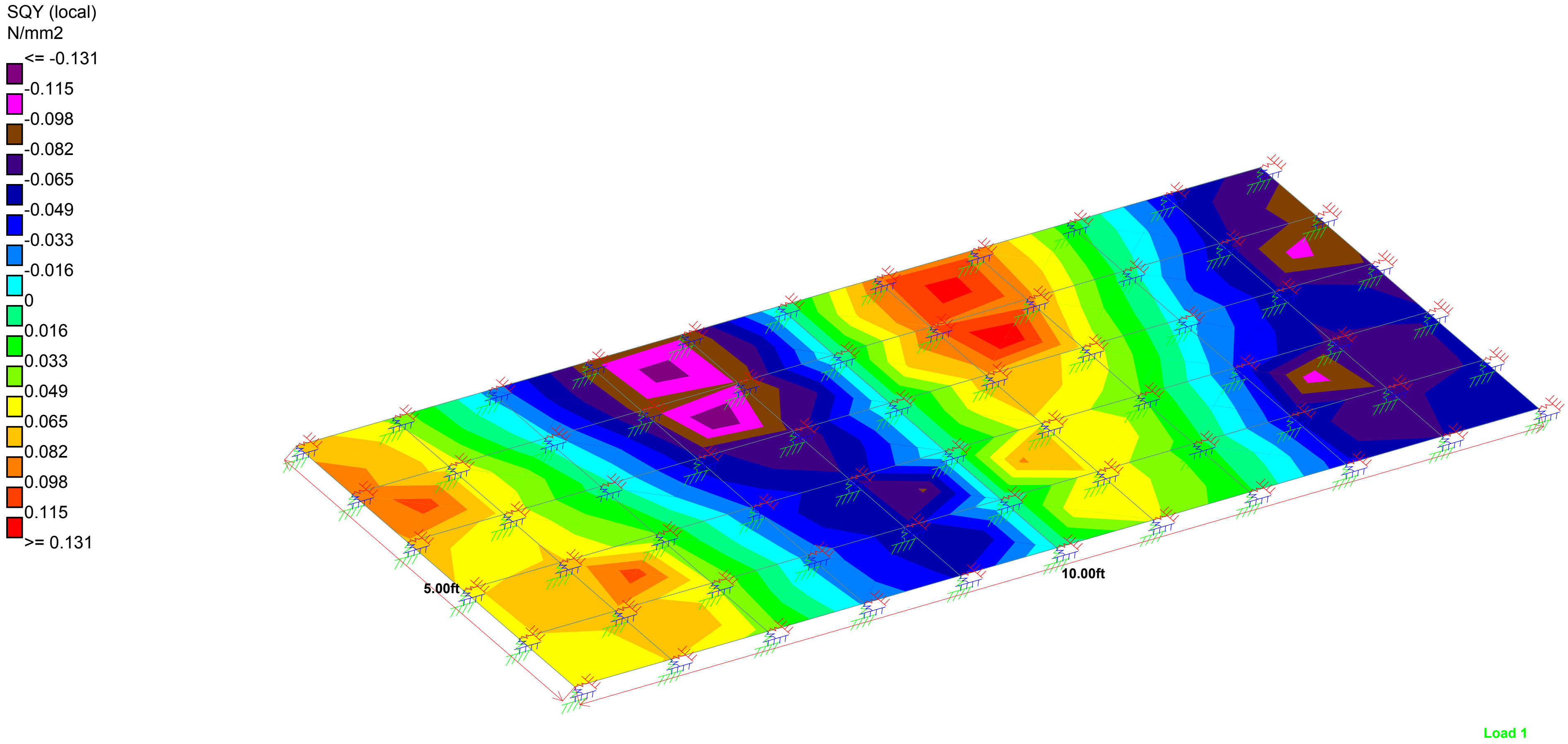


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 04:42	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 04:42	



TOC – Appendix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*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR 10, 2021                  *
*           Time=     4:42:56                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
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INPUT FILE: Panel Check - 5x10 type A (5W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 09-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 31 PR GY -3.885 0.25 0.33
    50. 32 PR GY -3.885 0.25 0
    51. 33 PR GY -3.885 0.25 -0.33
    52. 33 PR GY -3.885 0.25 0.33
    53. 34 PR GY -3.885 0.25 0
    54. 62 PR GY -3.885 0.25 0
    55. 63 PR GY -3.885 0.25 -0.33
    56. 63 PR GY -3.885 0.25 0.33
    57. 64 PR GY -3.885 0.25 0
    58. 65 PR GY -3.885 0.25 -0.33
    59. 5 PR GY -3.885 -0.25 0
    60. 8 PR GY -3.885 -0.25 -0.33
    61. 8 PR GY -3.885 -0.25 0.33
    62. 11 PR GY -3.885 -0.25 0
    63. 14 PR GY -3.885 -0.25 -0.33
    64. 47 PR GY -3.885 -0.25 0.33
    65. 50 PR GY -3.885 -0.25 0
    66. 53 PR GY -3.885 -0.25 -0.33
    67. 53 PR GY -3.885 -0.25 0.33
    68. 56 PR GY -3.885 -0.25 0
    69. PERFORM ANALYSIS


          P R O B L E M   S T A T I S T I C S
          -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     66/    50/    66

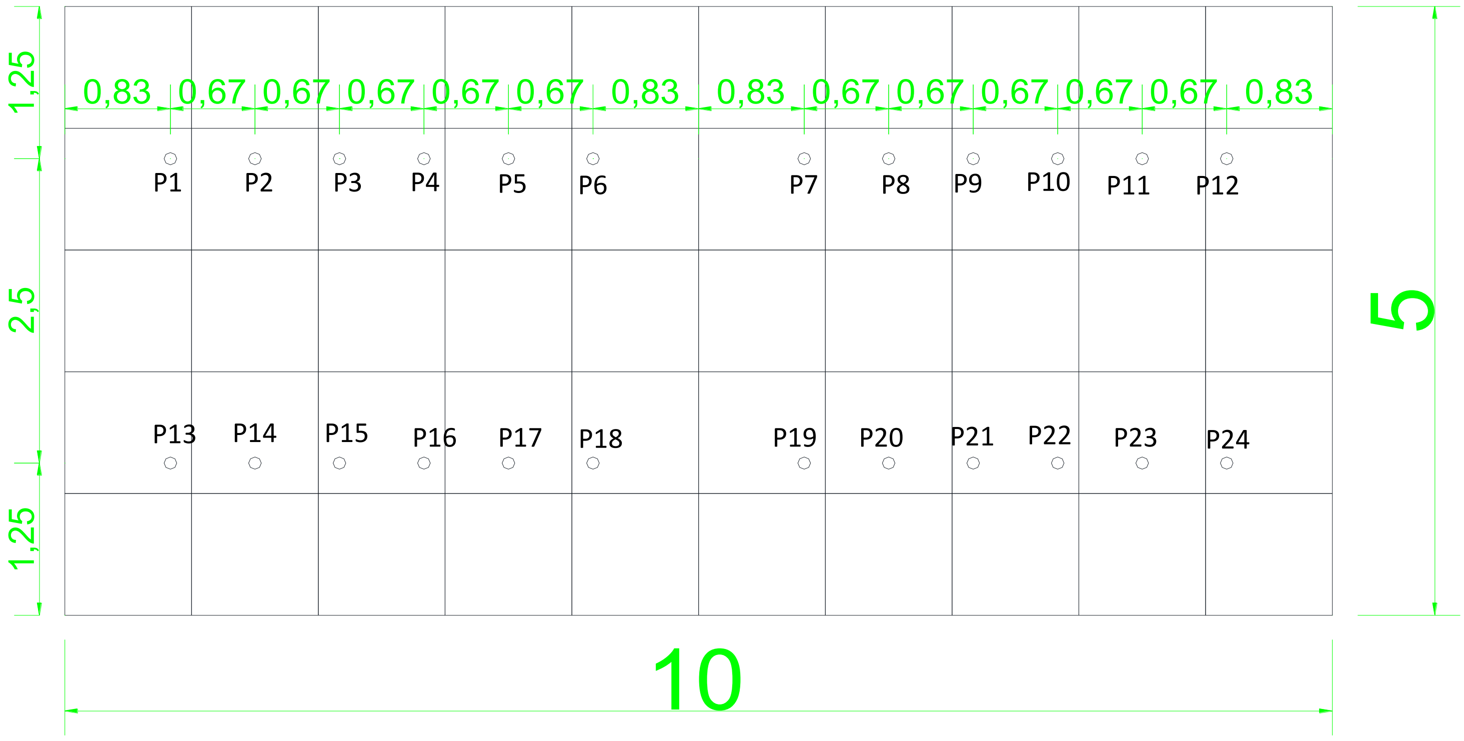
        SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =     396
 SIZE OF STIFFNESS MATRIX =        27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =      12.5/ 263349.3 MB


    70. FINISH
```

Typical Panel Type (mesh 6W11), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.33	0.25
P8	0	0.25
P9	-0.33	0.25
P10	0.33	0.25
P11	0	0.25
P12	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P13	0.33	-0.25
P14	0	-0.25
P15	-0.33	-0.25
P16	0.33	-0.25
P17	0	-0.25
P18	-0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P19	0.33	-0.25
P20	0	-0.25
P21	-0.33	-0.25
P22	0.33	-0.25
P23	0	-0.25
P24	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

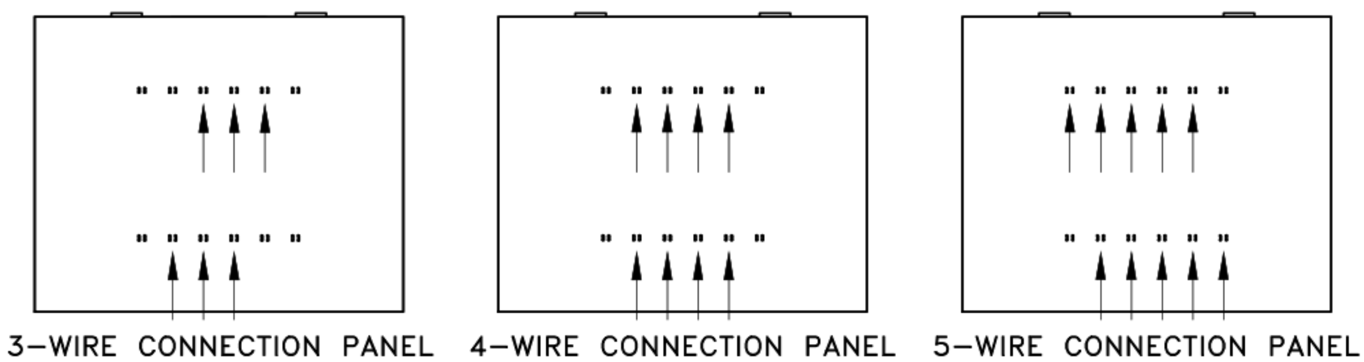
W11 - 75 Years

$A = 0.0797 \text{ in}^2$

$Fy = 75 \text{ ksi}$

$P = 0.65 \times A \times Fy$

$= 3.885$ Kips (per wire point)

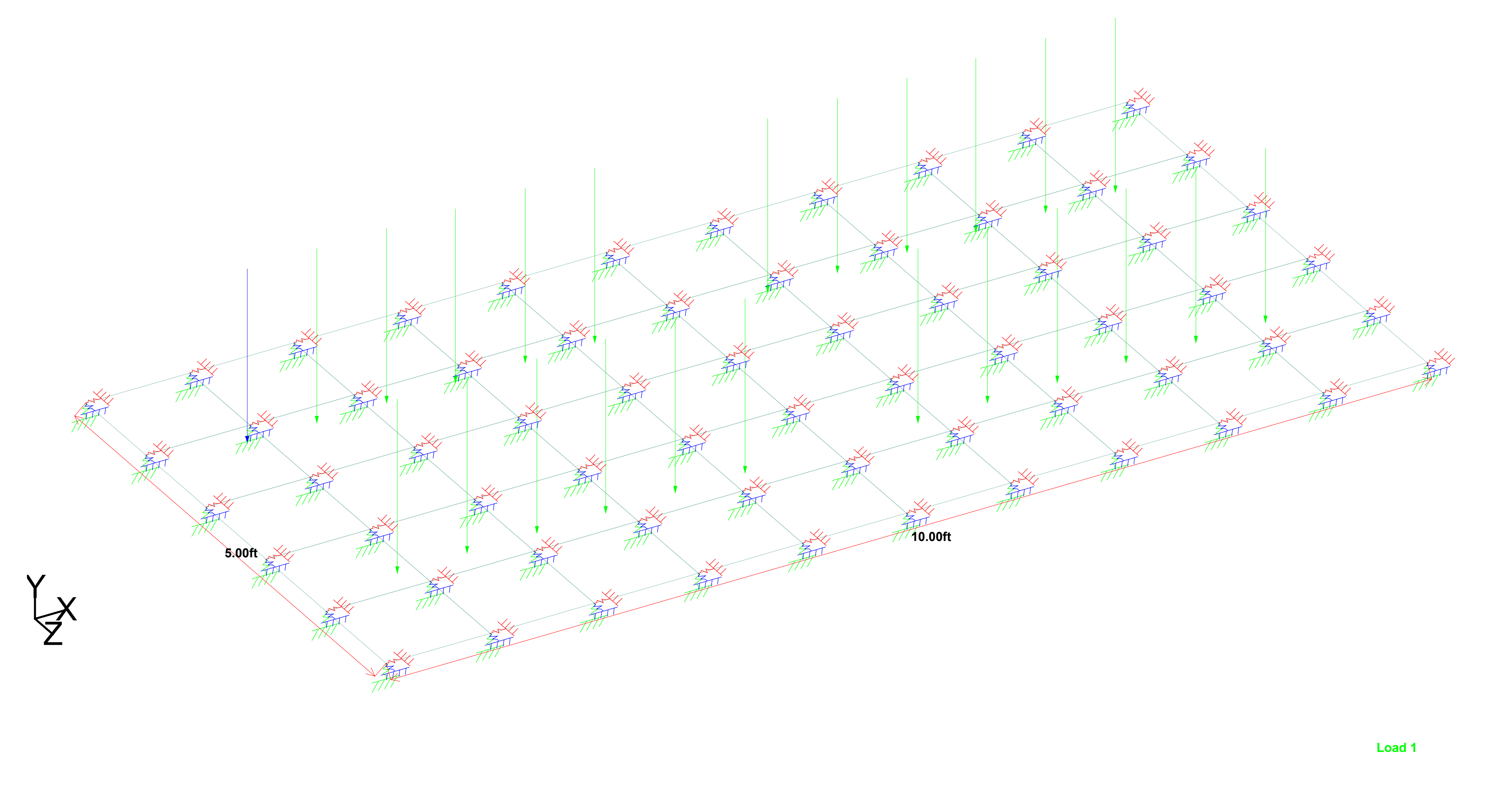


ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
	Part		
	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:23	



TOC – Appendix

Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
	Part		
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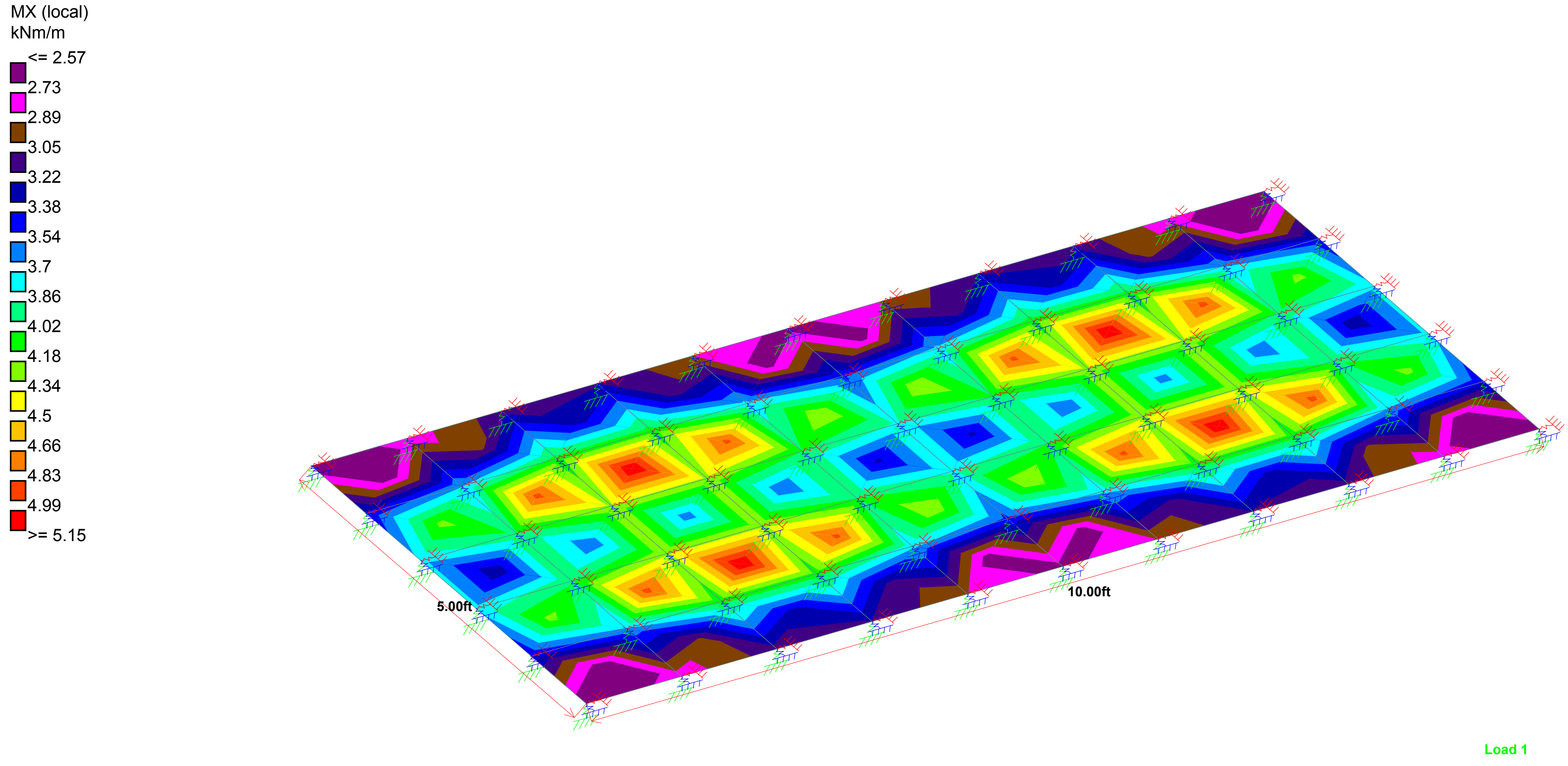
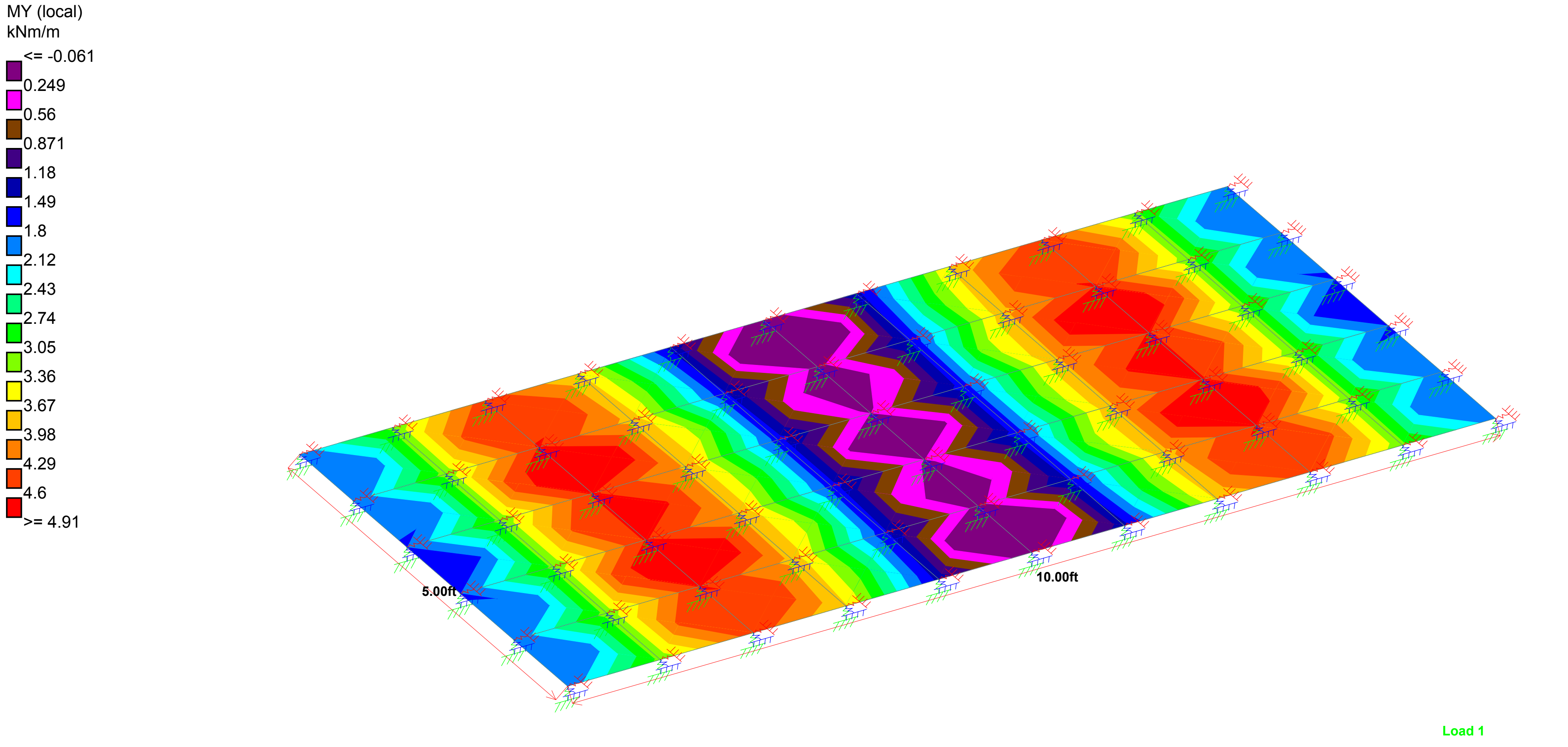
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:23	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:23	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:23	

SQX (local)
N/mm2

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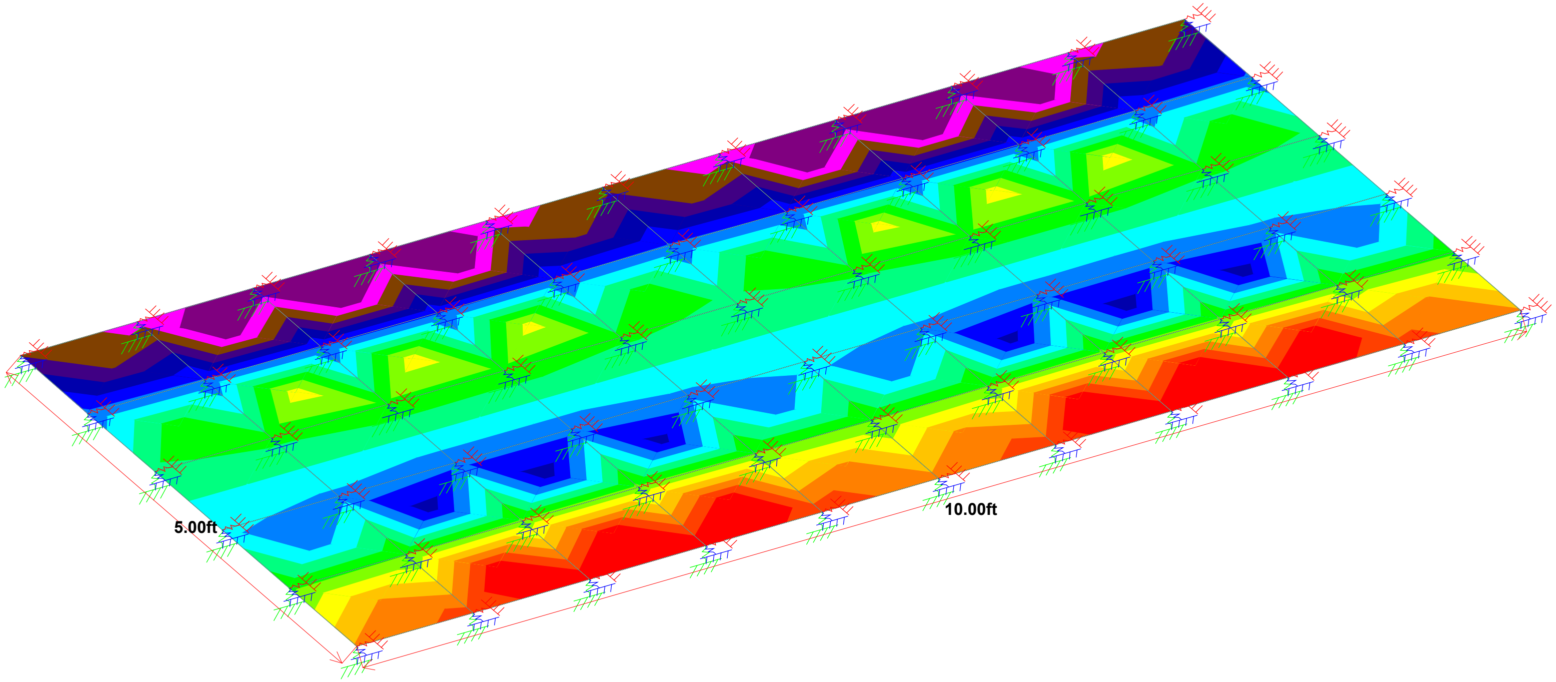
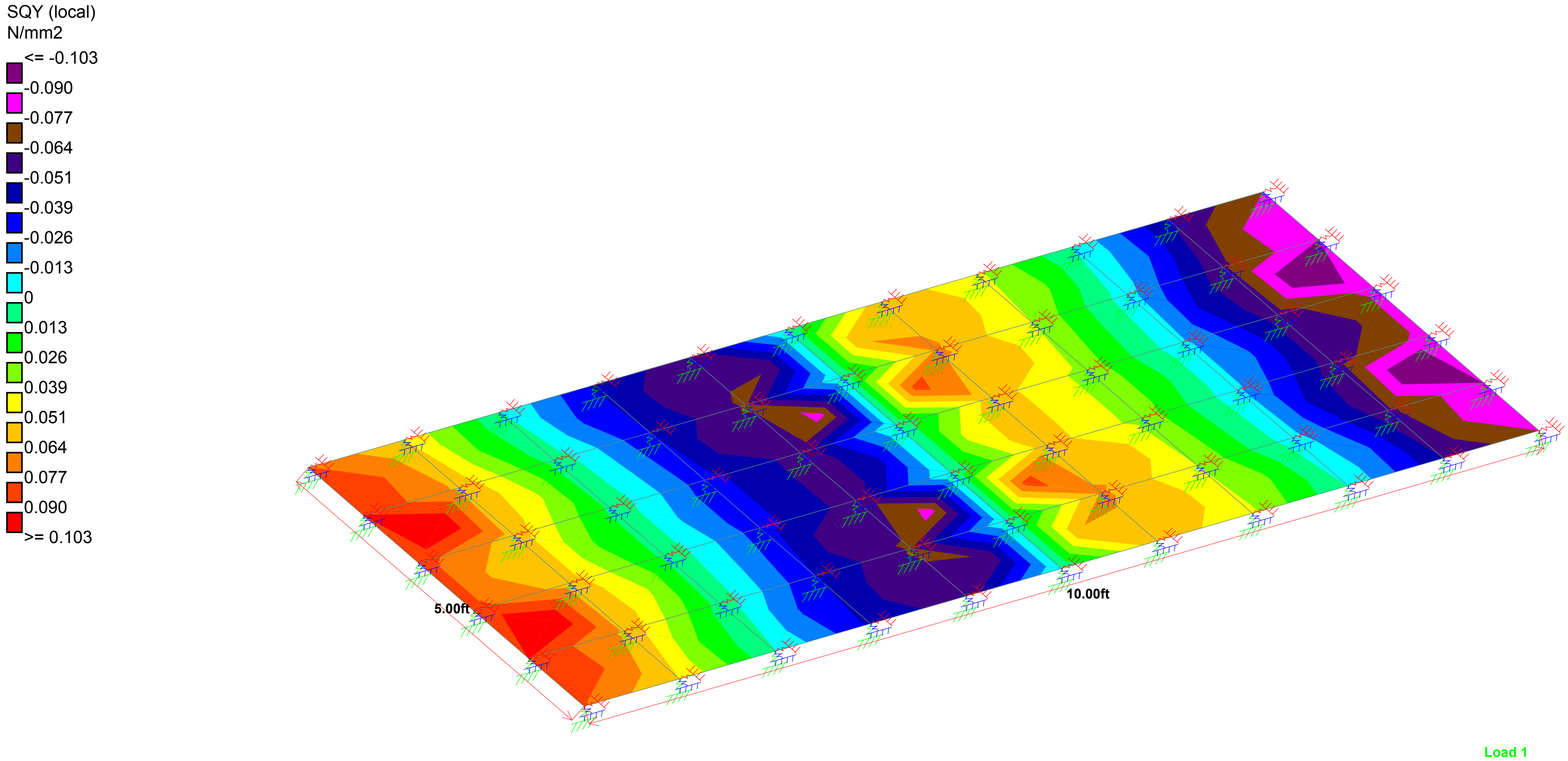
-0.134
-0.115
-0.095
-0.076
-0.057
-0.038
-0.019
0
0.019
0.038
0.057
0.076
0.095
0.115
0.134
>= 0.153



Load 1

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:23	



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     *           Proprietary Program of                 *
     *           Research Engineers,  Intl.             *
     *           Date=    MAR 10, 2021                  *
     *           Time=    21:23:47                      *
     *                                                  *
     *      USER ID: Optimal Engineering Support        *
     ****************************************************


     1. STAAD SPACE
INPUT FILE: Panel Check - 5x10 type A (6W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 31 PR GY -3.885 0.25 0.33
    50. 32 PR GY -3.885 0.25 0
    51. 33 PR GY -3.885 0.25 -0.33
    52. 33 PR GY -3.885 0.25 0.33
    53. 34 PR GY -3.885 0.25 0
    54. 35 PR GY -3.885 0.25 -0.33
    55. 61 PR GY -3.885 0.25 0.33
    56. 62 PR GY -3.885 0.25 0
    57. 63 PR GY -3.885 0.25 -0.33
    58. 63 PR GY -3.885 0.25 0.33
    59. 64 PR GY -3.885 0.25 0
    60. 65 PR GY -3.885 0.25 -0.33
    61. 2 PR GY -3.885 -0.25 0.33
    62. 5 PR GY -3.885 -0.25 0
    63. 8 PR GY -3.885 -0.25 -0.33
    64. 8 PR GY -3.885 -0.25 0.33
    65. 11 PR GY -3.885 -0.25 0
    66. 14 PR GY -3.885 -0.25 -0.33
    67. 47 PR GY -3.885 -0.25 0.33
    68. 50 PR GY -3.885 -0.25 0
    69. 53 PR GY -3.885 -0.25 -0.33
    70. 53 PR GY -3.885 -0.25 0.33
    71. 56 PR GY -3.885 -0.25 0
    72. 59 PR GY -3.885 -0.25 -0.33
    73. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    66/    50/    66

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263322.1 MB



    74. FINISH
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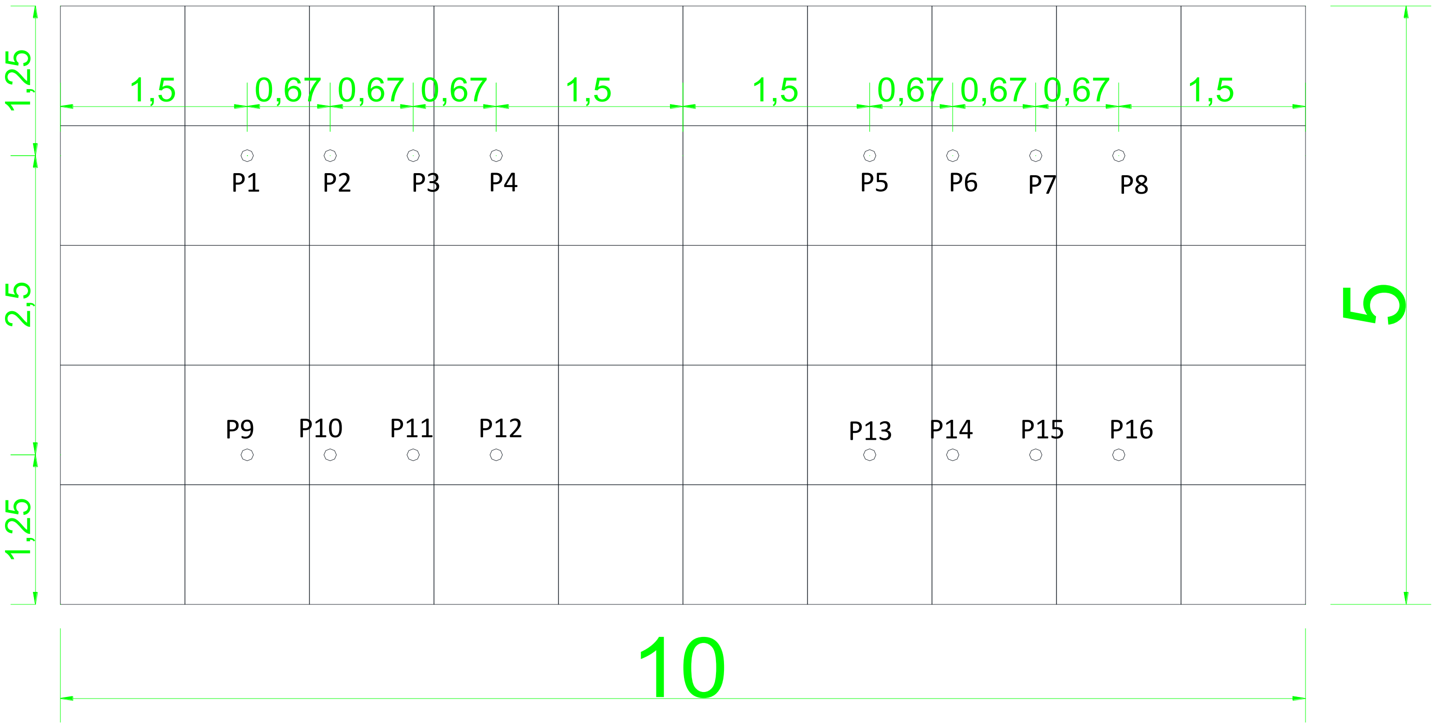
Typical Panel Type (mesh 4W20), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0	0.25
P2	-0.33	0.25
P3	0.33	0.25
P4	0	0.25
P5	0	0.25
P6	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.33	0.25
P8	0	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P9	0	-0.25
P10	-0.33	-0.25
P11	0.33	-0.25
P12	0	-0.25
P13	0	-0.25
P14	-0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P15	0.33	-0.25
P16	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

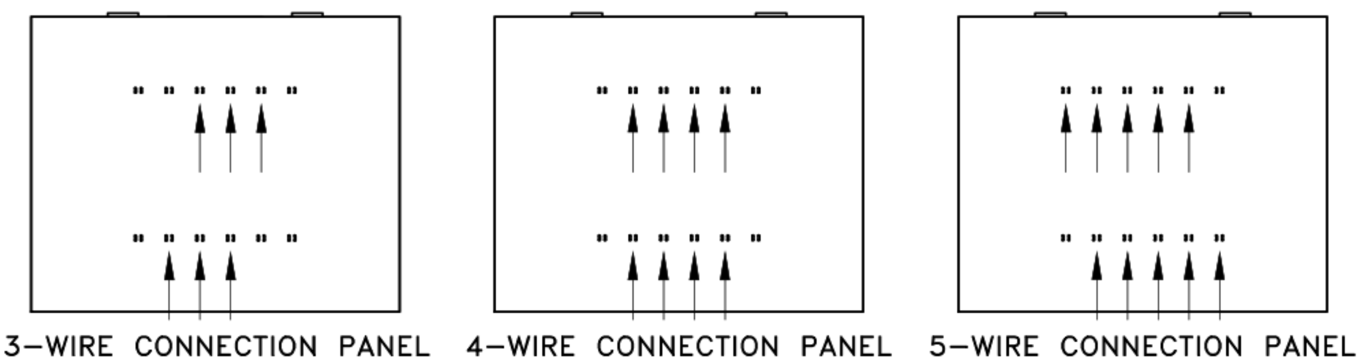
W11 - 75 Years

A = 0.1583 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

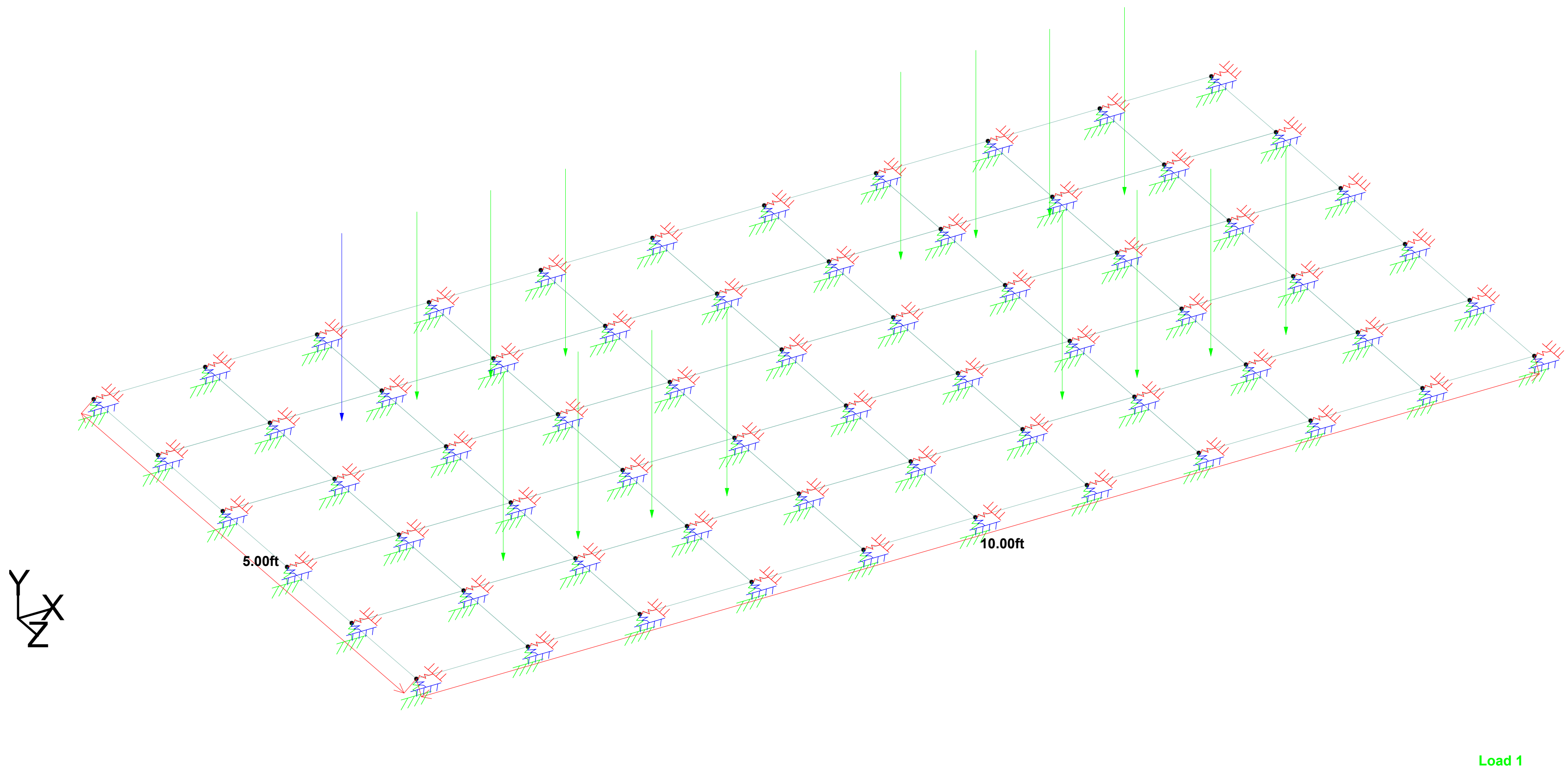
= 7.717 Kips (per wire point)



ATTACHMENT BY No. WIRES

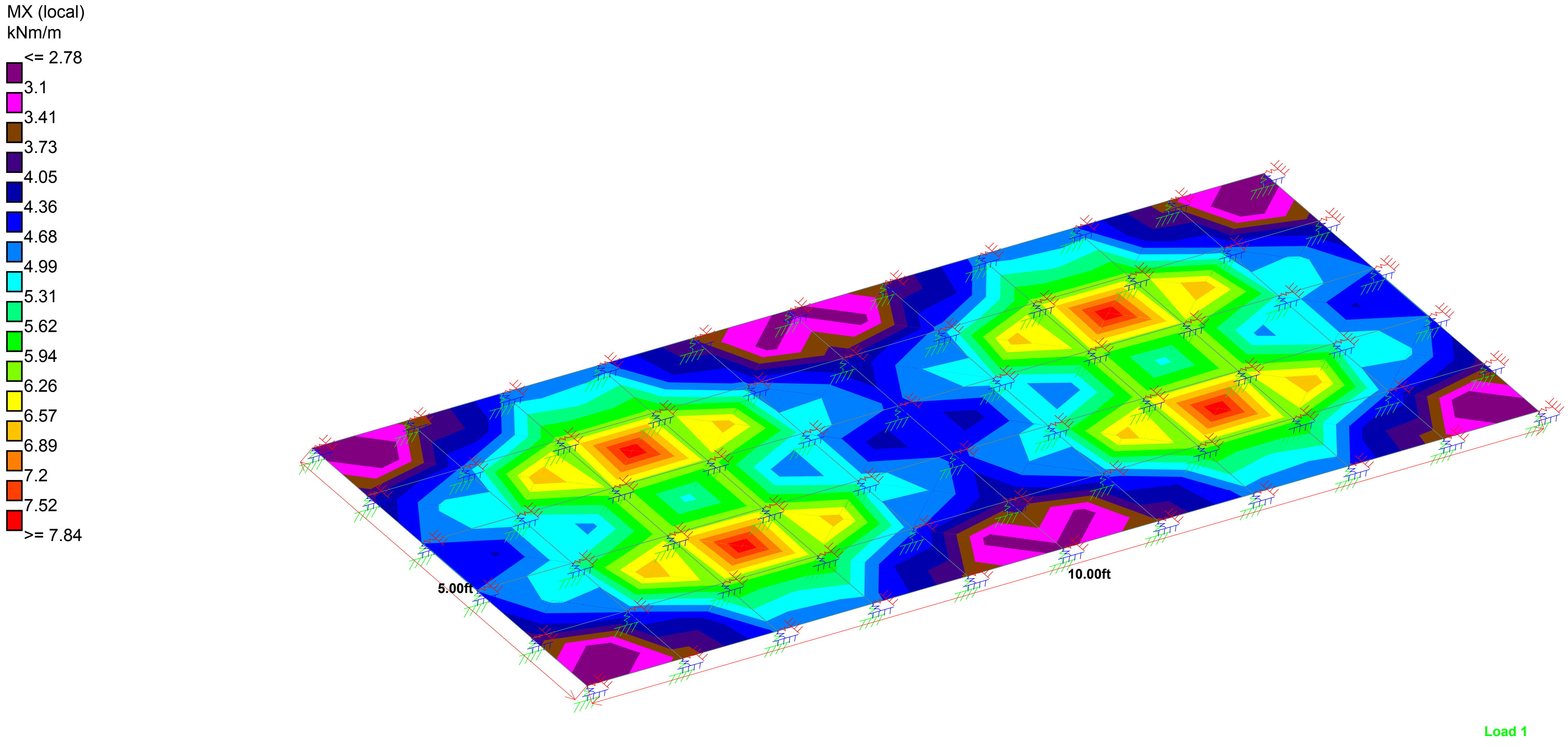
(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 05:20	

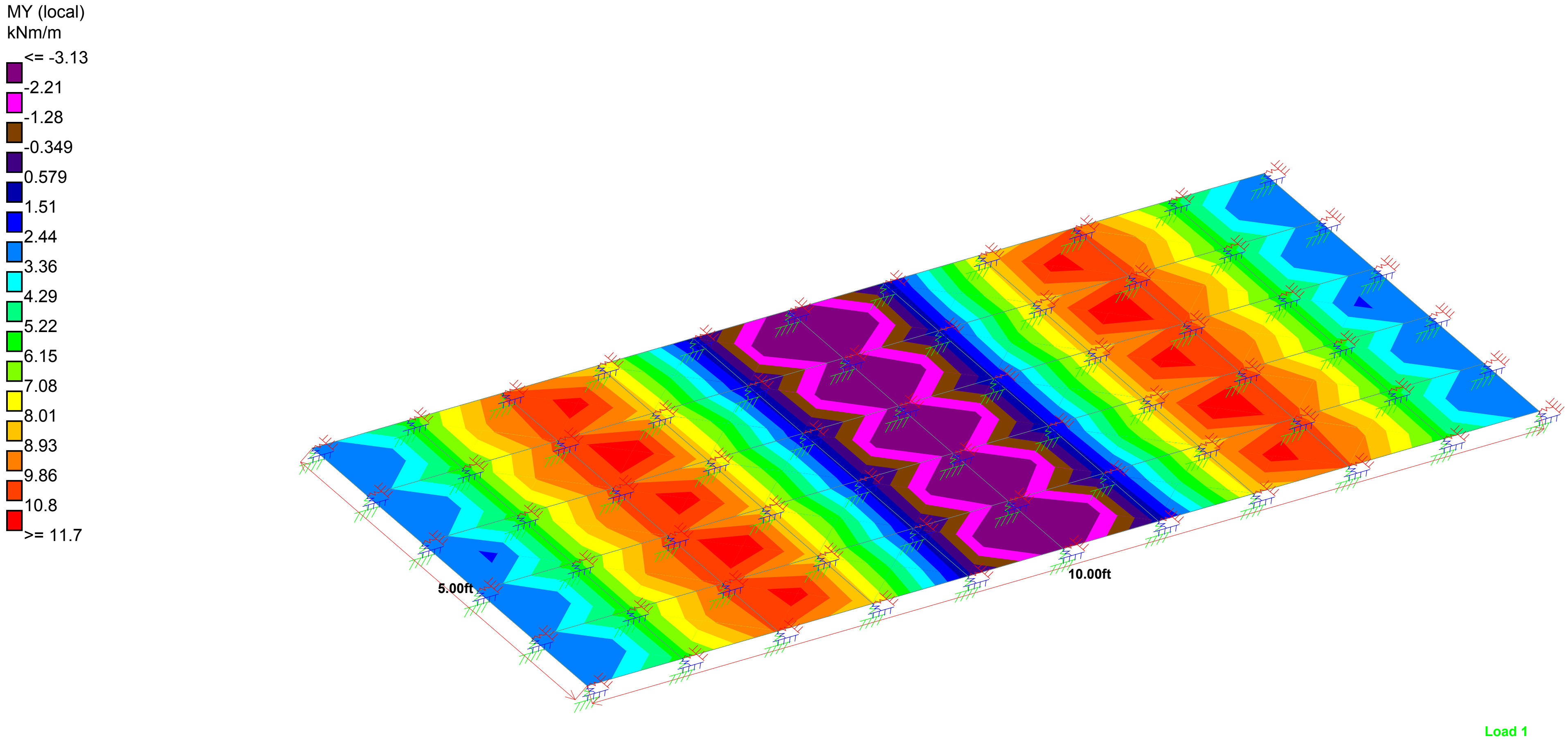


Software licensed to Optimal Engineering Support

Job No	Sheet No 1		Rev
Part			
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 05:20	

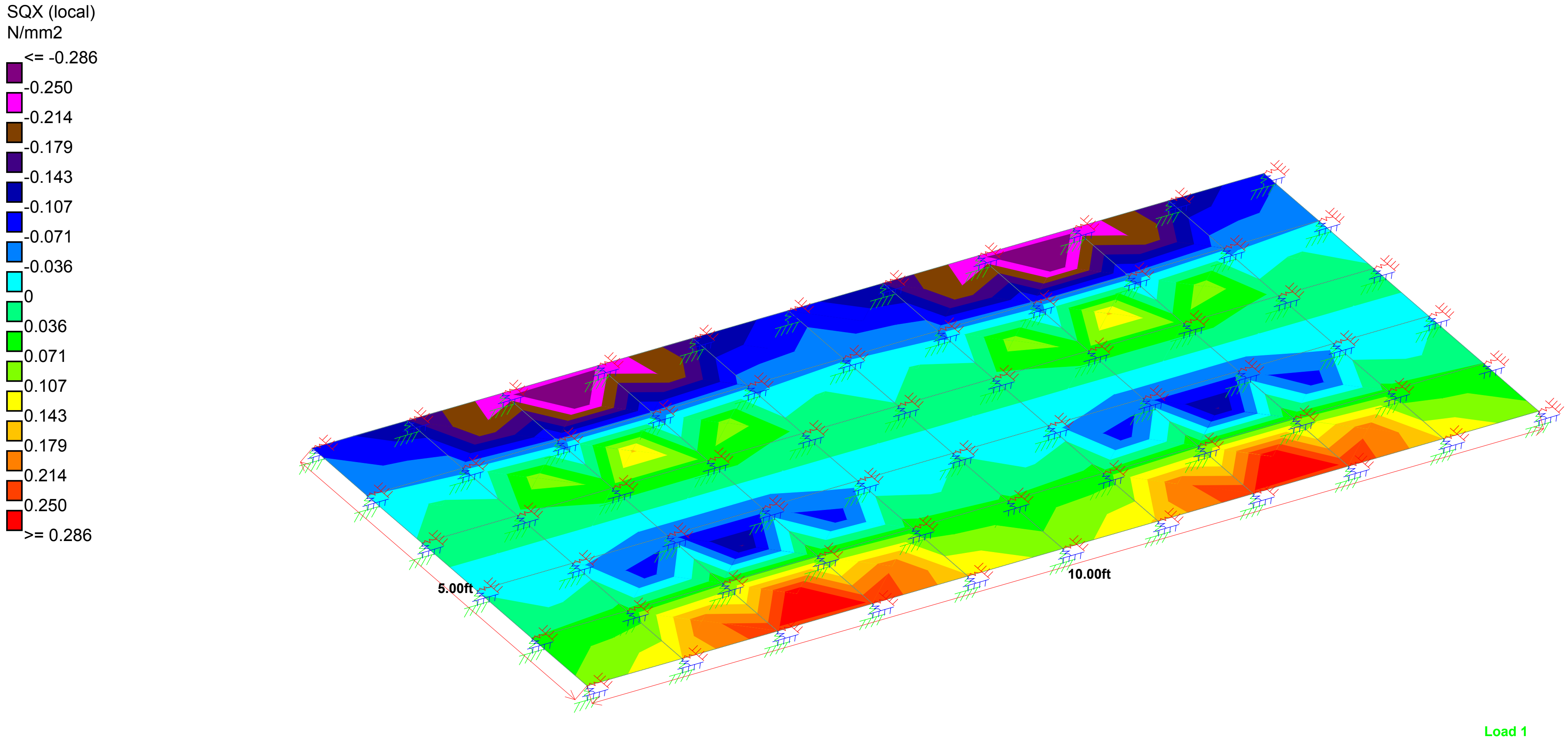


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 05:20	

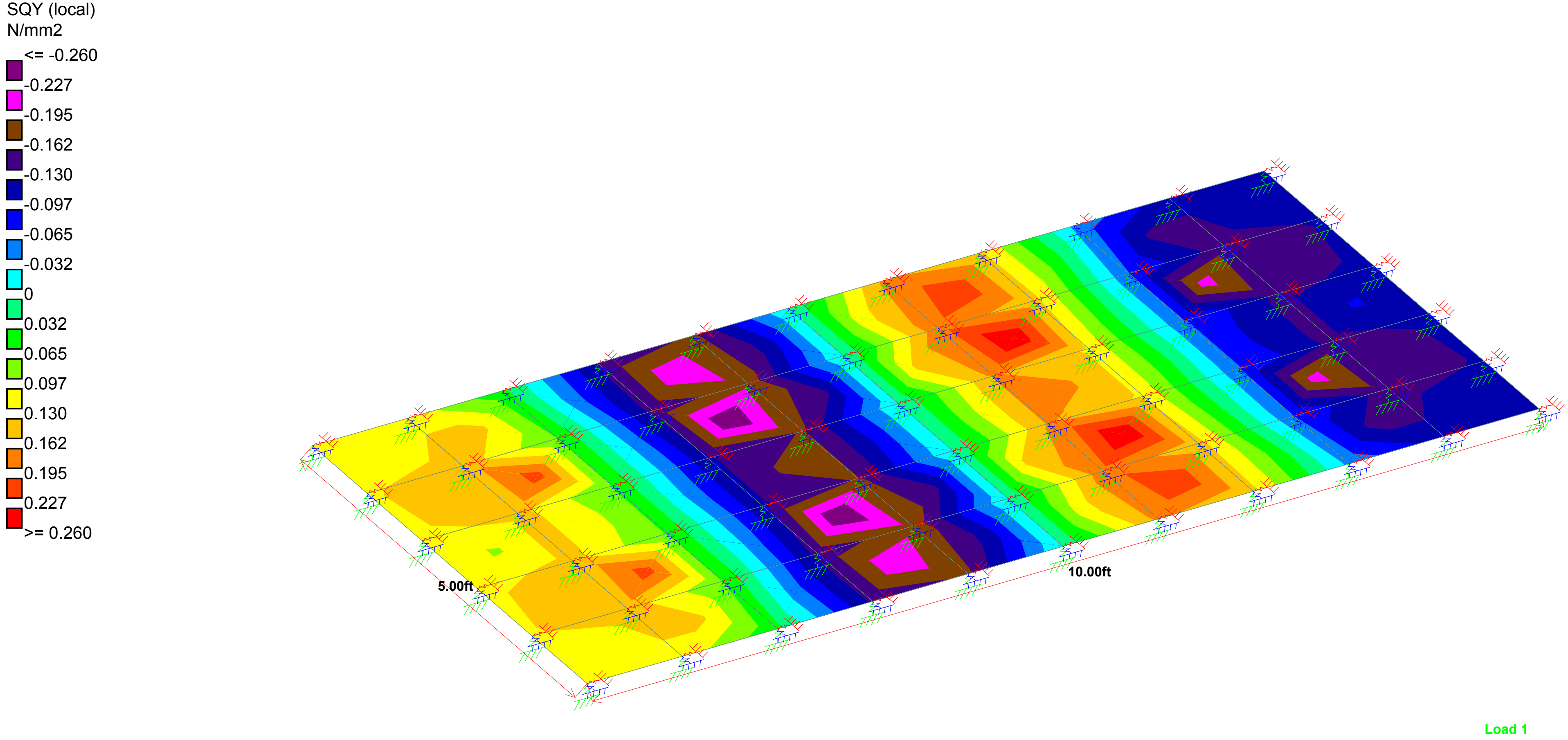


Software licensed to Optimal Engineering Support

Job No		Sheet No 1	Rev
		Part	
Job Title		Ref Panel Check	
		By CH	Date 09-Mar-21 Chd
Client SSL		File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 05:20



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 05:20	



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         *           STAAD.Pro                              *
         *           Version  2007    Build 04              *
         *           Proprietary Program of                 *
         *           Research Engineers,  Intl.             *
         *           Date=    MAR 10, 2021                  *
         *           Time=     5:37:50                      *
         *                                                  *
         *      USER ID: Optimal Engineering Support        *
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INPUT FILE: Panel Check - 5x10 type A (4W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 09-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 32 PR GY -7.717 0.25 0
    50. 33 PR GY -7.717 0.25 -0.33
    51. 33 PR GY -7.717 0.25 0.33
    52. 34 PR GY -7.717 0.25 0
    53. 62 PR GY -7.717 0.25 0
    54. 63 PR GY -7.717 0.25 -0.33
    55. 63 PR GY -7.717 0.25 0.33
    56. 64 PR GY -7.717 0.25 0
    57. 5 PR GY -7.717 -0.25 0
    58. 8 PR GY -7.717 -0.25 -0.33
    59. 8 PR GY -7.717 -0.25 0.33
    60. 11 PR GY -7.717 -0.25 0
    61. 50 PR GY -7.717 -0.25 0
    62. 53 PR GY -7.717 -0.25 -0.33
    63. 53 PR GY -7.717 -0.25 0.33
    64. 56 PR GY -7.717 -0.25 0
    65. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    66/    50/    66

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263347.2 MB
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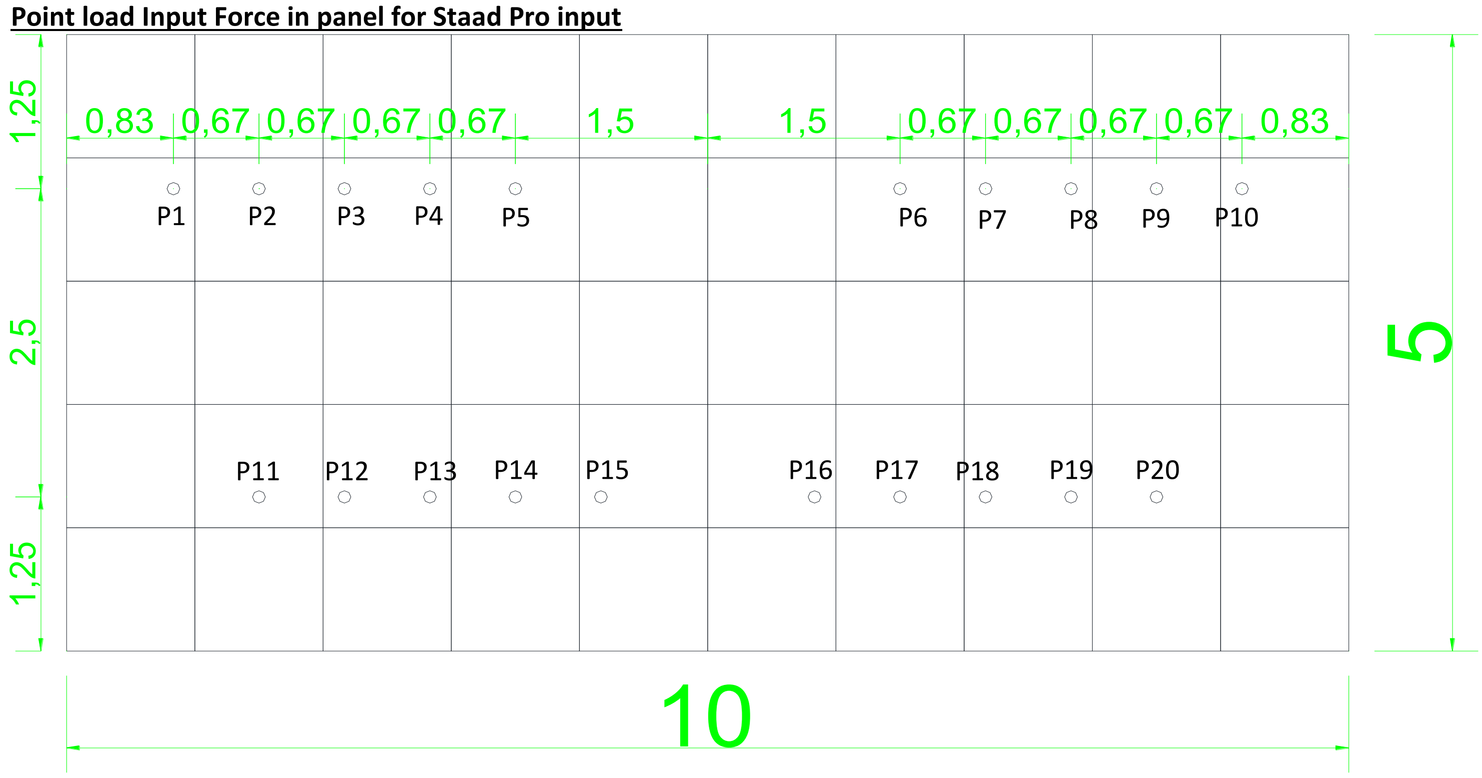
```
    66. FINISH
```

Typical Panel Type (mesh 5W20), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	0	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.33	0.25
P8	0.33	0.25
P9	0	0.25
P10	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P11	0	-0.25
P12	-0.33	-0.25
P13	0.33	-0.25
P14	0	-0.25
P15	-0.33	-0.25
P16	0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P17	0	-0.25
P18	-0.33	-0.25
P19	0.33	-0.25
P20	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

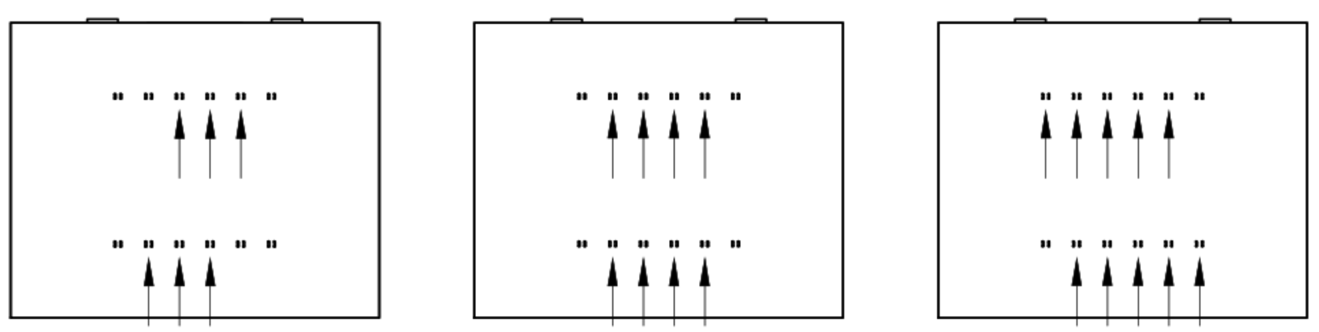
W11 - 75 Years

A = 0.1583 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

= 7.717 Kips (per wire point)



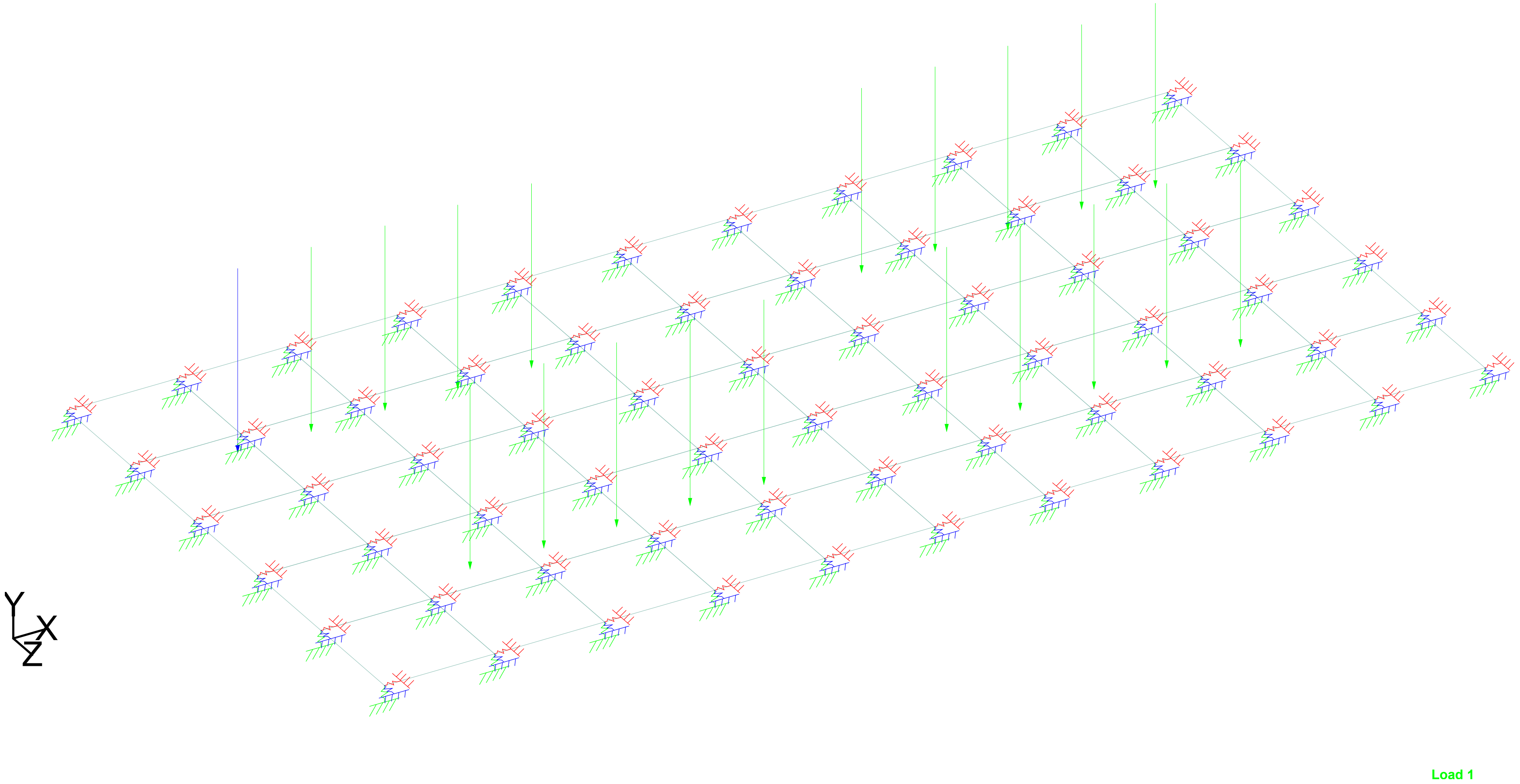
3–WIRE CONNECTION PANEL 4–WIRE CONNECTION PANEL 5–WIRE CONNECTION PANEL

ATTACHMENT BY No. WIRES

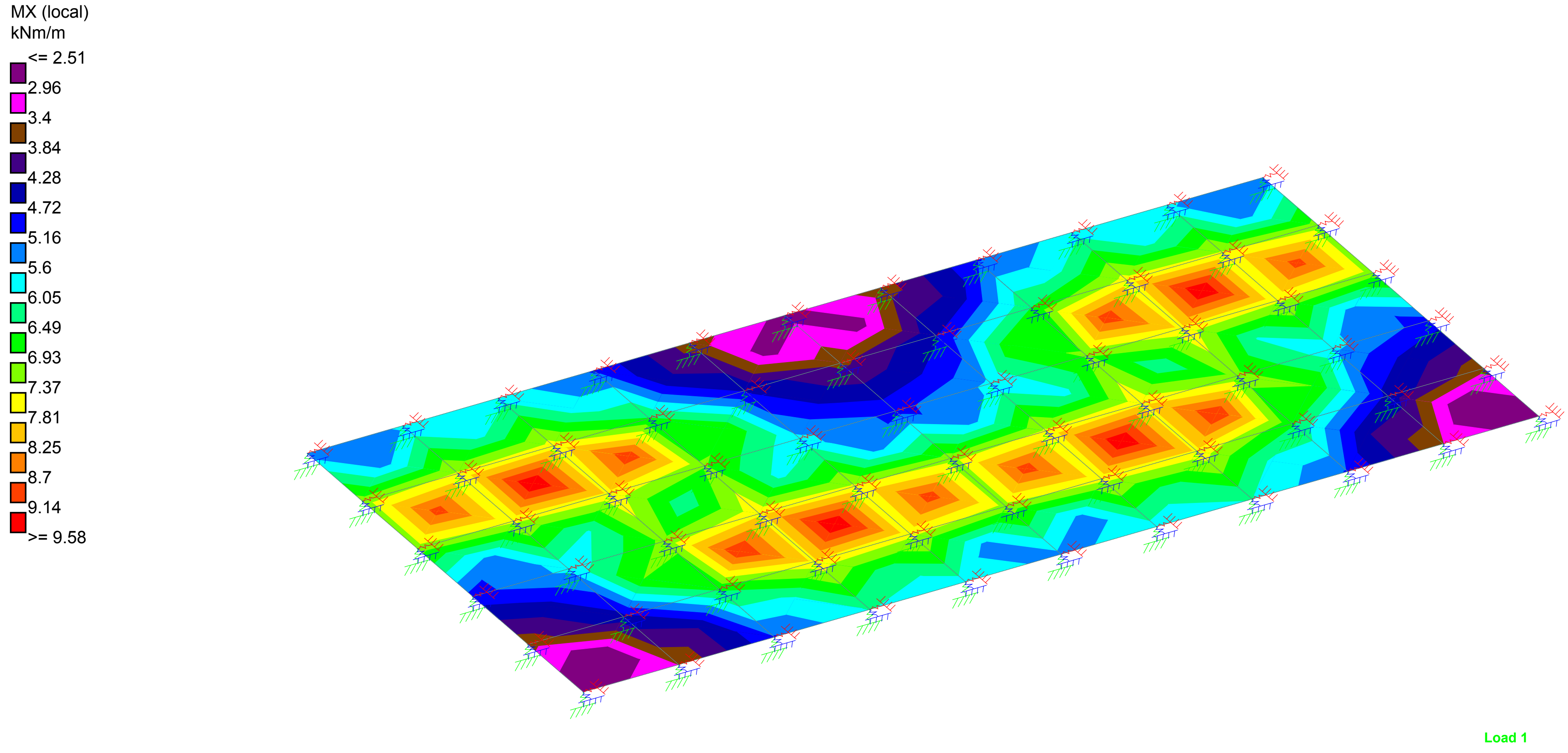
(STANDARD PANELS ONLY)

TOC – Appendix

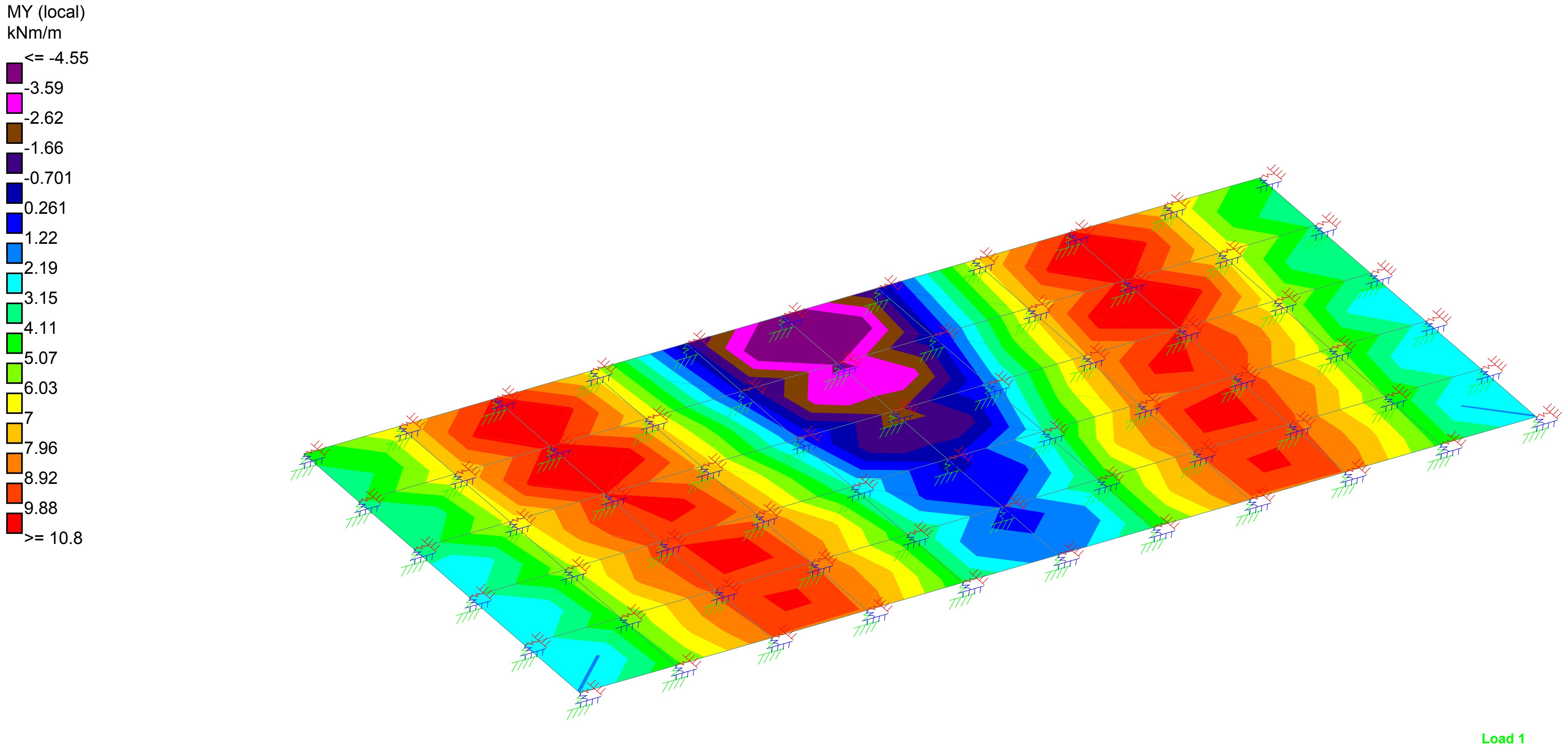
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 07:46	



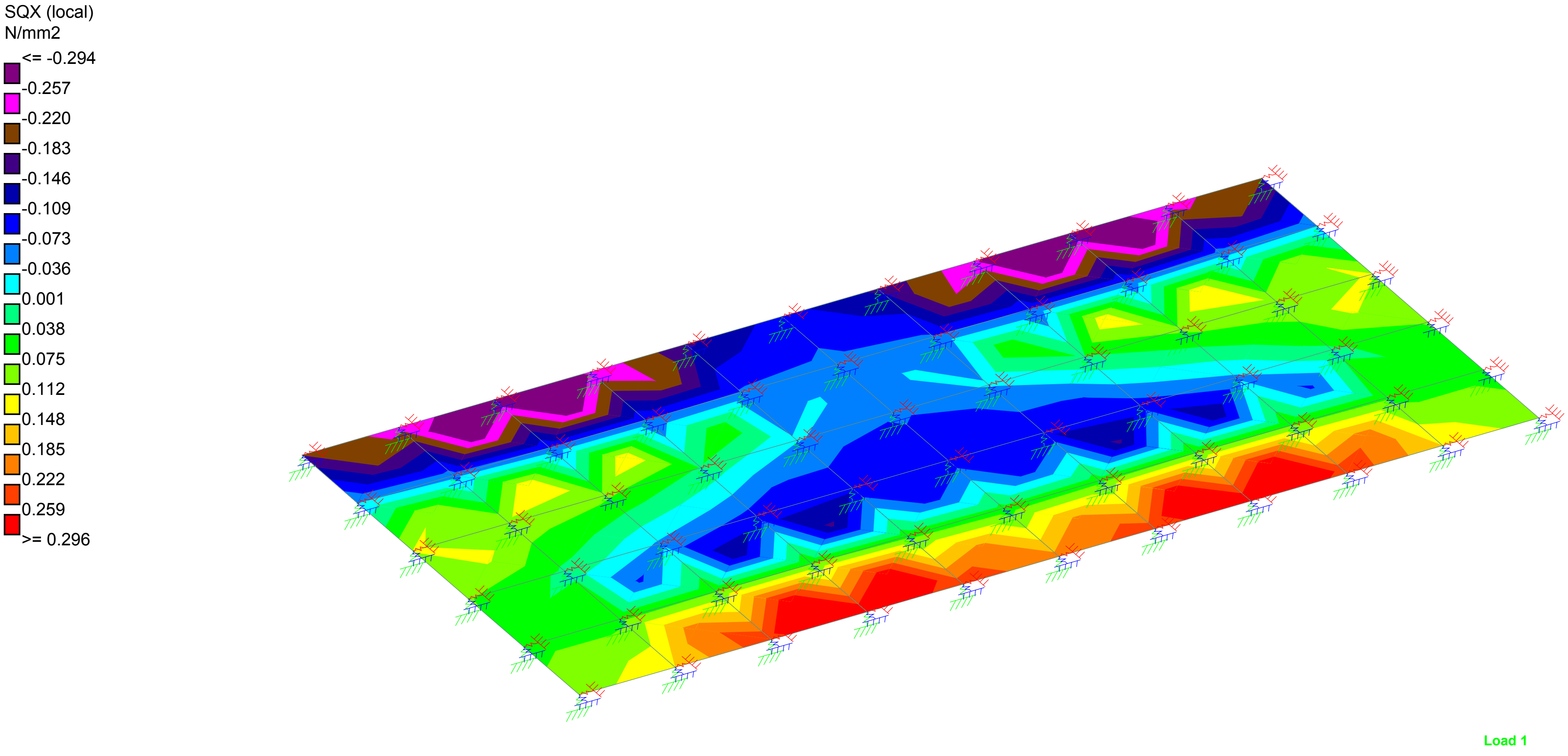
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 07:46	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 07:46	

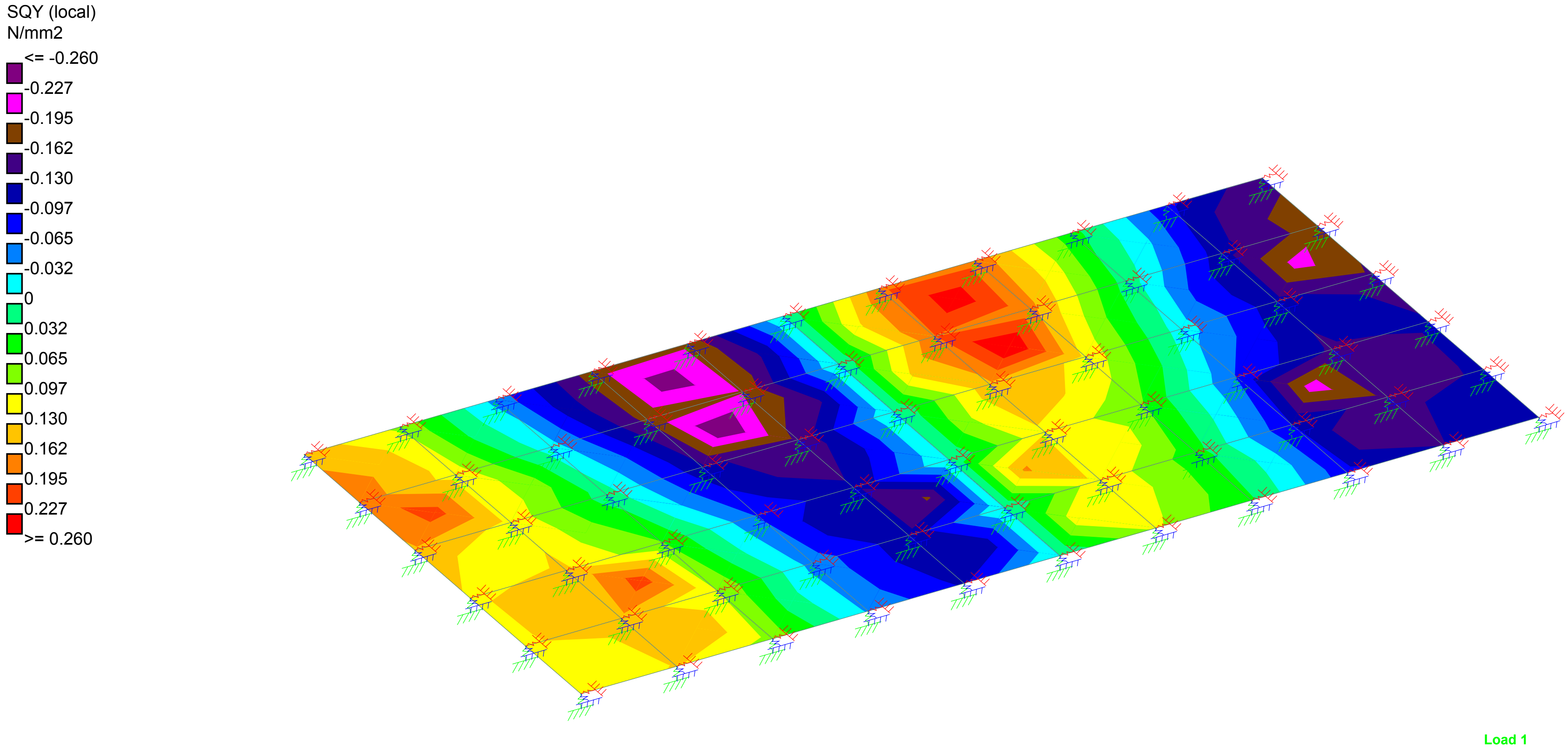


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 07:46	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 07:46	



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*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR 10, 2021                  *
*           Time=     7:47: 1                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
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```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x10 type A (5W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 09-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
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    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
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    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
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    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 31 PR GY -7.717 0.25 0.33
    50. 32 PR GY -7.717 0.25 0
    51. 33 PR GY -7.717 0.25 -0.33
    52. 33 PR GY -7.717 0.25 0.33
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    57. 64 PR GY -7.717 0.25 0
    58. 65 PR GY -7.717 0.25 -0.33
    59. 5 PR GY -7.717 -0.25 0
    60. 8 PR GY -7.717 -0.25 -0.33
    61. 8 PR GY -7.717 -0.25 0.33
    62. 11 PR GY -7.717 -0.25 0
    63. 14 PR GY -7.717 -0.25 -0.33
    64. 47 PR GY -7.717 -0.25 0.33
    65. 50 PR GY -7.717 -0.25 0
    66. 53 PR GY -7.717 -0.25 -0.33
    67. 53 PR GY -7.717 -0.25 0.33
    68. 56 PR GY -7.717 -0.25 0
    69. PERFORM ANALYSIS
```

```
        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    66/    50/    66

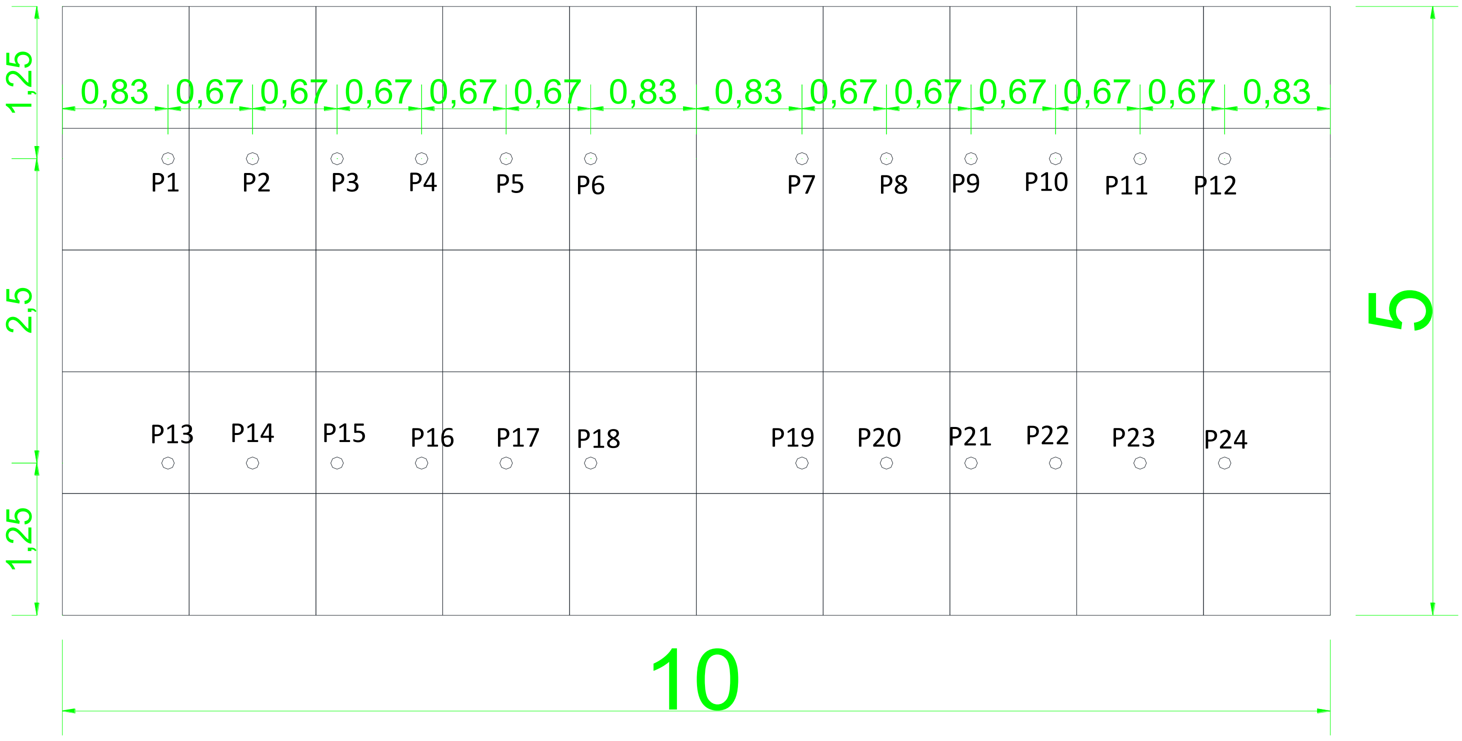
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263329.7 MB
```

```
    70. FINISH
```

Typical Panel Type (mesh 6W20), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.33	0.25
P8	0	0.25
P9	-0.33	0.25
P10	0.33	0.25
P11	0	0.25
P12	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P13	0.33	-0.25
P14	0	-0.25
P15	-0.33	-0.25
P16	0.33	-0.25
P17	0	-0.25
P18	-0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P19	0.33	-0.25
P20	0	-0.25
P21	-0.33	-0.25
P22	0.33	-0.25
P23	0	-0.25
P24	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

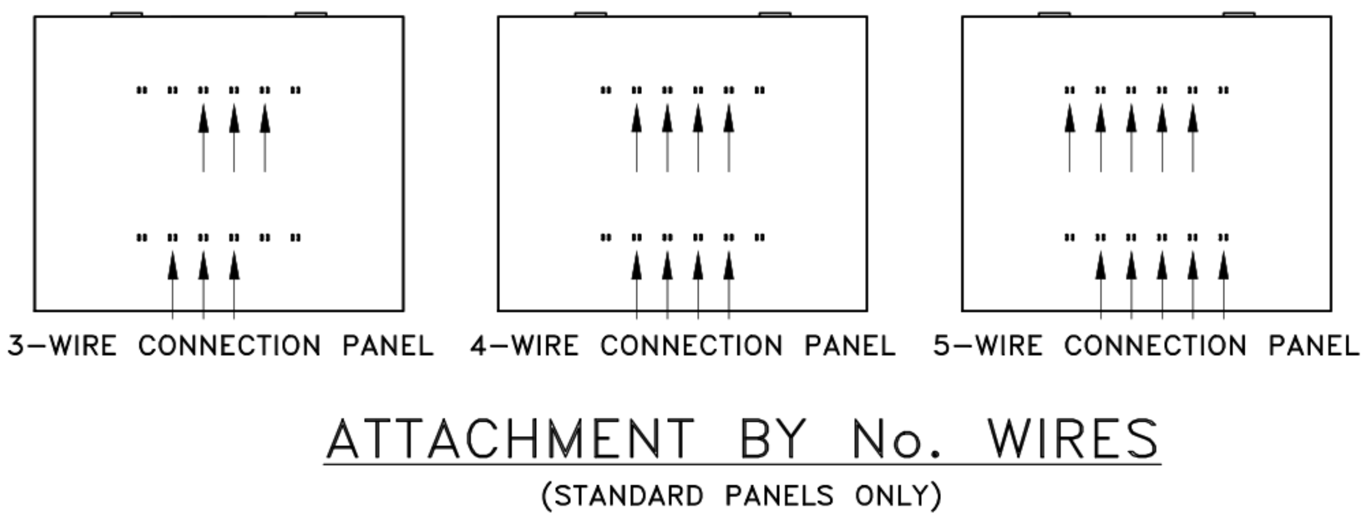
Bar Mat Used:
W11 - 75 Years

$A = 0.1583\ in^2$

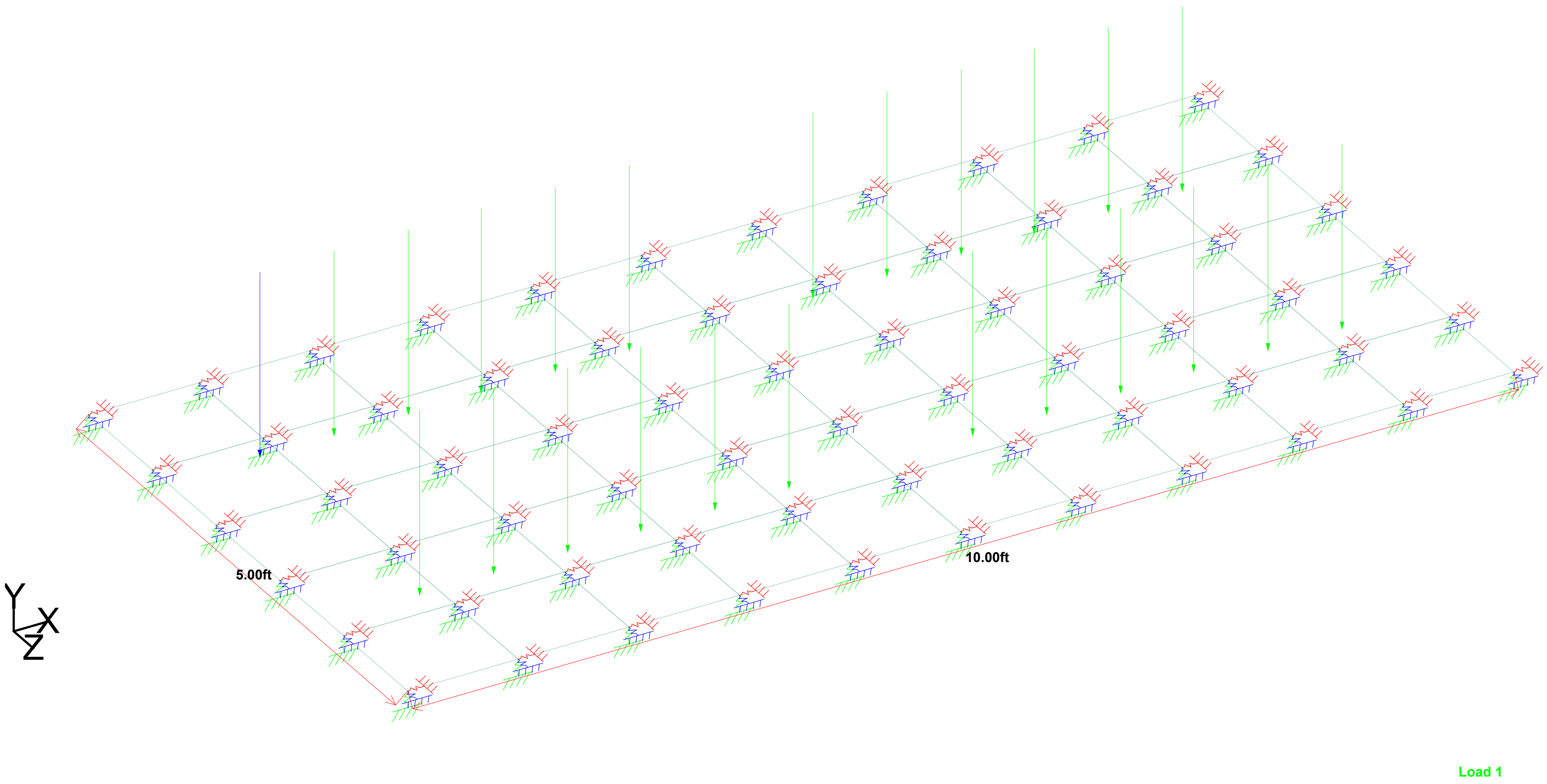
$Fy = 75\ ksi$

$P = 0.65 \times A \times Fy$

$= 7.717$ Kips (per wire point)

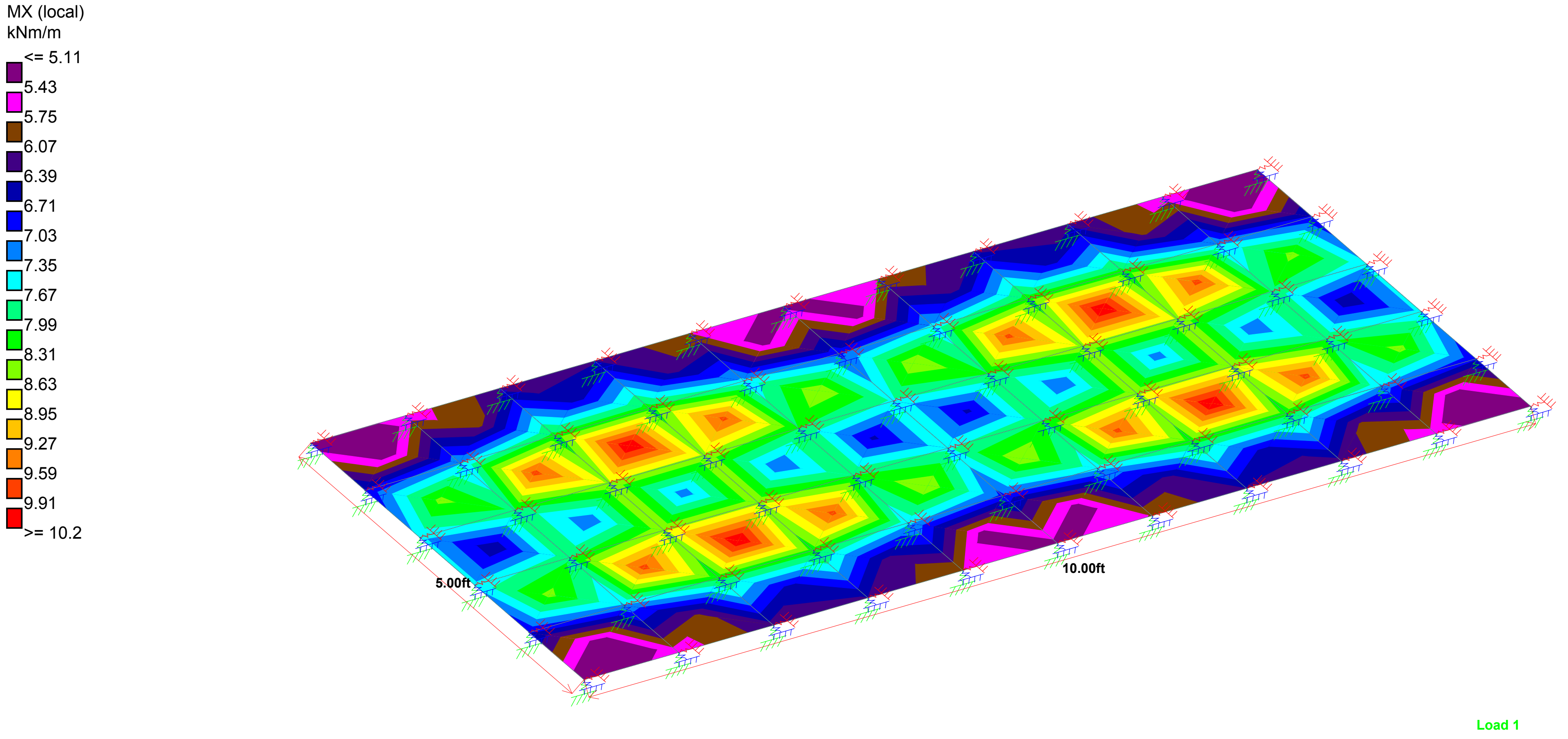


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:38	



TOC – Appendix

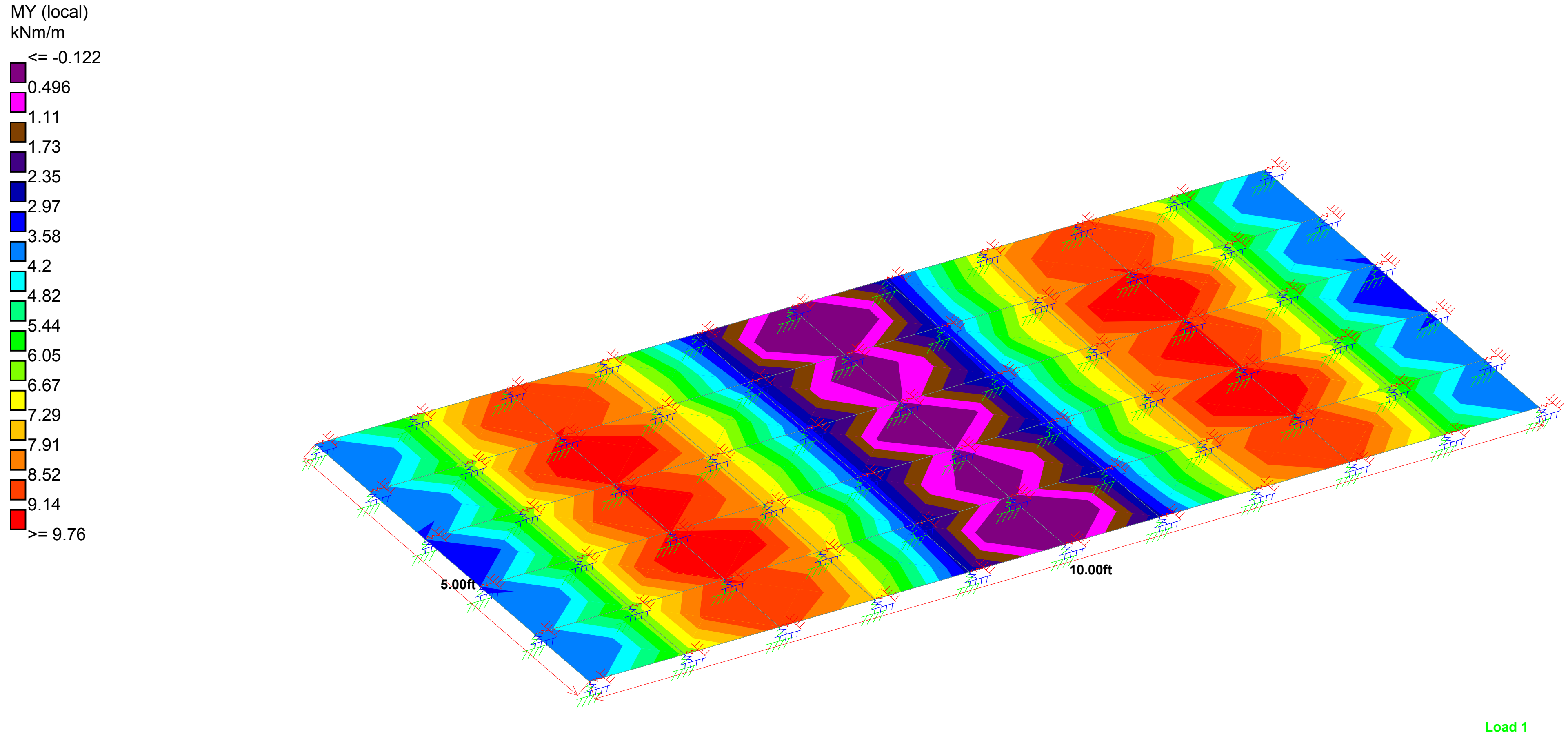
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:38	



TOC – Appendix

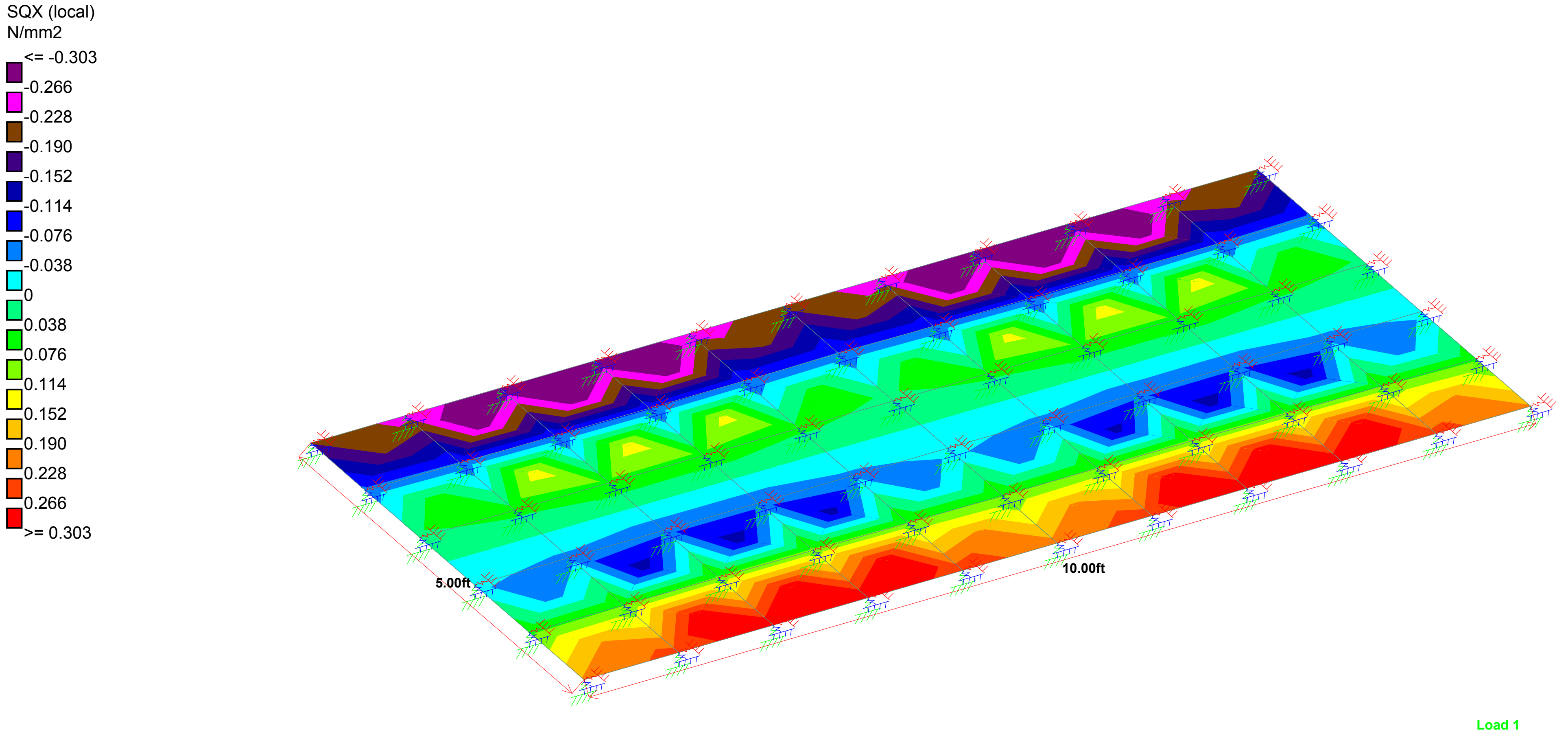
Software licensed to Optimal Engineering Support

Job No	Sheet No 1		Rev
Part			
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:38	



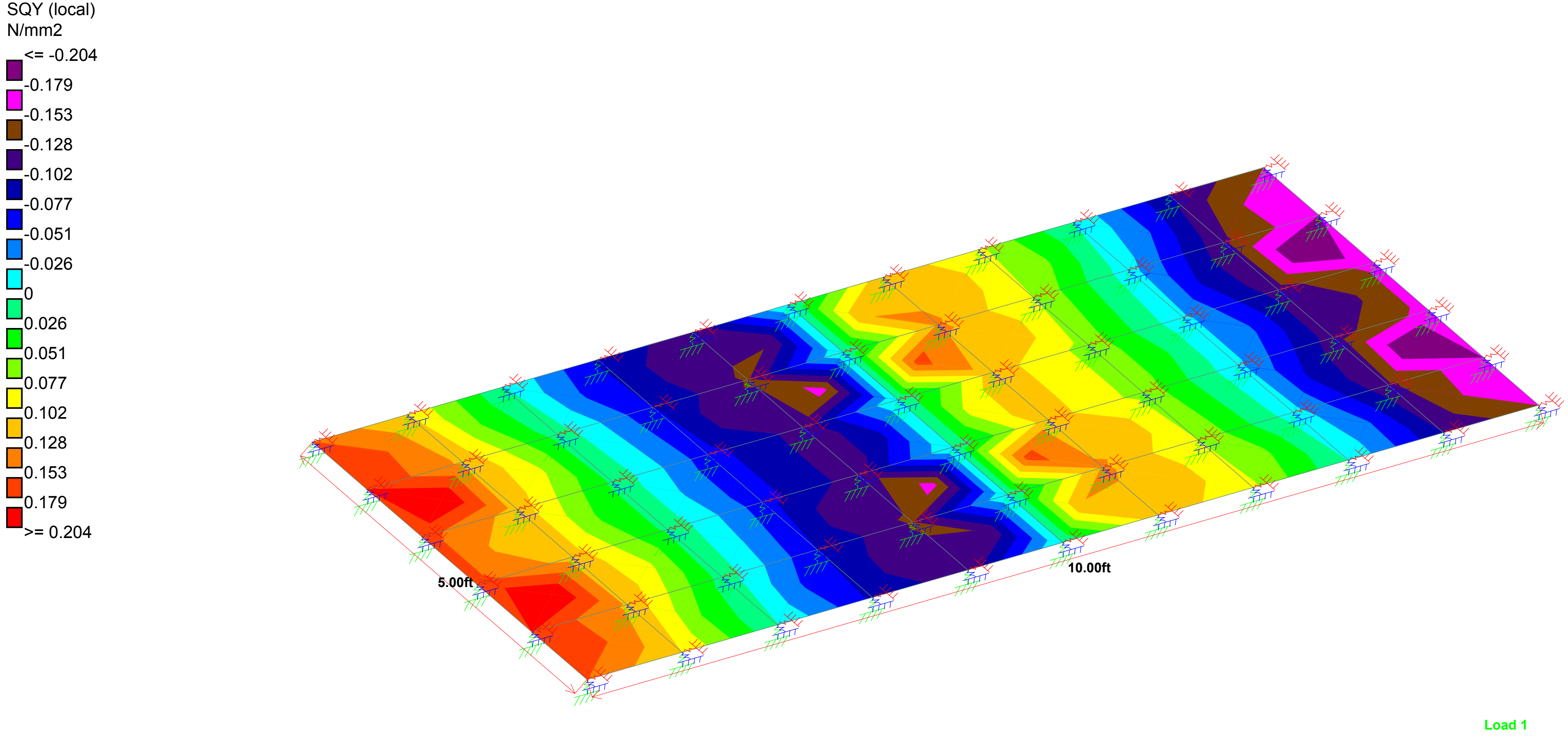
Software licensed to Optimal Engineering Support

Job Title	Job No	Sheet No 1	Rev
	Part		
	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:38	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 21:38	



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****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR 10, 2021                  *
*           Time=    21:38:56                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x10 type A (6W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 31 PR GY -7.717 0.25 0.33
    50. 32 PR GY -7.717 0.25 0
    51. 33 PR GY -7.717 0.25 -0.33
    52. 33 PR GY -7.717 0.25 0.33
    53. 34 PR GY -7.717 0.25 0
    54. 35 PR GY -7.717 0.25 -0.33
    55. 61 PR GY -7.717 0.25 0.33
    56. 62 PR GY -7.717 0.25 0
    57. 63 PR GY -7.717 0.25 -0.33
    58. 63 PR GY -7.717 0.25 0.33
    59. 64 PR GY -7.717 0.25 0
    60. 65 PR GY -7.717 0.25 -0.33
    61. 2 PR GY -7.717 -0.25 0.33
    62. 5 PR GY -7.717 -0.25 0
    63. 8 PR GY -7.717 -0.25 -0.33
    64. 8 PR GY -7.717 -0.25 0.33
    65. 11 PR GY -7.717 -0.25 0
    66. 14 PR GY -7.717 -0.25 -0.33
    67. 47 PR GY -7.717 -0.25 0.33
    68. 50 PR GY -7.717 -0.25 0
    69. 53 PR GY -7.717 -0.25 -0.33
    70. 53 PR GY -7.717 -0.25 0.33
    71. 56 PR GY -7.717 -0.25 0
    72. 59 PR GY -7.717 -0.25 -0.33
    73. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     66/    50/    66

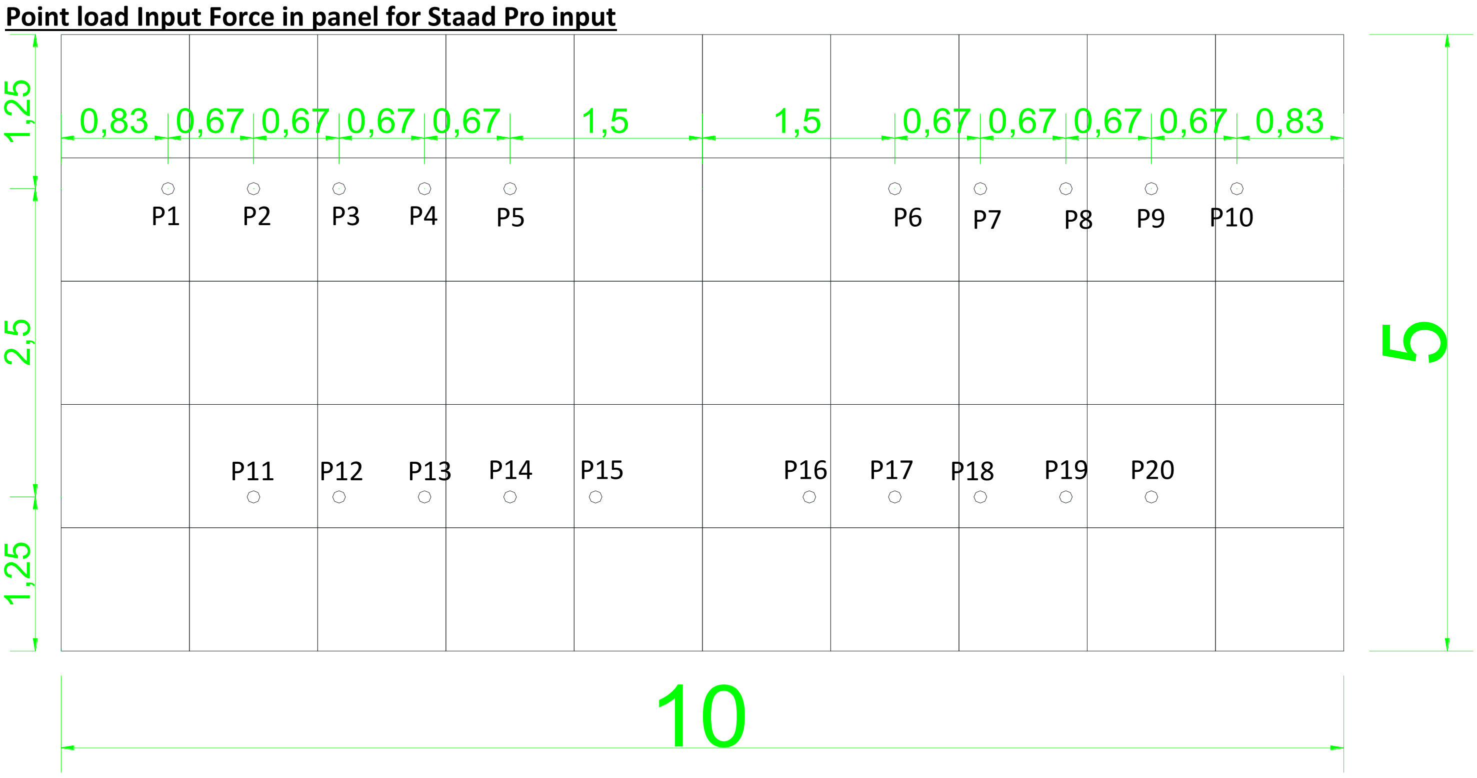
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263320.2 MB
```

```
    74. FINISH
```

Typical Panel Type (mesh 5W24), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	0	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.33	0.25
P8	0.33	0.25
P9	0	0.25
P10	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P11	0	-0.25
P12	-0.33	-0.25
P13	0.33	-0.25
P14	0	-0.25
P15	-0.33	-0.25
P16	0.33	-0.25

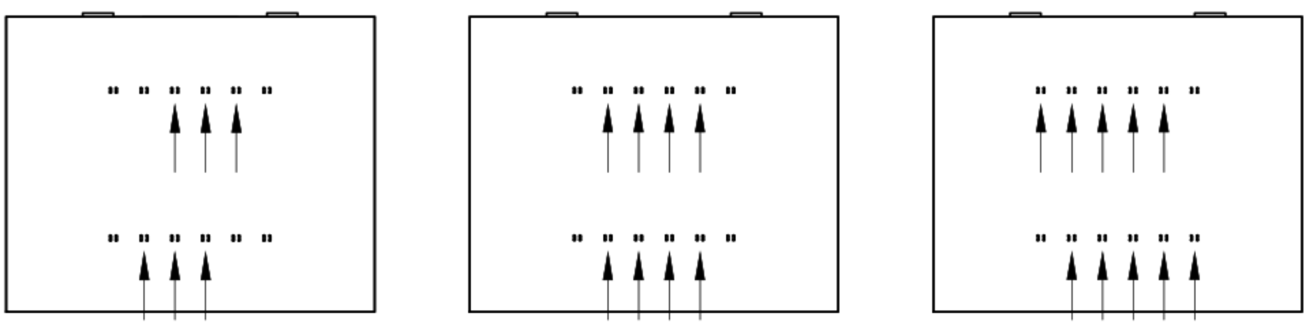
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P17	0	-0.25
P18	-0.33	-0.25
P19	0.33	-0.25
P20	0	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

A = 0.194 in^2
Fy = 75 ksi

P = 0.65 x A x Fy
= 9.458 Kips (per wire point)

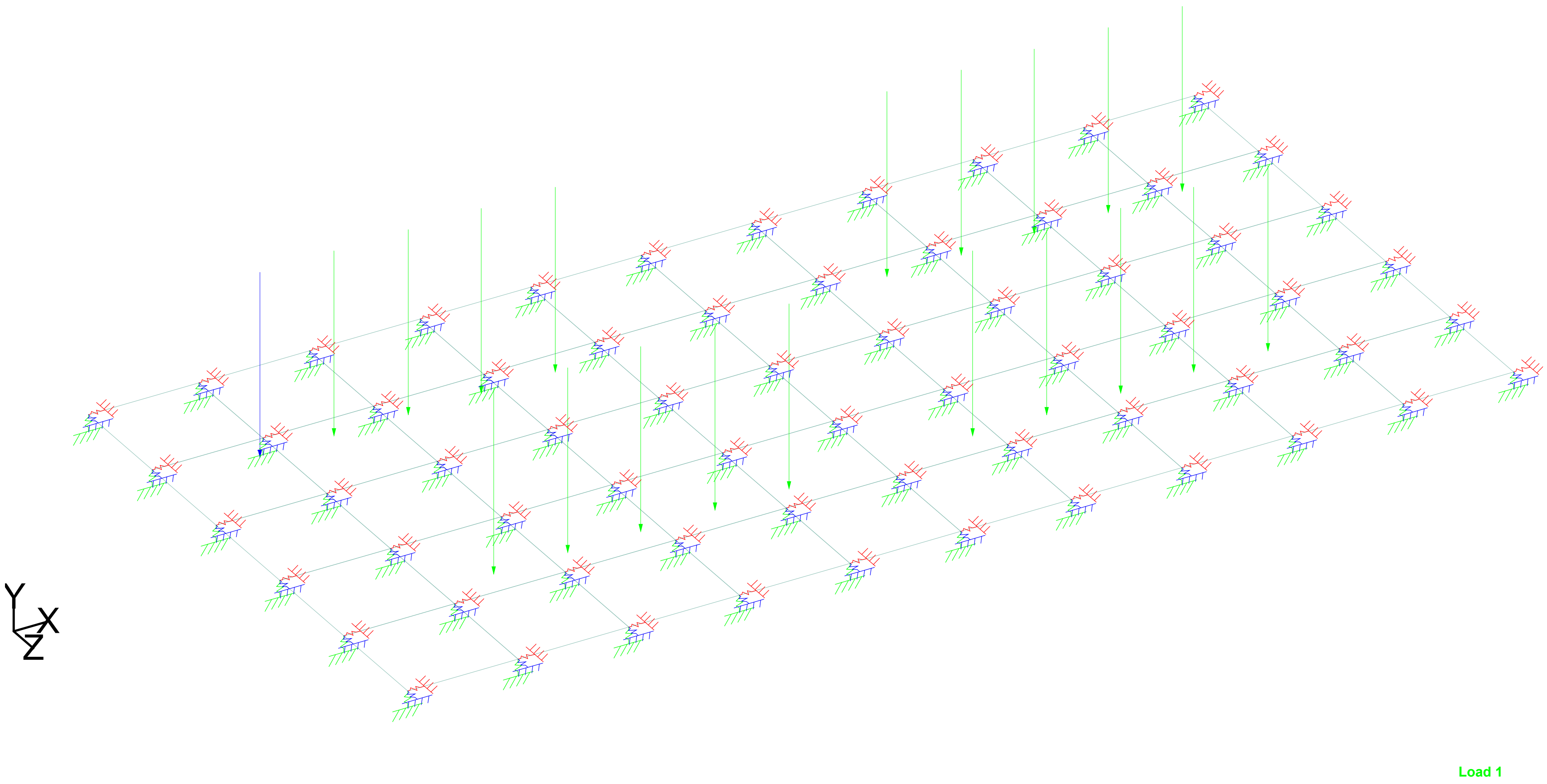


3–WIRE CONNECTION PANEL 4–WIRE CONNECTION PANEL 5–WIRE CONNECTION PANEL

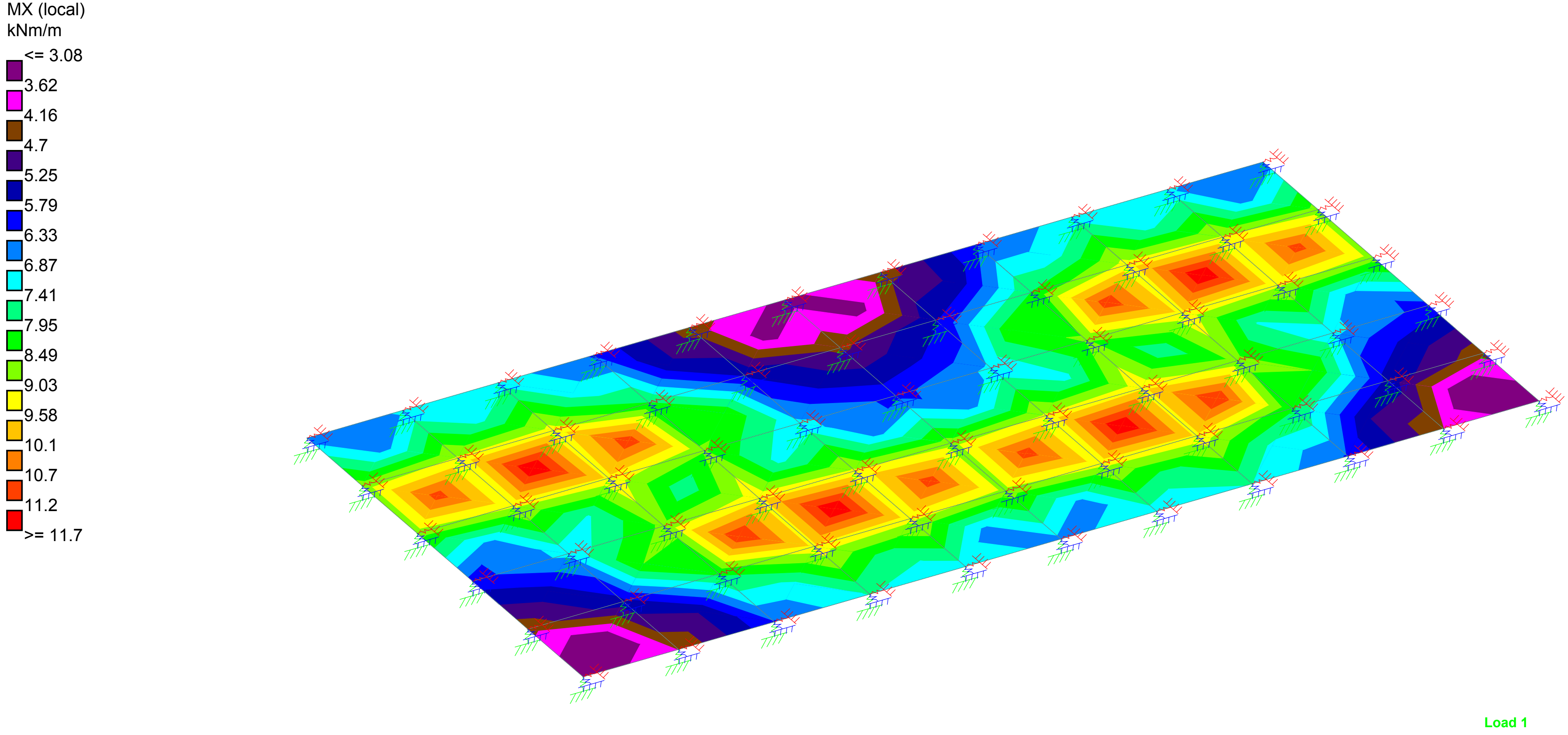
ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

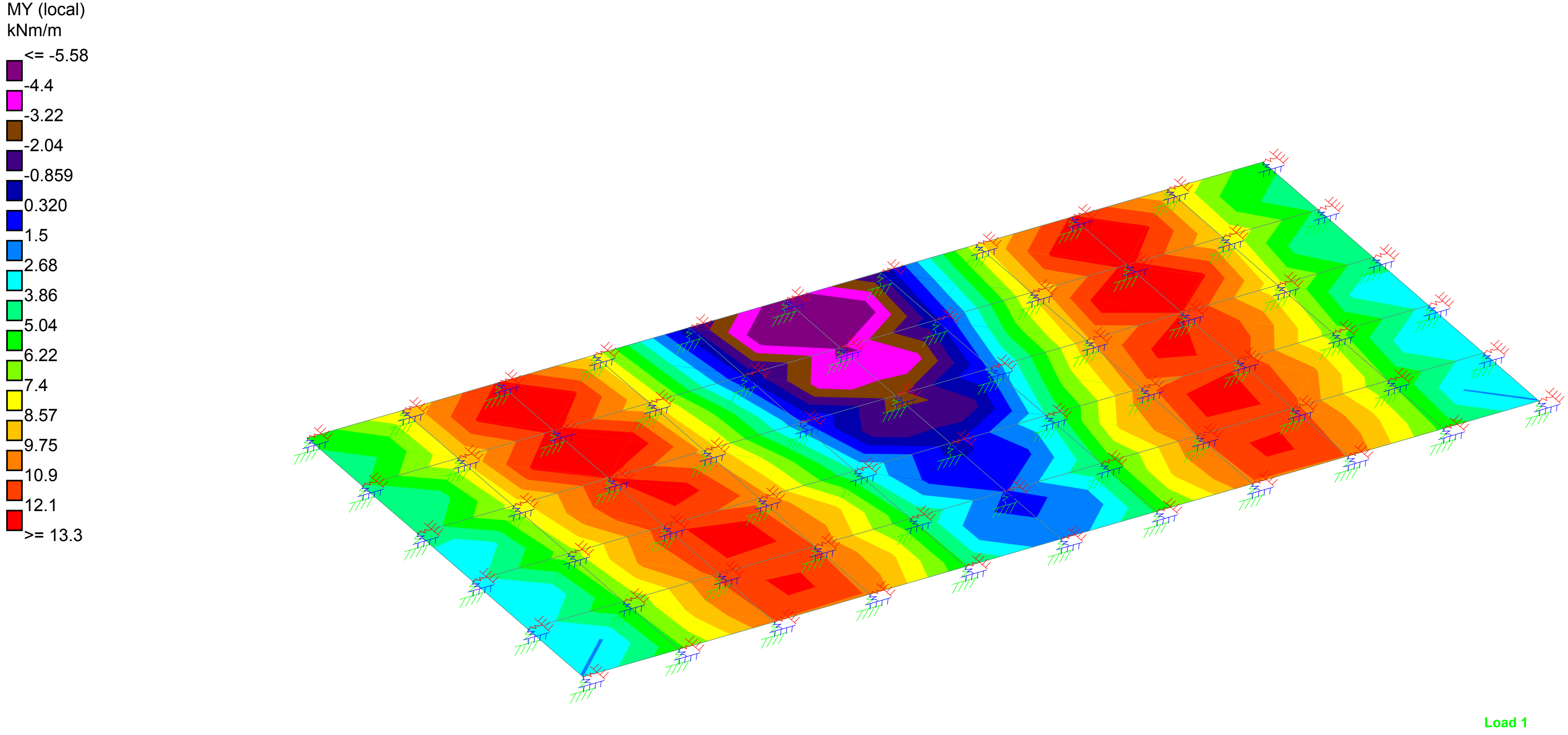
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 08:00	



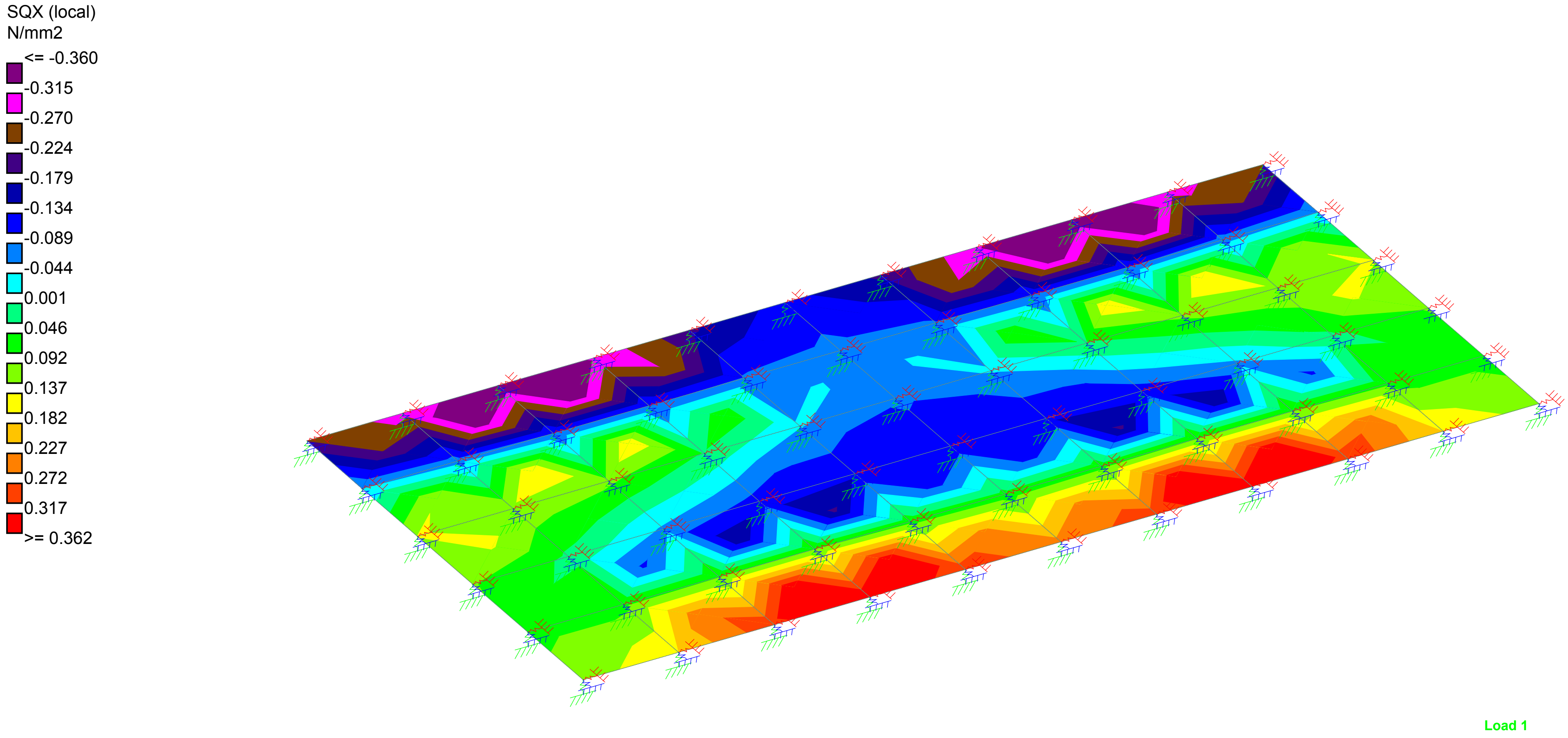
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 08:00	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 08:00	



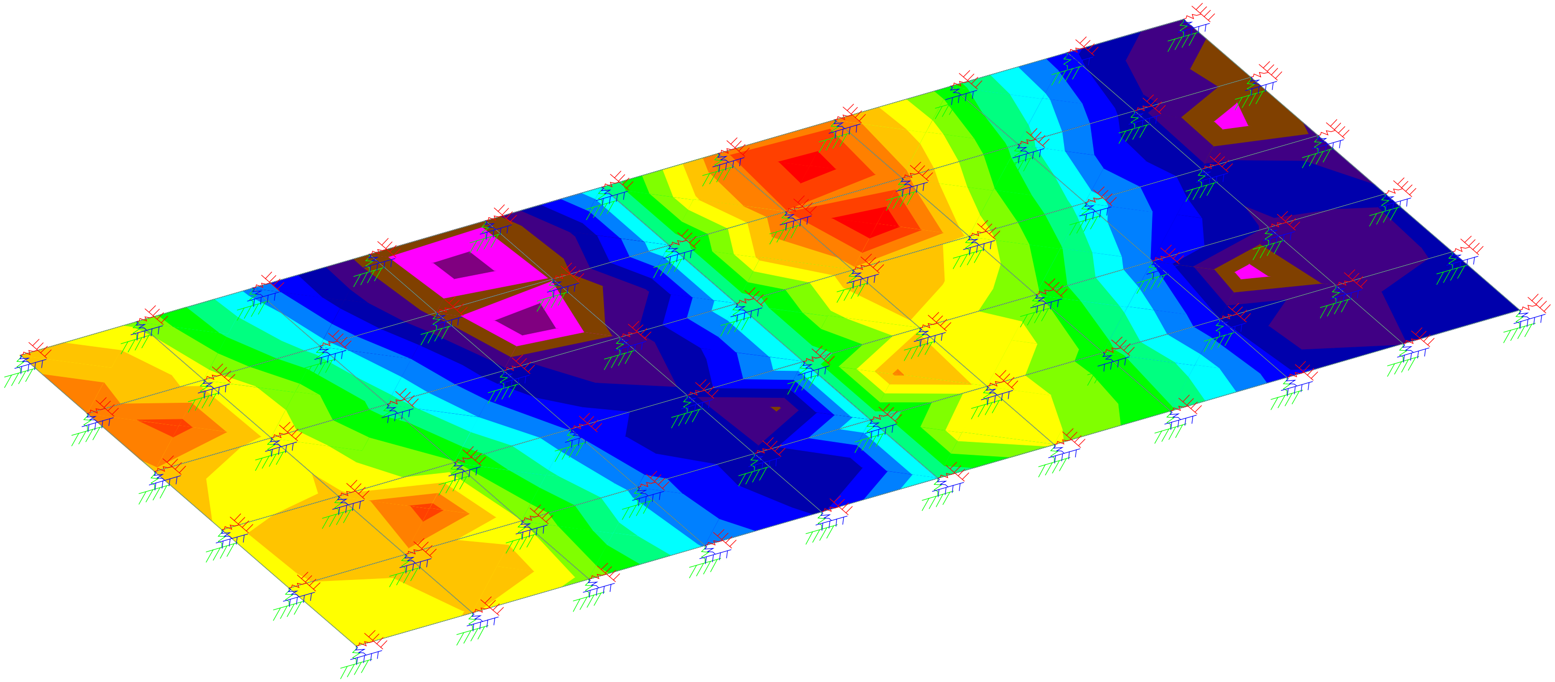
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 08:00	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 09-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 08:00	

SQY (local)
N/mm2

<= -0.319
-0.279
-0.239
-0.199
-0.159
-0.119
-0.080
-0.040
0
0.040
0.080
0.119
0.159
0.199
0.239
0.279
>= 0.319



Load 1

```
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          *                                                  *
          *           STAAD.Pro                              *
          *           Version  2007    Build 04              *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=    MAR 10, 2021                  *
          *           Time=     8: 1: 8                      *
          *                                                  *
          *      USER ID: Optimal Engineering Support        *
          ****************************************************



     1. STAAD SPACE
INPUT FILE: Panel Check - 5x10 type A (5W24).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 09-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 31 PR GY -9.458 0.25 0.33
    50. 32 PR GY -9.458 0.25 0
    51. 33 PR GY -9.458 0.25 -0.33
    52. 33 PR GY -9.458 0.25 0.33
    53. 34 PR GY -9.458 0.25 0
    54. 62 PR GY -9.458 0.25 0
    55. 63 PR GY -9.458 0.25 -0.33
    56. 63 PR GY -9.458 0.25 0.33
    57. 64 PR GY -9.458 0.25 0
    58. 65 PR GY -9.458 0.25 -0.33
    59. 5 PR GY -9.458 -0.25 0
    60. 8 PR GY -9.458 -0.25 -0.33
    61. 8 PR GY -9.458 -0.25 0.33
    62. 11 PR GY -9.458 -0.25 0
    63. 14 PR GY -9.458 -0.25 -0.33
    64. 47 PR GY -9.458 -0.25 0.33
    65. 50 PR GY -9.458 -0.25 0
    66. 53 PR GY -9.458 -0.25 -0.33
    67. 53 PR GY -9.458 -0.25 0.33
    68. 56 PR GY -9.458 -0.25 0
    69. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     66/    50/    66

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

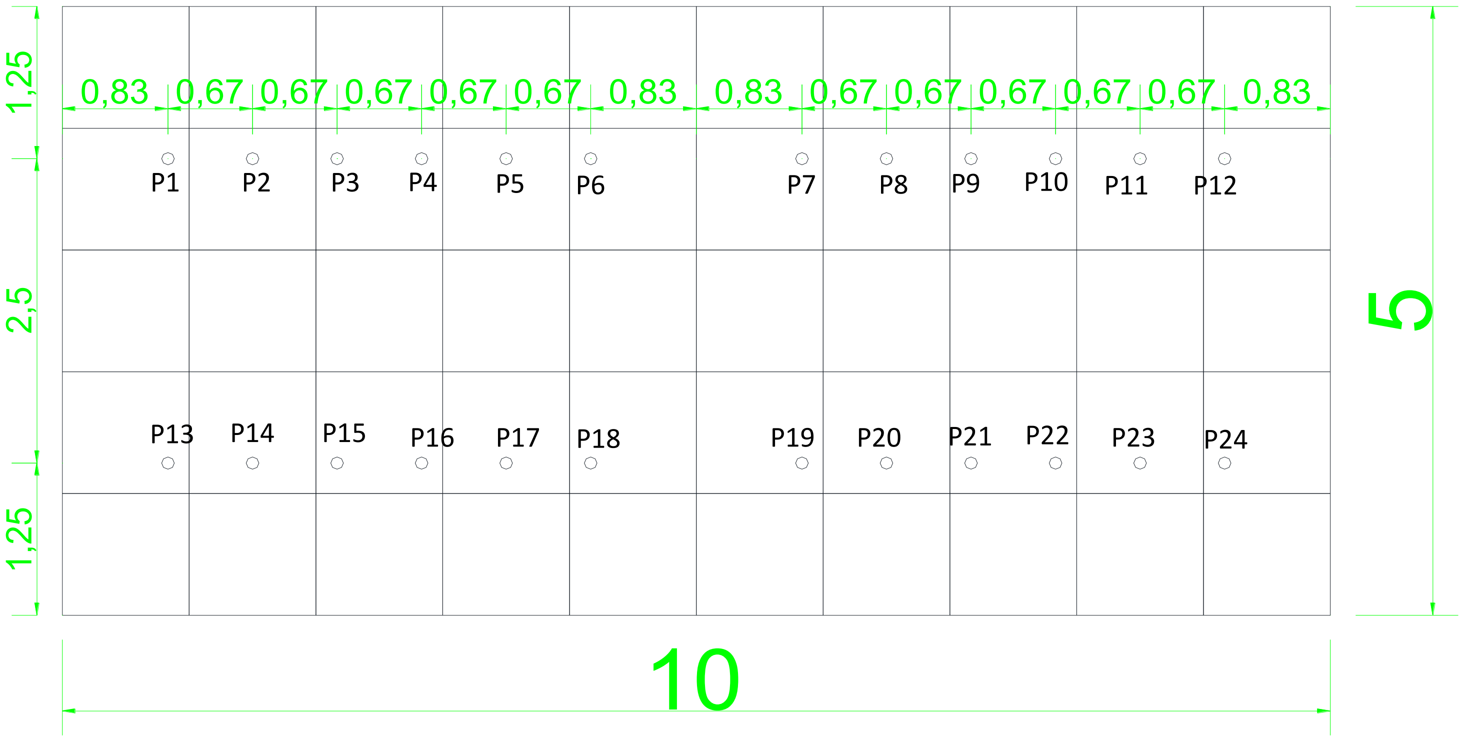
 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263327.2 MB



    70. FINISH
```

Typical Panel Type (mesh 6W24), Panel Thickness 6", 5'x10'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.33	0.25
P2	0	0.25
P3	-0.33	0.25
P4	0.33	0.25
P5	0	0.25
P6	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.33	0.25
P8	0	0.25
P9	-0.33	0.25
P10	0.33	0.25
P11	0	0.25
P12	-0.33	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P13	0.33	-0.25
P14	0	-0.25
P15	-0.33	-0.25
P16	0.33	-0.25
P17	0	-0.25
P18	-0.33	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P19	0.33	-0.25
P20	0	-0.25
P21	-0.33	-0.25
P22	0.33	-0.25
P23	0	-0.25
P24	-0.33	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

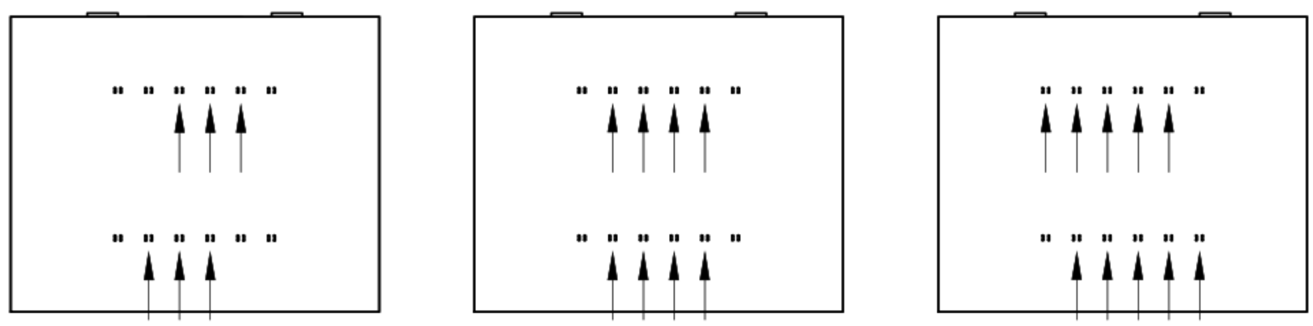
W11 - 75 Years

$A = 0.194\ in^2$

$Fy = 75\ ksi$

$P = 0.65 \times A \times Fy$

$= 9.458$ Kips (per wire point)

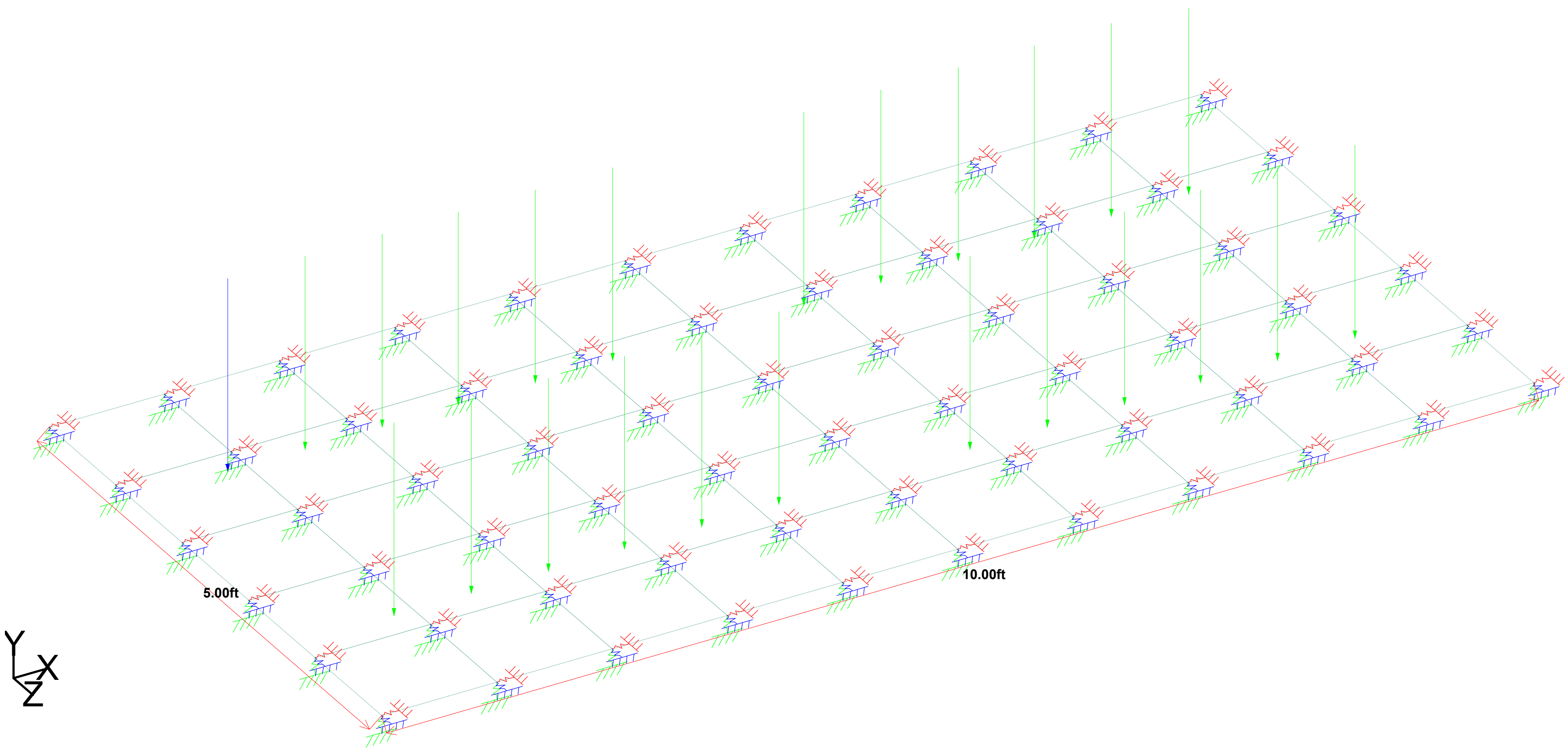


3–WIRE CONNECTION PANEL 4–WIRE CONNECTION PANEL 5–WIRE CONNECTION PANEL

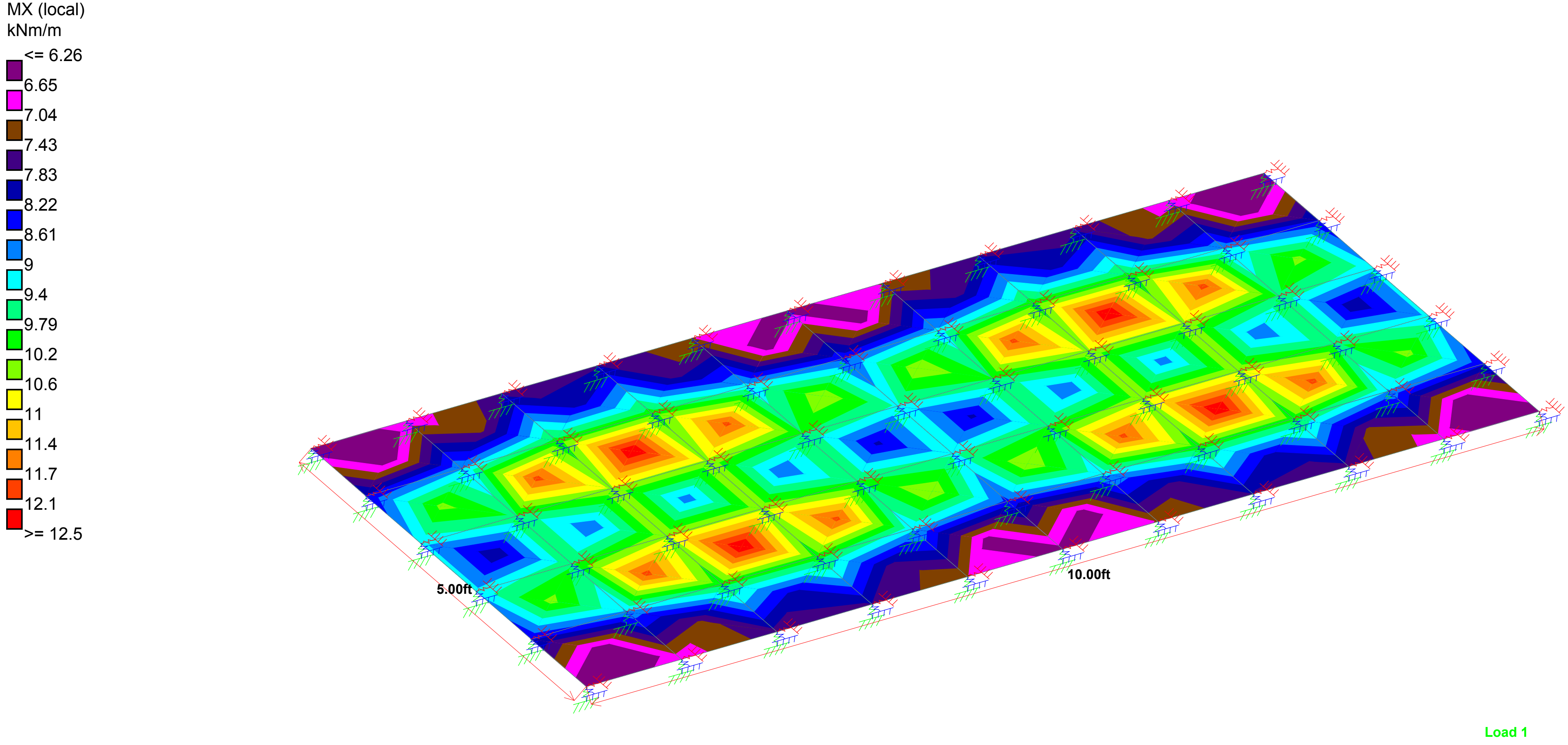
ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 22:13	



Job No	Sheet No 1	Rev	
Part			
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 22:13	

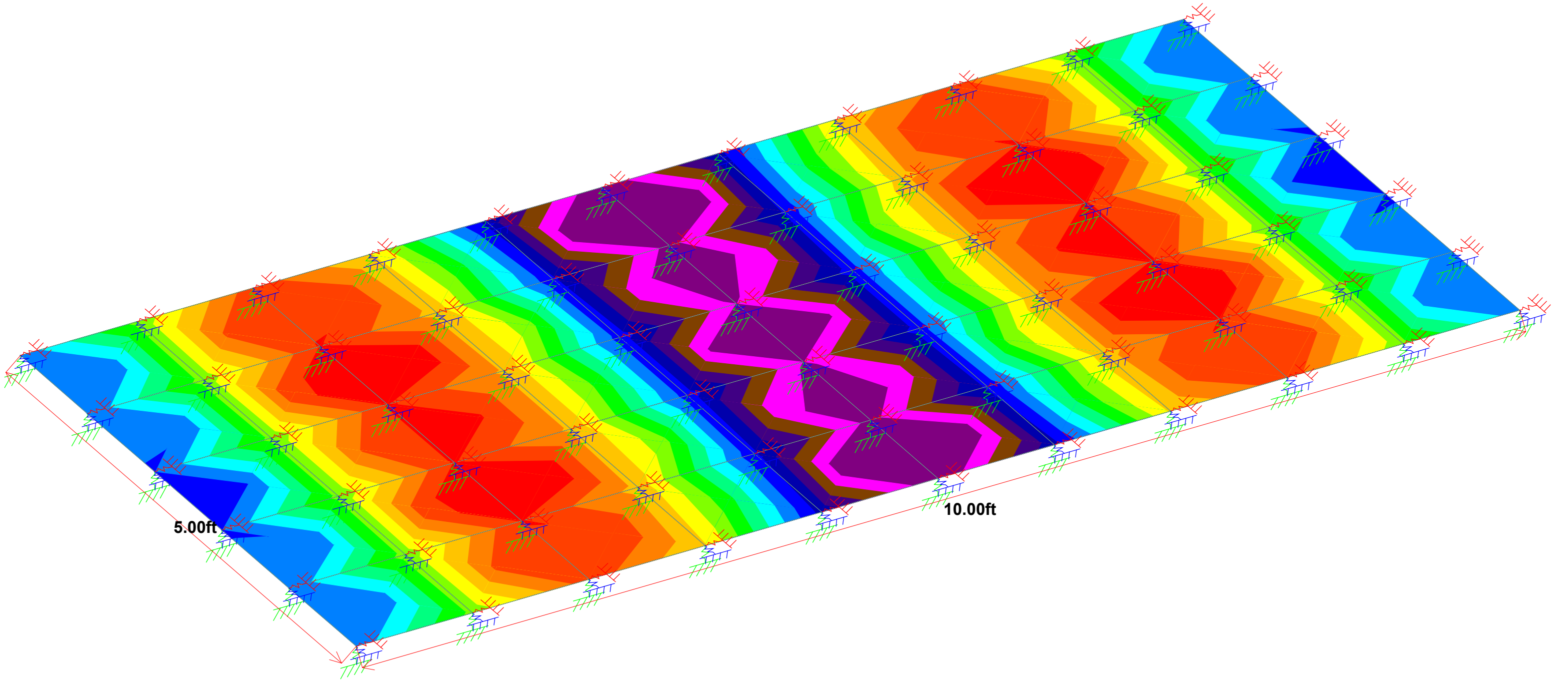


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 22:13	

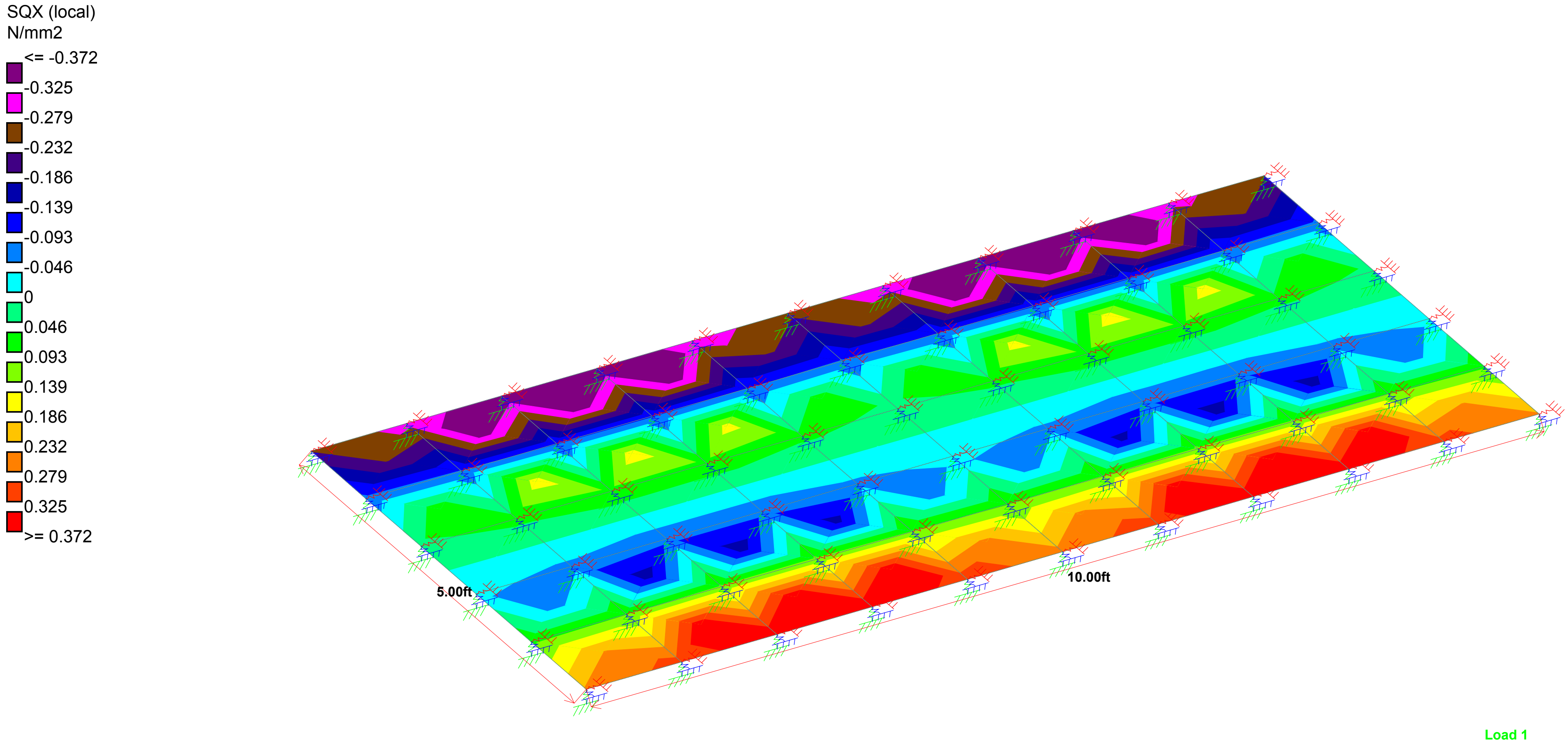
MY (local)
kNm/m

<= -0.150
0.607
1.36
2.12
2.88
3.64
4.39
5.15
5.91
6.66
7.42
8.18
8.93
9.69
10.4
11.2
>= 12



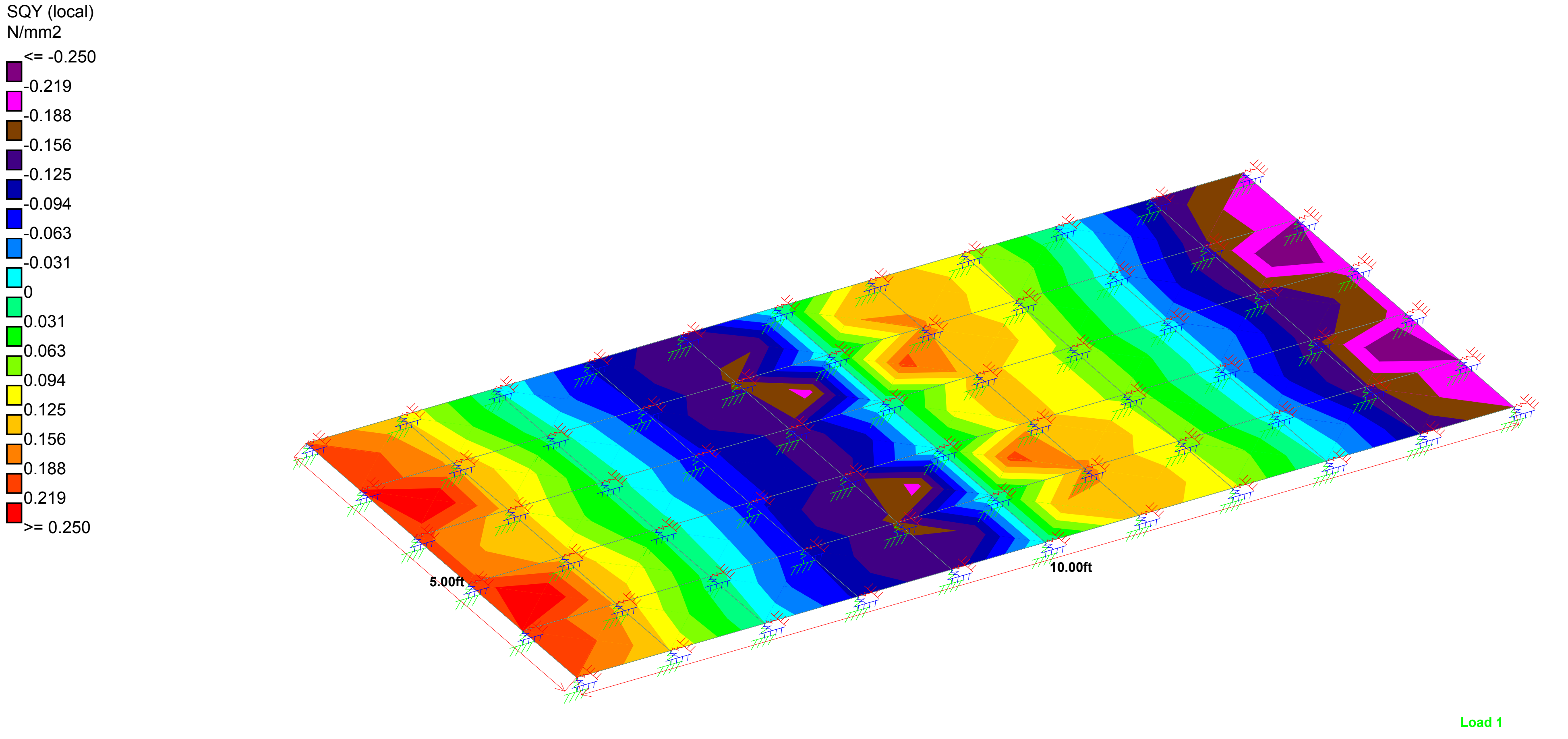
Load 1

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 22:13	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x10 type /	Date/Time 10-Mar-2021 22:13	



```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2007    Build 04              *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    MAR 10, 2021                  *
*           Time=    22:13:45                      *
*                                                  *
*      USER ID: Optimal Engineering Support        *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x10 type A (6W24).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 10 0 0 -1; 11 1 0 -1.
    12. 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 19 0 0 -2; 20 1 0 -2; 21 2 0 -2
    13. 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 28 0 0 -3; 29 1 0 -3; 30 2 0 -3; 31 3 0 -3
    14. 32 4 0 -3; 33 5 0 -3; 45 0 0 -4; 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4
    15. 50 5 0 -4; 56 0 0 -5; 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5
    16. 62 6 0 -1; 63 6 0 0; 64 6 0 -2; 65 6 0 -3; 66 7 0 -1; 67 7 0 0; 68 7 0 -2
    17. 69 7 0 -3; 70 8 0 -1; 71 8 0 0; 72 8 0 -2; 73 8 0 -3; 74 9 0 -1; 75 9 0 0
    18. 76 9 0 -2; 77 9 0 -3; 78 10 0 -1; 79 10 0 0; 80 10 0 -2; 81 10 0 -3; 82 6 0 -4
    19. 83 7 0 -4; 84 8 0 -4; 85 9 0 -4; 86 10 0 -4; 87 6 0 -5; 88 7 0 -5; 89 8 0 -5
    20. 90 9 0 -5; 91 10 0 -5
    21. ELEMENT INCIDENCES SHELL
    22. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    23. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    24. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    25. 31 28 45 46 29; 32 29 46 47 30; 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33
    26. 41 45 56 57 46; 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50
    27. 46 6 15 62 63; 47 15 24 64 62; 48 24 33 65 64; 49 63 62 66 67; 50 62 64 68 66
    28. 51 64 65 69 68; 52 67 66 70 71; 53 66 68 72 70; 54 68 69 73 72; 55 71 70 74 75
    29. 56 70 72 76 74; 57 72 73 77 76; 58 75 74 78 79; 59 74 76 80 78; 60 76 77 81 80
    30. 61 33 50 82 65; 62 65 82 83 69; 63 69 83 84 73; 64 73 84 85 77; 65 77 85 86 81
    31. 66 50 61 87 82; 67 82 87 88 83; 68 83 88 89 84; 69 84 89 90 85; 70 85 90 91 86
    32. ELEMENT PROPERTY
    33. 1 TO 15 31 TO 35 41 TO 70 THICKNESS 0.5
    34. DEFINE MATERIAL START
    35. ISOTROPIC CONCRETE
    36. E 614304
    37. POISSON 0.17
    38. DENSITY 0.15
    39. ALPHA 1E-005
    40. DAMP 0.05
```



```
    41. END DEFINE MATERIAL
    42. CONSTANTS
    43. MATERIAL CONCRETE ALL
    44. SUPPORTS
    45. 1 TO 6 10 TO 15 19 TO 24 28 TO 33 45 TO 50 56 TO 90 -
    46. 91 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    47. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    48. ELEMENT LOAD
    49. 31 PR GY -9.458 0.25 0.33
    50. 32 PR GY -9.458 0.25 0
    51. 33 PR GY -9.458 0.25 -0.33
    52. 33 PR GY -9.458 0.25 0.33
    53. 34 PR GY -9.458 0.25 0
    54. 35 PR GY -9.458 0.25 -0.33
    55. 61 PR GY -9.458 0.25 0.33
    56. 62 PR GY -9.458 0.25 0
    57. 63 PR GY -9.458 0.25 -0.33
    58. 63 PR GY -9.458 0.25 0.33
    59. 64 PR GY -9.458 0.25 0
    60. 65 PR GY -9.458 0.25 -0.33
    61. 2 PR GY -9.458 -0.25 0.33
    62. 5 PR GY -9.458 -0.25 0
    63. 8 PR GY -9.458 -0.25 -0.33
    64. 8 PR GY -9.458 -0.25 0.33
    65. 11 PR GY -9.458 -0.25 0
    66. 14 PR GY -9.458 -0.25 -0.33
    67. 47 PR GY -9.458 -0.25 0.33
    68. 50 PR GY -9.458 -0.25 0
    69. 53 PR GY -9.458 -0.25 -0.33
    70. 53 PR GY -9.458 -0.25 0.33
    71. 56 PR GY -9.458 -0.25 0
    72. 59 PR GY -9.458 -0.25 -0.33
    73. PERFORM ANALYSIS
```

```
        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     66/    50/    66

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    33/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    396
 SIZE OF STIFFNESS MATRIX =       27 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.5/ 263318.2 MB
```

```
    74. FINISH
```

Summary Result From Staad Pro Analysis Output

Standard Panel Size	Barmat Type	Panel Type	Horz Rebar	Vert Rebar	Staad Pro Output				Data for AASHTO LRFD Design Check			
					Mx (kNm/m)	My (kNm/m)	SQx (N/mm^2)	SQy (N/mm^2)	Mx (Kips-ft/ft)	My (Kips-ft/ft)	SQx (lbs/in^2)	SQy (lbs/in^2)
5'x10'	3W11	A	4 #4	7 #4	3.130	5.010	0.119	0.129	0.704	1.126	17.260	18.710
	4W11				3.950	**5.900**	0.144	0.131	0.888	**1.326**	20.885	19.000
	5W11				4.820	5.460	0.149	**0.131**	1.084	1.227	21.611	**19.000**
	6W11				**5.150**	4.910	**0.153**	0.103	**1.158**	1.104	**22.191**	14.939
	4W20	X	5 #4	10 #4	7.840	**11.700**	0.286	0.260	1.762	2.630	41.481	37.710
	5W20				9.580	10.800	0.296	**0.260**	2.154	**2.428**	42.931	**37.710**
	6W20				**10.200**	9.760	**0.303**	0.204	**2.293**	2.194	**43.947**	29.588
	5W24	Y	6 #4	10 #4	11.700	**13.300**	0.362	**0.319**	2.630	**2.990**	52.504	**46.267**
	6W24				**12.500**	12.000	**0.372**	0.250	**2.810**	2.698	**53.954**	36.260

* Maximum bending moment and shear for each standard panel size shown in **red bold** font

5’ x 10’ STANDARD

A PANEL

Typical Panel Type A, Panel Thickness 6", 5'x10', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.33	kip-ft	$+M_{u\_service}$	=	0.98	kip-ft	(FK = 1.35)
$-M_u$	=	0.52	kip-ft	$-M_{u\_service}$	=	0.39	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.447 kip-ft

Check $+\varphi M_n > +M_u$ 2.447 > 1.33 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 0.974 kip-ft

Check $-\varphi M_n > -M_u$ 0.974 > 0.52 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1 =	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3 =	0.67		(A615 steel)
concrete density modification factor		λ =	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r =	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c =	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr} =	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	1.76	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	1.76	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 2.447 > 1.76 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.69	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.69	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 0.974 > 0.69 **OK**

Typical Panel Type A, Panel Thickness 6", 5'x10', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$
$c = \dfrac{A_s \, . f_s}{\alpha_1 . f_c{}' . \beta_1 \, . b}$	c	=	0.226	in	
$d_v = t_{panel} - \dfrac{c}{2} - C_{panel} - \dfrac{d_b}{2}$	d_v	=	4.137	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \, . \beta \, . \alpha \, . \sqrt{f_c{}'} \, . \, b_v \, . d_v$	Vc	=	6.275	Kips
$V_s = \dfrac{A_v \, . f_y \, . d_v \, . (\cot\theta + \cot\alpha) \, . \sin\alpha}{s}$	Vs	=	2.708	Kips
	(1) Vn	=	8.982	Kips
(2) $V_n = 0.25 \, . f_c' . b_v \, . d_v$	(2) Vn	=	49.641	Kips
From (1) and (2) Vn should be:	Vn	=	8.982	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	8.084	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.131	N/mm^2		
	=	19.00	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1368.00	lbs		
	=	1.368	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x10', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\,\pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.32	kip-ft	$+M_{u\_service}$	=	0.97	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.152 kip-ft

Check $+\varphi M_n > +M_u$ 2.152 > 1.32 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.269 kip-ft

Check $-\varphi M_n > -M_u$ 1.269 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	1.75	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	1.75	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 2.152 > 1.75 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.269 > 0.00 **OK**

Typical Panel Type A, Panel Thickness 6", 5'x10', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c{}' . \beta_1 \,.\, b}$	c	=	0.226	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.137	in	

AASHTO 5.7.3.3

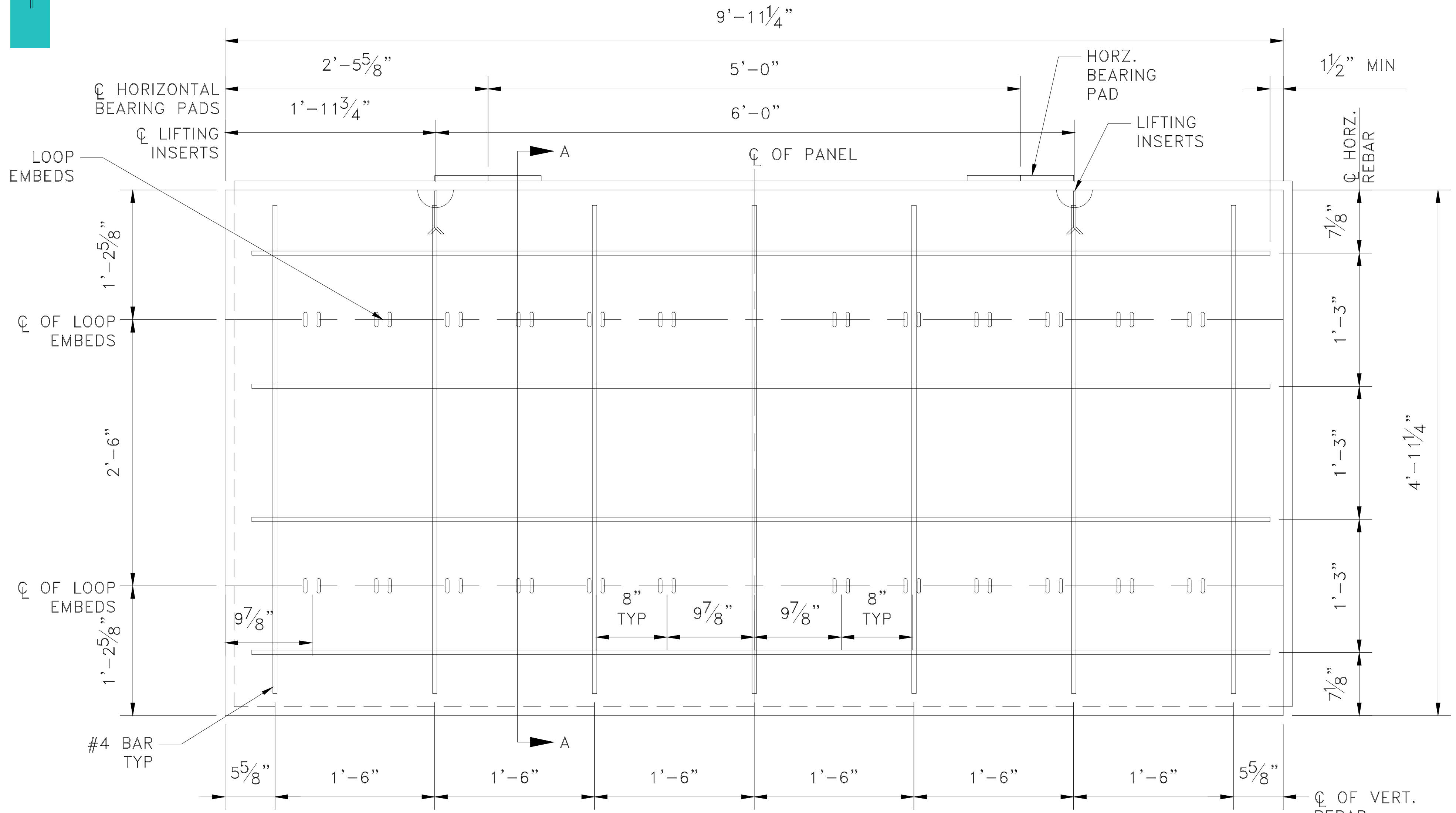
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c{}'} \,.\, b_v \,.\, d_v$	Vc	=	4.758	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	2.053	Kips
	(1) Vn	=	6.811	Kips
(2) $V_n = 0.25 \,.\, f_c' . b_v \,.\, d_v$	(2) Vn	=	37.641	Kips
From (1) and (2) Vn should be:	Vn	=	6.811	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.130	Kips

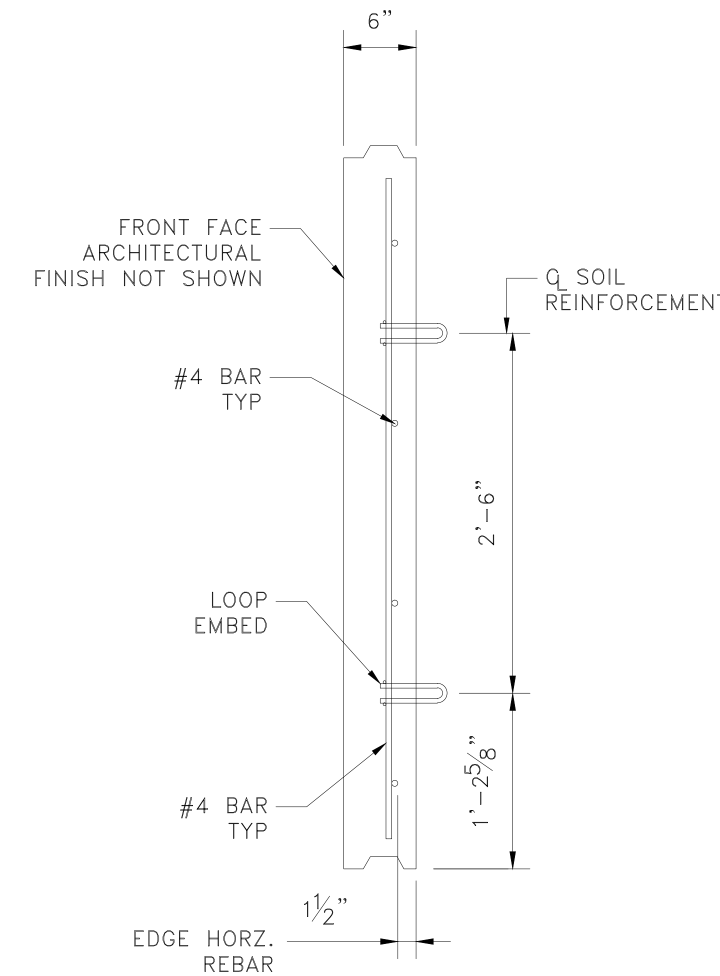
Shear Force:

From Staad Pro Result Vmax	=	0.153	N/mm^2	
	=	22.19	lbs/in^2	
Shear Section Area	=	b	x	tpanel
	=	12	x	6
Vmax	=	1597.74	lbs	
	=	1.598	Kips	**OK, Vmax less than Vn**



STANDARD "A" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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DRAWN BY: WM	01/24/22	
CHECK BY: FSH	01/24/22	
DESIGN BY: FSH	01/24/22	
CHECK BY: SR	01/24/22	
PROJ. ENGR: FSH		

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X10' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 10’ STANDARD

X PANEL

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x10', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\, \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.63	kip-ft	$+M_{u\_service}$	=	1.95	kip-ft	(FK = 1.35)
$-M_u$	=	1.02	kip-ft	$-M_{u\_service}$	=	0.76	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.628 kip-ft

Check $+\varphi M_n > +M_u$ 3.628 > 2.63 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.419 kip-ft

Check $-\varphi M_n > -M_u$ 1.419 > 1.02 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	3.50	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored +M_u and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 3.628 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	1.36	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored -M_u and M_{cr})	=	1.36	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 1.419 > 1.36 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x10', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \cdot f_s}{\alpha_1 . f_c{}' . \beta_1 \cdot b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.080	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \cdot \beta \cdot \alpha \cdot \sqrt{f_c{}'} \cdot b_v \cdot d_v$	Vc	=	6.189	Kips
$V_s = \frac{A_v \cdot f_y \cdot d_v \cdot (\cot\theta + \cot\alpha) \cdot \sin\alpha}{s}$	Vs	=	4.006	Kips
	(1) Vn	=	10.194	Kips
(2) $V_n = 0.25 \cdot f_c' \cdot b_v \cdot d_v$	(2) Vn	=	48.962	Kips
From (1) and (2) Vn should be:	Vn	=	10.194	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	9.175	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.26	N/mm^2		
	=	37.71	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	2715.11	lbs		
	=	2.715	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x10', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1\!/_4\,\pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1\!/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.29	kip-ft	$+M_{u\_service}$	=	1.70	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.186 kip-ft

Check $+\varphi M_n > +M_u$ 3.186 > 2.29 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.860 kip-ft

Check $-\varphi M_n > -M_u$ 1.860 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	3.05	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.05	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 3.186 > 3.05 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.860 > 0.00 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x10', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 .\, f_c' \,.\, \beta_1 \,.\, b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

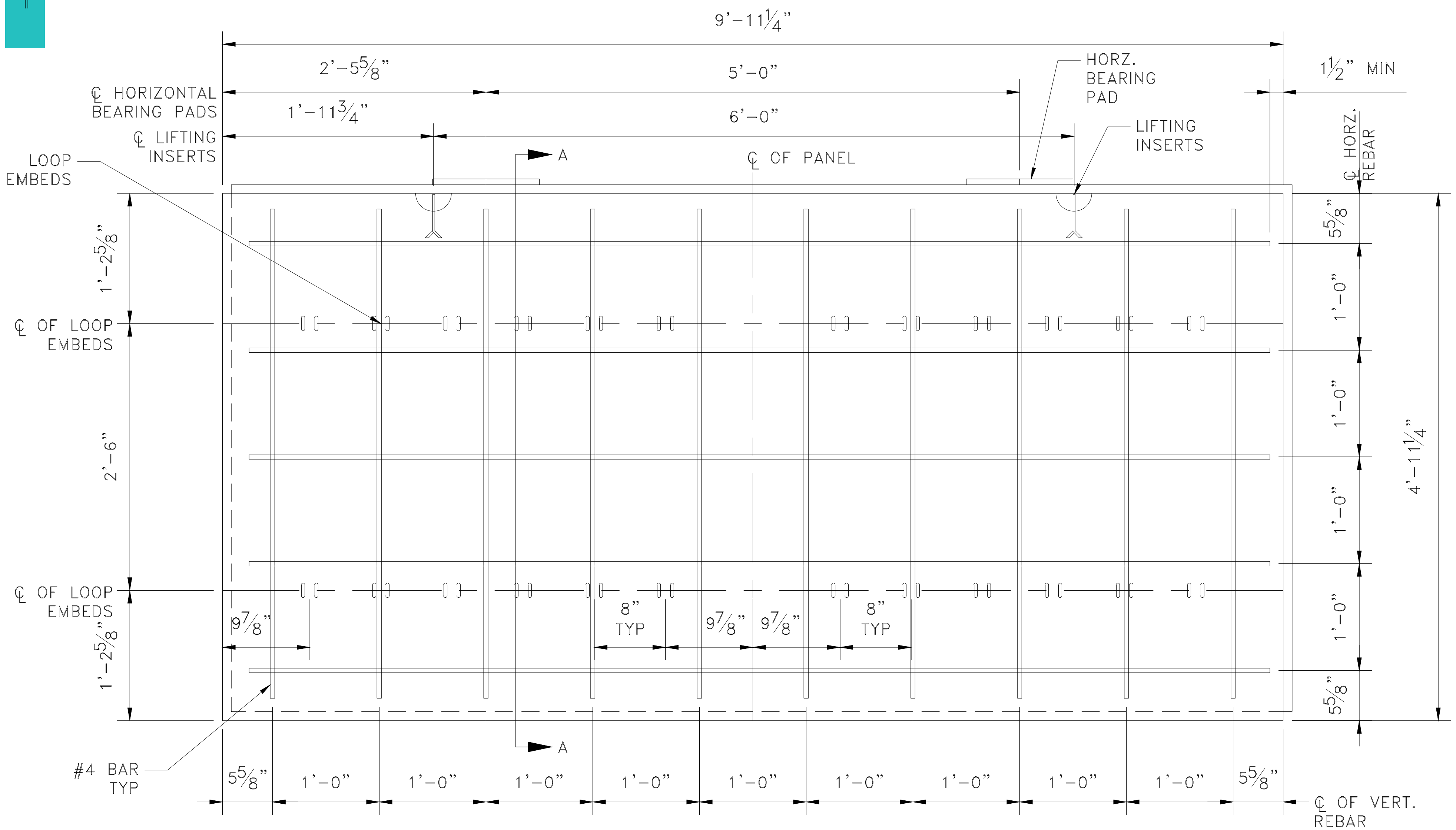
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c'} \,.\, b_v \,.\, d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 \,.\, f_c' .\, b_v \,.\, d_v$	(2) Vn	=	36.962	Kips
From (1) and (2) Vn should be:	Vn	=	7.696	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.926	Kips

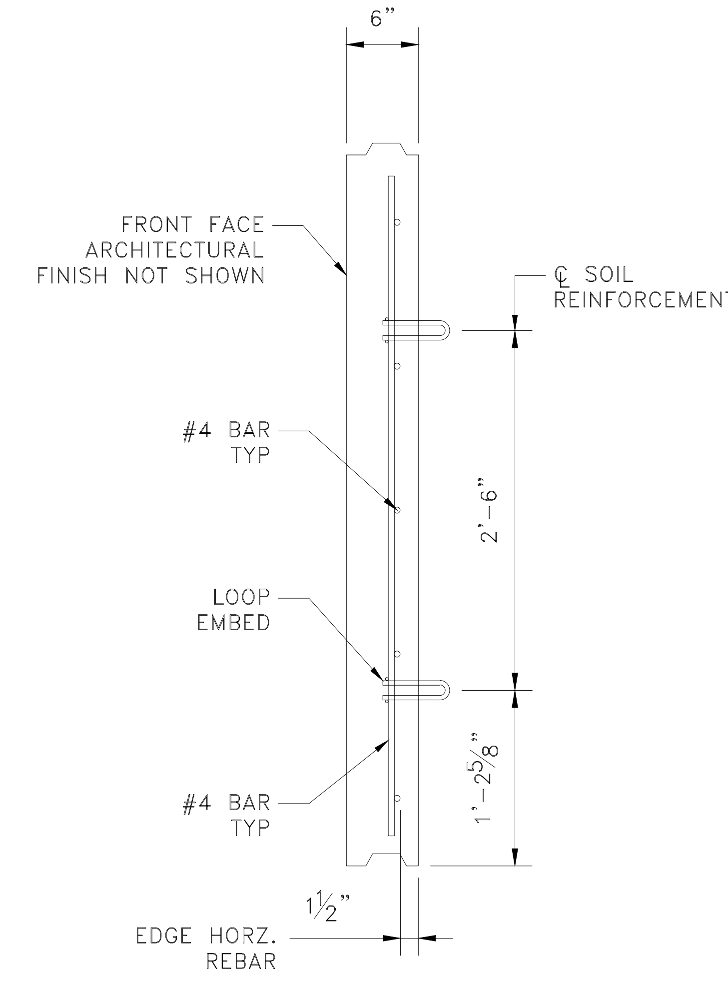
Shear Force:

From Staad Pro Result Vmax	=	0.303	N/mm^2		
	=	43.95	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3164.15	lbs		
	=	3.164	Kips	**OK, Vmax less than Vn**	



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A-A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'X' 5'X10' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 10’ STANDARD

Y PANEL

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x10', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.99	kip-ft	$+M_{u\_service}$	=	2.21	kip-ft	(FK = 1.35)
$-M_u$	=	1.25	kip-ft	$-M_{u\_service}$	=	0.93	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \frac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \frac{a}{2}\right)$ = 4.323 kip-ft

Check $+\varphi M_n > +M_u$ 4.323 > 2.99 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \frac{A_s f_y}{0.85 f'_c b}$ = 0.346 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \frac{a}{2}\right)$ = 1.672 kip-ft

Check $-\varphi M_n > -M_u$ 1.672 > 1.25 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	3.98	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 4.323 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	1.67	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	1.67	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.672 > 1.67 **OK**

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x10', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	10	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.236	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \cdot f_s}{\alpha_1 . f_c{}' . \beta_1 . b}$	c	=	0.408	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.046	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 . \beta . \alpha . \sqrt{f_c{}'} . b_v . d_v$	Vc	=	6.137	Kips
$V_s = \frac{A_v . f_y . d_v . (\cot\theta + \cot\alpha) . \sin\alpha}{s}$	Vs	=	4.767	Kips
	(1) Vn	=	10.904	Kips
(2) $V_n = 0.25 . f_c' . b_v . d_v$	(2) Vn	=	48.554	Kips
From (1) and (2) Vn should be:	Vn	=	10.904	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	9.814	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.319	N/mm^2		
	=	46.27	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3331.23	lbs		
	=	3.331	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x10', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\,\pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.81	kip-ft	$+M_{u\_service}$	=	2.08	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block	$a = \dfrac{A_s f_y}{0.85 f'_c b}$	=	0.289	in
Factored flexural resistance	$+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$	=	3.186	kip-ft
Check $+\varphi M_n > +M_u$	3.186	>	2.81	**OK**

Negative Moment Capacity

Depth of equivalent stress block	$a = \dfrac{A_s f_y}{0.85 f'_c b}$	=	0.289	in
Factored flexural resistance	$-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$	=	1.860	kip-ft
Check $-\varphi M_n > -M_u$	1.860	>	0.00	**OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f'_c}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	3.74	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 3.186 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.860 > 0.00 **OK**

Typical Panel Type Y, Panel Thickness 6", 5'x10', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi {d_b}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \cdot f_s}{\alpha_1 \cdot f_c' \cdot \beta_1 \cdot b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

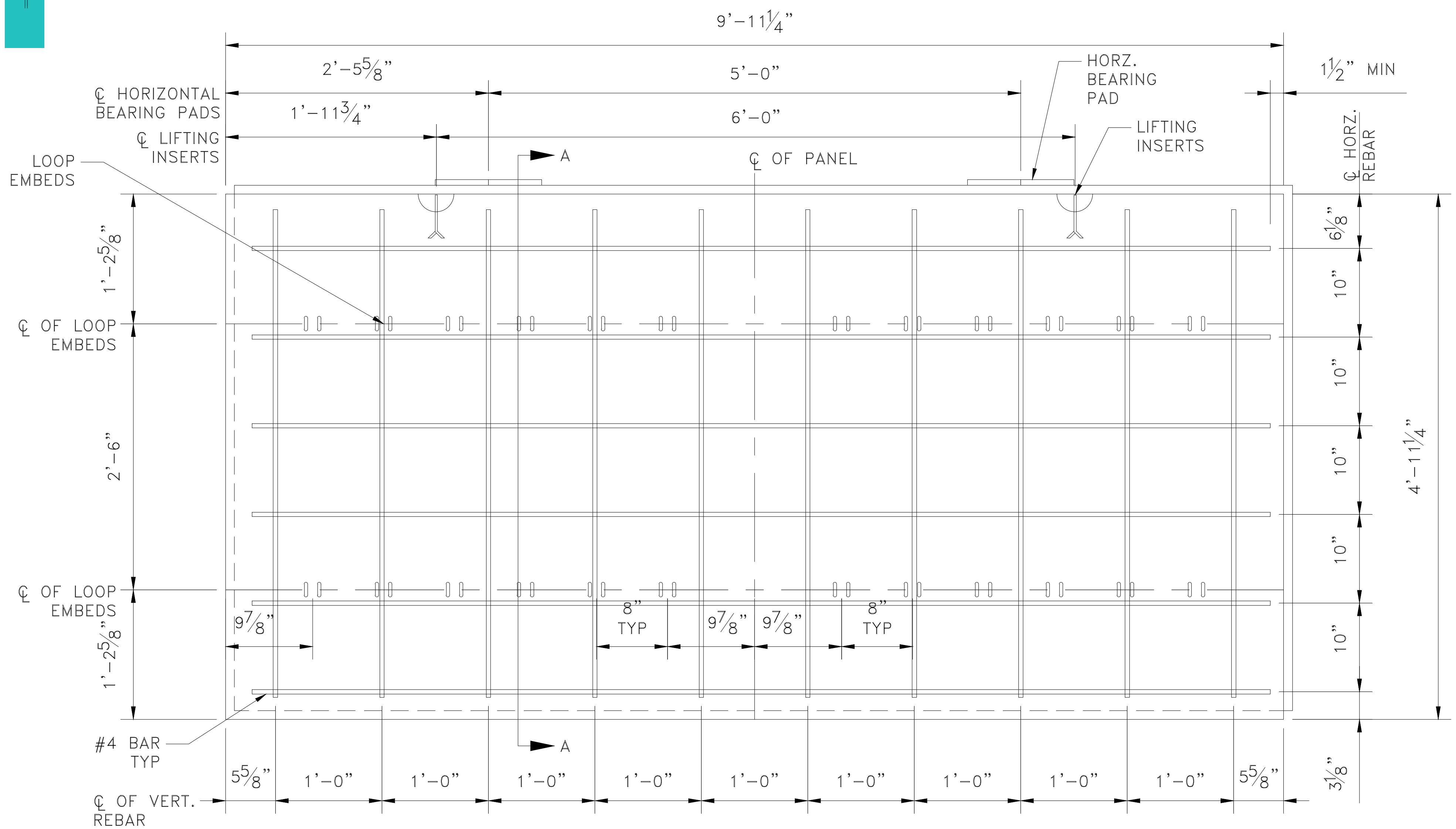
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \cdot \beta \cdot \alpha \cdot \sqrt{f_c'} \cdot b_v \cdot d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v \cdot f_y \cdot d_v \cdot (\cot\theta + \cot\alpha) \cdot \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 \cdot f_c' \cdot b_v \cdot d_v$	(2) Vn	=	36.962	Kips
From (1) and (2) Vn should be:	Vn	=	7.696	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.926	Kips

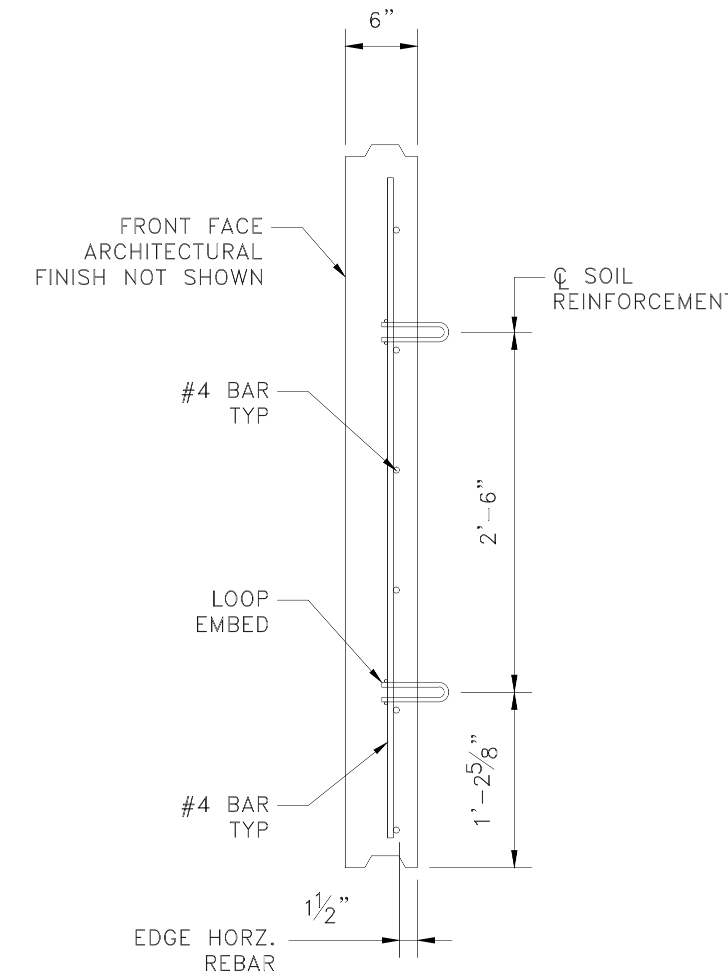
Shear Force:

From Staad Pro Result Vmax	=	0.372	N/mm^2		
	=	53.95	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3884.70	lbs		
	=	3.885	Kips	**OK, Vmax less than Vn**	



STANDARD "Y" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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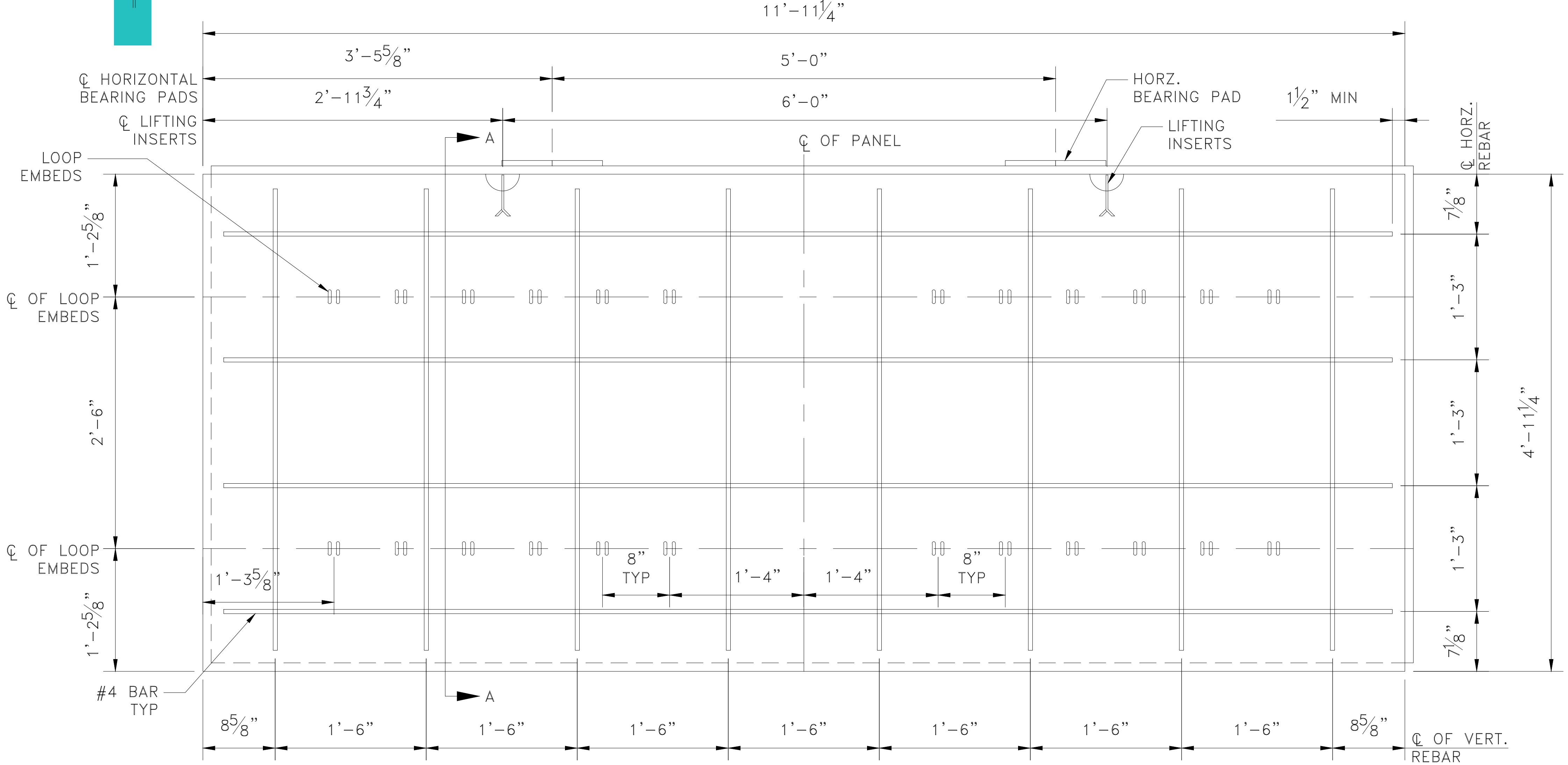
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR:	FSH	NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X10' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

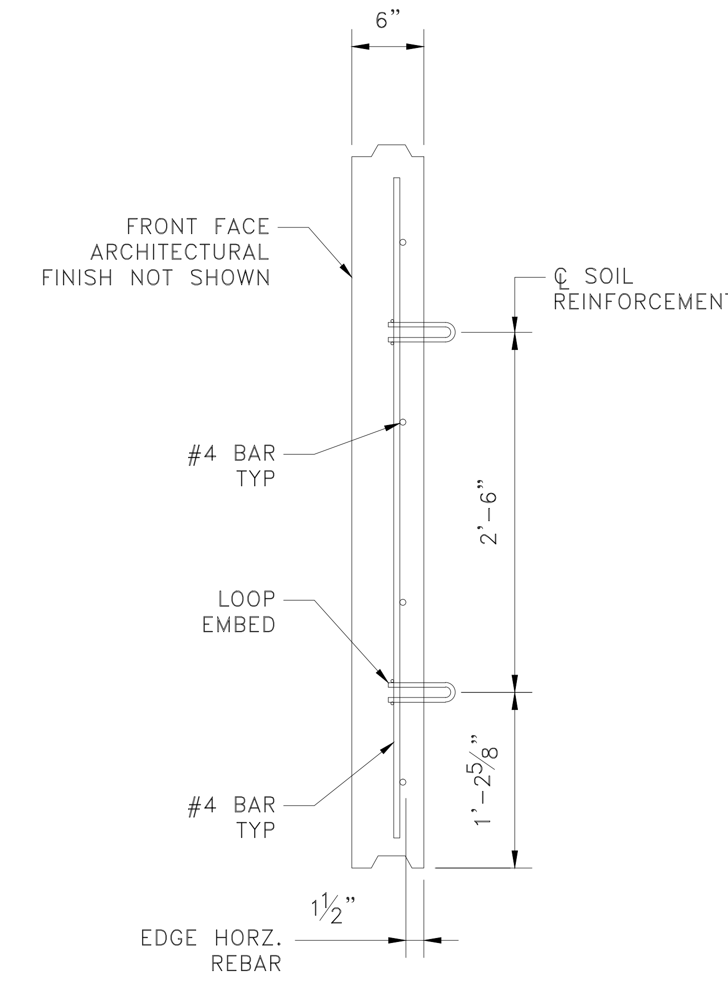
Scale: NTS
Job:
Sheet:
Sheet of

5’ x 12’ STANDARD PANELS



STANDARD "A" PANEL

SHOWN FROM BACK FACE



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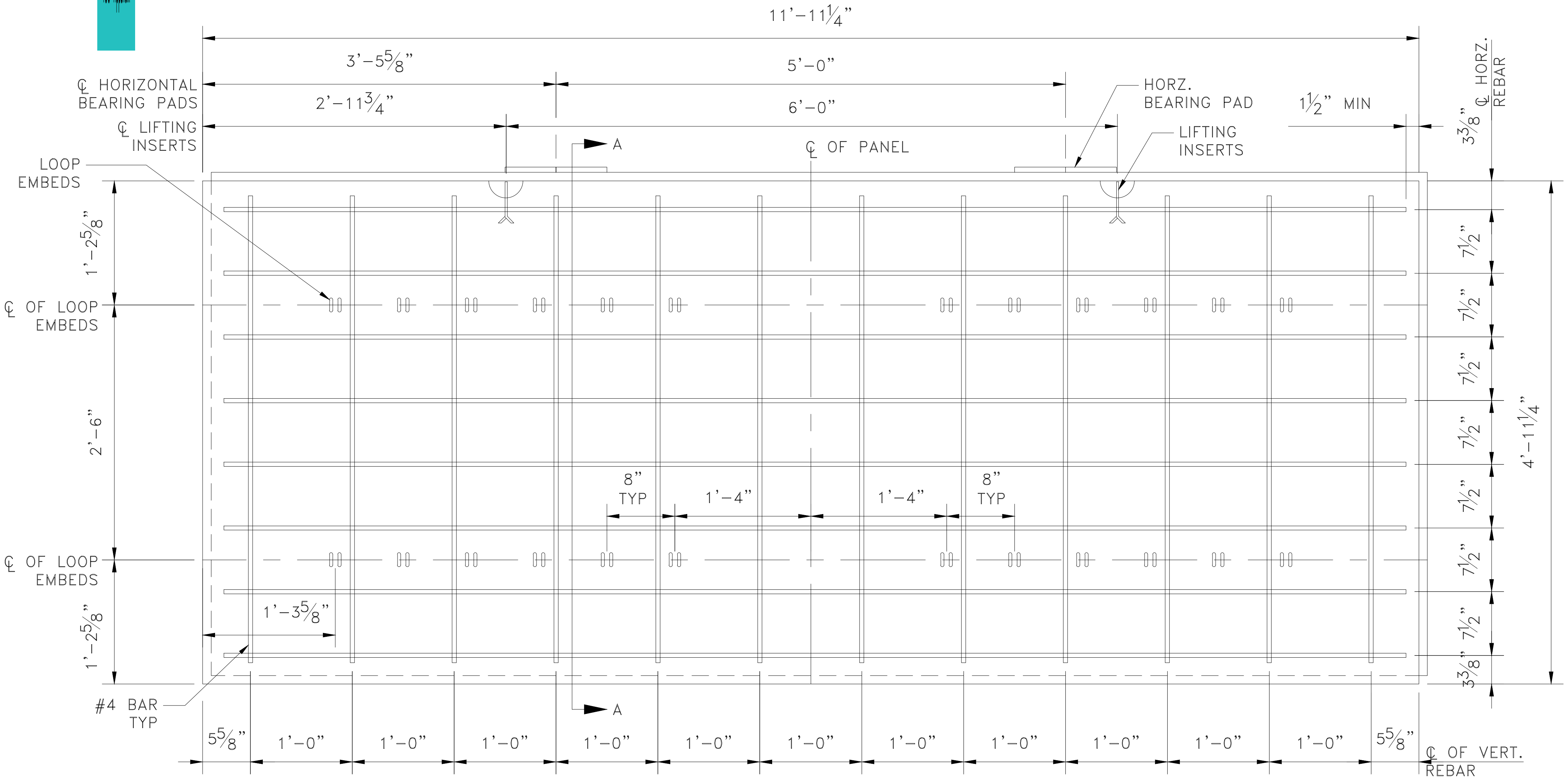
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X12' PANEL DETAILS

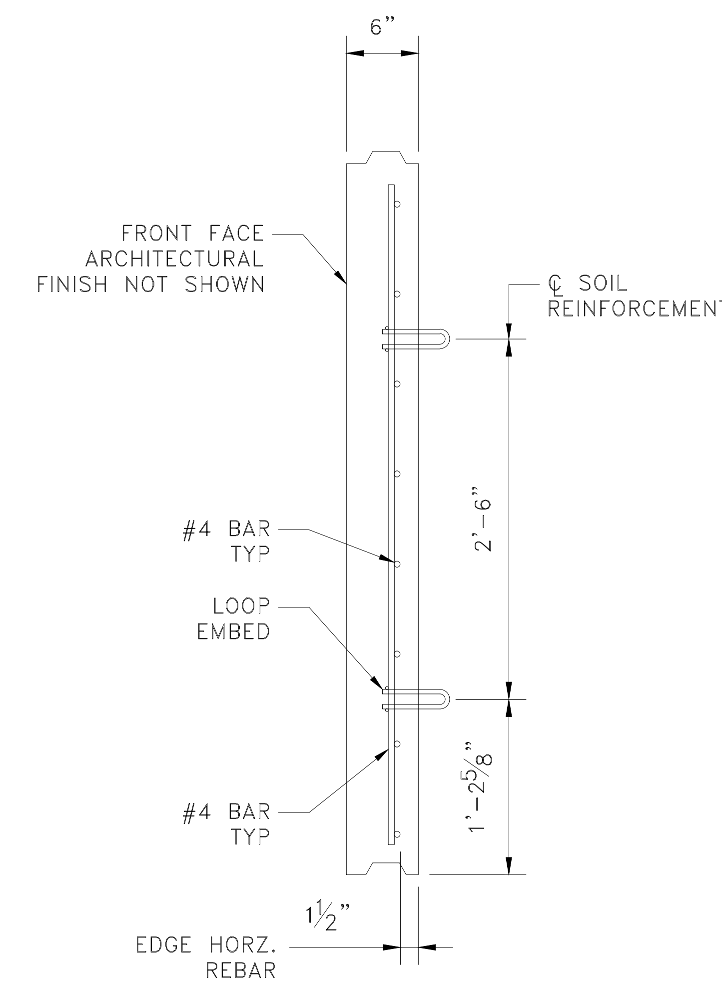
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A–A

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IDEA EVALUATION

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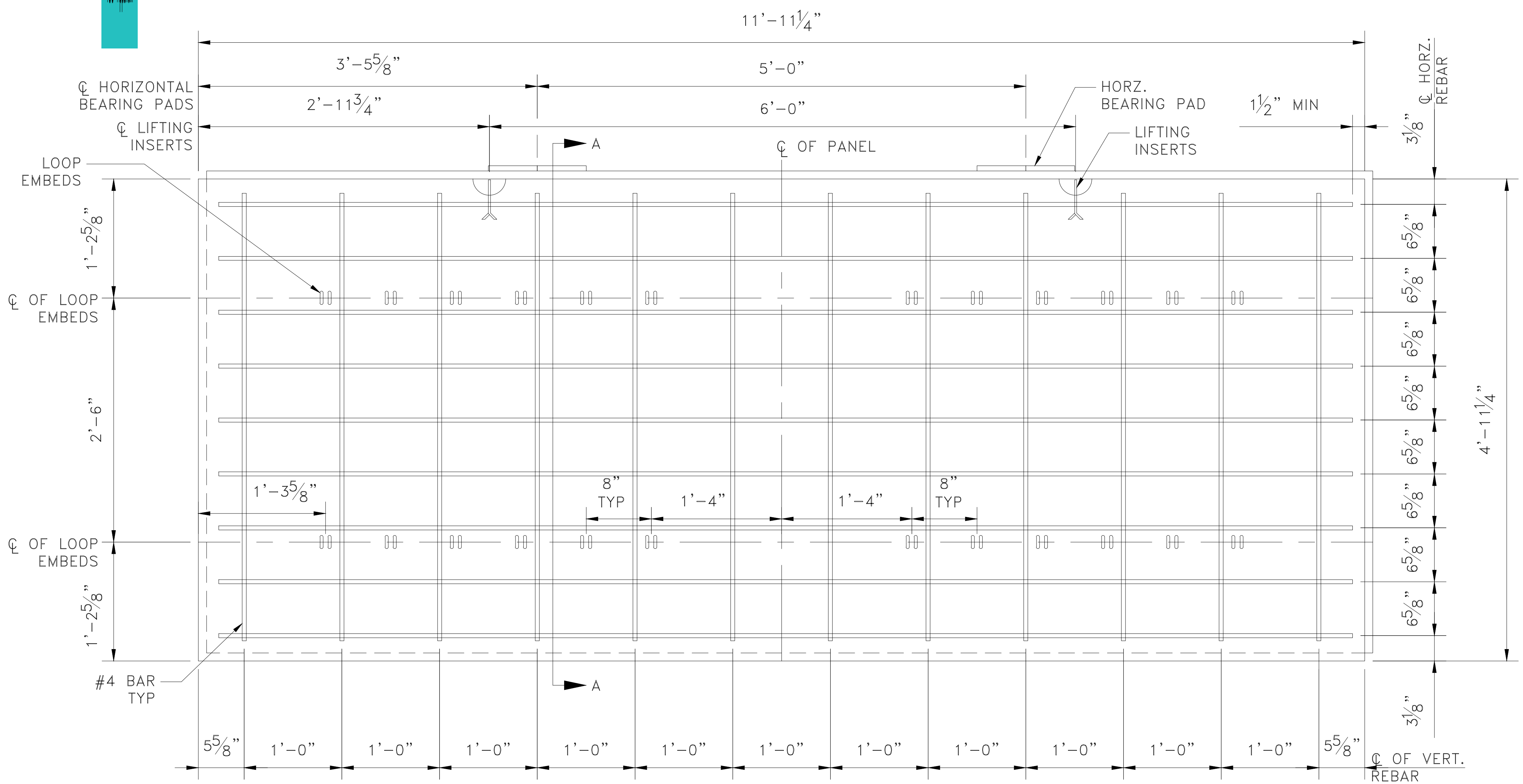
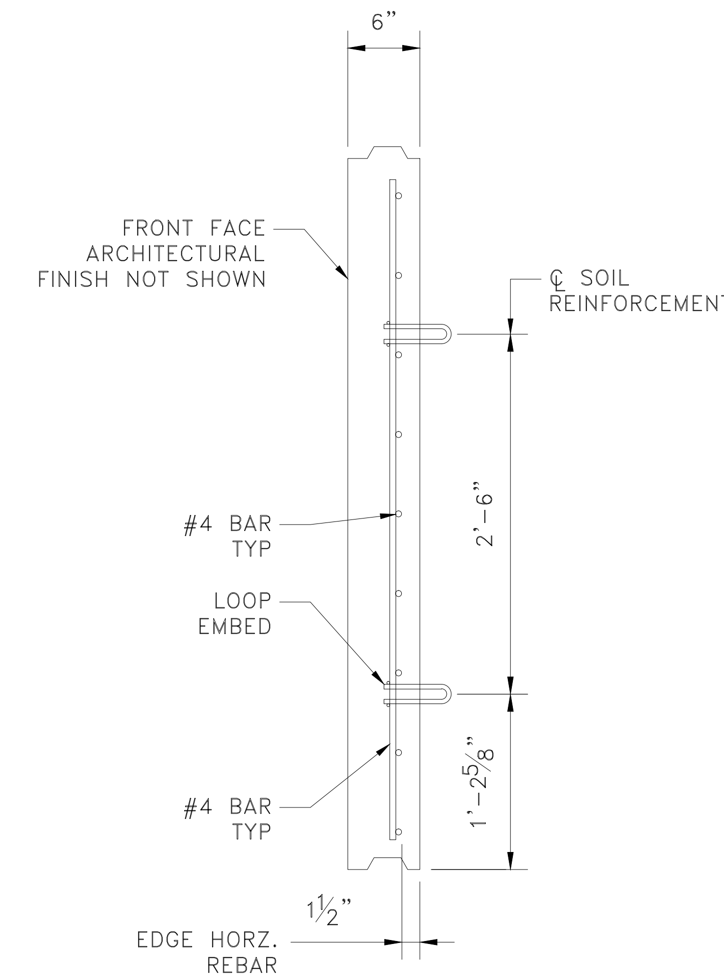
Job:
Sheet:
Sheet of



STANDARD "Y" PANEL

SHOWN FROM BACK FACE



SECTION A–A

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PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X12' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

TOC – Appendix

Area Diameter

16 Galvanize Life Coating

12 Corrosion Rate Carbon Steel (in microns)

75 Design Life

Wire	Area sqin	Diameter in	Diameter microns	Diameter after microns	Diameter after in	% effective	Area after sqin					6	7	8
W5	0.05	0.252	6408.757	4992.757	0.1966	0.6069	0.0303	2	3	4	5	0.1821	0.2124	0.2428
W8	0.08	0.319	8106.507	6690.507	0.2634	0.6812	0.0545	0.1090	0.1635	0.2180	0.2725	0.3270	0.3815	0.4359
W11	0.11	0.374	9505.722	8089.722	0.3185	0.7243	0.0797	0.1593	0.2390	0.3187	0.3983	0.4780	0.5577	0.6374
W15	0.15	0.437	11100.292	9684.292	0.3813	0.7611	0.1142	0.2283	0.3425	0.4567	0.5709	0.6850	0.7992	0.9134
W20	0.20	0.505	12817.513	11401.513	0.4489	0.7913	0.1583	0.3165	0.4748	0.6330	0.7913	0.9495	1.1078	1.2660
W24	0.24	0.553	14040.882	12624.882	0.4970	0.8085	0.1940	0.3881	0.5821	0.7761	0.9702	1.1642	1.3582	1.5523
W30	0.30	0.618	15698.184	14282.184	0.5623	0.8277	0.2483							

SPRING CONSTANT

Modulus of Sub-Grade Reaction and Spring Constant Check

From Principles of Foundation Engineering; Braja M. Das 8th Edition:

Table 8.2 Typical Subgrade Reaction Values, $k_{0.3}(k_1)$

Soil type	$k_{0.3}(k_1)$ MN/m³	$k_{0.3}(k_1)$ lb/in.³
Dry or moist sand:		
Loose	8–25	30–90
Medium	25–125	90–450
Dense	125–375	450–1350
Saturated sand:		
Loose	10–15	35–55
Medium	35–40	125–145
Dense	130–150	475–550
Clay:		
Stiff	10–25	40–90
Very stiff	25–50	90–185
Hard	>50	>185

$K_{0.3}$ (k_1) = 1350 lb/in³ (is selected)

(dense Sand, value is conservative considering no reinforcement is included)

Adjust to panel 5' x 10' (1.5m x 3m)

Foundations on Sandy Soils

For foundations on sandy soils,

$$k = k_{0.3}\left(\frac{B+0.3}{2B}\right)^2 \tag{8.45}$$

where $k_{0.3}$ and k = coefficients of subgrade reaction of foundations measuring 0.3 m × 0.3 m and B(m) × B(m), respectively (unit is kN/m³).

In English units, Eq. (8.45) may be expressed as

$$k = k_1\left(\frac{B+1}{2B}\right)^2 \tag{8.46}$$

where k_1 and k = coefficients of subgrade reaction of foundations measuring 1 ft × 1 ft and B(ft) × B(ft), respectively (unit is lb/in³).

$$k_{1.5} = k_{0.3} \cdot \left(\frac{B+0.3}{2B}\right)^2$$

$$k_{1.5} = 1350\ x \left(\frac{1.5+0.3}{2\ x\ 1.5}\right)^2$$

$k_{1.5}$ = 486 lb/in³

$$k_{1.5x3.0} = k_{1.5} \cdot \left(\frac{1+\frac{1.5}{3.0}}{1.5}\right)^2$$

$k_{1.5x3.0}$ = 486 lb/in³

$k_{1.5x3.0}$ = 839.755 kip/ft³

From Foundation Analysis And Design; Joseph E. Bowles, RE., S.E. 5th Edition:

10-5 MODULUS OF SUBGRADE REACTION k_s FOR MATS AND PLATES

All three discrete element methods given in this chapter for mats/plates use the modulus of subgrade reaction k_s to support the plate. The modulus k_s is used to compute node springs based on the contributing plan area of an element to any node as in Fig. 10-5. From the figure we see the following:

Node	Contributing area
1 (corner)	$\frac{1}{4}$ of rectangle *abde*
2 (side)	$\frac{1}{4}$ of *abde* + $\frac{1}{4}$ of *bcef*
3 (interior)	$\frac{1}{4}$ of each rectangle framing to a common node (as node 3)

For a triangle one should arbitrarily use one-third of the triangle area to any corner node. For these area contributions the fraction of k_s node resistance from any element is

$$K_i = k_s,\ \text{kN/m}^3, \times \text{Area},\ \text{m}^2 = \text{units of kN/m (or kips/ft in Fps)}$$

Since this computation gives units of a "spring" it is common to call the effect a *node spring*.

In this form the springs are independent of each other, the system of springs supporting the plate is termed a "Winkler" foundation, and the springs are uncoupled. Uncoupling means that the deflection of any spring is not influenced by adjacent springs.

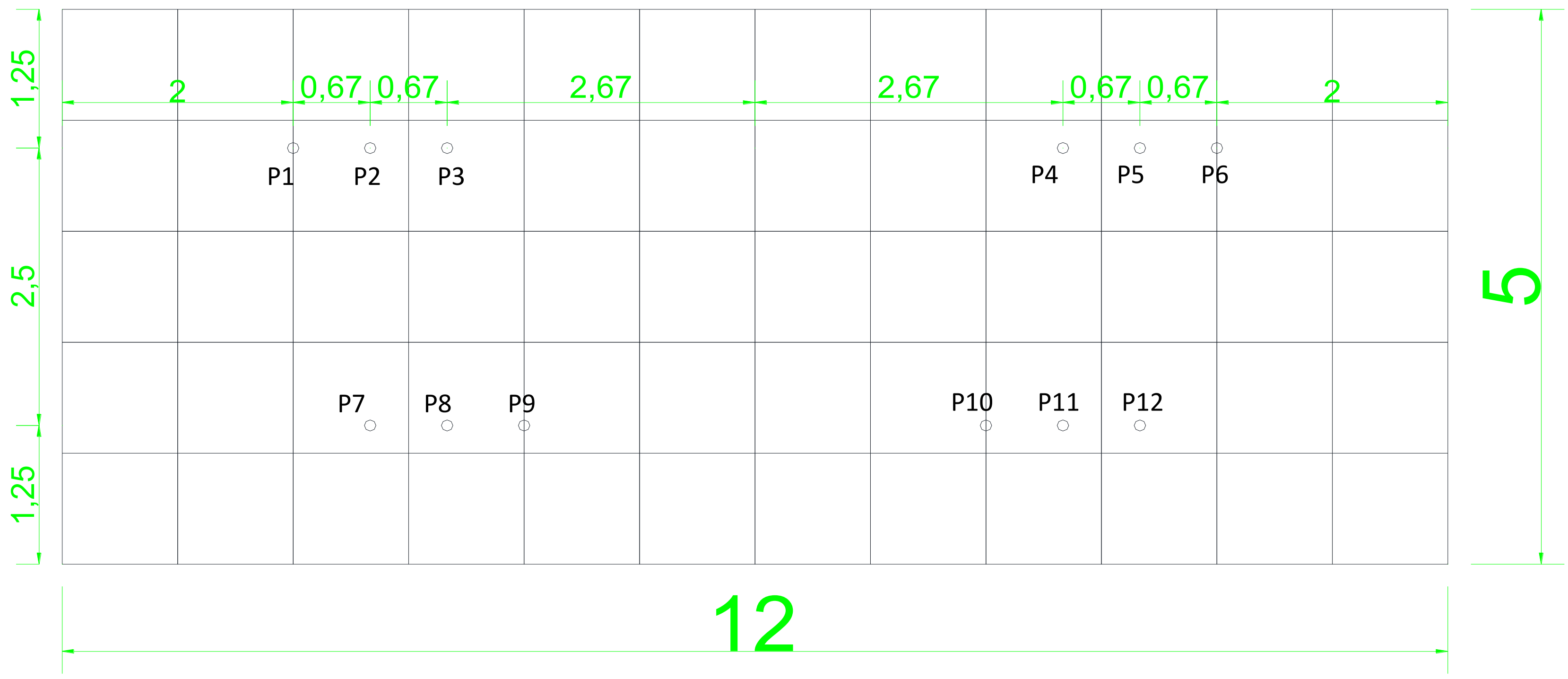
Spring Constant

Note Spacing:	1ft x 1ft		
Tributary Area:	1' x 1' = 1SF		
Ka =	k x a		
Ka =	839.755	kip/ft	(Input to Staad Pro)

MAXIMUM BENDING MOMENT AND SHEAR

Typical Panel Type (mesh 3W11), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.5	0.25
P2	0.1667	0.25
P3	-0.167	0.25
P4	0.1667	0.25
P5	-0.167	0.25
P6	-0.5	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.1667	-0.25
P8	-0.167	-0.25
P9	-0.5	-0.25
P10	0.5	-0.25
P11	0.1667	-0.25
P12	-0.167	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

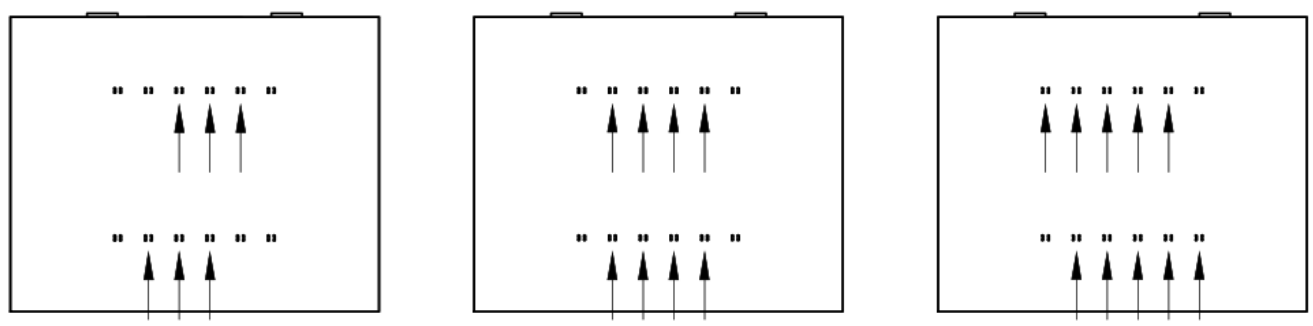
Bar Mat Used:
W11 - 75 Years

$A = 0.0797\ \text{in}^2$

$F_y = 75\ \text{ksi}$

$P = 0.65 \times A \times F_y$

$= 3.885\ \text{Kips}$ (per wire point)



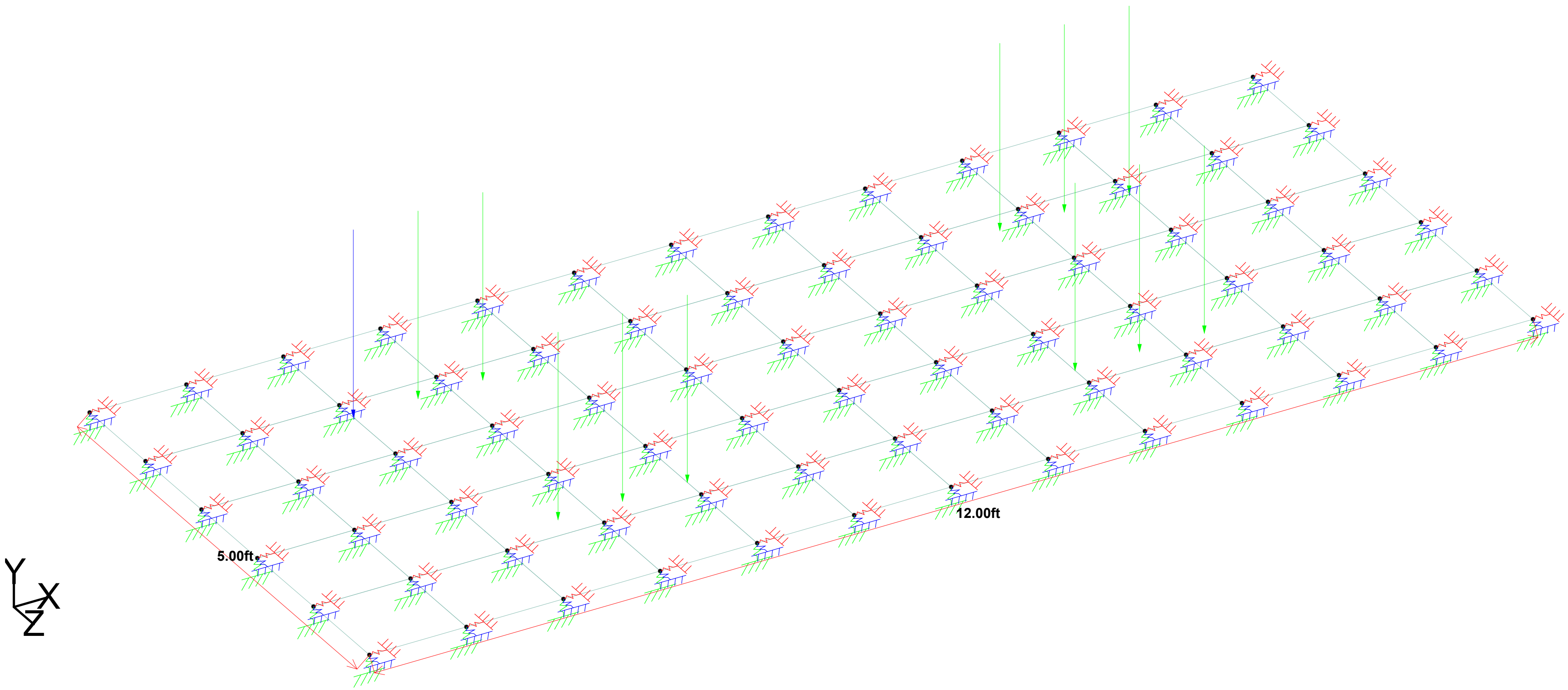
3–WIRE CONNECTION PANEL   4–WIRE CONNECTION PANEL   5–WIRE CONNECTION PANEL

ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:16	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
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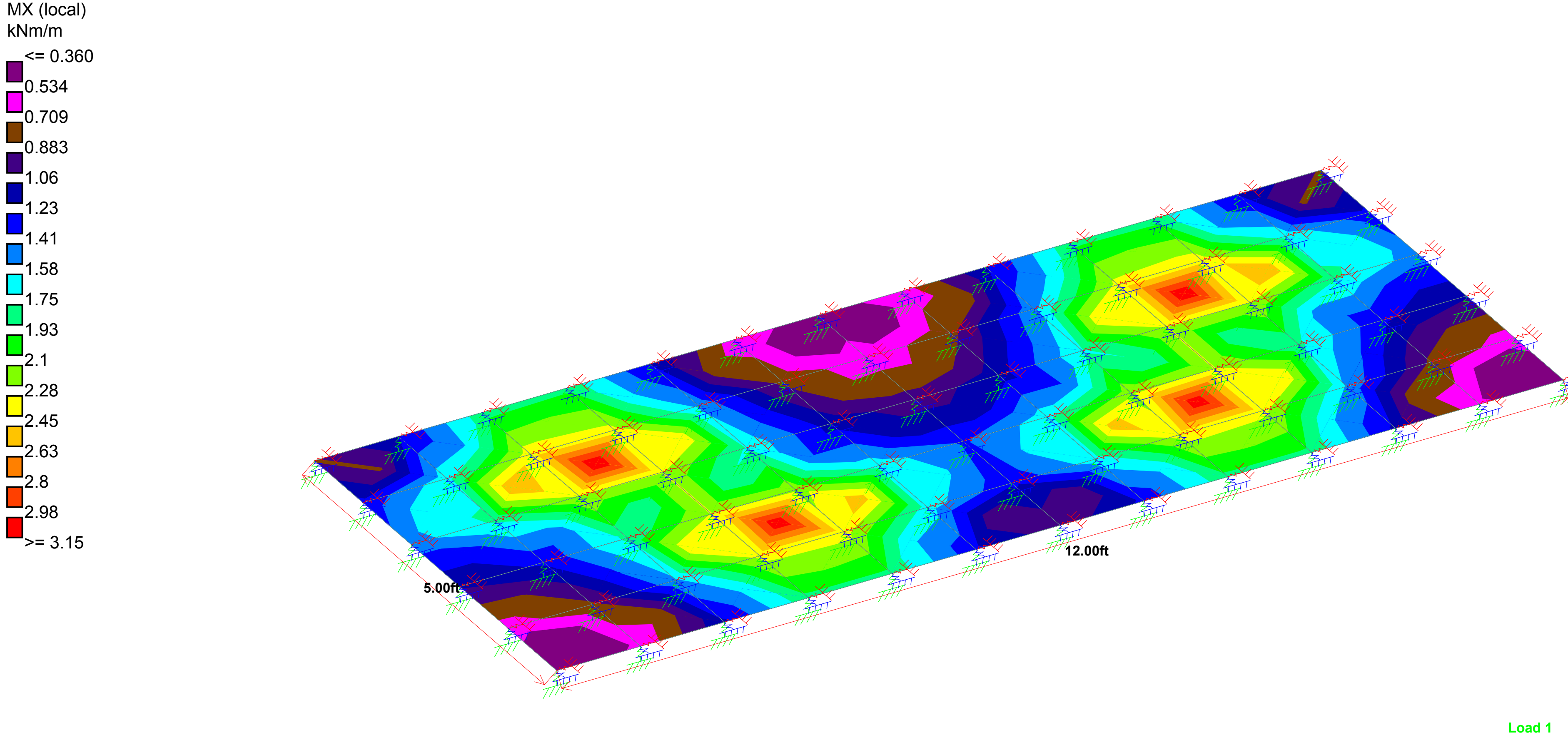

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Job Title	Job No	Sheet No 1	Rev
	Part		
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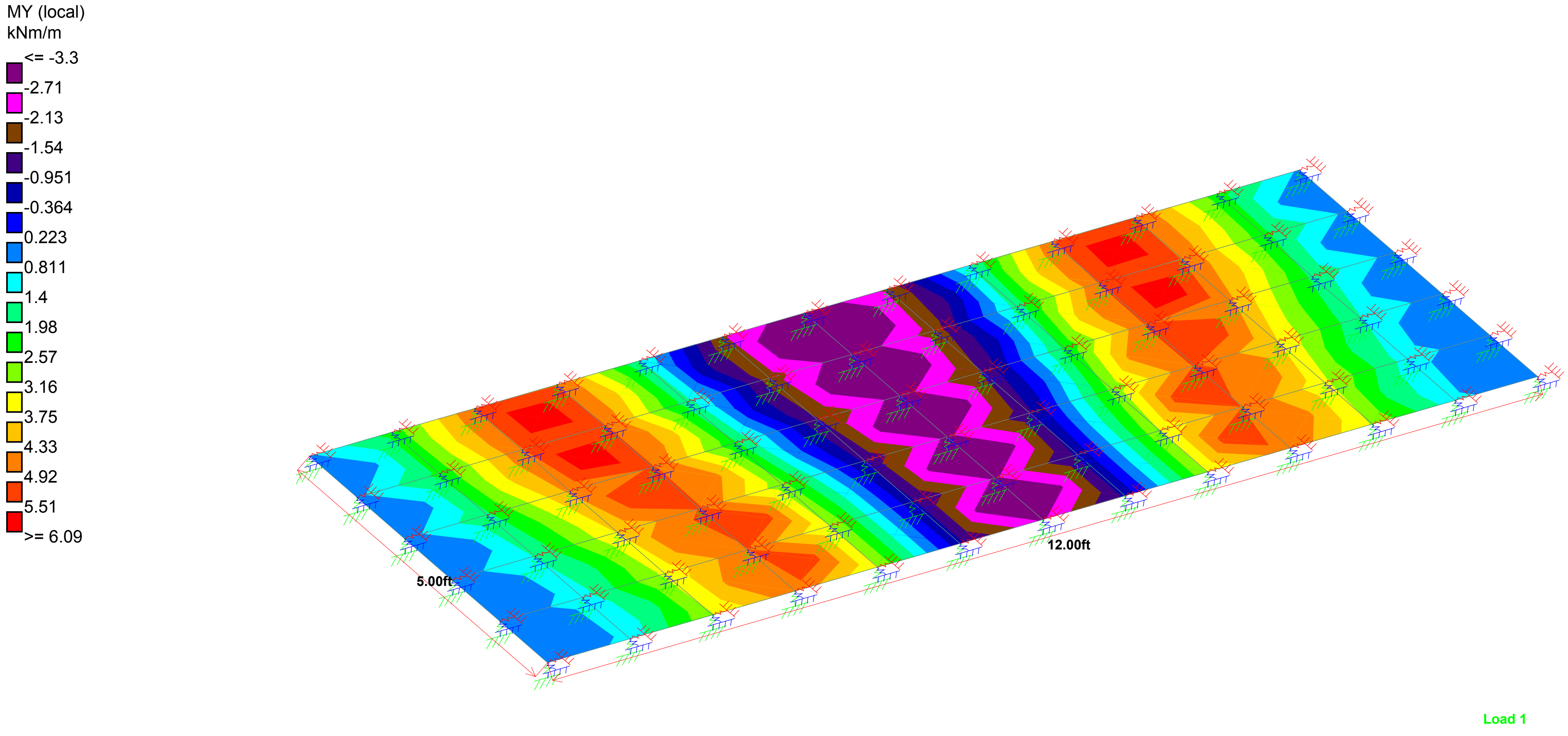
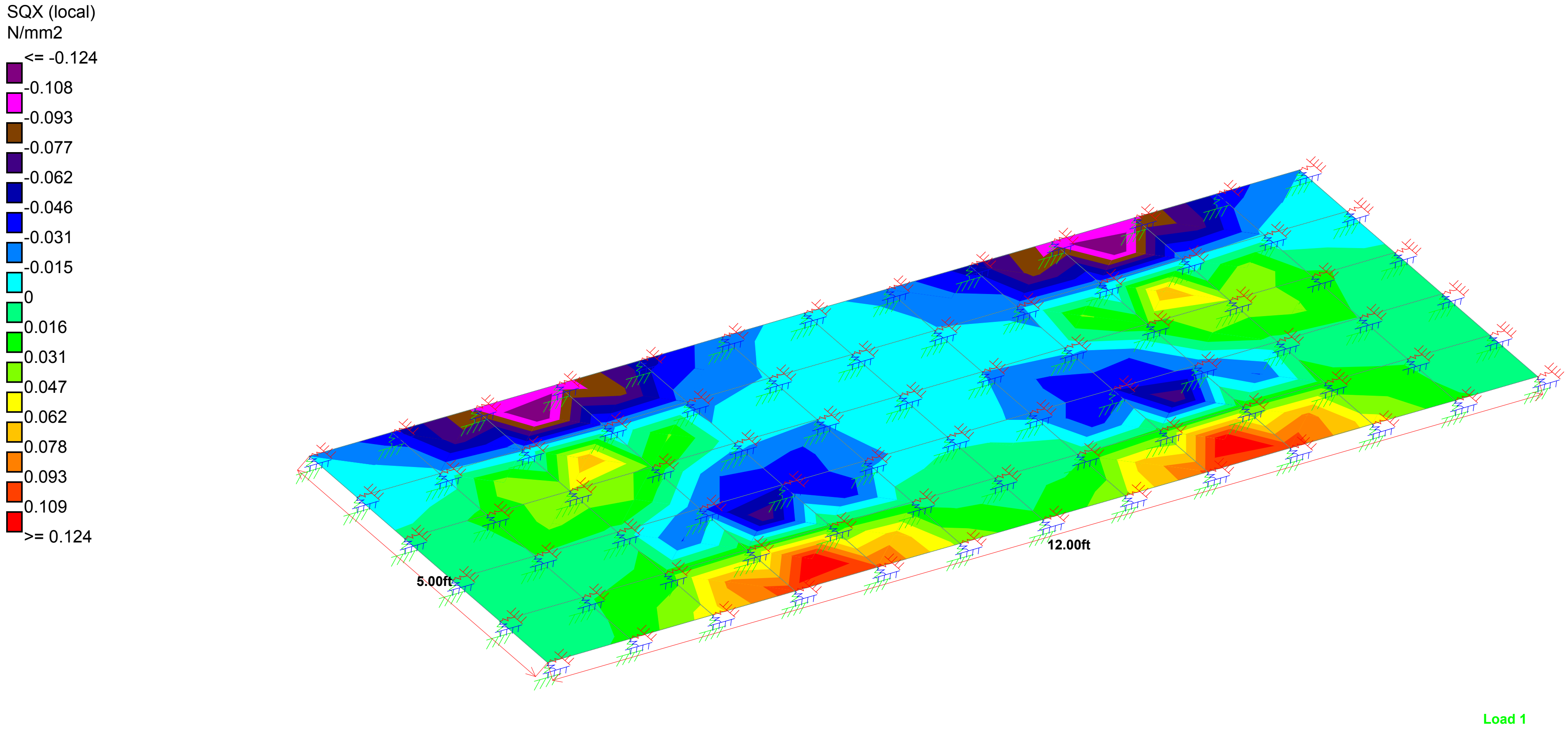
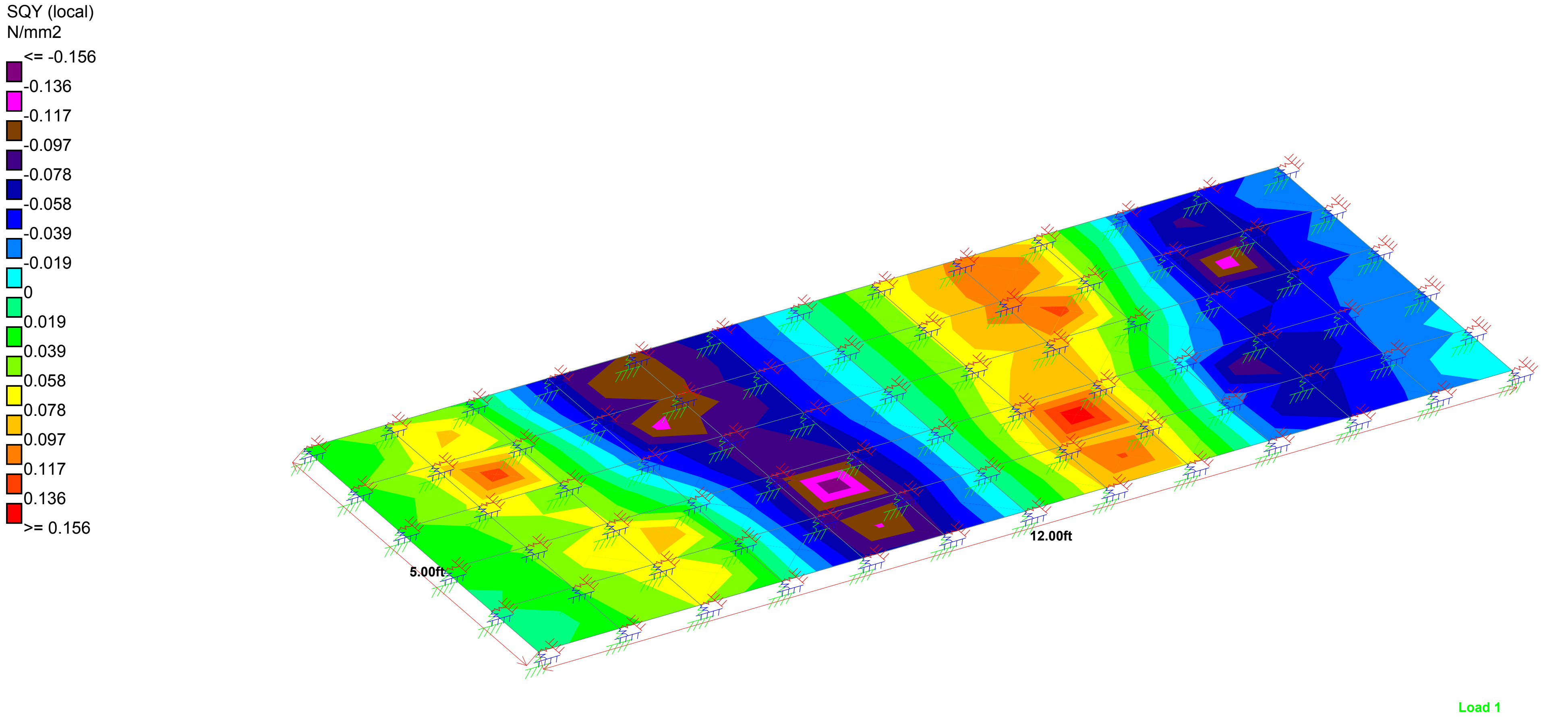
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:16	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:16	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:16	



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*                                                  *
*          STAAD.Pro                               *
*          Version  2007    Build 04               *
*          Proprietary Program of                  *
*          Research Engineers,  Intl.              *
*          Date=    MAR 11, 2021                   *
*          Time=     1:18:35                       *
*                                                  *
*     USER ID: Optimal Engineering Support         *
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     1. STAAD SPACE
INPUT FILE: Panel Check - 5x12 type A (3W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
    39. ISOTROPIC CONCRETE
    40. E 614304
```



```
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 32 PR GY -3.885 0.25 0.5
    54. 33 PR GY -3.885 0.25 0.1667
    55. 34 PR GY -3.885 0.25 -0.1667
    56. 67 PR GY -3.885 0.25 0.1667
    57. 68 PR GY -3.885 0.25 -0.1667
    58. 68 PR GY -3.885 0.25 0.5
    59. 8 PR GY -3.885 -0.25 0.1667
    60. 11 PR GY -3.885 -0.25 -0.1667
    61. 11 PR GY -3.885 -0.25 0.5
    62. 51 PR GY -3.885 -0.25 0.5
    63. 54 PR GY -3.885 -0.25 0.1667
    64. 57 PR GY -3.885 -0.25 -0.1667
    65. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     78/    60/    78

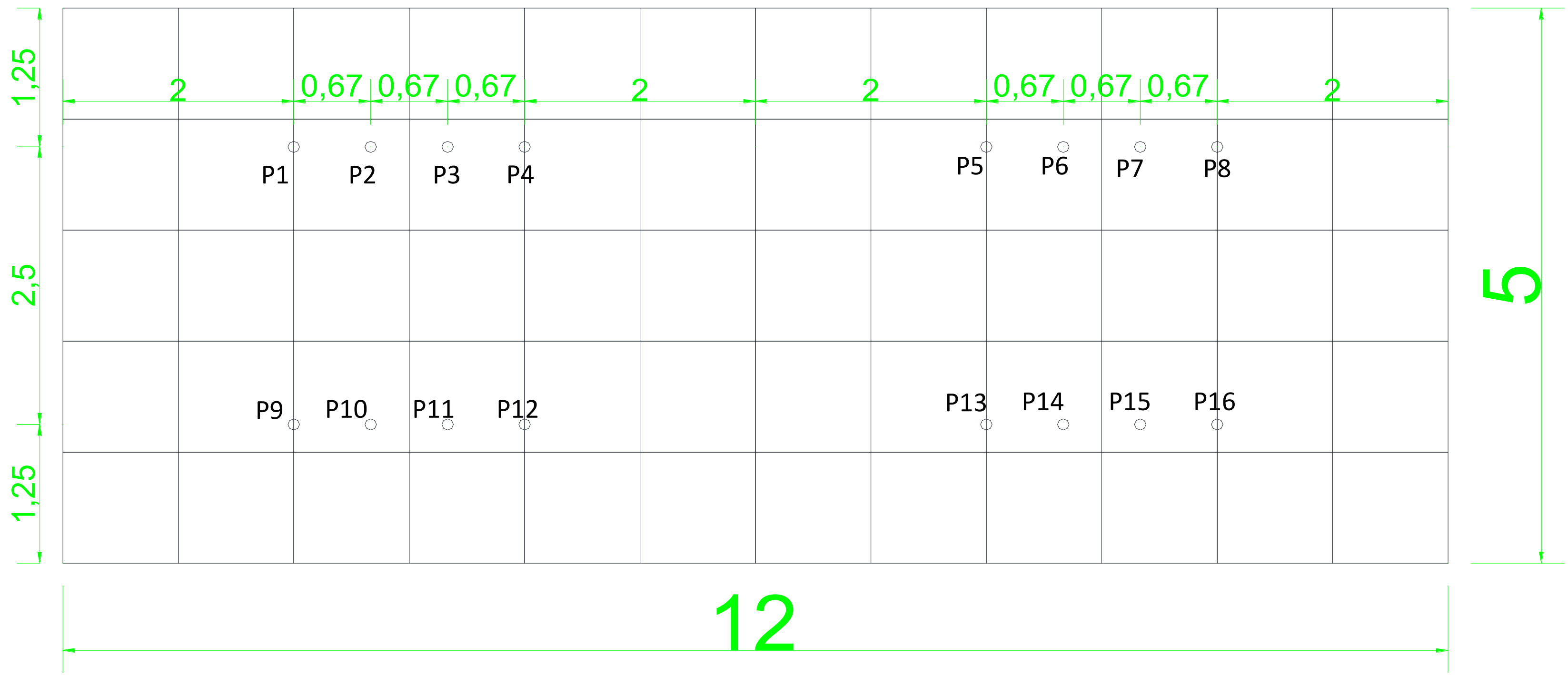
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    39/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =    468
 SIZE OF STIFFNESS MATRIX =       31 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.6/ 263314.0 MB


    66. FINISH
```

Typical Panel Type (mesh 4W11), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.5	0.25
P2	0.1667	0.25
P3	-0.167	0.25
P4	-0.5	0.25
P5	0.5	0.25
P6	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.167	0.25
P8	-0.5	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P9	0.5	-0.25
P10	0.1667	-0.25
P11	-0.167	-0.25
P12	-0.5	-0.25
P13	0.5	-0.25
P14	0.1667	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P15	-0.167	-0.25
P16	-0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

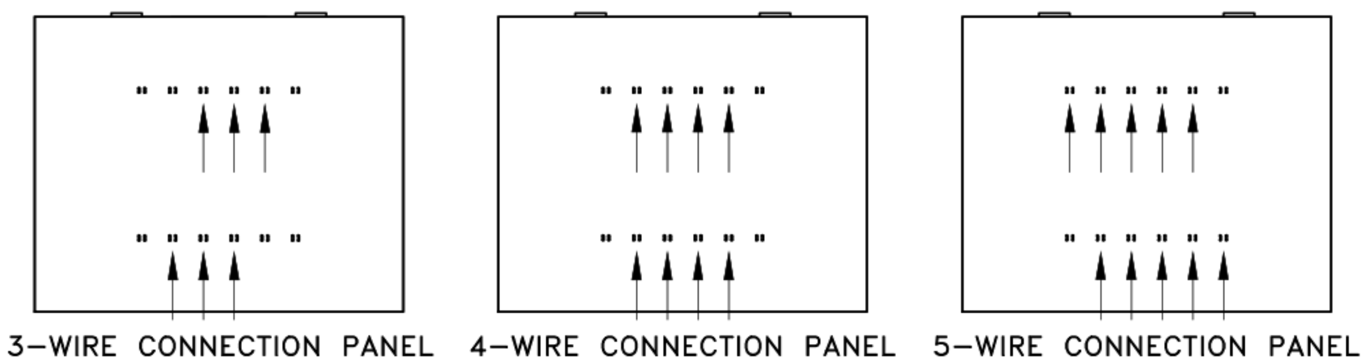
Bar Mat Used:
W11 - 75 Years

$A = 0.0797\ in^2$

$Fy = 75\ ksi$

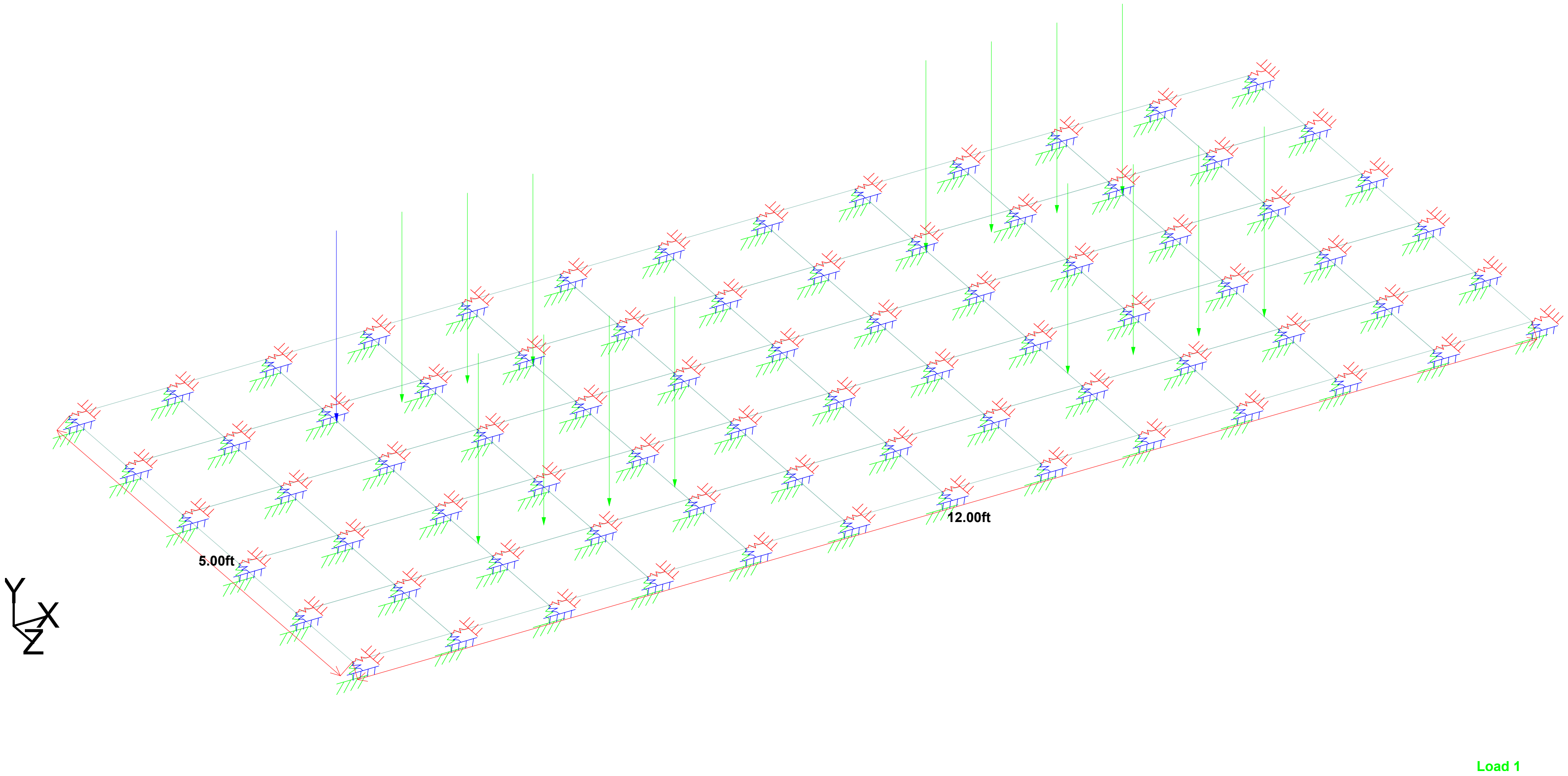
$P = 0.65 \times A \times Fy$

$= 3.885$ Kips (per wire point)

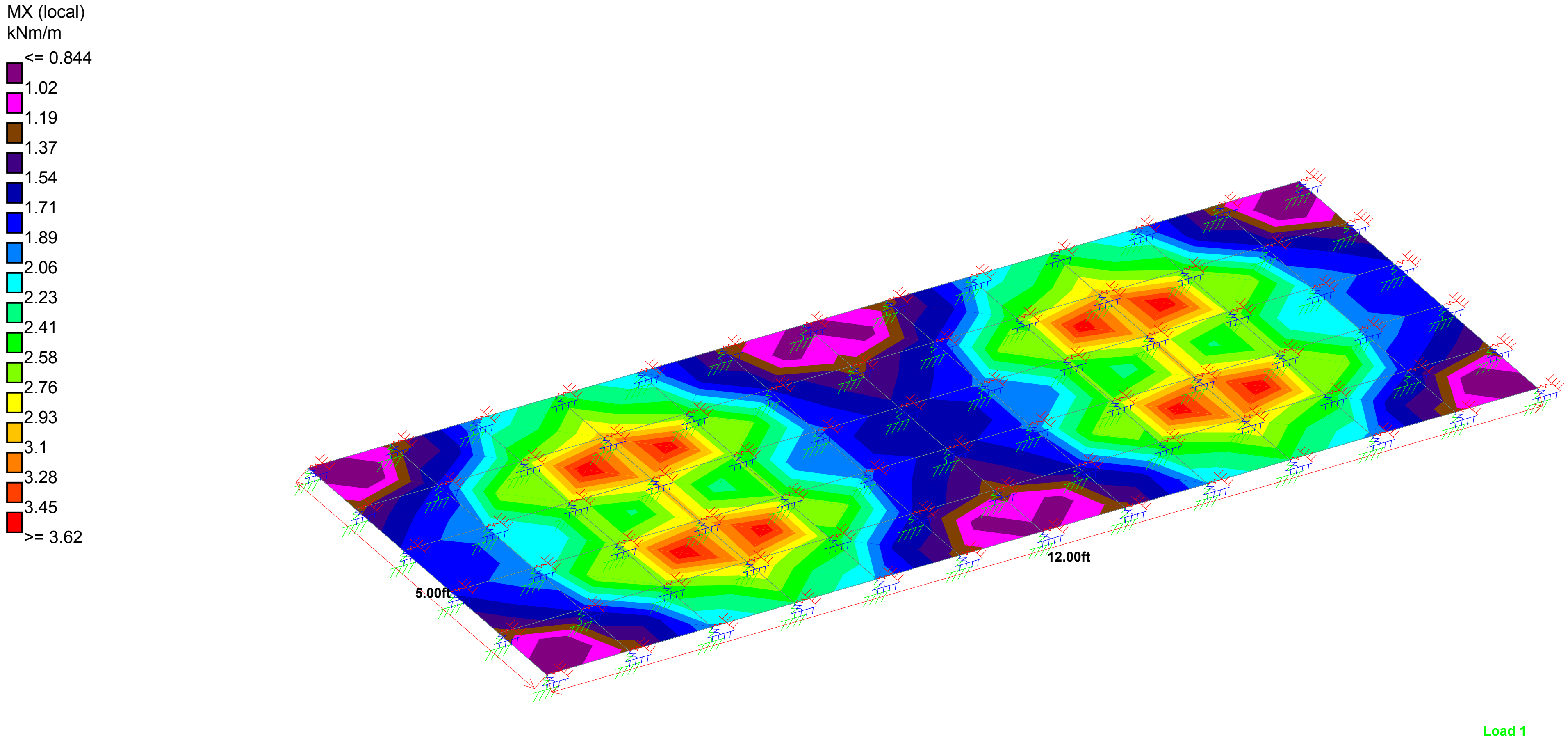


ATTACHMENT BY No. WIRES
(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:38	



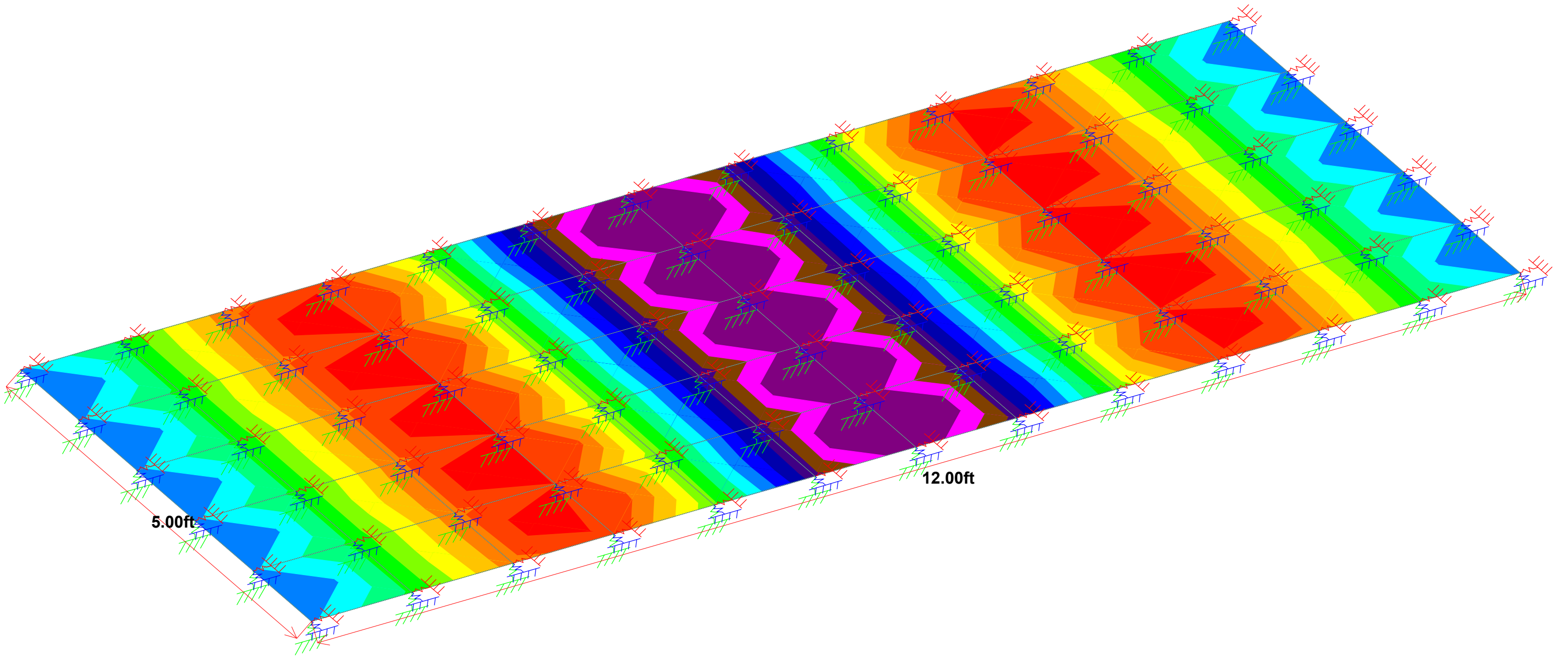
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:38	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:38	

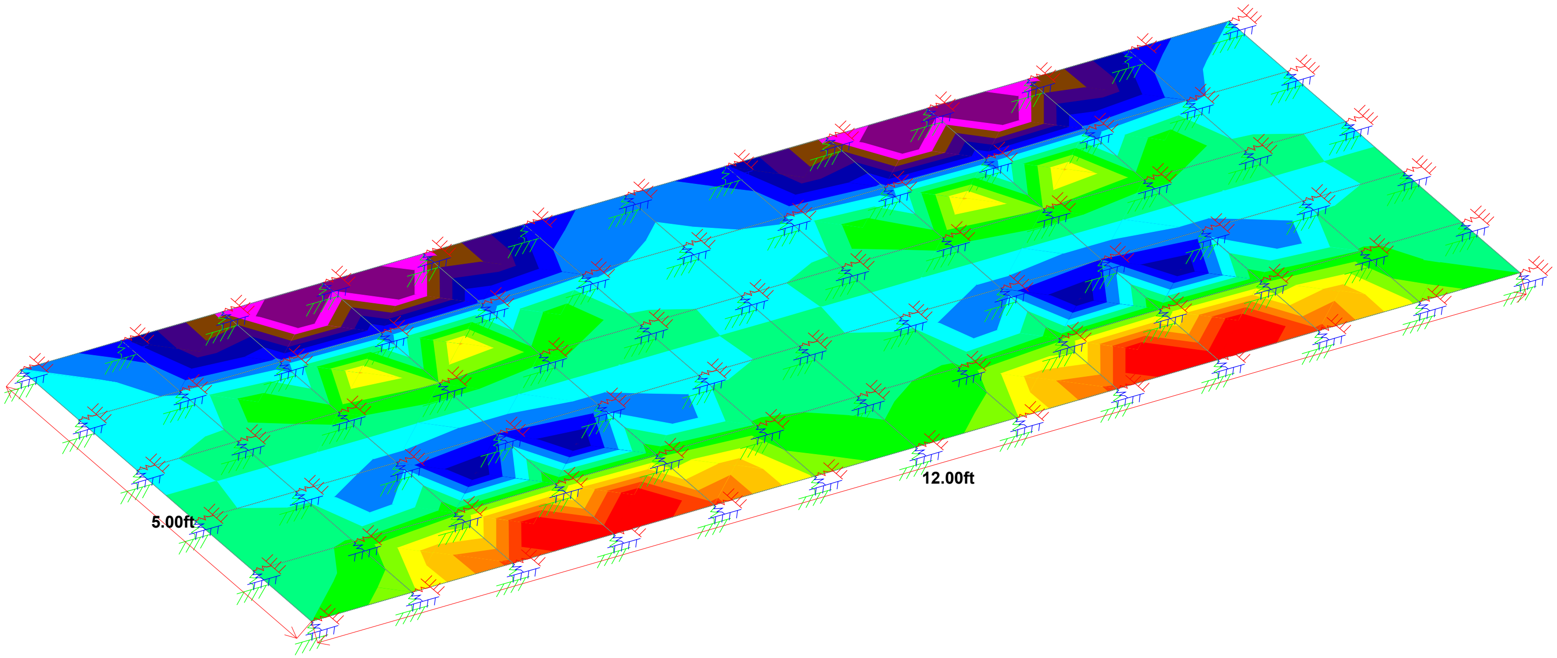
MY (local)
kNm/m
<= -3.86
-3.19
-2.53
-1.86
-1.2
-0.532
0.132
0.797
1.46
2.13
2.79
3.45
4.12
4.78
5.45
6.11
>= 6.78



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:38	

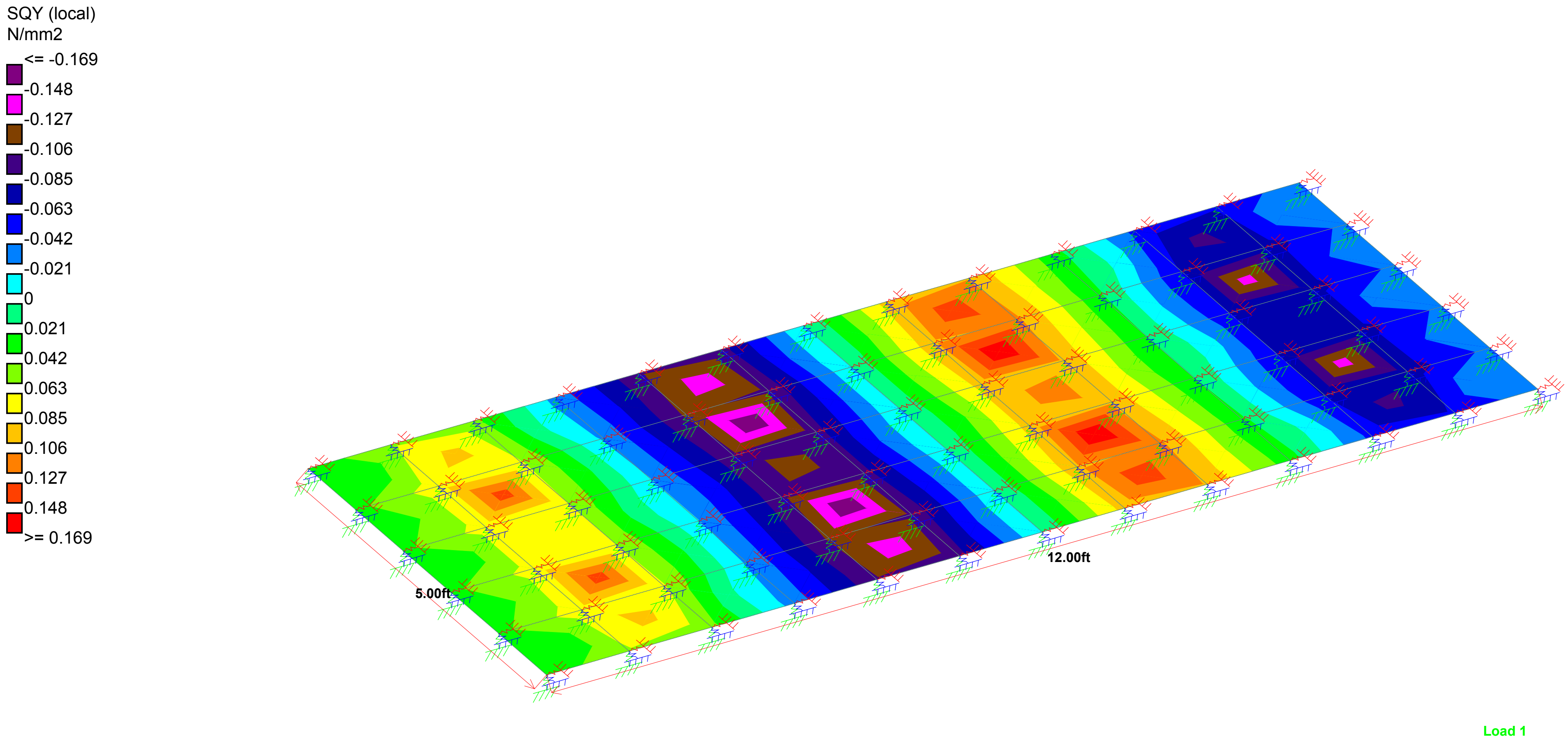
SQX (local)
N/mm2

<= -0.128
-0.112
-0.096
-0.080
-0.064
-0.048
-0.032
-0.016
0
0.016
0.032
0.048
0.064
0.080
0.096
0.112
>= 0.128



Load 1

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:38	



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     *           STAAD.Pro                               *
     *           Version  2007    Build 04               *
     *           Proprietary Program of                  *
     *           Research Engineers,  Intl.              *
     *           Date=    MAR 11, 2021                   *
     *           Time=     1:38: 6                       *
     *                                                   *
     *      USER ID: Optimal Engineering Support         *
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     1. STAAD SPACE
INPUT FILE: Panel Check - 5x12 type A (4W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
    39. ISOTROPIC CONCRETE
    40. E 614304
```



```
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 32 PR GY -3.885 0.25 0.5
    54. 33 PR GY -3.885 0.25 0.1667
    55. 34 PR GY -3.885 0.25 -0.1667
    56. 34 PR GY -3.885 0.25 0.5
    57. 66 PR GY -3.885 0.25 0.5
    58. 67 PR GY -3.885 0.25 0.1667
    59. 68 PR GY -3.885 0.25 -0.1667
    60. 68 PR GY -3.885 0.25 0.5
    61. 5 PR GY -3.885 -0.25 0.5
    62. 8 PR GY -3.885 -0.25 0.1667
    63. 11 PR GY -3.885 -0.25 -0.1667
    64. 11 PR GY -3.885 -0.25 0.5
    65. 51 PR GY -3.885 -0.25 0.5
    66. 54 PR GY -3.885 -0.25 0.1667
    67. 57 PR GY -3.885 -0.25 -0.1667
    68. 57 PR GY -3.885 -0.25 0.5
    69. PERFORM ANALYSIS


          P R O B L E M   S T A T I S T I C S
          -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    78/    60/    78

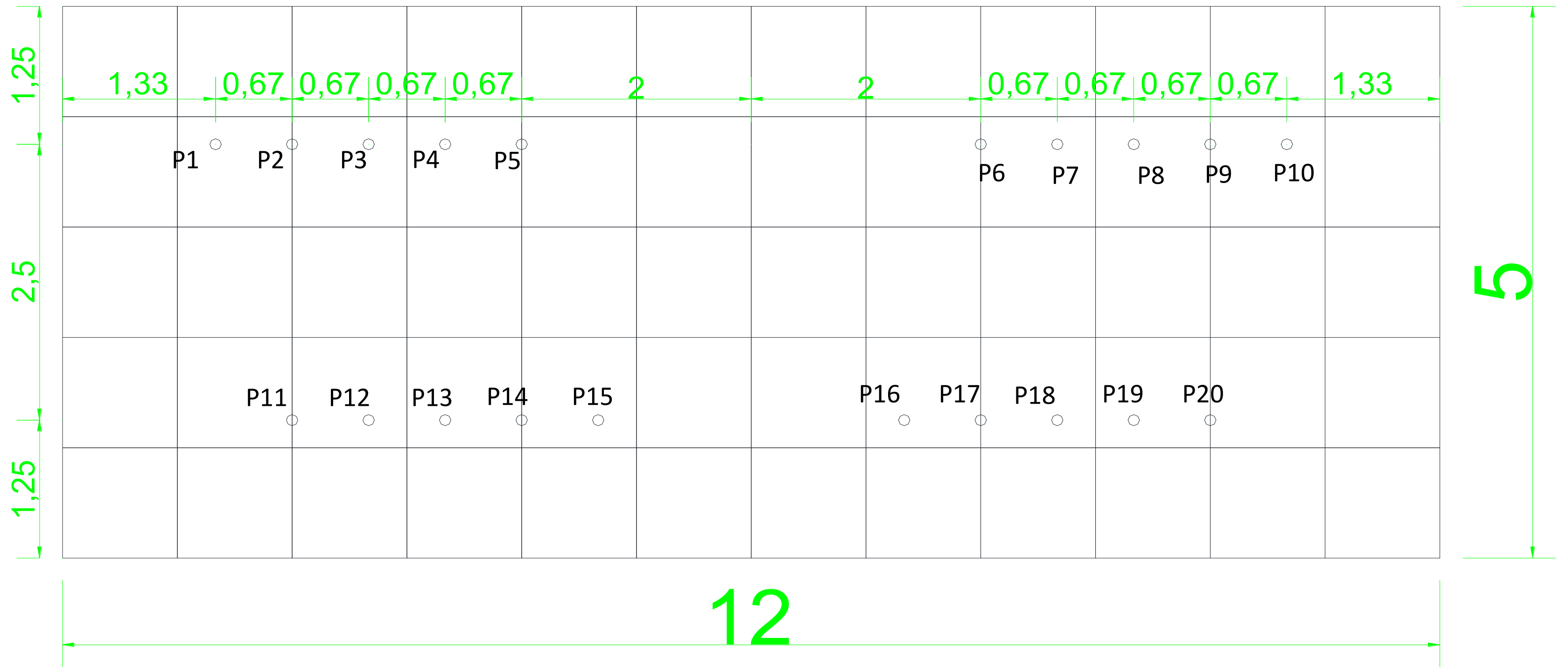
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    39/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =     468
 SIZE OF STIFFNESS MATRIX =        31 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.6/ 263312.2 MB


    70. FINISH
```

Typical Panel Type (mesh 5W11), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.167	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.167	0.25
P5	0.5	0.25
P6	-0.5	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.1667	0.25
P8	-0.167	0.25
P9	-0.5	0.25
P10	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P11	0.5	-0.25
P12	0.1667	-0.25
P13	-0.167	-0.25
P14	0.5	-0.25
P15	0.1667	-0.25
P16	-0.167	-0.25

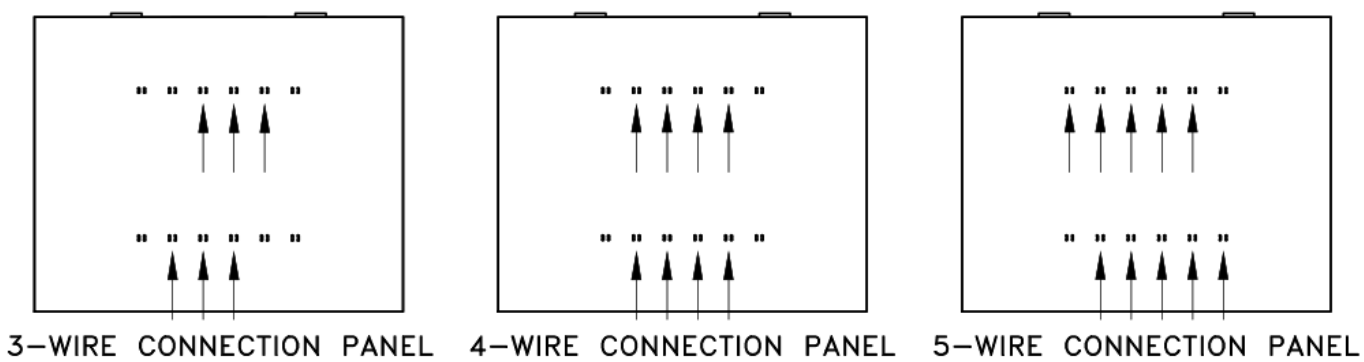
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P17	0	-0.25
P18	0.1667	-0.25
P19	-0.167	-0.25
P20	-0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

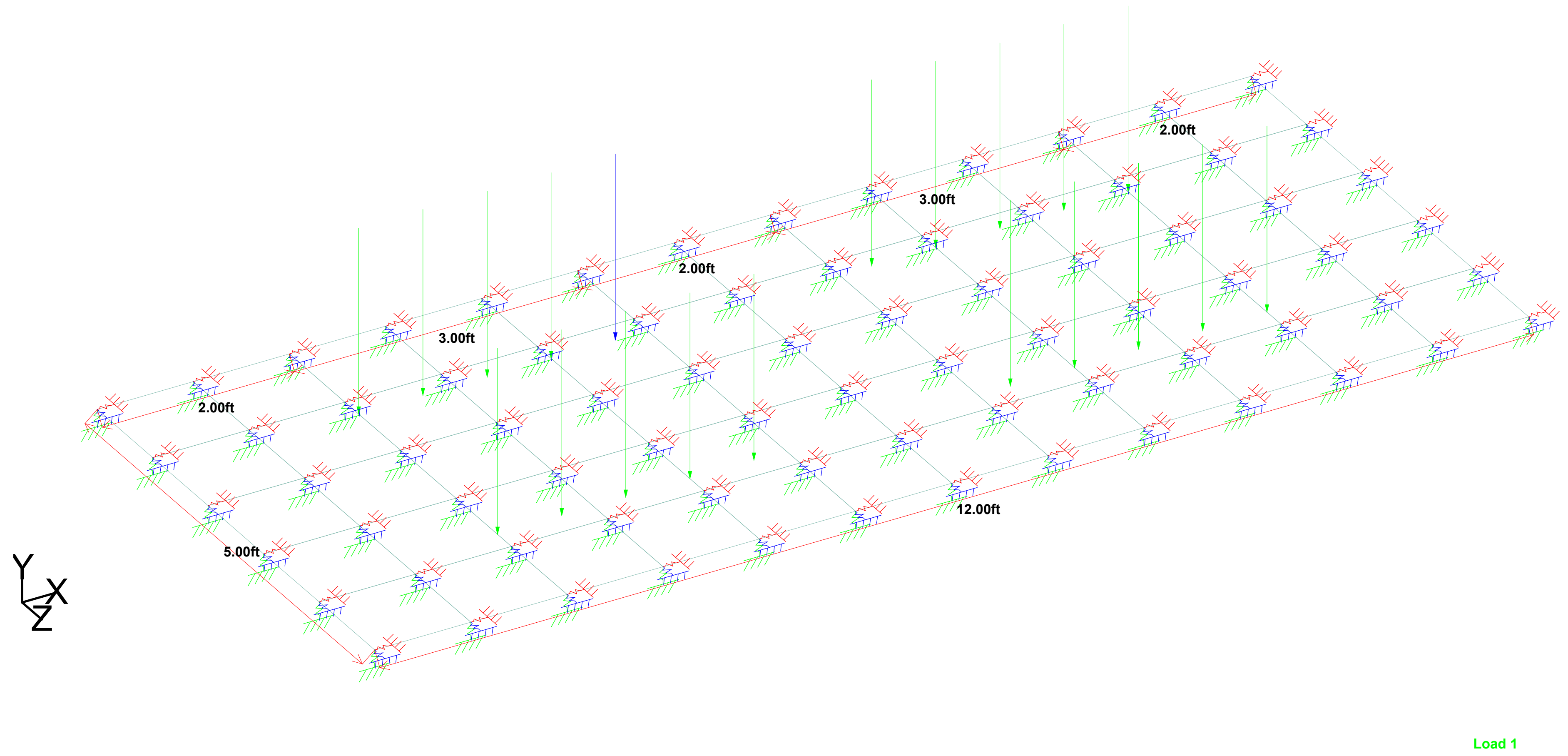
A = 0.0797 in^2
Fy = 75 ksi

P = 0.65 x A x Fy
= 3.885 Kips (per wire point)

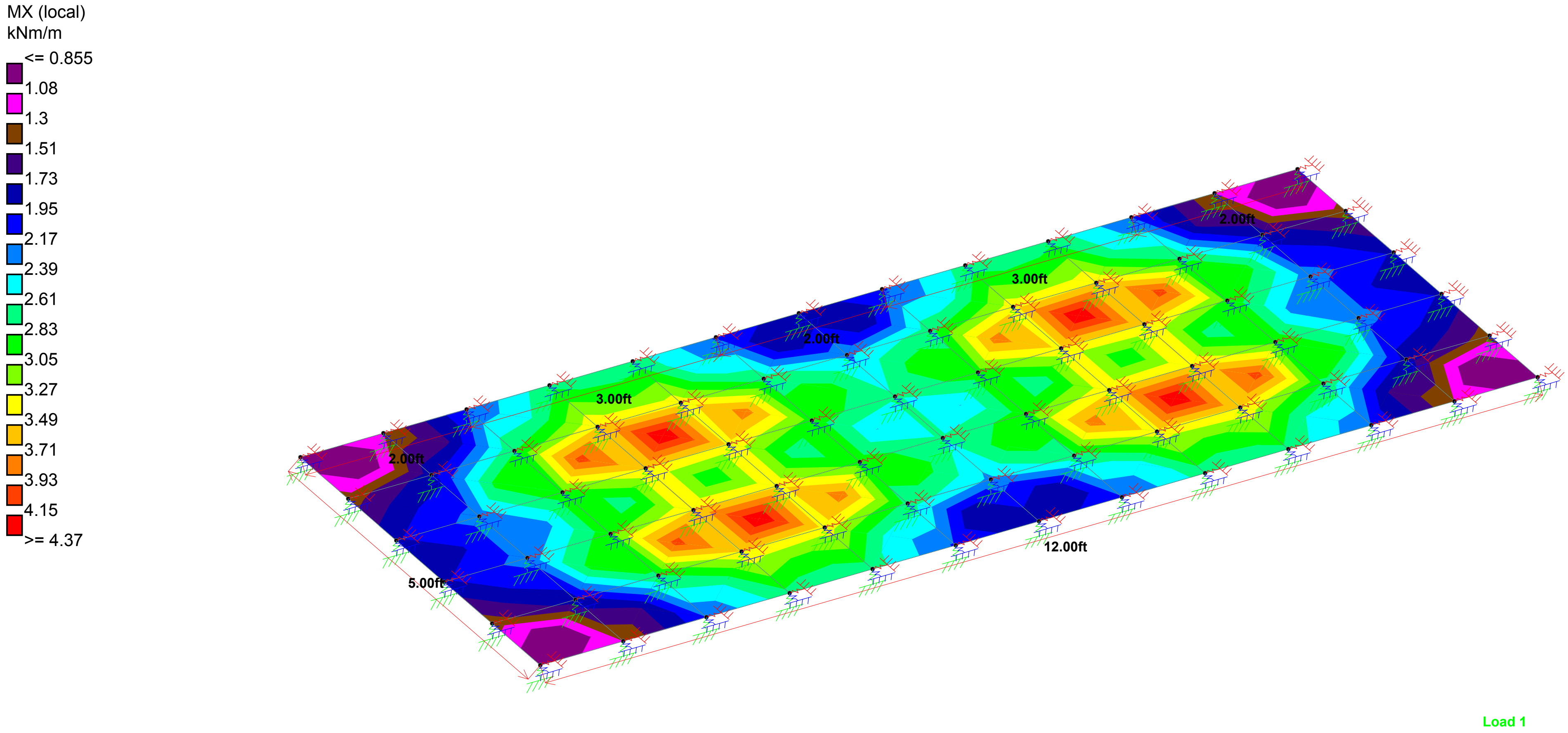


ATTACHMENT BY No. WIRES
(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 10:13	

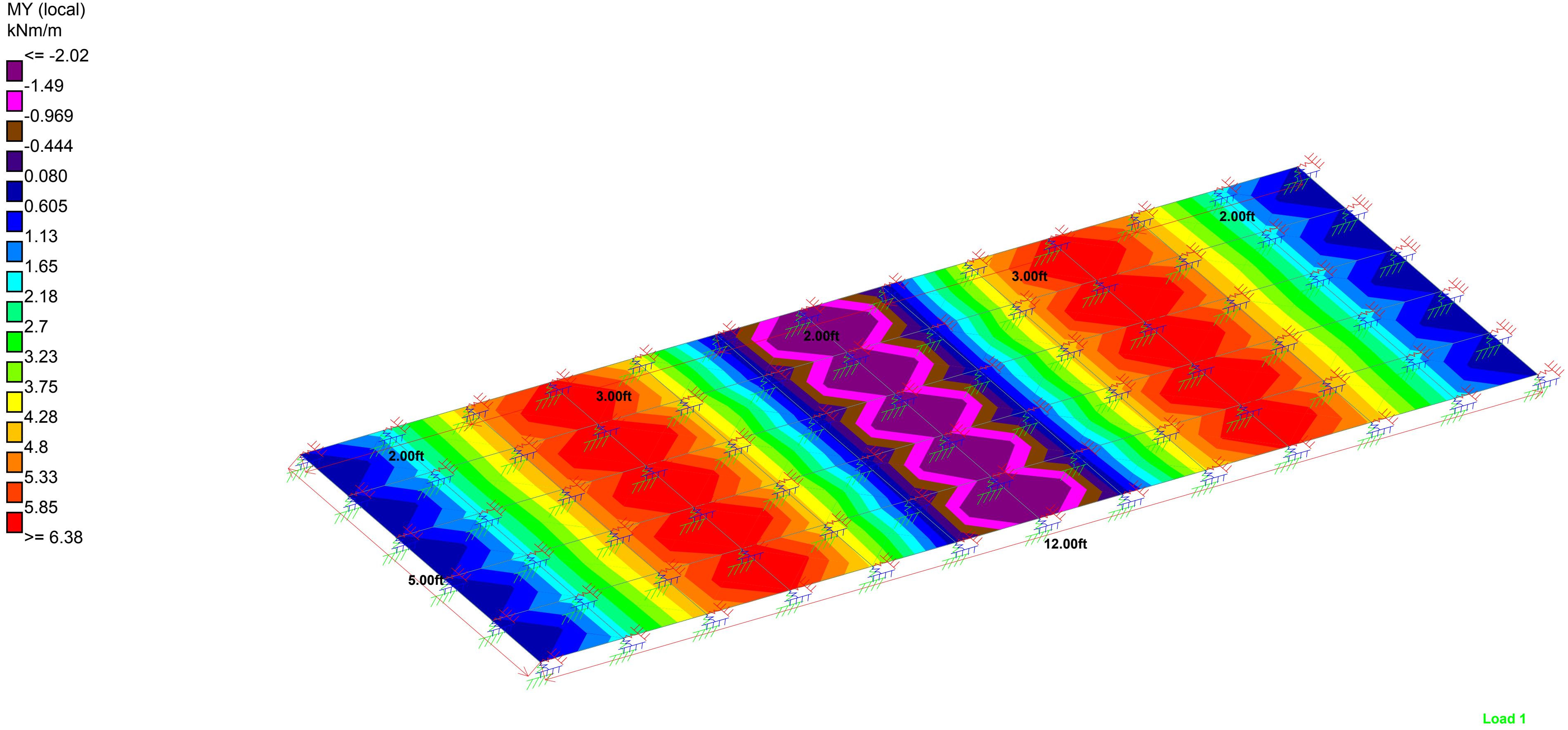


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 10:13	



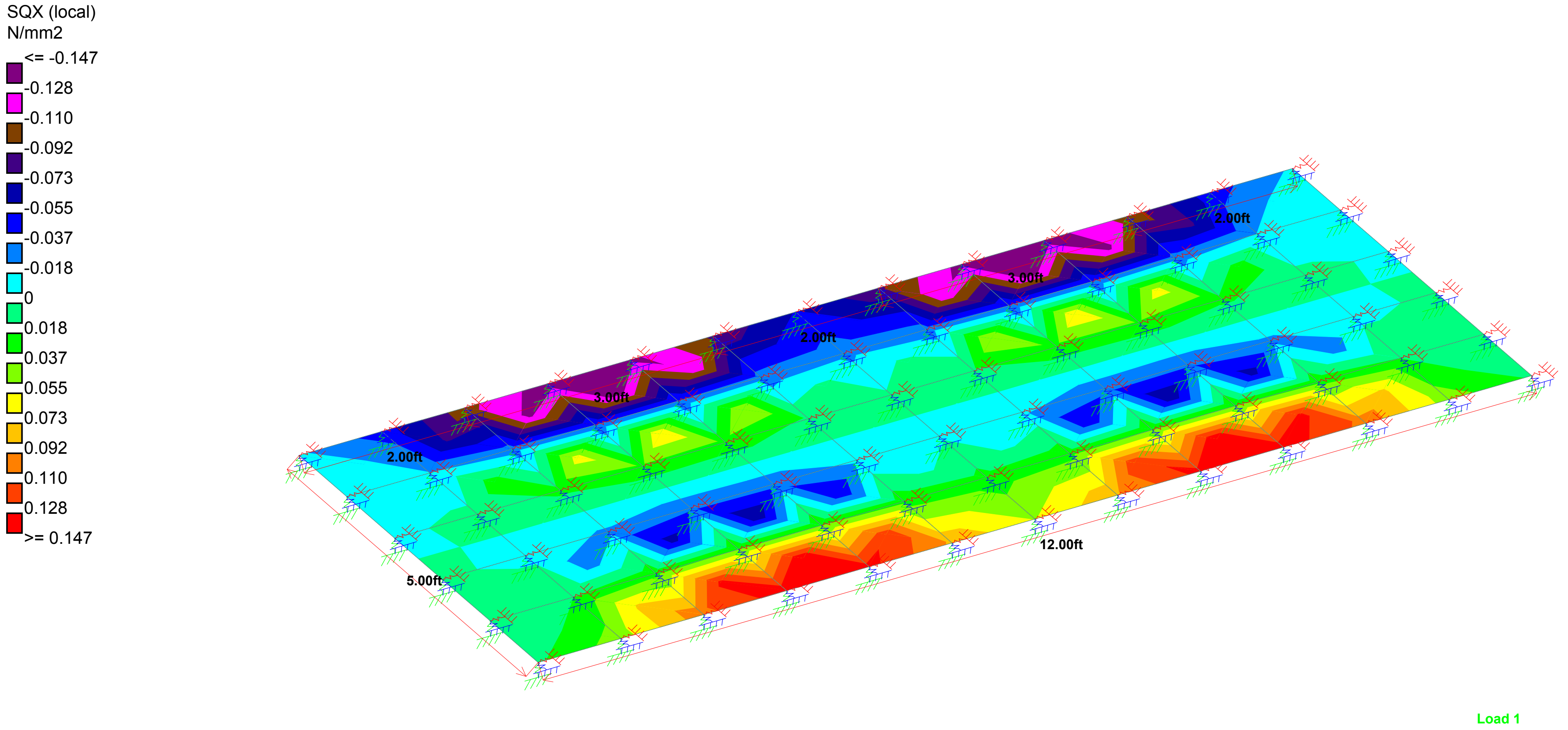
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 10:13	

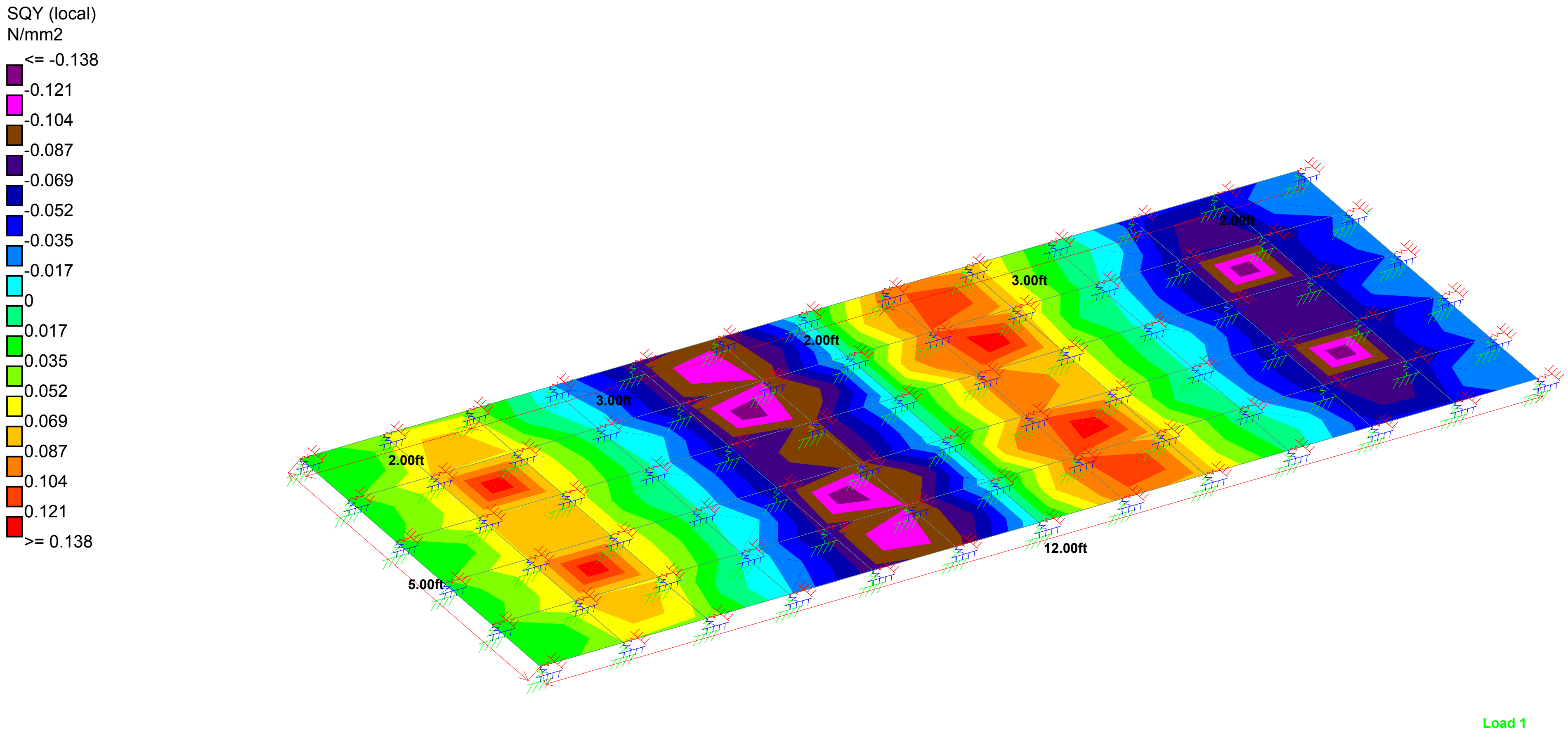


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 10:13	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 10:13	



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*           Proprietary Program of                    *
*           Bentley Systems, Inc.                     *
*           Date=    DEC 30, 2021                     *
*           Time=    10:13:52                         *
*                                                     *
*      USER ID: Optimal Engineering Support           *
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     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
```



```
    39. ISOTROPIC CONCRETE
    40. E 614304
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 35 PR GY -3.885 0.25 0.1667
    54. 32 PR GY -3.885 0.25 0.5
    55. 33 PR GY -3.885 0.25 0.1667
    56. 34 PR GY -3.885 0.25 -0.1667
    57. 34 PR GY -3.885 0.25 0.5
    58. 66 PR GY -3.885 0.25 0.5
    59. 67 PR GY -3.885 0.25 0.1667
    60. 68 PR GY -3.885 0.25 -0.1667
    61. 68 PR GY -3.885 0.25 0.5
    62. 66 PR GY -3.885 0.25 -0.1667
    63. 5 PR GY -3.885 -0.25 0.5
    64. 8 PR GY -3.885 -0.25 0.1667
    65. 11 PR GY -3.885 -0.25 -0.1667
    66. 11 PR GY -3.885 -0.25 0.5
    67. 14 PR GY -3.885 -0.25 0.1667
    68. 51 PR GY -3.885 -0.25 -0.1667
    69. 51 PR GY -3.885 -0.25 0.5
    70. 54 PR GY -3.885 -0.25 0.1667
    71. 57 PR GY -3.885 -0.25 -0.1667
    72. 57 PR GY -3.885 -0.25 0.5
    73. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

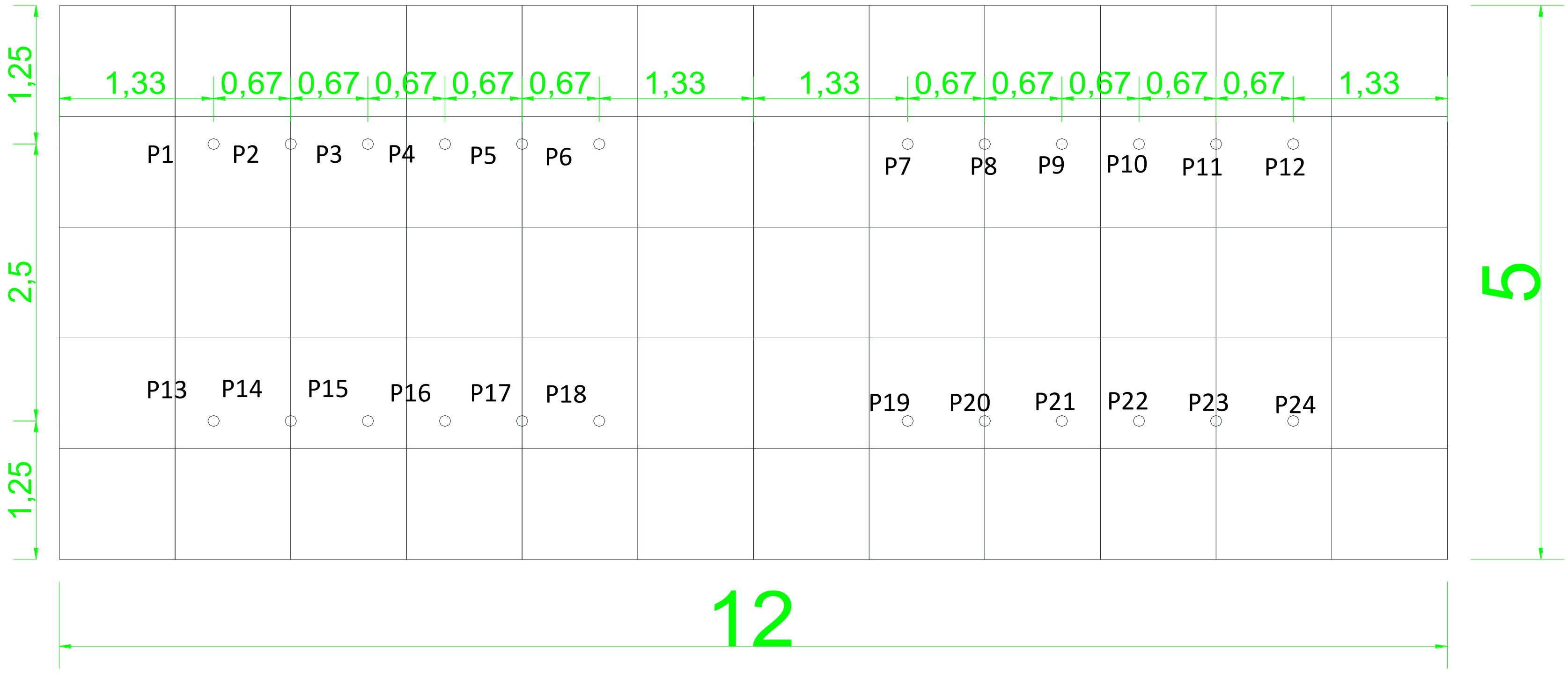
NUMBER OF JOINTS	**78**	**NUMBER OF MEMBERS**	**0**
NUMBER OF PLATES	**60**	**NUMBER OF SOLIDS**	**0**
NUMBER OF SURFACES	**0**	**NUMBER OF SUPPORTS**	**78**

SOLVER USED IS THE IN-CORE ADVANCED MATH SOLVER

TOTAL PRIMARY LOAD CASES = 1, TOTAL DEGREES OF FREEDOM = 468
TOTAL LOAD COMBINATION CASES = 0 SO FAR.

Typical Panel Type (mesh 6W11), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.167	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.167	0.25
P5	0.5	0.25
P6	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.167	0.25
P8	0.5	0.25
P9	0.1667	0.25
P10	-0.167	0.25
P11	0.5	0.25
P12	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P13	-0.167	-0.25
P14	0.5	-0.25
P15	0.1667	-0.25
P16	-0.167	-0.25
P17	0.5	-0.25
P18	0.1667	-0.25

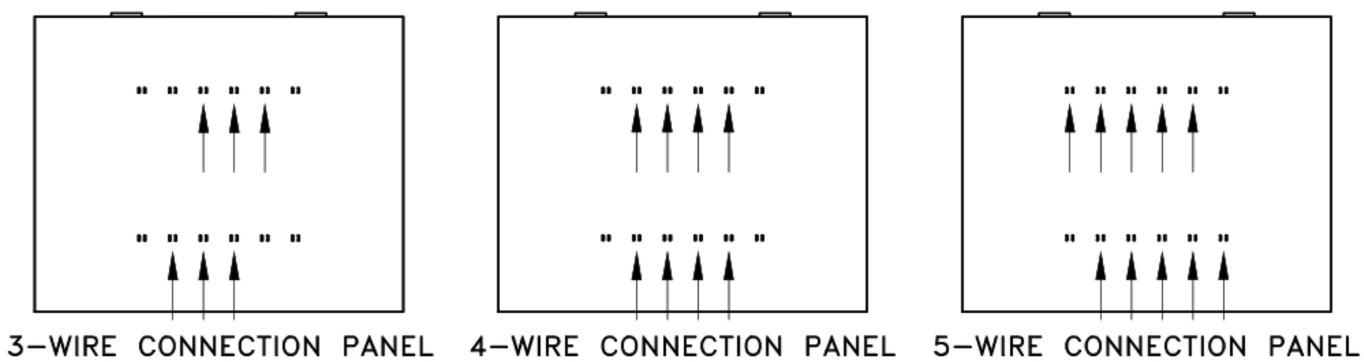
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P19	-0.167	-0.25
P20	0.5	-0.25
P21	0.1667	-0.25
P22	-0.167	-0.25
P23	0.5	-0.25
P24	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

A = 0.0797 in^2
Fy = 75 ksi

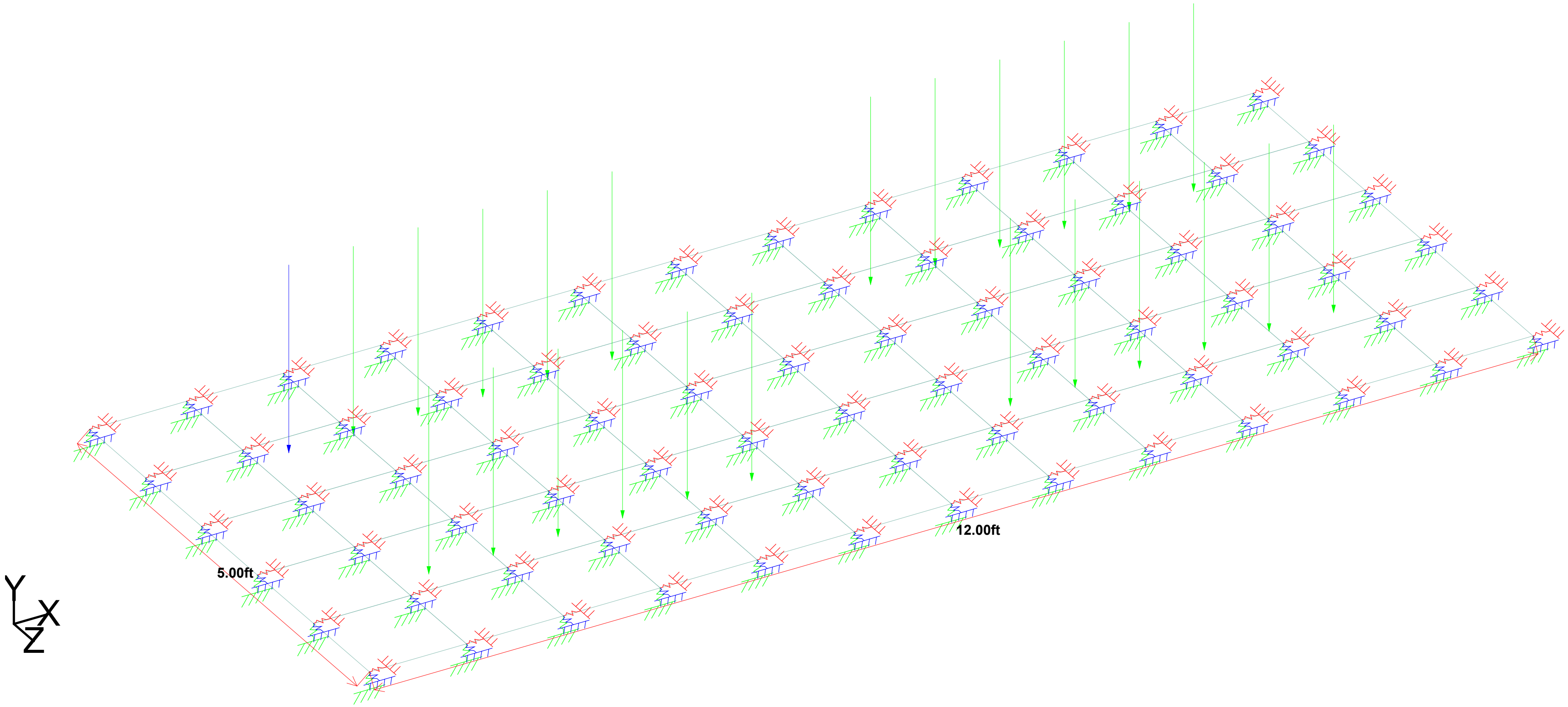
P = 0.65 x A x Fy
= 3.885 Kips (per wire point)



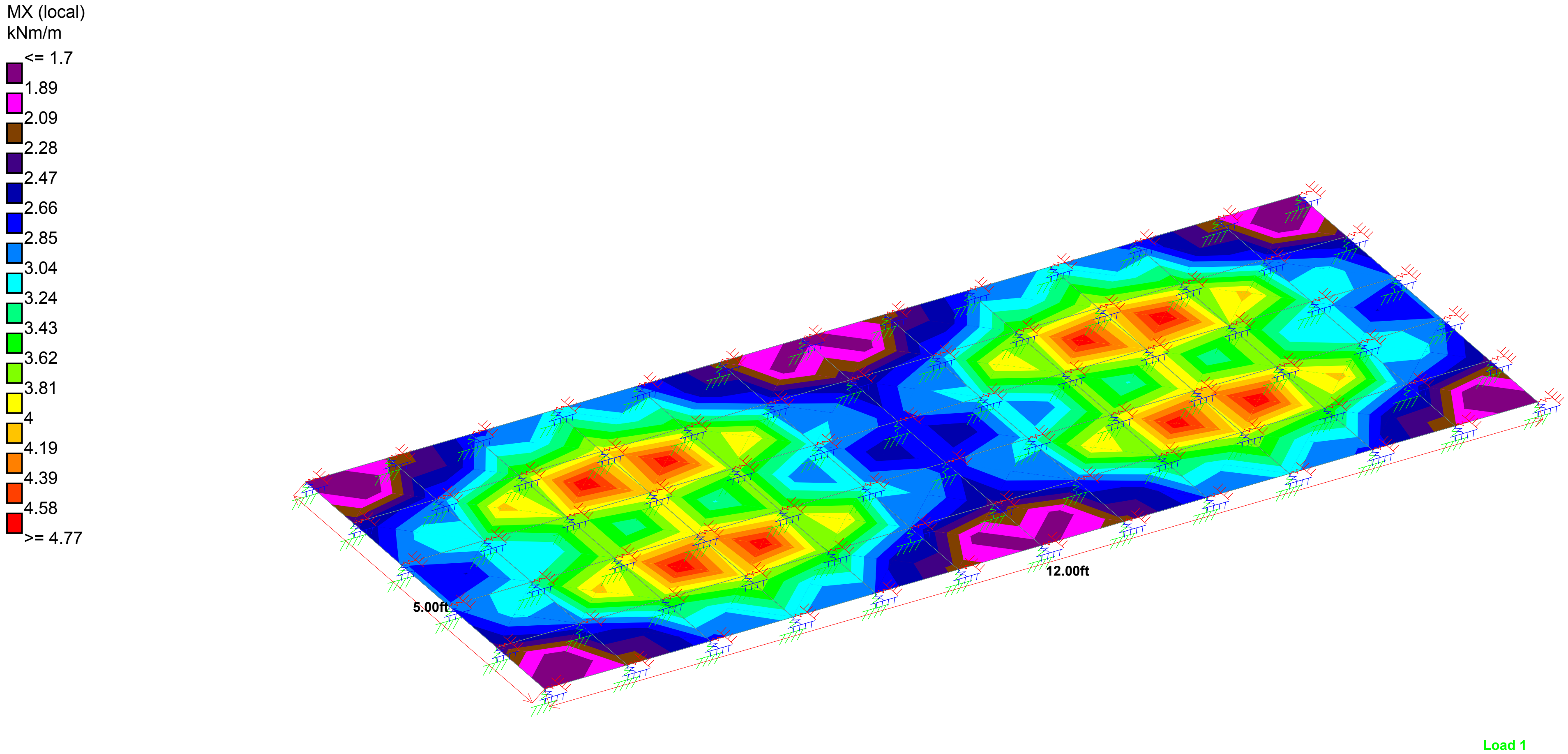
ATTACHMENT BY No. WIRES
(STANDARD PANELS ONLY)

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:11	

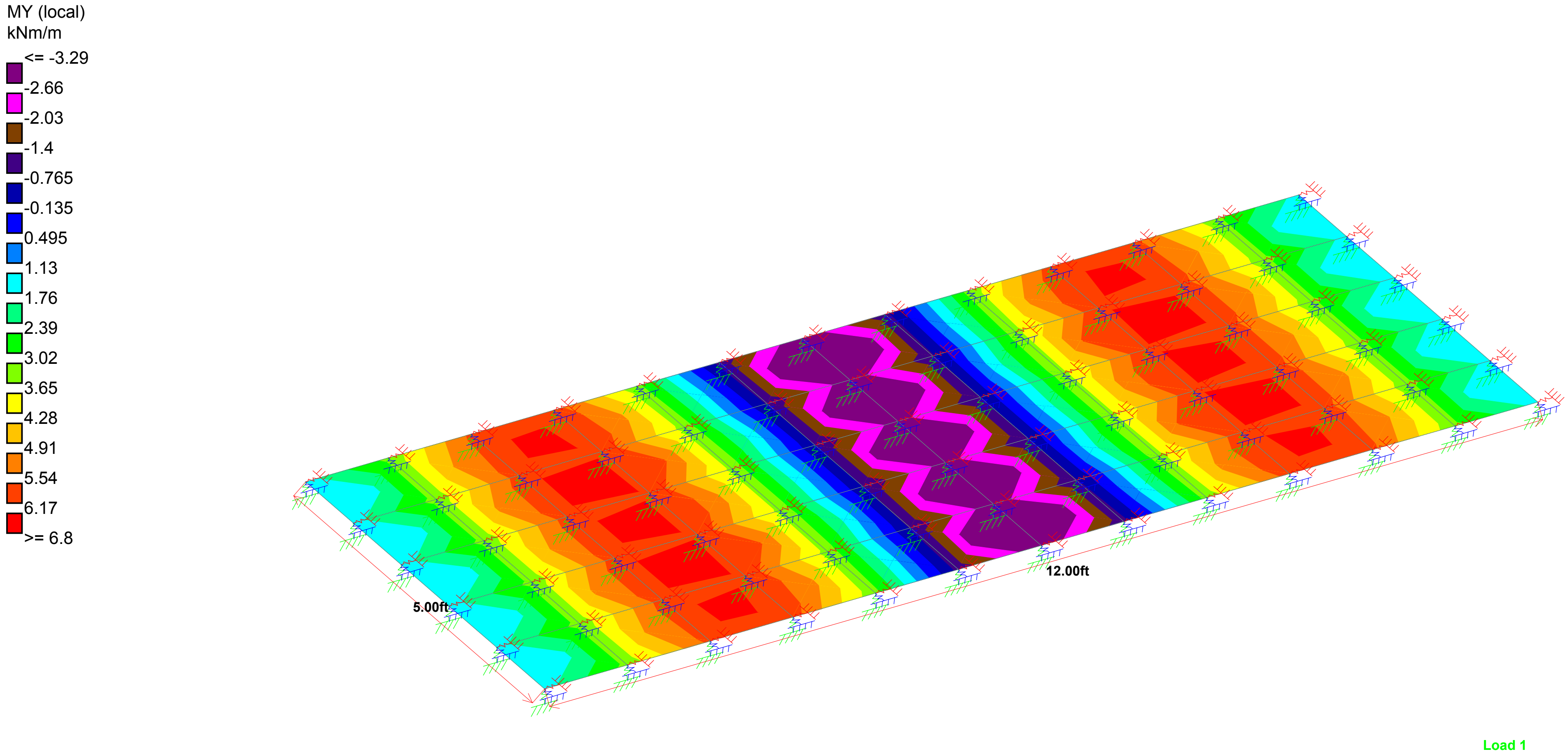


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:11	



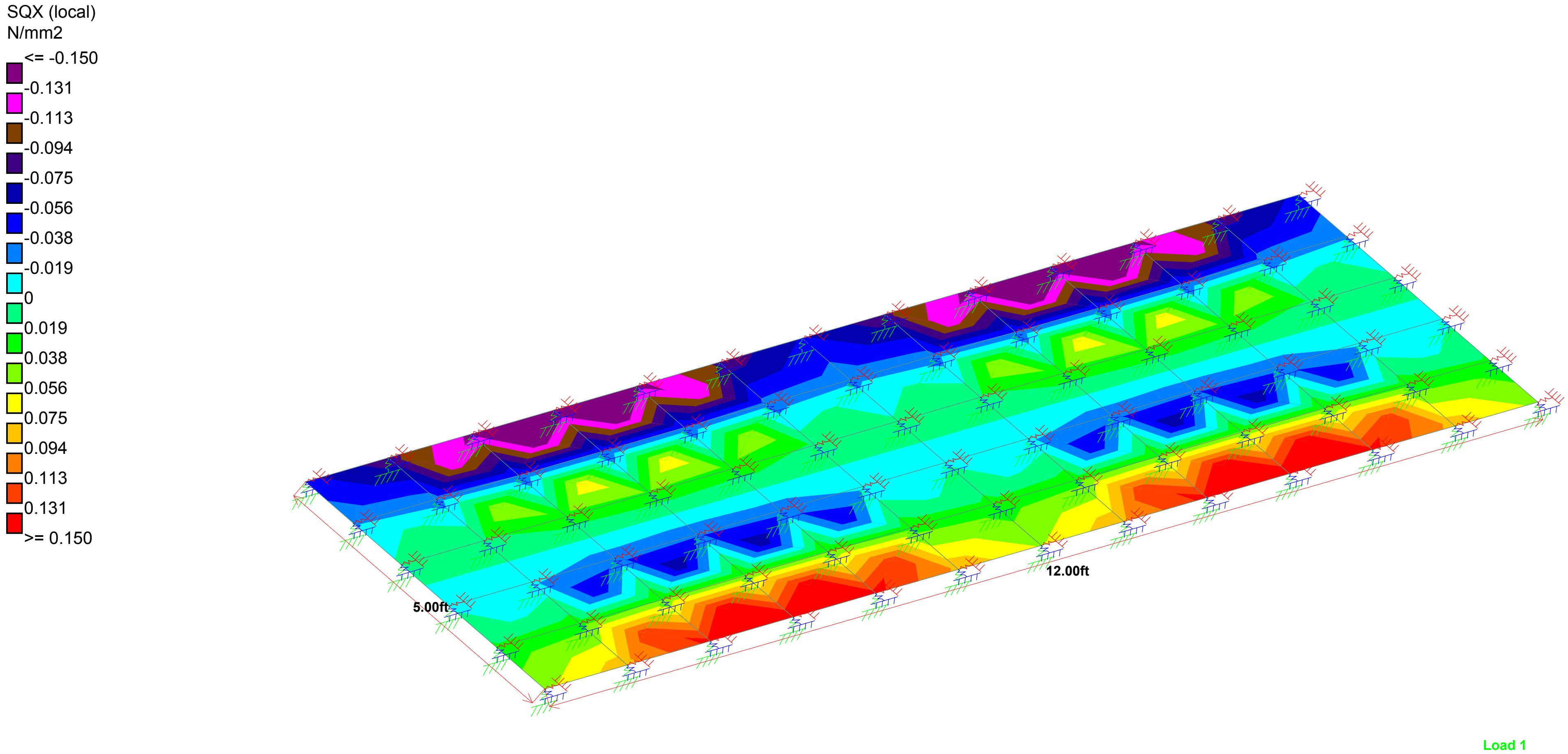
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:11	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:11	

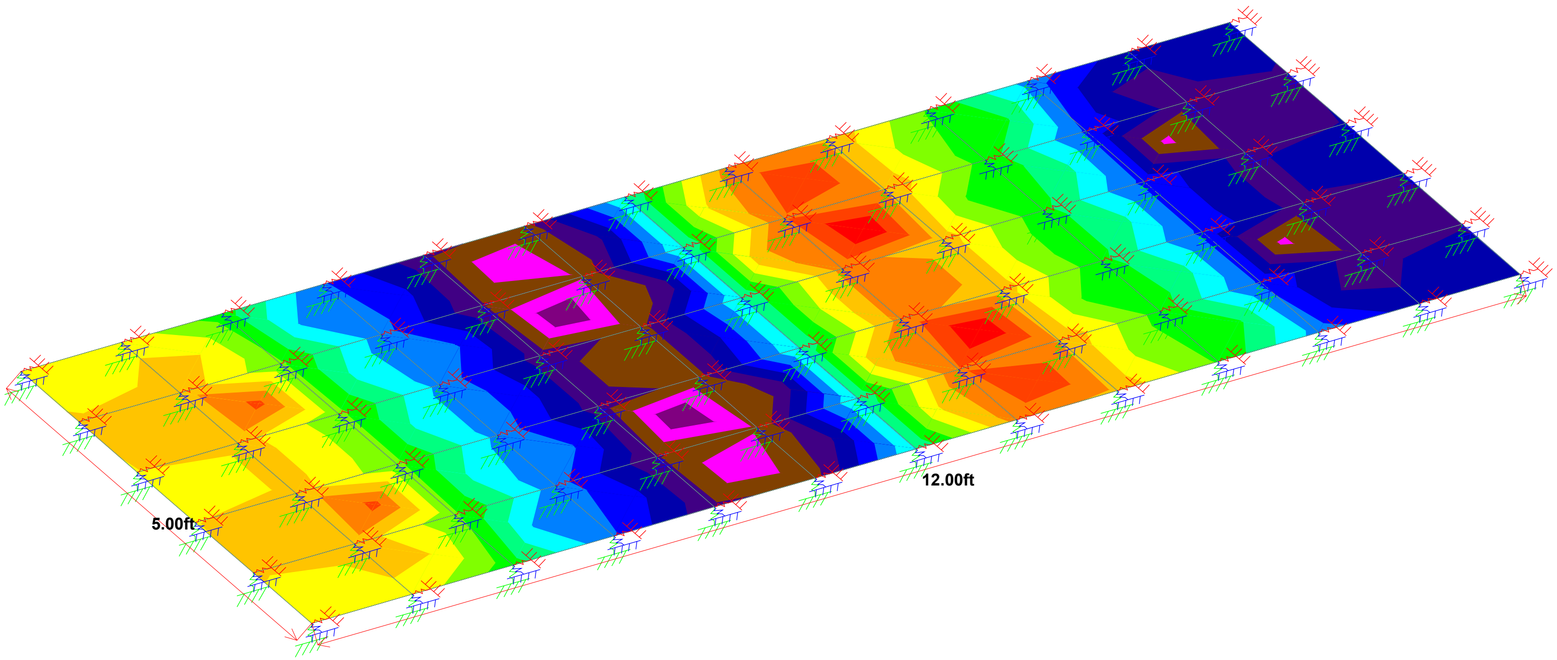


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 01:11	

SQY (local)
N/mm2

<= -0.143
-0.125
-0.107
-0.089
-0.072
-0.054
-0.036
-0.018
0
0.018
0.036
0.054
0.072
0.089
0.107
0.125
>= 0.143



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     *           Version  2007    Build 04              *
     *           Proprietary Program of                 *
     *           Research Engineers,  Intl.             *
     *           Date=    MAR 11, 2021                  *
     *           Time=     2: 5: 1                      *
     *                                                  *
     *      USER ID: Optimal Engineering Support        *
     ****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x12 type A (6W11).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
    39. ISOTROPIC CONCRETE
    40. E 614304
```



```
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 32 PR GY -3.885 0.25 -0.1667
    54. 32 PR GY -3.885 0.25 0.5
    55. 33 PR GY -3.885 0.25 0.1667
    56. 34 PR GY -3.885 0.25 -0.1667
    57. 34 PR GY -3.885 0.25 0.5
    58. 35 PR GY -3.885 0.25 0.1667
    59. 66 PR GY -3.885 0.25 -0.1667
    60. 66 PR GY -3.885 0.25 0.5
    61. 67 PR GY -3.885 0.25 0.1667
    62. 68 PR GY -3.885 0.25 -0.1667
    63. 68 PR GY -3.885 0.25 0.5
    64. 69 PR GY -3.885 0.25 0.1667
    65. 5 PR GY -3.885 -0.25 -0.1667
    66. 5 PR GY -3.885 -0.25 0.5
    67. 8 PR GY -3.885 -0.25 0.1667
    68. 11 PR GY -3.885 -0.25 -0.1667
    69. 11 PR GY -3.885 -0.25 0.5
    70. 14 PR GY -3.885 -0.25 0.1667
    71. 51 PR GY -3.885 -0.25 -0.1667
    72. 51 PR GY -3.885 -0.25 0.5
    73. 54 PR GY -3.885 -0.25 0.1667
    74. 57 PR GY -3.885 -0.25 -0.1667
    75. 57 PR GY -3.885 -0.25 0.5
    76. 60 PR GY -3.885 -0.25 0.1667
    77. PERFORM ANALYSIS
```

```
          P R O B L E M   S T A T I S T I C S
          -----------------------------------

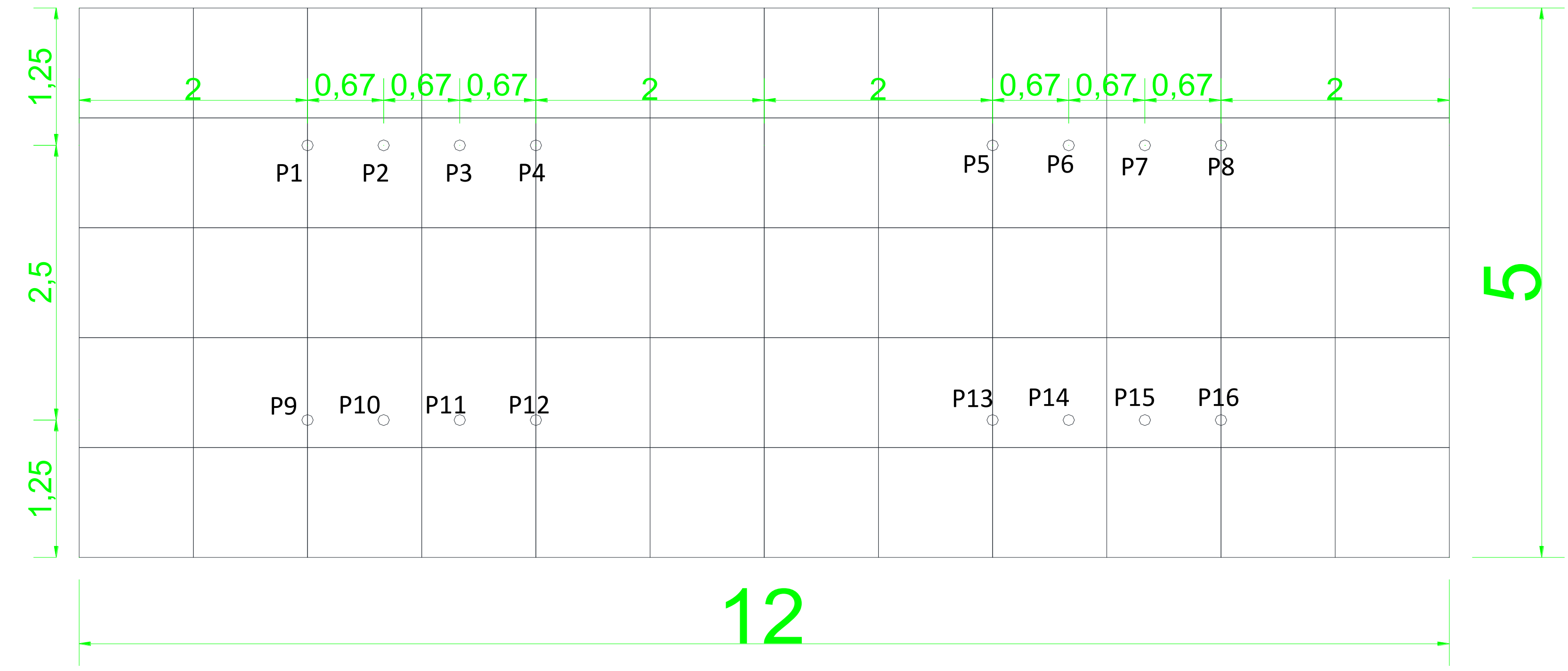
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     78/    60/    78

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    39/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =     468
 SIZE OF STIFFNESS MATRIX =       31 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.6/ 263308.8 MB
```

Typical Panel Type (mesh 4W20), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	0.5	0.25
P2	0.1667	0.25
P3	-0.167	0.25
P4	-0.5	0.25
P5	0.5	0.25
P6	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.167	0.25
P8	-0.5	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P9	0.5	-0.25
P10	0.1667	-0.25
P11	-0.167	-0.25
P12	-0.5	-0.25
P13	0.5	-0.25
P14	0.1667	-0.25

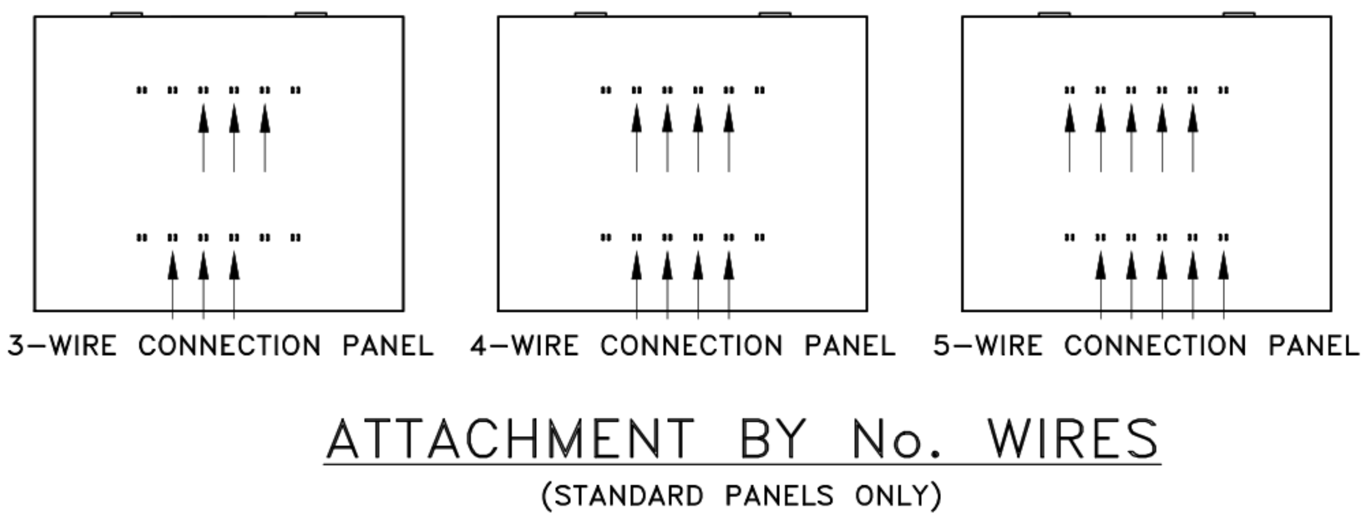
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P15	-0.167	-0.25
P16	-0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

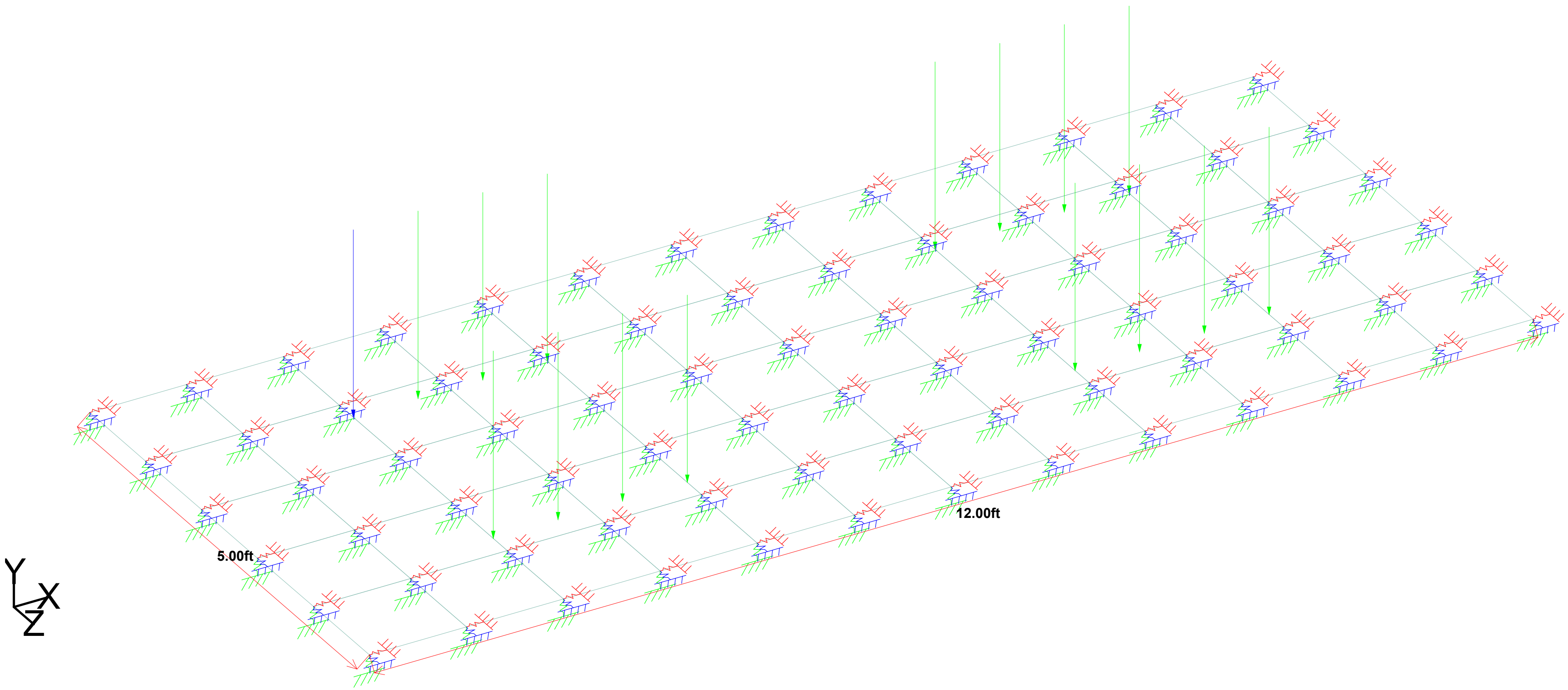
Bar Mat Used:
W11 - 75 Years

A = 0.1583 in^2
Fy = 75 ksi

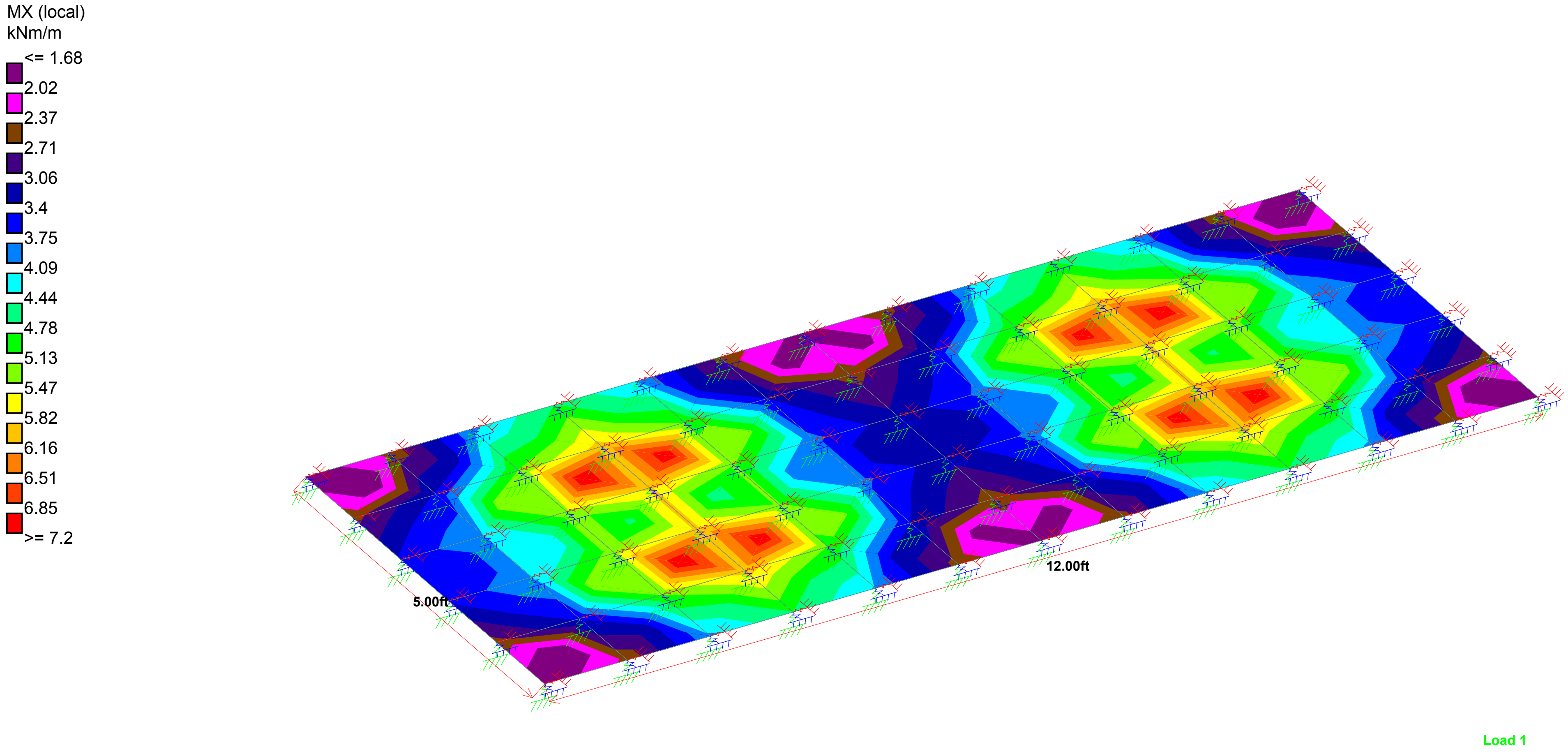
P = 0.65 x A x Fy
= 7.717 Kips (per wire point)



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 02:18	

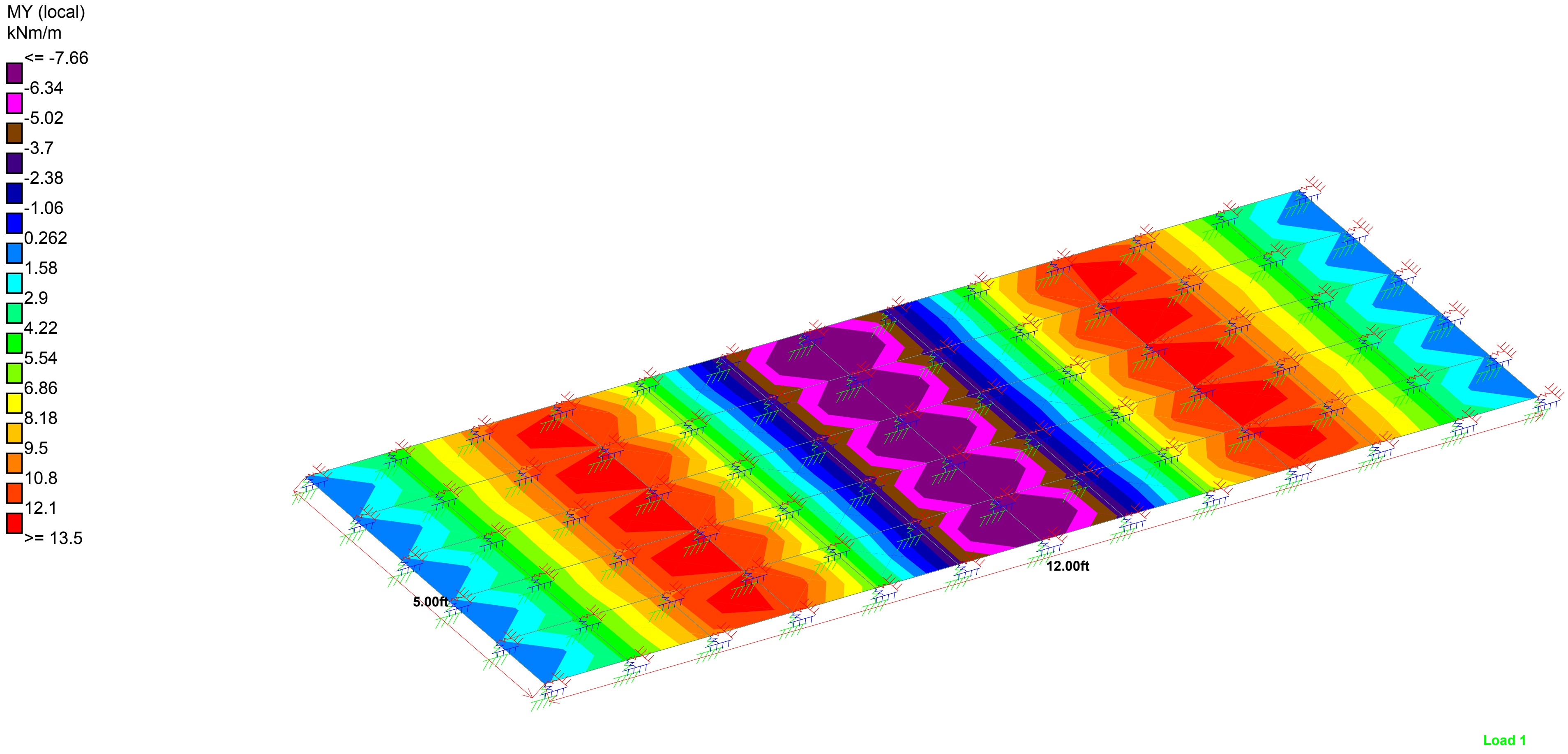


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 02:18	

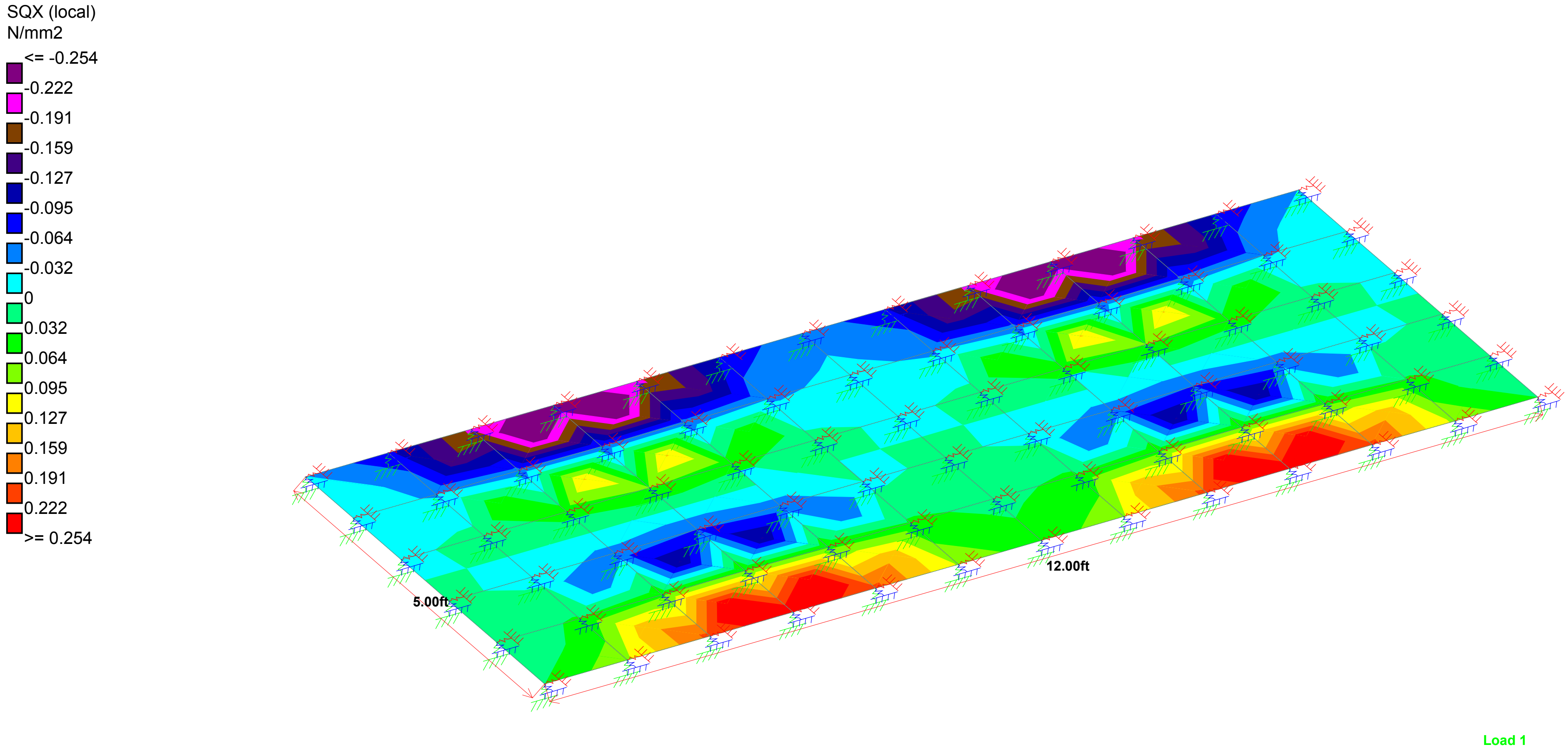


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 02:18	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 02:18	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
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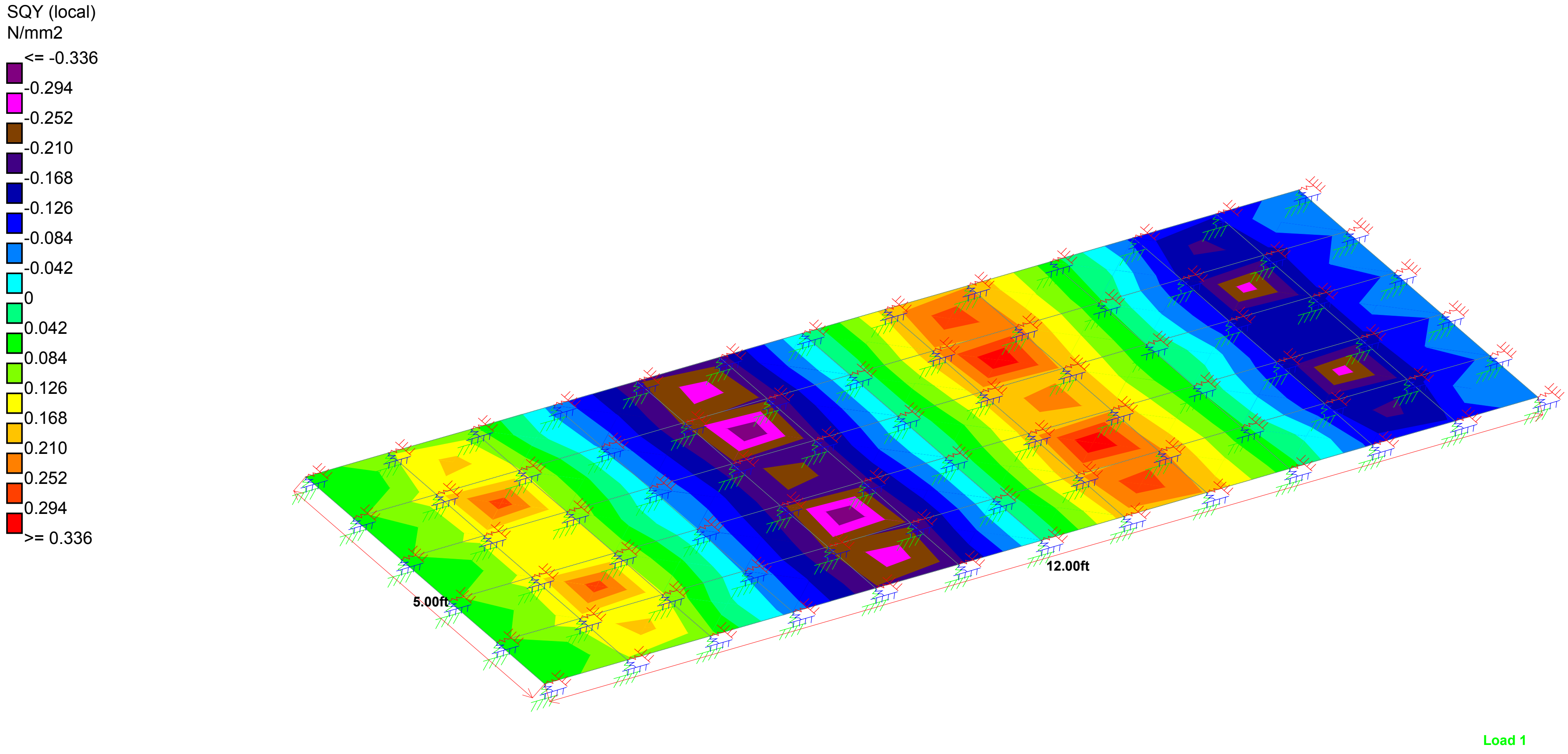
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 02:18	



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 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR 11, 2021                  *
 *           Time=     2:19:18                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
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```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x12 type A (4W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
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    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
    39. ISOTROPIC CONCRETE
    40. E 614304
```



```
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 32 PR GY -7.717 0.25 0.5
    54. 33 PR GY -7.717 0.25 0.1667
    55. 34 PR GY -7.717 0.25 -0.1667
    56. 34 PR GY -7.717 0.25 0.5
    57. 66 PR GY -7.717 0.25 0.5
    58. 67 PR GY -7.717 0.25 0.1667
    59. 68 PR GY -7.717 0.25 -0.1667
    60. 68 PR GY -7.717 0.25 0.5
    61. 5 PR GY -7.717 -0.25 0.5
    62. 8 PR GY -7.717 -0.25 0.1667
    63. 11 PR GY -7.717 -0.25 -0.1667
    64. 11 PR GY -7.717 -0.25 0.5
    65. 51 PR GY -7.717 -0.25 0.5
    66. 54 PR GY -7.717 -0.25 0.1667
    67. 57 PR GY -7.717 -0.25 -0.1667
    68. 57 PR GY -7.717 -0.25 0.5
    69. PERFORM ANALYSIS
```

```
        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     78/    60/    78

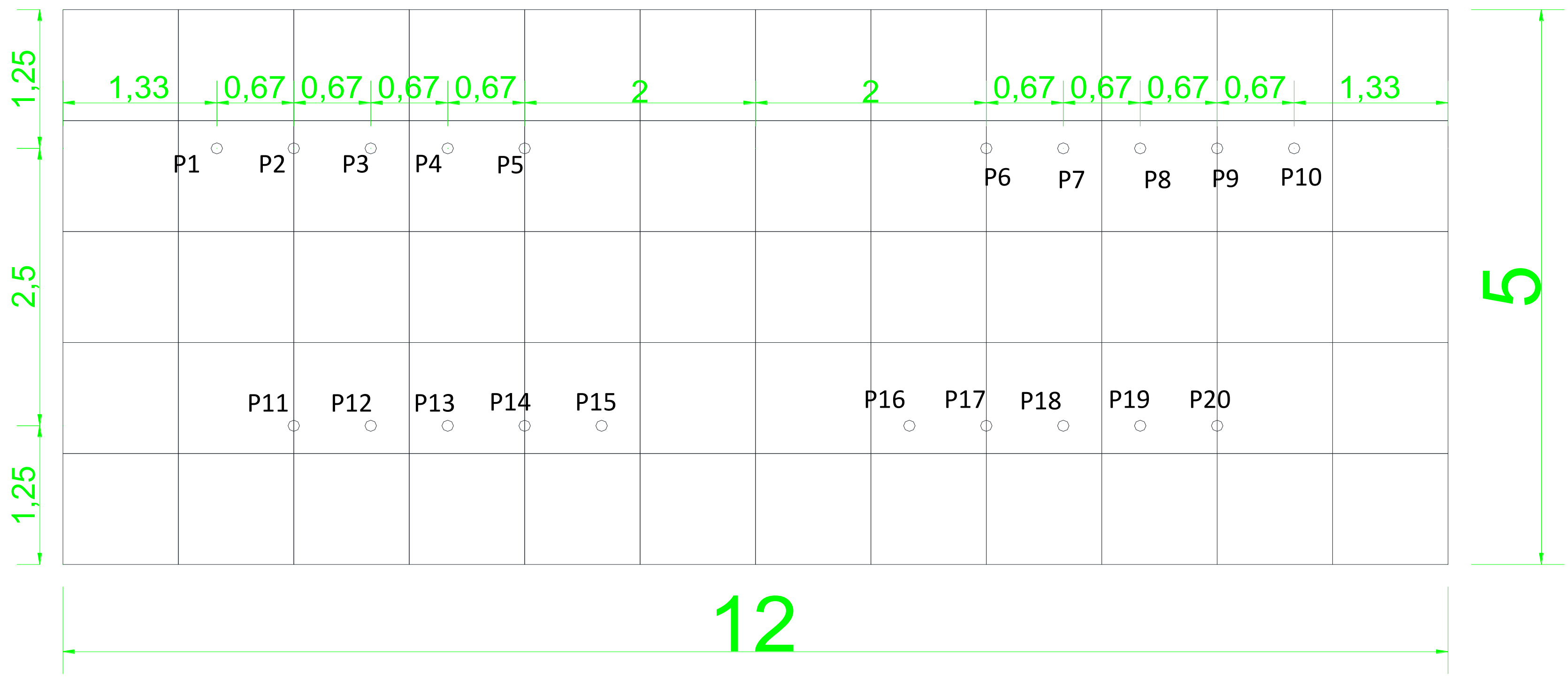
       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    39/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =     468
 SIZE OF STIFFNESS MATRIX =       31 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.6/ 263306.6 MB
```

```
    70. FINISH
```

Typical Panel Type (mesh 5W20), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.167	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.167	0.25
P5	0.5	0.25
P6	-0.5	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.1667	0.25
P8	-0.167	0.25
P9	-0.5	0.25
P10	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P11	0.5	-0.25
P12	0.1667	-0.25
P13	-0.167	-0.25
P14	0.5	-0.25
P15	0.1667	-0.25
P16	-0.167	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P17	0	-0.25
P18	0.1667	-0.25
P19	-0.167	-0.25
P20	-0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:

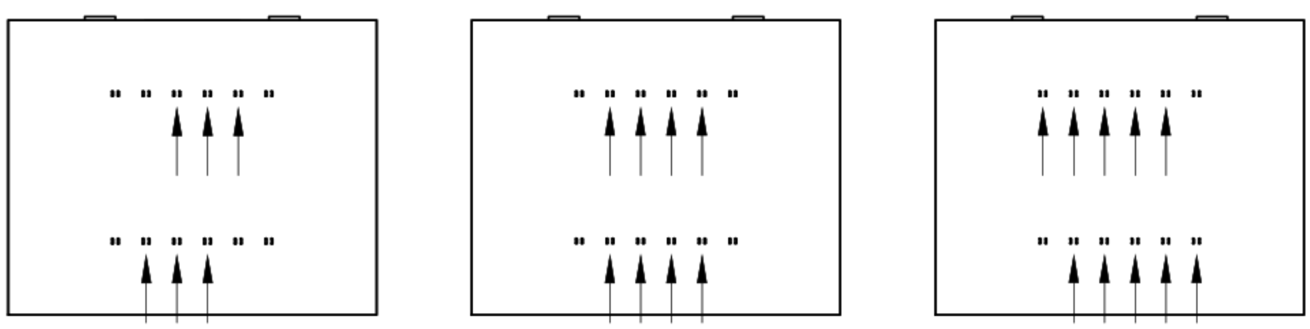
W11 - 75 Years

A = 0.1583 in^2

Fy = 75 ksi

P = 0.65 x A x Fy

= 7.717 Kips (per wire point)

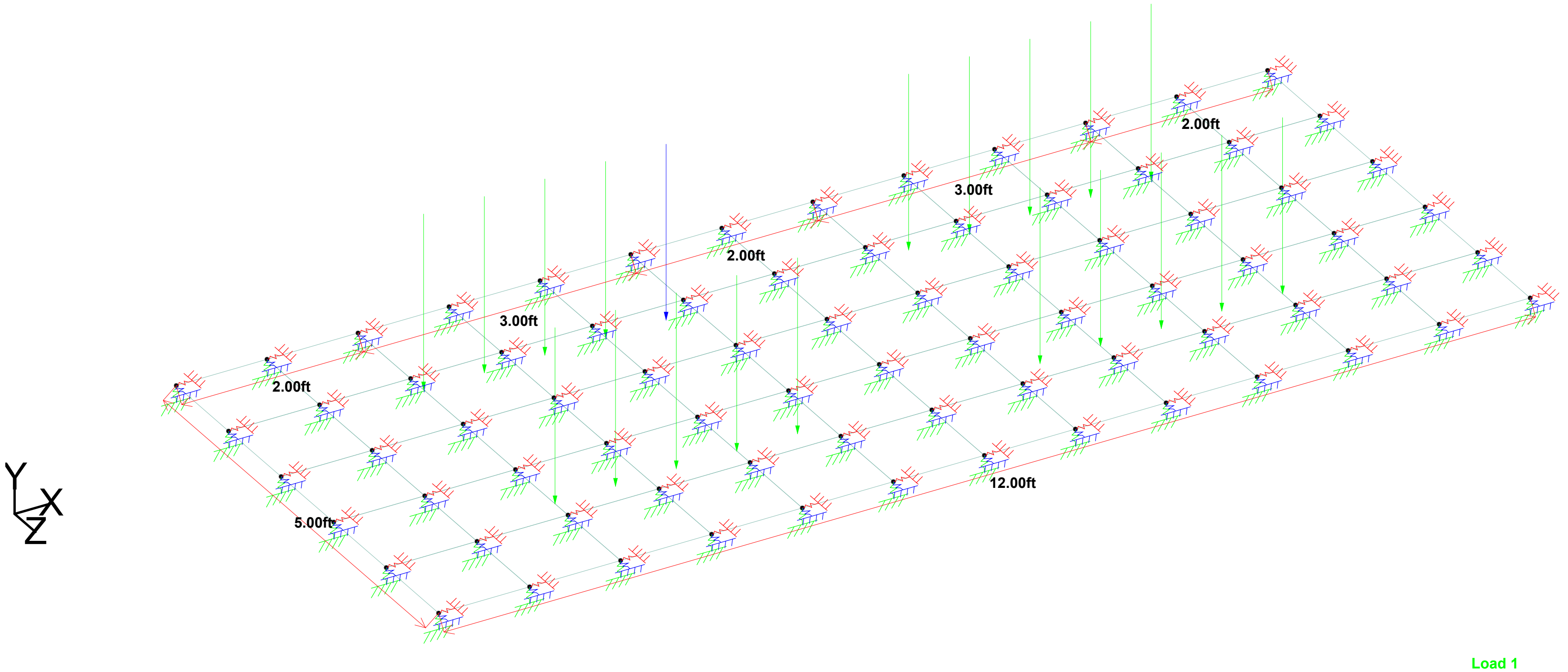


3–WIRE CONNECTION PANEL 4–WIRE CONNECTION PANEL 5–WIRE CONNECTION PANEL

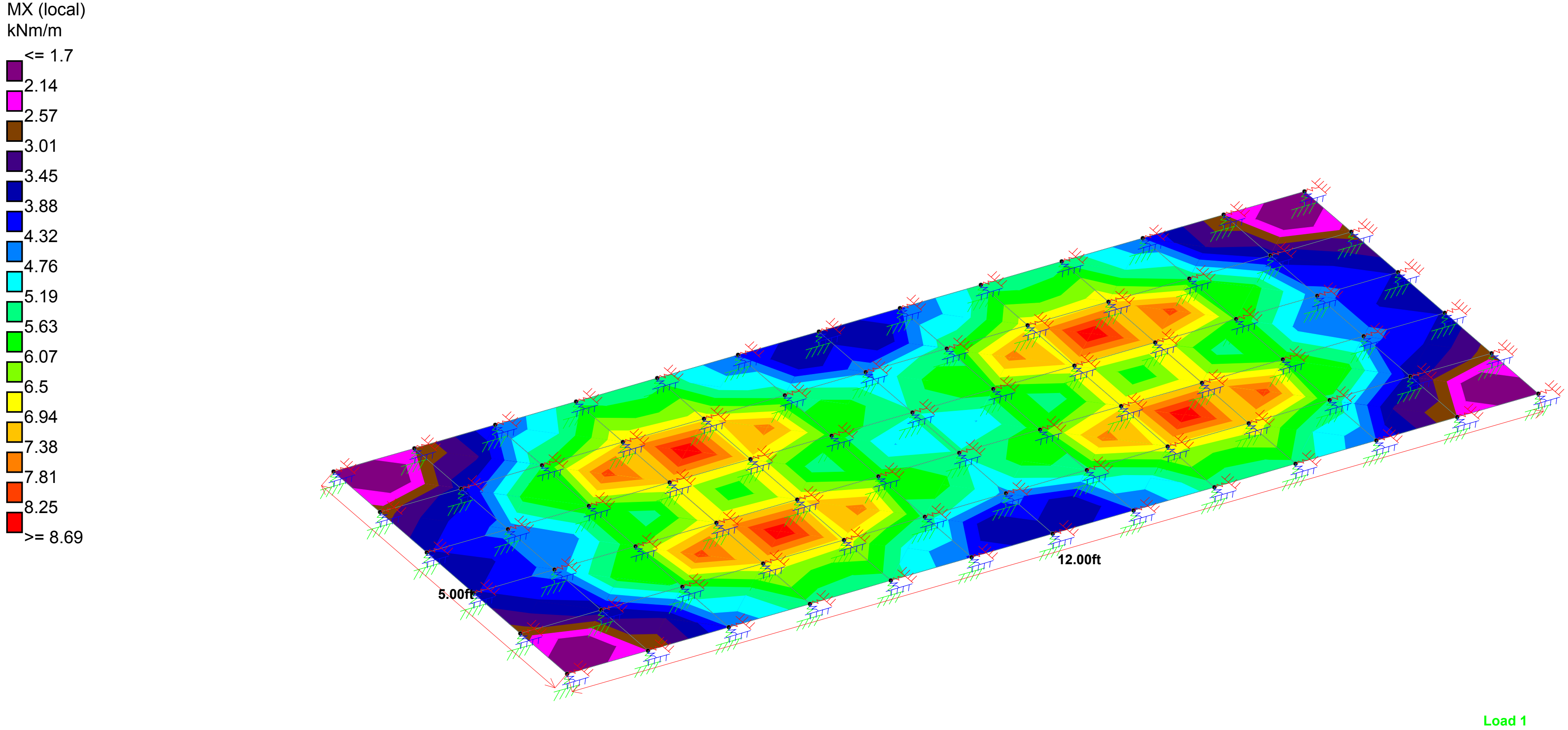
ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 00:57	

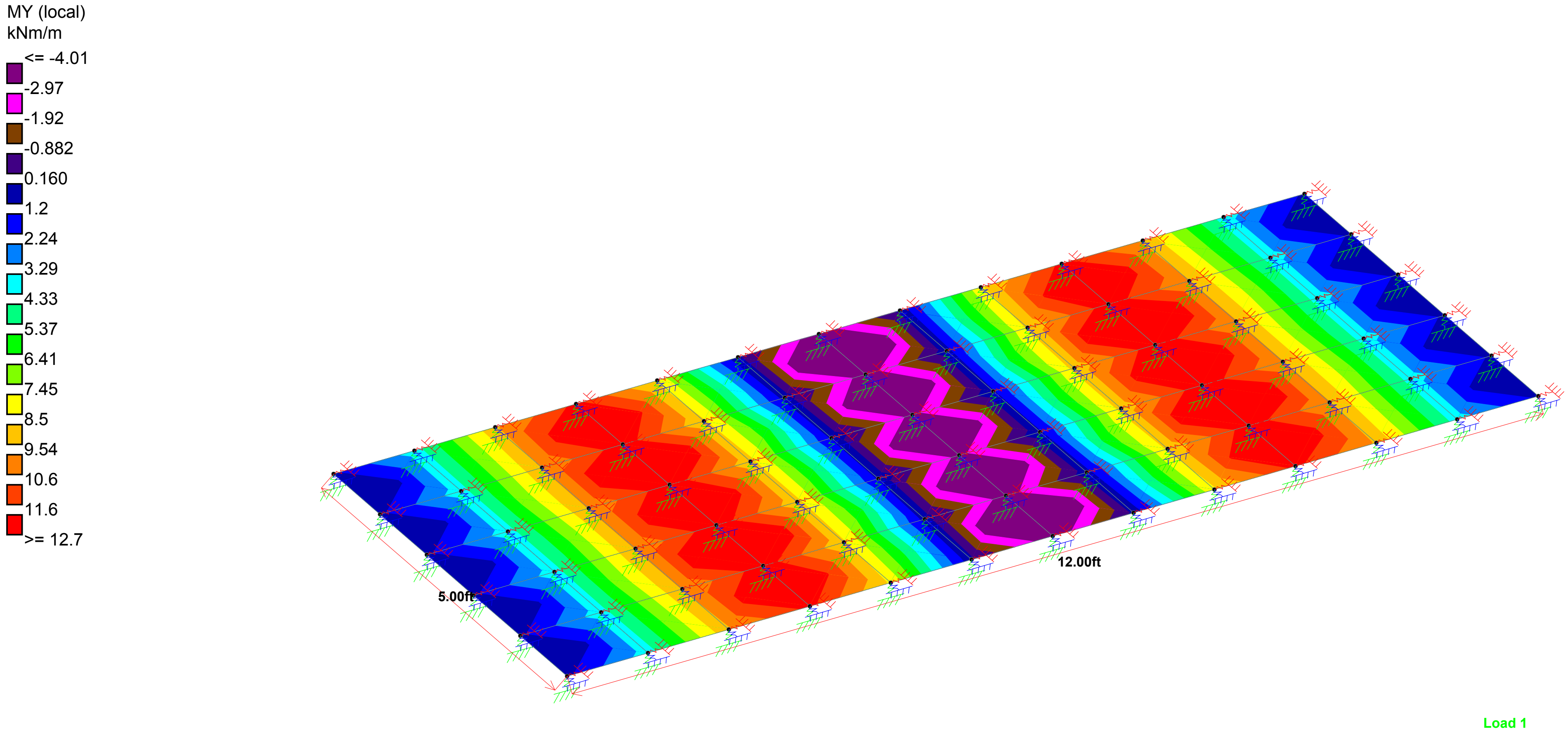


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 00:57	



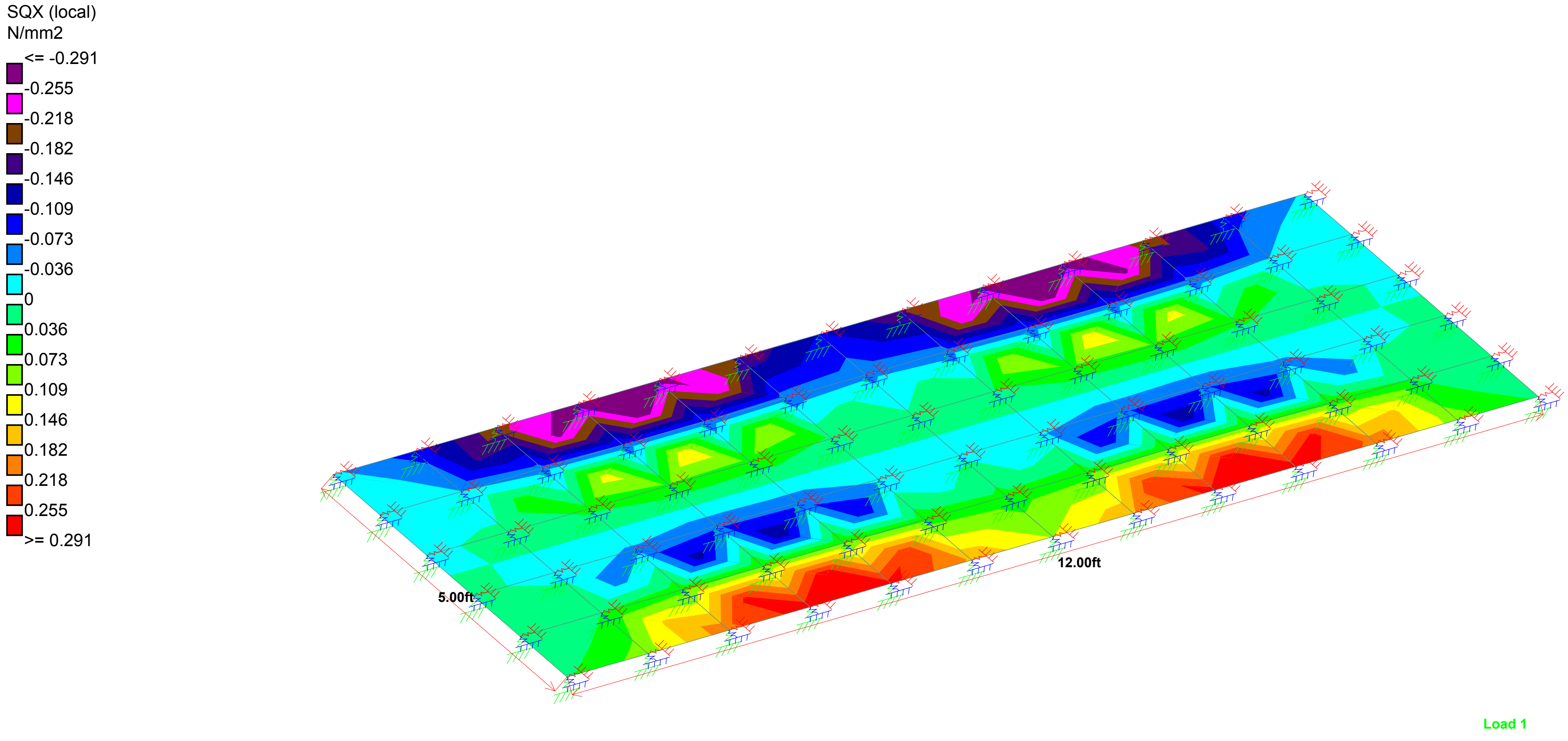
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 00:57	



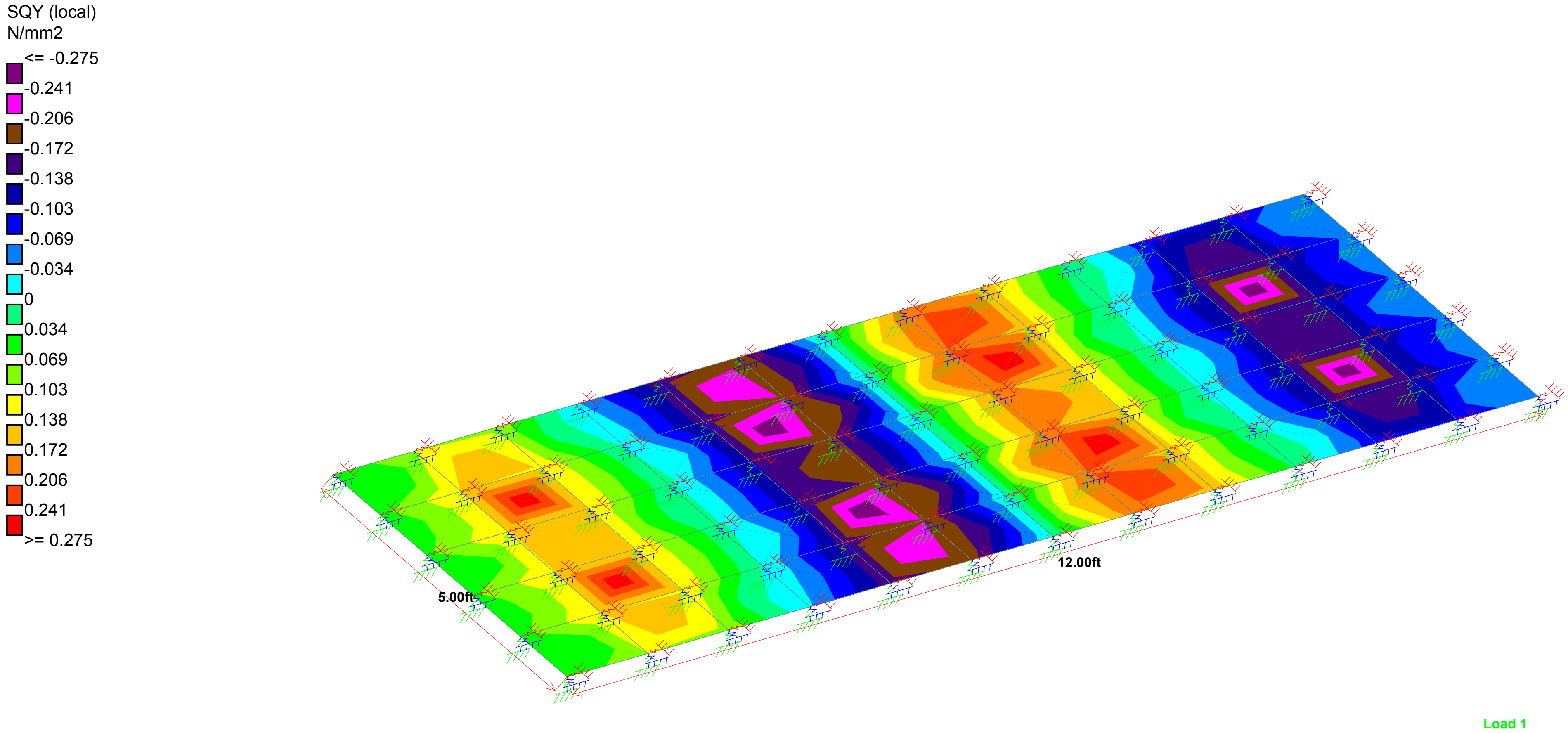
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 00:57	



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 00:57	



```
****************************************************
*                                                  *
*           STAAD.Pro V8i SELECTseries6            *
*           Version  20.07.11.33                   *
*           Proprietary Program of                 *
*           Bentley Systems, Inc.                  *
*           Date=    DEC 30, 2021                  *
*           Time=      0:57:22                     *
*                                                  *
*      USER ID: Optimal Engineering Support        *
****************************************************
```

```
    1. STAAD SPACE
INPUT FILE: D:\SSL\00 MSE Wall\000 Checking Only\Panel Design\staad\Panel Check - 5x12 type A (5W20)_R.. .STD
    2. START JOB INFORMATION
    3. ENGINEER DATE 10-MAR-21
    4. JOB CLIENT SSL
    5. ENGINEER NAME CH
    6. JOB REF PANEL CHECK
    7. END JOB INFORMATION
    8. INPUT WIDTH 79
    9. UNIT FEET KIP
   10. JOINT COORDINATES
   11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
   12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
   13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
   14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
   15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
   16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
   17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
   18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
   19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
   20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
   21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
   22. 97 11 0 -5; 98 12 0 -5
   23. ELEMENT INCIDENCES SHELL
   24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
   25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
   26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
   27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
   28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
   29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
   30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
   31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
   32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
   33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
   34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
   35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
   36. ELEMENT PROPERTY
   37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
   38. DEFINE MATERIAL START
```



```
   39. ISOTROPIC CONCRETE
   40. E 614304
   41. POISSON 0.17
   42. DENSITY 0.15
   43. ALPHA 1E-005
   44. DAMP 0.05
   45. END DEFINE MATERIAL
   46. CONSTANTS
   47. MATERIAL CONCRETE ALL
   48. SUPPORTS
   49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
   50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
   51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
   52. ELEMENT LOAD
   53. 35 PR GY -7.717 0.25 0.1667
   54. 32 PR GY -7.717 0.25 0.5
   55. 33 PR GY -7.717 0.25 0.1667
   56. 34 PR GY -7.717 0.25 -0.1667
   57. 34 PR GY -7.717 0.25 0.5
   58. 66 PR GY -7.717 0.25 0.5
   59. 67 PR GY -7.717 0.25 0.1667
   60. 68 PR GY -7.717 0.25 -0.1667
   61. 68 PR GY -7.717 0.25 0.5
   62. 66 PR GY -7.717 0.25 -0.1667
   63. 5 PR GY -7.717 -0.25 0.5
   64. 8 PR GY -7.717 -0.25 0.1667
   65. 11 PR GY -7.717 -0.25 -0.1667
   66. 11 PR GY -7.717 -0.25 0.5
   67. 14 PR GY -7.717 -0.25 0.1667
   68. 51 PR GY -7.717 -0.25 -0.1667
   69. 51 PR GY -7.717 -0.25 0.5
   70. 54 PR GY -7.717 -0.25 0.1667
   71. 57 PR GY -7.717 -0.25 -0.1667
   72. 57 PR GY -7.717 -0.25 0.5
   73. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

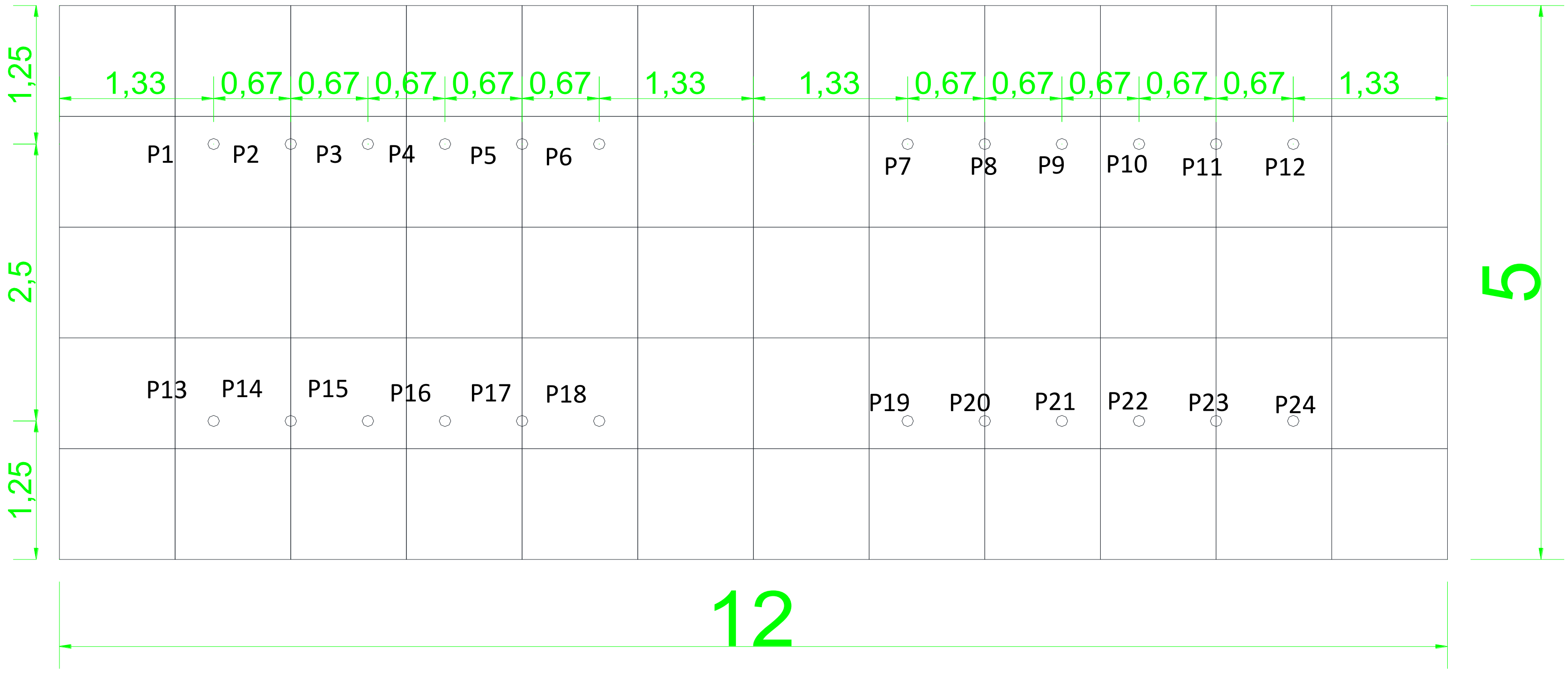
NUMBER OF JOINTS	78	NUMBER OF MEMBERS	0
NUMBER OF PLATES	60	NUMBER OF SOLIDS	0
NUMBER OF SURFACES	0	NUMBER OF SUPPORTS	78

SOLVER USED IS THE IN-CORE ADVANCED MATH SOLVER

TOTAL PRIMARY LOAD CASES = 1, TOTAL DEGREES OF FREEDOM = 468
TOTAL LOAD COMBINATION CASES = 0 SO FAR.

Typical Panel Type (mesh 6W20), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.167	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.167	0.25
P5	0.5	0.25
P6	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.167	0.25
P8	0.5	0.25
P9	0.1667	0.25
P10	-0.167	0.25
P11	0.5	0.25
P12	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P13	-0.167	-0.25
P14	0.5	-0.25
P15	0.1667	-0.25
P16	-0.167	-0.25
P17	0.5	-0.25
P18	0.1667	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P19	-0.167	-0.25
P20	0.5	-0.25
P21	0.1667	-0.25
P22	-0.167	-0.25
P23	0.5	-0.25
P24	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

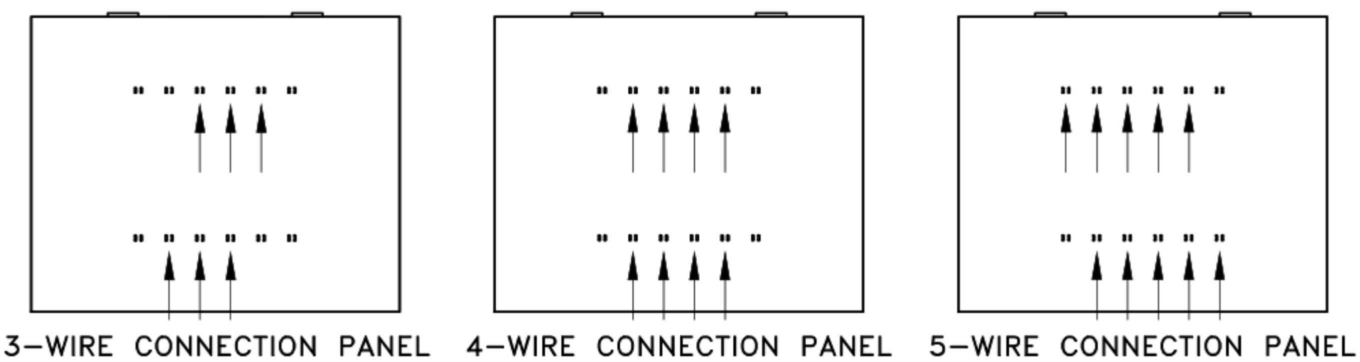
Bar Mat Used:
W11 - 75 Years

$A = 0.1583 \text{ in}^2$

$Fy = 75 \text{ ksi}$

$P = 0.65 \times A \times Fy$

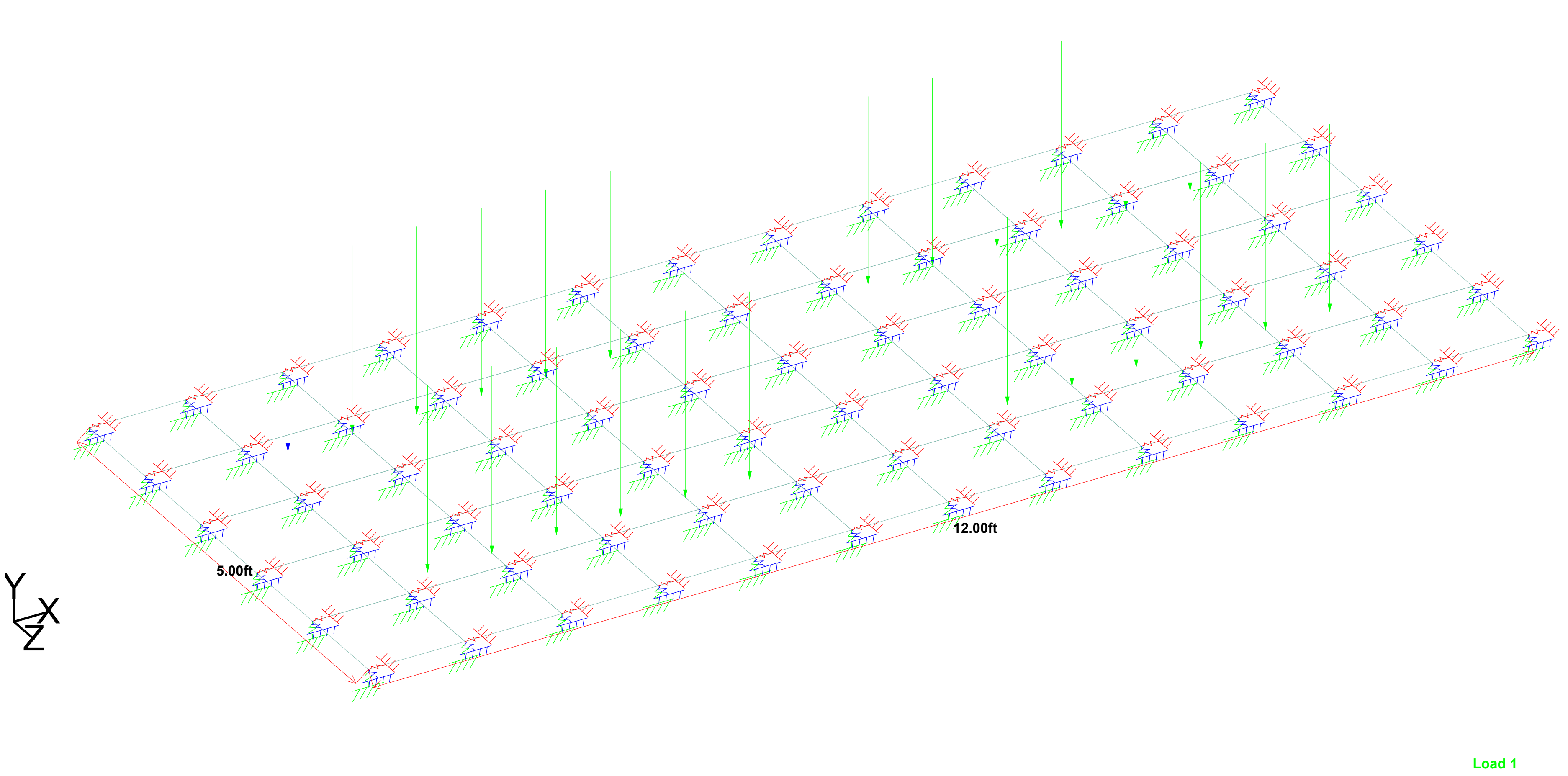
$= 7.717$ Kips (per wire point)



ATTACHMENT BY No. WIRES

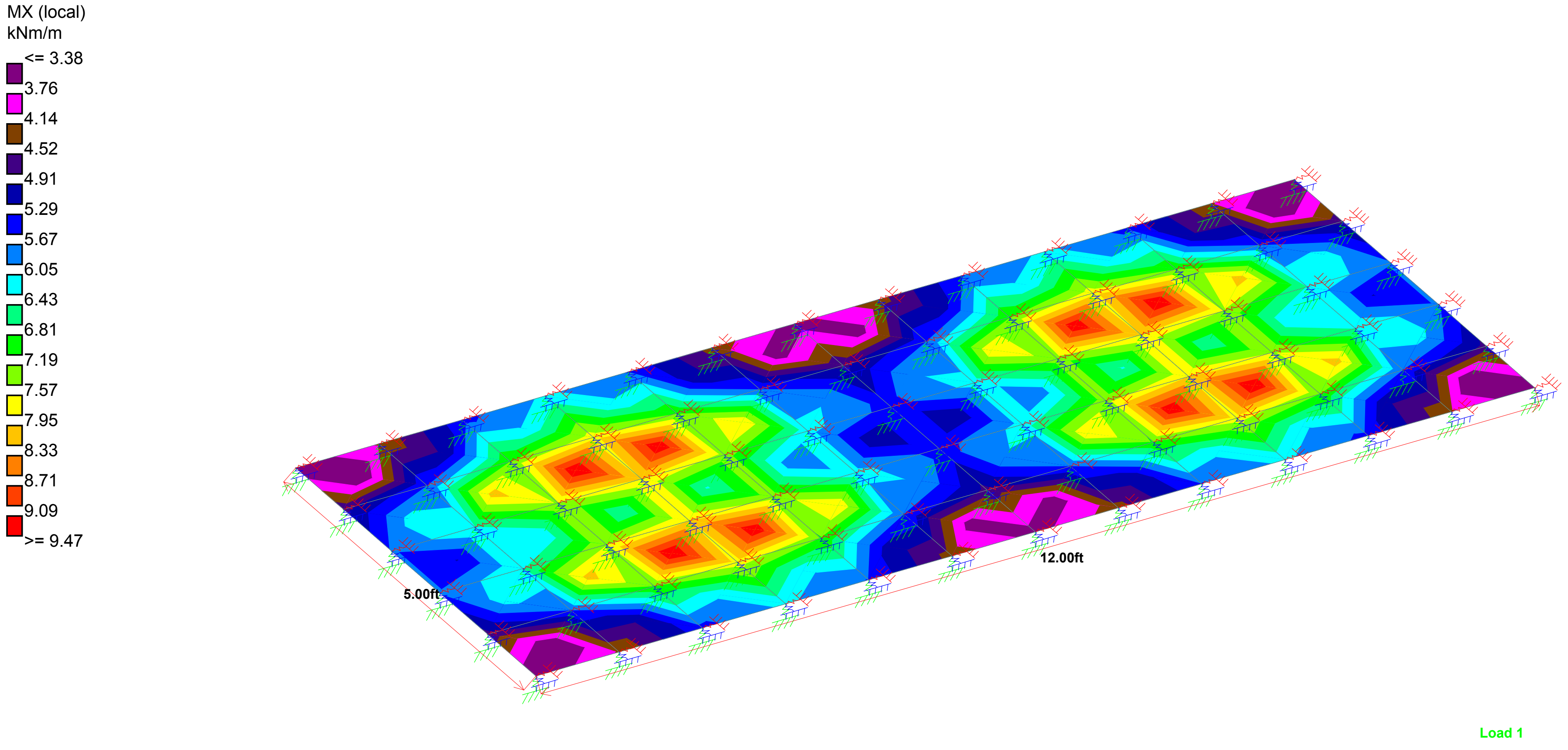
(STANDARD PANELS ONLY)

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 03:55	

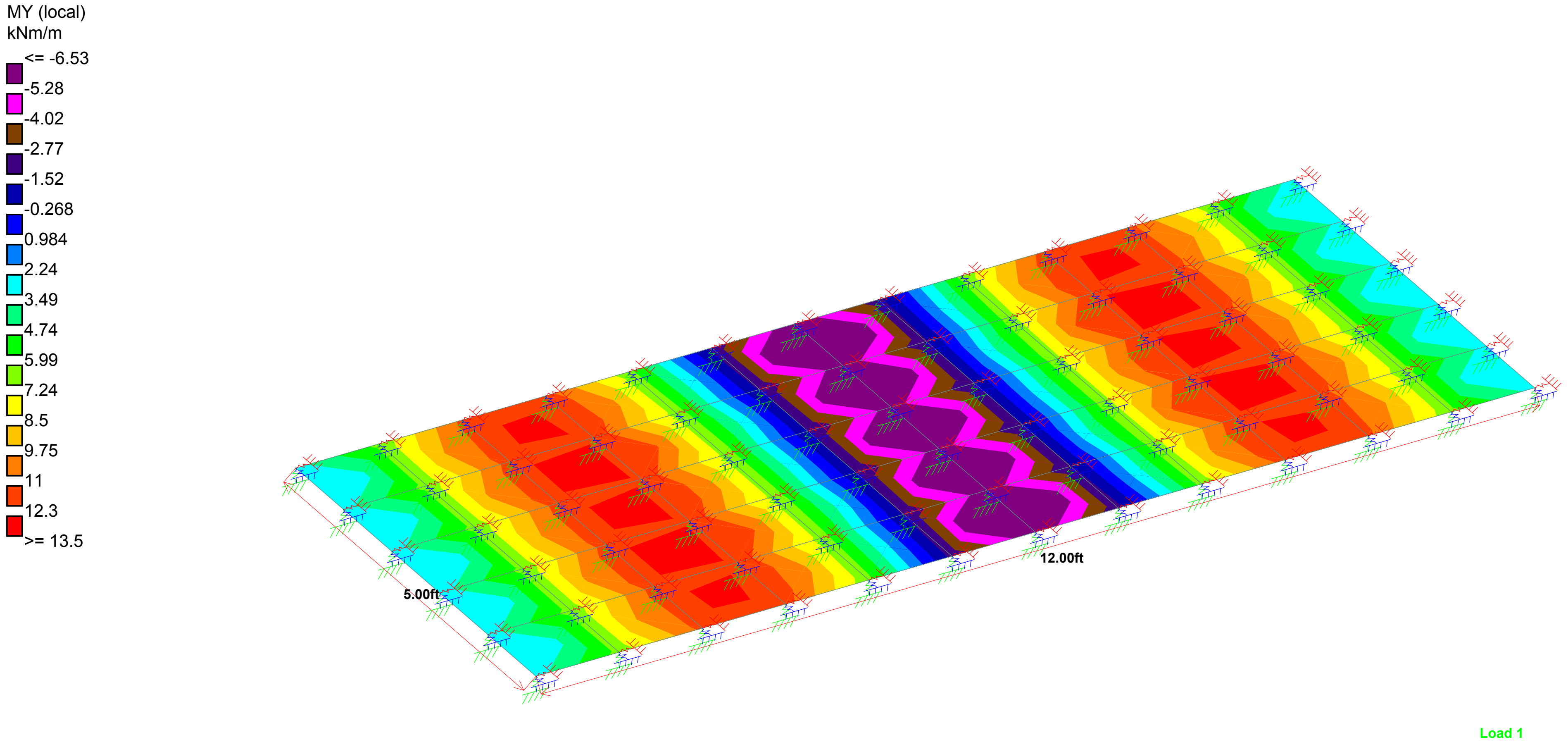


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 03:55	

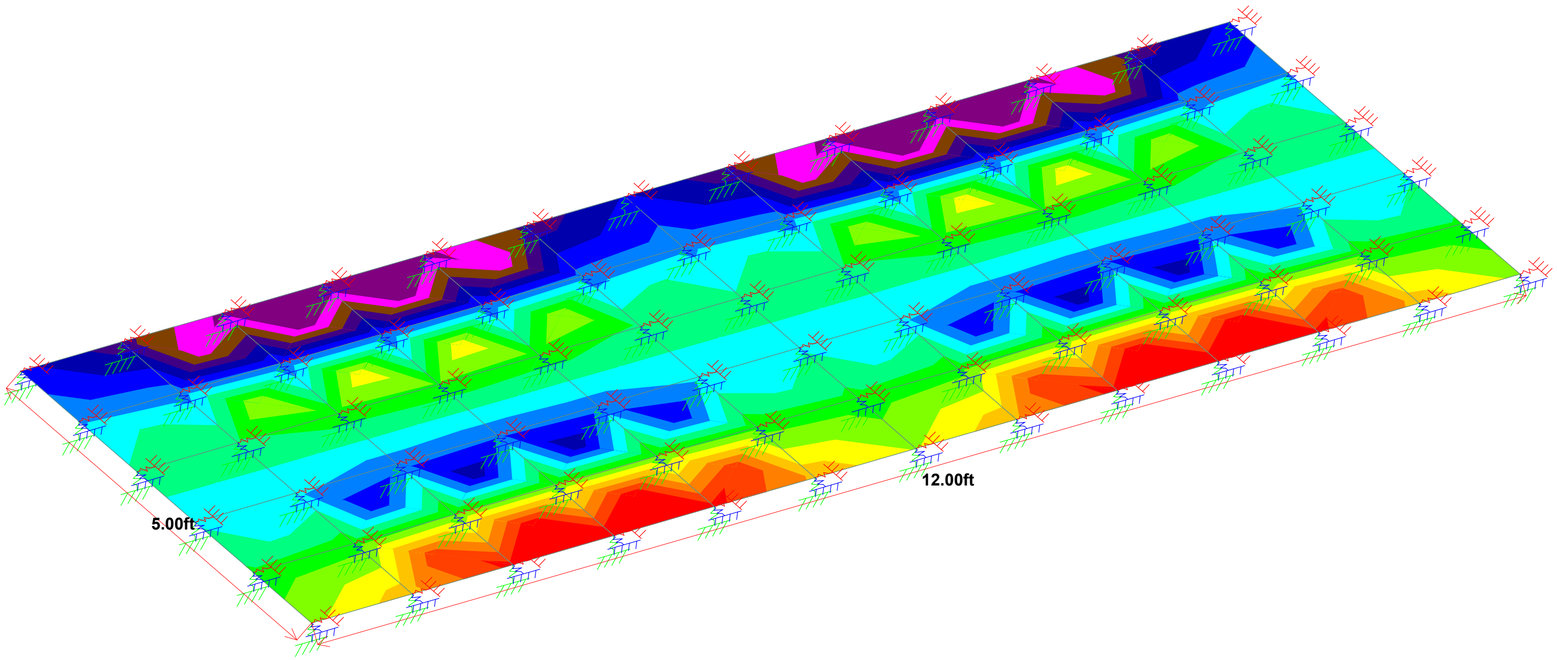


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 03:55	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 03:55	

SQX (local)
N/mm2
<= -0.298
-0.261
-0.223
-0.186
-0.149
-0.112
-0.074
-0.037
0
0.037
0.074
0.112
0.149
0.186
0.223
0.261
>= 0.298



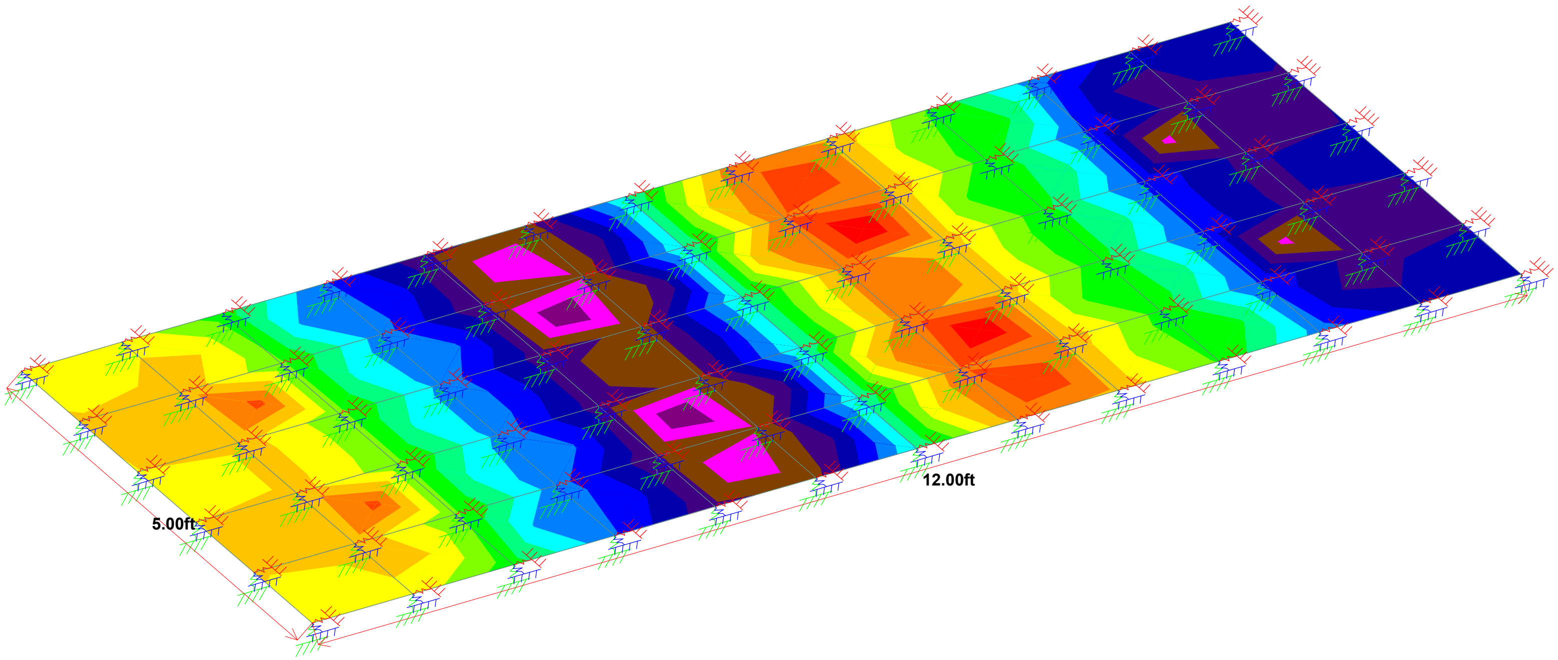
Load 1

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 03:55	

SQY (local)
N/mm2

<= -0.284
-0.249
-0.213
-0.178
-0.142
-0.107
-0.071
-0.036
0
0.036
0.071
0.107
0.142
0.178
0.213
0.249
>= 0.284



```
          ****************************************************
          *                                                  *
          *          STAAD.Pro                               *
          *          Version  2007    Build 04               *
          *          Proprietary Program of                  *
          *          Research Engineers,  Intl.              *
          *          Date=    MAR 11, 2021                   *
          *          Time=     3:56:29                       *
          *                                                  *
          *     USER ID: Optimal Engineering Support         *
          ****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Panel Check - 5x12 type A (6W20).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
    39. ISOTROPIC CONCRETE
    40. E 614304
```



```
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 32 PR GY -7.717 0.25 -0.1667
    54. 32 PR GY -7.717 0.25 0.5
    55. 33 PR GY -7.717 0.25 0.1667
    56. 34 PR GY -7.717 0.25 -0.1667
    57. 34 PR GY -7.717 0.25 0.5
    58. 35 PR GY -7.717 0.25 0.1667
    59. 66 PR GY -7.717 0.25 -0.1667
    60. 66 PR GY -7.717 0.25 0.5
    61. 67 PR GY -7.717 0.25 0.1667
    62. 68 PR GY -7.717 0.25 -0.1667
    63. 68 PR GY -7.717 0.25 0.5
    64. 69 PR GY -7.717 0.25 0.1667
    65. 5 PR GY -7.717 -0.25 -0.1667
    66. 5 PR GY -7.717 -0.25 0.5
    67. 8 PR GY -7.717 -0.25 0.1667
    68. 11 PR GY -7.717 -0.25 -0.1667
    69. 11 PR GY -7.717 -0.25 0.5
    70. 14 PR GY -7.717 -0.25 0.1667
    71. 51 PR GY -7.717 -0.25 -0.1667
    72. 51 PR GY -7.717 -0.25 0.5
    73. 54 PR GY -7.717 -0.25 0.1667
    74. 57 PR GY -7.717 -0.25 -0.1667
    75. 57 PR GY -7.717 -0.25 0.5
    76. 60 PR GY -7.717 -0.25 0.1667
    77. PERFORM ANALYSIS
```

```
        P R O B L E M   S T A T I S T I C S
        -----------------------------------

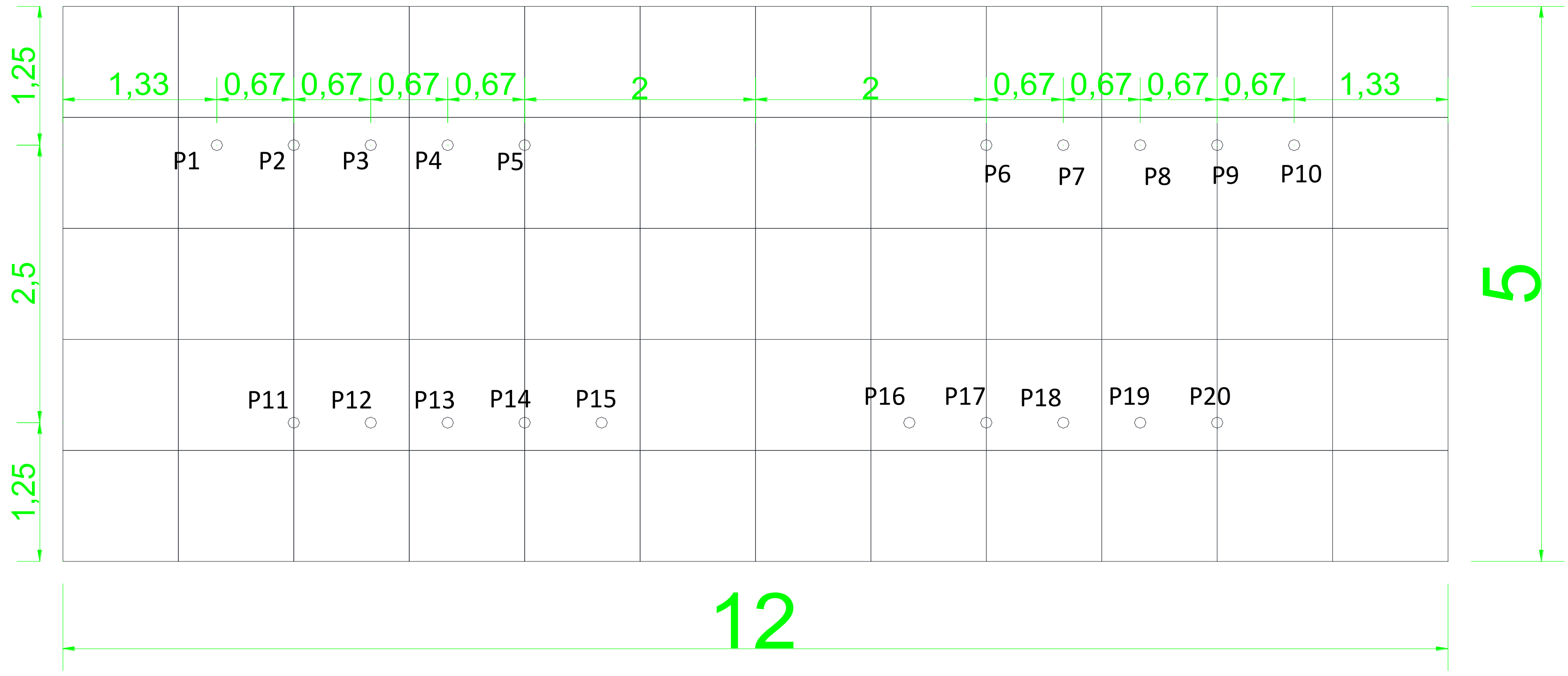
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     78/    60/    78

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    39/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =     468
 SIZE OF STIFFNESS MATRIX =       31 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.6/ 263301.6 MB
```

Typical Panel Type (mesh 5W24), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.167	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.167	0.25
P5	0.5	0.25
P6	-0.5	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	0.1667	0.25
P8	-0.167	0.25
P9	-0.5	0.25
P10	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P11	0.5	-0.25
P12	0.1667	-0.25
P13	-0.167	-0.25
P14	0.5	-0.25
P15	0.1667	-0.25
P16	-0.167	-0.25

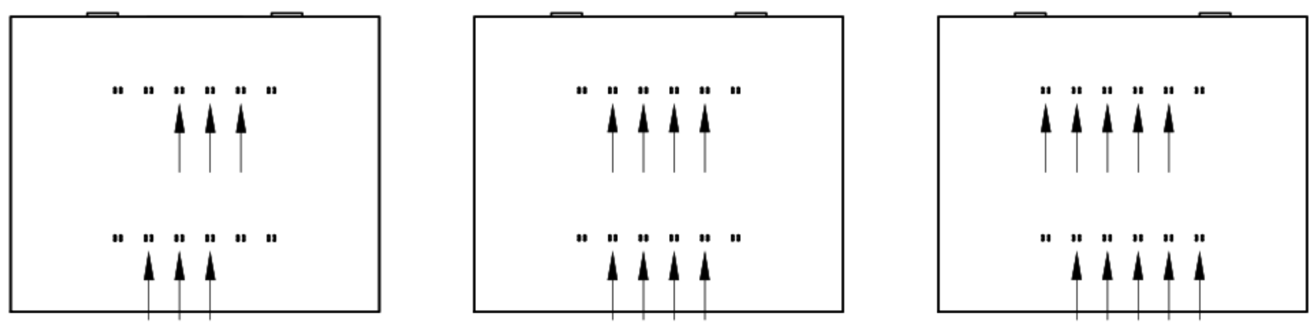
Location	Coordinated From Center Panel 1'x1'	
	X	Y
P17	0	-0.25
P18	0.1667	-0.25
P19	-0.167	-0.25
P20	-0.5	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

Bar Mat Used:
W11 - 75 Years

A = 0.194 in^2
Fy = 75 ksi

P = 0.65 x A x Fy
= 9.458 Kips (per wire point)

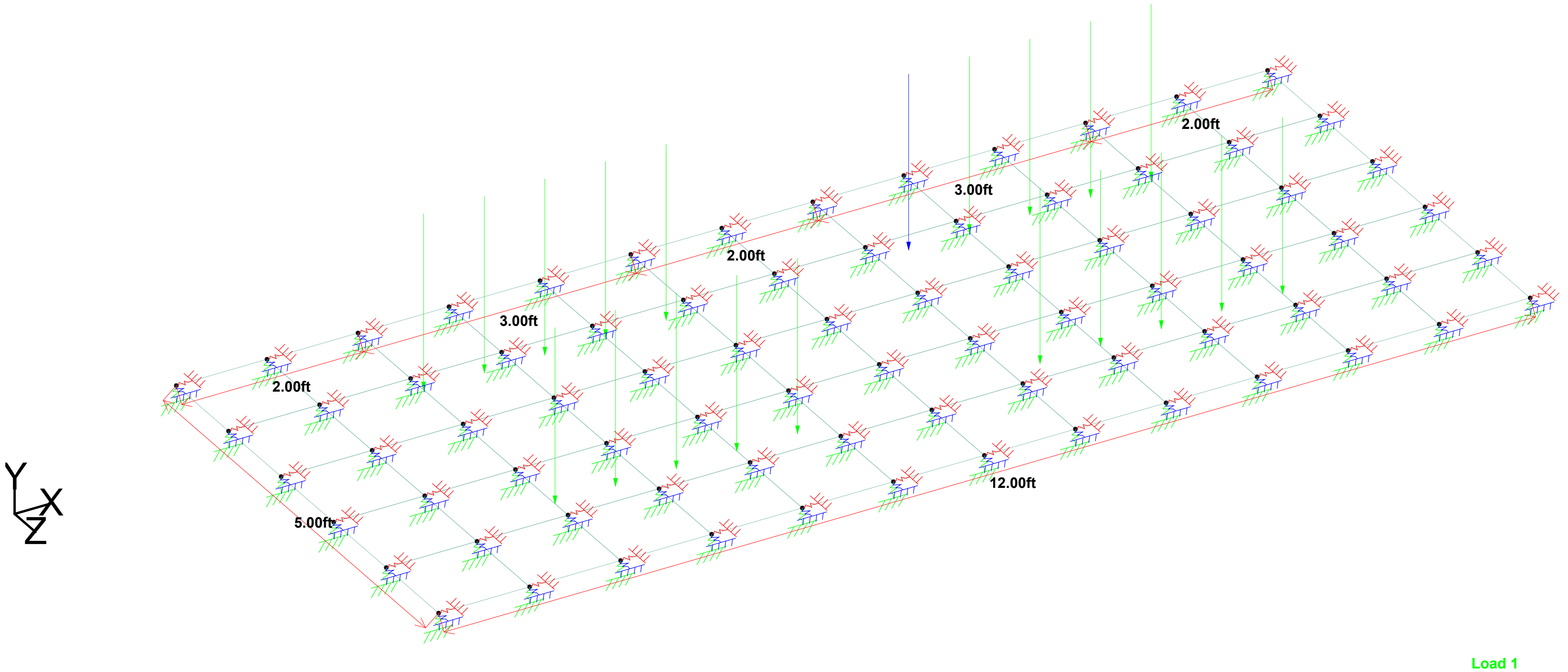


3–WIRE CONNECTION PANEL   4–WIRE CONNECTION PANEL   5–WIRE CONNECTION PANEL

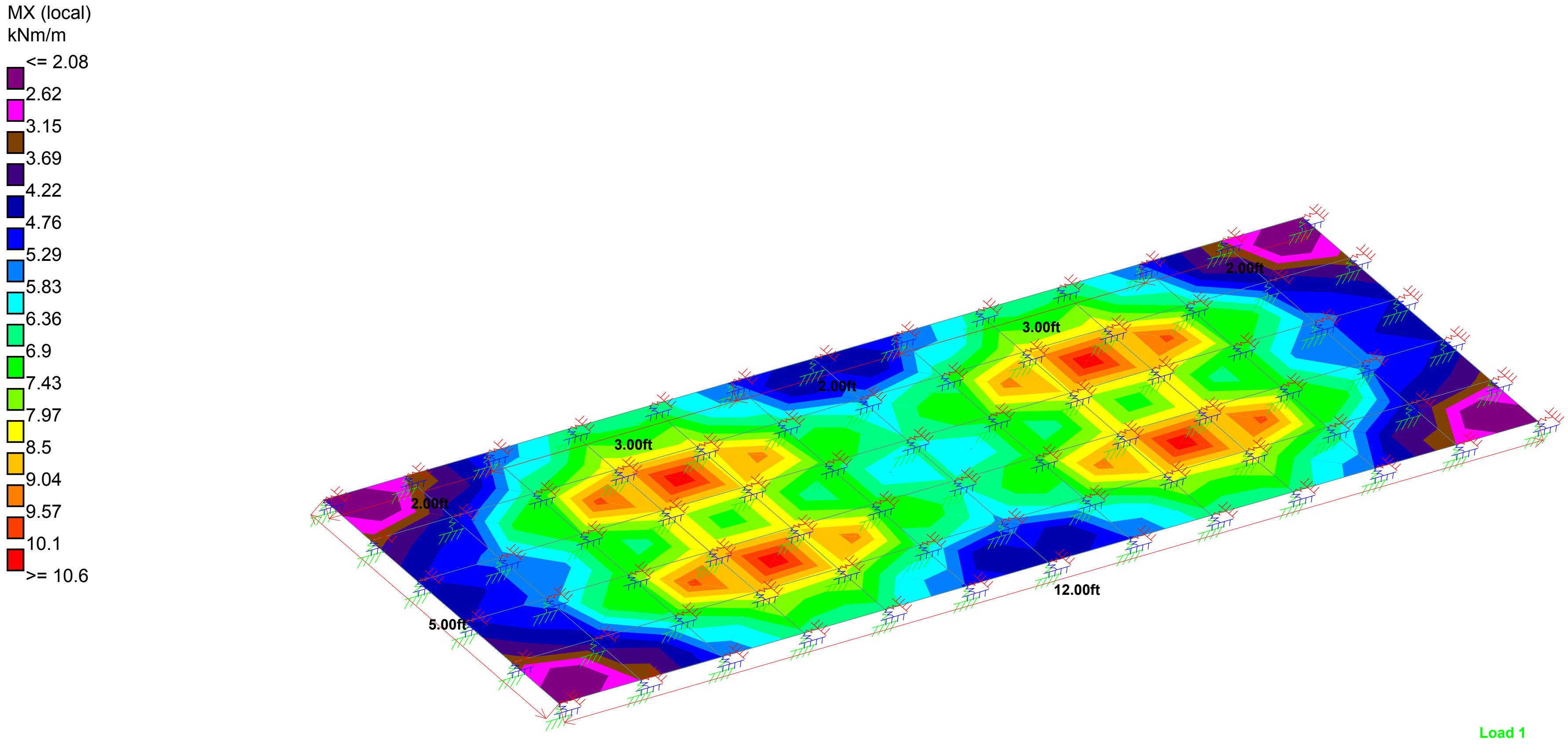
ATTACHMENT BY No. WIRES
(STANDARD PANELS ONLY)

TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 05:45	

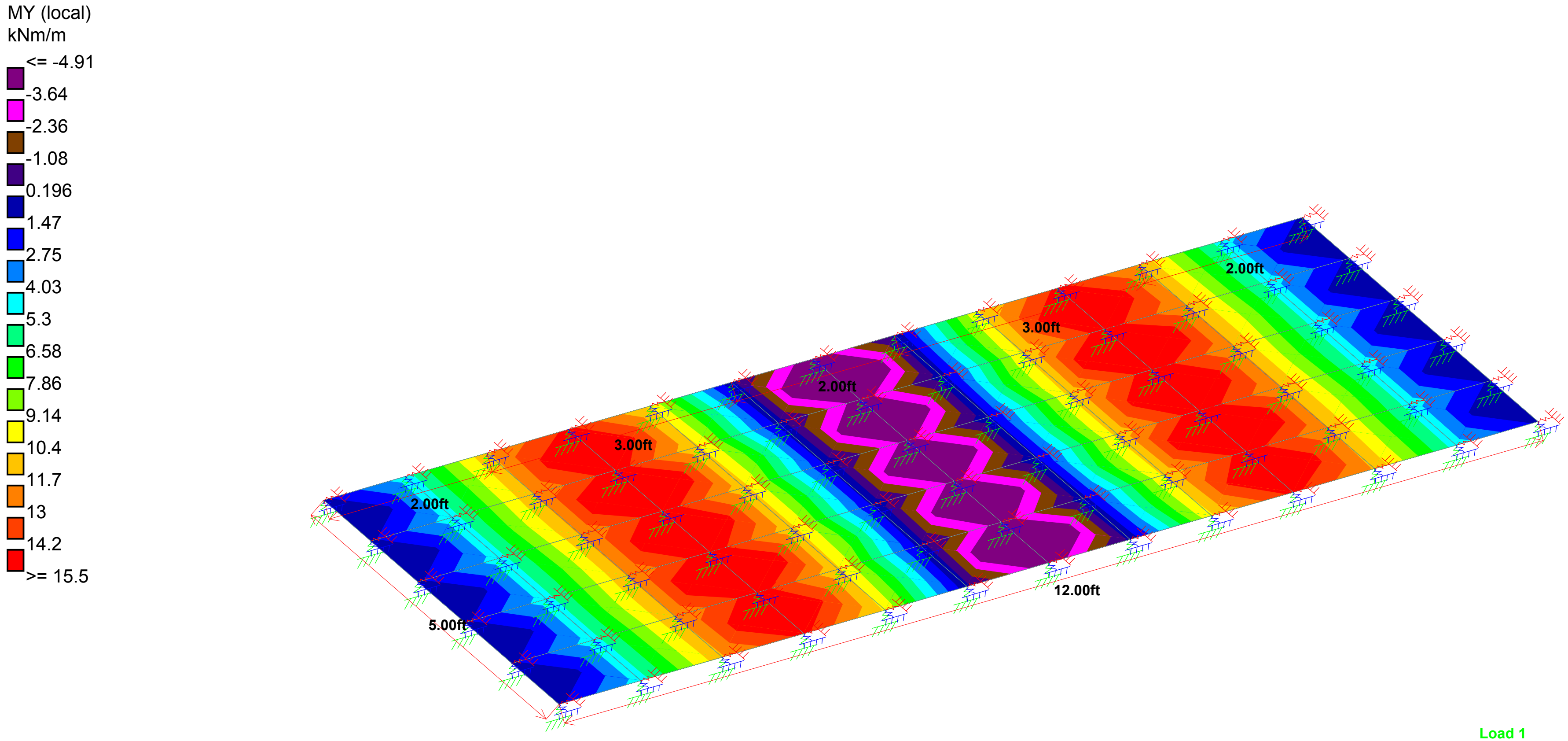


Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 05:45	



TOC – Appendix

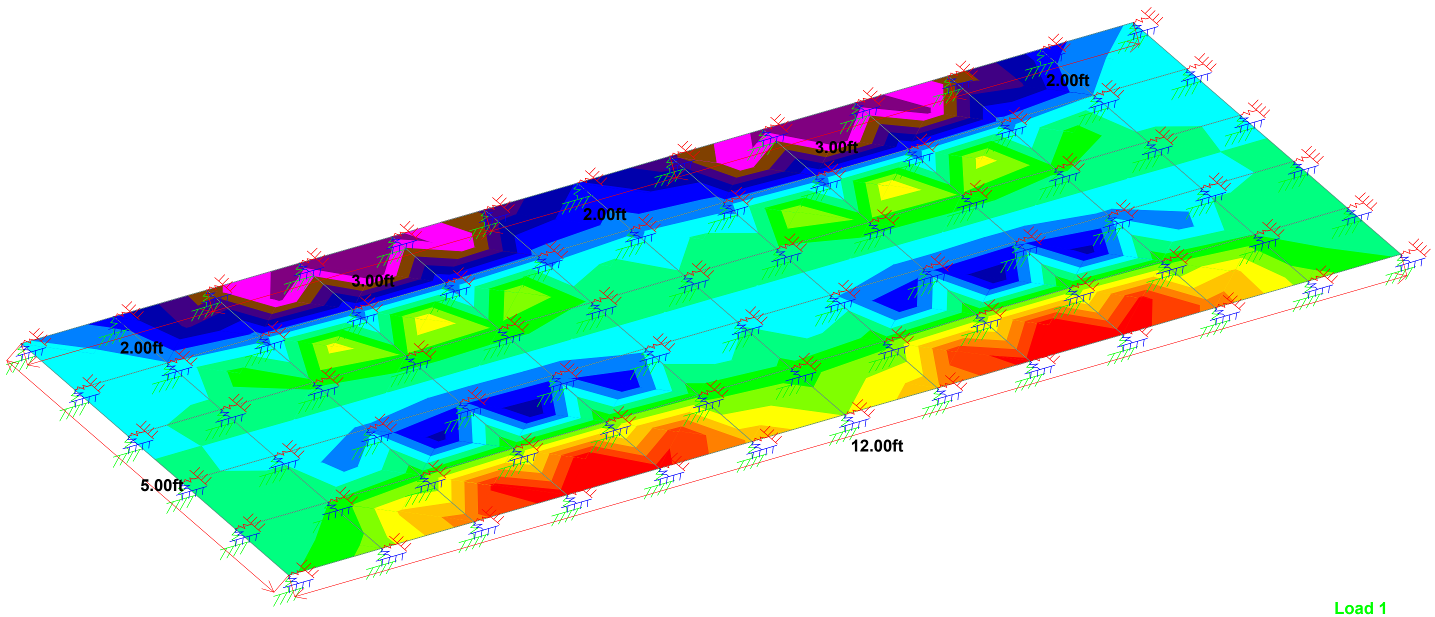
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 05:45	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 05:45	

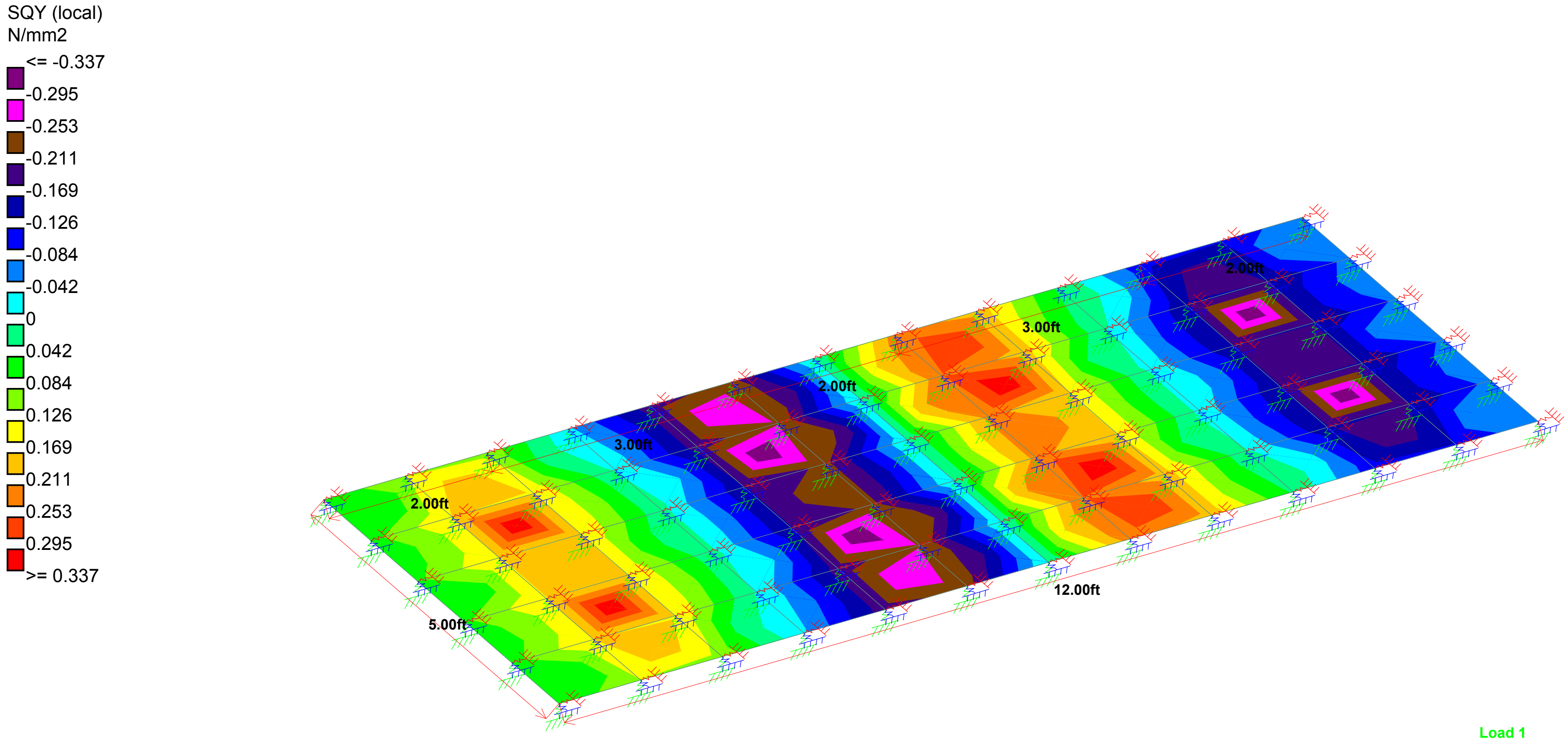
SQX (local)
N/mm2

<= -0.357
-0.312
-0.268
-0.223
-0.178
-0.134
-0.089
-0.045
0
0.045
0.089
0.134
0.178
0.223
0.268
0.312
>= 0.357



TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 30-Dec-2021 05:45	



TOC – Appendix


```
****************************************************
*                                                  *
*          STAAD.Pro V8i SELECTseries6             *
*          Version  20.07.11.33                    *
*          Proprietary Program of                  *
*          Bentley Systems, Inc.                   *
*          Date=    DEC 30, 2021                   *
*          Time=     5:45:17                       *
*                                                  *
*     USER ID: Optimal Engineering Support         *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: D:\SSL\00 MSE Wall\000 Checking Only\Panel Design\staad\Panel Check - 5x12 type A (5W24)_R.. .STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
```



```
    39. ISOTROPIC CONCRETE
    40. E 614304
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 35 PR GY -9.458 0.25 0.1667
    54. 32 PR GY -9.458 0.25 0.5
    55. 33 PR GY -9.458 0.25 0.1667
    56. 34 PR GY -9.458 0.25 -0.1667
    57. 34 PR GY -9.458 0.25 0.5
    58. 66 PR GY -9.458 0.25 0.5
    59. 67 PR GY -9.458 0.25 0.1667
    60. 68 PR GY -9.458 0.25 -0.1667
    61. 68 PR GY -9.458 0.25 0.5
    62. 66 PR GY -9.458 0.25 -0.1667
    63. 5 PR GY -9.458 -0.25 0.5
    64. 8 PR GY -9.458 -0.25 0.1667
    65. 11 PR GY -9.458 -0.25 -0.1667
    66. 11 PR GY -9.458 -0.25 0.5
    67. 14 PR GY -9.458 -0.25 0.1667
    68. 51 PR GY -9.458 -0.25 -0.1667
    69. 51 PR GY -9.458 -0.25 0.5
    70. 54 PR GY -9.458 -0.25 0.1667
    71. 57 PR GY -9.458 -0.25 -0.1667
    72. 57 PR GY -9.458 -0.25 0.5
    73. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

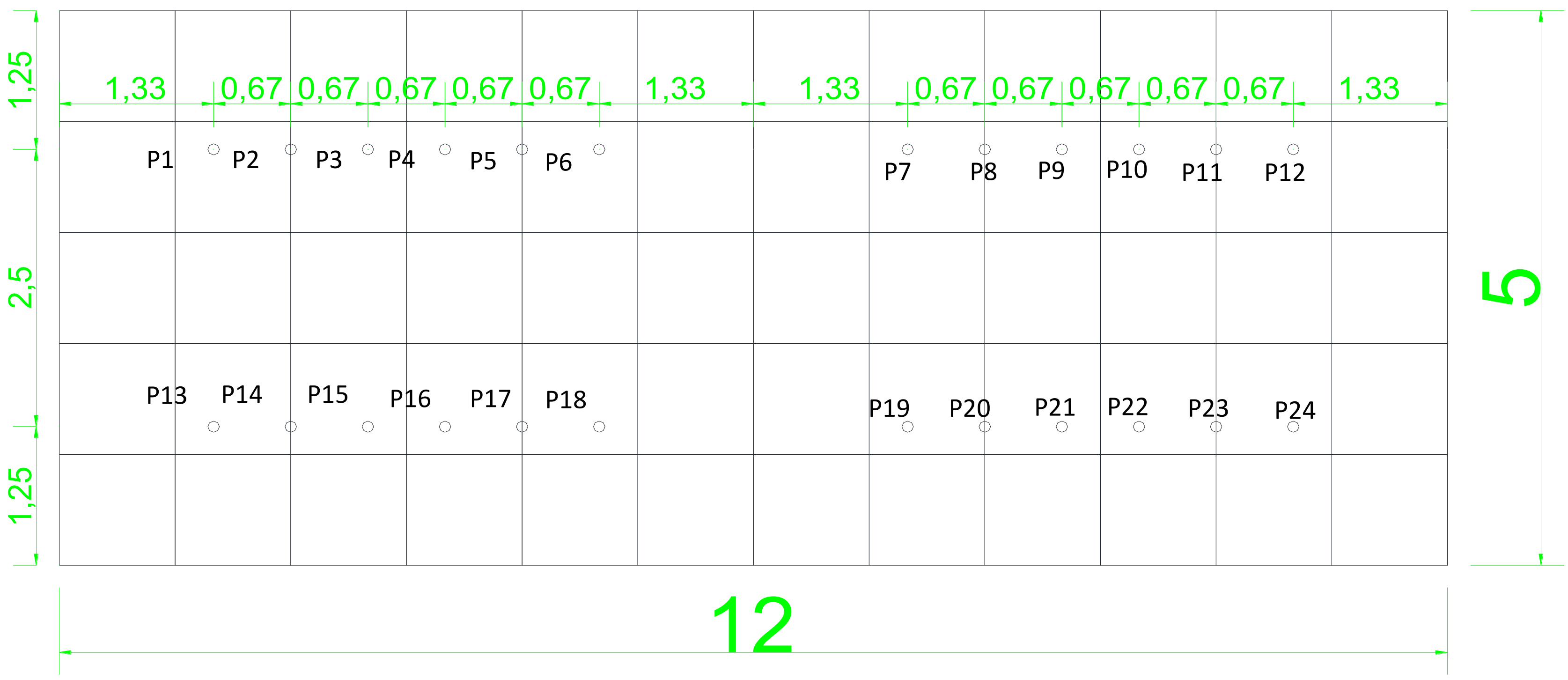
NUMBER OF JOINTS	78	NUMBER OF MEMBERS	0
NUMBER OF PLATES	60	NUMBER OF SOLIDS	0
NUMBER OF SURFACES	0	NUMBER OF SUPPORTS	78

SOLVER USED IS THE IN-CORE ADVANCED MATH SOLVER

TOTAL PRIMARY LOAD CASES = 1, TOTAL DEGREES OF FREEDOM = 468
TOTAL LOAD COMBINATION CASES = 0 SO FAR.

Typical Panel Type (mesh 6W24), Panel Thickness 6", 5'x12'

Point load Input Force in panel for Staad Pro input



Location	Coordinated From Center Panel 1'x1'	
	X	Y
P1	-0.167	0.25
P2	0.5	0.25
P3	0.1667	0.25
P4	-0.167	0.25
P5	0.5	0.25
P6	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P7	-0.167	0.25
P8	0.5	0.25
P9	0.1667	0.25
P10	-0.167	0.25
P11	0.5	0.25
P12	0.1667	0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P13	-0.167	-0.25
P14	0.5	-0.25
P15	0.1667	-0.25
P16	-0.167	-0.25
P17	0.5	-0.25
P18	0.1667	-0.25

Location	Coordinated From Center Panel 1'x1'	
	X	Y
P19	-0.167	-0.25
P20	0.5	-0.25
P21	0.1667	-0.25
P22	-0.167	-0.25
P23	0.5	-0.25
P24	0.1667	-0.25

Load to panel based on Bar Mat Capacity per Bar Mat Point

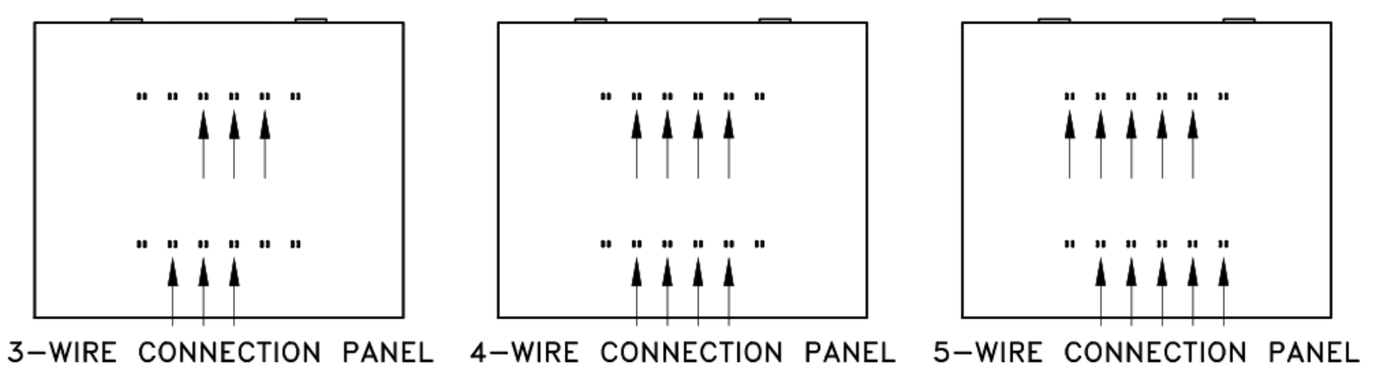
Bar Mat Used:
W11 - 75 Years

$A = 0.194\ in^2$

$Fy = 75\ ksi$

$P = 0.65 \times A \times Fy$

$= 9.458$ Kips (per wire point)

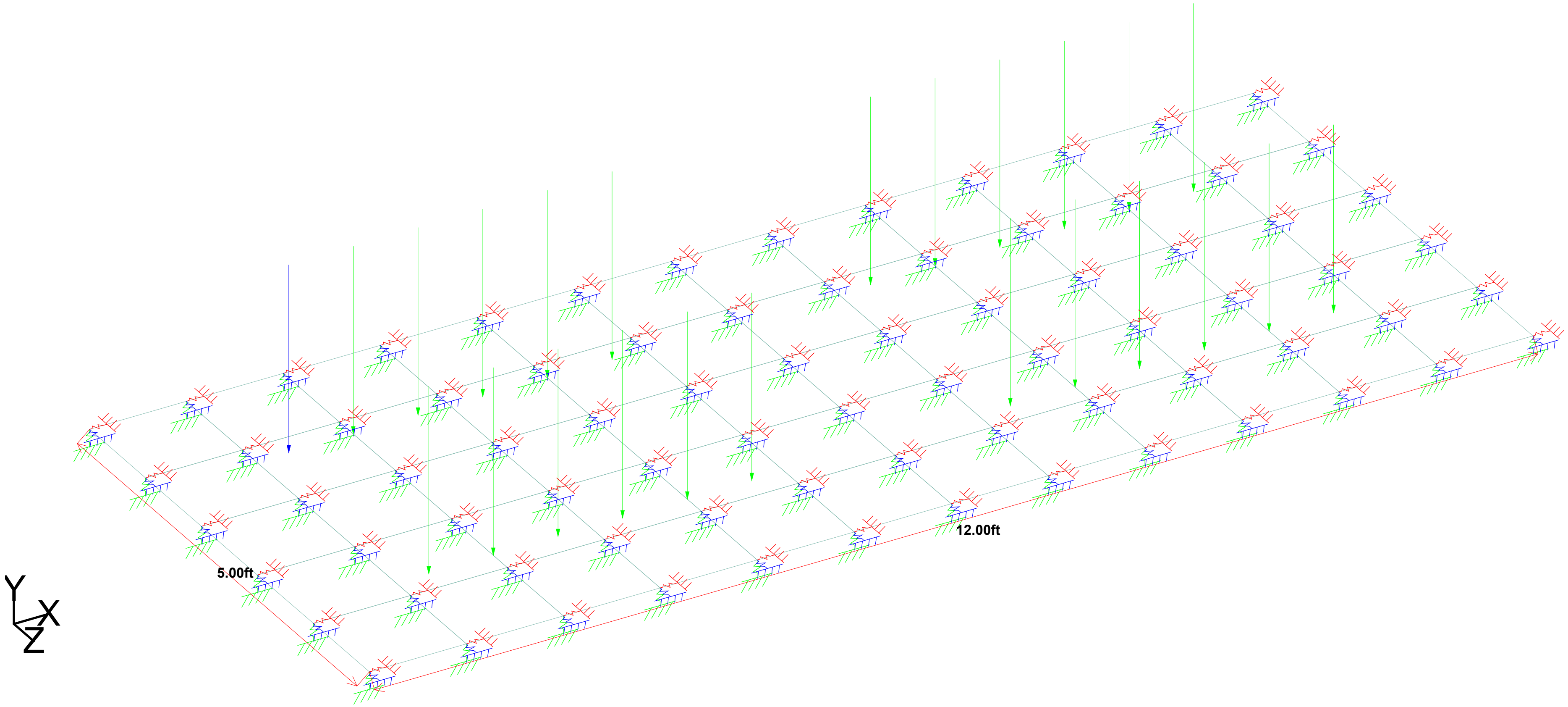


ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

TOC – Appendix

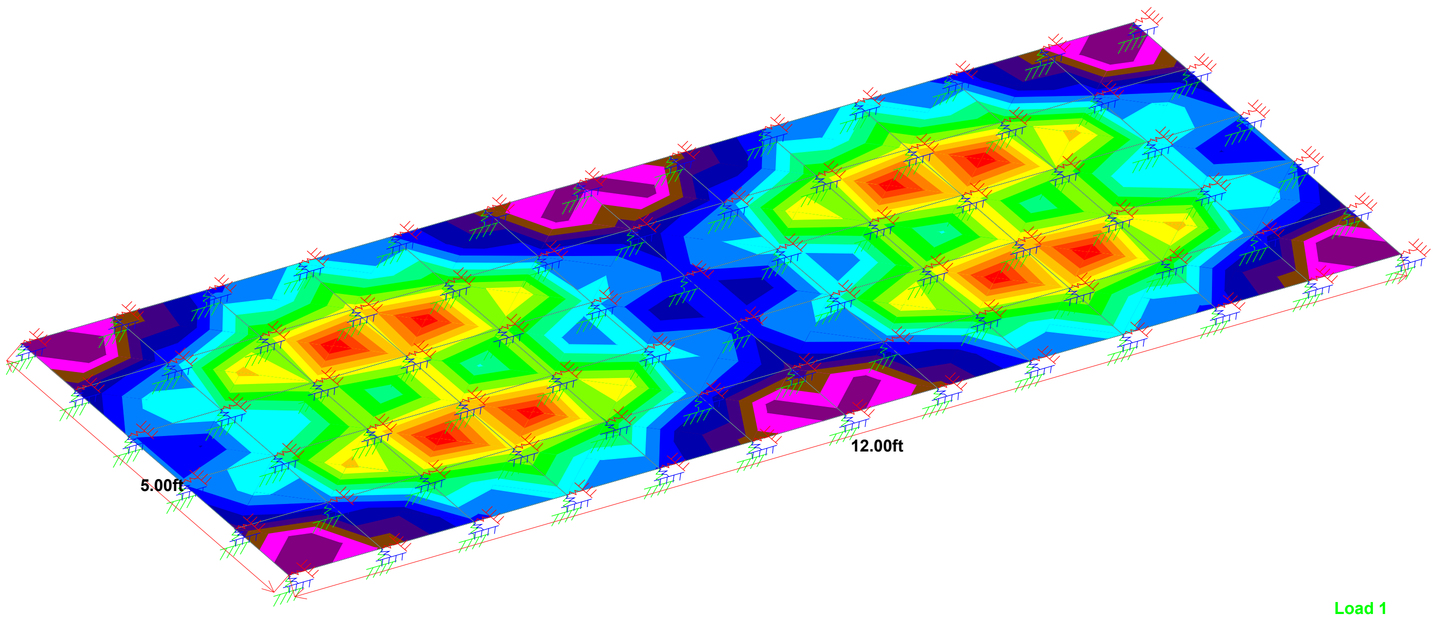
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 04:09	



TOC – Appendix

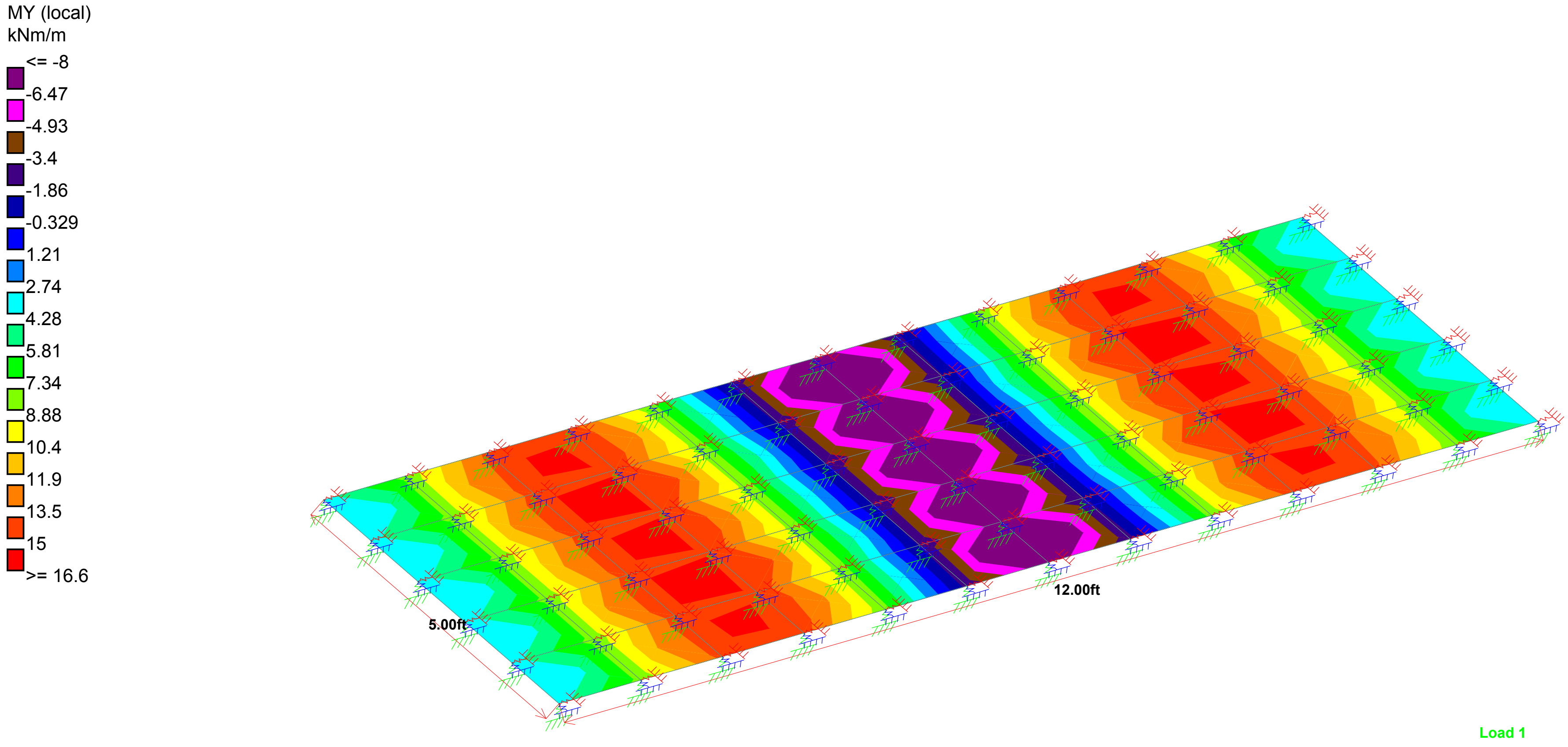
Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 04:09	

MX (local)
kNm/m
<= 4.15
4.61
5.08
5.55
6.01
6.48
6.95
7.41
7.88
8.35
8.81
9.28
9.75
10.2
10.7
11.1
>= 11.6



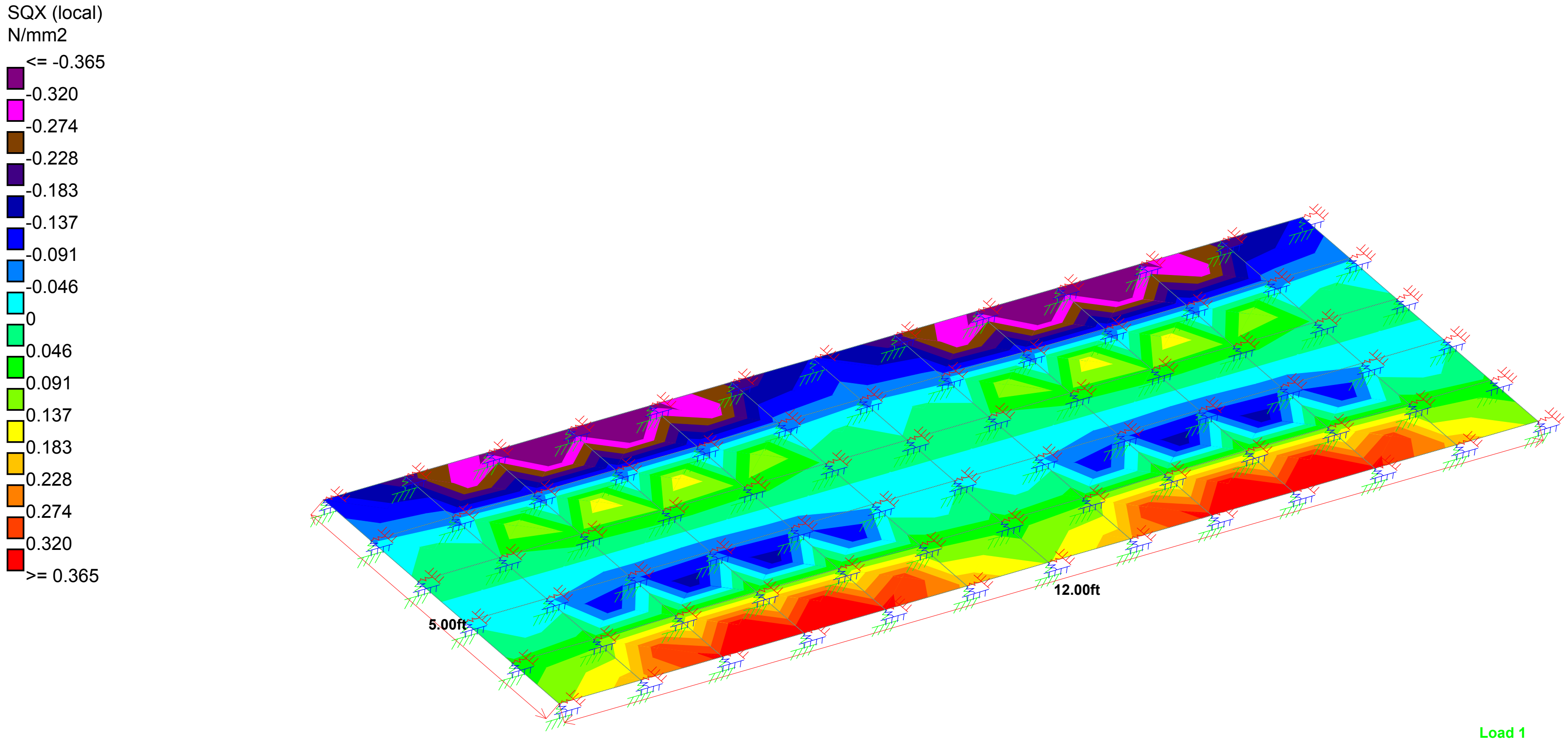
TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 04:09	

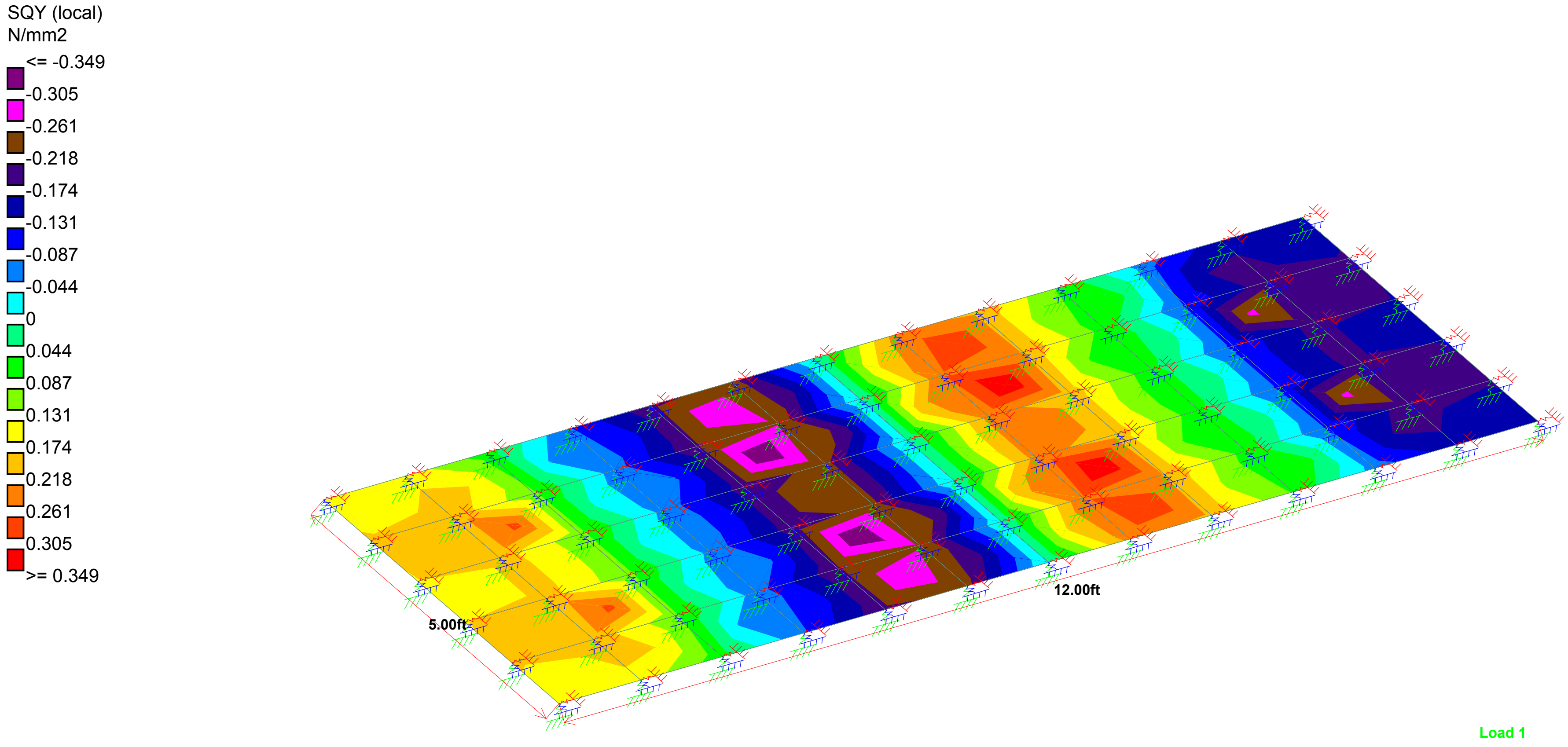


TOC – Appendix

Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 04:09	



Software licensed to Optimal Engineering Support	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref Panel Check		
	By CH	Date 10-Mar-21	Chd
Client SSL	File Panel Check - 5x12 type /	Date/Time 11-Mar-2021 04:09	



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 *           STAAD.Pro                              *
 *           Version  2007    Build 04              *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=    MAR 11, 2021                  *
 *           Time=     4: 9:50                      *
 *                                                  *
 *      USER ID: Optimal Engineering Support        *
 ****************************************************
```

```
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INPUT FILE: Panel Check - 5x12 type A (6W24).STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 10-MAR-21
     4. JOB CLIENT SSL
     5. ENGINEER NAME CH
     6. JOB REF PANEL CHECK
     7. END JOB INFORMATION
     8. INPUT WIDTH 79
     9. UNIT FEET KIP
    10. JOINT COORDINATES
    11. 1 0 0 0; 2 1 0 0; 3 2 0 0; 4 3 0 0; 5 4 0 0; 6 5 0 0; 7 6 0 0; 10 0 0 -1.
    12. 11 1 0 -1; 12 2 0 -1; 13 3 0 -1; 14 4 0 -1; 15 5 0 -1; 16 6 0 -1; 19 0 0 -2
    13. 20 1 0 -2; 21 2 0 -2; 22 3 0 -2; 23 4 0 -2; 24 5 0 -2; 25 6 0 -2; 28 0 0 -3
    14. 29 1 0 -3; 30 2 0 -3; 31 3 0 -3; 32 4 0 -3; 33 5 0 -3; 34 6 0 -3; 45 0 0 -4
    15. 46 1 0 -4; 47 2 0 -4; 48 3 0 -4; 49 4 0 -4; 50 5 0 -4; 51 6 0 -4; 56 0 0 -5
    16. 57 1 0 -5; 58 2 0 -5; 59 3 0 -5; 60 4 0 -5; 61 5 0 -5; 62 6 0 -5; 63 7 0 -1.
    17. 64 7 0 0; 65 7 0 -2; 66 7 0 -3; 67 8 0 -1; 68 8 0 0; 69 8 0 -2; 70 8 0 -3
    18. 71 9 0 -1; 72 9 0 0; 73 9 0 -2; 74 9 0 -3; 75 10 0 -1; 76 10 0 0; 77 10 0 -2
    19. 78 10 0 -3; 79 11 0 -1; 80 11 0 0; 81 11 0 -2; 82 11 0 -3; 83 12 0 -1.
    20. 84 12 0 0; 85 12 0 -2; 86 12 0 -3; 87 7 0 -4; 88 8 0 -4; 89 9 0 -4; 90 10 0 -4
    21. 91 11 0 -4; 92 12 0 -4; 93 7 0 -5; 94 8 0 -5; 95 9 0 -5; 96 10 0 -5
    22. 97 11 0 -5; 98 12 0 -5
    23. ELEMENT INCIDENCES SHELL
    24. 1 1 10 11 2; 2 10 19 20 11; 3 19 28 29 20; 4 2 11 12 3; 5 11 20 21 12
    25. 6 20 29 30 21; 7 3 12 13 4; 8 12 21 22 13; 9 21 30 31 22; 10 4 13 14 5
    26. 11 13 22 23 14; 12 22 31 32 23; 13 5 14 15 6; 14 14 23 24 15; 15 23 32 33 24
    27. 16 6 15 16 7; 17 15 24 25 16; 18 24 33 34 25; 31 28 45 46 29; 32 29 46 47 30
    28. 33 30 47 48 31; 34 31 48 49 32; 35 32 49 50 33; 36 33 50 51 34; 41 45 56 57 46
    29. 42 46 57 58 47; 43 47 58 59 48; 44 48 59 60 49; 45 49 60 61 50; 46 50 61 62 51
    30. 47 7 16 63 64; 48 16 25 65 63; 49 25 34 66 65; 50 64 63 67 68; 51 63 65 69 67
    31. 52 65 66 70 69; 53 68 67 71 72; 54 67 69 73 71; 55 69 70 74 73; 56 72 71 75 76
    32. 57 71 73 77 75; 58 73 74 78 77; 59 76 75 79 80; 60 75 77 81 79; 61 77 78 82 81
    33. 62 80 79 83 84; 63 79 81 85 83; 64 81 82 86 85; 65 34 51 87 66; 66 66 87 88 70
    34. 67 70 88 89 74; 68 74 89 90 78; 69 78 90 91 82; 70 82 91 92 86; 71 51 62 93 87
    35. 72 87 93 94 88; 73 88 94 95 89; 74 89 95 96 90; 75 90 96 97 91; 76 91 97 98 92
    36. ELEMENT PROPERTY
    37. 1 TO 18 31 TO 36 41 TO 76 THICKNESS 0.5
    38. DEFINE MATERIAL START
    39. ISOTROPIC CONCRETE
    40. E 614304
```



```
    41. POISSON 0.17
    42. DENSITY 0.15
    43. ALPHA 1E-005
    44. DAMP 0.05
    45. END DEFINE MATERIAL
    46. CONSTANTS
    47. MATERIAL CONCRETE ALL
    48. SUPPORTS
    49. 1 TO 7 10 TO 16 19 TO 25 28 TO 34 45 TO 51 56 TO 97 -
    50. 98 FIXED BUT KFX 839.76 KFY 839.76 KFZ 839.76 KMX 1 KMY 1 KMZ 1
    51. LOAD 1 LOADTYPE PUSH  TITLE WIRE STRENGTH
    52. ELEMENT LOAD
    53. 32 PR GY -9.458 0.25 -0.1667
    54. 32 PR GY -9.458 0.25 0.5
    55. 33 PR GY -9.458 0.25 0.1667
    56. 34 PR GY -9.458 0.25 -0.1667
    57. 34 PR GY -9.458 0.25 0.5
    58. 35 PR GY -9.458 0.25 0.1667
    59. 66 PR GY -9.458 0.25 -0.1667
    60. 66 PR GY -9.458 0.25 0.5
    61. 67 PR GY -9.458 0.25 0.1667
    62. 68 PR GY -9.458 0.25 -0.1667
    63. 68 PR GY -9.458 0.25 0.5
    64. 69 PR GY -9.458 0.25 0.1667
    65. 5 PR GY -9.458 -0.25 -0.1667
    66. 5 PR GY -9.458 -0.25 0.5
    67. 8 PR GY -9.458 -0.25 0.1667
    68. 11 PR GY -9.458 -0.25 -0.1667
    69. 11 PR GY -9.458 -0.25 0.5
    70. 14 PR GY -9.458 -0.25 0.1667
    71. 51 PR GY -9.458 -0.25 -0.1667
    72. 51 PR GY -9.458 -0.25 0.5
    73. 54 PR GY -9.458 -0.25 0.1667
    74. 57 PR GY -9.458 -0.25 -0.1667
    75. 57 PR GY -9.458 -0.25 0.5
    76. 60 PR GY -9.458 -0.25 0.1667
    77. PERFORM ANALYSIS
```

P R O B L E M   S T A T I S T I C S

```
 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     78/    60/    78

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

 ORIGINAL/FINAL BAND-WIDTH=    39/    10/     66 DOF
 TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =     468
 SIZE OF STIFFNESS MATRIX =        31 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.6/ 263298.9 MB
```

Summary Result From Staad Pro Analysis Output

Standard Panel Size	Barmat Type	Panel Type	Horz Rebar	Vert Rebar	Staad Pro Output				Data for AASHTO LRFD Design Check			
					Mx (kNm/m)	My (kNm/m)	SQx (N/mm^2)	SQy (N/mm^2)	Mx (Kips-ft/ft)	My (Kips-ft/ft)	SQx (lbs/in^2)	SQy (lbs/in^2)
5'x12'	3W11	A	4 #4	8 #4	3.150	6.090	0.124	0.156	0.708	1.369	17.985	22.626
	4W11				3.620	6.780	0.128	**0.169**	0.814	1.524	18.565	**24.511**
	5W11				4.370	6.380	0.147	0.138	0.982	1.434	21.321	20.015
	6W11				**4.770**	**6.800**	**0.150**	0.143	**1.072**	**1.529**	**21.756**	20.740
	4W20	X	8 #4	12 #4	7.200	13.500	0.254	**0.336**	1.619	3.035	36.840	**48.733**
	5W20				8.690	12.700	0.291	0.275	1.954	2.855	42.206	39.885
	6W20				**9.470**	**13.500**	**0.298**	0.284	**2.129**	**3.035**	**43.221**	41.191
	5W24	Y	9#4	12 #4	10.600	15.500	0.357	0.337	2.383	3.484	51.779	48.878
	6W24				**11.600**	**16.600**	**0.365**	**0.349**	**2.608**	**3.732**	**52.939**	**50.618**

* Maximum bending moment and shear for each standard panel size shown in **red bold** font

5’ x 12’ STANDARD

A PANEL

Typical Panel Type A, Panel Thickness 6", 5'x12', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	15	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.157	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.53	kip-ft	$+M_{u\_service}$	=	1.13	kip-ft	(FK = 1.35)
$-M_u$	=	0.74	kip-ft	$-M_{u\_service}$	=	0.55	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.231 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.923 kip-ft

Check $+\varphi M_n > +M_u$ 2.923 > 1.53 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.231 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.155 kip-ft

Check $-\varphi M_n > -M_u$ 1.155 > 0.74 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.20		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	2.32	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	2.03	kip-ft
Cracking moment	=	2.32	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	2.03	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 2.923 > 2.03 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.98	kip-ft
Cracking moment	=	2.32	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.98	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 1.155 > 0.98 **OK**

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x12', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^{1}/_{4}\,\pi d_b{}^2$
Rebar spacing	s	=	15	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.157	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s\,.\,f_s}{\alpha_1.\,f_c{}'.\,\beta_1\,.\,b}$	c	=	0.272	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	4.114	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316\,.\,\beta\,.\,\alpha\,.\sqrt{f_c{}'}\,.\,b_v\,.\,d_v$	Vc	=	6.240	Kips
$V_s = \frac{A_v\,.\,f_y\,.\,d_v\,.\,(\cot\theta + \cot\alpha)\,.\sin\alpha}{s}$	Vs	=	3.231	Kips
	(1) Vn	=	9.472	Kips
(2) $V_n = 0.25\,.\,f_c'.\,b_v\,.\,d_v$	(2) Vn	=	49.369	Kips
From (1) and (2) Vn should be:	Vn	=	9.472	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	8.524	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.169	N/mm^2		
	=	24.51	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1764.82	lbs		
	=	1.765	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type A, Panel Thickness 6", 5'x12', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\, \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	1.07	kip-ft	$+M_{u\_service}$	=	0.79	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 2.152 kip-ft

Check $+\varphi M_n > +M_u$ 2.152 > 1.07 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.192 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.269 kip-ft

Check $-\varphi M_n > -M_u$ 1.269 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	1.43	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	1.43	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 2.152 > 1.43 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.269 > 0.00 **OK**

Typical Panel Type A, Panel Thickness 6", 5'x12', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4\, \pi d_b{}^2$
Rebar spacing	s	=	18	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.131	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c' . \beta_1 \,.\, b}$	c	=	0.226	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.137	in	

AASHTO 5.7.3.3

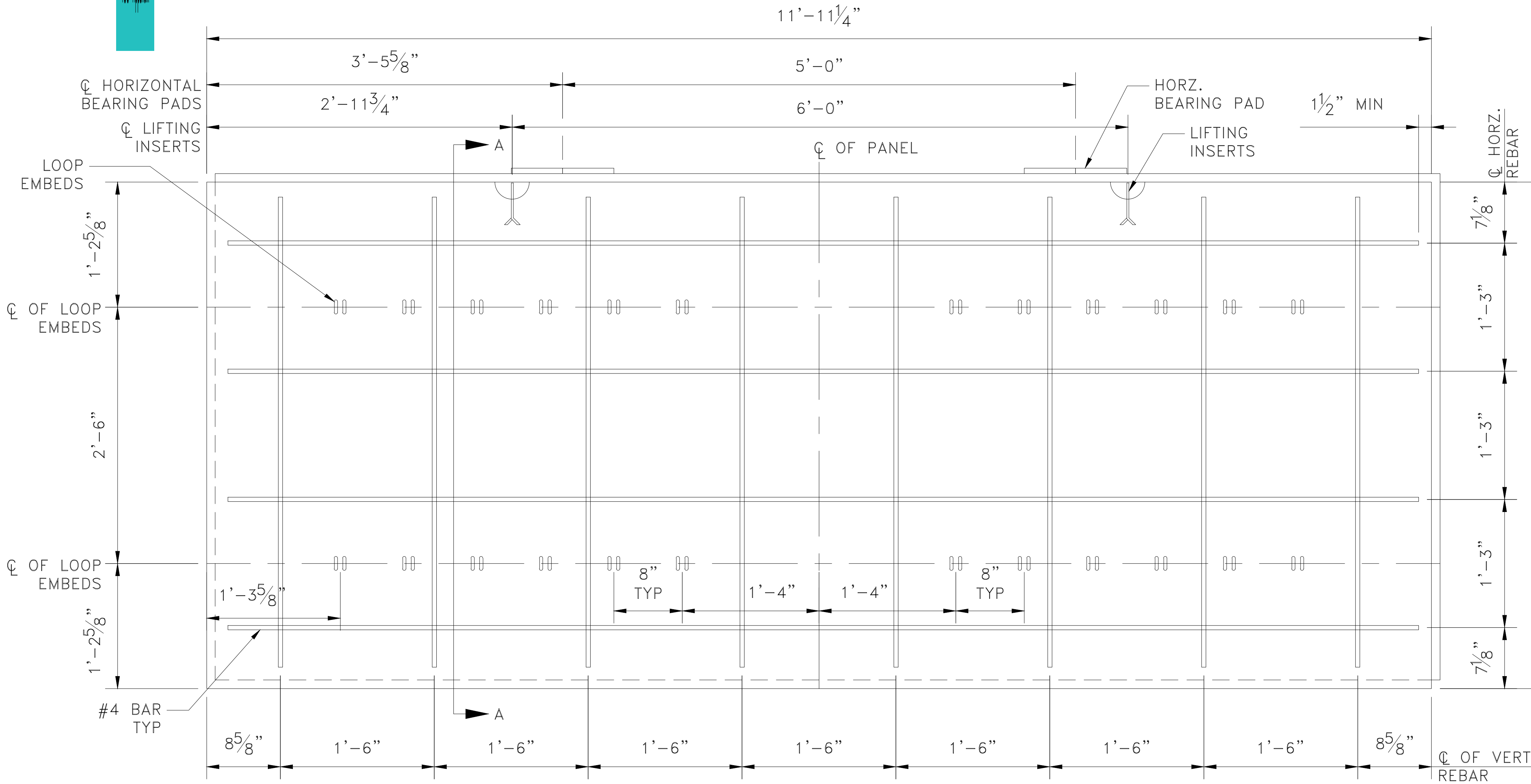
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c'} \,.\, b_v \,.\, d_v$	Vc	=	4.758	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	2.053	Kips
	(1) Vn	=	6.811	Kips
(2) $V_n = 0.25 \,.\, f_c' . b_v \,.\, d_v$	(2) Vn	=	37.641	Kips
From (1) and (2) Vn should be:	Vn	=	6.811	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.130	Kips

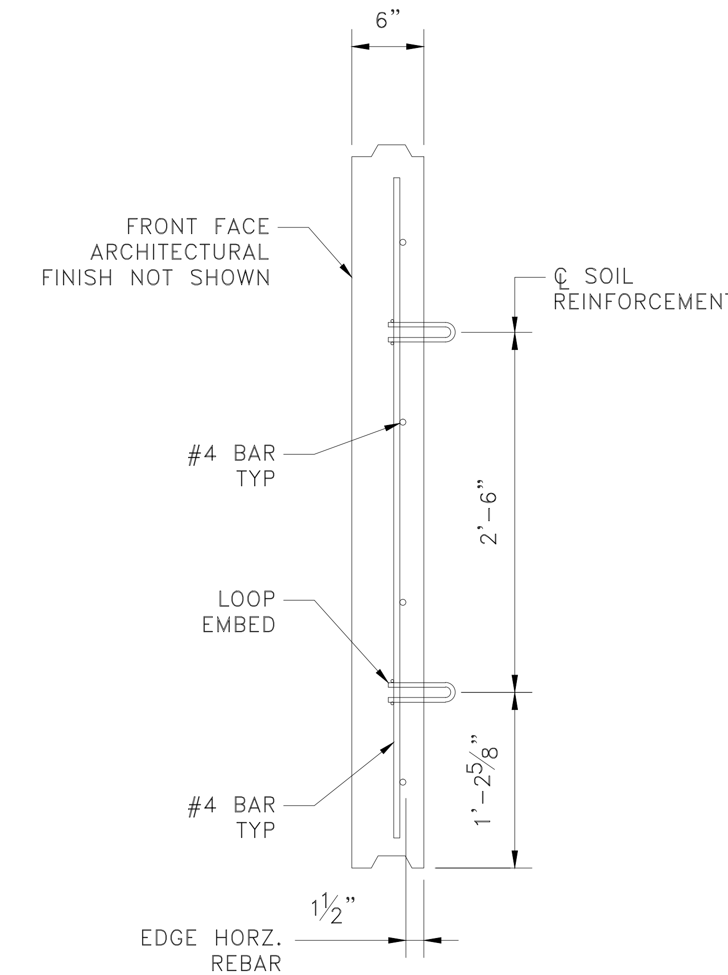
Shear Force:

From Staad Pro Result Vmax	=	0.15	N/mm^2		
	=	21.76	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	1566.41	lbs		
	=	1.566	Kips	**OK, Vmax less than Vn**	

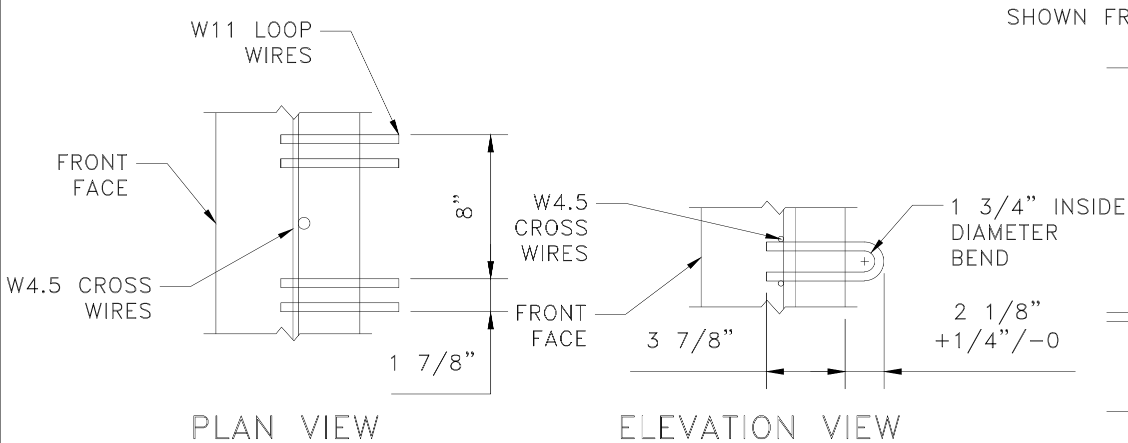


STANDARD "A" PANEL

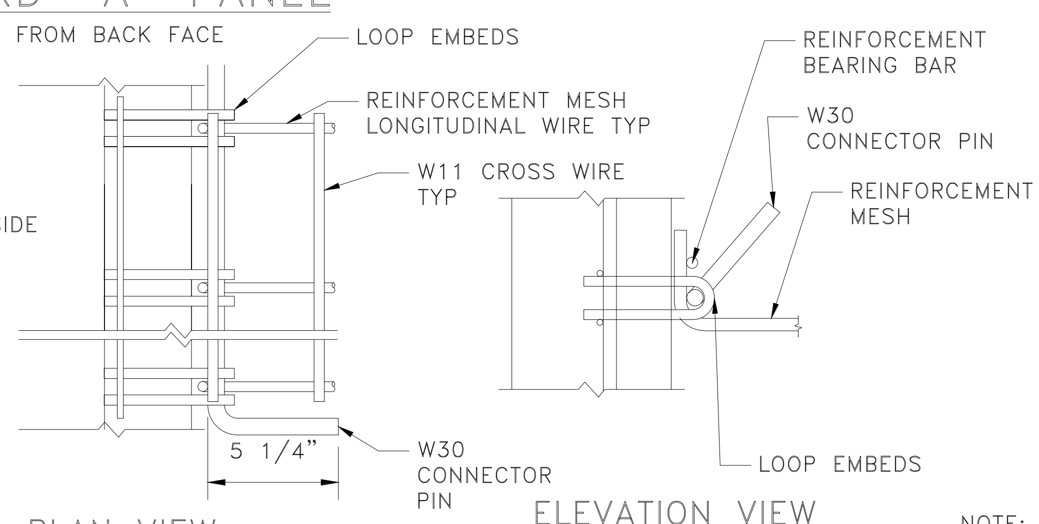
SHOWN FROM BACK FACE



SECTION A–A



LOOP EMBED DETAILS



REINFORCING MESH CONNECTOR BAR DETAIL

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'A' 5'X12' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 12’ STANDARD

X PANEL

Typical Panel Type X, Panel Thickness 6", 5'x12', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per

AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.

This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	7.5	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.314	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	3.04	kip-ft	$+M_{u\_service}$	=	2.25	kip-ft	(FK = 1.35)
$-M_u$	=	1.47	kip-ft	$-M_{u\_service}$	=	1.09	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.462 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 5.682 kip-ft

Check $+\varphi M_n > +M_u$ 5.682 > 3.04 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.462 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 2.147 kip-ft

Check $-\varphi M_n > -M_u$ 2.147 > 1.47 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right)\right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.20		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	2.32	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	4.04	kip-ft
Cracking moment	=	2.32	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	2.32	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 5.682 > 2.32 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	1.95	kip-ft
Cracking moment	=	2.32	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	1.95	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 2.147 > 1.95 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x12', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	8	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.314	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c{}' . \beta_1 \,.\, b}$	c	=	0.544	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.978	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c{}'} \,.\, b_v \,.\, d_v$	Vc	=	6.034	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	6.249	Kips
	(1) Vn	=	12.283	Kips
(2) $V_n = 0.25 \,.\, f_c' . b_v \,.\, d_v$	(2) Vn	=	47.739	Kips
From (1) and (2) Vn should be:	Vn	=	12.283	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	11.055	Kips

Shear Force:

From Staad Pro Result Vmax	=	0.336	N/mm^2		
	=	48.73	lbs/in^2		
Shear Section Area	=	b	x	tpanel	
	=	12	x	6	
Vmax	=	3508.76	lbs		
	=	3.509	Kips	**OK, Vmax less than Vn**	

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x12', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.13	kip-ft	$+M_{u\_service}$	=	1.58	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 3.186 kip-ft

Check $+\varphi M_n > +M_u$ 3.186 > 2.13 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 1.860 kip-ft

Check $-\varphi M_n > -M_u$ 1.860 > 0.00 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	2.83	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored +M_u and M_{cr})	=	2.83	kip-ft

Check: $+\varphi M_n > \min(+M_u\,, M_{cr})$ 3.186 > 2.83 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored -M_u and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u\,, M_{cr})$ 1.860 > 0.00 **OK**

TOC – Appendix

Typical Panel Type X, Panel Thickness 6", 5'x12', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s . f_s}{\alpha_1 . f_c{}' . \beta_1 . b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 . \beta . \alpha . \sqrt{f_c{}'} . b_v . d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v . f_y . d_v . (\cot\theta + \cot\alpha) . \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 . f_c' . b_v . d_v$	(2) Vn	=	36.962	Kips

From (1) and (2) Vn should be: Vn = 7.696 Kips

ϕ . Vn = 0.9 . Vn

= 6.926 Kips

Shear Force:

From Staad Pro Result Vmax = 0.298 N/mm^2

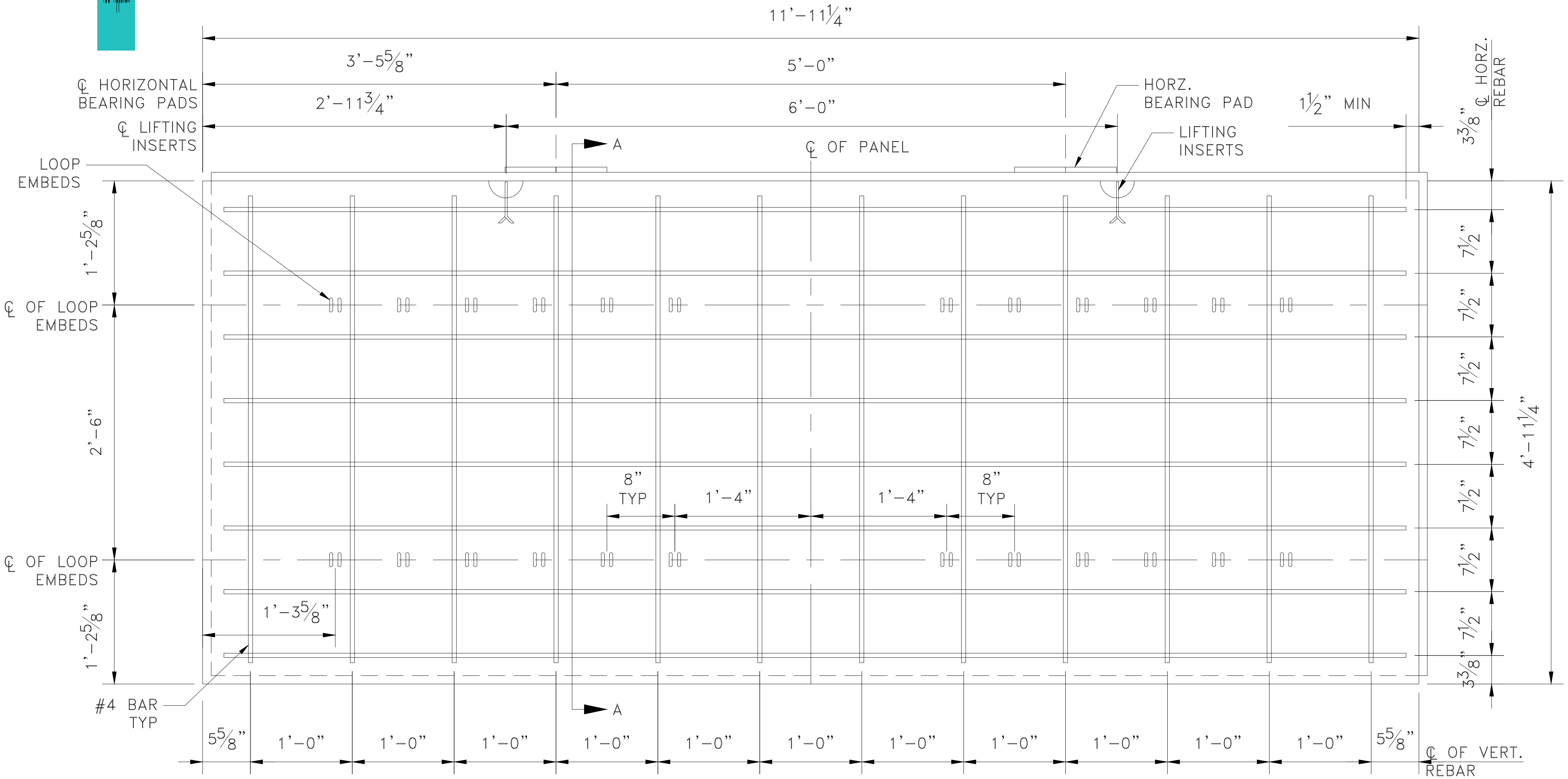
= 43.22 lbs/in^2

Shear Section Area = b x tpanel

= 12 x 6

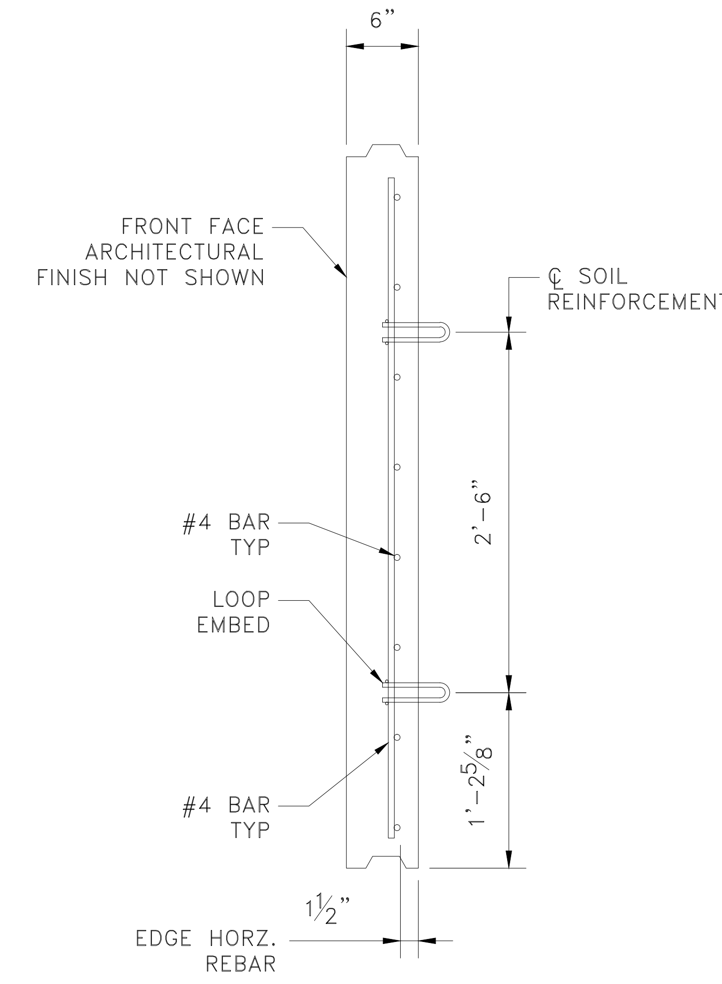
Vmax = 3111.94 lbs

= 3.112 Kips **OK, Vmax less than Vn**



STANDARD "X" PANEL

SHOWN FROM BACK FACE



SECTION A–A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
18" MAX SPACING BETWEEN BARS

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DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'X' 5'X12' PANEL DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

5’ x 12’ STANDARD

Y PANEL

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x12', Horizontal Rebar

Panel Strength Design

Design of panel reinforcement per

AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.

This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	6.66	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	4.25	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	1.75	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.354	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	3.73	kip-ft	$+M_{u\_service}$	=	2.76	kip-ft	(FK = 1.35)
$-M_u$	=	1.80	kip-ft	$-M_{u\_service}$	=	1.33	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.520 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \dfrac{a}{2}\right)$ = 6.352 kip-ft

Check $+\varphi M_n > +M_u$ 6.352 > 3.73 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.520 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \dfrac{a}{2}\right)$ = 2.372 kip-ft

Check $-\varphi M_n > -M_u$ 2.372 > 1.80 **OK**

TOC – Appendix

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.20		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	2.32	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment		=	4.96	kip-ft
Cracking moment		=	2.32	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})		=	2.32	kip-ft
Check: $+\varphi M_n > \min(+M_u, M_{cr})$	6.352	>	2.32	**OK**

check negative moment reinforcement:

1.33 x factored ultimate moment		=	2.39	kip-ft
Cracking moment		=	2.32	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})		=	2.32	kip-ft
Check: $-\varphi M_n > \min(-M_u, M_{cr})$	2.372	>	2.32	**OK**

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x12', Horizontal Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	1.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	7	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.354	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \,.\, f_s}{\alpha_1 . f_c{}' . \beta_1 \,.\, b}$	c	=	0.612	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.944	in	

AASHTO 5.7.3.3

Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \,.\, \beta \,.\, \alpha \,.\, \sqrt{f_c{}'} \,.\, b_v \,.\, d_v$	Vc	=	5.982	Kips
$V_s = \frac{A_v \,.\, f_y \,.\, d_v \,.\, (\cot\theta + \cot\alpha) \,.\, \sin\alpha}{s}$	Vs	=	6.977	Kips
	(1) Vn	=	12.959	Kips
(2) $V_n = 0.25 \,.\, f_c'.b_v \,.\, d_v$	(2) Vn	=	47.328	Kips

From (1) and (2) Vn should be: Vn = 12.959 Kips

ϕ . Vn = 0.9 . Vn

= 11.663 Kips

Shear Force:

From Staad Pro Result Vmax = 0.349 N/mm^2

= 50.62 lbs/in^2

Shear Section Area = b x tpanel

= 12 x 6

Vmax = 3644.51 lbs

= 3.645 Kips **OK, Vmax less than Vn**

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x12', Vertical Rebar

Panel Strength Design

Design of panel reinforcement per
AASHTO LRFD Bridge Design Specification 5.7.3 (typical rectangular beam design)

The following design method can be used for normal weight concrete with specified compressive strength up to 15.0 ksi.
This Design are to present the information about the acceptable panel reinforcement sizes and spacing.

Panel Thickness	t_{panel}	=	6	in	
Finishing Thickness		=	1	in	
Additional Load from Finishes		=	0.0125	Kip/ft^2	
Concrete Cover	C_{panel}	=	1.5	in	
Vertical Bar Size #4					Logitudinal Bar Size #4
Rebar Diameter	d_b	=	0.5	in	d_{bh} = 0.5 in
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Effective depth of section	d_s	=	3.75	in	$d_s = t_{panel} - C_{panel} - d_{bh} - {}^1/_2\, d_b$
Effective depth of section for Negative Moment	$d_{s(M^-)}$	=	2.25	in	$d_{s(M^-)} = t_{panel} - d_s$
Correction factor for source aggregate	K_1	=	1	in	AASHTO 5.4.2.4
Concrete Density	W_c	=	0.15	kcf	
Concrete Strength	f'_c	=	4.00	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Modulus Elasticity of concrete	Ec	=	4266	ksi	$E_c = 120000 k_1 W_c{}^2 f'_c{}^{0.33}$
Modulus Elasticity of reinforcement	Es	=	29000	ksi	
Modular Ratio	n	=	6.798		$n = Es/Ec$
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$

$+M_u$	=	2.61	kip-ft	$+M_{u\_service}$	=	1.93	kip-ft	(FK = 1.35)
$-M_u$	=	0.00	kip-ft	$-M_{u\_service}$	=	0.00	kip-ft	(FK = 1.35)

Resistance factor for tension-controlled section φ_{STR} = 0.90 AASHTO 5.5.4.2

Positive Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $+\varphi M_n = \varphi A_s f_y \left(d_s - \frac{a}{2}\right)$ = 3.186 kip-ft

Check $+\varphi M_n > +M_u$ 3.186 > 2.61 **OK**

Negative Moment Capacity

Depth of equivalent stress block $a = \dfrac{A_s f_y}{0.85 f'_c b}$ = 0.289 in

Factored flexural resistance $-\varphi M_n = \varphi A_s f_y \left(d_{s(M^-)} - \frac{a}{2}\right)$ = 1.860 kip-ft

Check $-\varphi M_n > -M_u$ 1.860 > 0.00 **OK**

Minimum Reinforcement AASHTO 5.7.3.3.2

Unless otherwise specified, the amount of prestressed and non-prestressed tensile reinforcement shall be adequate to develop a factored flexural resistance, Mr = φMn, at least equal to the lesser of:

1.33 times the positive factored ultimate moment

Cracking moment

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 \gamma_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right]$$ AASHTO 5.7.3.3.2-1

When simplified by removing all values applicable to prestressed and non composite section, this equation becomes the following:

$$M_{cr} = \gamma_3 \gamma_1 f_r S_c$$

where:

flexural cracking variability factor		γ_1	=	1.60		(non-segmental brg)
ratio of specified min. yield strength to ultimate tensile strength		γ_3	=	0.67		(A615 steel)
concrete density modification factor		λ	=	1.00		AASHTO 5.4.2.8
modulus of rapture	$f_r = 0.24\lambda\sqrt{f_c'}$	f_r	=	0.48	ksi	AASHTO 5.4.2.6
section modulus of design section	$S_c = \frac{b\,h^2}{6} = \frac{bt_{panel}{}^2}{6}$	S_c	=	72.00	in^3	
Cracking moment	$M_{cr} = \gamma_3 \gamma_1 f_r S_c$	M_{cr}	=	3.09	kip-ft	

check positive moment reinforcement:

1.33 x factored ultimate moment	=	3.47	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $+M_u$ and M_{cr})	=	3.09	kip-ft

Check: $+\varphi M_n > \min(+M_u, M_{cr})$ 3.186 > 3.09 **OK**

check negative moment reinforcement:

1.33 x factored ultimate moment	=	0.00	kip-ft
Cracking moment	=	3.09	kip-ft
min from (1.33 x factored $-M_u$ and M_{cr})	=	0.00	kip-ft

Check: $-\varphi M_n > \min(-M_u, M_{cr})$ 1.860 > 0.00 **OK**

TOC – Appendix

Typical Panel Type Y, Panel Thickness 6", 5'x12', Vertical Rebar

Shear on Panel

Panel Thickness	t_{panel}	=	6	in	
Concrete Cover	C_{panel}	=	2.5	in	
Concrete Strength	f'_c	=	4.0	ksi	(Concrete Class A compressive strength)
Reinforcement Strength	f_y	=	60	ksi	(Minimum yield strength of grade 60 steel)
Bar Size #4					
Rebar Diameter	d_b	=	0.500	in	
Rebar Area	A_b	=	0.196	in^2	$A_b = {}^1/_4 \pi d_b{}^2$
Rebar spacing	s	=	12	in	
Width of the design section	b	=	12	in	
Area of Steel per Design Strip	A_s	=	0.196	in^2	$A_s = b(\frac{A_b}{s})$
$c = \frac{A_s \, . \, f_s}{\alpha_1 . f_c{}' . \beta_1 \, . \, b}$	c	=	0.340	in	
$d_v = t_{panel} - \frac{c}{2} - C_{panel} - \frac{d_b}{2}$	d_v	=	3.080	in	

AASHTO 5.7.3.3

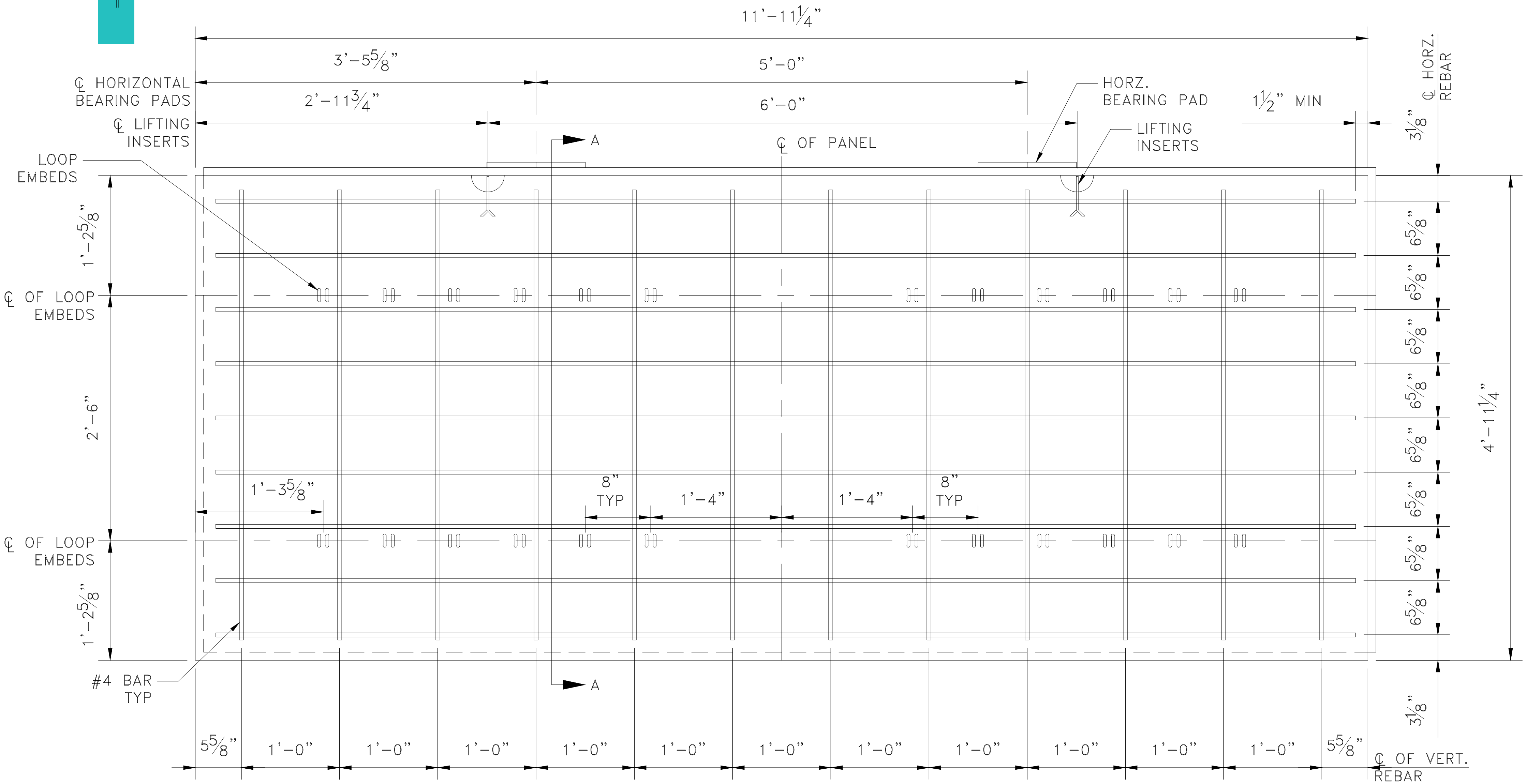
Vn shall be the lesser of:

(1) $V_n = V_c + V_s$

$V_c = 0.0316 \, . \, \beta \, . \, \alpha \, . \sqrt{f_c{}'} \, . \, b_v \, . \, d_v$	Vc	=	4.672	Kips
$V_s = \frac{A_v \, . \, f_y \, . \, d_v \, . \, (\cot\theta + \cot\alpha) \, . \sin\alpha}{s}$	Vs	=	3.024	Kips
	(1) Vn	=	7.696	Kips
(2) $V_n = 0.25 \, . \, f_c' . \, b_v \, . \, d_v$	(2) Vn	=	36.962	Kips
From (1) and (2) Vn should be:	Vn	=	7.696	Kips
	ϕ . Vn	=	0.9 . Vn	
		=	6.926	Kips

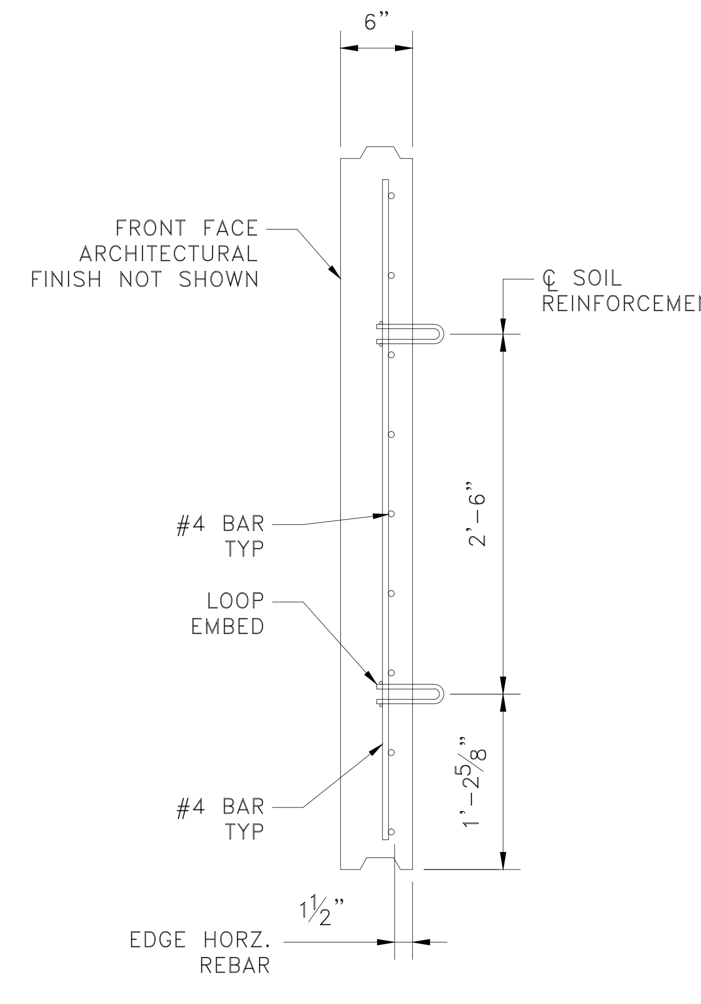
Shear Force:

From Staad Pro Result Vmax	=	0.365	N/mm^2	
	=	52.94	lbs/in^2	
Shear Section Area	=	b	x	tpanel
	=	12	x	6
Vmax	=	3811.60	lbs	
	=	3.812	Kips	**OK, Vmax less than Vn**



STANDARD "Y" PANEL

SHOWN FROM BACK FACE



SECTION A-A

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

NOTE:
TYPICAL PANEL REINFORCEMENT SHOWN, ALTERNATIVE REINFORCEMENT MAY BE USED AS LONG AS MINIMUM CROSS SECTIONAL AREAS ARE EQUIVALENT.
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DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

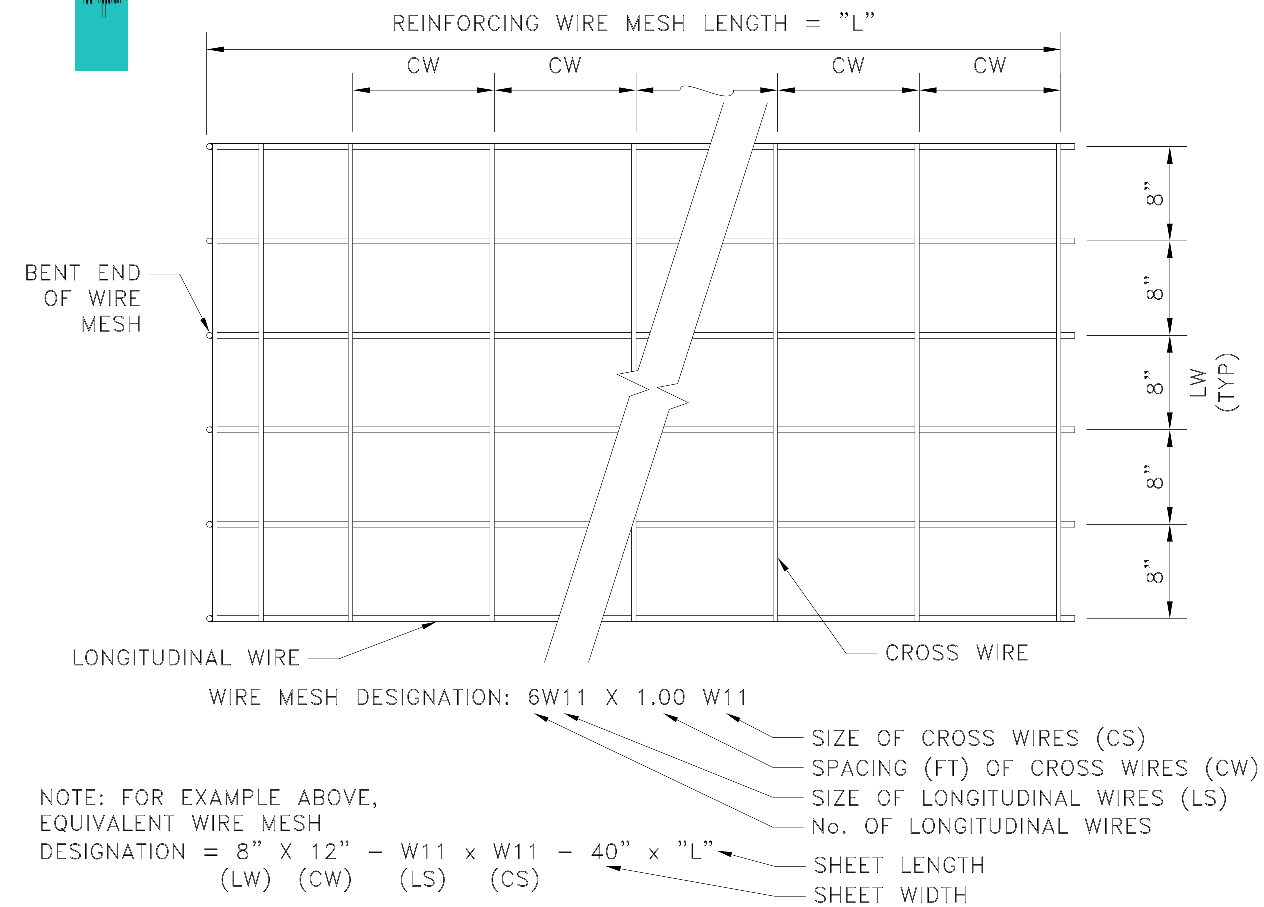
NO.	DATE	REVISION DESCRIPTION	BY

TYPE 'Y' 5'X12' PANEL DETAILS

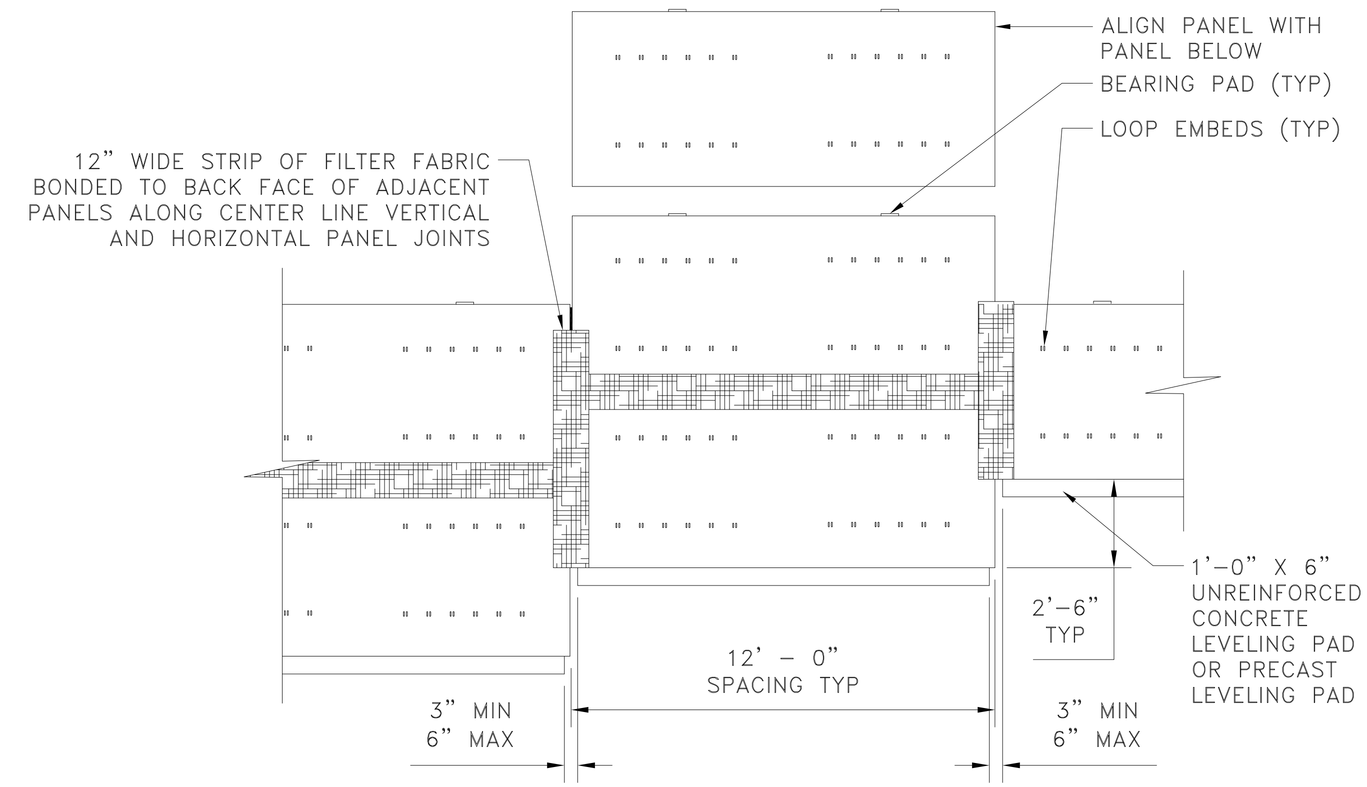
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

1.1.8 Face Unit Bearing Devices

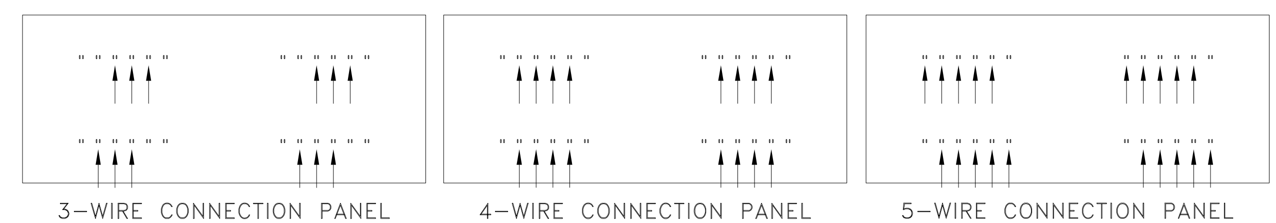


REINFORCING MESH DETAIL



FILTER FABRIC DETAIL & PANEL PLACEMENT

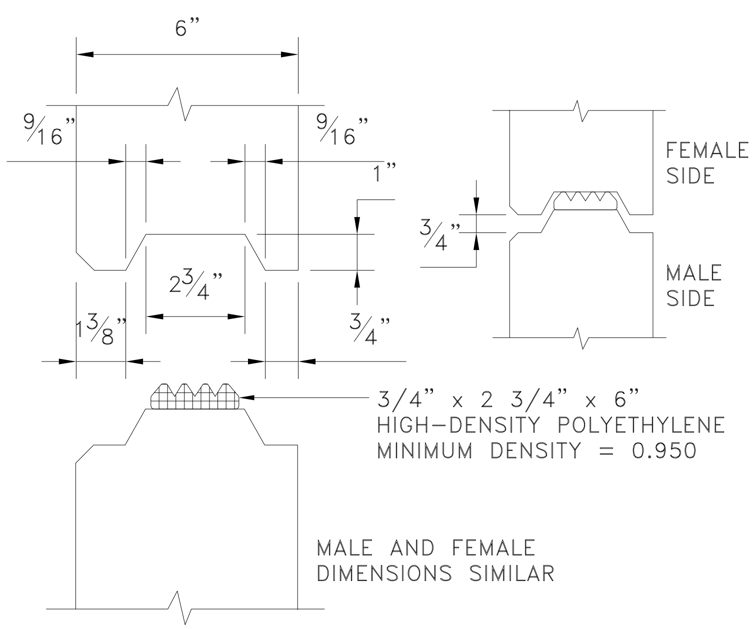
BACK FACE VIEW



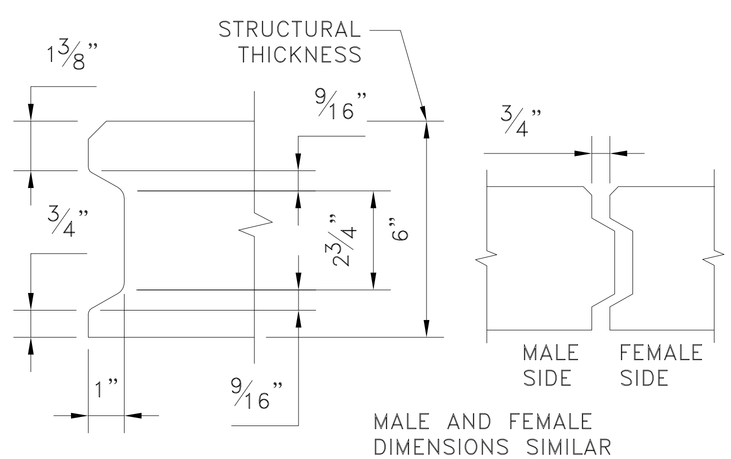
ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

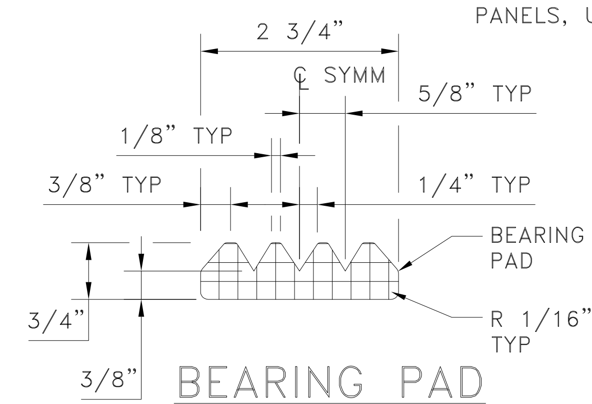
NOTE: FOR SIX AND EIGHT WIRE CONNECTION PANELS, USE ALL CONNECTION POINTS PROVIDED.



HORIZONTAL PANEL JOINT DETAIL



VERTICAL PANEL JOINT DETAIL



BEARING PAD DETAIL

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

STANDARD DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

INNOVATIVE CONSTRUCTION PRODUCTS

1.1.9 Facing Unit Filter Cloth Specification

TOC – Appendix

TenCate Mirafi®

SEPARATION FILTRATION EROSION PROTECTION

Mirafi® FW402

Mirafi® FW402 is composed of high-tenacity monofilament polypropylene yarns, which are woven into a stable network such that the yarns retain their relative position. Mirafi® FW402 geotextile is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids

TenCate Geosynthetics Americas Laboratories are accredited by Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP Listed

MECHANICAL PROPERTIES	TEST METHOD	UNIT	MINIMUM AVERAGE ROLL VALUE	
			MD	CD
Grab Tensile Strength	ASTM D4632	lbs (N)	365 (1624)	200 (890)
Grab Tensile Elongation	ASTM D4632	%	24	10
Trapezoid Tear Strength	ASTM D4533	lbs (N)	115 (512)	75 (334)
CBR Puncture Strength	ASTM D6241	lbs (N)	675 (3004)	

MECHANICAL PROPERTIES	TEST METHOD	UNIT	MINIMUM ROLL VALUE
Percent Open Area	COE-02215	%	10
Permittivity	ASTM D4491	sec^{-1}	2.1
Flow Rate	ASTM D4491	$gal/min/ft^2$ ($l/min/m^2$)	145 (5907)
			Maximum Opening Size
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve (mm)	40 (0.425)
			Minimum Test Value
UV Resistance (at 500 Hours)	ASTM D4355	% strength retained	90

PHYSICAL PROPERTIES	UNIT	TYPICAL ROLL VALUE
Roll Dimensions (width x length)	ft (mm)	12.5 x 300 (3.8 x 91)
Roll Area	yd^2 (m^2)	417 (348)
Roll Weight	lbs (kg)	178 (81)

FSG000070
ETQR64

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Pendergrass, GA 30567
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www.tencategeo.us

NTPEP NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM GMA TENCATE GEOSYNTHETICS

1.1.10 Facing Unit Aesthetic Options

Fracture Fin with Buttresses

Vertical Flute with Artwork

Seashells

Offset Vertical Flute

Integral Color Raised Relief with Exposed Aggregate

Fracture Fin with Pattern

1.2
Inextensible Reinforcements

1.2.3 Soil Reinforcement Properties
ASTM A1064

INTERNATIONAL

Designation: A1064/A1064M – 17

Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete[1]

This standard is issued under the fixed designation A1064/A1064M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers carbon-steel wire and welded wire reinforcement produced from hot-rolled rod to be used for the reinforcement of concrete. The steel wire is cold-worked, drawn or rolled, plain (non-deformed, as-drawn or galvanized), or deformed. Welded wire reinforcement is made from plain or deformed wire, or a combination of plain and deformed wire. Common wire sizes and dimensions are given in Table 1, Table 2, Table 3, and Table 4. Actual wire sizes are not restricted to those shown in the tables.

NOTE 1—Welded wire for concrete reinforcement has historically been described by various terms: welded wire fabric, WWF, fabric, and mesh. The wire reinforcement industry has adopted the term *welded wire reinforcement* (WWR) as being more representative of the applications of the products being manufactured. Therefore, the term *welded wire fabric* has been replaced with the term *welded wire reinforcement* in this specification and in related specifications.

1.2 The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text the SI units are shown in brackets (except in Table 2 and Table 4). The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values may result in nonconformance with the specification.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A641/A641M Specification for Zinc–Coated (Galvanized) Carbon Steel Wire

E83 Practice for Verification and Classification of Extensometer Systems

2.2 *U.S. Military Standard:*[3]

MIL-STD-129 Marking for Shipment and Storage

2.3 *U.S. Military Standard:*[3]

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

2.4 *American Concrete Institute (ACI) Standard:*[4]

ACI 318 Building Code Requirements for Structural Concrete

2.5 *Adjuncts:*

Weld Tester Drawing [5]

3. Terminology

3.1 *Definitions of Terms Specific to This Specification:*

3.1.1 *convoluted wire*—plain wire for welded wire reinforcement that is formed into a sinusoidal wave shape; deformed wire is not subject to convolution unless agreed upon by the purchaser and manufacturer.

3.1.1.1 *Discussion*—The wire is used in the manufacture of cages for certain applications of concrete pipe reinforcement.

3.1.2 *deformed wire and deformed welded wire reinforcement*—a material composed of cold-worked deformed steel wire as cold-drawn or cold-rolled from hot-rolled steel rod.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

Current edition approved March 15, 2017. Published March 2017. Originally approved in 2009. Last previous edition approved in 2016 as A1064/A1064M – 16b. DOI: 10.1520/A1064_A1064M-17.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.

[5] Available from ASTM International Headquarters. Order Adjunct No. ADJA0185. Original adjunct produced in 1967.

***A Summary of Changes section appears at the end of this standard**

TABLE 1 Dimensional Requirements for Plain Wire—Inch-Pound Units[A]

SizeNumber[B,C,D]	Nominal Diameter in. [mm][E]	Nominal Area in.^{2} [mm^2]
W 0.5	0.080 [2.03]	0.005 [3.23]
W 1.2	0.124 [3.14]	0.012 [7.74]
W 1.4	0.134 [3.39]	0.014 [9.03]
W 2	0.160 [4.05]	0.020 [12.9]
W 2.5	0.178 [4.53]	0.025 [16.1]
W 2.9	0.192 [4.88]	0.029 [18.7]
W 3.5	0.211 [5.36]	0.035 [22.6]
W 4	0.226 [5.73]	0.040 [25.8]
W 4.5	0.239 [6.08]	0.045 [29.0]
W 5	0.252 [6.41]	0.050 [32.3]
W 5.5	0.265 [6.72]	0.055 [35.5]
W 6	0.276 [7.02]	0.060 [38.7]
W 8	0.319 [8.11]	0.080 [51.6]
W 10	0.357 [9.06]	0.100 [64.5]
W 11	0.374 [9.50]	0.110 [71.0]
W 12	0.391 [9.93]	0.120 [77.4]
W 14	0.422 [10.7]	0.140 [90.3]
W 16	0.451 [11.5]	0.160 [103]
W 18	0.479 [12.2]	0.180 [116]
W 20	0.505 [12.8]	0.200 [129]
W 22	0.529 [13.4]	0.220 [142]
W 24	0.553 [14.0]	0.240 [155]
W 26	0.575 [14.6]	0.260 [168]
W 28	0.597 [15.2]	0.280 [181]
W 30	0.618 [15.7]	0.300 [194]
W 31	0.628 [16.0]	0.310 [200]
W 45	0.757 [19.2]	0.450 [290]

[A] Table 1 should be used on projects that are designed using inch-pound units; Table 2 should be used on projects that are designed using SI units.
[B] The number following the prefix indicates the nominal cross-sectional area of the wire in square inches multiplied by 100.
[C] For sizes other than those shown above, the Size Number shall be the number of one hundredth of a square inch in the nominal area of the wire cross section, prefixed by the W.
[D] These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufactures can produce them in 0.0015 in.^{2} increments.
[E] The nominal diameter is based on the nominal area of the wire.

TABLE 2 Dimensional Requirements for Plain Wire—SI Units[A]

Size Number[B, C, D]	Nominal Diameter mm [in.][E]	Nominal Area mm^2 [in.^{2}]
MW 5	2.52 [0.099]	5 [0.008]
MW 10	3.57 [0.140]	10 [0.016]
MW 15	4.37 [0.172]	15 [0.023]
MW 20	5.05 [0.199]	20 [0.031]
MW 25	5.64 [0.222]	25 [0.039]
MW 30	6.18 [0.243]	30 [0.047]
MW 35	6.68 [0.263]	35 [0.054]
MW 40	7.14 [0.281]	40 [0.062]
MW 45	7.57 [0.298]	45 [0.070]
MW 50	7.98 [0.314]	50 [0.078]
MW 55	8.37 [0.329]	55 [0.085]
MW 60	8.74 [0.344]	60 [0.093]
MW 65	9.10 [0.358]	65 [0.101]
MW 70	9.44 [0.372]	70 [0.109]
MW 80	10.1 [0.397]	80 [0.124]
MW 90	10.7 [0.421]	90 [0.140]
MW 100	11.3 [0.444]	100 [0.155]
MW 120	12.4 [0.487]	120 [0.186]
MW 130	12.9 [0.507]	130 [0.202]
MW 200	16.0 [0.628]	200 [0.310]
MW 290	19.2 [0.757]	290 [0.450]

[A] The wire sizes in Table 1 should be used on projects that are designed using inch-pound units; the wire sizes in Table 2 should be used on projects that are designed using SI units.
[B] The number following the prefix indicates the nominal cross-sectional area of the wire in square milimetres.
[C] For sizes other than those shown above, the Size Number shall be the number of square millimetres in the nominal area of the wire cross section, prefixed by the MW.
[D] These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufactures can produce them in 1 mm^2 increments.
[E] The nominal diameter is based on the nominal area of the wire.

3.1.2.1 *Discussion*—Deformations can be either indented or

TABLE 3 Dimensional Requirements for Deformed Wire—Inch-Pound Units

	Nominal Dimensions			Deformation Requirements
Deformed Wire Size[A, B, C, D]	Unit Weight, lb/ft	Diameter, in.[E]	Cross-Sectional Area, in.^{2} [F]	Minimum Average Height of Deformations, in.[G, H]
D 1	0.034	0.113	0.010	0.0045
D 2	0.068	0.160	0.020	0.0063
D 3	0.102	0.195	0.030	0.0078
D 4	0.136	0.226	0.040	0.0101
D 5	0.170	0.252	0.050	0.0113
D 6	0.204	0.276	0.060	0.0124
D 7	0.238	0.299	0.070	0.0134
D 8	0.272	0.319	0.080	0.0143
D 9	0.306	0.339	0.090	0.0152
D 10	0.340	0.357	0.100	0.0160
D 11	0.374	0.374	0.110	0.0187
D 12	0.408	0.391	0.120	0.0195
D 13	0.442	0.407	0.130	0.0203
D 14	0.476	0.422	0.140	0.0211
D 15	0.510	0.437	0.150	0.0218
D 16	0.544	0.451	0.160	0.0225
D 17	0.578	0.465	0.170	0.0232
D 18	0.612	0.479	0.180	0.0239
D 19	0.646	0.492	0.190	0.0245
D 20	0.680	0.505	0.200	0.0252
D 21	0.714	0.517	0.210	0.0259
D 22	0.748	0.529	0.220	0.0265
D 23	0.782	0.541	0.230	0.0271
D 24	0.816	0.553	0.240	0.0277
D 25	0.850	0.564	0.250	0.0282
D 26	0.884	0.575	0.260	0.0288
D 27	0.918	0.586	0.270	0.0293
D 28	0.952	0.597	0.280	0.0299
D 29	0.986	0.608	0.290	0.0304
D 30	1.02	0.618	0.300	0.0309
D 31	1.05	0.628	0.310	0.0314
D 45	1.53	0.757	0.450	0.0379

[A] The wire sizes in Table 3 should be used on projects that are designed using inch-pound units; the wire sizes in Table 4 should be used on projects that are designed using SI units.
[B] The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square inches multiplied by 100.
[C] For sizes other than those shown above, the Size Number shall be the number of one hundredths of a square inch in the nominal area of the deformed wire cross section, prefixed by the D.
[D] These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 0.0015 in.^{2} increments.
[E] The nominal diameter of a deformed wire is equivalent to the nominal diameter of a plain wire having the same weight per foot as the deformed wire.
[F] The cross-sectional area is based on the weight of the wire. The area in square inches may be calculated by dividing the weight in pounds by 0.2833 (weight of 1 in.^{3} of steel) or by dividing the weight per lineal foot of specimen in pounds by 3.4 (weight of steel 1 in. square and 1 foot long).
[G] Measurements shall be made as described in 7.2.4.7.
[H] See 7.2.4.3 for average number of deformations per unit length.

raised transverse ribs (protrusions). The deformations and the welded intersections provide bond strength and anchorage.

3.1.3 *plain wire and plain welded wire reinforcement*—a material composed of cold-worked plain steel wire, as cold-drawn or cold-rolled from hot-rolled steel rod.

3.1.3.1 *Discussion*—The welded intersections provide anchorage.

4. Ordering Information

4.1 Orders for wire or welded wire reinforcement under this specification shall contain the following information:

4.1.1 Quantity (weight [mass]) or square area for welded wire reinforcement,

4.1.2 Name of material (cold-drawn or rolled steel wire, or welded wire reinforcement, plain or deformed, for concrete),

4.1.3 Wire size number, wire spacing, and sheet or roll width and length for welded wire reinforcement,

4.1.4 Minimum yield strength or Grade,

4.1.5 Packaging (see Section 15), and

4.1.6 ASTM designation and year of issue.

4.2 The purchaser shall have the option to specify additional requirements, including but not limited to, the following:

4.2.1 Exclusion of over-steeling (see 10.4.2 and 10.5.1),

4.2.2 Report on tests performed on the steel wire or welded wire reinforcement being furnished (see 14.1), and

4.2.3 Special requirements (if desired).

5. Materials

5.1 The steel shall be made by any commercially accepted process.

5.2 Unless otherwise specified, the wire shall be supplied uncoated. When plain wire is specified as galvanized, it shall be galvanized at finish size as described in Specification A641/A641M.

5.3 Wire used in the manufacture of welded wire reinforcement shall conform to this specification either solely or in combination of plain or deformed wire, or both.

TABLE 4 Dimensional Requirements for Deformed Wire—SI Units

	Nominal Dimensions				Deformation Requirements
Deformed Wire Size[A, B, C, D]	D [in.^{2} × 100]	Unit Mass, kg/m	Diameter, mm[E]	Cross-Sectional Area, mm^2 [F]	Minimum Average Height of Deformations, mm[G, H]
MD 25	[D 3.9]	0.196	5.64	25	0.252
MD 30	[D 4.7]	0.235	6.18	30	0.279
MD 35	[D 5.4]	0.275	6.68	35	0.302
MD 40	[D 6.2]	0.314	7.14	40	0.320
MD 45	[D 7.0]	0.353	7.57	45	0.342
MD 50	[D 7.8]	0.392	7.98	50	0.360
MD 55	[D 8.5]	0.432	8.37	55	0.378
MD 60	[D 9.3]	0.471	8.74	60	0.392
MD 65	[D 10.1]	0.510	9.10	65	0.455
MD 70	[D 10.9]	0.549	9.44	70	0.470
MD 80	[D 12.4]	0.628	10.1	80	0.505
MD 90	[D 14.0]	0.706	10.7	90	0.535
MD 100	[D 15.5]	0.785	11.3	100	0.565
MD 120	[D 18.6]	0.942	12.4	120	0.620
MD 130	[D 20.2]	1.02	12.9	130	0.645
MD 200	[D 31.0]	1.57	16.0	200	0.800
MD 290	[D 45.0]	2.28	19.2	290	0.961

[A] The wire sizes in Table 3 should be used on projects that are designed using inch-pound units; the wire sizes in Table 4 should be used on projects that are designed using SI units.
[B] The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square millimetres.
[C] For sizes other than those shown above, the Size Number shall be the number of square millimetres in the nominal area of the deformed wire cross section, prefixed by the MD.
[D] These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 1 mm^2 increments.
[E] The nominal diameter of a deformed wire is equivalent to the nominal diameter of a plain wire having the same weight per metre as the deformed wire.
[F] The cross-sectional area is based on the mass of the wire. The area in square millimetres may be calculated by dividing the unit mass in kg/mm by 7.849×10^{-6} (mass of 1 mm^3 of steel) or by dividing the unit mass in kg/m by 0.007849 (mass of steel 1 mm square and 1 m long).
[G] Measurements shall be made as described in 7.2.4.7.
[H] See 7.2.4.3 for average number of deformations per unit length.

6. Manufacture

6.1 The wire shall be cold-worked, drawn or rolled, from rods that have been hot-rolled from billets.

6.2 For welded wire reinforcement, the wires shall be assembled by automatic machines or by other suitable mechanical means which will assure accurate spacing and alignment of all wires of the finished product. The finished welded wire reinforcement shall be furnished in flat or bent sheets or in rolls as specified by the purchaser.

6.3 Longitudinal and transverse wires shall be securely connected at every intersection by a process of electrical resistance welding which employs the principle of fusion combined with pressure.

6.4 Welded wire reinforcement of proper yield strength and quality when manufactured in the manner herein required shall result in a strong, serviceable mat-type product having substantially square or rectangular openings, and shall conform to this specification.

NOTE 2—A variation of manufacturing includes the application of one or more longitudinal convoluted wires at one edge of welded wire reinforcement for concrete pipe reinforcing cages. This shape allows the cage ends to be expanded to a larger diameter to accommodate the bell-shaped ends of concrete pipe.

7. Mechanical Property Requirements—Wire, Plain and Deformed

7.1 *General Requirements for Plain Wire:*

7.1.1 The relation between size number, diameter, and area shown in Table 1 or Table 2 shall apply, whichever is applicable.

7.1.2 Specimens for mechanical properties testing shall be full wire sections and shall be obtained from ends of wire coils as drawn or rolled. The specimens shall be of sufficient length to perform testing described in Test Methods and Definitions A370.

7.1.3 If any test specimen exhibits obvious isolated imperfections not representative of the product, it shall be discarded and another specimen substituted.

7.1.4 *Tension Test:*

7.1.4.1 When tested as described in Test Methods and Definitions A370, the material, except as specified in 7.1.4.2, shall conform to the tensile property requirements in Table 5 or Table 6, whichever is applicable, based on the nominal area of the wire.

TABLE 5 Tension Test Requirements—Plain Wire

	Grade 70 [485]	Grade 72.5 [500]	Grade 75 [515]	Grade 77.5 [533]	Grade 80 [550]
Tensile strength, min, psi [MPa]	80 000 [550]	82 500 [568]	85 000 [585]	87 500 [603]	90 000 [620]
Yield strength, min, psi [MPa]	70 000 [485]	72 500 [500]	75 000 [515]	77 500 [533]	80 000 [550]
Reduction of area, min, %	30[A]	30[A]	30[A]	30[A]	30[A]

[A] For material testing over 100 000 psi [690 MPa] tensile strength, the reduction of area shall be not less than 25 %.

TABLE 6 Tension Test Requirements—Plain Wire for Welded Wire Reinforcement

	Size W1.2 [MW 7.7] and Larger					
	Grade 65 [450]	Grade 70 [485]	Grade 72.5 [500]	Grade 75 [515]	Grade 77.5 [533]	Grade 80 [550]
Tensile strength, min, psi [MPa]	75 000 [515]	80 000 [550]	82 500 [568]	85 000 [585]	87 500 [603]	90 000 [620]
Yield strength, min, psi [MPa]	65 000 [450]	70 000 [485]	72 500 [500]	75 000 [515]	77 500 [533]	80 000 [550]
Reduction of area, min, %	30[A]	30[A]	30[A]	30[A]	30[A]	30[A]

	Smaller than Size W1.2 [MW 7.7]
	Grade 56 [385]
Tensile strength, min, psi [MPa]	70 000 [485]
Yield strength, min, psi [MPa]	56 000 [385]
Reduction of area, min, %	30[A]

[A] For material testing over 100 000 psi [690 MPa] tensile strength, the reduction of area shall be not less than 25 %.

TABLE 7 Permissible Variation in Plain Wire Diameter

Size Number, in.-lbs [SI]	Nominal Diameter in. [mm]	Permissible Variation Plus and Minus, in. [mm]	Maximum Permissible Out-of-Round, in. [mm][A]
Smaller than W 5 [MW 32]	under 0.252 [6.40]	0.003 [0.08]	0.003 [0.08]
W 5 [MW 32] to W 12 [MW 77], incl	0.252 [6.40] to 0.391 [9.93] incl	0.004 [0.10]	0.004 [0.10]
Over W 12 [MW 77] to W 20 [MW 129], incl	over 0.391 [9.93] to 0.505 [12.83], incl	0.006 [0.15]	0.006 [0.15]
Over W 20 [MW 129]	over 0.505 [12.83]	0.008 [0.20]	0.008 [0.20]

[A] Out-of-round is the difference between maximum and minimum diameters of the wire, measured at the same transverse cross section.

TABLE 8 Bend Test Requirements—Plain Wire

Size Number of Wire	Pin Diameter for Bend Tests[A]
W 7 [MW 45] and smaller	1d[B]
Larger than W 7 MW 45]	2d

[A] Bend specimen 180° unless noted otherwise.
[B] d = nominal wire diameter.

TABLE 9 Tension Test Requirements—Deformed Wire

	Grade 75 [515]	Grade 77.5 [533]	Grade 80 [550]
Tensile strength, min, psi [MPa]	85 000 [585]	87 500 [603]	90 000 [620]
Yield strength, min, psi [MPa]	75 000 [515]	77 500 [533]	80 000 [550]

TABLE 10 Tension Test Requirements—Deformed Wire for Welded Wire Reinforcement

	Grade 70 [485]	Grade 72.5 [500]	Grade 75 [515]	Grade 77.5 [533]	Grade 80 [550]
Tensile strength, min, psi [MPa]	80 000 [550]	82 500 [568]	85 000 [585]	87 500 [603]	90 000 [620]
Yield strength, min, psi [MPa]	70 000 [485]	72 500 [500]	75 000 [515]	77 500 [533]	80 000 [550]

7.1.4.2 When required by the purchaser, yield strength shall be determined as described using a Class B-l extensometer as described in Practice E83. The yield strength shall be determined as described in Test Methods and Definitions A370 at an extension under load of 0.5 % of gage length or by the offset method (0.2 %). It shall be permissible to remove the extensometer after the yield strength has been determined. The wire shall meet the requirements of Table 5 or Table 6, whichever is applicable.

7.1.4.3 For wire to be used in the manufacture of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 6, based on the nominal area of the wire.

7.1.5 *Bend Test*—The bend test specimen shall be bent at room temperature through 180° without cracking on the outside of the bent portion visible to a person with normal or corrected vision, as prescribed in Table 8.

7.1.6 *Reduction of Area Test*—The reduction of area shall be determined as described in Test Methods and Definitions A370. The wire shall conform to the reduction of area requirements in Table 5 or Table 6, whichever is applicable.

7.1.7 *Permissible Variation in Wire Diameter:*

7.1.7.1 The permissible variation in wire diameter shall conform to the requirements in Table 7.

7.1.7.2 The difference between the maximum and minimum diameters, as measured on any given cross section of the wire, shall not exceed the tolerances listed in Table 7 for the given wire size.

NOTE 3—Cold-worked wire generally does not exhibit a definite yield point as evidenced by a distinct arrest or halt in the load indication gauge of the testing machine prior to reaching ultimate tensile load.

7.2 *General Requirements for Deformed Wire:*

7.2.1 The relation between size number, diameter, and area shown in Table 3 or Table 4 shall apply, whichever is applicable.

7.2.2 Specimens for mechanical properties testing shall be full wire sections and shall be obtained from ends of wire coils as rolled. The specimens shall be of sufficient length to perform testing described in Test Methods and Definitions A370.

7.2.3 If any test specimen exhibits obvious isolated imperfections not representative of the product, it shall be discarded and another specimen substituted.

7.2.4 *Deformation Criteria:*

7.2.4.1 Deformations shall be spaced along the wire at a substantially uniform distance and shall be symmetrically dispersed around the perimeter. The deformations on all longitudinal lines of the wire shall be similar in size and shape. A minimum of 25 % of the total surface area shall be deformed by measurable deformations.

7.2.4.2 Deformed wire shall have two or more lines of deformations.

7.2.4.3 The average longitudinal spacing of deformations shall be not less than 3.5 nor more than 5.5 deformations per inch [25 mm] in each line of deformations on the wire.

7.2.4.4 The minimum average height of the center of typical deformations based on the nominal wire diameters shown in Table 3 or Table 4 shall be as follows:

Wire Sizes	Minimum Average Height of Deformations Percent of Nominal Wire Diameter
D 3 [MD 20] and smaller	4
Larger than D 3 [MD 20] through D 10 [MD 65]	4½
Larger than D 10 [MD 65]	5

7.2.4.5 The deformations shall be placed with respect to the axis of the wire so that the included angle is not less than 45°; or if deformations are curvilinear, the angle formed by the transverse axis of the deformation and the wire axis shall be not less than 45°. Where the line of deformations forms an included angle with the axis of the wire from 45° to 70° inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the included angle is over 70°, a reversal in direction is not required.

7.2.4.6 The average spacing of deformations shall be determined by dividing a measured length (10 in. [250 mm] min) of the wire specimen by the number of individual deformations in any one row of deformations on any side of the wire specimens. A measured length of the wire specimen shall be considered the distance from a point on a deformation to a corresponding point on any other deformation in the same line of deformations on the wire.

7.2.4.7 The minimum average height of deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentations or raised ribs.

TABLE 11 Bend Test Requirements—Deformed Wire

Size Number of Wire	Pin Diameter for Bend Tests[A]
D 6 [MD 39] and smaller	2d[B]
Larger than D 6 [MD 39]	4d

[A] Bend specimen 90° unless noted otherwise.
[B] d = nominal wire diameter.

7.2.5 *Tension Test:*

7.2.5.1 When tested as described in Test Methods and Definitions A370, the material, except as specified in 7.2.5.2, shall conform to the tensile property requirements in Table 9, based on the nominal area of wire.

7.2.5.2 When required by the purchaser, the yield strength shall be determined as described in Test Methods and Definitions A370 at an extension of 0.5 % of gage length or by the offset method (0.2 %). For determining the yield strength, use a Class B-l extensometer as described in Practice E83. It shall be permissible to remove the extensometer after the yield strength has been determined. The wire shall meet the requirements of Table 9 or Table 10, whichever is applicable.

7.2.5.3 For material to be used in the manufacture of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 10, based on the nominal area of the wire.

7.2.6 *Bend Test*—The bend test specimen shall be bent at room temperature through 90° without cracking on the outside of the bent portion visible to a person with normal or corrected vision, as prescribed in Table 11.

7.2.7 *Permissible Variation in Weight [Mass]:*

7.2.7.1 The permissible variation in weight [mass] of any deformed wire is ±6 % of its nominal weight [mass]. The theoretical weight [mass] shown in Table 3 or Table 4, or similar calculations on unlisted sizes, shall be used to establish the variation.

7.3 *Number of Tests*—One tension and one bend test shall be made from each 10 tons [9000 kg] or less of each size of wire or fraction thereof in a lot, or a total of seven samples, whichever is less. A lot shall consist of all the coils of a single size offered for delivery at the same time.

7.4 *Quality, Finish, and Appearance:*

7.4.1 The wire shall be free of detrimental imperfections and shall meet the requirements of this specification.

7.4.2 Rust, surface seams, or surface irregularities shall not be a cause for rejection provided the requirements of 7.4.3 are met, and the minimum dimensions and mechanical properties of a hand wire-brushed test specimen meet the requirements of this specification.

7.4.3 Wire intended for welded wire reinforcement shall be sufficiently free of rust and drawing lubricant so as not to interfere with electric resistance welding.

8. Mechanical Property Requirements—Welded Wire Reinforcement

8.1 *Tension Test:*

8.1.1 Wire for the production of welded wire reinforcement, plain and deformed, is described in Section 7. Tensile tests shall be made on wire cut from the welded wire reinforcement and tested either across or between the welds; no less than 50 % shall be across welds. Tensile tests across a weld shall have the welded intersection located approximately at the center of the wire being tested and the transverse wire forming the welded intersection shall extend approximately 1 in. [25 mm] beyond each side of the intersection.

8.1.2 When required by the purchaser, the yield strength shall be determined as described in Test Methods and Definitions A370 at an extension of 0.5 % of gage length or by the offset method (0.2 %). For determining the yield strength use a Class B-l extensometer as described in Practice E83. It shall be permissible to remove the extensometer from the specimen after yield strength has been determined.

8.2 *Bend Test*—The wire shall withstand the bend test as described in 7.1.5 or 7.2.6, whichever is applicable, and shall be performed on a specimen taken from between the welds.

8.3 *Weld Shear Strength:*

8.3.1 The weld shear strength between longitudinal and transverse wires shall be tested as described in Section 9. The minimum average shear value in pounds-force shall not be less than 35 000 multiplied by the nominal area of the larger wire in square inches [in Newtons shall not be less than 241 multiplied by the nominal area of the larger wire in square millimetres], where the smaller wire has an area of 40 % or more of the area of the larger wire. For deformed welded wire reinforcement, the smaller wire shall not be less than D 4 [MD 26].

8.3.2 Deformed welded wire reinforcement having a relationship of larger and smaller wires other than that covered in 8.3.1 shall meet an average weld shear strength requirement of not less than 800 lbf [3.6 kN], provided that the smaller wire is not smaller than D 4 [MD 26]. Plain welded wire reinforcement having a relationship of larger and smaller wires other than those covered in 8.3.1 shall not be subject to the weld shear requirement.

8.3.3 Weld-shear tests for determination of conformance to the requirements of 8.3 shall be conducted using a weld tester as described in Section 9.

8.3.4 Four welds selected at random from the specimen described in 11.2 shall be tested for weld shear strength. The transverse wire of each test specimen shall extend approximately 1 in. [25 mm] on each side of the longitudinal wire. The longitudinal wire of each test specimen shall be of such length below the transverse wire so as to be adequately engaged by the grips of the testing machine. The longitudinal wire shall be of such length above the transverse wire that its end shall be above the center line of the upper bearing of the weld tester.

8.3.5 The material shall be deemed to conform to the requirements for weld shear strength if the average of the test results of the four specimens complies with the value stipulated in 8.3. If the average fails to meet the prescribed value, all the welds across the specimen shall then be tested. The welded wire reinforcement shall be deemed acceptable if the average of all weld shear test values across the specimen meets the prescribed minimum value.

8.4 *Number of Tests:*

8.4.1 One test for conformance to tensile strength and bend requirements shall be made for each 75 000 ft^2 [7 000 m^2] of welded wire reinforcement or remaining fraction thereof. For testing prior to fabrication, one test for each 20 tons [18 metric tonnes] of wire shall be made.

8.4.2 One test for conformance to weld shear strength requirements shall be made for each 300 000 ft^2 [28 000 m^2] or remaining fraction thereof.

9. Weld Shear Test Apparatus and Methods

9.1 As the welds in welded wire reinforcement contribute to the bond and anchorage value of the wires in concrete, the weld acceptance tests shall be made in a weld tester that stresses the weld in a manner similar to which it is stressed in concrete. In order to accomplish this, the vertical wire in the weld tester shall be stressed in an axis close to its center line. Also the horizontal wire shall be held closely to the vertical wire, and in the same relative position, so as to prevent rotation of the horizontal wire. When the welded wire reinforcement is manufactured with different wire sizes, the larger diameter wire shall be the "vertical wire" when tested (see Fig. 1).

9.2 The weld tester shown in Fig. 1 shall be hung in a ball and socket, or similar self aligning arrangement, at the center of the machine and used with an anvil sized such that it fully supports the horizontal wire and allows the vertical wire of the test specimen to move freely in the vertical direction. This, or a similarly effective fixture designed on the same principle, shall be acceptable.

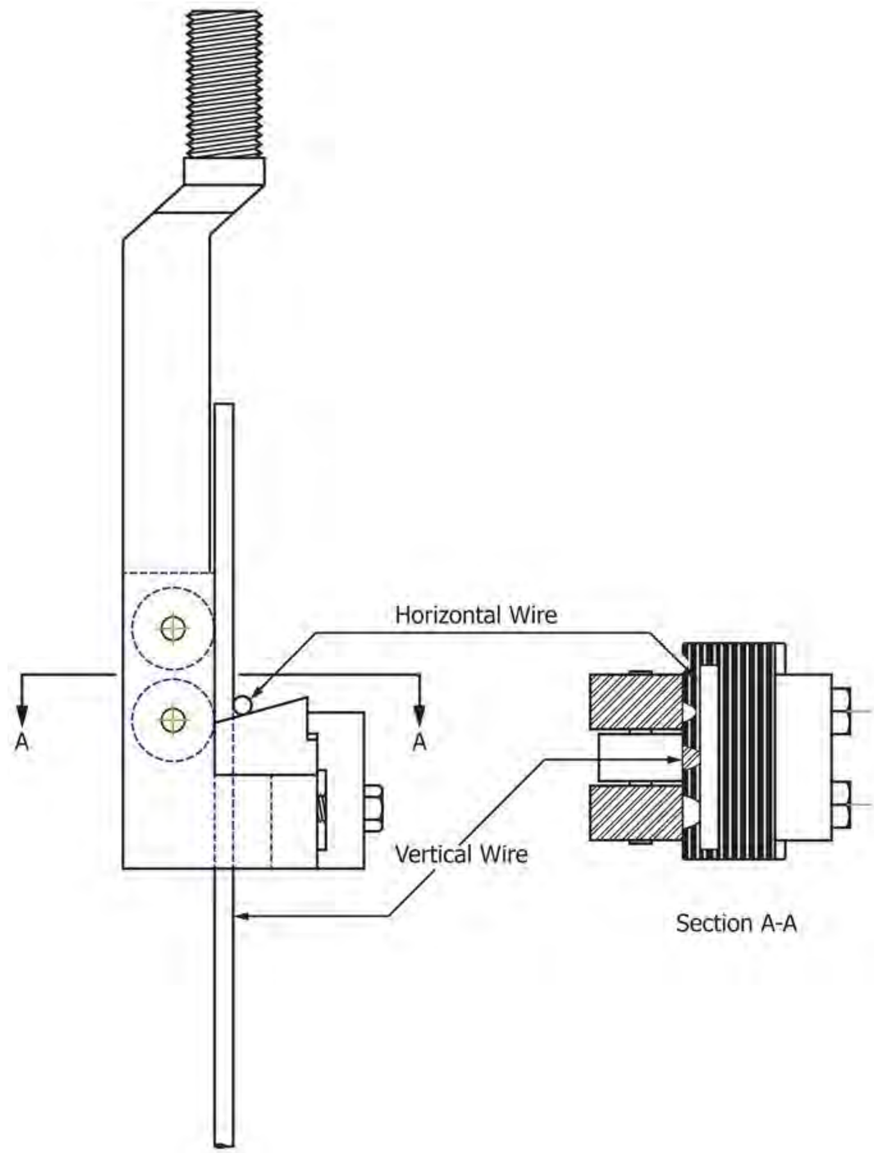
9.3 Test specimens shall be inserted through the notch in the anvil using the smallest notch available in which the vertical wire fits loosely. The vertical wire shall be in contact with the surface of the free rotating rollers while the horizontal wire shall be supported by the anvil on each side of the slot. The bottom jaws of the testing machine shall grip the lower end of the vertical wire and the load shall be applied at a rate of stressing not to exceed 100 000 psi/min [689 MPa/min].

10. Dimensions and Permissible Variations for Welded Wire Reinforcement

10.1 *Width*—The width of welded wire reinforcement shall be considered to be the center-to-center distance between outside longitudinal wires. The permissible variation shall not exceed 0.5 in. [13 mm] greater or less than the specified width. In case the width of flat sheets or rolls is specified as the overall width (tip-to-tip length of transverse wires), the width shall not vary more than ±1 in. [±25 mm] from the specified width. When measurements involve a convoluted wire, the measurement shall be made to the approximate center of the sinusoidal wave shape.

10.2 *Length*—The overall length of flat sheets, measured on any wire, shall not vary more than ±1 in. [±25 mm], or 1 %, whichever is greater.

10.3 Overhang of the transverse wires shall not project beyond the centerline of each longitudinal edge wire more than a distance of 1 in. [25 mm], unless otherwise specified. When transverse wires are specified to project a specific length beyond the center line of a longitudinal edge wire, the permissible variation shall not exceed 0.5 in. [13 mm] greater or less than the specified length.



NOTE 1—A detailed drawing showing complete dimensions of the weld tester may be obtained from ASTM Headquarters. (See Weld Tester Drawing, available from ASTM International Headquarters. Order Adjunct No. ADJA0185. Original adjunct produced in 1967.)

FIG. 1 Welded Wire Reinforcement Weld Tester

10.4 For plain welded wire reinforcement, the permissible variation in wire diameter of any wire in the finished product shall conform to the tolerances prescribed for the wire before welding, with the following exceptions:

10.4.1 Because of the mechanical characteristics of manufacturing welded wire reinforcement, the out-of-round requirements shall not apply.

10.4.2 Unless otherwise precluded by the purchaser in 4.2, the manufacturer shall be permitted to use over-sized plain wire. The size differential shall not exceed two "W" [ten "MW"] size increments on sizes W 8 [MW 52] and smaller, and four "W" [twenty "MW"] size increments on sizes larger than W 8 [MW 52]. A "W" ["MW"] size increment is a whole number increment, for example, W 5 to W 6 [MW 25 to MW 26], or W 5.4 to W 6.4 [MW 30 to MW 31]. In all cases where such over-steeling is practiced, the manufacturer shall identify the welded wire reinforcement with the style originally ordered. With the permission of the purchaser, the manufacturer shall be permitted to exceed the limits of this section.

10.5 For deformed welded wire reinforcement, the permissible variation in wire weight of any wire in the finished product shall conform to the tolerances prescribed for the wire before welding, with the following exceptions:

10.5.1 Unless otherwise precluded by the purchaser in 4.2, the manufacturer shall be permitted to apply over-sized deformed wire. The size differential shall not exceed two "D" [ten "MD"] size increments on sizes D 8 [MD 52] and smaller, and four "D" [twenty "MD"] size increments on sizes larger than D 8 [MD 52]. A "D" ["MD"] size increment is a whole number increment, for example, D 5 to D 6 [MD 25 to MD 26], or D 5.4 to D 6.4 [MD 30 to MD 31]. In all cases where such over-steeling is practiced, the manufacturer shall identify the welded wire reinforcement with the style originally ordered. With the permission of the purchaser, the manufacturer shall be permitted to exceed the limits of this section.

10.6 The average spacing of wires shall be such that the total number of wires contained in a sheet or roll is equal to or greater than that determined by the specific spacing, but the center-to-center distance between individual wires shall not vary more than 0.25 in. [6.3 mm] from the specified spacing. Sheets of welded wire reinforcement having the specified length shall not be required to contain an identical number of transverse wires, and therefore, shall be permitted to have various lengths of longitudinal overhang.

11. Sampling

11.1 Test specimens for testing mechanical properties shall be obtained by cutting from the finished welded wire reinforcement, a full width section of sufficient length to perform testing described in 7.1, 7.2, and Section 8.

11.2 Test specimens for determining weld-shear properties shall be obtained by cutting from the finished welded wire reinforcement, a full width section of sufficient length to perform testing described in 8.3.4.

11.3 Measurements for conformance to dimensional characteristics shall be made on full sheets or rolls.

11.4 Any test specimen exhibiting obvious imperfections shall be discarded and another specimen substituted.

12. Inspection

12.1 Inspection of the wire or welded wire reinforcement shall be agreed upon between the purchaser and the manufacturer as part of the purchase order or contract.

12.2 All tests shall be made at the manufacturer's facilities prior to shipment, unless otherwise specified, such as at other approved testing facilities. Such tests shall be so conducted as not to interfere unnecessarily with the operation of the manufacturer's facilities.

13. Rejection and Retest

13.1 Unless otherwise specified, any rejection shall be reported to the manufacturer within five working days from the time of selection of test specimens.

13.2 In case a specimen fails to meet the tension or bend test, the material shall not be rejected until two additional specimens taken from other wires in the same sheet or roll have been tested. The material shall be considered as meeting the specification with respect to any prescribed tensile property, provided the average of the test results for the three specimens, including the specimen originally tested, is equal to or exceeds the required minimum for the particular property in question and provided further that none of the three specimens develops less than 80 % of the required minimum for the tensile property in question. The material shall be considered as meeting this specification with respect to bend test requirements, provided both additional specimens pass the prescribed bend test.

13.3 Welded intersections shall withstand normal shipping and handling without becoming broken, but the presence of broken welds, regardless of cause, shall not constitute cause for rejection unless the number of broken welds per sheet exceeds 1 % of the total number of intersections in a sheet. For material furnished in rolls, not more than 1 % of the total number of intersections in 150 ft^2 [14 m^2] of welded wire reinforcement shall be broken. Not more than one-half the permissible maximum number of broken welds shall be located on any one wire.

13.4 In the event of rejection because of failure to meet the weld shear requirements, four additional specimens shall be taken from four different sheets or rolls and tested in accordance with Section 9. If the average of all the weld shear tests performed does not meet the requirement, the material shall be rejected.

13.5 In the event of rejection because of failure to meet the requirements for dimensions, the amount of material rejected shall be limited to those individual sheets or rolls which fail to meet this specification.

13.6 Rust, surface seams, or surface irregularities shall not be cause for rejection provided the minimum welded wire reinforcement dimensions, cross-sectional area, tensile properties, and weld shear strength of a hand wire-brushed test specimen meet the requirements of this specification. The height of deformations above the minimum height requirements shall not be cause for rejection.

13.7 *Rehearing*—Rejected materials shall be preserved for a period of at least two weeks from the date of inspection, during which time the manufacturer shall be permitted to make claim for a rehearing and retesting.

14. Certification

14.1 If outside inspection is waived, a manufacturer's certification that the material has been manufactured in accordance with and meets the requirements of this specification shall be the basis of acceptance of the material. The certification shall include the specification number, year-date of issue, and revision letter, if any.

14.2 This conformance is predicated upon testing and acceptance of wire prior to fabrication, coupled with random shear testing during production. The purchaser shall be furnished a manufacturer's certification of conformance to this specification for each production date or production lot shipped. A production lot shall not exceed 300 000 ft^2 [28 000 m^2].

14.3 Test results for yield strength, tensile strength, and bend tests shall be reported for plain wire above Grade 70 [485], plain welded wire reinforcement above Grade 65 [450], deformed wire above Grade 75 [515], and deformed welded wire reinforcement above Grade 70 [485].

14.4 A material test report, certificate of inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document shall meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the manufacturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 4—The industry definition as invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

15. Packaging and Marking

15.1 For plain and deformed wire, the size of the wire, Specification A1064/A1064M, and name or mark of the manufacturer shall be marked on a tag securely attached to each coil of wire.

15.2 When welded wire reinforcement is furnished in flat sheets, it shall be assembled in bundles of convenient size containing not more than 150 sheets and securely fastened together.

15.3 When welded wire reinforcement is furnished in rolls, each roll shall be secured so as to prevent unwinding during shipping and handling.

15.4 Each bundle of flat sheets, bundle of rolls, and each roll weighing over 400 lb [180 kg] shall have attached thereto a minimum of one suitable tag bearing the name of the manufacturer, description of the material, ASTM designation A1064/A1064M, and such other information as may be specified by the purchaser.

15.5 Packaging, marking, and loading for shipment shall be agreed upon between the purchaser and manufacturer.

15.6 When specified in the contract or order, and for the direct procurement by or direct shipment to the U.S. government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for U.S. military agencies and in accordance with Fed. Std. No. 123 for U.S. government civil agencies.

16. Keywords

16.1 concrete reinforcement; deformations; deformed wire; reinforced concrete; reinforcing steels; steel wire; welded wire reinforcement

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A1064/A1064M – 16b) that may impact the use of this standard. (Approved March 15, 2017.)

(1) Revised 3.1, 7.1.5, and 7.2.6.

Committee A01 has identified the location of selected changes to this standard since the last issue (A1064/A1064M – 16a) that may impact the use of this standard. (Approved Sept. 1, 2016.)

(1) Revised 12.2.
(2) Removed 12.3.

Committee A01 has identified the location of selected changes to this standard since the last issue (A1064/A1064M – 16) that may impact the use of this standard. (Approved May 1, 2016.)

(1) Revised 2.1 and 15.5.
(2) Revised the footnotes of Table 3 and Table 4.
(3) Added Note 3 and removed 7.1.4.4 and 7.2.5.4.

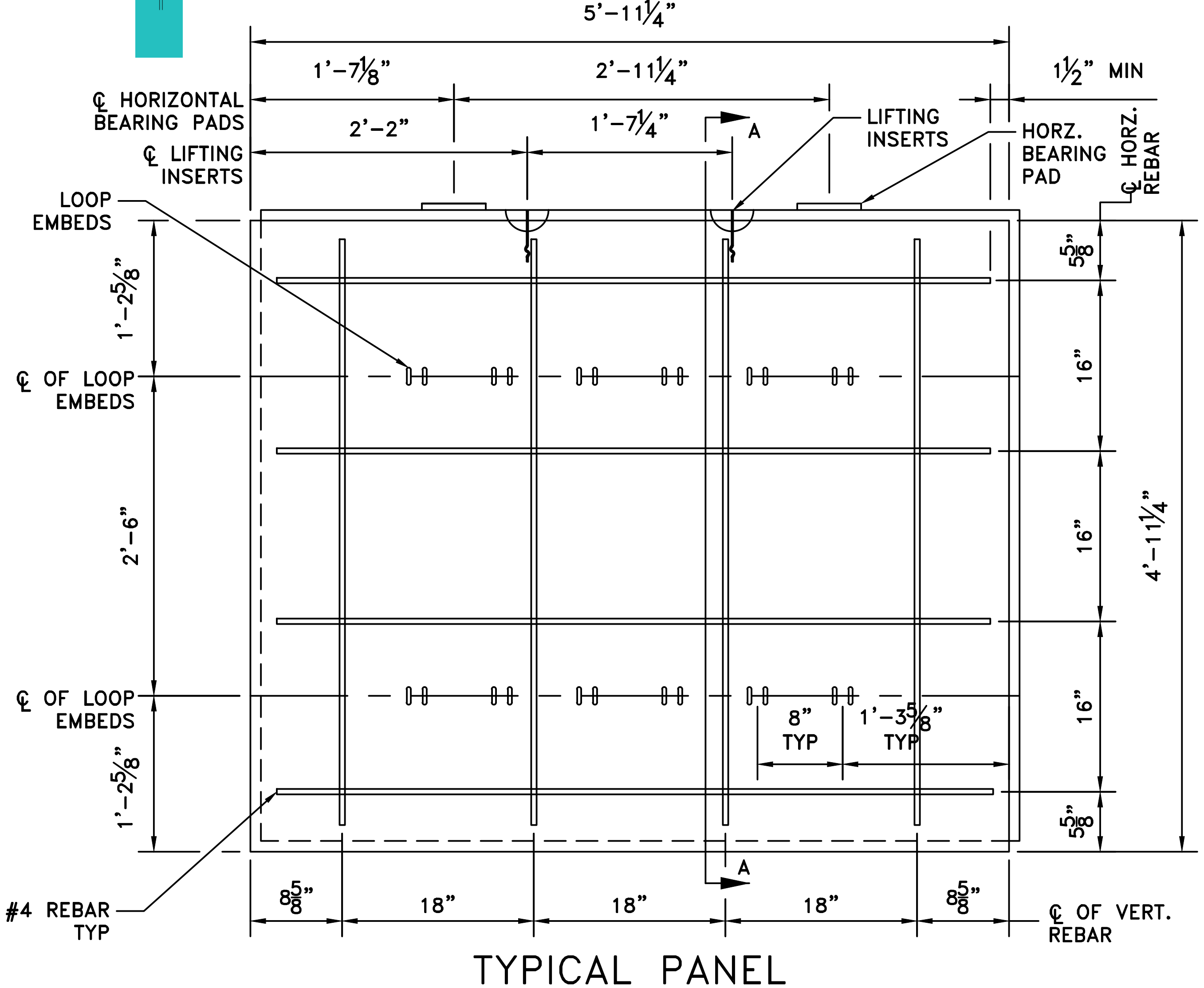
Committee A01 has identified the location of selected changes to this standard since the last issue (A1064/A1064M – 15a) that may impact the use of this standard. (Approved March 1, 2016.)

(1) Revised 12.1 and deleted 12.4.

Committee A01 has identified the location of selected changes to this standard since the last issue (A1064/A1064M – 15) that may impact the use of this standard. (Approved Nov. 1, 2015.)

(1) Revised Section 4.
(2) Revised Table 7 to include a table footnote.
(3) Revised 14.4.

1.2.8 Soil Reinforcing Connection



TYPICAL PANEL

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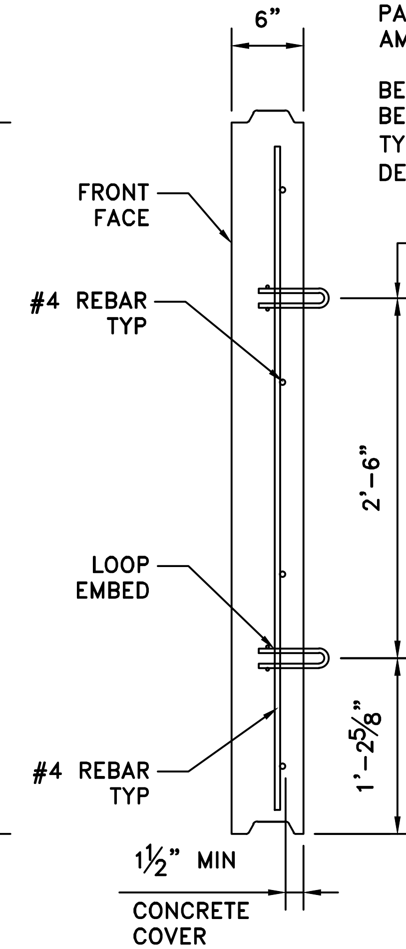
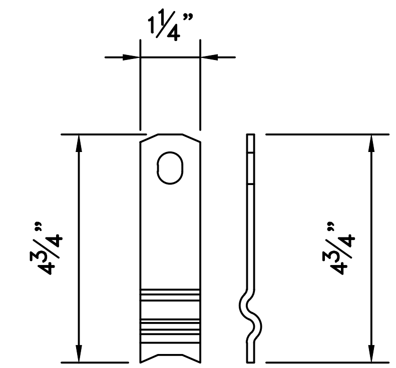


SECTION A-A

REBAR NOTE:
PANEL TYPES "A" & "Ai" REQUIRE THE SAME AMOUNT OF PANEL REINFORCEMENT.

BEARING PAD NOTE:
BEARING PAD PLACEMENT SHOWN IS FOR TYPICAL "A" PANEL ONLY, SEE STANDARD DETAILS: 5 OF 5 FOR "X" AND "Y" PANELS.



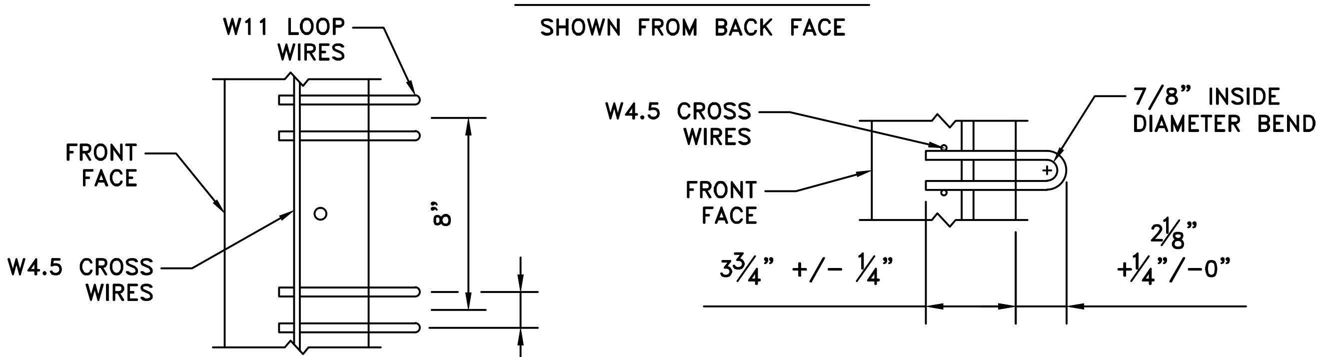
LIFTING INSERT DETAIL

NOTE:
"WAVY-TAIL" STYLE OF INSERT SHOWN. OTHER INSERTS OF EQUAL OR GREATER CAPACITY MAY BE USED IF APPROVED BY SSL.

PANEL REINFORCEMENT TABLE

Panel Type	Vertical Bars Num / Size	Horz. Bars Num / Size
A	4 / #4	4 / #4
A2	4 / #4	2 / #4

18" MAX SPACING BETWEEN BARS



PLAN VIEW

ELEVATION VIEW

LOOP EMBED DETAILS

PANEL TOLERANCES:

OVERALL DIMENSIONS:

- STANDARD PANEL
  ± ½" VERTICAL
  ± ½" HORIZONTAL
- TOP AND SPECIAL PANELS
  ± 1" VERTICAL
  ± ½" HORIZONTAL

CONNECTION DEVICE LOCATIONS:

- EMBEDS
  ± 1" VERTICAL
  ± 1" HORIZONTAL

PANEL SQUARENESS:

- 90° PANEL CORNERS
  ± $\frac{3}{16}$" USING 2' SQUARE
  (MEASURE 3 PANEL CORNERS)

PANEL DIAGONAL:

- PANELS WITH 90° CORNERS
  ½" MAX. DIFFERENCE BETWEEN DIAGONALS

SURFACE FINISH:

- FINISH AT FRONT FACE
  ± ⅛" IN 5'

STANDARD TYPE "A" PANEL DETAILS

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

REGISTERED PROFESSIONAL ENGINEER FRANSISCUS S. HARDIANTO No. C60215 EXP. 06-30-22 CIVIL STATE OF CALIFORNIA

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DRAWN BY: WM	03/09/21
CHECK BY: WM	03/09/21
DESIGN BY: FSH	03/09/21
CHECK BY: FSH	03/09/21
PROJ. ENGR:	FSH

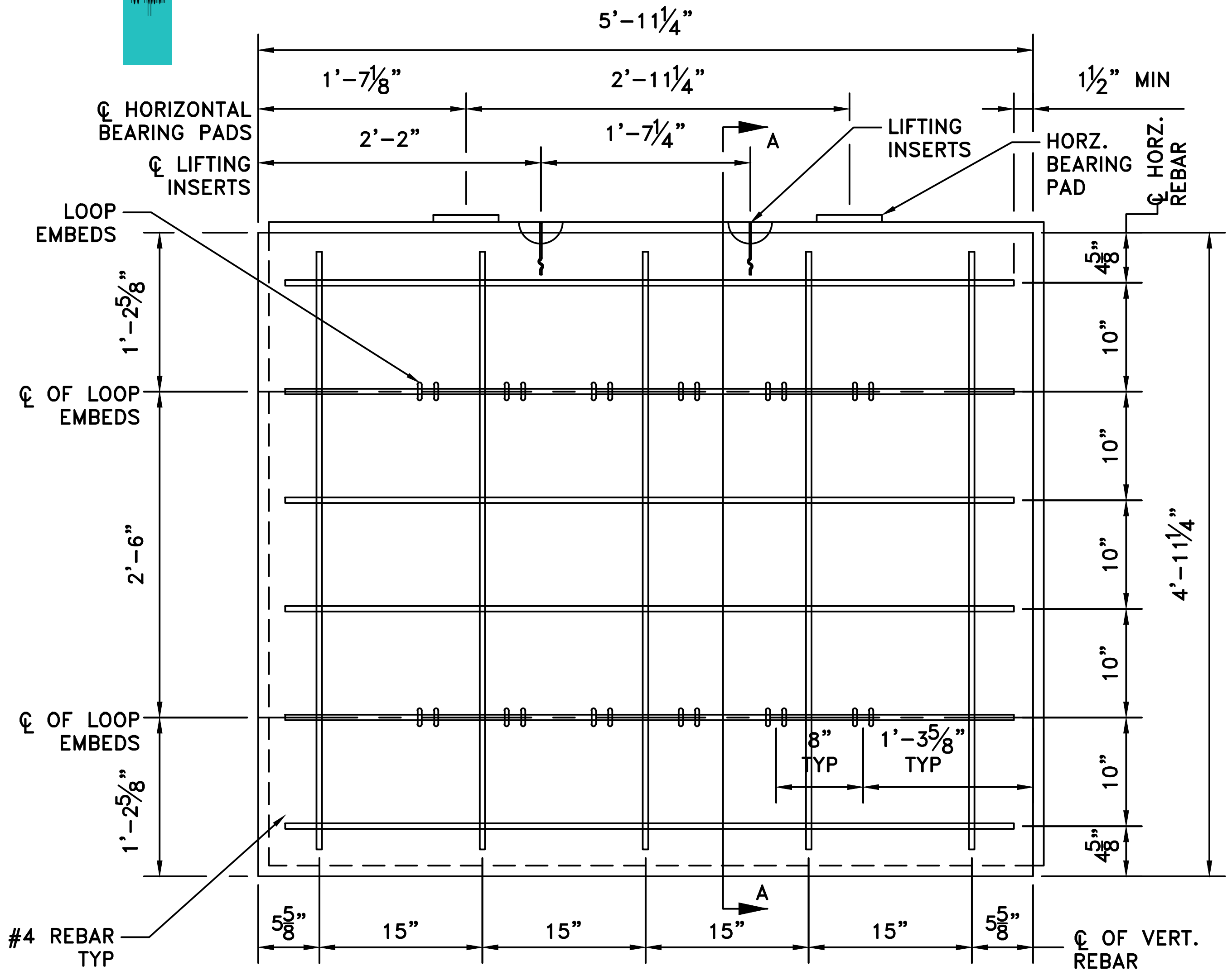
NO.	DATE	REVISION DESCRIPTION	BY

STANDARD DETAILS: 1 OF 5

STANDARD MSE WALL DETAILS

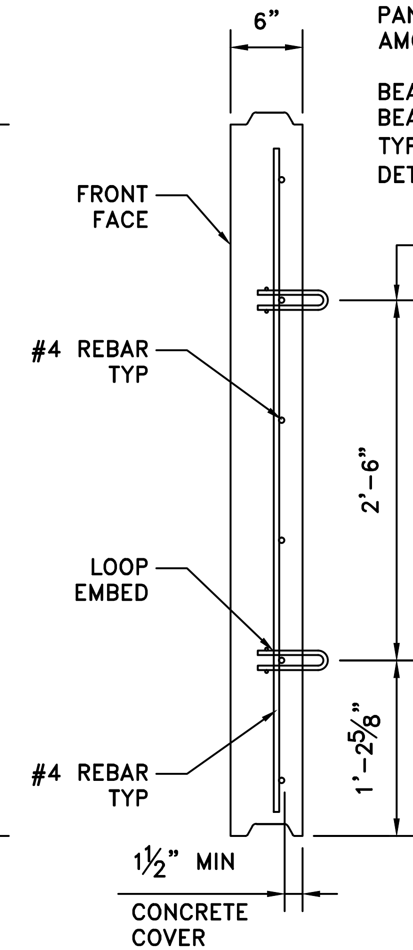
Scale: NTS
Job: --
Sheet: RW-01
Sheet 1 of 5

FRANSISCUS S. HARDIANTO
03/09/21



TYPICAL PANEL

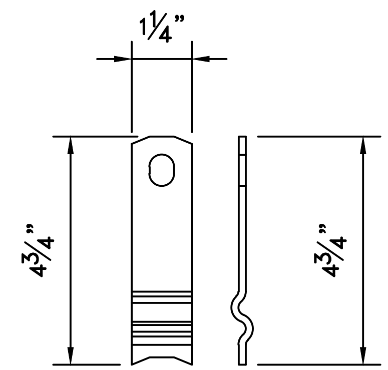
SHOWN FROM BACK FACE



SECTION A-A

REBAR NOTE:
PANEL TYPES "X" & "XI" REQUIRE THE SAME AMOUNT OF PANEL REINFORCEMENT.

BEARING PAD NOTE:
BEARING PAD PLACEMENT SHOWN IS FOR TYPICAL "A" PANEL ONLY, SEE STANDARD DETAILS: 5 OF 5 FOR "X" AND "Y" PANELS.



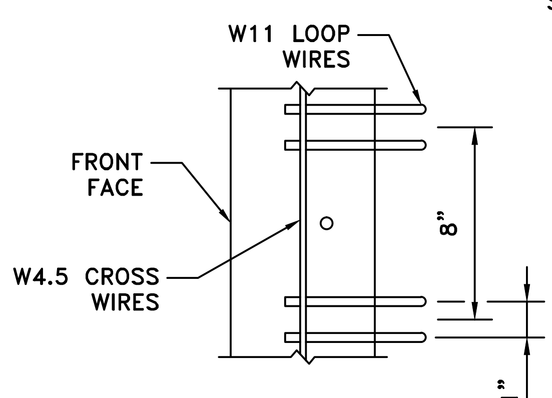
LIFTING INSERT DETAIL

NOTE:
"WAVY-TAIL" STYLE OF INSERT SHOWN. OTHER INSERTS OF EQUAL OR GREATER CAPACITY MAY BE USED IF APPROVED BY SSL.

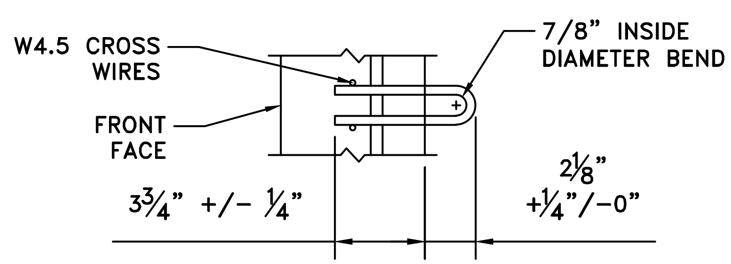
PANEL REINFORCEMENT TABLE

Panel Type	Vertical Bars Num / Size	Horz. Bars Num / Size
X	5 / #4	6 / #4
X2	5 / #4	3 / #4

18" MAX SPACING BETWEEN BARS



PLAN VIEW



ELEVATION VIEW

LOOP EMBED DETAILS

PANEL TOLERANCES:

OVERALL DIMENSIONS:

- STANDARD PANEL
  ± ½" VERTICAL
  ± ½" HORIZONTAL
- TOP AND SPECIAL PANELS
  ± 1" VERTICAL
  ± ½" HORIZONTAL

CONNECTION DEVICE LOCATIONS:

- EMBEDS
  ± 1" VERTICAL
  ± 1" HORIZONTAL

PANEL SQUARENESS:

- 90° PANEL CORNERS
  ± 3⁄16" USING 2' SQUARE
  (MEASURE 3 PANEL CORNERS)

PANEL DIAGONAL:

- PANELS WITH 90° CORNERS
  ½" MAX. DIFFERENCE BETWEEN DIAGONALS

SURFACE FINISH:

- FINISH AT FRONT FACE
  ± ⅛" IN 5'

STANDARD TYPE "X" PANEL DETAILS

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

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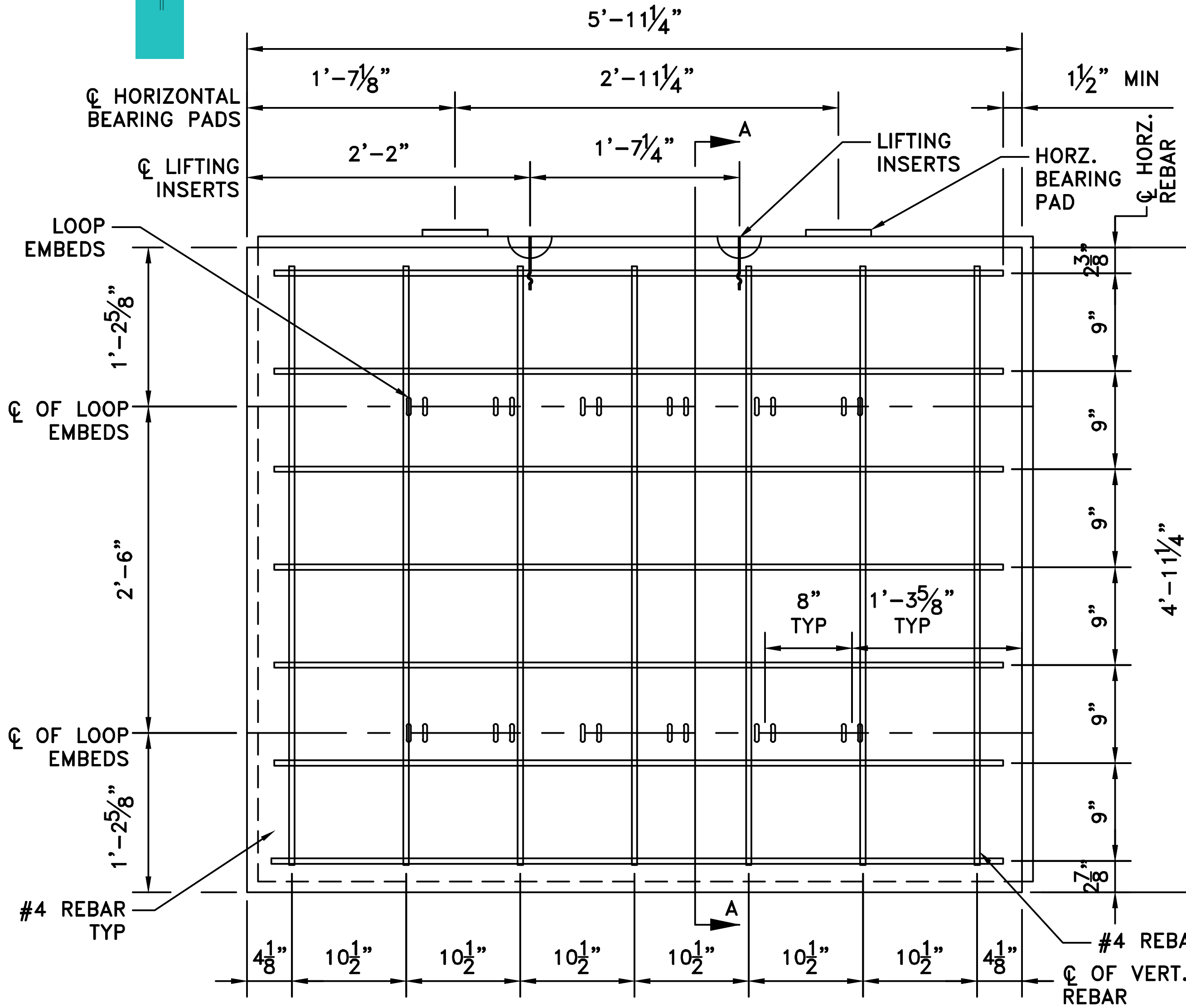
DESIGN BY: FSH	03/09/21				
CHECK BY: FSH	03/09/21				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

STANDARD DETAILS: 2 OF 5

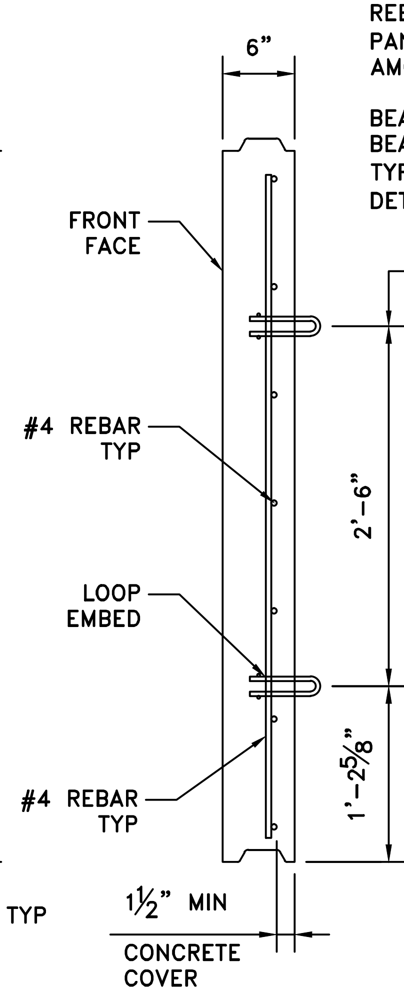
STANDARD MSE WALL DETAILS

Scale: NTS
Job: --
Sheet: RW-02
Sheet 2 of 5



TYPICAL PANEL

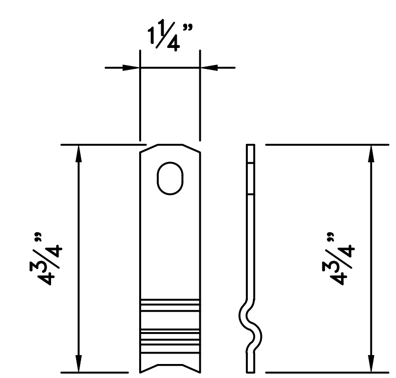
SHOWN FROM BACK FACE



SECTION A–A

REBAR NOTE:
PANEL TYPES "Y" & "Yi" REQUIRE THE SAME AMOUNT OF PANEL REINFORCEMENT.

BEARING PAD NOTE:
BEARING PAD PLACEMENT SHOWN IS FOR TYPICAL "A" PANEL ONLY, SEE STANDARD DETAILS: 5 OF 5 FOR "X" AND "Y" PANELS.



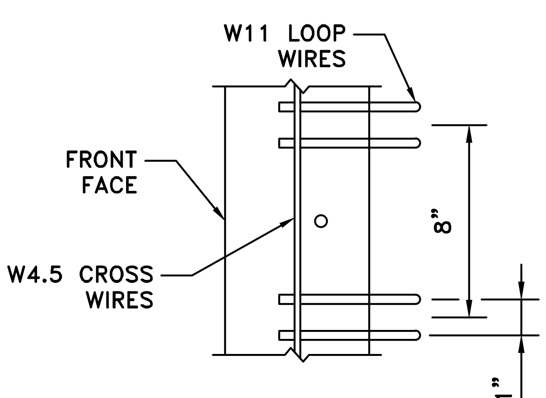
LIFTING INSERT DETAIL

NOTE:
"WAVY-TAIL" STYLE OF INSERT SHOWN. OTHER INSERTS OF EQUAL OR GREATER CAPACITY MAY BE USED IF APPROVED BY SSL.

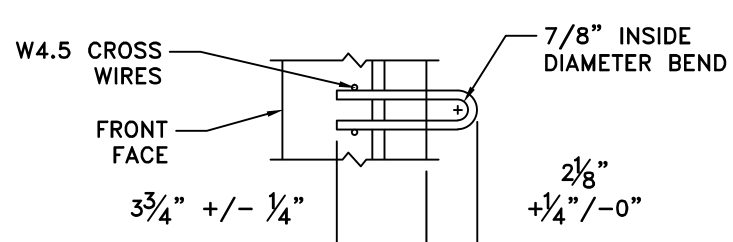
PANEL REINFORCEMENT TABLE

Panel Type	Vertical Bars Num / Size	Horz. Bars Num / Size
Y	7 / #4	7 / #4
Y2	7 / #4	4 / #4

18" MAX SPACING BETWEEN BARS



PLAN VIEW



ELEVATION VIEW

LOOP EMBED DETAILS

PANEL TOLERANCES:

OVERALL DIMENSIONS:

- STANDARD PANEL
  ± ½" VERTICAL
  ± ½" HORIZONTAL
- TOP AND SPECIAL PANELS
  ± 1" VERTICAL
  ± ½" HORIZONTAL

CONNECTION DEVICE LOCATIONS:

- EMBEDS
  ± 1" VERTICAL
  ± 1" HORIZONTAL

PANEL SQUARENESS:

- 90° PANEL CORNERS
  ± $\frac{3}{16}$" USING 2' SQUARE
  (MEASURE 3 PANEL CORNERS)

PANEL DIAGONAL:

- PANELS WITH 90° CORNERS
  ½" MAX. DIFFERENCE BETWEEN DIAGONALS

SURFACE FINISH:

- FINISH AT FRONT FACE
  ± ⅛" IN 5'

STANDARD TYPE "Y" PANEL DETAILS

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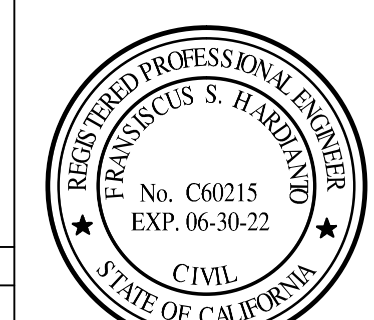

FRANSISCUS S. HARDIANTO
03/09/21

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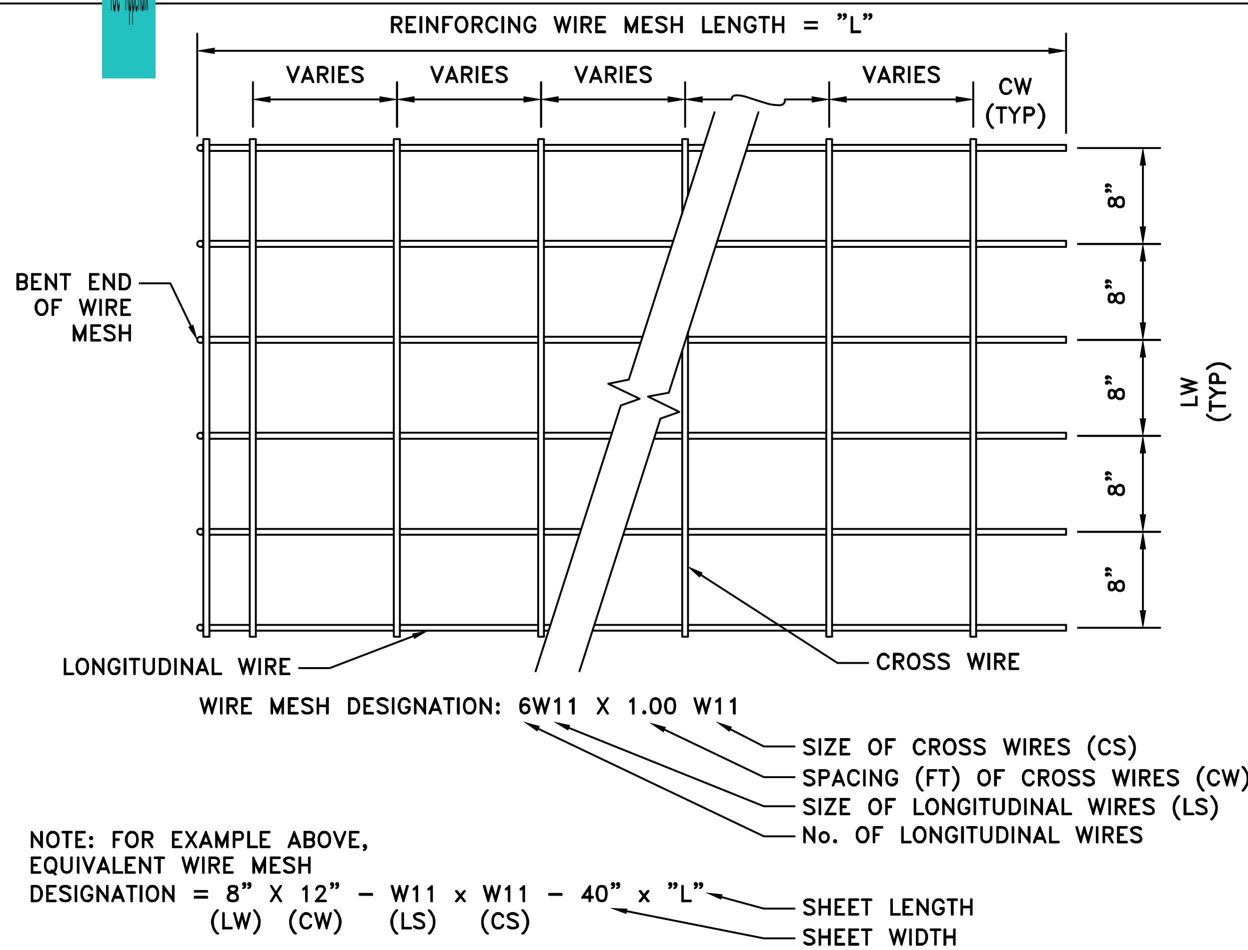
CHECK BY: FSH	03/09/21
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

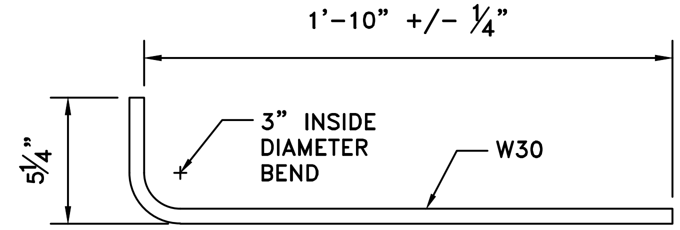
STANDARD DETAILS: 3 OF 5

STANDARD MSE WALL DETAILS

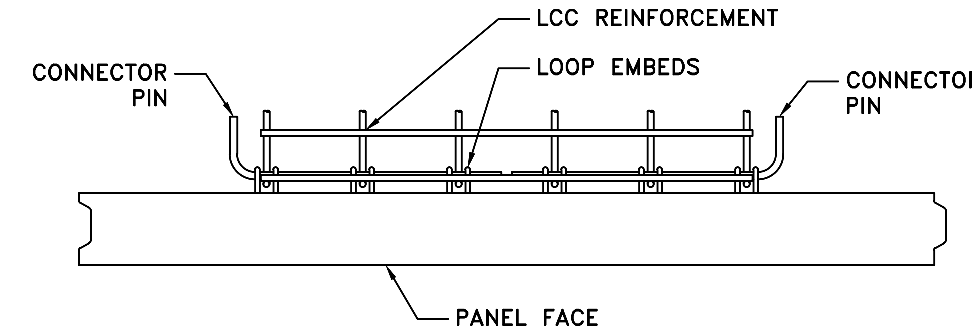
Scale: NTS
Job: --
Sheet: RW-03
Sheet 3 of 5



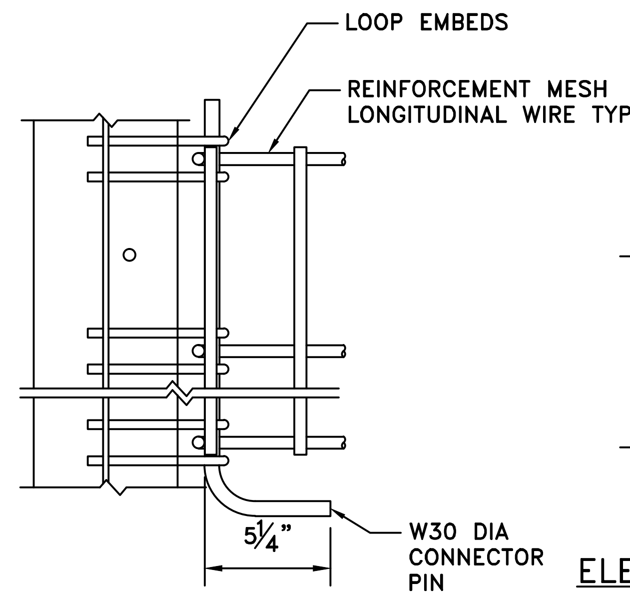
EXAMPLE REINFORCEMENT DETAIL



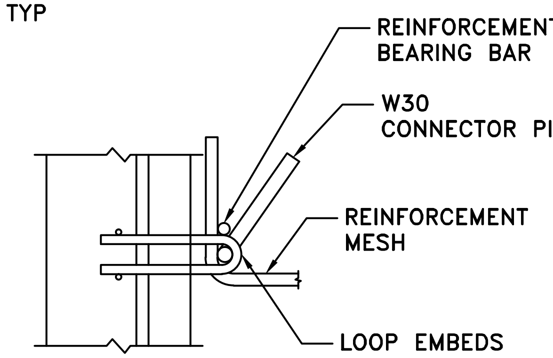
CONNECTOR PIN DETAIL



REINFORCEMENT CONNECTION DETAIL

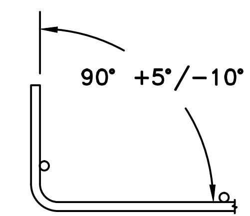


PLAN VIEW

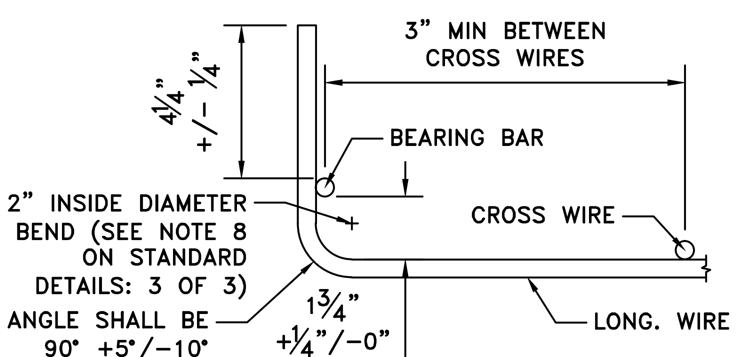


ELEVATION VIEW

REINFORCING MESH CONNECTOR BAR DETAIL

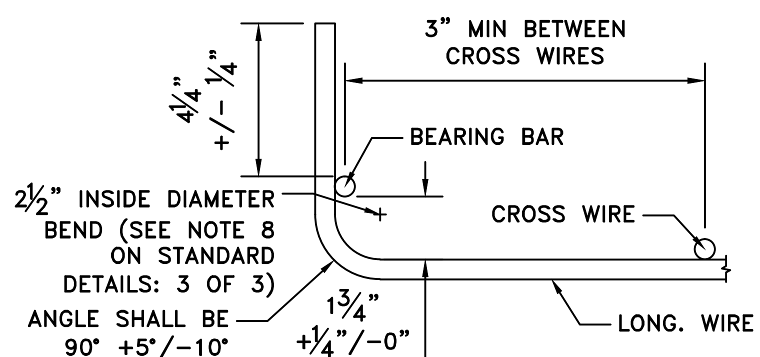


BEND TOLERANCE



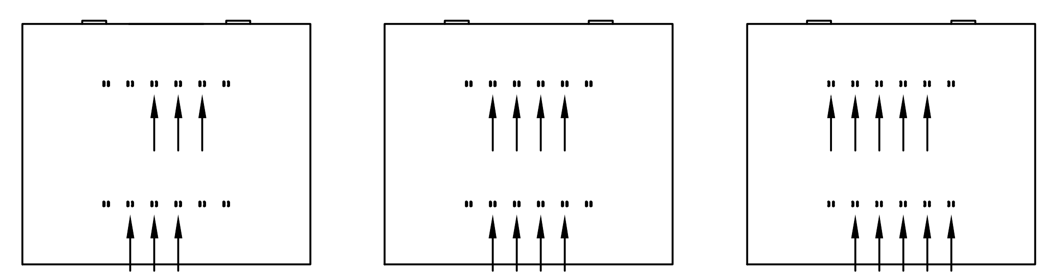
W11 & W20 WIRE MESH LOOP DETAIL

(CROSS WIRES & BEARING BAR SHALL MATCH CROSS SECTIONAL AREA OF LONGITUDINAL WIRES)



W24 WIRE MESH LOOP DETAIL

(CROSS WIRES & BEARING BAR SHALL MATCH CROSS SECTIONAL AREA OF LONGITUDINAL WIRES)



3-WIRE CONNECTION PANEL 4-WIRE CONNECTION PANEL 5-WIRE CONNECTION PANEL

ATTACHMENT BY No. WIRES

(STANDARD PANELS ONLY)

NOTE: FOR SIX AND EIGHT WIRE CONNECTION PANELS, USE ALL CONNECTION POINTS PROVIDED.

SOIL REINFORCING DETAILS

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

REGISTERED PROFESSIONAL ENGINEER
FRANSISCUS S. HARDIANTO
No. C60215
EXP. 06-30-22
CIVIL
STATE OF CALIFORNIA

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		NO.	DATE	REVISION DESCRIPTION	BY
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CHECK BY: FSH	03/09/21				
PROJ. ENGR: FSH					

STANDARD DETAILS: 4 OF 5

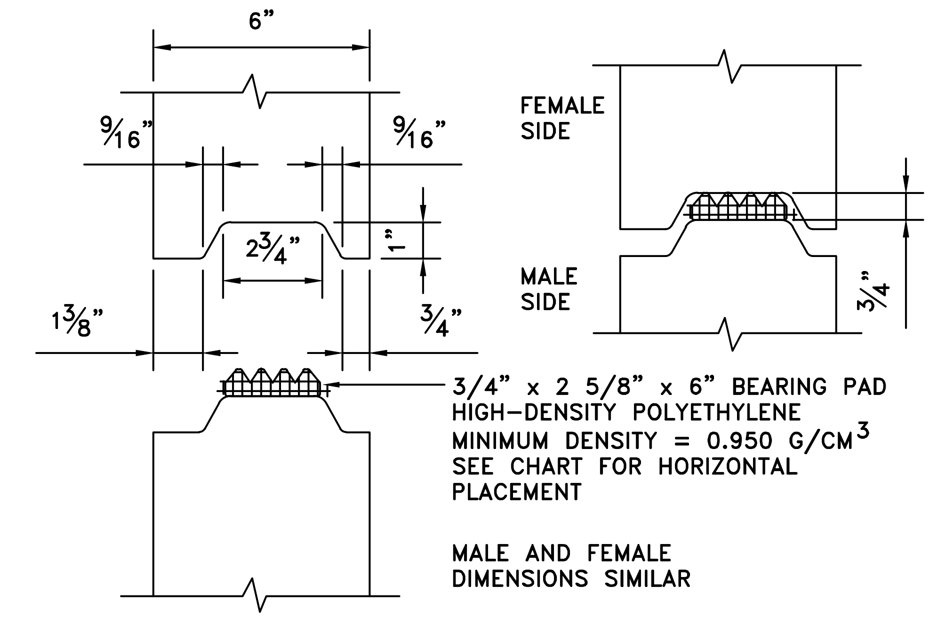
STANDARD MSE WALL DETAILS

Scale: NTS
Job: --
Sheet: RW-04
Sheet 4 of 5

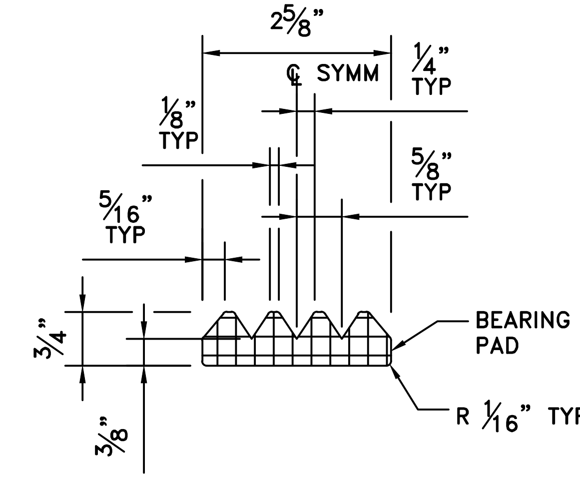
FRANSISCUS S. HARDIANTO
03/09/21

MATERIAL PROPERTIES NOTES:

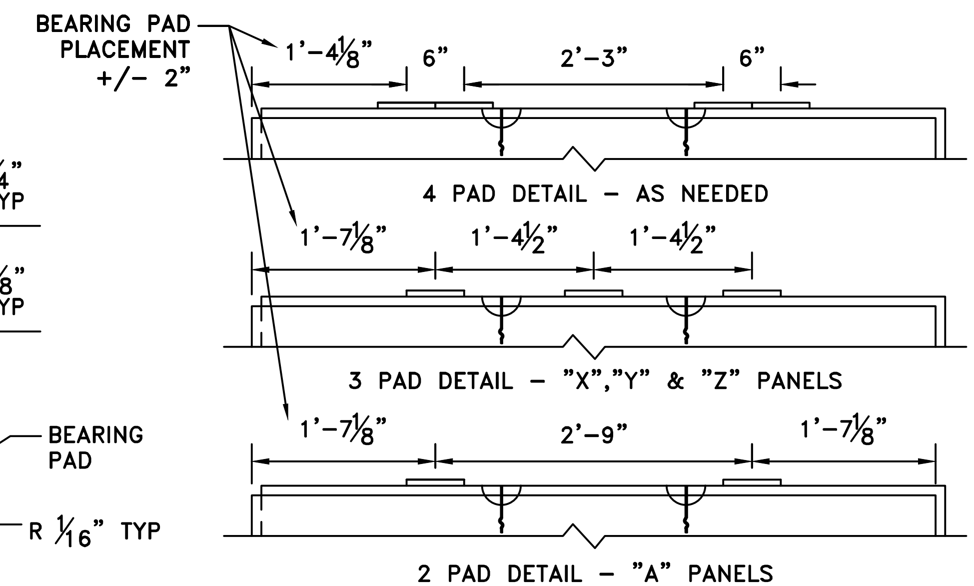
1. PANEL REINFORCEMENT BARS SHALL BE DEFORMED BILLET STEEL BARS FOR CONCRETE REINFORCEMENT CONFORMING TO THE SPECIFICATION OF ASTM DESIGNATION A 615, GRADE 60, INCLUDING SUPPLEMENTARY REQUIREMENT S1 OR LOW ALLOY STEEL DEFORMED BARS CONFORMING TO THE SPECIFICATIONS OF ASTM DESIGNATION A706. STRUCTURAL WELDED WIRE REINFORCEMENT THAT CONFORMS TO ASTM A1064 SPECIFICATIONS MAY BE SUBSTITUTED FOR ASTM DESIGNATION A615.
2. W11, W20 & W24 STEEL WIRE SHALL CONFORM TO THE ASTM DESIGNATION A1064. THE WELDED WIRE SOIL REINFORCEMENT AND LOOP EMBED SHALL BE WELDED IN ACCORDANCE WITH ASTM DESIGNATION A1064. ALL SOIL REINFORCEMENT MESH SHALL BE COMPOSED OF SMOOTH WIRE, DEFORMED WIRE SHALL NOT BE USED FOR SOIL REINFORCEMENT, LOOP EMBEDS AND CONNECTION PIN.
3. THE LOOP EMBEDS, SOIL REINFORCEMENT AND CONNECTION PINS SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM DESIGNATION A123 AFTER BENDING.
4. CONCRETE PANELS TO HAVE A 28-DAY COMPRESSIVE STRENGTH OF 4000 PSI.
5. ALL PANEL REINFORCEMENT MUST HAVE A MINIMUM OF 1 1/2" COVERAGE WITH CONCRETE ON ALL SIDES.
6. FOR PANELS WITH W11 & W20 MESH USE "A" PANEL REINFORCEMENT. PANELS WITH 6 W24 MESH USE "X" PANEL REINFORCEMENT. PANELS WITH 7 OR 8 W24 MESH USE "Y" PANEL REINFORCEMENT. PANELS WITH 2x6 W20 & 8 W24 USE "Z" PANEL REINFORCEMENT.
7. FILTER FABRIC IS A NON-WOVEN GEOTEXTILE COMPOSED OF POLYPROPYLENE FIBERS, WHICH ARE FORMED INTO A STABLE NETWORK SUCH THAT THE FIBERS RETAIN THEIR RELATIVE POSITION. FILTER FABRIC IS INERT TO BIOLOGICAL DEGRADATION AND RESISTS NATURALLY ENCOUNTERED CHEMICALS, ALKALIDS AND ACIDS.
8. THE MINIMUM INSIDE BEND DIAMETER FOR THE SOIL REINFORCEMENT SHALL BE NO LESS THAN TWICE THE NOMINAL DIAMETER OF THE WIRE SIZE AND IN NO INSTANCE BE LESS THAN 1 INCH.
9. CROSS WIRES, BEARING BARS WIRE AND LONGITUDINAL WIRES ON SOIL REINFORCEMENT SHALL BE THE SAME SIZE.
10. UNIVERSAL MESH SHALL BE SUPPLIED FOR THE USE OF REPLACING ANY STYLE OF MESH FOR THE PROJECT. THE UNIVERSAL MESH SHALL HAVE THE GREATEST NUMBER OF LONGITUDINAL WIRES, THE LARGEST CROSS SECTIONAL AREA OF LONGITUDINAL WIRES, THE SMALLEST CROSS BAR SPACING, THE GREATEST CROSS SECTIONAL AREA OF CROSS BARS, AND THE LONGEST LENGTH OF ANY STYLE OF SOIL REINFORCEMENT ON THE PROJECT. THE CONTRACTOR IS RESPONSIBLE FOR NOTING WHERE THE UNIVERSAL SOIL REINFORCING IS PLACED DURING CONSTRUCTION.



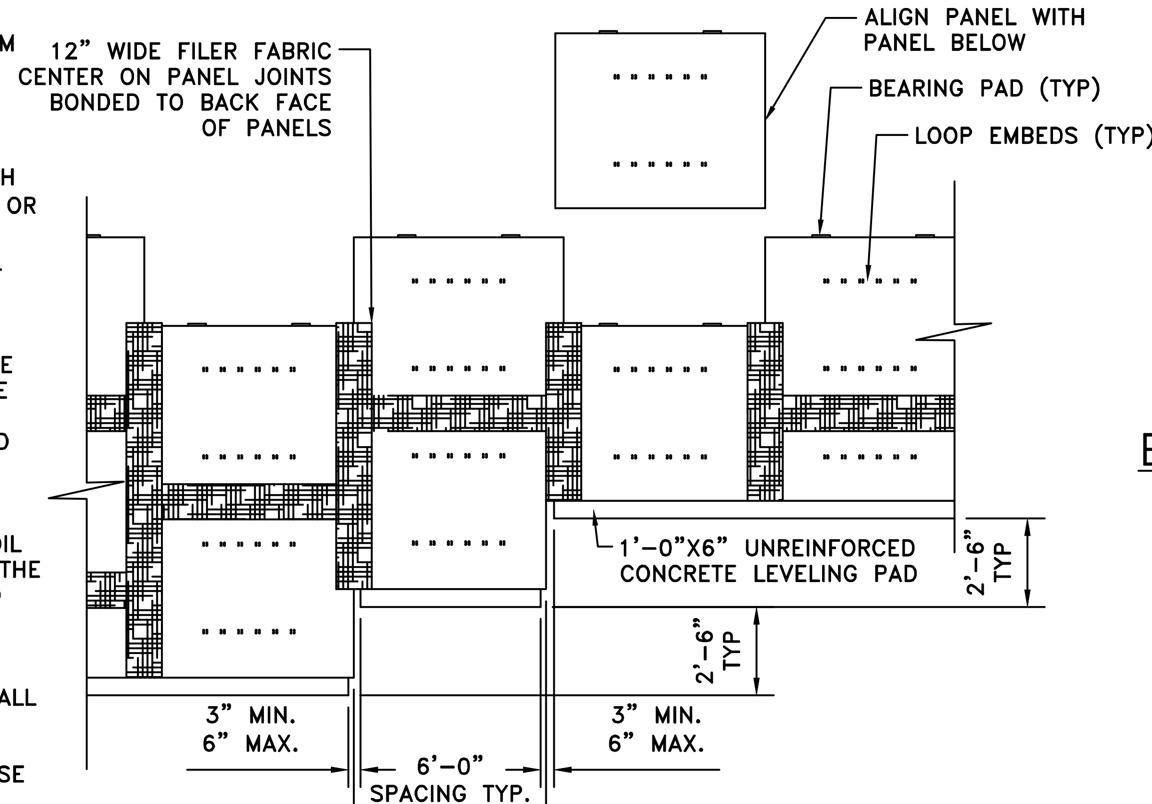
HORIZONTAL PANEL JOINT DETAIL



BEARING PAD DETAIL



BEARING PAD PLACEMENT

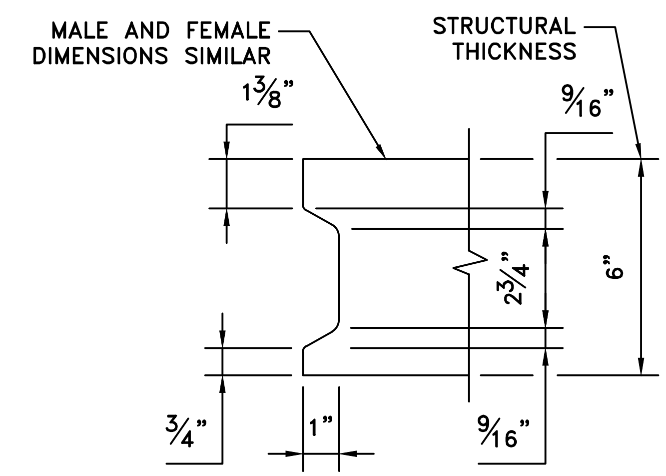


FILTER FABRIC DETAIL AND PANEL PLACEMENT

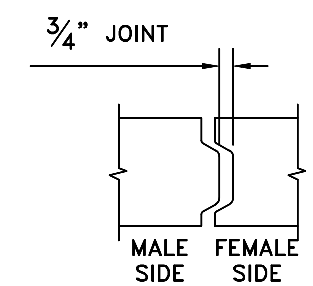
(BACK VIEW)

PANEL HT	Qty.
5 ft	2
10 ft	2
15 ft	2
20 ft	2
25 ft	2
30 ft	2
35 ft	3
40 ft	3
45 ft	3
50 ft	3

BEARING PAD CHART



VERTICAL PANEL JOINT DETAIL



MSE WALL INSTALLATION DETAILS

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

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03/09/21

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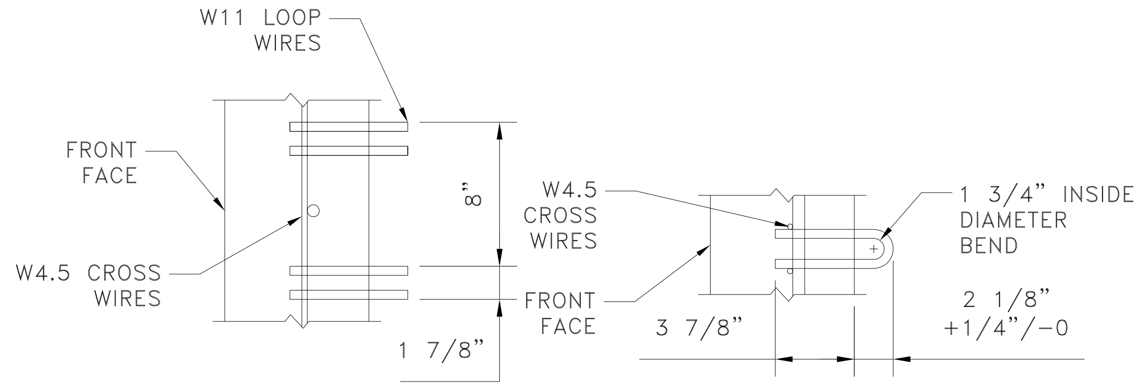
NO.	DATE	REVISION DESCRIPTION	BY

STANDARD DETAILS: 5 OF 5

STANDARD MSE WALL DETAILS

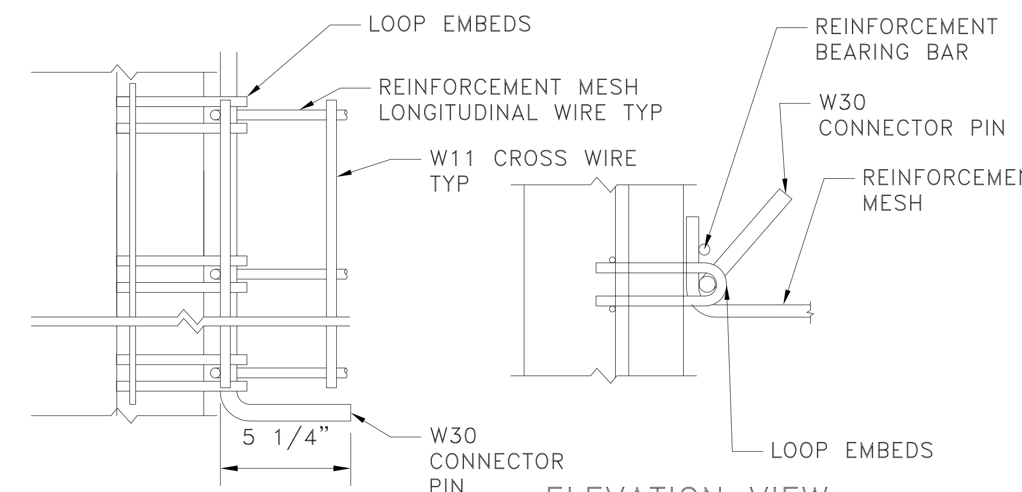
Scale: NTS
Job: --
Sheet: RW-05



PLAN VIEW

ELEVATION VIEW

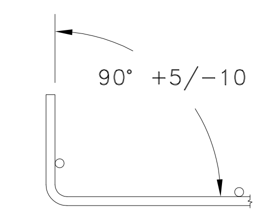
LOOP EMBED DETAILS



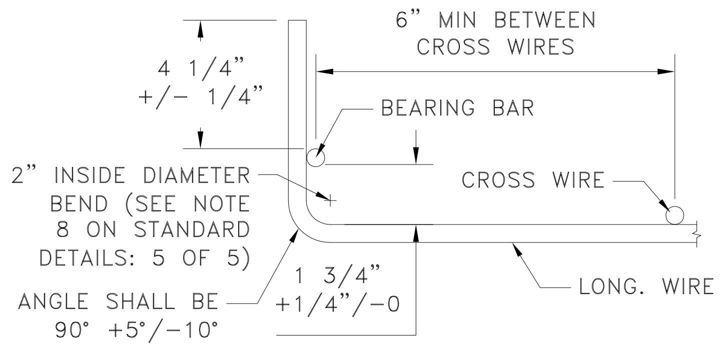
PLAN VIEW

ELEVATION VIEW

REINFORCING MESH CONNECTOR BAR DETAIL

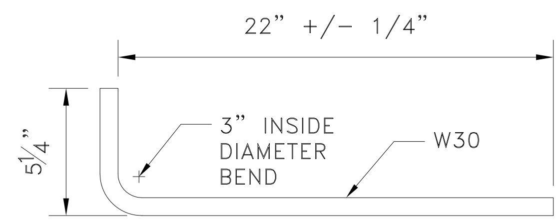


BEND TOLERANCE



WIRE MESH LOOP DETAIL

(CROSS WIRES, BEARING BAR WIRES AND LONGITUDINAL WIRES ON SOIL REINFORCEMENT SHALL BE THE SAME SIZE)



BENT PIN DETAIL

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DESIGN BY: FSH	01/24/22				
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SOIL REINFORCEMENT CONNECTION

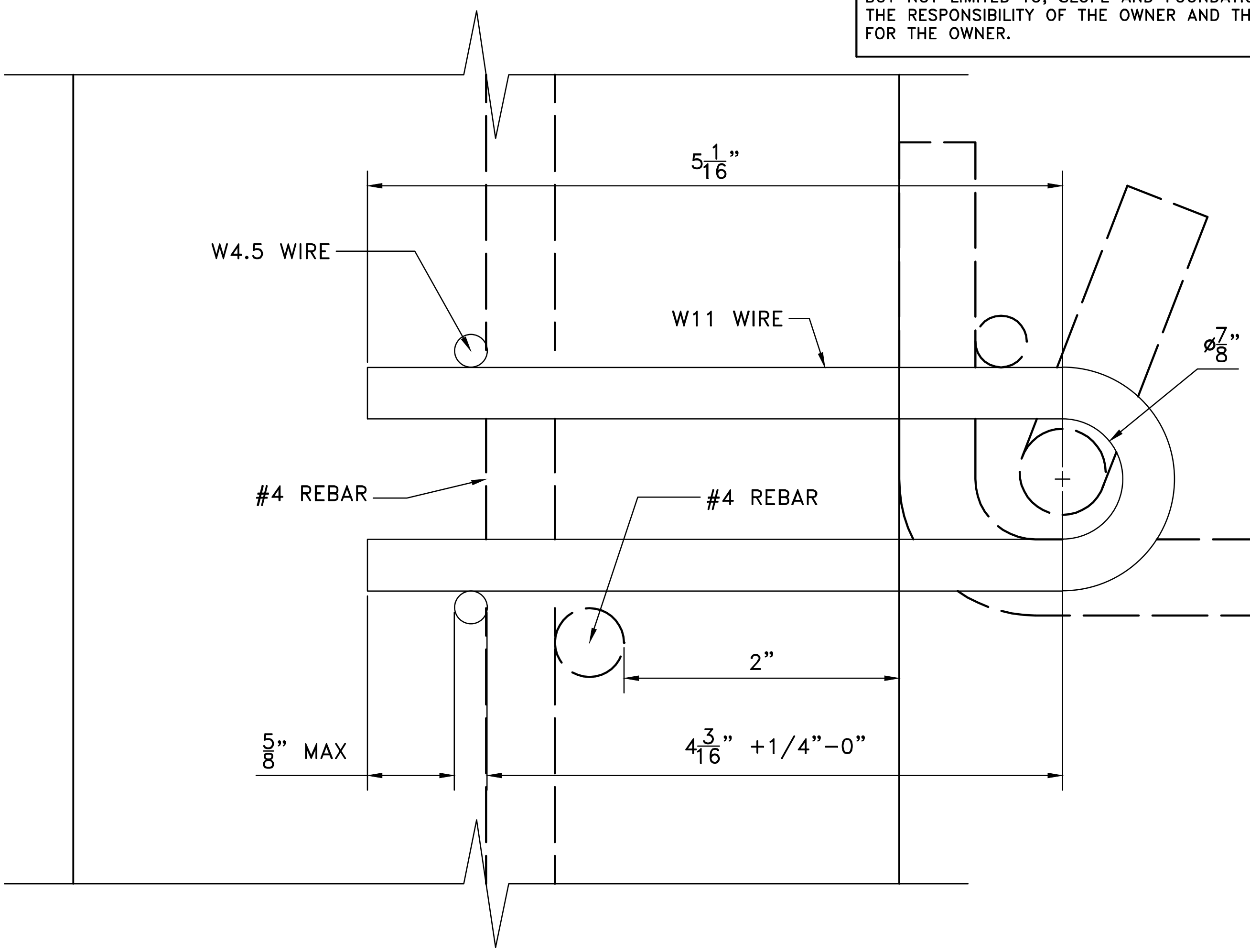
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

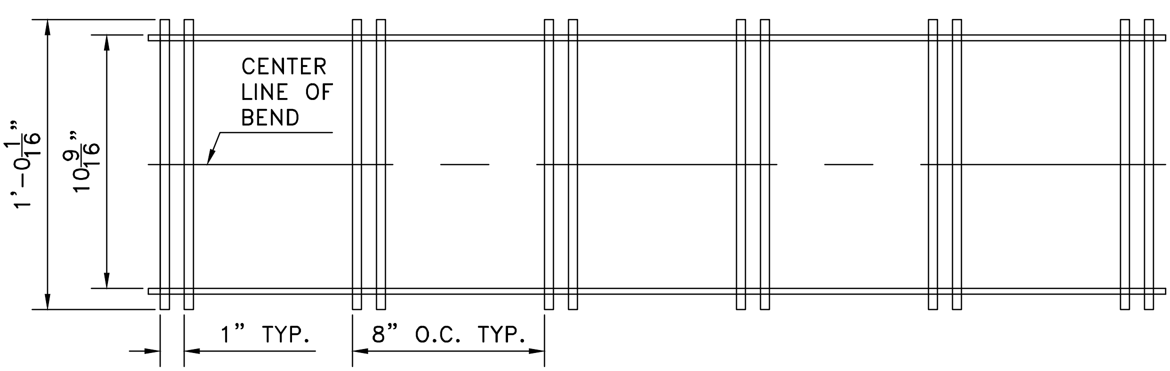
1.2.14 Connection Device Dimension

THE DESIGN OF ALL MSE PLUSE™ WALLS IS BASED ON THE ASSUMPTION THAT ALL MATERIALS, INCLUDING THE BACKFILL AND METHODS OF CONSTRUCTION, CONFORM TO THE SPECIFICATIONS FOR MSE PLUSE™ RETAINING WALLS AND THE PROJECT BID DOCUMENTS

THESE DRAWINGS, AS WELL AS THE DESIGN, ARE CERTIFIED WITH RESPECT TO THE INTERNAL STABILITY OF THE MSE PLUS™ STRUCTURES ONLY. EXTERNAL STABILITY INCLUDING, BUT NOT LIMITED TO, SLOPE AND FOUNDATION STABILITY IS THE RESPONSIBILITY OF THE OWNER AND THE ENGINEER FOR THE OWNER.



EMBED: ELEVATION VIEW (IN PANEL)



EMBED RACK (BEFORE BEND)

NO.	DATE	REVISION DESCRIPTION	BY

8" SPACING EMBED LOOP

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Scale: NTS
Job: XXXX
Sheet: RW-01
Sheet 01 of XX

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1.2.15 Soil Reinforcing Connection Strength and Testing

TOC – Appendix

SSL Connection Test: MSE*Plus*™ Panel Wall System

December 6, 2012

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Nick Haven
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INNOVATIVE CONSTRUCTION PRODUCTS

TABLE OF CONTENTS

INNOVATIVE CONSTRUCTION PRODUCTS

1. ABSTRACT

Mechanically Stabilized Earth (MSE) retaining walls are structures consisting of multiple layers of soil reinforcement placed in select backfill and connected to a facing element. SSL has developed a soil reinforcement connection for MSE retaining walls which uses welded wire mesh as soil reinforcement and precast concrete panels as a facing element.

This report details a test program developed by SSL to examine the capacity of the connection system along with the interaction of the soil reinforcement and the concrete panel facing element. Caltrans requires that all elements of the soil reinforcement connection system can reach the yield strength of the steel. This test will show that the steel reinforcing wire and all elements of SSL's connection system can reach the yield strength of the longitudinal wire element (65 ksi) before failure.

During the test, load is applied to soil reinforcement that is connected to a concrete panel. The soil reinforcement is gripped using a steel wire chuck that is fastened to the longitudinal wire and load is applied using a hollow-cylinder hydraulic ram that is supported by a steel frame placed on the concrete panel. A satisfactory or "passing" test run is one in which the yield strength of the steel or Target Load is reached without failure of the connection system. An unsatisfactory or "failing" test run is one in which any element of the connection system fails before Target Load is reached.

The test program included six steel soil reinforcement samples which consisted of single-wire W24 samples with W24 transverse bars. Each sample passed demonstrating that the SSL Panel Wall system can satisfy Caltrans requirements.

2. INTRODUCTION

The MSE Plus™ connection system has undergone the following changes to the welded wire mesh soil reinforcing elements:

- The bend radius of the longitudinal wires has been increased to 1.25” for W24 wire gauges.
- For Caltrans projects, the gauge of all transverse wires will equal to the gauge of the longitudinal wires.
- The use of *deformed* wire as soil reinforcement has been eliminated and only smooth wire will be used.

The Caltrans LRFD connection test requires the capacity of the MSE panel connection system to meet or exceed the yield strength of the reinforcing element.

The following report will detail the test program that was administered by SSL in order to ensure that the updated connection system, as a whole, can reach or exceed the yield strength of the longitudinal wire element.

2.1 BACKGROUND AND CALCULATIONS

SSL's system will utilize W11, W20 and W24 welded wire mesh as soil reinforcement for Caltrans projects. The samples for this test will be smooth-rolled wire in the W24 size, data for W11 and W20 wire sizes has been provided in the SSL Test Report dated March 20, 2012.

For this test, the Target Load (TL) is the yield strength of the longitudinal wire element of the soil reinforcing mesh (65,000 psi) multiplied by the cross sectional area of the wire. For W24 wire, the cross sectional area of the wire is 0.24 in^2. The TL requirement for W24 wire is shown below:

- W24: 65,000 psi x (0.24 in^2) = 15,600 Lbs.

The connection system will undergo elongation as load is applied. Different components of the connection system will contribute to elongation as the load increases. During a test run in which target load is met, the sequence of elongation is typically as follows:

- Phase 1: The 90˚ bend in the longitudinal wire opens until the free end comes in to contact with the back of the test panel (see Figure 1).

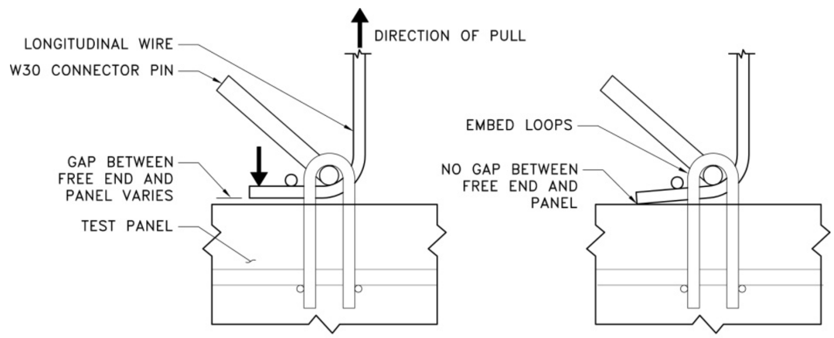

FIGURE 1

- Phase 1A: The transverse bearing bar is pulled tight against the concrete panel's embed loops (see Figure 2). *NOTE: Depending on the initial placement of the sample, Phase 1A of elongation may not occur*.

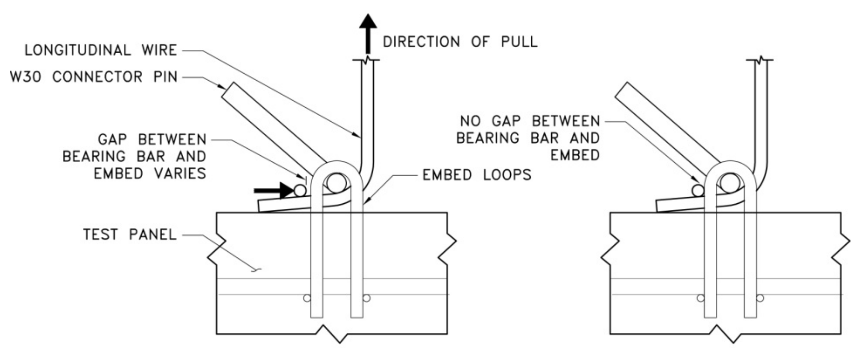

FIGURE 2

- Phase 2: The bend of the longitudinal wire will be pulled tightly against the W30 connector pin (see Figure 3).

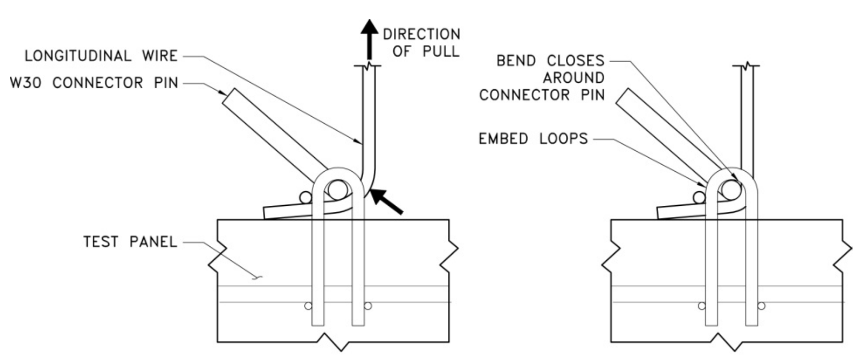

FIGURE 3

- Phase 3: The longitudinal wire element of the soil reinforcement will elongate in the length between the connector pin and the grip point of the steel wire chuck. *NOTE: 0.0574 in of elongation is expected to occur in a wire sample with a free length of 26.5 in. (see calculation in Section 9).*

- Phase 4: Loads in excess of the yield strength of the steel will cause plastic deformation or *necking down* of the longitudinal wire followed by fracture (see Photo's 1 and 2). *NOTE: Similar to W20, during test runs performed on W24 samples, the higher loads approaching and following yield strength will likely cause some deformation of the connector pin and embed loop elements of the system (the embed loops will deform by approximately 0.030 in as shown in Photo's 3, 4 and 5).*

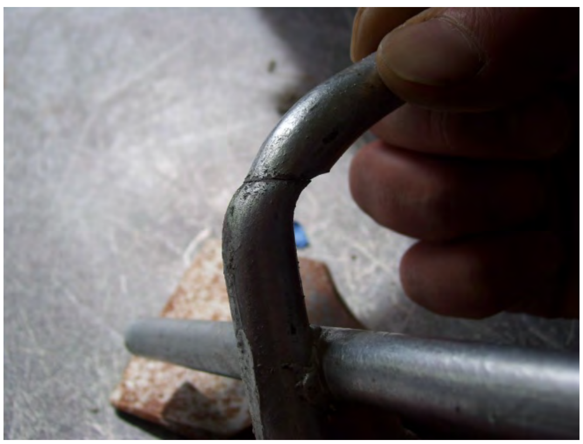

PHOTO 1: W20 NECKED DOWN AND FRACTURED

PHOTO 2: W11 NECKED DOWN AND FRACTURED

PHOTO 3: EMBED LOOP PRIOR TO TESTING (0.933 in)

PHOTO 4: EMBED LOOP AFTER W20 TEST (0.963 in)

PHOTO 5: DEFORMATION OF EMBED LOOP

The rate and length of elongation in all of the connection elements will vary due to any one of the following: wire size; bend angle; embed loop clearance and the initial placement of the wire sample (e.g, it is possible to connect the sample so that the transverse bearing bar is snug against the embed loops, eliminating Phase 1A of elongation).

Due to the arrangement of the steel test apparatus and the position of the hydraulic ram (See Figure 4) there is potential for deflection at the center of the beam that is supporting the ram. This deflection could interfere with the measurements being taken to record elongation. To minimize deflection, the subsequent supporting perpendicular beams are placed as close together as possible, typically around 10.5 in. apart. The expected maximum deflection caused by a point load of over 15,600 lbs on the center of a simply supported steel beam as exists in the test apparatus is .002 in. (See the calculations included in Section 9). Also, care should be taken to ensure that the base of the dial indicator is placed directly over the point at which the simply supported beam and the beam below intersect.

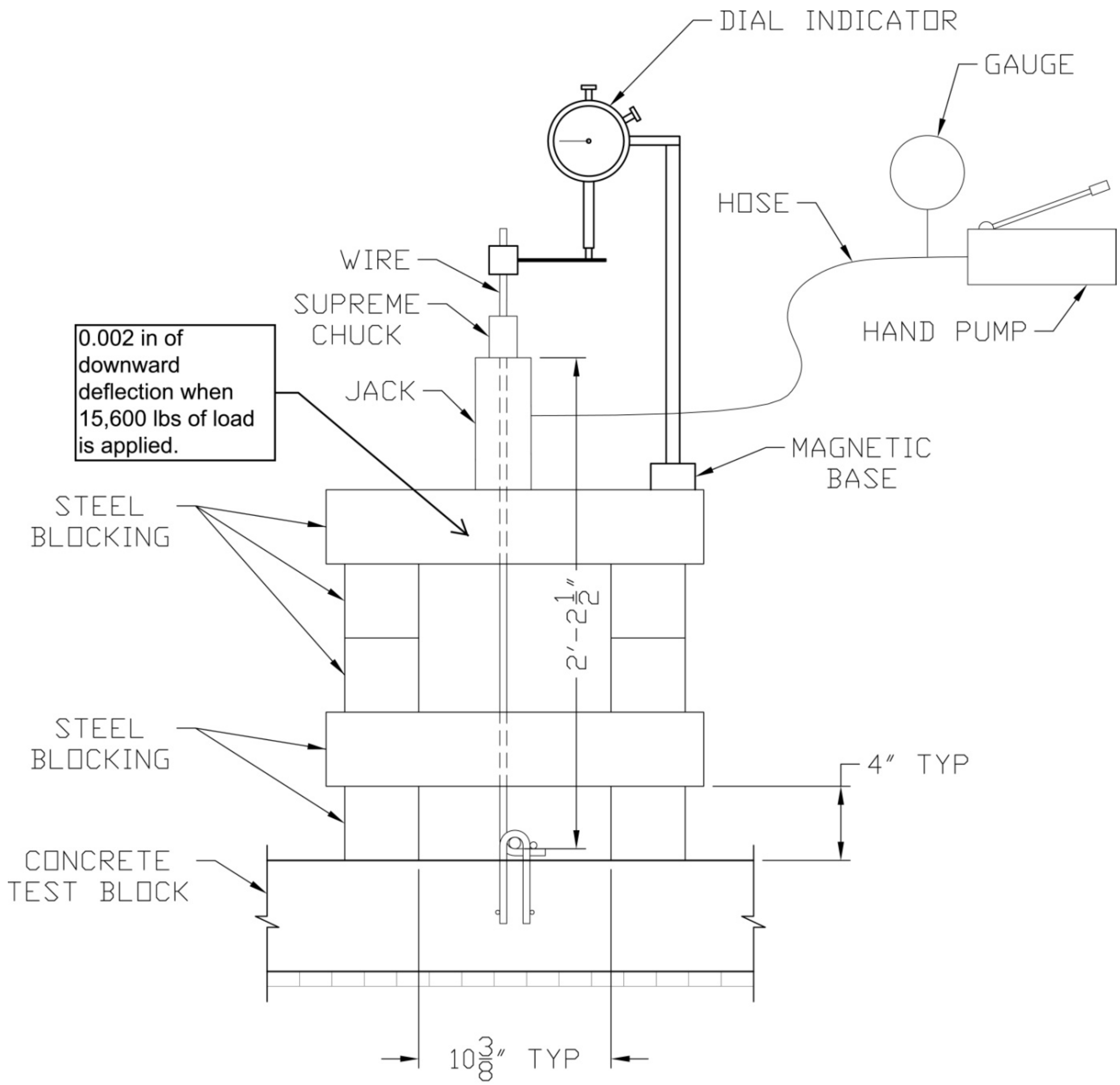

FIGURE 4: DEFLECTION IN TEST APPARATUS

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2.2 MATERIALS AND EQUIPMENT

Wire samples were manufactured in accordance with ASTM A82 and the mesh sheets were fabricated in accordance with ASTM A185 and then galvanized in accordance with ASTM A123 (See compliance certifications included in Section 10).

Four, hollow-cylinder ram and gauge combinations were calibrated prior to testing by Technical Associated Services (TAS). The calibration reports provided by TAS are included in Section 7 of this report. The ram/gauge combinations are identified as follows with identical labels for both the ram and gauge:

- Ram/Gauge #1 (12k-12-1)
- Ram/Gauge #2 (12k-12-2)
- Ram/Gauge #3 (12k-12-3)
- Ram/Gauge #4 (12k-12-4)

Based on the calibration reports, the following gauge readings coincide with the target load (TL) for each wire size:

- W24:
  - 12k-12-1: 6,555 psi = 15,600 lbs force
  - 12k-12-2: 5,690 psi = 15,600 lbs force
  - 12k-12-3: 5,650 psi = 15,600 lbs force
  - 12k-12-4: 5,710 psi = 15,600 lbs force

The gauge reading at the initial 500 lb data point and the subsequent data points at 1,000 lb intervals are taken directly from the calibration reports. The gauge reading at target load (TL) is taken directly from the calibration report and will be highlighted yellow and marked TL on the data sheet.

The test frame as detailed in Figure 4 and Section 8, consists of short pieces (between 3 ft. and 5 ft. long) of 0.25 in thick, 4 in. square steel tubing. The lowest supporting beams are placed parallel to the embed loops to allow access for the connector pin, the next course of beams are placed perpendicular to the lowest beams at a distance apart that allows access to the desired number of wire samples. Beams are stacked perpendicular to one another until the desired height of the test apparatus is achieved. The top beam that supports the hydraulic ram must be placed perpendicular to the bottom beams and it will have a 0.75 in hole drilled in the center of the beam. The wire sample will be threaded through the hole in the top beam. It may be necessary to have beams stacked on each other in parallel in order to ensure that the beam supporting the hydraulic ram(s) is perpendicular to the bottom beams.

2.3 TEST REQUIREMENTS

This test will confirm:

- The tensile capacity of the reinforcing wire will meet or exceed the yield strength of the longitudinal wire.
- The load capacity of all elements of the panel to soil-reinforcement connection.
- The rotational ductility of the "L" portion of the bend under load.
- Measurement of the total elongation in the connection while under load, and comparison with expected elongation of the longitudinal wire at yield.

Each test-run will be concluded when one of the following events occurs:

- The weld between the transverse bearing bar and the longitudinal wire is broken.
- The transverse bearing bar is sheared by the panel embed loops.
- The longitudinal wire breaks at any location.

Below are the Pass/Fail criteria:

- Pass: If the connection breaks at any location after reaching the Target Load.
- Fail: If the connection breaks at any location before reaching the Target Load.

A representative from a qualified independent testing laboratory shall be present during all testing, a report prepared by the lab will be included in the final testing report.

3. TEST PROCEDURE

3.1 TEST PANEL FABRICATION

1. Install connector and reinforcing steel.
2. Pour test panel.
3. Form concrete cylinders for testing. Testing may be performed upon 4,000 PSI concrete cylinders breaks.

3.2 WIRE SAMPLE PREPARATION

1. When single wire sample is being tested, ensure that the transverse bearing bar does not overlap or come into contact with adjacent embed loops. A length less than 12'' for the transverse bearing bar is recommended.

2. When multiple wires of a sheet are being tested simultaneously, extreme care must be taken to ensure that there are no additional effects caused by the interaction between the transverse bearing bar and the adjacent embed loops. This can be done by:
   - Prior to testing, visually inspect embed loops to ensure that they are at a uniform height above the test panel
   - During testing, maintaining a consistent and even load to each wire that is being tested.
3. Prior to each test run, the wire sample must be thoroughly inspected with hand magnification device to look for cracks, condition of welds, condition of galvanizing, and any other structural or cosmetic defects. Record any observations.
4. Prior to each test run, the wire sample must be measured and recorded for length, angle of bend, distance between bend and transverse bearing bar, and the distance between the bend and the transverse cross bar (if present).
5. Prior to each test run, the wire diameter of all longitudinal and transverse wires must be confirmed and recorded. Measurements include thickness attributed to galvanizing.

3.3 PULL TEST

1. Attach wire mesh sheet with "L" connection to the test panel using W30 connector pin.
2. Install hollow cylinder ram onto the desired number of longitudinal wires and fasten with steel wire chuck. Care must be taken to ensure that all slack is out of the connection prior to installation of steel wire chuck.
3. For each wire being tested, attach measurement clip above steel chuck and align with magnetic base dial indicator. Care must be taken to place the base of the dial indicator above the point at which the top and subsequent steel tubes of the test apparatus cross this will minimize the effects of the maximum expected downward deflection of the test apparatus.
4. Apply load to connection(s), extreme care must be taken to ensure that equal load is being applied to each longitudinal wire. Unbalanced loads will be evident by differences in gauge readings. To balance the loads, make small increases in the trailing ram's pressure.
5. *Alignment Load 1, 500 lbs (AL1)*: Record elongation reading from dial indicator beginning at Alignment Load 1 and continue applying load and recording at 1,000 lb intervals until Alignment Load 2 is reached.
6. *Alignment Load 2 (AL2), varies by wire size:* When the free end of the longitudinal wire reinforcing element is pulled against the test panel (Phase 1) rotational ductility has been exhibited and Alignment Load 2 has been reached, record elongation and identify on data sheet as "AL2". Continue applying load and recording at 1,000 lb intervals until Target Load is reached.
7. *Alignment Load 3 (varies by wire size)*: When the transverse bearing bar is pulled tight against the embed loops (Phase 1A) Alignment Load 3 has been reached, record

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elongation and identify on data sheet as "AL3". Continue applying load and recording at 1,000 lb intervals until Alignment Load 3 is reached. *Depending on the initial attachment of the wire sample, Alignment Load 2 and Alignment Load 3 may be reached simultaneously. If this is the case only AL2 will be notated on the data sheet.*

8. Due to a stroke limitations of 1", the Dial Indicator will likely need to be adjusted back to zero at some point during the test run, ideally this will be performed as close to TL or 1" of elongation as possible. The test administrator will make a notation on the data sheet indicating at which points the adjustment occurred. On the typed data sheet, the adjustment point will be indicated by a thick black line under the last elongation measurement taken before the adjustment.
9. Once Target Load is reached, record elongation and remove dial-indicator, continue applying load and recording elongation at 1,000 lb intervals using a tape measure until conclusion of test.
10. Record all aspects of the sample's performance including how/where breakage occurred, load at breakage or load at conclusion if no breakage occurred.
11. The wire sample must be thoroughly inspected after testing with hand magnification to look for cracks, weld condition and galvanizing condition. Record any observations.
12. The wire sample should be measured after testing and recorded for length, angle of bend, distance between bend and transverse bearing bar, and the distance between the bend and the transverse cross bar (if present). *If the test run is concluded by a longitudinal wire fracture, no relevant measurements of the sample can be made other than the examination of weld condition.*
13. Repeat test on remaining samples.

4. SUMMARY AND CONCLUSION

4.1 SUMMARY

For this test, Target Load (TL) was based upon the yield strength of the steel adjusted for the theoretical area of the samples. For W24 samples the TL is 15,600 lbs. In order to pass, each sample must reach TL before any type of failure in the connection.

Target load was reached in every test run, meaning that each sample passed testing. The W24 samples reached anywhere from 103% to 114% of TL.

Five out of six test runs were concluded by the longitudinal wire fracturing at or directly above the bend where the wire deformed around the connector pin as shown in Photos 1 and 2, one test run was concluded when the transverse bar weld sheared. All samples exhibited similar or identical fracture characteristics.

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The results of the testing are presented in Tables 1:

TABLE 1: DATA SUMMARY (W24 X W24)								
TEST	SAMPLE	PASS/FAIL	TARGET LOAD (lbs)	LOAD REACHED (lbs)	% of TARGET LOAD (65 ksi)	ELONGATION (in)		RESULT
1	W24 X W24	PASS	15,600	16,667	107%	Phase 1	0.218	Weld Shear
						Phase 2	1.030	
						Phase 3	0.0574	
						Phase 4	0.143	
						Total	1.448	
2	W24 X W24	PASS	15,600	17,750	114%	Phase 1	0.125	Longitudinal Wire Fracture
						Phase 2	1.290	
						Phase 3	0.0574	
						Phase 4	0.278	
						Total	1.750	
3	W24 X W24	PASS	15,600	16,000	103%	Phase 1	0.256	Longitudinal Wire Fracture
						Phase 2	1.069	
						Phase 3	0.0574	
						Phase 4	-	
						Total	1.382	
4	W24 X W24	PASS	15,600	16,000	103%	Phase 1	0.206	Longitudinal Wire Fracture
						Phase 2	0.948	
						Phase 3	0.0574	
						Phase 4	-	
						Total	1.211	
5	W24 X W24	PASS	15,600	17,500	112%	Phase 1	0.228	Longitudinal Wire Fracture
						Phase 2	1.150	
						Phase 3	0.0574	
						Phase 4	0.315	
						Total	1.750	
6	W24 X W24	PASS	15,600	17,750	114%	Phase 1	0.210	Longitudinal Wire Fracture
						Phase 2	1.150	
						Phase 3	0.0574	
						Phase 4	0.333	
						Total	1.750	

For the six W24 samples, the total elongation ranged from 1.211 in to 1.750 in with an average of 1.549 in. Phase 1 of elongation ranged from 0.125 in to 0.256 in with an average of 0.207 in. Phase 2 of elongation ranged from 0.948 in to 1.290 in with an average of 1.106 in. Phase 3 measurements are based up the expected elongation calculation provided in Section 9. Phase 4 measurements were taken using a standard tape measure after the Target Load had been reached and the dial indicator had been removed. Five of six test-runs were concluded with a longitudinal wire fracture, meaning that an accurate measurement of the plastic deformation is largely impossible. The first test run was concluded with a shearing of the transverse bar weld, plastic deformation was 0.143 in. Phase 4 elongation ranged from 0 in to 0.333 in with an average of 0.178 in. (See Table 2 and Charts provided in Section 5).

The phases of elongation for both wire sizes are summarized in Table 2:

TABLE 2: ELONGATION BY PHASE	
PHASE 1	
90 degree bend in longitudinal wire opens until free-end comes in to contact with test panel.	
W24	
Average (in)	0.207
Range (in)	0.125 to 0.256
PHASE 2	
The bend radius of the longitudinal wire closes around the connector pin.	
W24	
Average (in)	1.106
Range (in)	0.948 to 1.290
PHASE 3	
The yield strength of the longitudinal wire is reached causing elastic deformation.	
W24	
Average (in)*	0.0574
Range (in)*	0.0574
PHASE 4	
The yield strength of the longitudinal wire is exceeded causing plastic deformation or necking down, followed by fracture.	
W24	
Average (in)	0.178
Range (in)	0 to .333
TOTAL	
The sum of all the phases of elongation.	
W24	
Average (in)	1.549
Range (in)	1.211 to 1.750

*Phase 3 measurement is based upon expected elongation.

All samples tested were given a thorough visual inspection prior to testing, as noted on the Material Measurement sheets provided in Section 5, the condition of all samples was "OK".

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4.2 CONCLUSION

The test results provided herein conclude that all elements of the panel to soil-reinforcement connection of the MSE*Plus*^{TM} system meet or exceed the tensile capacity of the reinforcing wire for W24 sizes which satisfies Caltrans requirements

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5. TEST DATA

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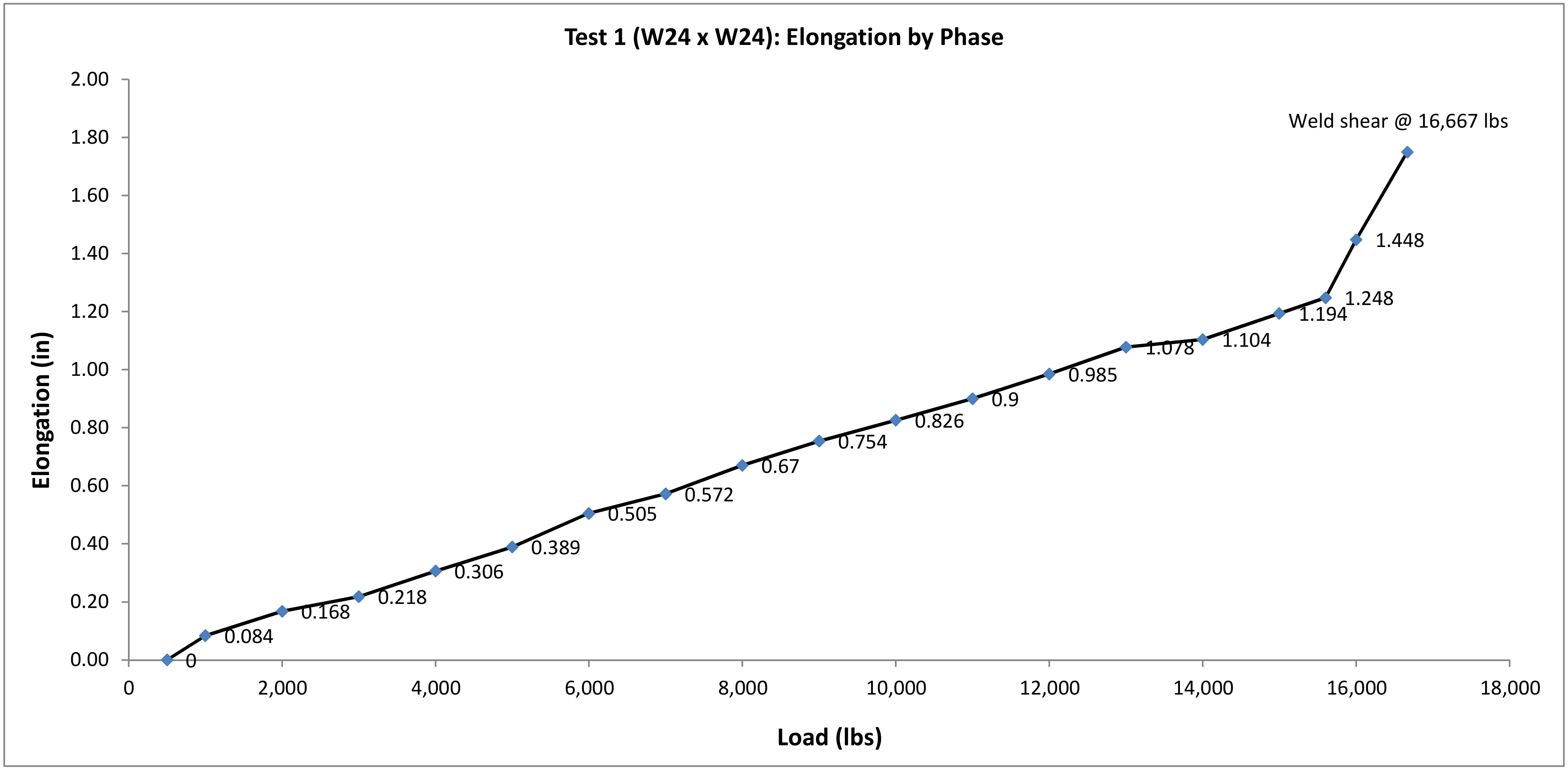
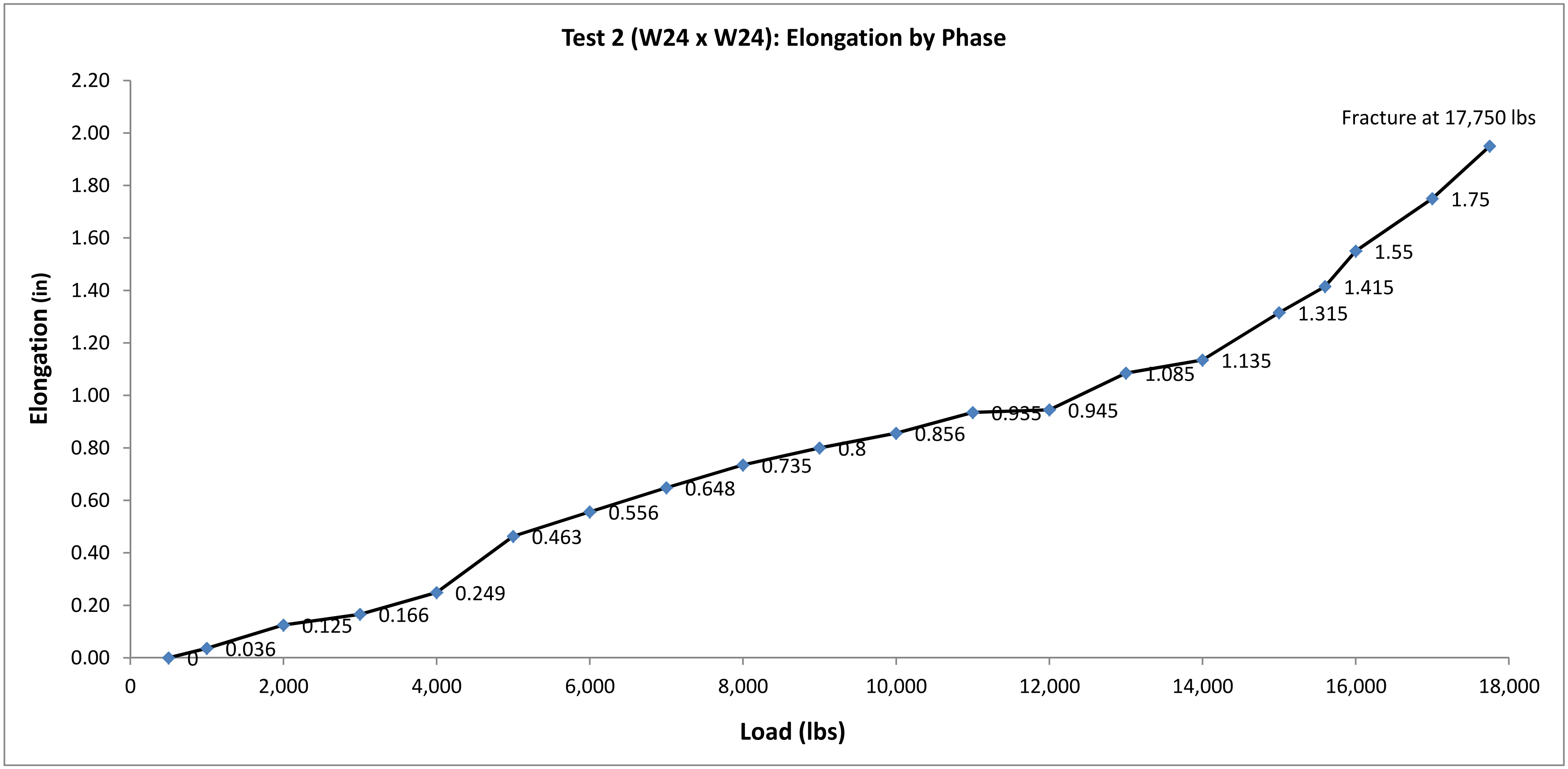
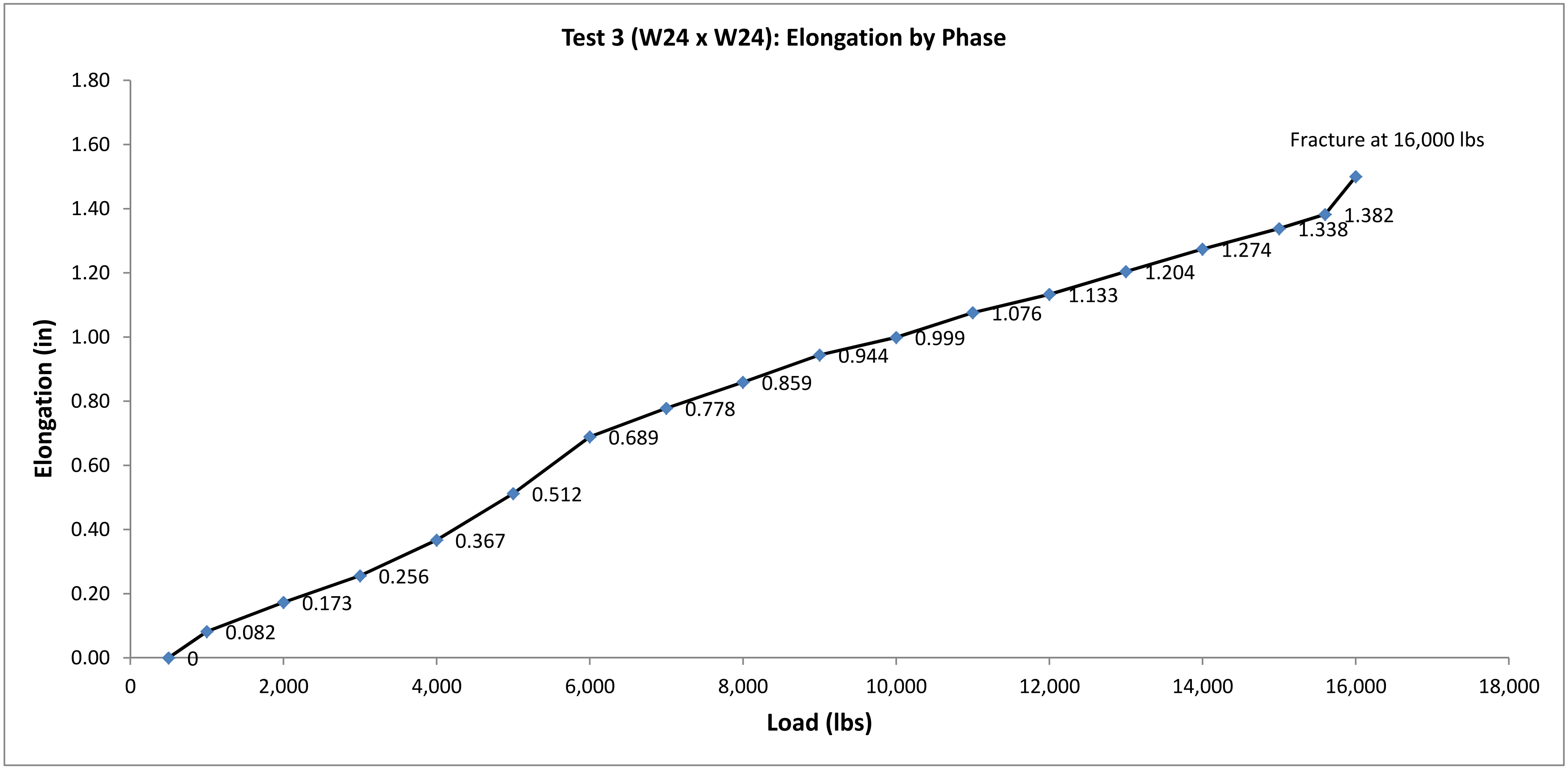
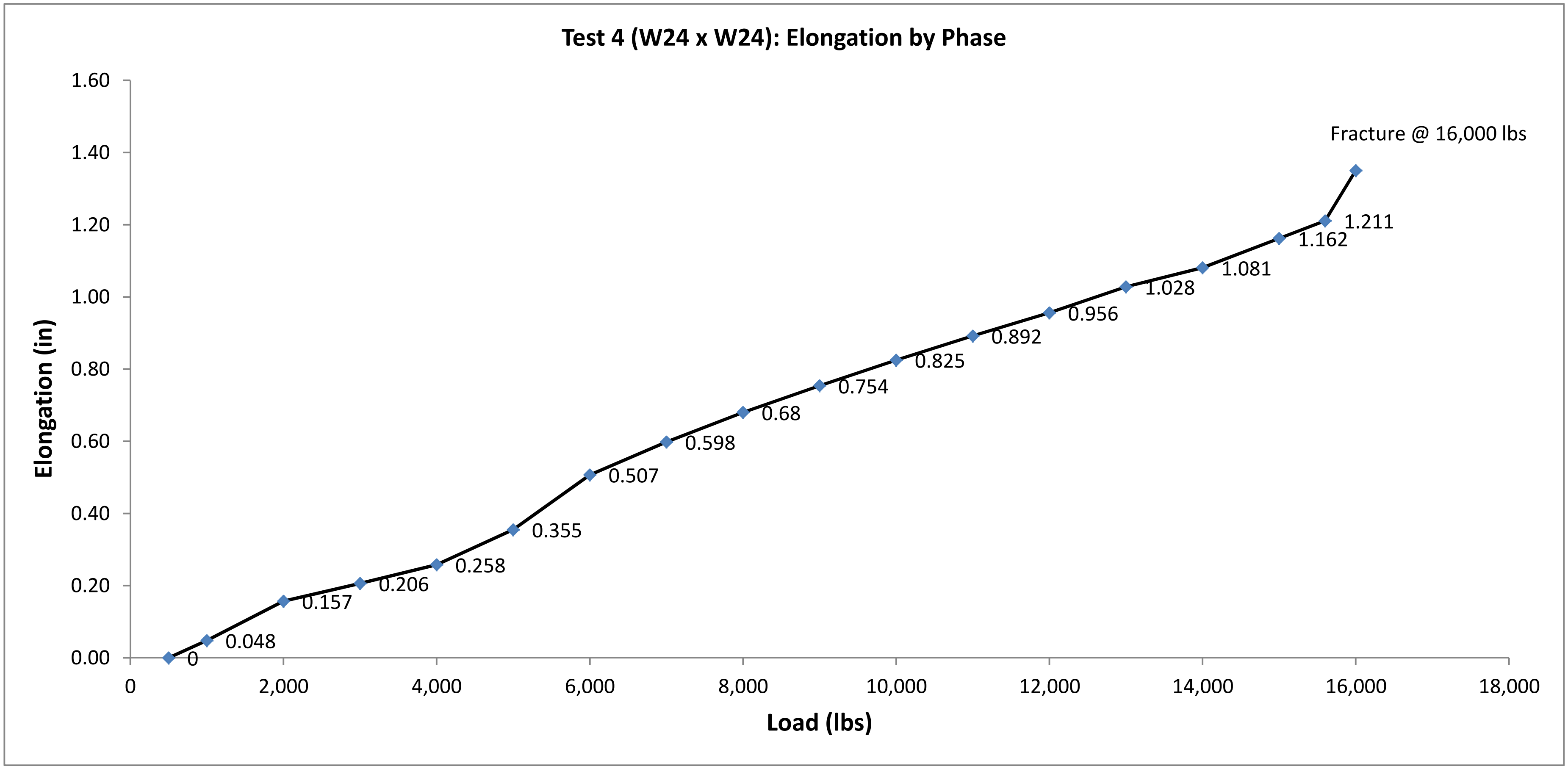
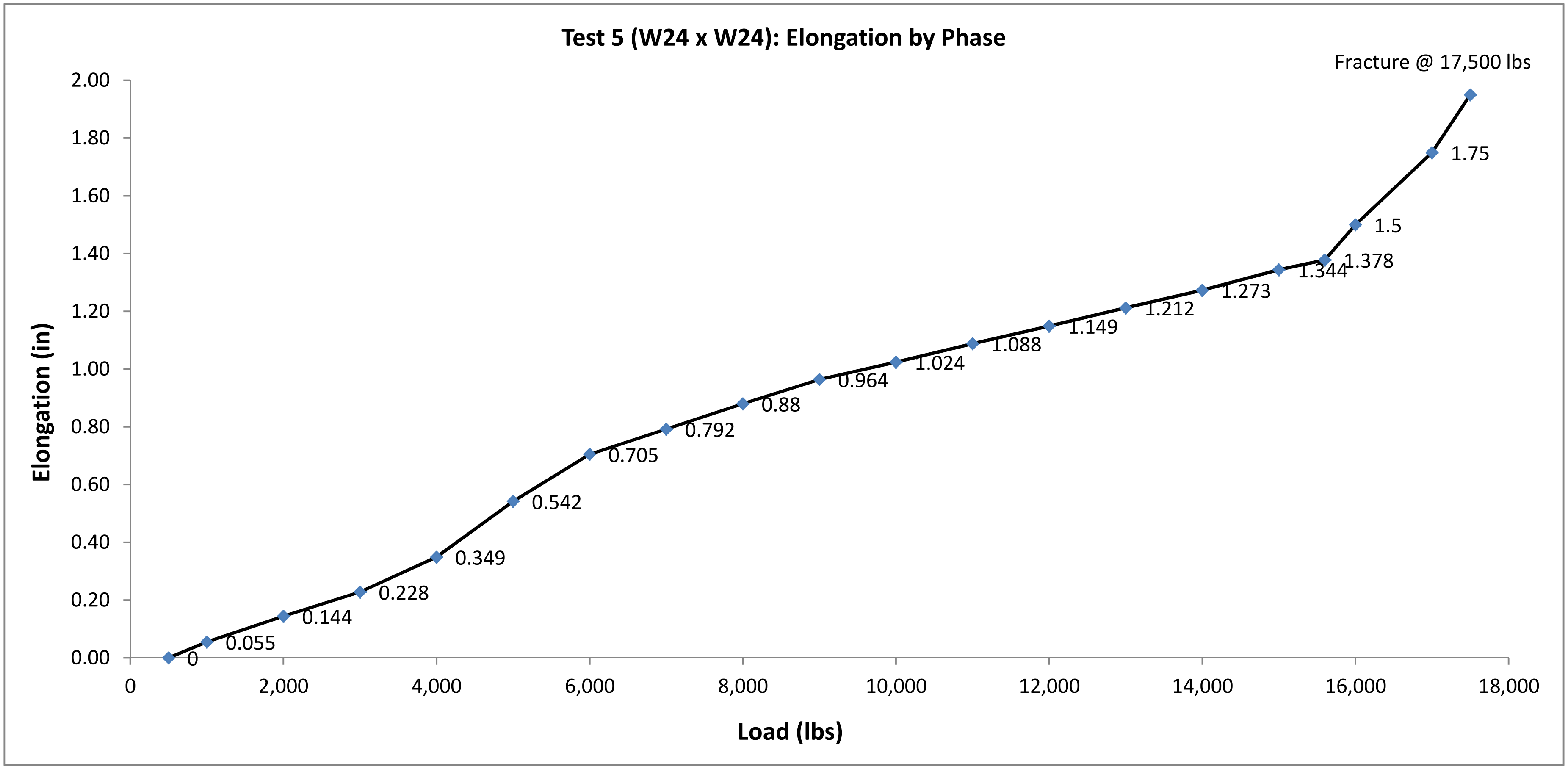
5.1 CHARTS DETAILING ELONGATION BY PHASE

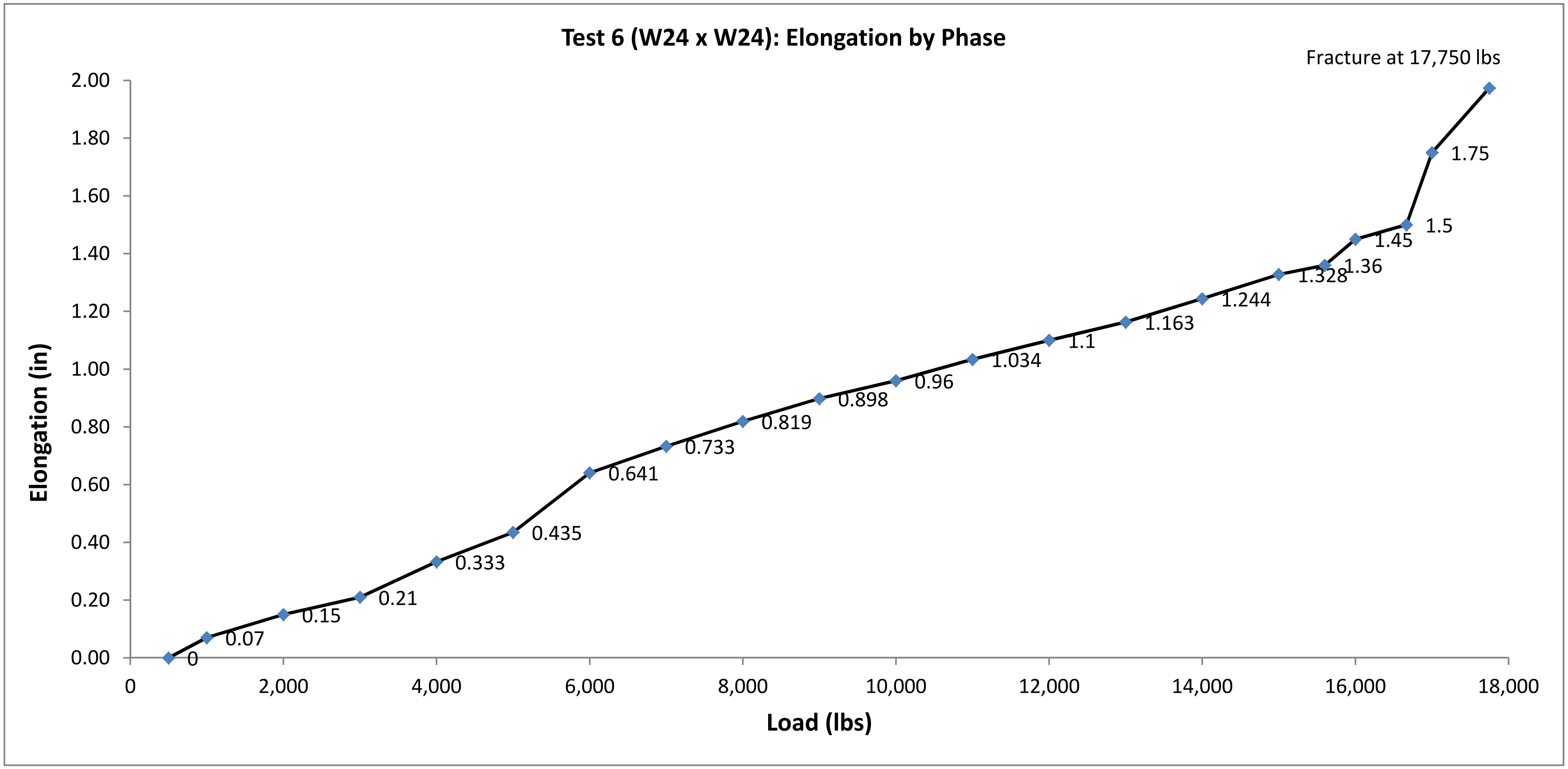

Test 1 (W24 x W24): Elongation by Phase
Elongation (in)
Load (lbs)
Weld shear @ 16,667 lbs
0
0.084
0.168
0.218
0.306
0.389
0.505
0.572
0.67
0.754
0.826
0.9
0.985
1.078
1.104
1.194
1.248
1.448
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000


Test 2 (W24 x W24): Elongation by Phase
Elongation (in)
Load (lbs)
Fracture at 17,750 lbs
0
0.036
0.125
0.166
0.249
0.463
0.556
0.648
0.735
0.8
0.856
0.935
0.945
1.085
1.135
1.315
1.415
1.55
1.75
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000


Test 3 (W24 x W24): Elongation by Phase
Elongation (in)
Load (lbs)
Fracture at 16,000 lbs
0
0.082
0.173
0.256
0.367
0.512
0.689
0.778
0.859
0.944
0.999
1.076
1.133
1.204
1.274
1.338
1.382
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000


Test 4 (W24 x W24): Elongation by Phase
Fracture @ 16,000 lbs
Elongation (in)
Load (lbs)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
0
0.048
0.157
0.206
0.258
0.355
0.507
0.598
0.68
0.754
0.825
0.892
0.956
1.028
1.081
1.162
1.211


Test 5 (W24 x W24): Elongation by Phase
Fracture @ 17,500 lbs
Elongation (in)
Load (lbs)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
0
0.055
0.144
0.228
0.349
0.542
0.705
0.792
0.88
0.964
1.024
1.088
1.149
1.212
1.273
1.344
1.378
1.5
1.75


Test 6 (W24 x W24): Elongation by Phase
Fracture at 17,750 lbs
Elongation (in)
Load (lbs)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
0
0.07
0.15
0.21
0.333
0.435
0.641
0.733
0.819
0.898
0.96
1.034
1.1
1.163
1.244
1.328
1.36
1.45
1.5
1.75

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5.2 TEST DATA

SSL Connection Test

Test Date: 12/7/2012 Test #: 1 **RESULTS:** PASS, Weld shear at 16,667 lbs of forces

Sample Identification: W24 x W24 (#1) Administered by: Nick Haven (SSL), Robert Ellefritz (SSL), witnessed by Jose Jimenez (Twining)

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250/AL1	-	500
450	0.084	1,000
775	0.168	2,000
1125/AL2	0.218	3,000
1,500	0.306	4,000
1,825	0.389	5,000
2,225	0.505	6,000
2,550	0.572	7,000
2,925	0.670	8,000
3,300	0.754	9,000
3,650	0.826	10,000
4,000	0.900	11,000
4,350	0.985	12,000
4,725	1.078	13,000
5,050	1.104	14,000
5,425	1.194	15,000
5,650	**1.248**	**15,600**
5,800	1.448	16,000
6,000	Weld Shear	16,667
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Elongation by Phase		
Phase 1	0.218	in
Phase 1A	-	in
Phase 2	1.030	in
Phase 3*	0.0574	in
Phase 4	0.143	in
Total	1.448	in

SSL Connection Test

Test Date: 12/7/2012 | Test #: 2 | **RESULTS:** PASS, Longitudinal wire fracture at 17,750 lbs.

Sample Identification: W24 x W24 (#2)

Administered by: Nick Haven (SSL), Robert Ellefritz (SSL), witnessed by Jose Jimenez (Twining)

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250/AL1	-	500
450	0.036	1,000
775/AL2	0.125	2,000
1,125	0.166	3,000
1,500	0.249	4,000
1,825	0.463	5,000
2,225	0.556	6,000
2,550	0.648	7,000
2,925	0.735	8,000
3,300	0.800	9,000
3,650	0.856	10,000
4,000	0.935	11,000
4,350	0.945	12,000
4,725	1.085	13,000
5,050	1.135	14,000
5,425	1.315	15,000
5,650	**1.415**	**15,600**
5,800	1.550	16,000
6,100	1.750	17,000
6,400	Fracture @ Bend	17,750
6,500		18,000
6,850		19,000
7,250		20,000

Elongation by Phase		
Phase 1	0.125	in
Phase 1A	-	in
Phase 2	1.290	in
Phase 3*	0.0574	in
Phase 4	0.278	in
Total	1.750	in

SSL Connection Test

Test Date: 12/7/2012 | Test #: 3 | **RESULTS:** PASS, Longitudinal wire fracture at 16,000 lbs.

Sample Identification: W24 x W24 (#3)

Administered by: Nick Haven (SSL), Robert Ellefritz (SSL), witnessed by Jose Jimenez (Twining)

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250/AL1	-	500
450	0.082	1,000
775	0.173	2,000
1125/AL2	0.256	3,000
1,500	0.367	4,000
1,825	0.512	5,000
2,225	0.689	6,000
2,550	0.778	7,000
2,925	0.859	8,000
3,300	0.944	9,000
3,650	0.999	10,000
4,000	1.076	11,000
4,350	1.133	12,000
4,725	1.204	13,000
5,050	1.274	14,000
5,425	1.338	15,000
5,650	**1.382**	**15,600**
5,800	Fracture @ Bend	16,000
6,000		16,667
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Elongation by Phase		
Phase 1	0.256	in
Phase 1A	-	in
Phase 2	1.069	in
Phase 3*	0.0574	in
Phase 4	-	in
Total	1.382	in

SSL Connection Test

Test Date: 12/7/2012

Test #: 4

RESULTS: PASS, Longitudinal wire fracture at 16,000 lbs.

Sample Identification: W24 x W24 (#4)

Administered by: Nick Haven (SSL), Robert Ellefritz (SSL), witnessed by Jose Jimenez (Twining)

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250/AL1	-	500
450	0.048	1,000
775	0.157	2,000
1125/AL2	0.206	3,000
1,500	0.258	4,000
1,825	0.355	5,000
2,225	0.507	6,000
2,550	0.598	7,000
2,925	0.680	8,000
3,300	0.754	9,000
3,650	0.825	10,000
4,000	0.892	11,000
4,350	0.956	12,000
4,725	1.028	13,000
5,050	1.081	14,000
5,425	1.162	15,000
5,650	**1.211**	**15,600**
5,800	Fracture @ Bend	16,000
6,000		16,667
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Elongation by Phase		
Phase 1	0.206	in
Phase 1A	-	in
Phase 2	0.948	in
Phase 3*	0.0574	in
Phase 4	-	in
Total	1.211	in

SSL Connection Test

Test Date: 12/7/2012

Test #: 5

RESULTS: PASS, Longitudinal wire fracture at 17,500 lbs.

Sample Identification: W24 x W24 (#5)

Administered by: Nick Haven (SSL), Robert Ellefritz (SSL), witnessed by Jose Jimenez (Twining)

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250/AL1	-	500
450	0.055	1,000
775	0.144	2,000
1125/AL2	0.228	3,000
1,500	0.349	4,000
1,825	0.542	5,000
2,225	0.705	6,000
2,550	0.792	7,000
2,925	0.880	8,000
3,300	0.964	9,000
3,650	1.024	10,000
4,000	1.088	11,000
4,350	1.149	12,000
4,725	1.212	13,000
5,050	1.273	14,000
5,425	1.344	15,000
5,650	**1.378**	**15,600**
5,800	1.500	16,000
6,100	1.750	17,000
6,300	Fracture @ Bend	17,500
6,500		18,000
6,850		19,000
7,250		20,000

Elongation by Phase		
Phase 1	0.228	in
Phase 1A	-	in
Phase 2	1.150	in
Phase 3*	0.0574	in
Phase 4	0.315	in
Total	1.750	in

SSL Connection Test

Test Date: 12/7/2012

Test #: 6

RESULTS: PASS, Longitudinal wire fracture at 17,750 lbs.

Sample Identification: W24 x W24 (#6)

Administered by: Nick Haven (SSL), Robert Ellefritz (SSL), witnessed by Jose Jimenez (Twining)

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250/AL1	-	500
450	0.070	1,000
775	0.150	2,000
1125/AL2	0.210	3,000
1,500	0.333	4,000
1,825	0.435	5,000
2,225	0.641	6,000
2,550	0.733	7,000
2,925	0.819	8,000
3,300	0.898	9,000
3,650	0.960	10,000
4,000	1.034	11,000
4,350	1.100	12,000
4,725	1.163	13,000
5,050	1.244	14,000
5,425	1.328	15,000
5,650	**1.360**	**15,600**
5,800	1.450	16,000
6,000	1.500	16,667
6,100	1.750	17,000
6,400	Fracture @ Bend	17,750
6,500		18,000
6,850		19,000
7,250		20,000

Elongation by Phase		
Phase 1	0.210	in
Phase 1A	-	in
Phase 2	1.150	in
Phase 3*	0.0574	in
Phase 4	0.333	in
Total	1.750	in

5.3 ORIGINAL TEST DATA

SSL Connection Test

Test Date: 12/7/12 Test #: **RESULTS:**

Sample Identification: 24/24 #6 Administered by: RJZ

Ram/Gauge 12k-12-1

PSI	Elong	Load (lbs)
250		500
475		1,000
850		2,000
1,275		3,000
1,700		4,000
2,150		5,000
2,525		6,000
2,925		7,000
3,025		**7,150**
3,350		8,000
3,800		9,000
4,200		10,000
4,625		11,000
5,050		12,000
5,475		**13,000**
5,900		14,000
6,300		15,000
6,725		16,000
7,150		17,000
7,600		18,000
8,000		19,000
8,425		20,000

Ram/Gauge 12k-12-2

PSI	Elong	Load (lbs)
250		500
450		1,000
800		2,000
1,150		3,000
1,525		4,000
1,900		5,000
2,250		6,000
2,625		7,000
2,690		**7,150**
2,950		8,000
3,325		9,000
3,675		10,000
4,050		11,000
4,400		12,000
4,750		**13,000**
5,125		14,000
5,450		15,000
5,850		16,000
6,200		17,000
6,525		18,000
6,900		19,000
7,275		20,000

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250	0	500
450	0.070	1,000
775	0.150	2,000
1,125	0.210	3,000
1,500	0.333	4,000
1,825	0.435	5,000
2,225	0.641	6,000
2,550	0.733	7,000
2,625	0.755	**7,150**
2,925	0.519	8,000
3,300	0.898	9,000
3,650	0.960 +	10,000
4,000		0.079 11,000
4,350		0.140 12,000
4,725		0.203 **13,000**
5,050		0.284 14,000
5,425		0.368 15,000
5650 5,800	1.36"	0.400 16,000
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Ram/Gauge 12k-12-4

PSI	Elong	Load (lbs)
200		500
400		1,000
775		2,000
1,150		3,000
1,525		4,000
1,875		5,000
2,250		6,000
2,625		7,000
2,650		**7,150**
2,975		8,000
3,350		9,000
3,700		10,000
4,050		11,000
4,450		12,000
4,800		**13,000**
5,150		14,000
5,500		15,000
5,850		16,000
6,250		17,000
6,600		18,000
6,950		19,000
7,325		20,000

Break @ Bend
6400 PSI
Tape Measured 1'-15/16" @ 5650 PSI

SSL Connection Test

Test Date: 12-7-12 | Test #: | **RESULTS:**

Sample Identification: 21/21 #1 | Administered by: RTF

Ram/Gauge 12k-12-1

PSI	Elong	Load (lbs)
250		500
475		1,000
850		2,000
1,275		3,000
1,700		4,000
2,150		5,000
2,525		6,000
2,925		7,000
3,025		**7,150**
3,350		8,000
3,800		9,000
4,200		10,000
4,625		11,000
5,050		12,000
5,475		**13,000**
5,900		14,000
6,300		15,000
6,725		16,000
7,150		17,000
7,600		18,000
8,000		19,000
8,425		20,000

Ram/Gauge 12k-12-2

PSI	Elong	Load (lbs)
250		500
450		1,000
800		2,000
1,150		3,000
1,525		4,000
1,900		5,000
2,250		6,000
2,625		7,000
2,690		**7,150**
2,950		8,000
3,325		9,000
3,675		10,000
4,050		11,000
4,400		12,000
4,750		**13,000**
5,125		14,000
5,450		15,000
5,850		16,000
6,200		17,000
6,525		18,000
6,900		19,000
7,275		20,000

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250	0	500
450	0.034	1,000
775	0.168	2,000
1,125	0.315	3,000
1,500	0.306	4,000
1,825	0.389	5,000
2,225	0.505	6,000
2,550	0.572	7,000
2,625	0.594	**7,150**
2,925	0.670	8,000
3,300	0.754	9,000
3,650	0.826	10,000
4,000	0.900	11,000
4,350	0.985	12,000
4,725	+	0.093 **13,000**
5,050		0.119 14,000
5,425		0.309 15,000
5650 5,800	1.248"	0.363 16,000
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Ram/Gauge 12k-12-4

PSI	Elong	Load (lbs)
200		500
400		1,000
775		2,000
1,150		3,000
1,525		4,000
1,875		5,000
2,250		6,000
2,625		7,000
2,650		**7,150**
2,975		8,000
3,350		9,000
3,700		10,000
4,050		11,000
4,450		12,000
4,800		**13,000**
5,150		14,000
5,500		15,000
5,850		16,000
6,250		17,000
6,600		18,000
6,950		19,000
7,325		20,000

Break @ Transverse Bar Weld
6000 PSI
Tape Measured 1'-1 1/4" @ 5650 PSI

TOC – Appendix

SSL Connection Test

Test Date: 12-7/12

Test #:

RESULTS:

Sample Identification: 24/24 #2

Administered by: RK

Ram/Gauge 12k-12-1

PSI	Elong	Load (lbs)
250		500
475		1,000
850		2,000
1,275		3,000
1,700		4,000
2,150		5,000
2,525		6,000
2,925		7,000
3,025		**7,150**
3,350		8,000
3,800		9,000
4,200		10,000
4,625		11,000
5,050		12,000
5,475		**13,000**
5,900		14,000
6,300		15,000
6,725		16,000
7,150		17,000
7,600		18,000
8,000		19,000
8,425		20,000

Ram/Gauge 12k-12-2

PSI	Elong	Load (lbs)
250		500
450		1,000
800		2,000
1,150		3,000
1,525		4,000
1,900		5,000
2,250		6,000
2,625		7,000
2,690		**7,150**
2,950		8,000
3,325		9,000
3,675		10,000
4,050		11,000
4,400		12,000
4,750		**13,000**
5,125		14,000
5,450		15,000
5,850		16,000
6,200		17,000
6,525		18,000
6,900		19,000
7,275		20,000

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250	0	500
450	0.036	1,000
775	0.125	2,000
1,125	0.166	3,000
1,500	0.349	4,000
1,825	0.463	5,000
2,225	0.556	6,000
2,550	0.648	7,000
2,625	0.677	**7,150**
2,925	0.735	8,000
3,300	0.800	9,000
3,650	0.856	10,000
4,000	0.935	11,000
4,350	+	0.010 12,000
4,725		0.150 **13,000**
5,050		0.200 14,000
5,425		0.350 15,000
5650 5,800	1.415"	0.450 16,000
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Ram/Gauge 12k-12-4

PSI	Elong	Load (lbs)
200		500
400		1,000
775		2,000
1,150		3,000
1,525		4,000
1,875		5,000
2,250		6,000
2,625		7,000
2,650		**7,150**
2,975		8,000
3,350		9,000
3,700		10,000
4,050		11,000
4,450		12,000
4,800		**13,000**
5,150		14,000
5,500		15,000
5,850		16,000
6,250		17,000
6,600		18,000
6,950		19,000
7,325		20,000

Break @ Bend
6400 PSI
Tape Measured at 1'-1 3/8" @ 5650 PSI

SSL Connection Test

Test Date: 12/7/12 Test #: **RESULTS:**

Sample Identification: 24/24 #3 Administered by: DAE

Ram/Gauge 12k-12-1

PSI	Elong	Load (lbs)
250		500
475		1,000
850		2,000
1,275		3,000
1,700		4,000
2,150		5,000
2,525		6,000
2,925		7,000
3,025		**7,150**
3,350		8,000
3,800		9,000
4,200		10,000
4,625		11,000
5,050		12,000
5,475		**13,000**
5,900		14,000
6,300		15,000
6,725		16,000
7,150		17,000
7,600		18,000
8,000		19,000
8,425		20,000

Ram/Gauge 12k-12-2

PSI	Elong	Load (lbs)
250		500
450		1,000
800		2,000
1,150		3,000
1,525		4,000
1,900		5,000
2,250		6,000
2,625		7,000
2,690		**7,150**
2,950		8,000
3,325		9,000
3,675		10,000
4,050		11,000
4,400		12,000
4,750		**13,000**
5,125		14,000
5,450		15,000
5,850		16,000
6,200		17,000
6,525		18,000
6,900		19,000
7,275		20,000

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250	0	500
450	0.082	1,000
775	0.173	2,000
1,125	0.256	3,000
1,500	0.367	4,000
1,825	0.512	5,000
2,225	0.659	6,000
2,550	0.778	7,000
2,625	0.811	**7,150**
2,925	0.859	8,000
3,300	0.944	9,000
3,650	+	0.055 10,000
4,000		0.132 11,000
4,350		0.159 12,000
4,725		0.271 **13,000**
5,050		0.330 14,000
5,425		0.394 15,000
5650 5,800	1.382"	0.438 16,000
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Ram/Gauge 12k-12-4

PSI	Elong	Load (lbs)
200		500
400		1,000
775		2,000
1,150		3,000
1,525		4,000
1,875		5,000
2,250		6,000
2,625		7,000
2,650		**7,150**
2,975		8,000
3,350		9,000
3,700		10,000
4,050		11,000
4,450		12,000
4,800		**13,000**
5,150		14,000
5,500		15,000
5,850		16,000
6,250		17,000
6,600		18,000
6,950		19,000
7,325		20,000

Break @ Bend
5800 PSI
Tape Measured 1'-1¼" @ 5650 PSI

SSL Connection Test

Test Date: 12/7/10 Test #: RESULTS:

Sample Identification: 24/24 #21 Administered by: RJE

Ram/Gauge 12k-12-1

PSI	Elong	Load (lbs)
250		500
475		1,000
850		2,000
1,275		3,000
1,700		4,000
2,150		5,000
2,525		6,000
2,925		7,000
3,025		**7,150**
3,350		8,000
3,800		9,000
4,200		10,000
4,625		11,000
5,050		12,000
5,475		**13,000**
5,900		14,000
6,300		15,000
6,725		16,000
7,150		17,000
7,600		18,000
8,000		19,000
8,425		20,000

Ram/Gauge 12k-12-2

PSI	Elong	Load (lbs)
250		500
450		1,000
800		2,000
1,150		3,000
1,525		4,000
1,900		5,000
2,250		6,000
2,625		7,000
2,690		**7,150**
2,950		8,000
3,325		9,000
3,675		10,000
4,050		11,000
4,400		12,000
4,750		**13,000**
5,125		14,000
5,450		15,000
5,850		16,000
6,200		17,000
6,525		18,000
6,900		19,000
7,275		20,000

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250	0	500
450	0.045	1,000
775	0.157	2,000
1,125	0.216	3,000
1,500	0.258	4,000
1,825	0.355	5,000
2,225	0.507	6,000
2,550	0.598	7,000
2,625	0.610	**7,150**
2,925	0.680	8,000
3,300	0.754	9,000
3,650	0.525	10,000
4,000	0.842	11,000
4,350	0.956	12,000
4,725	+	0.072 **13,000**
5,050		0.125 14,000
5,425		0.206 15,000
5650 ~~5,800~~	1.211"	0.251 ~~16,000~~
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Ram/Gauge 12k-12-4

PSI	Elong	Load (lbs)
200		500
400		1,000
775		2,000
1,150		3,000
1,525		4,000
1,875		5,000
2,250		6,000
2,625		7,000
2,650		**7,150**
2,975		8,000
3,350		9,000
3,700		10,000
4,050		11,000
4,450		12,000
4,800		**13,000**
5,150		14,000
5,500		15,000
5,850		16,000
6,250		17,000
6,600		18,000
6,950		19,000
7,325		20,000

Transverse Bar Broke @ Weld
5800 PSI
Tape Measured 1'-1 3/8" @ 5650 PSI

SSL Connection Test

Test Date: 12/7/22
Test #:
RESULTS:

Sample Identification: 24/24 # 5
Administered by: KLE

Ram/Gauge 12k-12-1

PSI	Elong	Load (lbs)
250		500
475		1,000
850		2,000
1,275		3,000
1,700		4,000
2,150		5,000
2,525		6,000
2,925		7,000
3,025		**7,150**
3,350		8,000
3,800		9,000
4,200		10,000
4,625		11,000
5,050		12,000
5,475		**13,000**
5,900		14,000
6,300		15,000
6,725		16,000
7,150		17,000
7,600		18,000
8,000		19,000
8,425		20,000

Ram/Gauge 12k-12-2

PSI	Elong	Load (lbs)
250		500
450		1,000
800		2,000
1,150		3,000
1,525		4,000
1,900		5,000
2,250		6,000
2,625		7,000
2,690		**7,150**
2,950		8,000
3,325		9,000
3,675		10,000
4,050		11,000
4,400		12,000
4,750		**13,000**
5,125		14,000
5,450		15,000
5,850		16,000
6,200		17,000
6,525		18,000
6,900		19,000
7,275		20,000

Ram/Gauge 12k-12-3

PSI	Elong	Load (lbs)
250	0	500
450	0.055	1,000
775	0.144	2,000
1,125	0.228	3,000
1,500	0.349	4,000
1,825	0.542	5,000
2,225	0.705	6,000
2,550	0.722	7,000
2,625	0.823	**7,150**
2,925	0.880	8,000
3,300	0.964	9,000
3,650	+	0.060 10,000
4,000		0.124 11,000
4,350		0.185 12,000
4,725		0.245 **13,000**
5,050		0.309 14,000
5,425		0.380 15,000
5650 5,800	1.378"	0.414 16,000
6,100		17,000
6,500		18,000
6,850		19,000
7,250		20,000

Ram/Gauge 12k-12-4

PSI	Elong	Load (lbs)
200		500
400		1,000
775		2,000
1,150		3,000
1,525		4,000
1,875		5,000
2,250		6,000
2,625		7,000
2,650		**7,150**
2,975		8,000
3,350		9,000
3,700		10,000
4,050		11,000
4,450		12,000
4,800		**13,000**
5,150		14,000
5,500		15,000
5,850		16,000
6,250		17,000
6,600		18,000
6,950		19,000
7,325		20,000

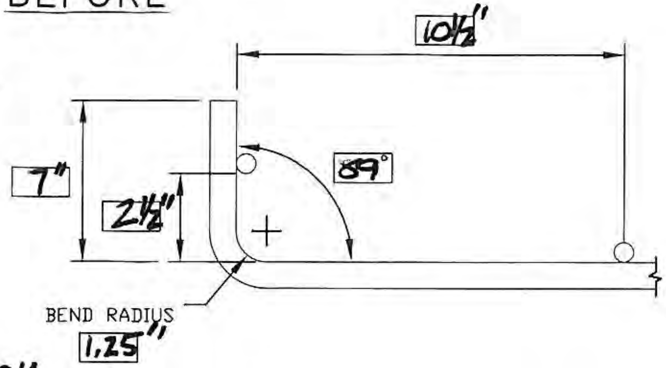
Break @ Bond
6300 PSI
Tape Measured 1'-1 3/8" @ 5650 PSI

INNOVATIVE CONSTRUCTION PRODUCTS

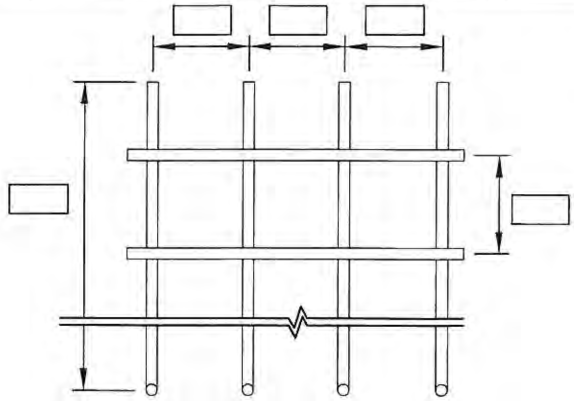
5.4 MATERIAL MEASUREMENTS

SPECIMEN NUMBER: #1

BEFORE



MESH BEND X-SECTION

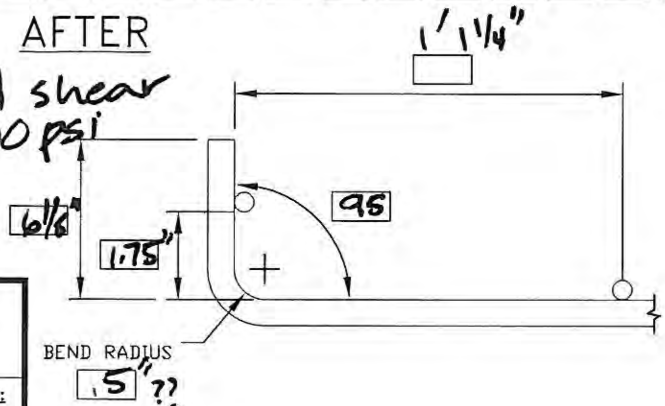


MESH PLAN VIEW

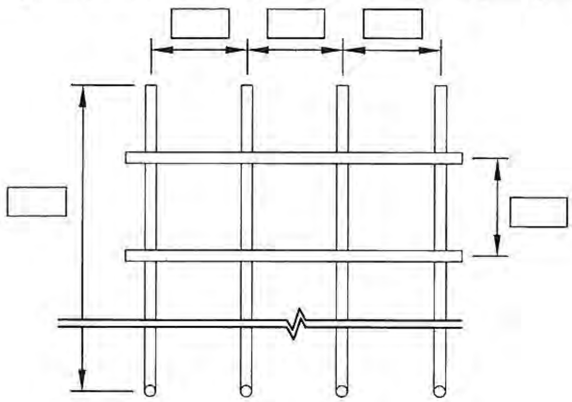
Weld OK

AFTER

★ Weld shear @ 6,000 psi



MESH BEND X-SECTION



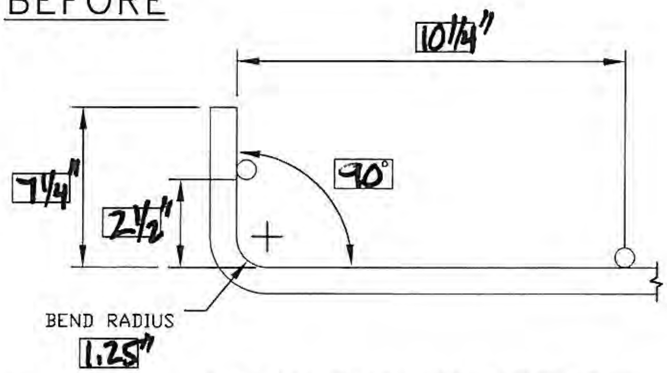
MESH PLAN VIEW

DATE TESTED: 12/7

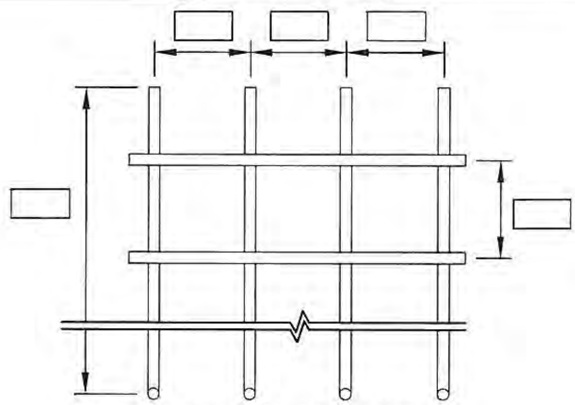
TESTER INITIALS: NH

SPECIMEN NUMBER: #2

BEFORE



MESH BEND X-SECTION

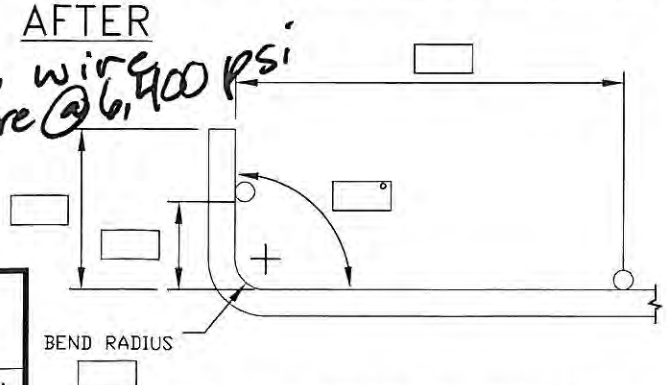


MESH PLAN VIEW

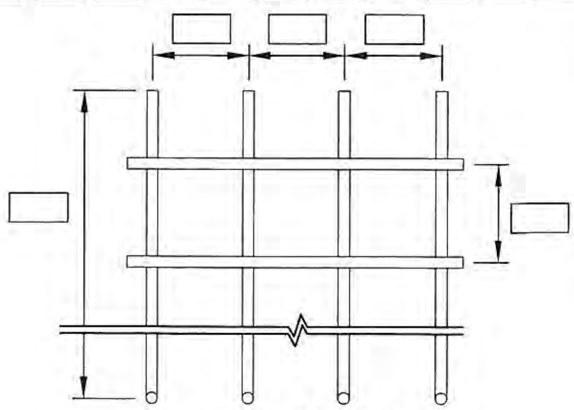
Weld OK

AFTER

★ Long wire fracture @ 6,400 psi



MESH BEND X-SECTION



MESH PLAN VIEW

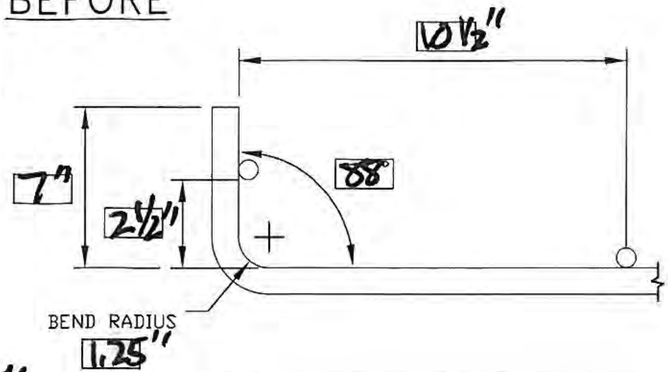
DATE TESTED: 12/7

TESTER INITIALS: NH

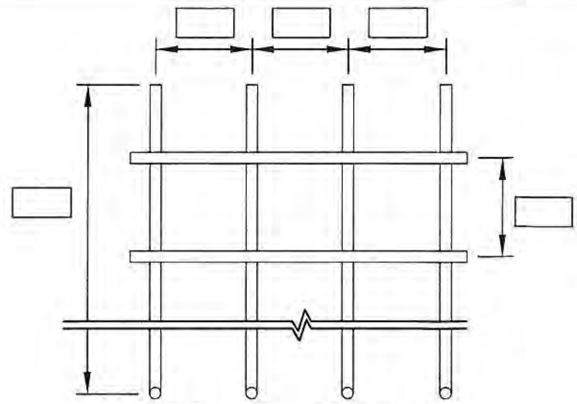
TOC – Appendix

SPECIMEN NUMBER:
#3

BEFORE



MESH BEND X-SECTION

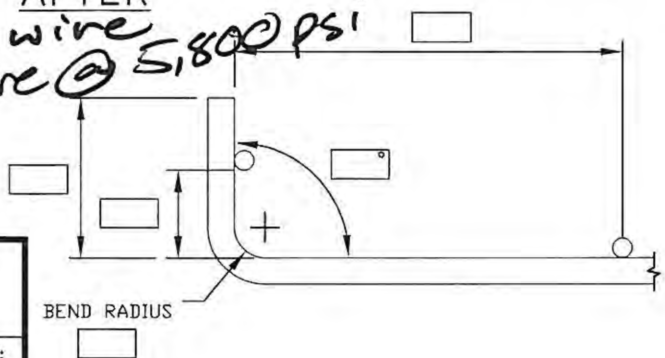


MESH PLAN VIEW

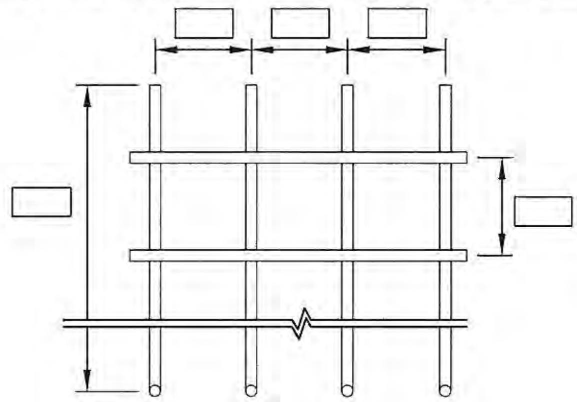
Weld OK

AFTER

*Long wire fracture @ 5,800 psi



MESH BEND X-SECTION



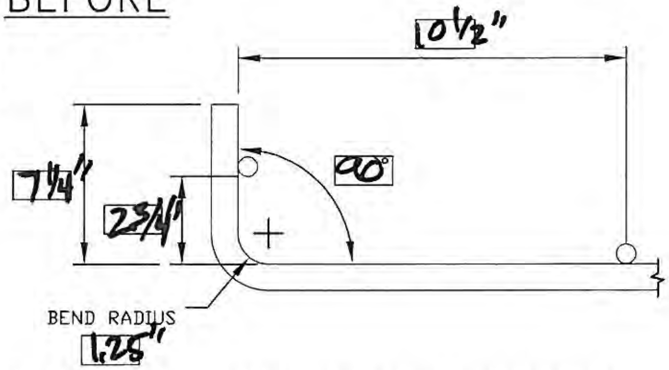
MESH PLAN VIEW

DATE TESTED:
12/7

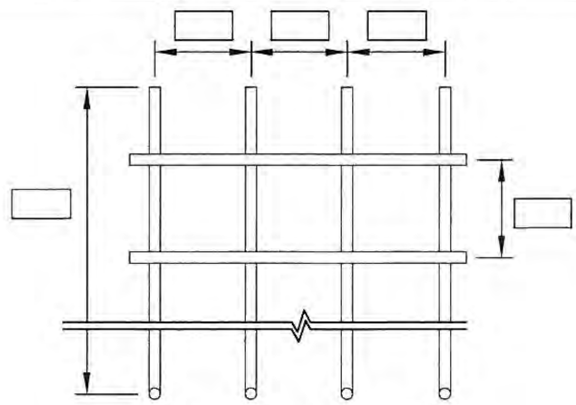
TESTER INITIALS:
NA

SPECIMEN NUMBER:
#4

BEFORE



MESH BEND X-SECTION

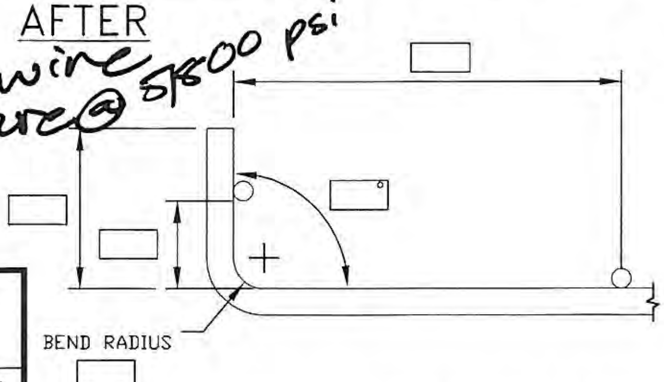


MESH PLAN VIEW

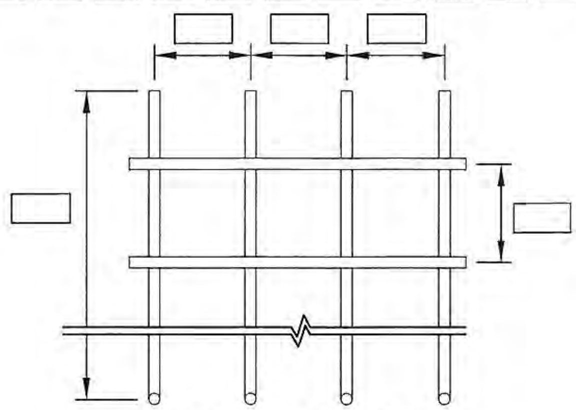
Weld OK

AFTER

*Long wire fracture @ 5,800 psi



MESH BEND X-SECTION



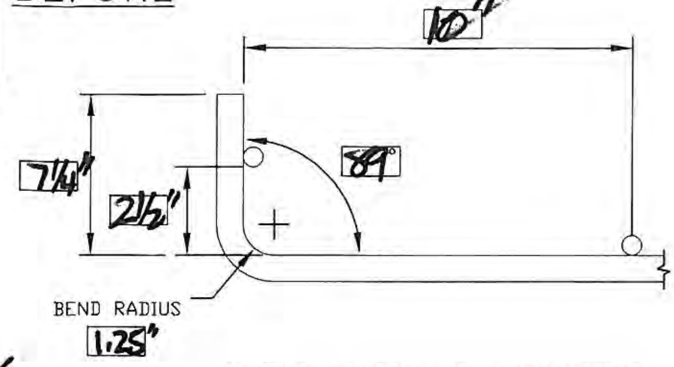
MESH PLAN VIEW

DATE TESTED:
12/7

TESTER INITIALS:
NA

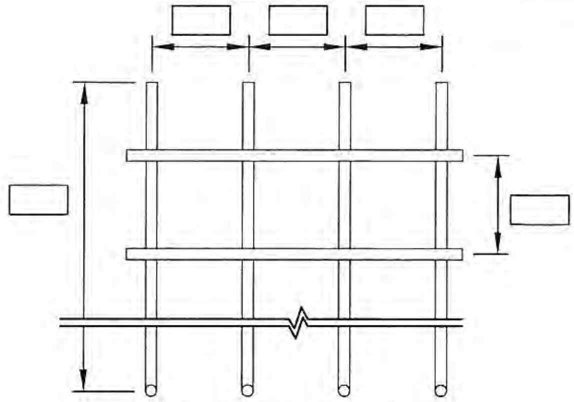
SPECIMEN NUMBER: #5

BEFORE



Weld OK

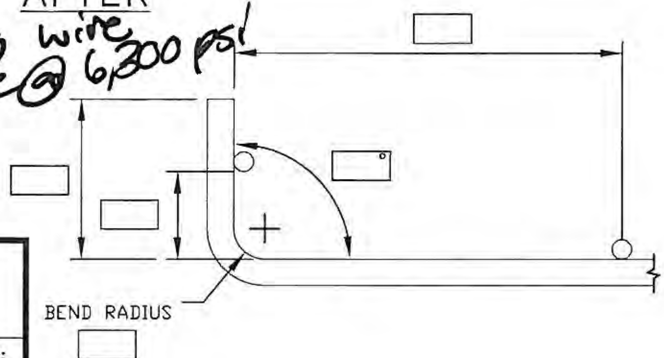
MESH BEND X-SECTION



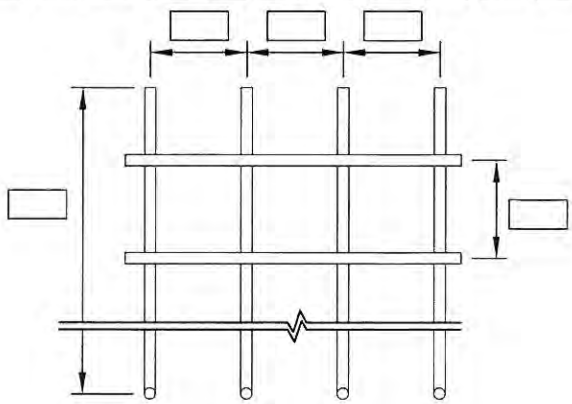
MESH PLAN VIEW

AFTER

* Long wire Fracture @ 6,300 psi!



MESH BEND X-SECTION



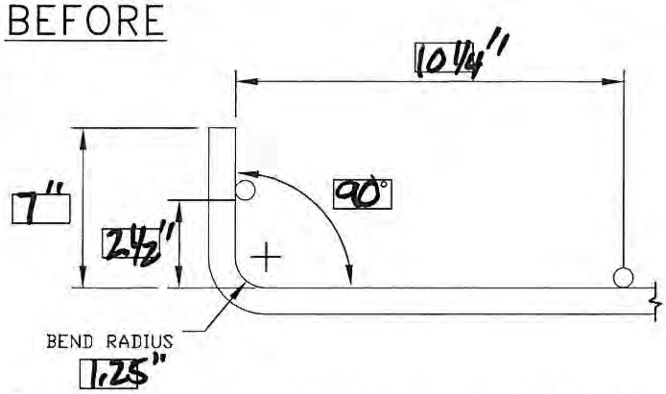
MESH PLAN VIEW

DATE TESTED: 12/7

TESTER INITIALS: NH

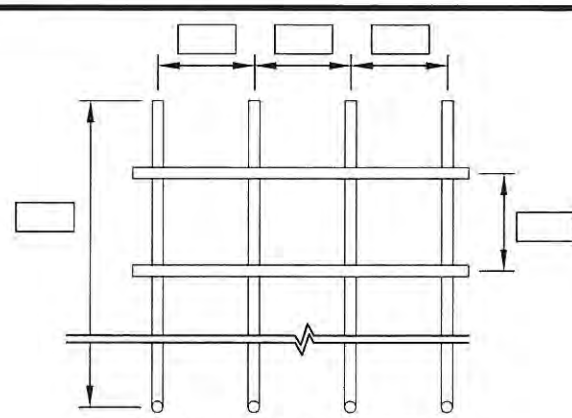
SPECIMEN NUMBER: #6

BEFORE



Weld ok

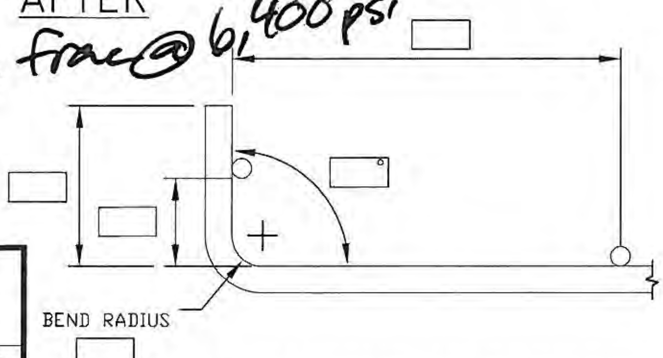
MESH BEND X-SECTION



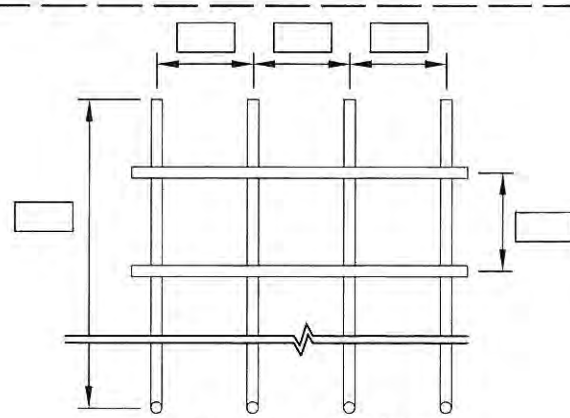
MESH PLAN VIEW

AFTER

* Long frac @ 6,400 psi



MESH BEND X-SECTION



MESH PLAN VIEW

DATE TESTED:

TESTER INITIALS:

6. INDEPENDENT VERIFICATION REPORTS

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TWINING

Long Beach 562.426.3355 / Sacramento 916.649.9000 / San Bernardino 909.383.6660
San Diego 858.974.3750 / Ventura 805.644.5100 / www.twininginc.com

SERVICE TICKET

41100

CLIENT: SURECAST WEST	DATE: 12-7-12
ADDRESS:	PO NO:
CITY: STATE: ZIP CODE:	TWINING JOB NO.: 120018-3
PHONE: FAX:	PROJECT NO:

JOB NAME: SURECAST WEST	OSHPD NO. / DSA-APPL/PERMIT NO:
ADDRESS: 8203 ALABAMA ST	CONTRACTOR:
CITY: REDLANDS STATE: CA ZIP CODE:	CONTACT PERSON: ANDREW SORIA
PHONE: FAX:	PHONE NO: 909-335-6336

SERVICE(S) PERFORMED

- ☐ PACHOMETER
- ☒ PULL TEST
- ☐ TORQUE TEST
- ☐ MOISTURE TEST
- ☐ IN PLACE SHEAR TEST
- ☐ REBOUND HAMMER TEST
- ☐ CORE SAMPLING / REBAR SAMPLING
- ☐ MOBILE TESTING
- ☐ FIREPROOFING TEST
- ☐ OTHER(S) ____________

DESCRIPTION OF WORK OBSERVED 6 PULL TESTS TO 15600 LBS ON W24x24 L CONNECTION WITH W30 CONNECTOR PIN, ELONG RESULTS TEST #1) 1.248" 2) 1.415" 3) 1.382" 4) 1.21" 5) 1.378" 6) 1.36"
ALL PASSED PULL OUT TEST.
OBSERVED 2 PULL TESTS TO 13000 LBS ON W20x11 L CONNECTION WITH W30 CONNECTOR PIN. BOTH TESTS WERE INCONCLUSIVE. OBSERVED 5 PULL TESTS TO 7150 LBS ON W11x11 L CONNECTION WITH W30 CONNECTOR PIN. ELONG RESULTS. TEST #1) .976" 2) .960" 3) 1.22" 4) 1.25" 5) 1.20"
ALL ~~TESTS~~ PASSED PULL OUT TEST.

START TRAVEL ☐ AM ☐ PM	TIME IN 8:00 ☒ AM ☐ PM	REGULAR 4	1.5 X (PREMIUM) Ø	2 X (PREMIUM) Ø
TIME OUT 12:00 ☐ AM ☒ PM	END TRAVEL ☐ AM ☐ PM	MEAL PERIOD (TIME) ☐ YES ☐ NO	MILEAGE 70 ☐ ROUND TRIP ☒ ONE WAY	EXPENSES

All field services performed are based on a portal to portal basis, unless agreed upon otherwise.

PERFORMED BY

(1) JOSE G. JIMENEZ	(2)	(3)
(4)	(5)	(6)

VERIFIED BY

COMPANY NAME: SURECAST WEST	NAME (PRINT): Rob Elliott
DATE: 12/7/12.	NAME (SIGNATURE): [signature]

INNOVATIVE CONSTRUCTION PRODUCTS

7. EQUIPMENT CALIBRATION RECORDS

TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: *SURECAST West*
Contact: Rusty

Address: 8203 Alabama
City/St/Zip: Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 2-27-2012
Calibration Interval: 12 months
Due Date: 2-27-2013
Location of Equip. Calibrated: Lab

Test Number: HB-212111
Temp./Humidity: 17°C 61% Rh
Procedure: Mfg

Equipment Information

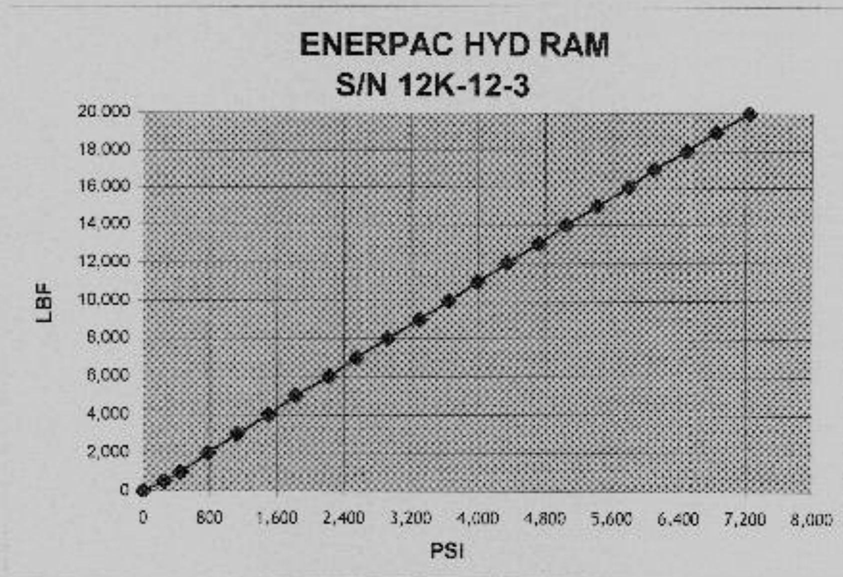
Description: Holl-O-Ram
Manufacturer: Enerpac

Model: RCH-123
Serial Number: 12K-12-3

Range: 12 ton
Gauge S/N: 12K-12-3

PSI	LBF	LBF/PSI
0	0	0
250	500	2.000
450	1,000	2.222
775	2,000	2.581
1,125	3,000	2.667
1,500	4,000	2.667
1,825	5,000	2.740
2,225	6,000	2.697
2,550	7,000	2.745
2,925	8,000	2.735
3,300	9,000	2.727
3,650	10,000	2.740
4,000	11,000	2.750
4,350	12,000	2.759
4,725	13,000	2.751
5,050	14,000	2.772
5,425	15,000	2.765
5,800	16,000	2.759
6,100	17,000	2.787
6,500	18,000	2.769
6,850	19,000	2.774
7,250	20,000	2.759

Calibration Results



7,150 lbf = 2,625 PSI
13,000 lbf =4,725 PSI

APPROVAL: Terry Summers

Calibration Standards

S/N or ID#	Due Date	Mfg.
9392	7/26/2012	Control
9205	4/7/2012	Strainsense

Remarks:

1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
3.) Calibration data results relate only to the specified serial number stated in the equipment information section in this certificate.
4.) Equipment condition statements are the opinions of Technical Associated Services and are based on, but not limited to, data from measurements made, professional experience, and procedures utilized. It is ithe responsibility of the customer/user of this equipment to determine if the results identified meet the specific requirements of accuracy for its intended use.
5.) This report shall not be reproduced, except in full, without the written approval of Technical Associated Services.

TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: *SURECAST West* **Address:** 8203 Alabama

Contact: Rusty **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 2-27-2012 **Test Number:** HB-212111

Calibration Interval: 12 months **Temp./Humidity:** 17°C 61% Rh

Due Date: 2-27-2013 **Procedure:** Mfg

Location of Equip. Calibrated: Lab

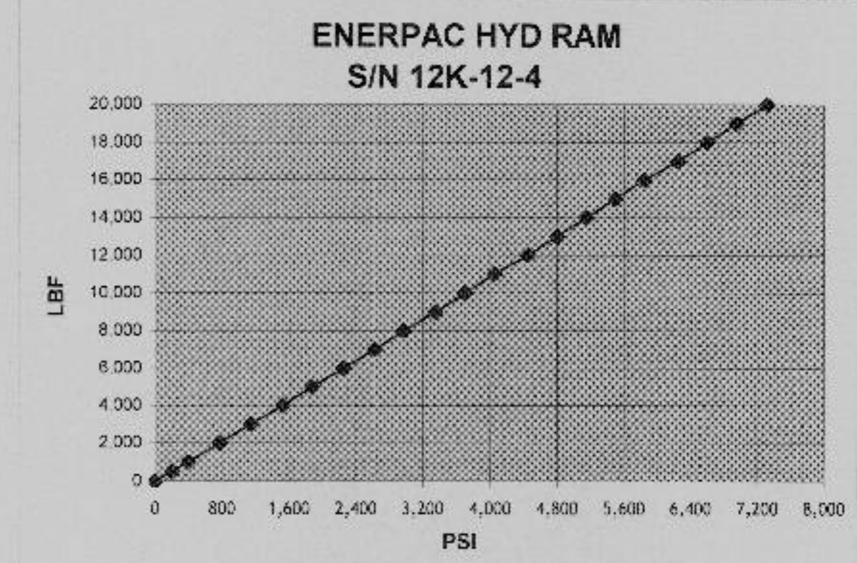
Equipment Information

Description: Holl-O-Ram **Model:** RCH-123 **Range:** 12 ton

Manufacturer: Enerpac **Serial Number:** 12K-12-4 **Gauge S/N:** 12K-12-4

PSI	LBF	LBF/PSI
0	0	0
200	500	2.500
400	1,000	2.500
775	2,000	2.581
1,150	3,000	2.609
1,525	4,000	2.623
1,875	5,000	2.667
2,250	6,000	2.667
2,625	7,000	2.667
2,975	8,000	2.689
3,350	9,000	2.687
3,700	10,000	2.703
4,050	11,000	2.716
4,450	12,000	2.697
4,800	13,000	2.708
5,150	14,000	2.718
5,500	15,000	2.727
5,850	16,000	2.735
6,250	17,000	2.720
6,600	18,000	2.727
6,950	19,000	2.734
7,325	20,000	2.730

Calibration Results



7,150 Lbf = 2,650 PSI
13,000 Lbf =4,800 PSI

APPROVAL: Terry Summers

Calibration Standards

SN# or ID#	Due Date	Mfg.
9392	7/26/2012	Control
9205	4/7/2012	Strainsense

Remarks:

1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
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TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: *SURECAST West*
Contact: Rusty

Address: 8203 Alabama
City/St/Zip: Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 2-27-2012
Calibration Interval: 12 months
Due Date: 2-27-2013
Location of Equip. Calibrated: Lab

Test Number: HB-212111
Temp./Humidity: 17°C 61% Rh
Procedure: Mfg

Equipment Information

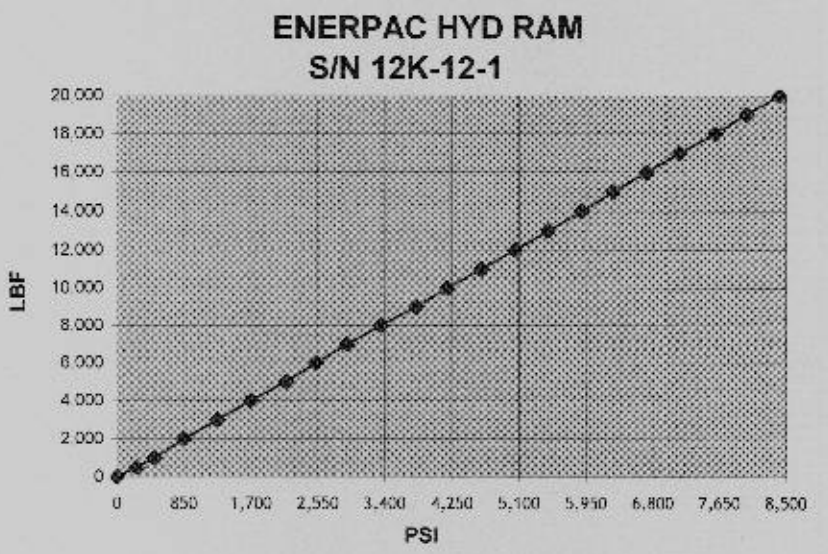
Description: Holl-O-Ram
Manufacturer: Enerpac

Model: RCH-123
Serial Number: 12K-12-1

Range: 12 ton
Gauge S/N: 12K-12-1

PSI	LBF	LBF/PSI
0	0	0
250	500	2.000
475	1,000	2.105
850	2,000	2.353
1,275	3,000	2.353
1,700	4,000	2.353
2,150	5,000	2.326
2,525	6,000	2.376
2,925	7,000	2.393
3,350	8,000	2.388
3,800	9,000	2.368
4,200	10,000	2.381
4,625	11,000	2.378
5,050	12,000	2.376
5,475	13,000	2.374
5,900	14,000	2.373
6,300	15,000	2.381
6,725	16,000	2.379
7,150	17,000	2.378
7,600	18,000	2.368
8,000	19,000	2.375
8,425	20,000	2.374

Calibration Results



7,150 lbf = 3,025 PSI
13,000 lbf =5,475 PSI

APPROVAL: Terry Summers

Calibration Standards

SN# or ID#	Due Date	Mfg.
9392	7/26/2012	Control
9205	4/7/2012	Strainsense

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
3.) Calibration data results relate only to the specified serial number stated in the equipment information section in this certificate.
4.) Equipment condition statements are the opinions of Technical Associated Services and are based on, but not limited to, data from measurements made, professional experience, and procedures utilized. It is ithe responsibility of the customer/user of this equipment to determine if the results identified meet the specific requirements of accuracy for its intended use.
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TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: *SURECAST West* **Address:** 8203 Alabama

Contact: Rusty **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 2-27-2012 **Test Number:** HB-212111

Calibration Interval: 12 months **Temp./Humidity:** 17°C 61% Rh

Due Date: 2-27-2013 **Procedure:** Mfg

Location of Equip. Calibrated: Lab

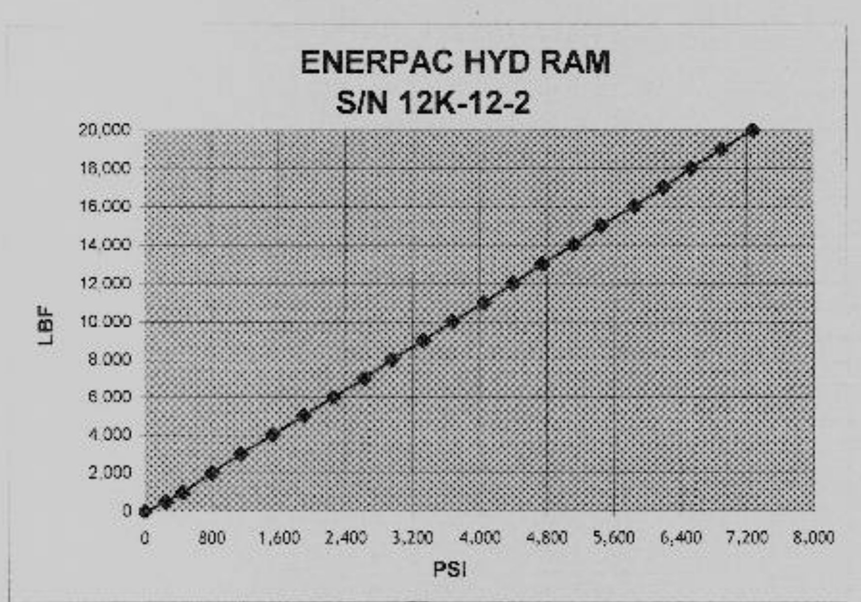
Equipment Information

Description: Holl-O-Ram **Model:** RCH-123 **Range:** 12 ton

Manufacturer: Enerpac **Serial Number:** 12K-12-2 **Gauge S/N:** 12K-12-2

PSI	LBF	LBF/PSI
0	0	0
250	500	2.000
450	1,000	2.222
800	2,000	2.500
1,150	3,000	2.609
1,525	4,000	2.623
1,900	5,000	2.632
2,250	6,000	2.667
2,625	7,000	2.667
2,950	8,000	2.712
3,325	9,000	2.707
3,675	10,000	2.721
4,050	11,000	2.716
4,400	12,000	2.727
4,750	13,000	2.737
5,125	14,000	2.732
5,450	15,000	2.752
5,850	16,000	2.735
6,200	17,000	2.742
6,525	18,000	2.759
6,900	19,000	2.754
7,275	20,000	2.749

Calibration Results



7,150 lbf = 2,690 PSI
13,000 lbf =4,750 PSI

APPROVAL: Terry Summers

Calibration Standards

S/N or ID#	Due Date	Mfg.
9392	7/26/2012	Control
9205	4/7/2012	Strainsense

Remarks:

1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
3.) Calibration data results relate only to the specified serial number stated in the equipment information section in this certificate.
4.) Equipment condition statements are the opinions of Technical Associated Services and are based on, but not limited to, data from measurements made, professional experience, and procedures utilized. It is ithe responsibility of the customer/user of this equipment to determine if the results identified meet the specific requirements of accuracy for its intended use.
5.) This report shall not be reproduced, except in full, without the written approval of Technical Associated Services.

8. EQUIPMENT AND MATERIAL DETAILS

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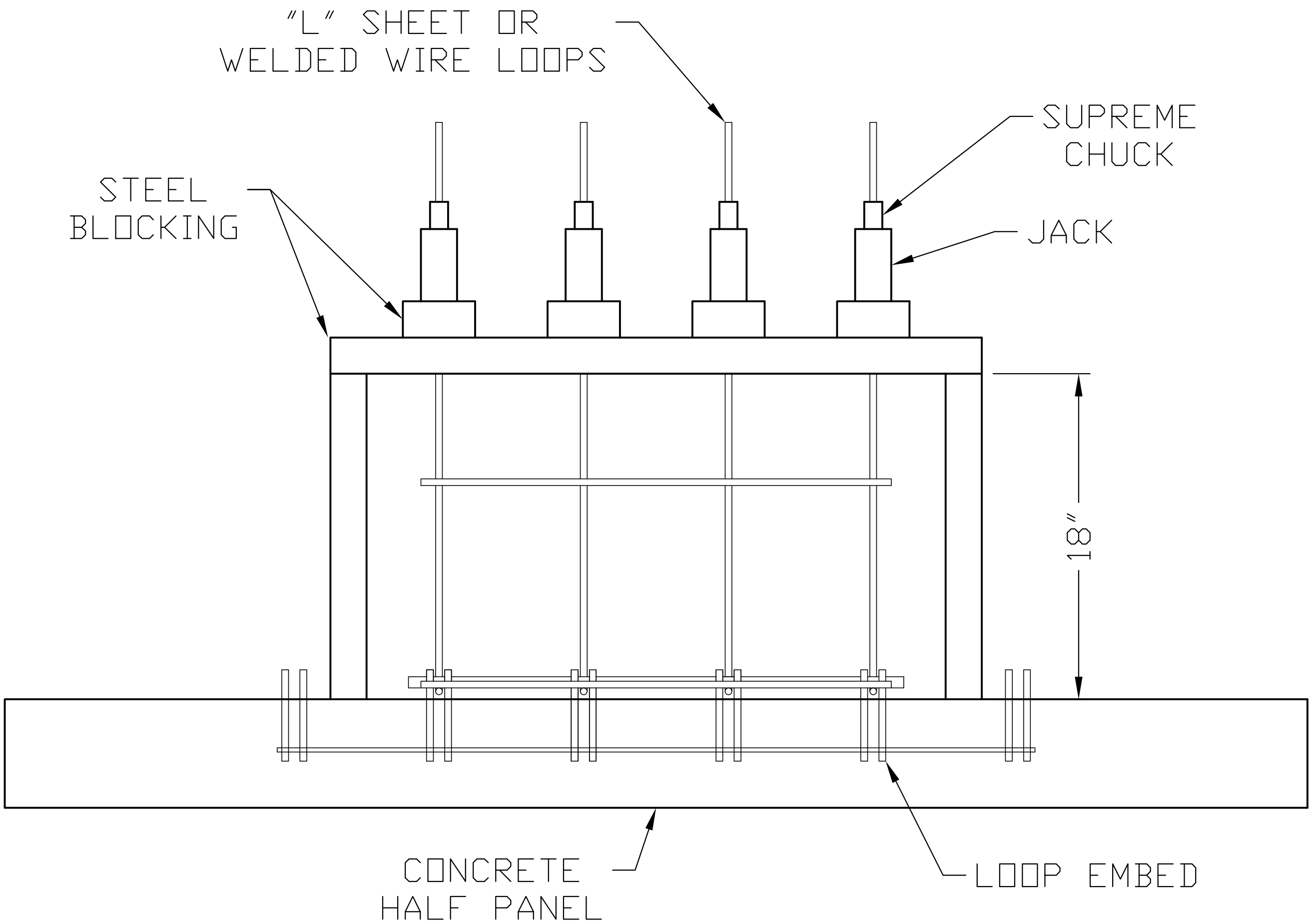
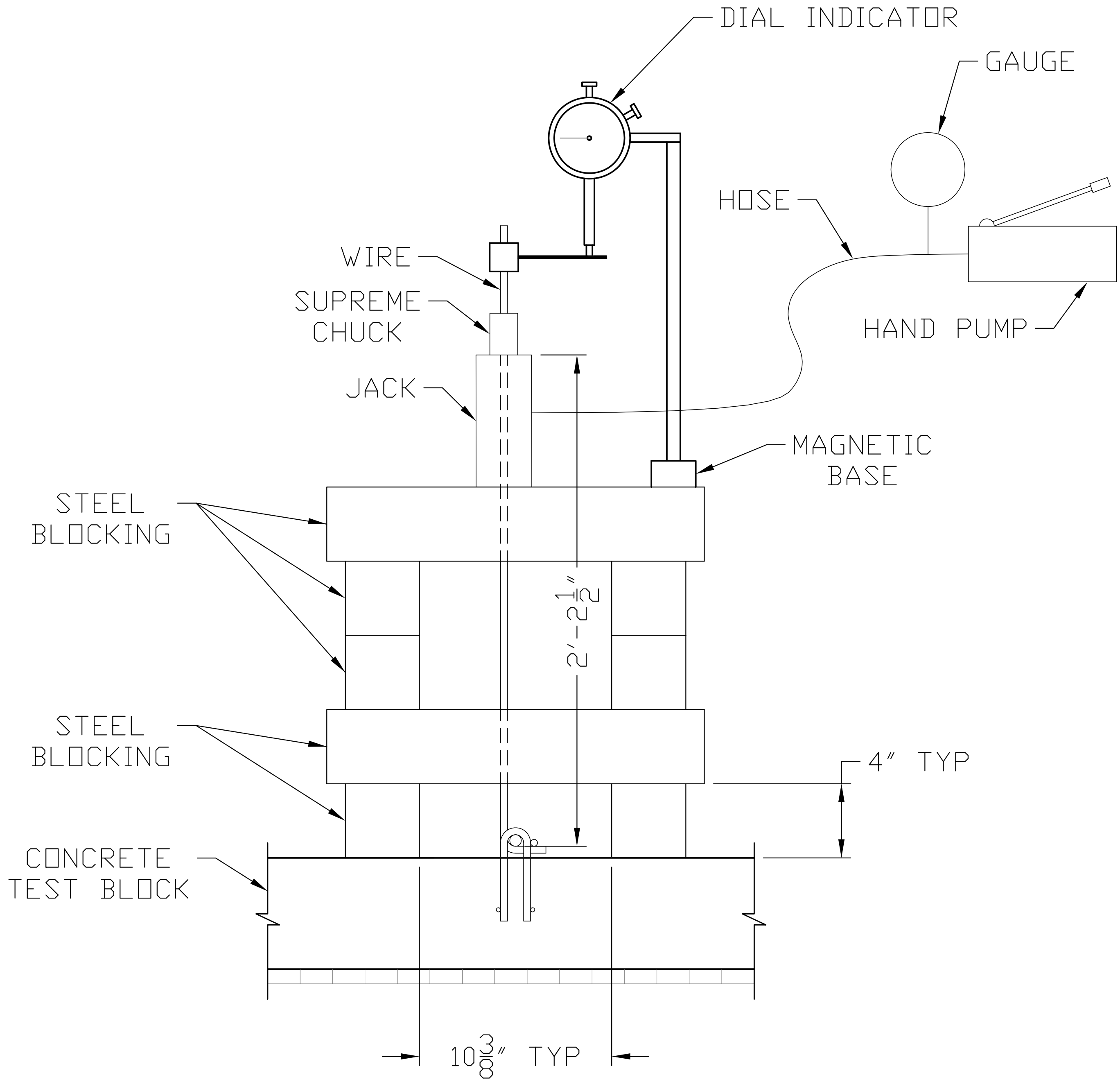
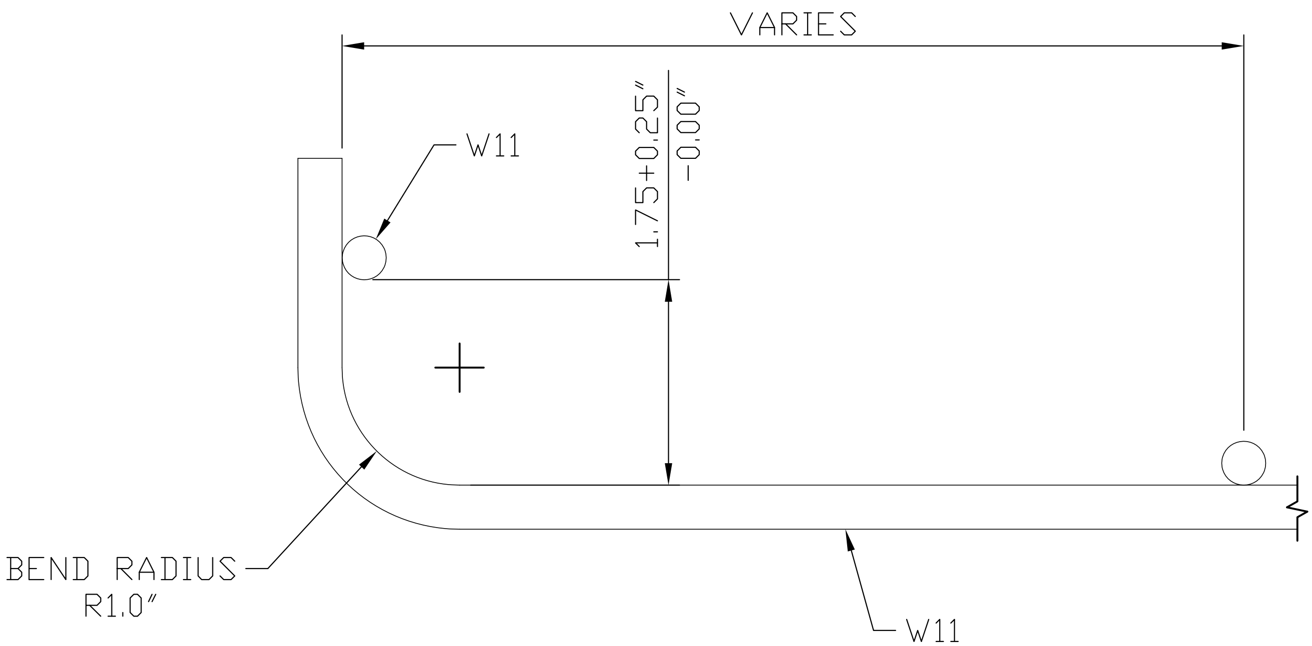


NOTE: 4 RAMS SHOWN FOR INFORMATIONAL PURPOSES ONLY. TEST MAY BE RUN WITH 1-4 JACKS AT A TIME.

Date: 2/22/12	SSL LOOP HALF PANEL TEST BLOCK	SSL Specializing in Construction Products	Job. No. 0000
Designed by: DSM			
Checked by:	FIGURE 1A	4740 Suite E Scotts Valley Dr. Scotts Valley, California 95066 Phone: 831 430 9300 Fax: 831 430 9340	Of



Date: 03/05/12	SSL LOOP TEST BLOCK SETUP	SSL Specializing in Construction Products 4740 Suite E Scotts Valley Dr. Scotts Valley, California 95066 Phone: 831 430 9300 Fax: 831 430 9340	Job. No. 0000
Designed by: GTF			
Checked by:	FIGURE 2		Of



Date: 02/24/12	SSL W11 "L" LOOP MESH WIRE END DETAIL	SSL Specializing in Construction Products	Job. No. 0000
Designed by: DSM			
Checked by:	FIGURE 3	4740 Suite E Scotts Valley Dr. Scotts Valley, California 95066 Phone: 831 430 9300 Fax: 831 430 9340	Of

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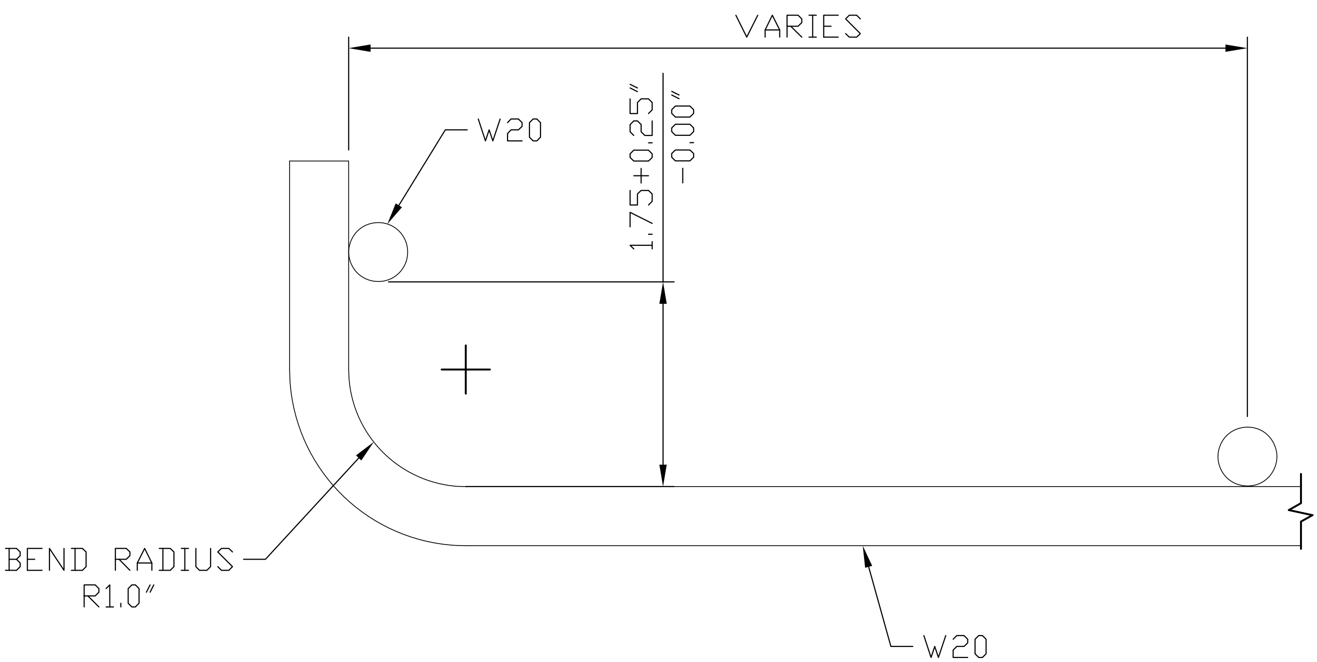
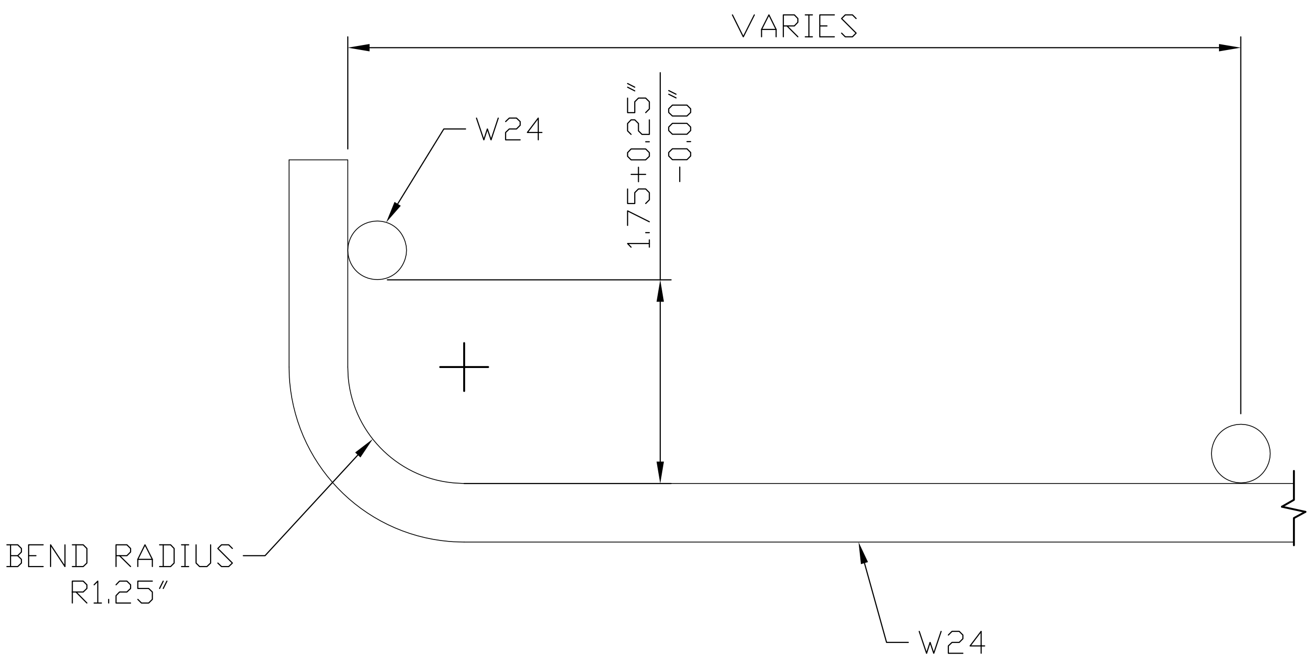


Date: 02/24/12	SSL W20 "L" LOOP MESH WIRE END DETAIL	SSL Specializing in Construction Products 4740 Suite E Scotts Valley Dr. Scotts Valley, California 95066 Phone: 831 430 9300 Fax: 831 430 9340	Job. No. 0000
Designed by: DSM	FIGURE 3A		Of
Checked by:			



Date: 01/18/13	SSL W24 "L" LOOP MESH WIRE END DETAIL	SSL Specializing in Construction Products	Job. No. 0000
Designed by: DSM			
Checked by:	FIGURE 3B	4740 Suite E Scotts Valley Dr. Scotts Valley, California 95066 Phone: 831 430 9300 Fax: 831 430 9340	Of

INNOVATIVE CONSTRUCTION PRODUCTS

9. CALCULATIONS

INNOVATIVE CONSTRUCTION PRODUCTS

The expected elongation of the 26.5 in longitudinal wire sample is calculated using Young's Modulus:

$$E = \textit{Tensile Strength}/\textit{Tensile Strain} = \sigma/\varepsilon = (F/A_0)/(\Delta/L_0) = FL_0/A_0\Delta L$$

Where:

E is Young's Modulus of Elasticity

F is the force exerted on an object under tension

A_0 is the original cross-sectional area through which force is applied

ΔL is the amount by which the object changes

L_0 is the original length of the object

Therefore:

$$\Delta L = 65{,}000 \text{ psi } (26.5 \text{ in}) \,/\, 30\,(10^6) = 0.0574 \text{ in}$$

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Cal
5x6 6" Panel Calculations

Title :
Engineer:
Project Desc.:

Project Notes :

Job #

Printed: 18 JAN 2013, 12:52PM

Steel Beam

File: c:\Users\daniel\Documents\ENERCALC Data Files\colton panel calc.ec6
ENERCALC, INC. 1983-2011, Build:6.12.01.12, Ver:6.11.5.3

Lic. # : KW-06008867 **Licensee : SSL**

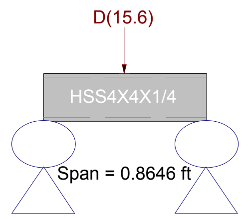
Description : HSS4"x4"x0.25" Steel Beam Deflection Calculation

Material Properties

Calculations per AISC 360-05, IBC 2009, CBC 2010, ASCE 7-05

Analysis Method : Load Resistance Factor Design
Beam Bracing : Completely Unbraced
Bending Axis : Major Axis Bending
Load Combination 2006 IBC & ASCE 7-05

Fy : Steel Yield : 50.0 ksi
E: Modulus : 29,000.0 ksi



HSS4X4X1/4

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Load(s) for Span Number 1
Point Load : D = 15.60 k @ 0.4323 ft, (Jack)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.268** : 1	Maximum Shear Stress Ratio =	**0.263** : 1
Section used for this span	**HSS4X4X1/4**	Section used for this span	**HSS4X4X1/4**
Mu : Applied	4.721 k-ft	Vu : Applied	10.920 k
Mn * Phi : Allowable	17.588 k-ft	Vn * Phi : Allowable	41.533 k
Load Combination	+1.40D	Load Combination	+1.40D
Location of maximum on span	0.432ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Upward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.002 in	Ratio =	6417
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 0.86 ft	1	0.268	0.263	4.72		4.72	19.54	17.59	1.32	1.00	10.92	46.15	41.53

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
	1	0.0000	0.000		0.0000	0.000

Vertical Reactions - Unfactored

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	7.800	7.800
D Only	7.800	7.800

INNOVATIVE CONSTRUCTION PRODUCTS

10. MATERIAL COMPLIANCE CERTIFICATIONS

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Concrete Reinforcements, Inc.

Quality Control Department

Test Data Sheet

DATE: 8/21/2012 **PROJECT NUMBER:** 23000T

CUSTOMER: SSL

TESTING DATE: 8/20/12

23000T-1	8XV W24XW24 TAG: TEST SHEETS - MK-1--5 SHEETS
23000T-2	8XV W24XW20 TAG: TEST SHEETS - MK-2--5 SHEETS
23000T-3	8XV W20XW11 TAG: TEST SHEETS - MK-4--5 SHEETS

The mechanical properties of the material ordered were tested for compliance with A.S.T.M. A-496 & A-497 the results are as follows:

WIRE SIZE	W24	W20	W11								
HEAT NUMBER	1290008743	1290010950	1290010433								
SAMPLE NUMBER	1	1	1								
LOAD (LBS)	22300	19700	11230								
TENSILE (PSI)	93.1K	98.5K	102K								
BEND TEST	PASS	PASS	PASS								
YIELD STRENGTH	82.1K	87.8K	84.9K								
WELD SHEAR	PASS	PASS	PASS								

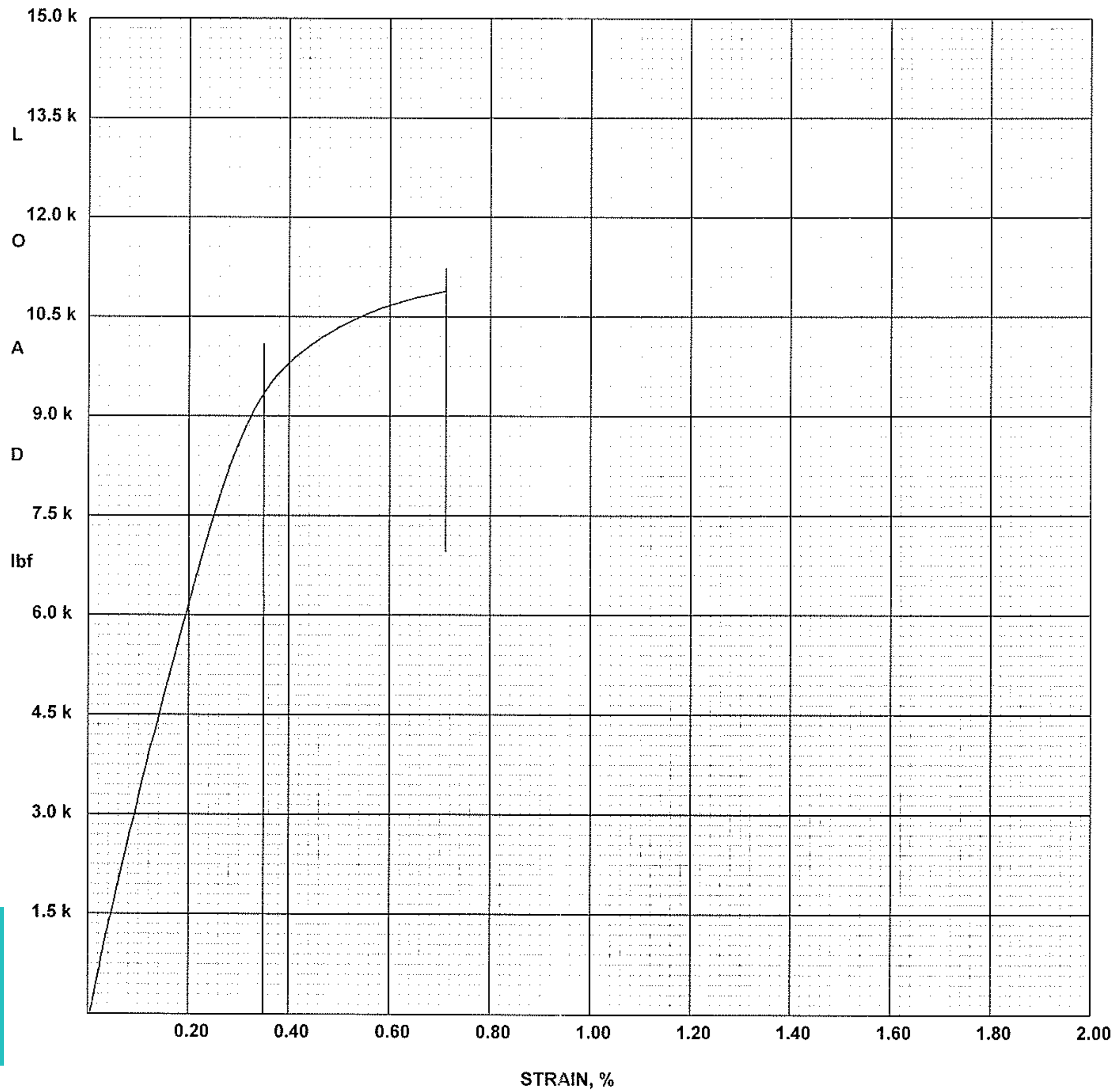
The undersigned certifies that the above is a true and accurate representation of the test results obtained on the described material as appearing on company records. This document certifies that the material mentioned above meets the required A.S.T.M. A-496/ A-497/ and A1064 designation. All of the material herein has been melted and manufactured in the U.S.A.

Very Truly Yours,
Concrete Reinforcements, Inc.

Shawn K. McElwee

Shawn K. McElwee
Quality Assurance

13450 W. Peoria Ave. Surprise, Arizona 85379 Phone 623-975-2970 Fax 623-975-2790



Concrete Reinforcements Inc.
13450 West Peoria Avenue
Surprise, AZ 85379

Tensile Test

Job No.:	.372 /.378
Wire Size:	W11
Rod Mfg./Heat:	1290010433
Rod Size/Carb. Content:	1010
Operator:	ML
Weight, lbf:	0.0000
Area, in²:	0.1100
Ultimate, lbf:	11230
Ultimate, psi:	102000
YIELD .35, psi:	84900

RA=.63

Aug 7, 2012 3:17:53 PM
SN: 207004-R0 V7.01.17

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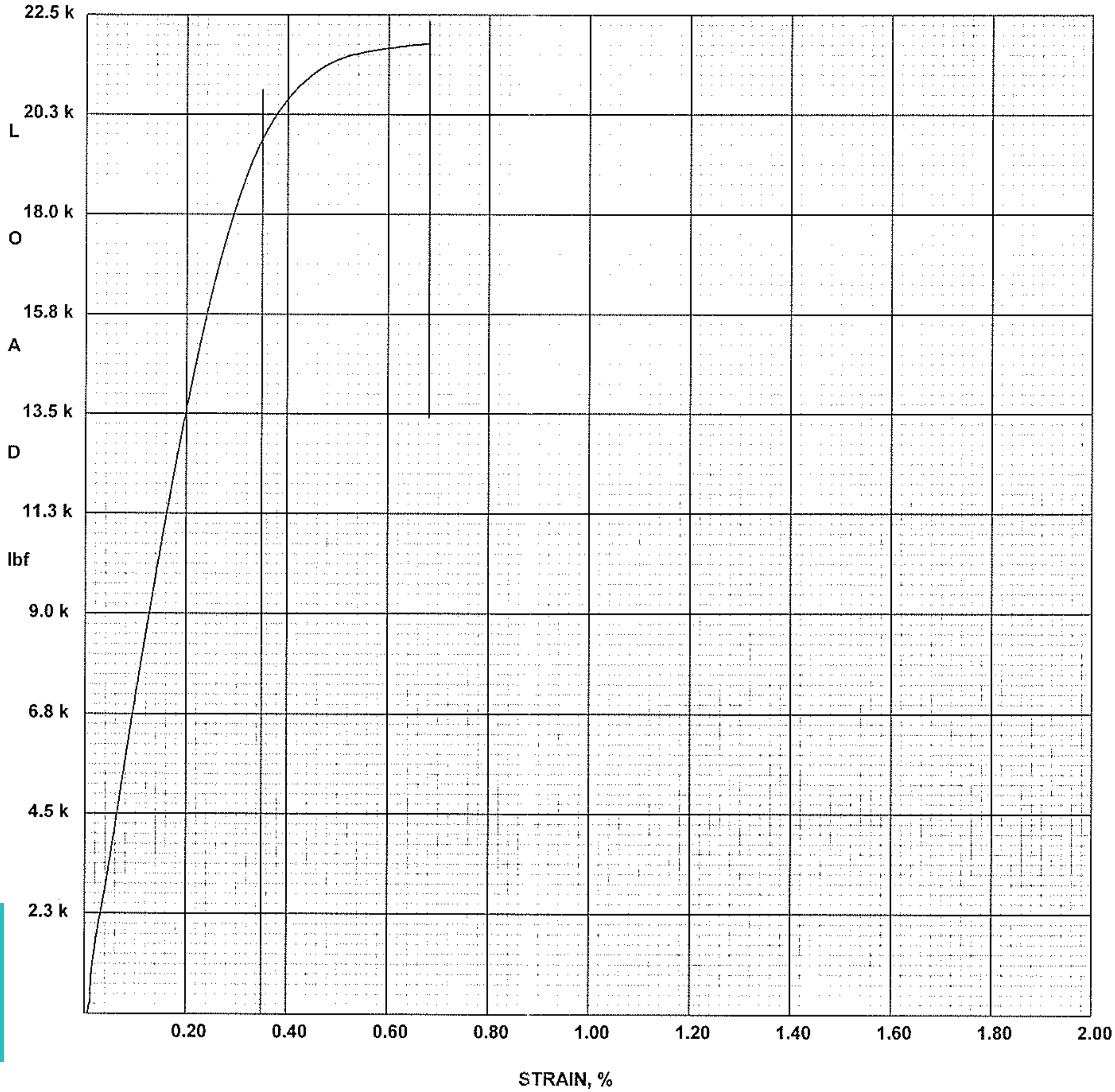


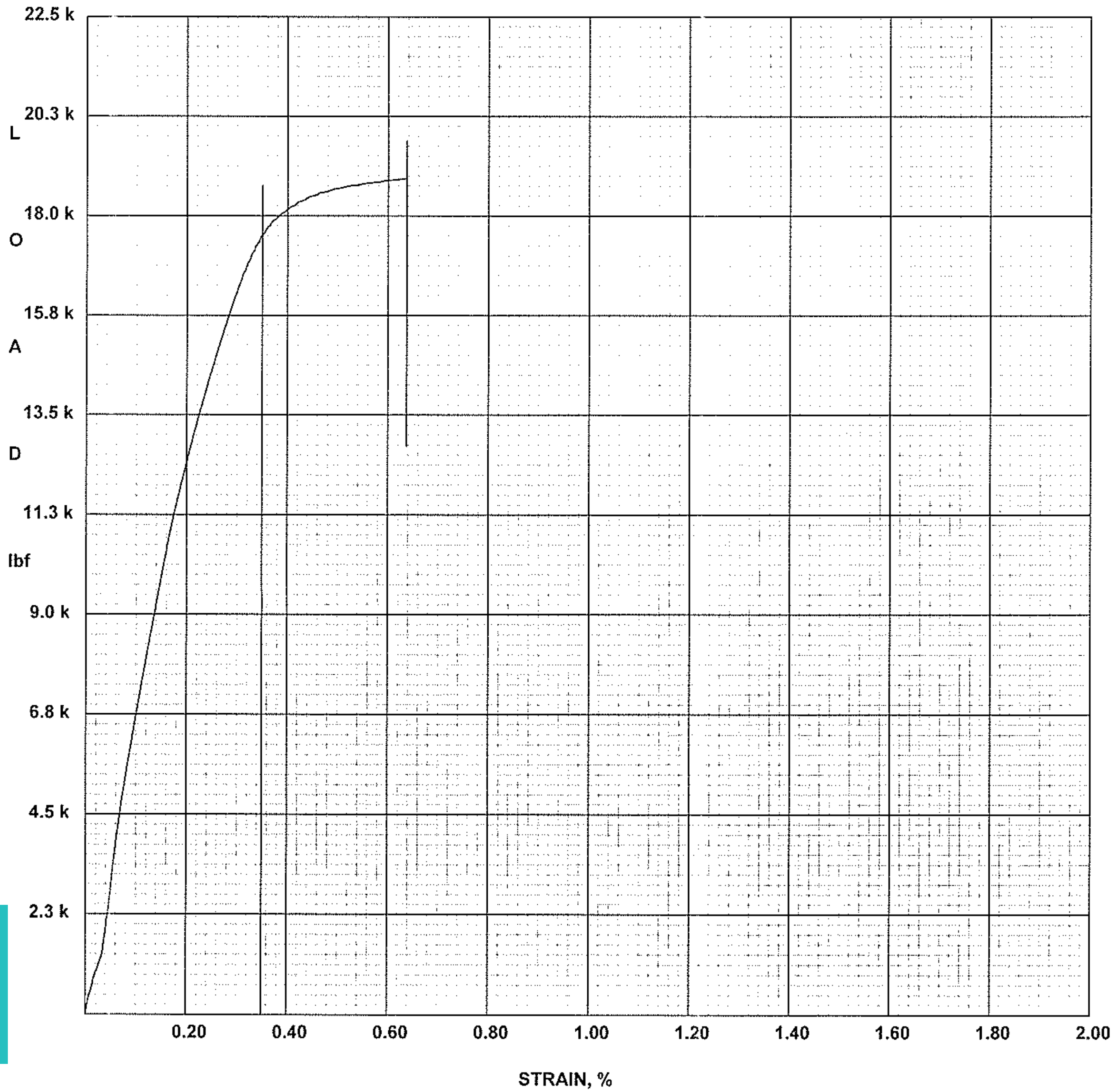
Concrete Reinforcements Inc.
13450 West Peoria Avenue
Surprise, AZ 85379

Tensile Test

Job No.:	.547/.560
Wire Size:	W24
Rod Mfg./Heat:	1290008743
Rod Size/Carb. Content:	1010
Operator:	JL
Weight, lbf:	0.0000
Area, in²:	0.2400
Ultimate, lbf:	22300
Ultimate, psi:	93100
YIELD .35, psi:	82100

RA = .62

Jul 12, 2012 7:36:50 AM
SN: 207004-R0 V7.01.17



Concrete Reinforcements Inc.
13450 West Peoria Avenue
Surprise, AZ 85379

Tensile Test

Job No.:	.501/.511
Wire Size:	W20
Rod Mfg./Heat:	1290010450
Rod Size/Carb. Content:	1010
Operator:	ML
Weight, lbf:	0.0000
Area, in²:	0.2000
Ultimate, lbf:	19700
Ultimate, psi:	98500
YIELD .35, psi:	87800

RA=.64

Aug 10, 2012 1:36:07 PM
SN: 207004-R0 V7.01.17

SOLD TO: CONCRETE REINFORCEMENTS INC
13450 W PEORIA AVE
SURPRISE, AZ 85379-

NUCOR
NUCOR STEEL KINGMAN, LLC

CERTIFIED MILL TEST REPORT

SHIP TO: CONCRETE REINFORCEMENTS INC
13450 W PEORIA AVE
SURPRISE, AZ 85379-

Ship from:

Nucor Steel Kingman, LLC
3000 WEST OLD HIGHWAY 66
KINGMAN, AZ 86413
(928) 718-7035

Date: 12-Jul-2012
B.L. Number: 311190
Load Number: 111387

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # / HEAT #	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	0009662												
KG1290010433	Nucor Steel - Kingman LLC		64,763				.12	.45	.012	.033	.13	.29	
PL11106244	7/16(.437) WireRodCoil		447MPa				.11	.12	.030				
	1010IQ tensile =62-68ksi												
	ASTM A510-08												
	ROA% = 65												

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: Vijay Choksi

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TOC – Appendix

.D KING STEEL CORP
: 5225 E COOK RD
GRAND BLANC, MI 48439-0423

NUCOR
NUCOR STEEL KINGMAN, LLC

CERTIFIED MILL TEST REPORT

Page: 1

› KING STEEL CORP - KINGMAN AREA
3000 WEST OLD HWY 66
KING STEEL LOCATION
KINGMAN, AZ 86413-

Ship from:
Nucor Steel Kingman, LLC
3000 WEST OLD HIGHWAY 66
KINGMAN, AZ 86413
(928) 718-7035

Date: 23-Jan-2012
B.L. Number: 308529
Load Number: 108756

ıterial Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # / HEAT #	DESCRIPTION	PHYSICAL TESTS: YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	CHEMICAL TESTS: C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	010864												
G1290008739	Nucor Steel - Kingman LLC		62,656				.11	.48	.015	.027	.17	.26	
L11107010	5/8(.625) WireRodCoil		432MPa				.09	.13	.010				
	1010IQ tensile =58-65ksi												
	ASTM A510-08												
	ROA% = 62												
PO# =>	010864												
G1290008740	Nucor Steel - Kingman LLC		62,557				.09	.42	.011	.025	.14	.30	
L11206969	5/8(.625) WireRodCoil		431MPa				.10	.09	.020				
	1010IQ tensile =58-65ksi												
	ASTM A510-08												
	ROA% = 65												
PO# =>	010864												
G1290008741	Nucor Steel - Kingman LLC		61,240				.09	.45	.010	.032	.14	.28	
L11206968	5/8(.625) WireRodCoil		422MPa				.09	.09	.010				
	1010IQ tensile =58-65ksi												
	ASTM A510-08												
	ROA% = 65												
PO# =>	010864												
G1290008742	Nucor Steel - Kingman LLC		64,881				.11	.44	.012	.033	.14	.29	
L11206967	5/8(.625) WireRodCoil		447MPa				.10	.11	.020				
	1010IQ tensile =58-65ksi												
	ASTM A510-08												
	ROA% = 62												
# =>	010864												
)0008743	Nucor Steel - Kingman LLC		62,591				.09	.47	.010	.014	.14	.29	
l02299	5/8(.625) WireRodCoil		432MPa				.12	.13	.030				
	1010IQ tensile =58-65ksi												
	ASTM A510-08												
	ROA% = 68												

ıereby certify that the material described herein has been manufactured in accordance with
ı specifications and standards listed above and that it satisfies those requirements.

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SOLD TO: CONCRETE REINFORCEMENTS INC
13450 W PEORIA AVE
SURPRISE, AZ 85379-

NUCOR
NUCOR STEEL KINGMAN, LLC

CERTIFIED MILL TEST REPORT

Ship from:

Nucor Steel Kingman, LLC
3000 WEST OLD HIGHWAY 66
KINGMAN, AZ 86413
(928) 718-7035

SHIP TO: CONCRETE REINFORCEMENTS INC
13450 W PEORIA AVE
SURPRISE, AZ 85379-

Date: 12-Jul-2012
B.L. Number: 311183
Load Number: 111400

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # / HEAT #	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	0009662												
KG1290010449	Nucor Steel - Kingman LLC		66,425				.13	.50	.008	.019	.15	.14	
SE11105439	9/16(.562) WireRodCoil		458MPa				.05	.08	.010				
	1010IQ tensile =58-66ksi												
	ASTM A510-08												
	ROA% = 61												
PO# =>	0009662												
KG1290010450	Nucor Steel - Kingman LLC		65,325				.09	.45	.014	.017	.16	.34	
PL12102723	9/16(.562) WireRodCoil		450MPa				.12	.11	.020				
	1010IQ tensile =58-66ksi												
	ASTM A510-08												
	ROA% = 65												

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: Vijay Choksi

SSL Panel Connection Test
MSE*Plus*™ Wall System

Steven Ruel, P.E.
SSL, LLC
4740 Scotts Valley Drive, Suite E
Scotts Valley, CA 95066
Phone: 831 430 9300
Email: Steve@MSEPlus.com

Date Performed: July 20, 2023

Test Location: Surecast West Redlands, CA
8203 Alabama Street
Redlands, CA 92373

TABLE OF CONTENTS

1. INTRODUCTION

SSL developed a panel connection system for MSE retaining walls which uses welded wire soil reinforcement with precast concrete fascia panels. A dimensional description of the connection and test setup is provided in the attached figures. This test is a supplementary test to be used in conjunction with previous connecting testing performed by SSL in November 2013. The previous test was more focused on the capacity of the connection bends in the individual wires to ensure loading of 100% of yield strength of the wire could be achieved.

This test will be administered by SSL and will be witnessed by an independent testing agency to ensure that the precast panel connectors can meet or exceed the factored tensile capacity as required by AASHTO.

1.1 BACKGROUND AND CALCULATIONS

SSL's system utilizes W11, W20 and W24 welded wire sizes as the primary soil reinforcement sizes for MSE wall projects.

For this test, the Target Load (TL), is determined using the yield strength of the longitudinal wire element of the soil reinforcing mesh of 75,000 PSI multiplied by the cross sectional area of the wire. The largest wire mesh size for the SSL's retaining wall system is a six wire sheet that is comprised of individual W24 wires. For an individual W24 wire, the cross sectional area of the wire is 0.24 in^2. The TL requirement for an individual W24 wire using an AASHTO LRFD load factor of 0.65 is determined as follows. We have also included second load using a load factor of 0.70 for additional information and data.

- Target Load 1 (TL1) = 1 x 75,000 psi x 0.24 in^2 x 0.65 = 11,700 Lbs. per wire
- Target Load 2 (TL2) = 1 x 75,000 psi x 0.24 in^2 x 0.70 = 12,600 Lbs. per wire

2. TEST PROCEDURE OVERVIEW

The pull rod shown in Figure 3 will undergo an exceedingly small elongation as the TL test load is applied to the pull rod system.

Phase 1: Any slack in the pull rod will be eliminated as pull rod is preloaded one until the free end restrained by the connector pin comes in to contact with the back of the panel connectors.

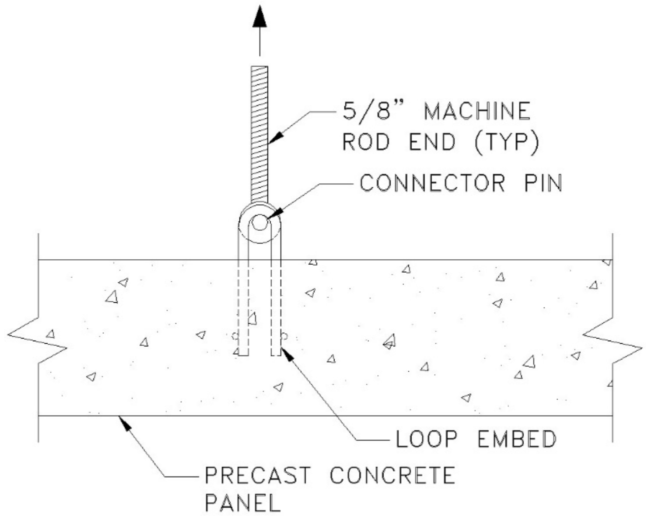

Figure 1

- Phase 2: The eyes of the pull rod will be pulled tightly against the W30 connector pin (see Figure 2).

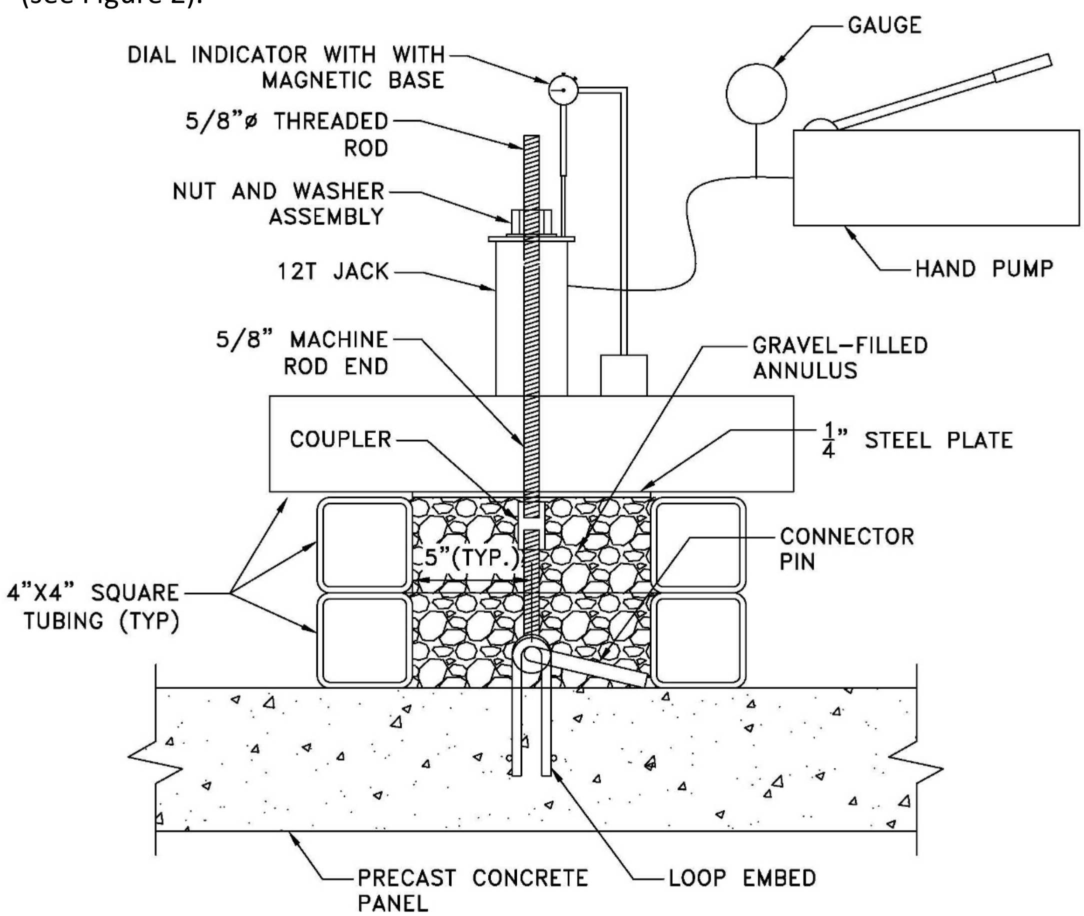

Figure 2

- Phase 3: During testing, the 18 inch pull rod element will elongate in the length between the connector pin and the nut and washer assembly location at the top of the 12 ton jack. *NOTE: The elongation of the pull rod system for TL1 is as follows = (11,700 LB / 0.3068 in^2) / (36,000,000) = 0.0191 inches.*

Due to the configuration of the test apparatus and the position of the hydraulic rams there is a small deflection of the aggregate from the applied load to the steel plate from the hydraulic jacks. This anticipated compression of the aggregate is undetermined. However, measurements being taken to record vertical displacement.

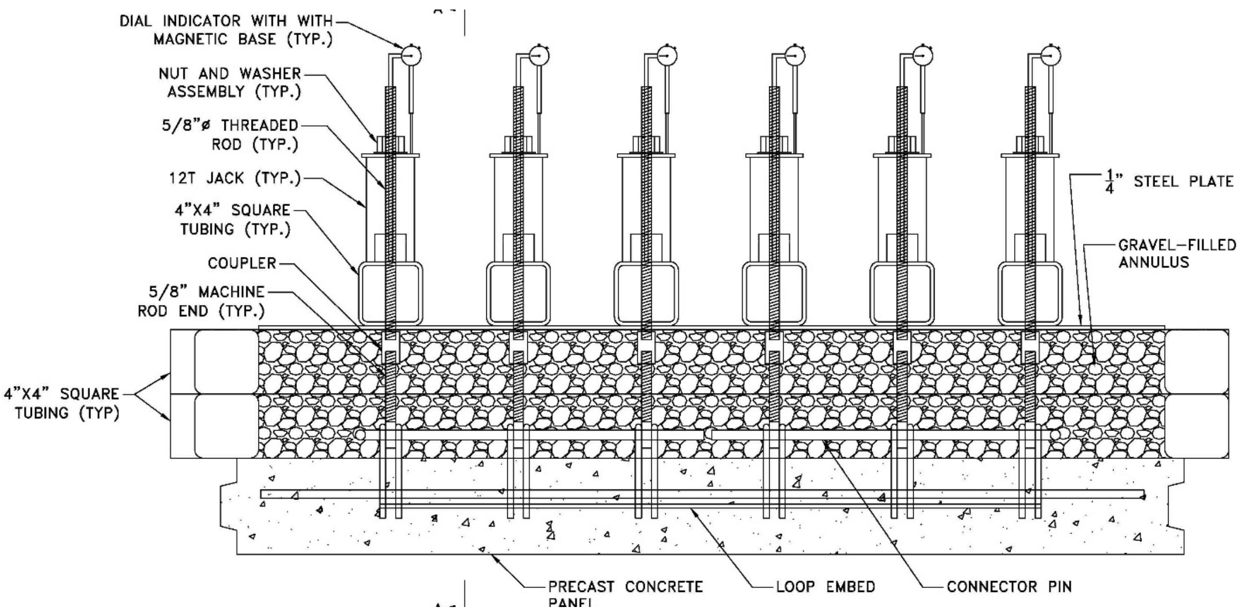

Figure 3

2.2 MATERIALS AND EQUIPMENT

The panel connectors are to be manufactured and fabricated in accordance with ASTM A 1064 and galvanized in accordance with ASTM A123. These connectors are standard panel connectors randomly selected for our production inventory.

Six 12-ton hollow-cylinder calibrated ram and gauge combinations by Technical Associated Services (TAS). The calibration reports provided by TAS are included in Section 6.

The 5' x 5' test panel is a standard production panel fabricated as shown in Section 7 using 60 KSI rebar reinforcement configured for a W24 "Y" panel.

The ram and gauge combinations are identified as follows with identical labels for both the ram and gauge:

INNOVATIVE CONSTRUCTION PRODUCTS

- The six jack numbers as follows - 12K-12-2, 12K-12-3, 234281, 234282, 234283, 234285
- The two gauge combinations are 12K-12-2 and 12K-12-3

Based on the two sets of calibration reports which were compiled by using the average of the results of all jacks for each gauge, the following gauge values were used for the target load (TL) for the W24 wire size:

- TL1 – 11,700 Lbs. equals 4,200 PSI gauge pressure.
- TL2 – 12,600 Lbs. equals 4,600 PSI gauge pressure.

2.3 TEST REQUIREMENTS

This test will confirm:

- The capacity of a group of six connectors will meet or exceed the LRFD strength requirement of six wires of the W24 mesh sheet. The W24 wire, which is the largest diameter longitudinal wire used in a mesh sheet in the MSE Plus™ system.

The test will be concluded when one of the following events occurs:

- If the panel show significant visual cracks of approximately 1/8 inch in width in the panel or that the vertical displacement of panel connectors exceed 1/8 inch, or a wire loop is broken.

Below are the Pass-Fail criteria:

- If the panel connector achieves the TL1 as indicated above without any significant visual cracks in the panel or deformation of the precast panel of metallic connectors.

A representative from a qualified independent testing laboratory shall be present during all testing. A statement of qualifications and a report prepared by the lab stating they witnessed the test procedure, and that testing was performed in accordance with this test procedure.

3. TEST PANEL SETUP and PROCEDURE

3.1 TEST PANEL FABRICATION

1. Install panel connector and panel reinforcing steel.
2. Pour the standard test panel.
3. Form concrete cylinders for testing. Connection testing may be performed upon a minimum of 4,000 PSI concrete cylinders breaks.

3.2 PANEL CONNECTOR PREPARATION

1. When six panel connectors are being tested simultaneously, extreme care must be taken to ensure that there are no additional effects caused by the interaction of the testing apparatus and the test panel.
   - Prior to testing, visually inspect the connectors and loops to ensure that they are at a uniform height above the test panel.
   - During testing, maintain a consistent and even load to each loop that is being evaluated as possible.
2. Prior to the test run, the panel connector must be thoroughly inspected with a hand magnification device to look for cracks, condition of welds, condition of galvanizing, and any other structural or cosmetic defects.

3.3 PULL TEST PROCEDURE

1. Attach all pull rods to the six panel connector using a standard W30 connector pin as shown in Section 8 of this report.
2. Install the test frame and fill the test frame cavity with crushed rock.
3. Tamp the crushed rock in the cavity and install and level the plate.
4. Install the tubing beam and one hollow cylinder ram at the end of each rod on top of the plate.
5. For each connector tested, attach measurement clip at the top of the jack and align with magnetic base dial indicator.
6. Apply loading to all six rods simultaneously with the jacks through a hydraulic manifold.
7. Apply an alignment Load of 1,000 PSI gauge pressure. Set the all the dial indicator gauges to zero. After Alignment Load 1 is applied continue applying load on all rams in 500 PSI increments and record the dial indicator reading on all six gauges at each increment.
8. Once Target Load TL1 is reached, record the final dial indication values. Continue applying loading until TL2 has been reached and then record the final dial indicator values.
9. This is the conclusion of the test.

3.4 EVALUATION AND RE-TESTING IN THE EVENT OF FAILURE

1. Identify which element of the connection system failed.
2. If the failure was caused by something other than the panel connectors in the panel, it is highly likely that the test apparatus was not set-up properly. Examine test apparatus, identify problem, and adjust the apparatus. Select a fresh sample and re-test.

4. Summary and Conclusion

4.1 SUMMARY

INNOVATIVE CONSTRUCTION PRODUCTS

For this test, the Target Load (TL1) was determined using the yield strength of the steel of 75,000 PSI. To pass the connection system test, as shown in the calculations in Section 1.1, the six panel connectors must simultaneously achieve the TL1 of 6 x 11,700 pounds for a total load of 70,200 pounds.

The test was successful based upon the results as the panel connectors and panel did not show any signs of distress, movement, or cracking of the panel as shown in Section 8 of the test photos.

In addition, we subject the panel connectors to a greater load of TL2 which uses a load 0.70 factor which is greater than AASHTO's requirement of 0.65. TL2 load testing was successful with the connectors and panel showing no signs of distress, movement, or cracking with a total load of 75,600 pounds as shown in Section 8 in Figures 6 through 12.

Gauge Pressure - PSI	Target Load	Dial Indicator 1	Dial Indicator 2	Dial Indicator 3	Dial Indicator 4	Dial Indicator 5	Dial Indicator 6
1,000		-	-	-	-	-	-
1,500		0.015	0.016		0.019	0.019	0.024
2,000		0.029	0.029		0.031	0.031	0.038
2,500		0.038	0.039		0.037	0.042	0.049
3,000		0.051	0.049		0.057	0.057	0.060
3,500		0.061	0.059	0.005	0.065	0.066	0.069
4,000		0.071	0.071	0.015	0.078	0.078	0.080
4,200	TL1	0.077	0.075	0.020	0.082	0.085	0.086
4,600	TL2	0.084	0.082	0.029	0.090	0.092	0.092
Displacement TL2- TL1		0.007	0.007	0.009	0.008	0.007	0.006
Displacement TL2 - AL		0.084	0.082		0.090	0.092	0.092
Rod Elongation = 0.0191		0.019	0.019		0.019	0.019	0.019
Net Displacement - TL1		(0.012)	(0.012)		(0.011)	(0.012)	(0.013)

Date 20-Jul-23

Witness VL

Figure 4

4.2 CONCLUSION

The test results shown in Figure 4 the capacity was reached but the displacement was not what we expected. As can be seen from the test data the average net displacement at the top of the jacks is approximately -0.012 inches. This is only possible since the aggregate in the testing frame was consolidated further from the applied load of 75,600 pounds under the steel plate. However, what is important is that the net displacement results are very consistent with the margin of error more likely from reading the dial indicators faces. We also had an error with gauge number 3 as it slipped from the magnetic base. However, the displacement from loading of TL1 to TL2 is consistent with the other five measurements.

In summary, we can conclude that all elements of the panel connection system meet and exceed the AASHTO requirements with respect to connection load capacity.

INNOVATIVE CONSTRUCTION PRODUCTS

5. Independent Verification Report

TWINING

Twining, Inc.- Long Beach Lab
3310 Airport Way, Long Beach, CA 90806
Ph: 562.426.3355
Fax: 562.426.6424
www.twininginc.com

Daily Field Report

Report No: DFR:W01-23-26183-01
Date of Issue: 07/25/2023 **Issue No: 1**

Customer:	Surecast West Pmb 338, 700 E Redlands Blvd., Suite U Redlands, CA 92373	**Project No:** 230477.1 **Permit No:** **HCAI:**
Project:	Surecast West, 8203 Alabama St Redlands 8203 Alabama Street Redlands, CA 92373	**DSA File #:** **DSA AP #:**
Distribution:		
Jurisdiction:		Approved Signatory: Hesam Sajed

Test Date:	Thursday, July 20, 2023		**Inspector:**	Vanessa Garcia Linares	
Inspection No.:	23-26183				
Contractor:	surecast				
Equipment Obsv.:	Pull rod				
Time Arrived:	7:00 AM	**Time Departed:**	3:22 PM	**Time on Site:**	8 Hrs
Lunch Start:	12:00 PM	**Lunch End:**	12:28 PM	**Travel Time:**	
Mileage:		**Weather:**	Clear		

Types of Testing / Observations

Panel connection test

Referenced Documents

Observations / Remarks

*****Regular: ___ OT:___ DT:___ Reason for Travel:___ Miles to Jobsite:___ Miles from Jobsite:___ Travel to Jobsite (start):___ Travel to Jobsite (end):___ Travel from Jobsite (start):___ Travel from Jobsite (end):___ Expenses:________ Equipment Used: _________*****

On site as requested to observe panel connection test. Test to confirm the capacity of a group of 6 connectors will meet or exceed the LRFD strength requirement of 6 wires of the W24 mesh sheet. The W24 wire which is the largest diameter longitudinal wire used in a mesh sheet in the MSE Plus system.

Observation of test set up and procedure per SSL Panel Connection Test MSE Plus Wall System.

All inspections based on minimum of 4 hours and over 4 hours - 8 hours minimum. If inspector is called to a project and no work is performed, a 2 hour minimum charge will be applied.

Remarks:

This report will be distributed to architect, engineer, client, and governing jurisdiction (e.g. DSA) as required by applicable codes and project documents.

Certificate of Compliance

The Work ☑ Was ☐ Was Not inspected in accordance with the requirements of the jurisdiction approved documents	**The Work Inspected** ☑ Met ☐ Did Not Meet the requirements of the jurisdiction approved documents	**The Material Sampling** ☑ Was ☐ Was Not performed in accordance with the requirements of the jurisdiction approved documents

INNOVATIVE CONSTRUCTION PRODUCTS

Twining, Inc.- Long Beach Lab
3310 Airport Way, Long Beach, CA 90806
Ph: 562.426.3355
Fax: 562.426.6424
www.twininginc.com

TWINING

Daily Field Report

Report No: DFR:W01-23-26183-O1
Date of Issue: 7/25/2023 Issue No: 1

Customer: Surecast West
Pmb 338, 700 E Redlands Blvd., Suite U
Redlands, CA, 92373

Project: Surecast West, 8203 Alabama St Redlands
8203 Alabama Street
Redlands, CA, 92373

Project No.: 230477.1
Permit No.:
HCAI:
DSA File #:
DSA AP #:

Jurisdiction:
Distribution:

Approved Signatory: Hesam Sajed (V.P. Long Beach Operations)

INNOVATIVE CONSTRUCTION PRODUCTS

TWINING

Daily Field Report

Twining, Inc.- Long Beach Lab
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Date of Issue: 7/25/2023 **Issue No: 1**

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Permit No.:
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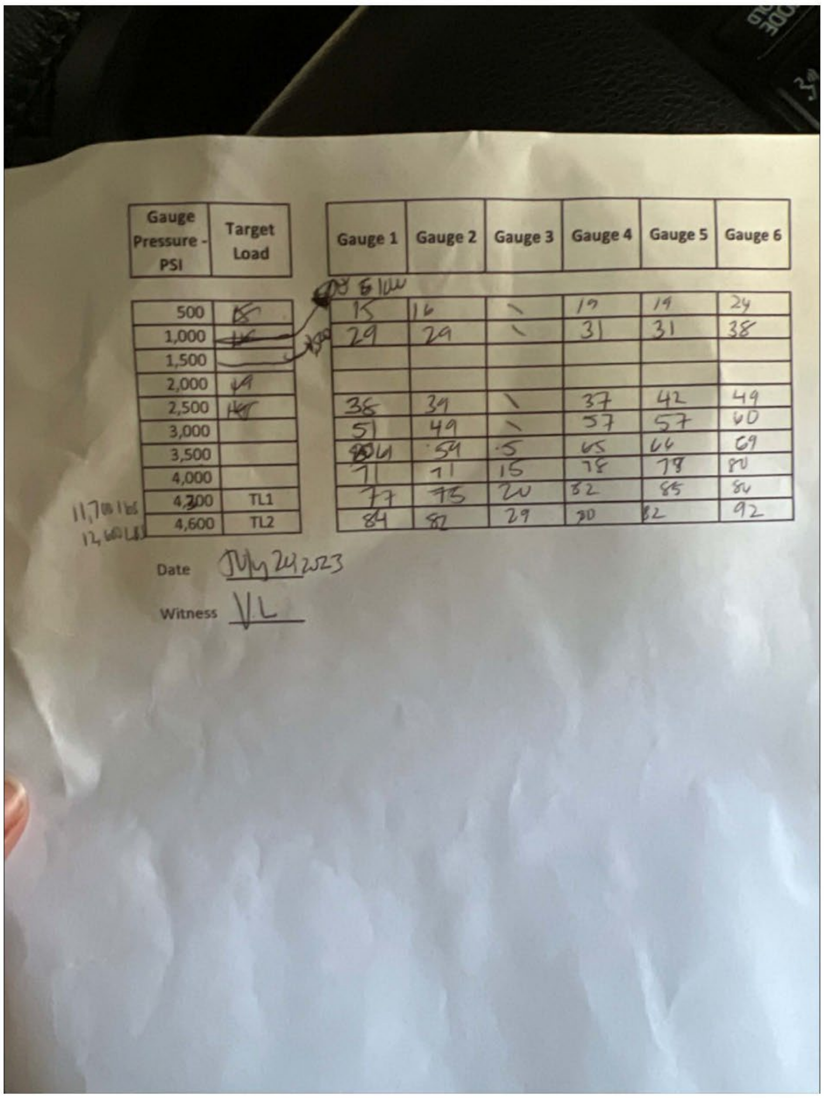
DSA File #:
DSA AP #:

Jurisdiction:
Distribution:

Approved Signatory: Hesam Sajed (V.P. Long Beach Operations)



Gauge Pressure - PSI	Target Load	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6
500	~~15~~	15	16	\	19	19	24
1,000	~~16~~	29	29	\	31	31	38
1,500							
2,000	49						
2,500	48	38	39	\	37	42	49
3,000		51	49	\	57	57	60
3,500		64	54	5	65	66	69
4,000		71	71	15	78	78	80
11,700 lbs 4,300	TL1	77	75	20	82	85	86
12,600 lbs 4,600	TL2	84	82	29	80	82	92

08 & 1000

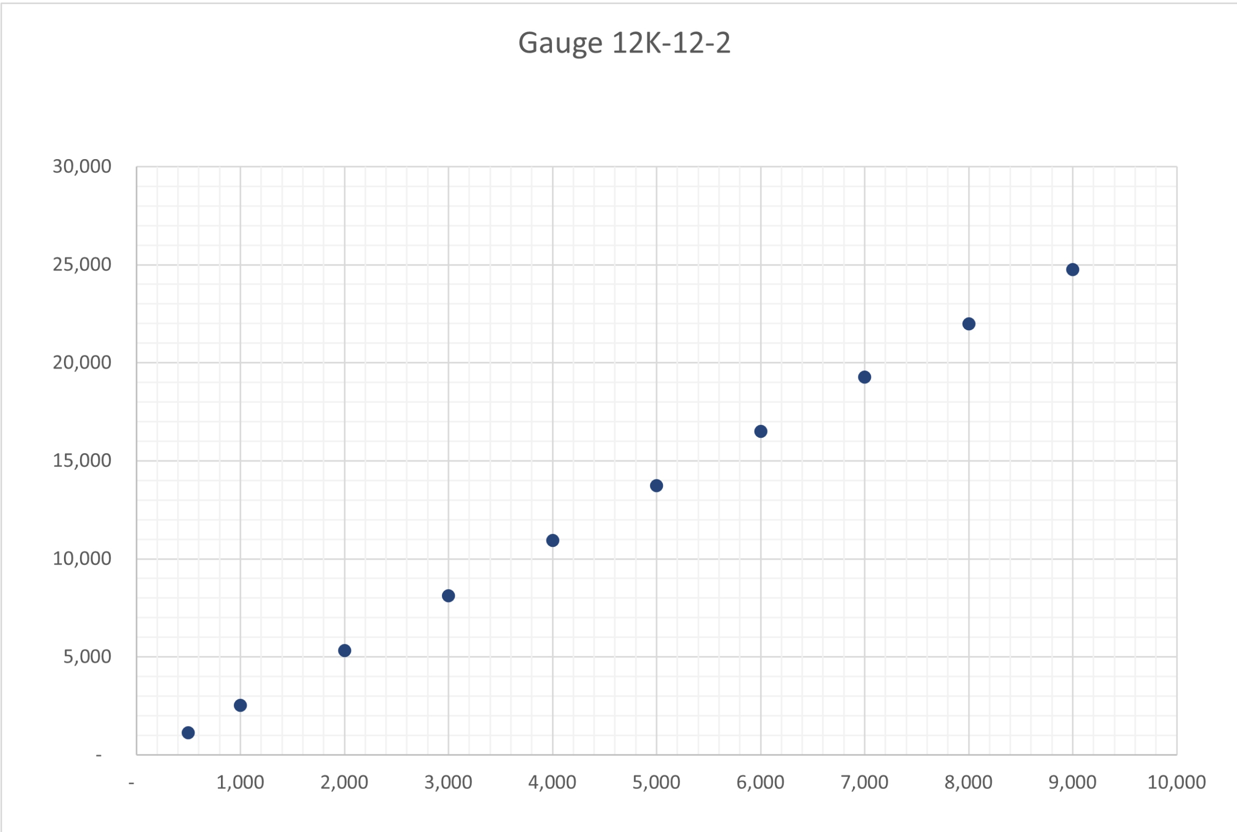
1500

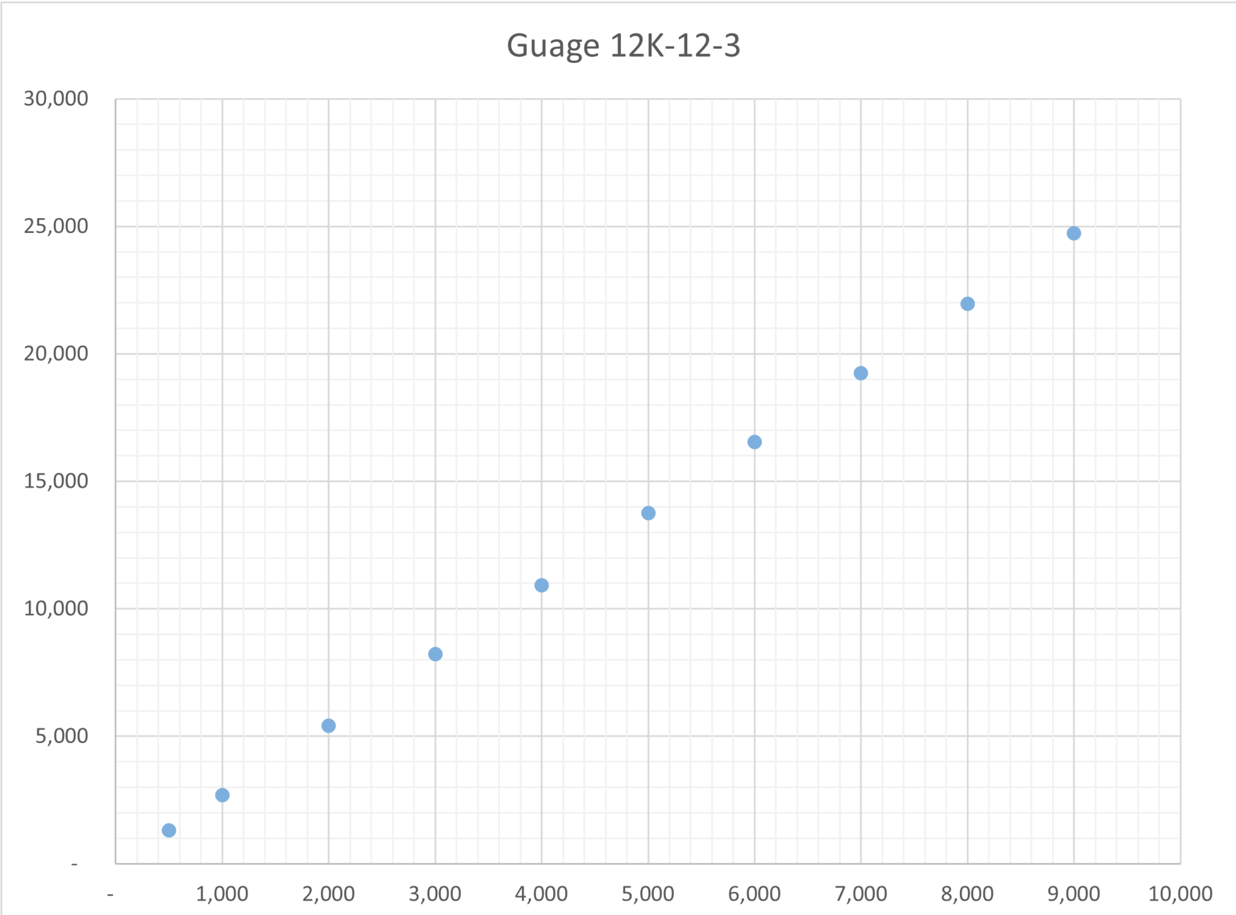
Date July 24 2023

Witness VL

6. Technical Information and Data

Jack Calibration Curves




Guage 12K-12-3
30,000
25,000
20,000
15,000
10,000
5,000
-
-
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000

INNOVATIVE CONSTRUCTION PRODUCTS

TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: SURECAST WEST
Contact: Cody
Address: 8203 Alabama
City/St/Zip: Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023
PO #: Cody
Due Date: 4/29/2024
Location of Equip. Calibrated: Lab
Test Number: HB-23317
Temp./Humidity: 68°F 51%
Procedure: ASTM E4-Caltrans

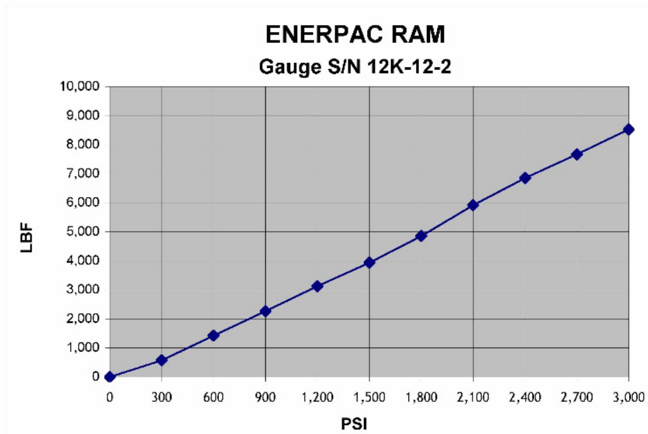
Equipment Information

Description: Hyd Ram
Manufacturer: Enerpac
Model: Holl-O Ram
Ram ID: 12K-12-2
Range: 10 Ton
Customer ID: n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	574	1.913
600	1,423	2.372
900	2,266	2.518
1,200	3,124	2.603
1,500	3,939	2.626
1,800	4,854	2.697
2,100	5,917	2.818
2,400	6,851	2.855
2,700	7,677	2.843
3,000	8,531	2.844

AVERAGE:	2.6088
STDEV:	0.2926



COMMENTS: Average of three runs taken

APPROVAL: Terry Summers

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
3.) Calibration data results relate only to the specified serial number stated in the equipment information section in this certificate.
4.) Equipment condition statements are the opinions of Technical Associated Services and are based on, but not limited to, data from measurements made, professional experience, and procedures utilized. It is ithe responsibility of the customer/user of this equipment to determine if the results identified meet the specific requirements of accuracy for its intended use.
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Calibration Standards

SN# or ID#	Due Date	Traceability
123369A	9/6/2024	53712-2
22620	6/13/2024	4185-12720905

INNOVATIVE CONSTRUCTION PRODUCTS

TECHNICAL ASSOCIATED SERVICES

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Customer: SURECAST WEST **Address:** 8203 Alabama

Contact: Cody **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** HB-23317

PO #: Cody **Temp./Humidity:** 68°F 51%

Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans

Location of Equip. Calibrated: Lab

Equipment Information

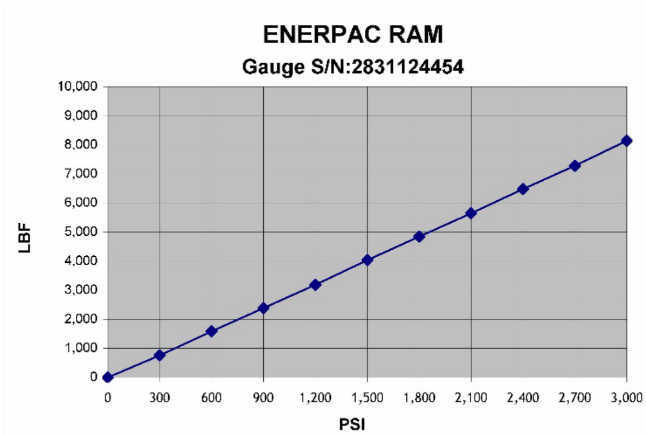
Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton

Manufacturer: Enerpac **Ram ID: 12K-12-2** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	762	2.540
600	1,581	2.635
900	2,385	2.650
1,200	3,185	2.654
1,500	4,041	2.694
1,800	4,849	2.694
2,100	5,652	2.691
2,400	6,483	2.701
2,700	7,284	2.698
3,000	8,149	2.716

AVERAGE:	2.6674
STDEV:	0.0519



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:

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CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023
PO #: Cody
Due Date: 4/29/2024
Location of Equip. Calibrated: Lab

Test Number: HB-23317
Temp./Humidity: 68°F 51%
Procedure: ASTM E4-Caltrans

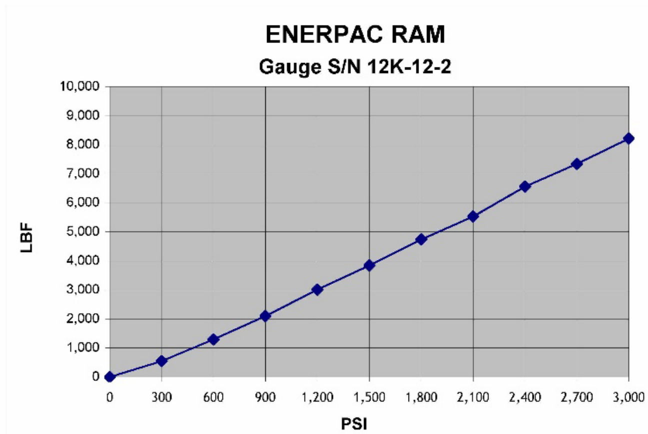
Equipment Information

Description: Hyd Ram
Manufacturer: Enerpac
Model: RCH123
Ram ID: 12K-12-3
Range: 10 Ton
Customer ID: n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	551	1.837
600	1,295	2.158
900	2,102	2.336
1,200	3,010	2.508
1,500	3,844	2.563
1,800	4,738	2.632
2,100	5,533	2.635
2,400	6,563	2.735
2,700	7,347	2.721
3,000	8,216	2.739

AVERAGE:	2.4863
STDEV:	0.2949



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
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Contact: Cody **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** HB-23317

PO #: Cody **Temp./Humidity:** 68°F 51%

Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans

Location of Equip. Calibrated: Lab

Equipment Information

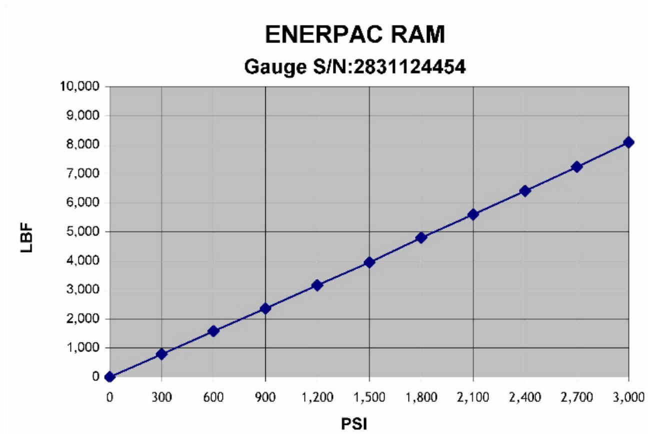
Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton

Manufacturer: Enerpac **Ram ID: 12K-12-3** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	788	2.627
600	1,575	2.625
900	2,361	2.623
1,200	3,158	2.632
1,500	3,949	2.633
1,800	4,799	2.666
2,100	5,601	2.667
2,400	6,412	2.672
2,700	7,231	2.678
3,000	8,086	2.695

AVERAGE:	2.6518
STDEV:	0.0266



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
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INNOVATIVE CONSTRUCTION PRODUCTS

TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: SURECAST WEST **Address:** 8203 Alabama
Contact: Cody **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** HB-23317
PO #: Cody **Temp./Humidity:** 68°F 51% Rh
Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans
Location of Equip. Calibrated: Lab

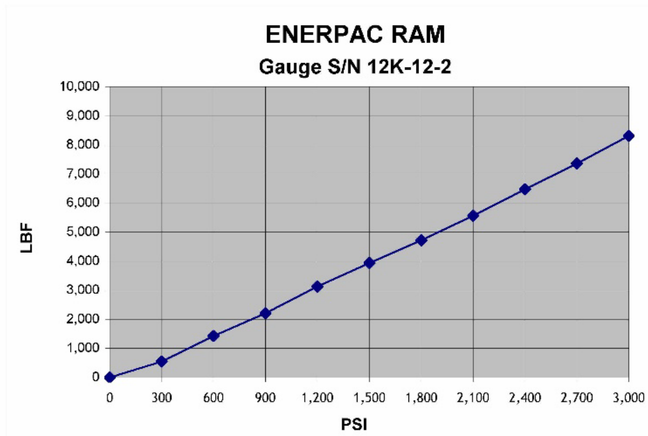
Equipment Information

Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton
Manufacturer: Enerpac **Ram ID: 234281** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	551	1.837
600	1,428	2.380
900	2,212	2.458
1,200	3,132	2.610
1,500	3,936	2.624
1,800	4,722	2.623
2,100	5,564	2.650
2,400	6,472	2.697
2,700	7,358	2.725
3,000	8,314	2.771

AVERAGE:	2.5374
STDEV:	0.2729



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
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TOC – Appendix

INNOVATIVE CONSTRUCTION PRODUCTS

TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: SURECAST WEST
Contact: Cody
Address: 8203 Alabama
City/St/Zip: Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023
PO #: Cody
Due Date: 4/29/2024
Location of Equip. Calibrated: Lab
Test Number: HB-23317
Temp./Humidity: 68°F 51%
Procedure: ASTM E4-Caltrans

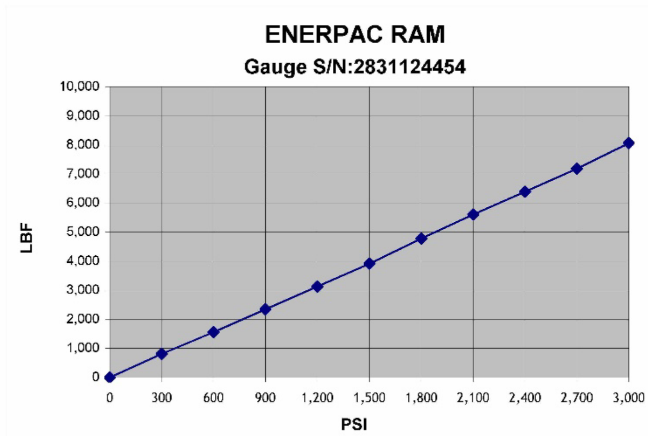
Equipment Information

Description: Hyd Ram
Manufacturer: Enerpac
Model: RCH123
Ram ID: 234281
Range: 10 Ton
Customer ID: n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	811	2.703
600	1,563	2.605
900	2,348	2.609
1,200	3,125	2.604
1,500	3,915	2.610
1,800	4,783	2.657
2,100	5,611	2.672
2,400	6,388	2.662
2,700	7,184	2.661
3,000	8,058	2.686

AVERAGE:	2.6469
STDEV:	0.0369



COMMENTS: Average of three runs taken

APPROVAL: Terry Summers

Remarks:
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INNOVATIVE CONSTRUCTION PRODUCTS

TECHNICAL ASSOCIATED SERVICES

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Customer: SURECAST WEST **Address:** 8203 Alabama

Contact: Cody **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** **HB-23317**

PO #: Cody **Temp./Humidity:** 68°F 51%

Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans

Location of Equip. Calibrated: Lab

Equipment Information

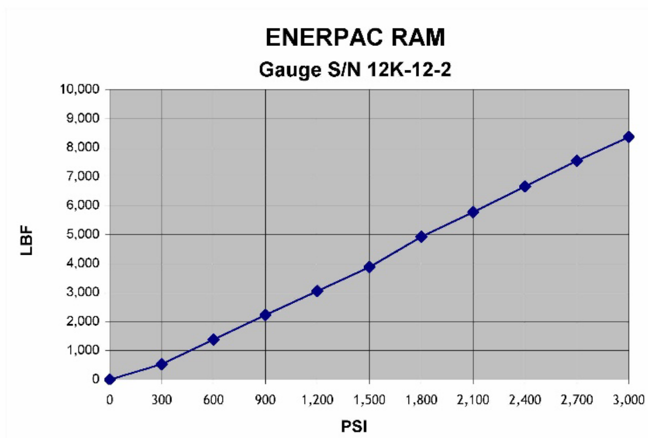
Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton

Manufacturer: Enerpac **Ram ID: 234282** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	531	1.770
600	1,386	2.310
900	2,223	2.470
1,200	3,056	2.547
1,500	3,882	2.588
1,800	4,925	2.736
2,100	5,775	2.750
2,400	6,661	2.775
2,700	7,543	2.794
3,000	8,367	2.789

AVERAGE:	2.5529
STDEV:	0.3190



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
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Customer: SURECAST WEST
Contact: Cody
Address: 8203 Alabama
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CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023
PO #: Cody
Due Date: 4/29/2024
Location of Equip. Calibrated: Lab
Test Number: **HB-23317**
Temp./Humidity: 68°F 51%
Procedure: ASTM E4-Caltrans

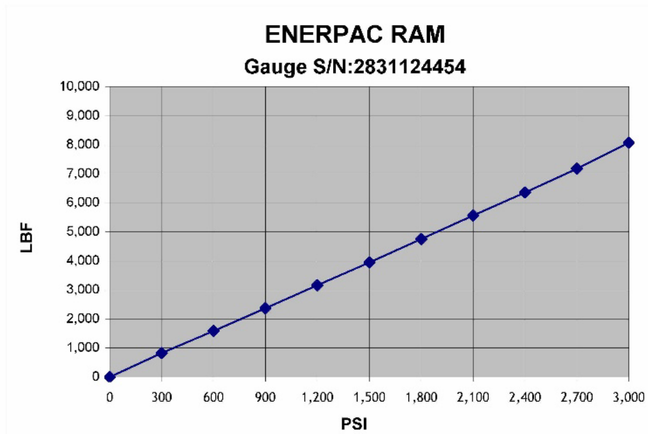
Equipment Information

Description: Hyd Ram
Manufacturer: Enerpac
Model: RCH123
Ram ID: 234282
Range: 10 Ton
Customer ID: n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	830	2.767
600	1,581	2.635
900	2,369	2.632
1,200	3,160	2.633
1,500	3,950	2.633
1,800	4,756	2.642
2,100	5,565	2.650
2,400	6,354	2.648
2,700	7,177	2.658
3,000	8,067	2.689

AVERAGE:	2.6587
STDEV:	0.0416



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
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CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** HB-23317
PO #: Cody **Temp./Humidity:** 68°F 51% Rh
Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans
Location of Equip. Calibrated: Lab

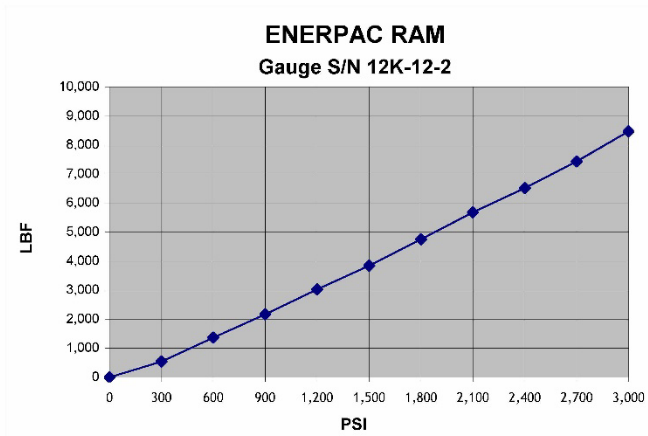
Equipment Information

Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton
Manufacturer: Enerpac **Ram ID: 234283** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	537	1.790
600	1,362	2.270
900	2,171	2.412
1,200	3,028	2.523
1,500	3,843	2.562
1,800	4,756	2.642
2,100	5,682	2.706
2,400	6,519	2.716
2,700	7,436	2.754
3,000	8,474	2.825

AVERAGE:	2.5200
STDEV:	0.3063



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
3.) Calibration data results relate only to the specified serial number stated in the equipment information section in this certificate.
4.) Equipment condition statements are the opinions of Technical Associated Services and are based on, but not limited to, data from measurements made, professional experience, and procedures utilized. It is ithe responsibility of the customer/user of this equipment to determine if the results identified meet the specific requirements of accuracy for its intended use.
5.) This report shall not be reproduced, except in full, without the written approval of Technical Associated Services.

Calibration Standards

SN# or ID#	Due Date	Traceability
123369A	9/6/2024	53712-2
22620	6/13/2024	4185-12720905

INNOVATIVE CONSTRUCTION PRODUCTS

TECHNICAL ASSOCIATED SERVICES

7832 Franklin Drive Huntington Beach, CA 92648 T.(714) 841-0475 F. (714) 841-4180 http://www.tascalibration.com

Customer: SURECAST WEST **Address:** 8203 Alabama

Contact: Cody **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** **HB-23317**

PO #: Cody **Temp./Humidity:** 68°F 51%

Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans

Location of Equip. Calibrated: Lab

Equipment Information

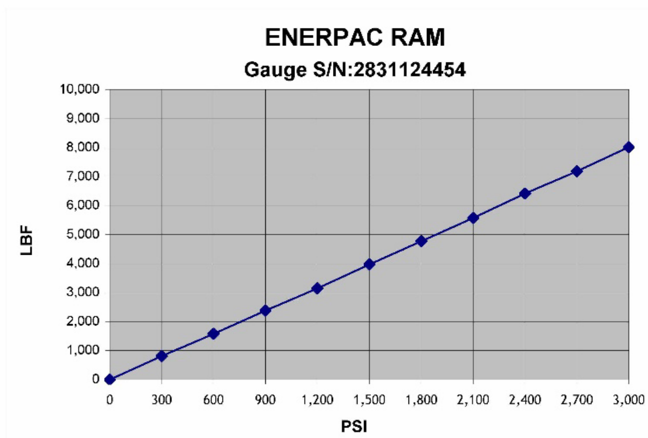
Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton

Manufacturer: Enerpac **Ram ID: 234283** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	807	2.690
600	1,573	2.622
900	2,378	2.642
1,200	3,144	2.620
1,500	3,971	2.647
1,800	4,769	2.649
2,100	5,575	2.655
2,400	6,417	2.674
2,700	7,183	2.660
3,000	8,021	2.674

AVERAGE:	2.6533
STDEV:	0.0224



COMMENTS: Average of three runs taken

APPROVAL: Terry Summers

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
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SN# or ID#	Due Date	Traceability
123369A	9/6/2024	53712-2
22620	6/13/2024	4185-12720905

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Contact: Cody **City/St/Zip:** Highland, CA 92346

CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023 **Test Number:** HB-23317
PO #: Cody **Temp./Humidity:** 68°F 51%
Due Date: 4/29/2024 **Procedure:** ASTM E4-Caltrans
Location of Equip. Calibrated: Lab

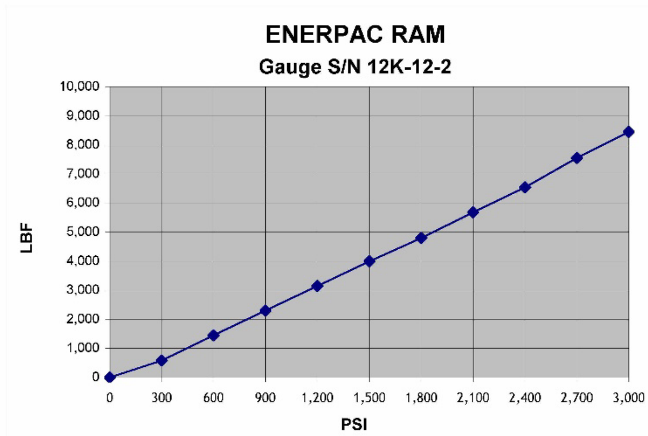
Equipment Information

Description: Hyd Ram **Model:** RCH123 **Range:** 10 Ton
Manufacturer: Enerpac **Ram ID: 234284** **Customer ID:** n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	578	1.927
600	1,453	2.422
900	2,301	2.557
1,200	3,149	2.624
1,500	3,994	2.663
1,800	4,795	2.664
2,100	5,680	2.705
2,400	6,547	2.728
2,700	7,552	2.797
3,000	8,451	2.817

AVERAGE:	2.5902
STDEV:	0.2599



COMMENTS: Average of three runs taken

APPROVAL: Terry Summers

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
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22620	6/13/2024	4185-12720905

INNOVATIVE CONSTRUCTION PRODUCTS

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CERTIFICATE OF CALIBRATION

Event Information

Calibration Date: 4/29/2023
PO #: Cody
Due Date: 4/29/2024
Location of Equip. Calibrated: Lab
Test Number: HB-23317
Temp./Humidity: 68°F 51%
Procedure: ASTM E4-Caltrans

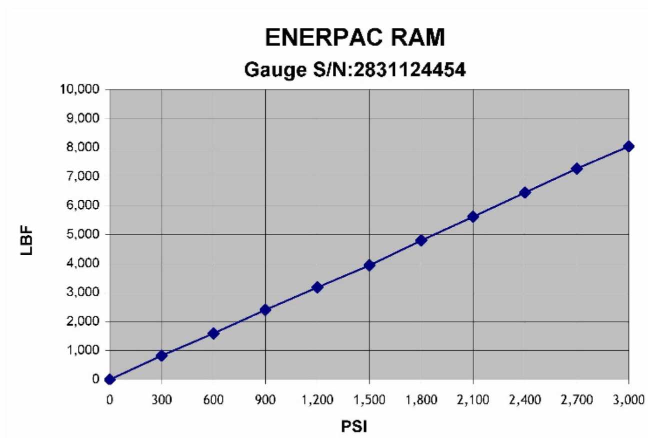
Equipment Information

Description: Hyd Ram
Manufacturer: Enerpac
Model: RCH123
Ram ID: 234284
Range: 10 Ton
Customer ID: n/a

Calibration Results

PSI	LBF	LBF/PSI
0	0	0
300	826	2.753
600	1,596	2.660
900	2,406	2.673
1,200	3,179	2.649
1,500	3,941	2.627
1,800	4,794	2.663
2,100	5,613	2.673
2,400	6,452	2.688
2,700	7,277	2.695
3,000	8,041	2.680

AVERAGE:	2.6763
STDEV:	0.0334



APPROVAL: Terry Summers

COMMENTS: Average of three runs taken

Remarks:
1.) Test conforms to ANSI/Z540 and ISO/IEC 17025.
2.) Calibration Standards used are traceable to NIST unless otherwise specified.
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Calibration Standards

SN# or ID#	Due Date	Traceability
123369A	9/6/2024	53712-2
22620	6/13/2024	4185-12720905

TOC – Appendix

INNOVATIVE CONSTRUCTION PRODUCTS

Cylinder Test Break and Concrete Mix Design

SURECAST WEST

PROJECT	PULL-OUT TEST	DATE	7/14/2023
LOCATION	SURECAST WEST	DAY	FRIDAY

CONC. SUPPLIER	CEMEX	BATCH TIME	8:09 AM	CONCRETE	TYPE II / V
LOAD NUMBER	1	CAST TIME	8:38 AM	TYPE	1611831
TICKET NUMBER	30832998	FINISH TIME	9:19 AM	USE	PANELS

TEST RESULTS

WEATHER	SUNNY	AIR CONTENT %	N/A	VOLUME cy	7
AMBIENT TEMP.	81	SLUMP "	4.5	UNIT WT	N/A
CONCRETE TEMP.	88	KELLY BALL	N/A	CYLINDERS	5

COMPRESSION TEST RESULTS

CYLINDER MARK	DIA. "in"	DATE TESTED	AGE DAYS	MAX LOAD (LBS.)	COMPRESSIVE STRENGTH psi	MPa	TESTED BY	na	COMMENTS
A	6.01	7-20-23	6	131800	4650		DB		
B	6.01	7-20-23	6	129230	4560		DB		
C									
D									
				AVG = 4605					

BREAK TYPES: TYPE 1 | TYPE 2 | TYPE 3 | TYPE 4 | TYPE 5

PRODUCT PRODUCED

MSE PANELS

7-20-23
DATE OF REPORT

TECHNICIAN SIGNATURE

SSL
INNOVATIVE CONSTRUCTION PRODUCTS™

INVOICE

WEIGHMASTER CERTIFICATE

THIS IS TO CERTIFY that the following described commodity was weighed, measured, or counted by a weighmaster, whose signature is on this certificate, who is a recognized authority of accuracy, as prescribed by Chapter 7 (commencing with Section 12700) of Division 5 of the California Business and Professions Code, administered by the Division of Measurement Standards of the California Department of Food and Agriculture.

CEMEX

42802720

Plt B, 8203 Alabama St., Highland, CA 92346

NOTE: Excess water is detrimental to concrete quality. Increased water in concrete mix reduces strength and durability and increases shrinkage. Buyer accepts responsibility for water added on job site, which exceeds accepted water/cement ratio and workability specifications.

Plant:	Begin Loading:	To Job:	Arrive Job:	Start Unload:	Finish Unload:	Leave Job:	Return Plant:
4484B	8:09	0825	0834	0838	9:19		

Total Amount for This Ticket Not Including Standby Charges:

Cash / Check / Charge	Check # / Auth Code:	Signature of Driver Receiving Cash:	Cash Received:	Total COD Order Amount to Collect Without Standby Charges:

Customer Code: 3113228
Customer Name: SURECAST WEST LLC/SSL
Customer Job Number:
Order Code / Date: 3245

Project Code: 41225461
Project Name: REDLANDS PLANT
Deputy Weighmaster: G HERNANDEZ
Order P.O. Number: NONE

Ticket Date: 07/14/23
Delivery Address: 8203 ALABAMA STREET, REDLANDS
Map Page: SR607H2

Delivery Instructions:
Ticket Number: 30832998

Due On Job:	Slump:	Load:	Truck Number:	Driver Number:	Driver Name:	End Use:
08:00	4.00	1	10067825	448234	WALTERS, ERNEST Y E	OTHER

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDERED QUANTITY	MATERIAL CODE	PRODUCTION DESCRIPTION	UOM	UNIT PRICE	AMOUNT
7.00	7.00	7.00	1611831	CT 4000 42 DAYS .40 COR P/P	yd3		
1.00		0.00	1247817	STANDARD FUEL SURCHARGE,PC-D	EA		
1.00		0.00	1202749	ENVIRONMENTAL CHARGE PER LOA	EA		

S 4½"
AT 81°F
CT 88°F

ALWAYSGET OUT AND LOOK BEFORE BACKING YOUR TRUCK
SCRAPEN GO? YES NO

MINIMUM LOAD CHARGE

Drum Counter: 0,81,134
Previous Truck:
Concrete Disposal Fee
Partial Full Load

Water Added IN GALLONS:	Curb Line Crossed At Owner's Agent's Request:	AUTHORIZED SIGNATURE	SUB TOTAL
		Print Name: Joey Brickler — Date: 7-14-23	TAX
ⓧ INITIALS	ⓧ INITIALS	Signature above signifies receipt and acceptance of the listed materials and acknowledgement of and agreement to the CEMEX terms and conditions.	TOTAL

BATCH DATA:

42802720

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
10067825	448234	operator	30832998	53051565	8:09	7/14/23

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
7.00 CYDS	1611831				D2	51782

Material	Batched	% Moisture	Actual Wat	Tot.Wat	Trim
1X4GRAVL	9140.00 lb				
3/8 RND	2400.00 lb				
NSCOM	8880.00 lb	6.38% A	63.79 gl	63.79	
CEMENT	2775.00 lb				
SLAG	2700.00 lb				
HYD STAB	56.00 oz				100.00 %
HRWR D	198.00 oz				100.00 %
WATER	180.23 gal		180.23 gl	180.23	-3.00 gl

Actual Num Batches: 1 Manual 8:09:46
Load Total: 27495 lb Actual 244.0 gl To Add: 22.0 gl
Slump: 5.00 in # Trim Water: -3.0 gl / CYD

80UNIVERSAL Rev 4/12

INNOVATIVE CONSTRUCTION PRODUCTS

Original Test Data Sheet

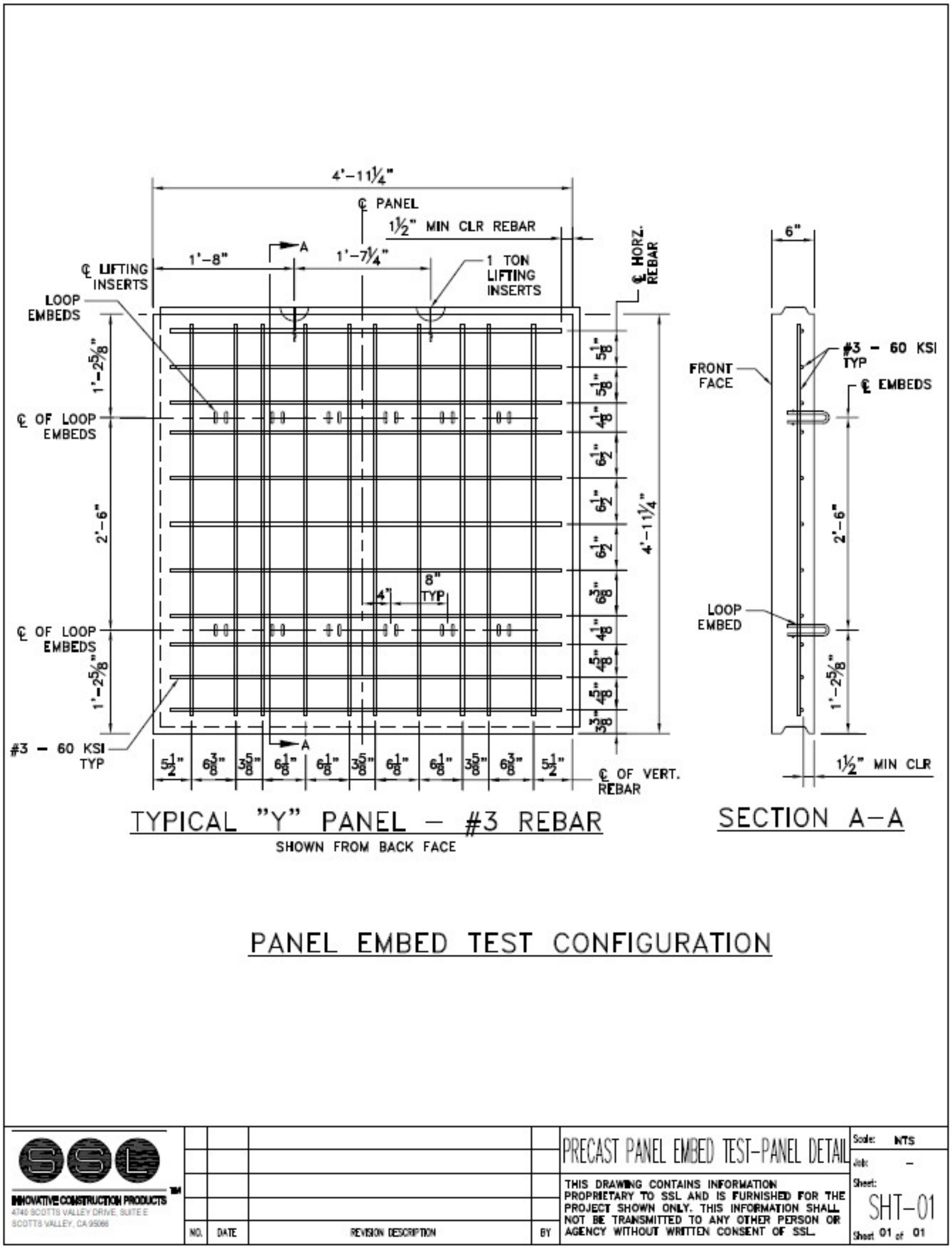
	Gauge Pressure - PSI	Target Load	Gauge 1	Gauge 2	Gauge 3	Gauge 4	Gauge 5	Gauge 6
	500	15	15	16	\	19	19	24
	1,000	~~45~~	29	29	\	31	31	38
	1,500							
	2,000	49						
	2,500	48	38	39	\	37	42	49
	3,000		51	49	\	57	57	60
	3,500		~~80~~ 61	59	5	65	64	69
	4,000		71	71	15	75	78	80
11,700 lbs	4,300	TL1	77	75	20	82	85	86
12,600 LBS	4,600	TL2	84	82	29	80	82	92

Date July 24 2023

Witness V.L

INNOVATIVE CONSTRUCTION PRODUCTS

7. Test Panel Details



INNOVATIVE CONSTRUCTION PRODUCTS

8. Test Photos

Figure 1 – Panel Reinforcement

Figure 2 – Assembling the test frame and pull rods

`f

Figure 3 – Installation of the aggregate and top plate

Figure 4 – Test apparatus complete with dial indicators with connection number 1 is at the top of the photo

Figure 5 – Disassembling the test setup to view the connectors

Figure 6 – Connection system and the aggregate removed and panel cleaned

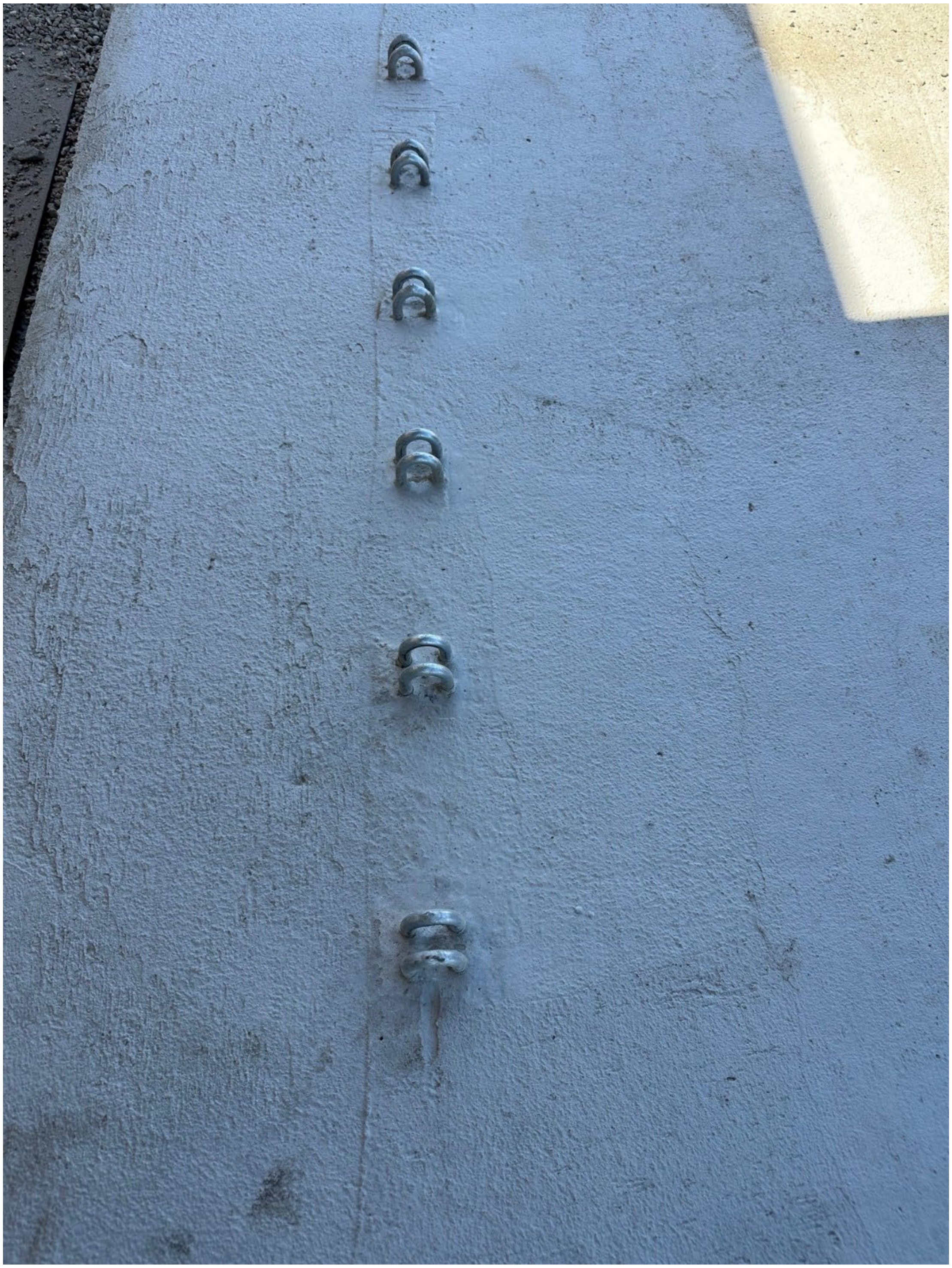


Figure 7 – Connection 1

Figure 8 – Connection 2

Figure 9 – Connection 3

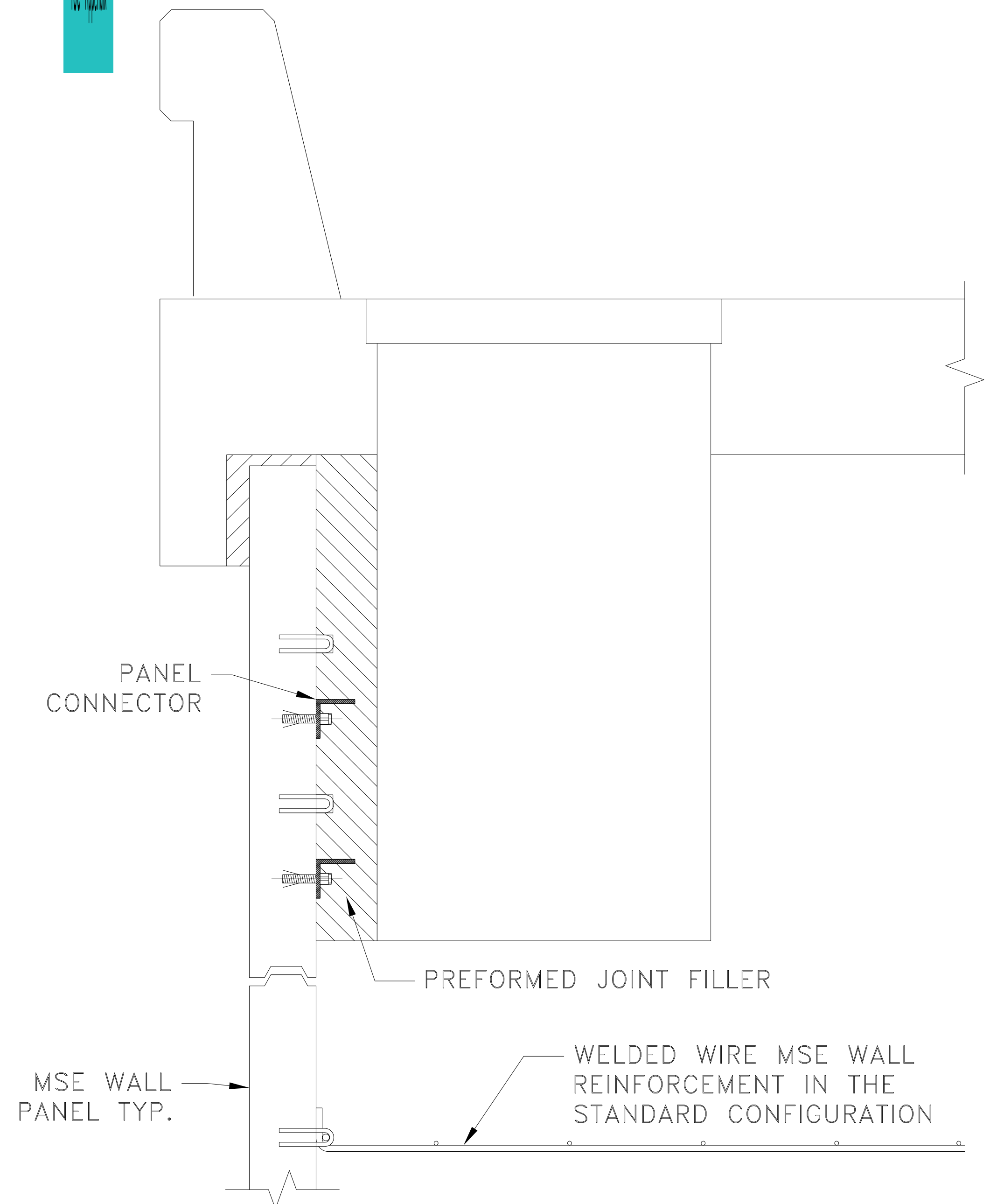
Figure 10 – Connection 4

Figure 11 – Connection 5

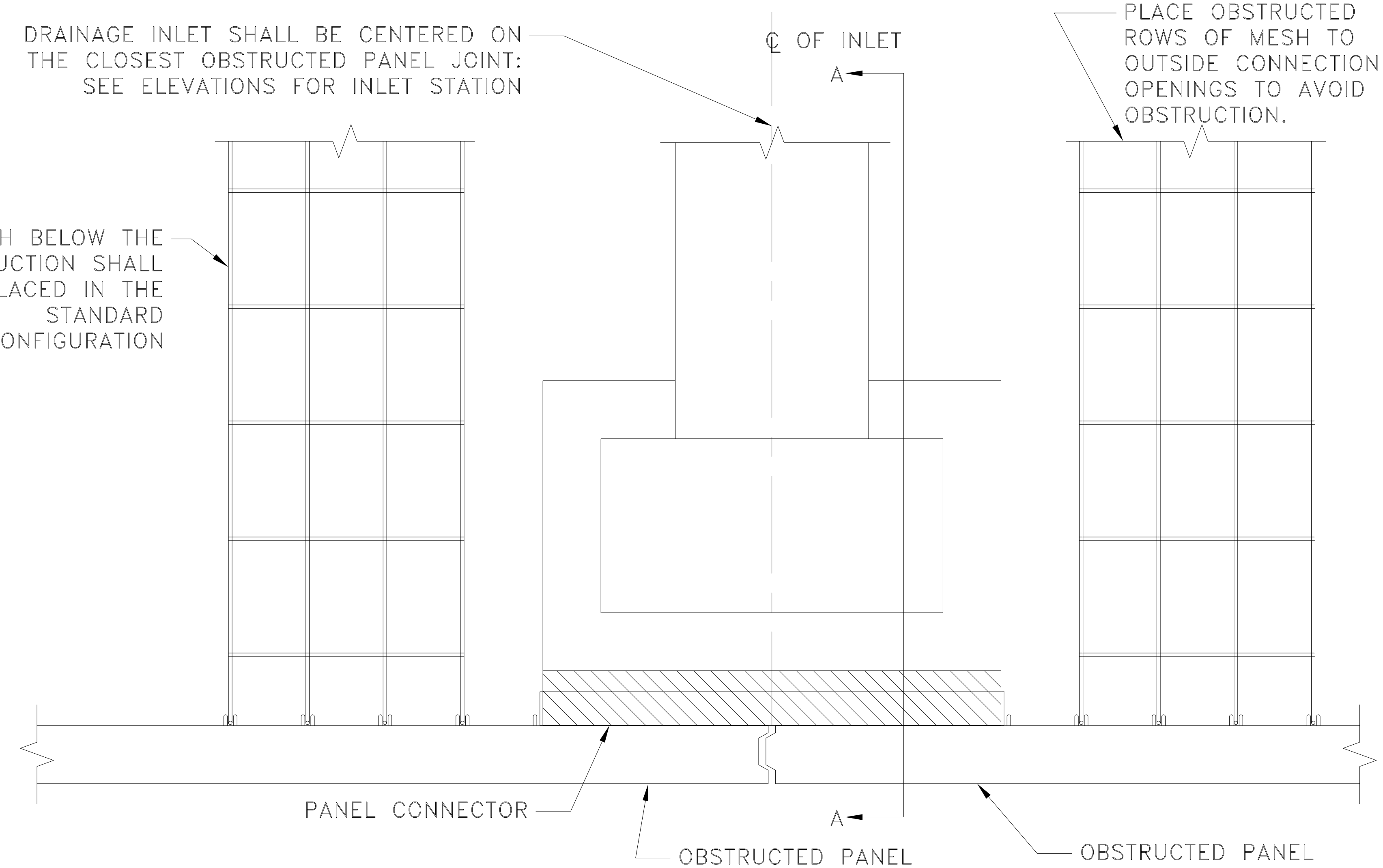
Figure 12 – Connection 6

1.3
Other Components

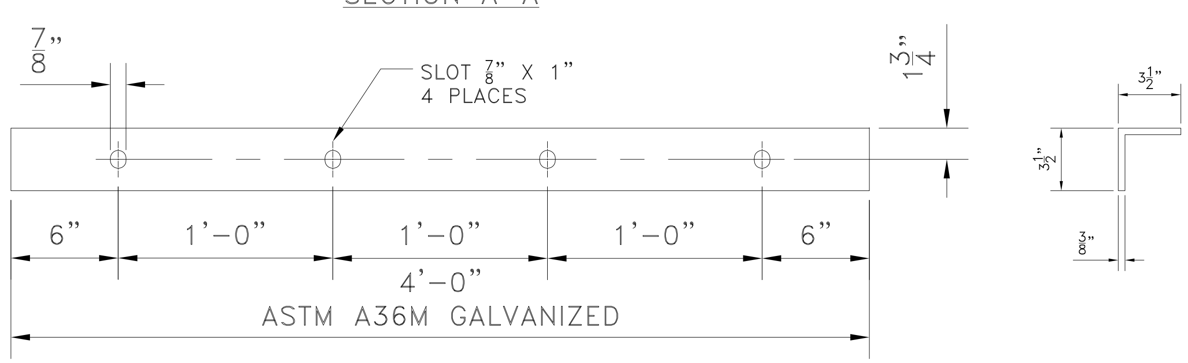
1.3.3 ERS Drainage



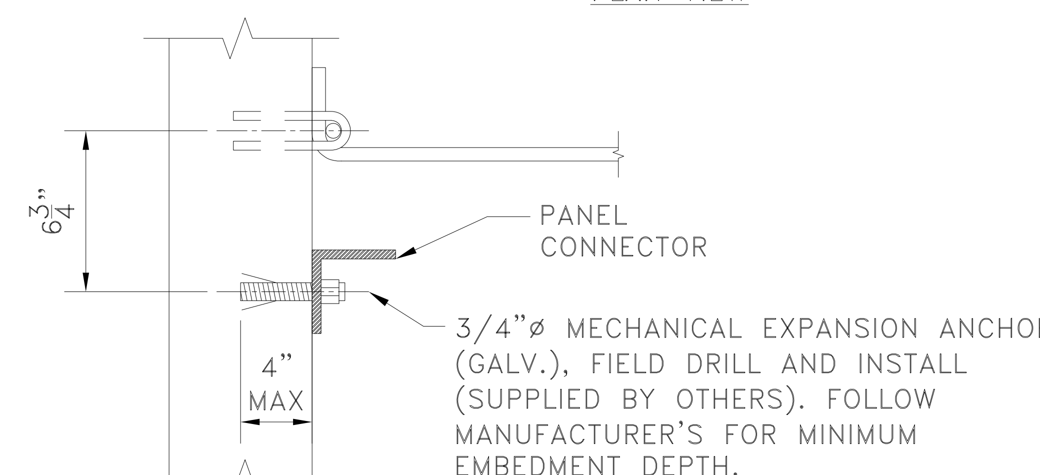
SECTION A–A



PLAN VIEW



PANEL CONNECTOR DETAIL



PANEL CONNECTOR INSTALLATION DETAIL

SOIL REINFORCEMENT INSTALLATION AT DRAINAGE INLET DETAILS

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SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

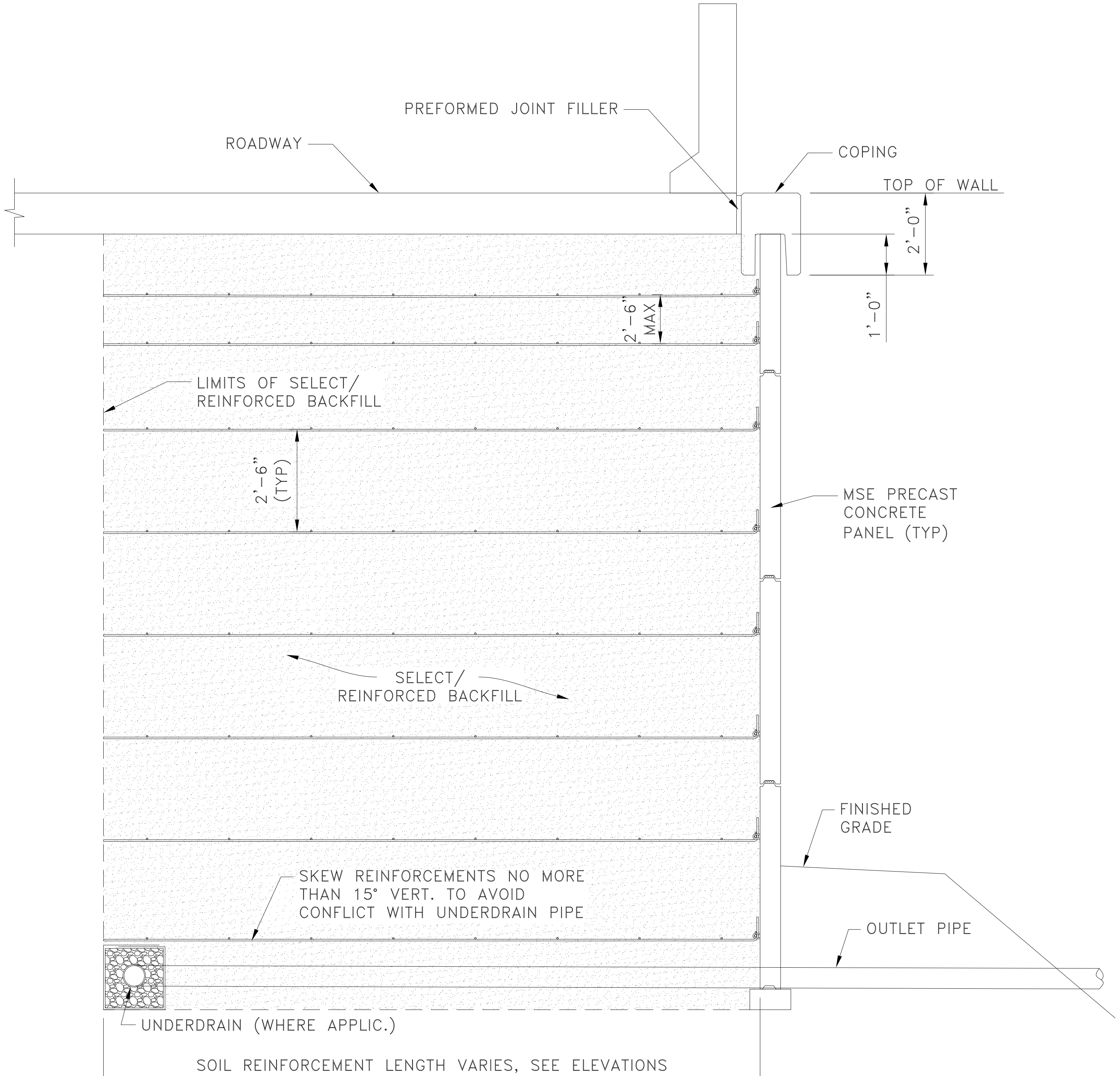
THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR:	FSH	NO.	DATE	REVISION DESCRIPTION	BY

SOIL REINFORCEMENT AT DRAINAGE INLET

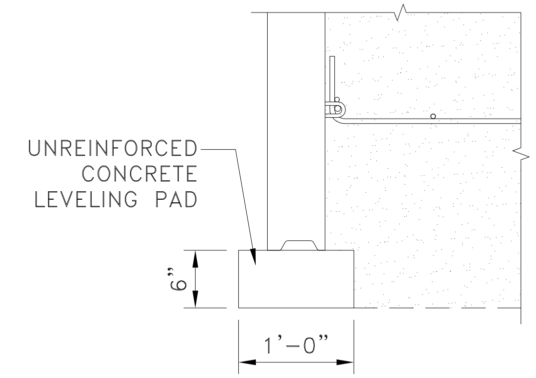
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of



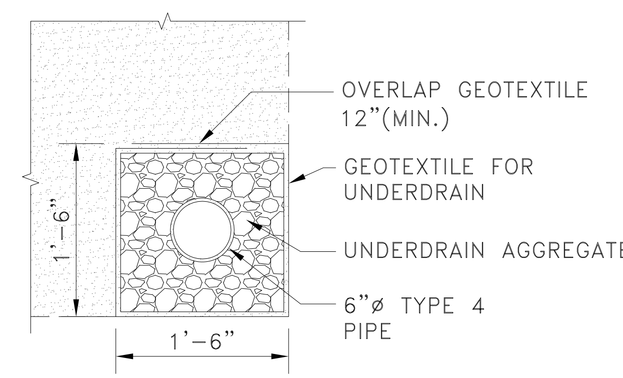
MSE WALL TYPICAL SECTION

SCALE: NTS



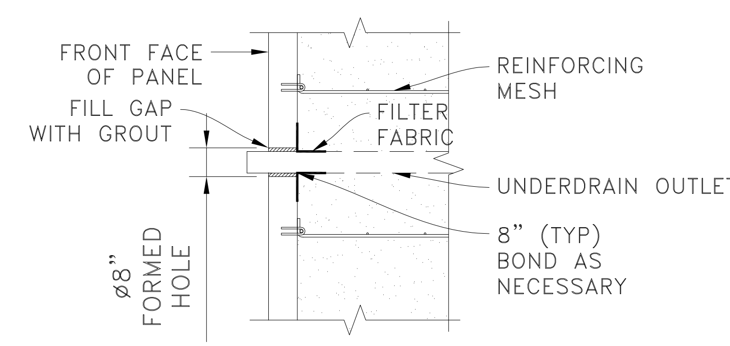
LEVELING PAD DETAIL

SCALE: NTS



UNDERDRAIN DETAIL

SCALE: NTS



UNDERDRAIN OUTLET THROUGH MSE PANEL DETAIL

SCALE: NTS

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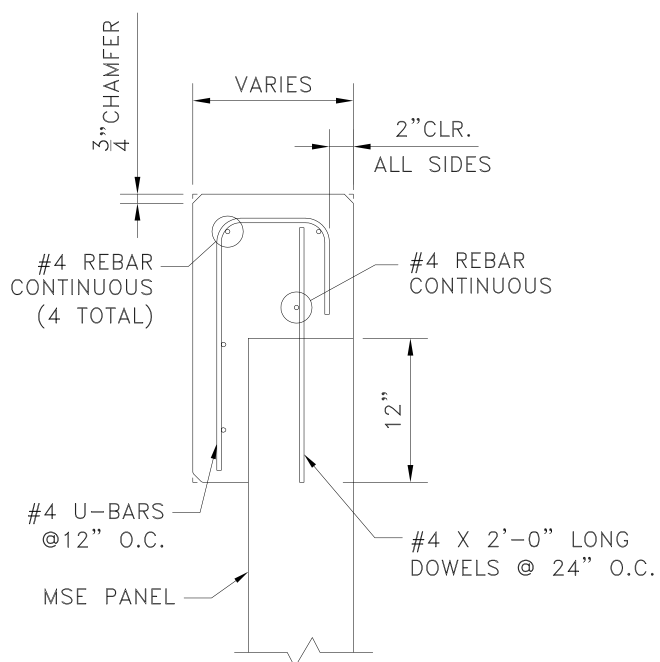
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

UNDERDRAIN DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

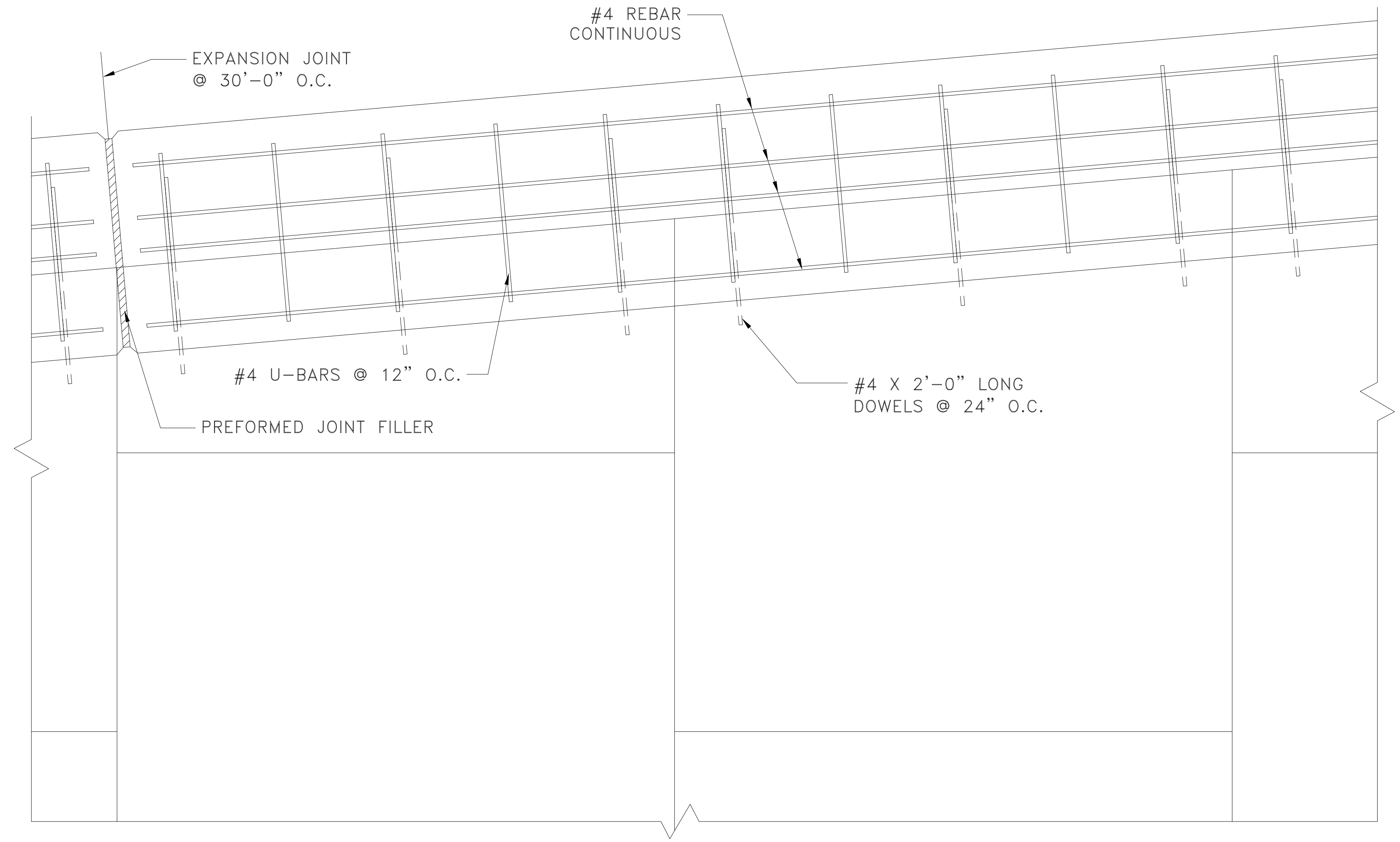
Scale: NTS
Job:
Sheet:
Sheet of

1.3.4 ERS Coping



NOTE:
EXPANSION JOINTS AT 30'-0" O.C.

CAST-IN-PLACE COPING
CROSS SECTION



CAST-IN-PLACE COPING DETAIL

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

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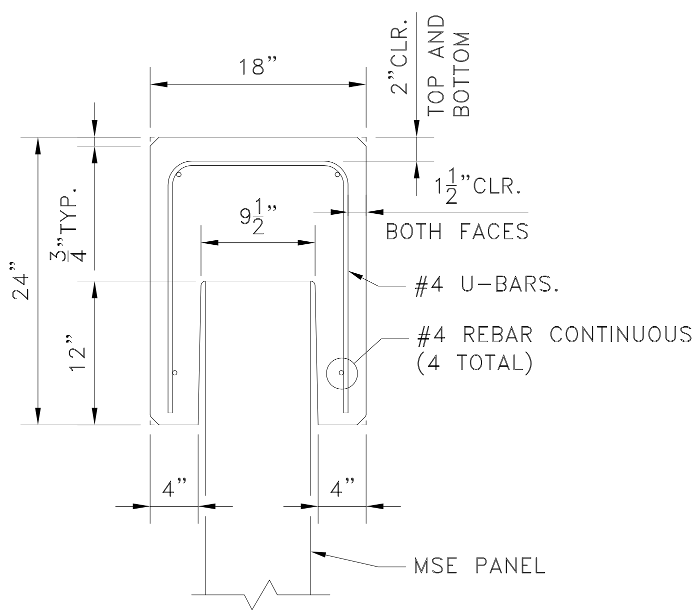
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

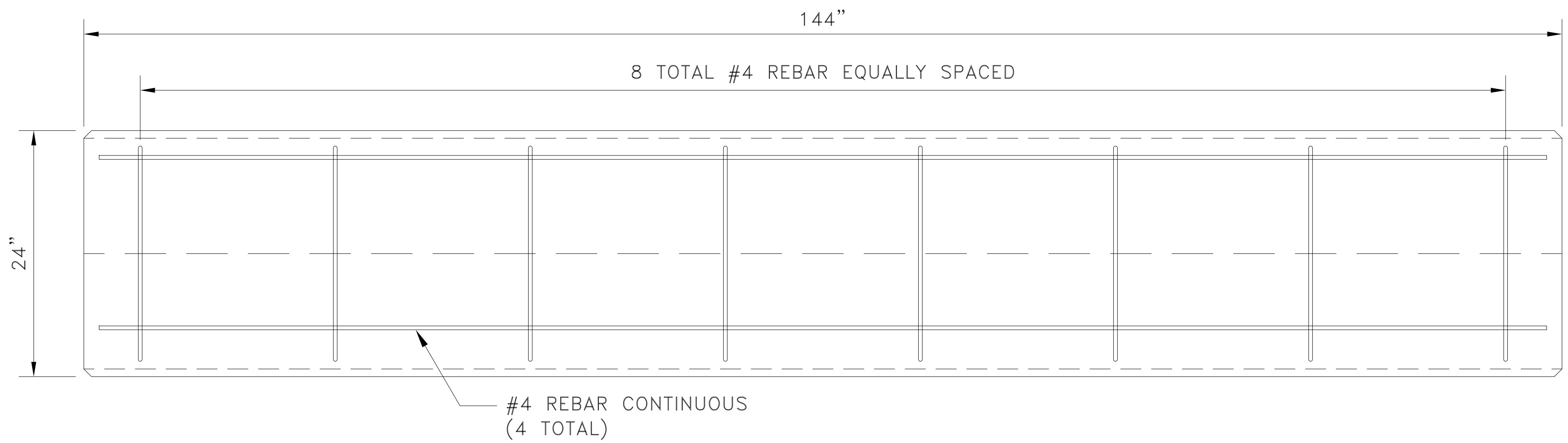
CAST-IN-PLACE COPING DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

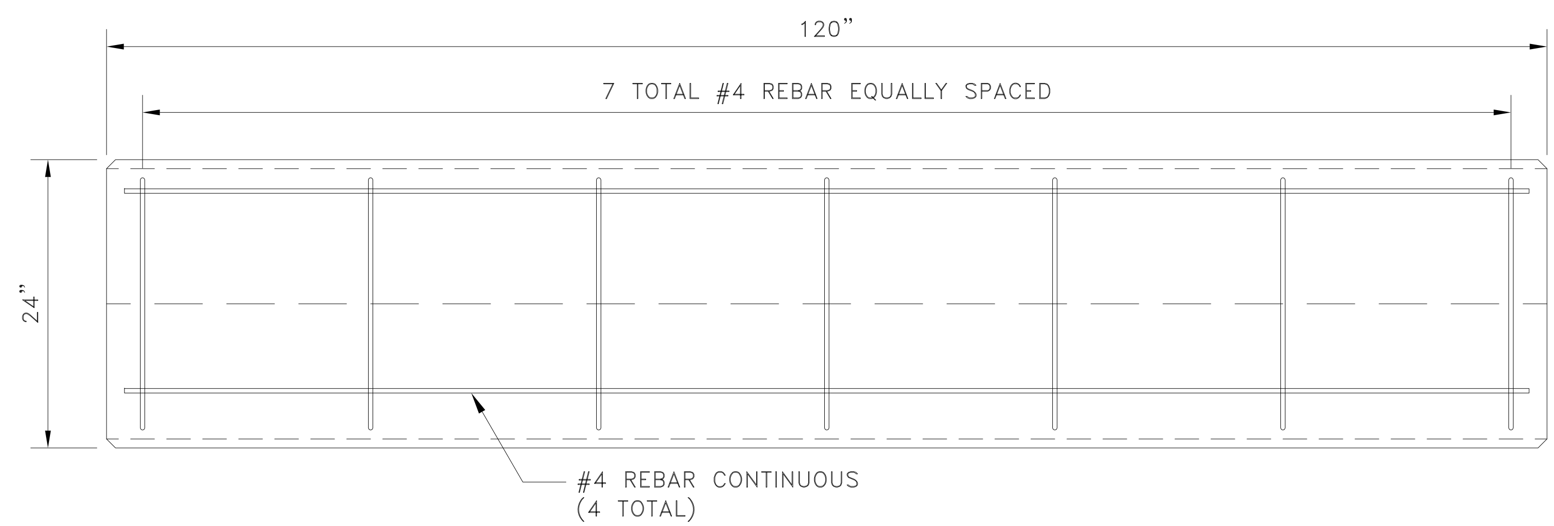
Scale: NTS
Job:
Sheet:
Sheet of



PRECAST COPING CROSS SECTION



12'-0" LONG COPING OPTION



10'-0" LONG COPING OPTION

PRECAST COPING DETAIL

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

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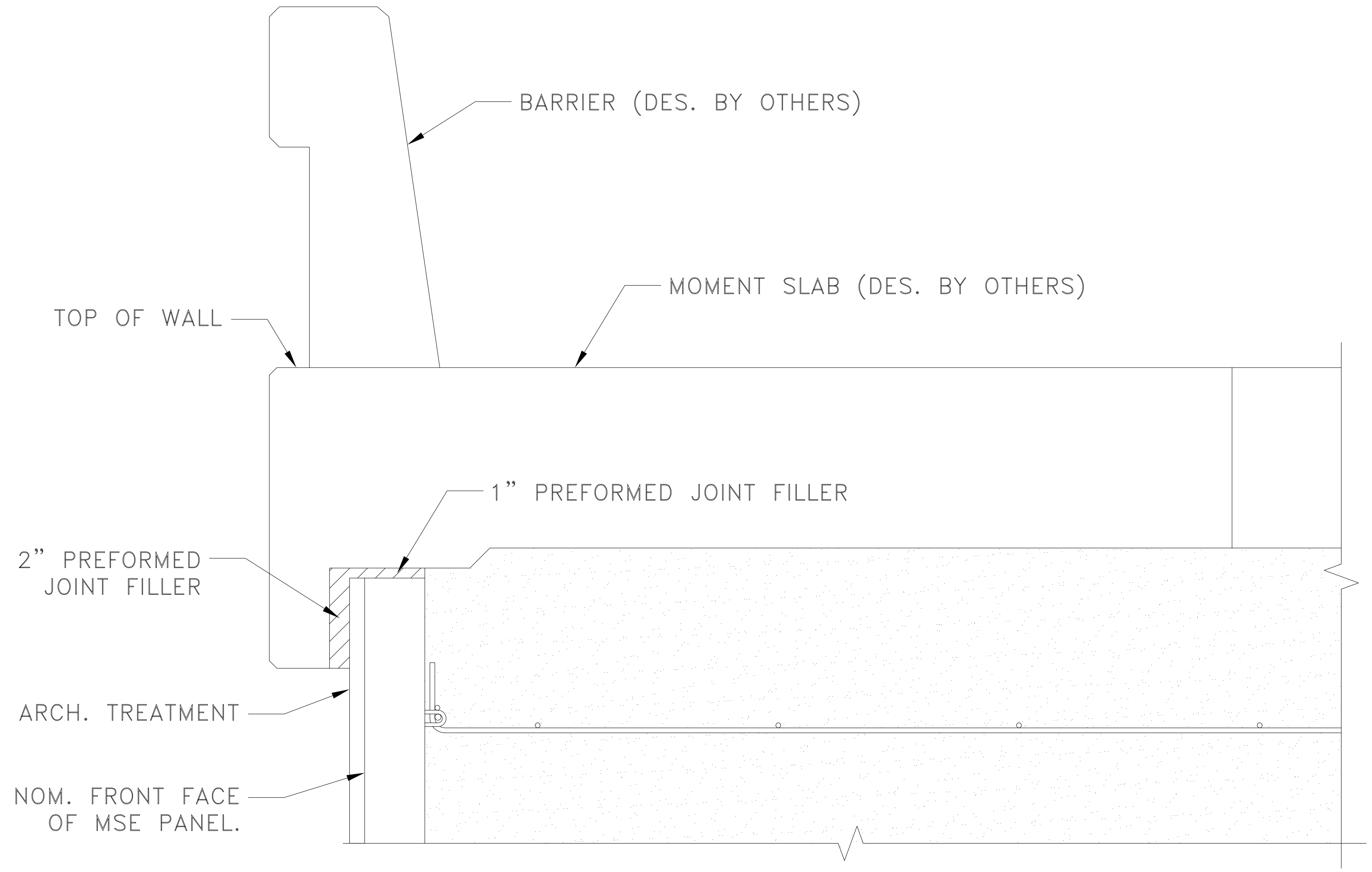
DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

PRECAST COPING DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

1.3.5 ERS Traffic Barrier



BARRIER WITH MOMENT SLAB DETAIL

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

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SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

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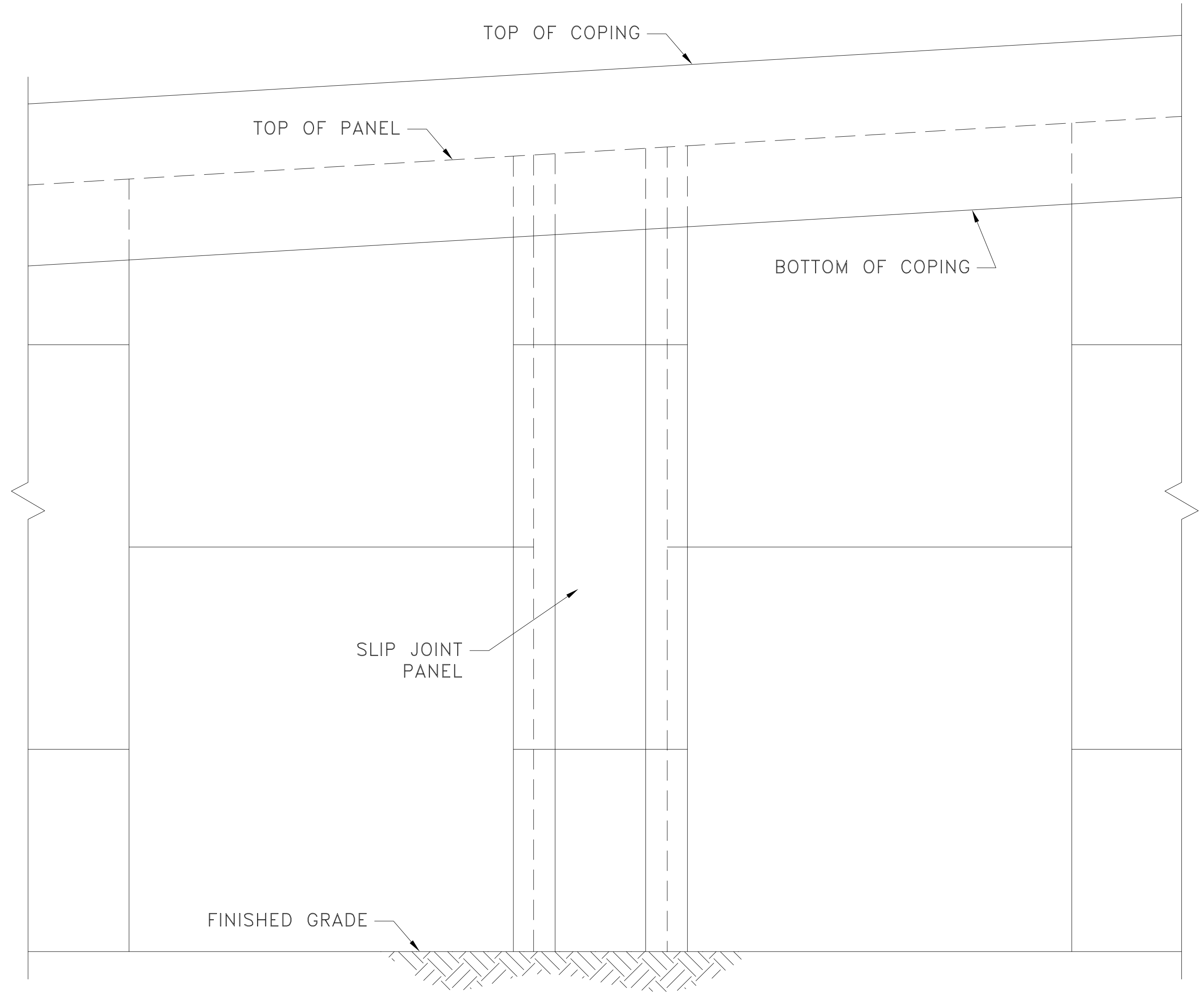
DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR:	FSH	NO.	DATE	REVISION DESCRIPTION	BY

BARRIER WITH MOMENT SLAB DETAIL

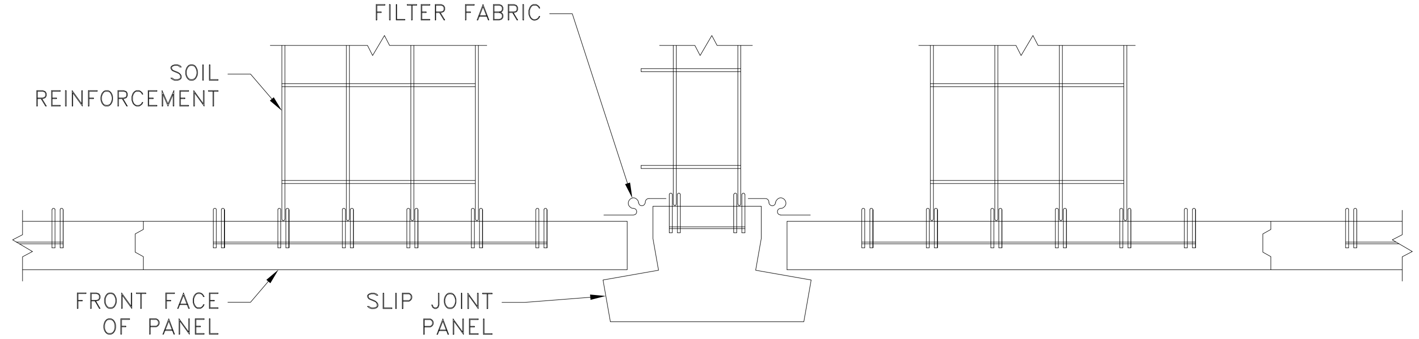
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

1.3.6 ERS Slip Joint Detail



ELEVATION VIEW



PLAN VIEW

MSE WALL SLIP JOINT PANEL DETAILS

CERTIFIED ONLY WITH RESPECT TO INTERNAL STABILITY OF REINFORCED EARTH STRUCTURES

SSL™
INNOVATIVE CONSTRUCTION PRODUCTS
4740 SCOTTS VALLEY DRIVE, SUITE E
SCOTTS VALLEY, CA 95066
PHONE: (831) 430-9300 FAX: (831) 430-9340

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE CONTRACTOR. ON THE BASIS OF THIS INFORMATION, SSL HAS DESIGNED THE STRUCTURE(S) SHOWN AND IS RESPONSIBLE FOR INTERNAL STABILITY ONLY. THE ENGINEER OF RECORD REMAINS RESPONSIBLE FOR EXTERNAL STABILITY INCLUDING FOUNDATION (BEARING CAPACITY AND SETTLEMENT) AND SLOPE STABILITY (SLIDING AND ROTATION).

DRAWN BY: WM	01/24/22
CHECK BY: FSH	01/24/22
DESIGN BY: FSH	01/24/22
CHECK BY: SR	01/24/22
PROJ. ENGR: FSH	

NO.	DATE	REVISION DESCRIPTION	BY

SLIP JOINT PANEL DETAIL

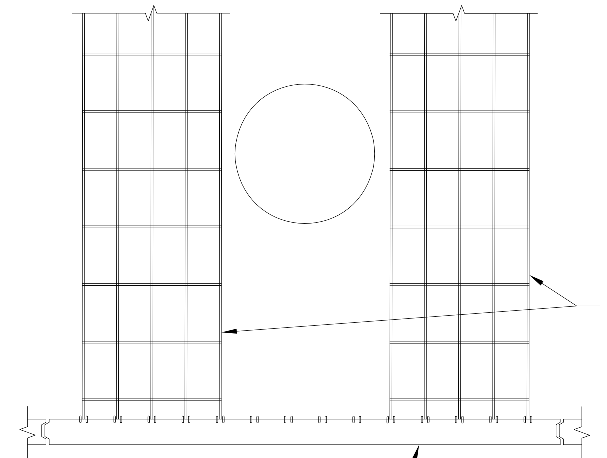
MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

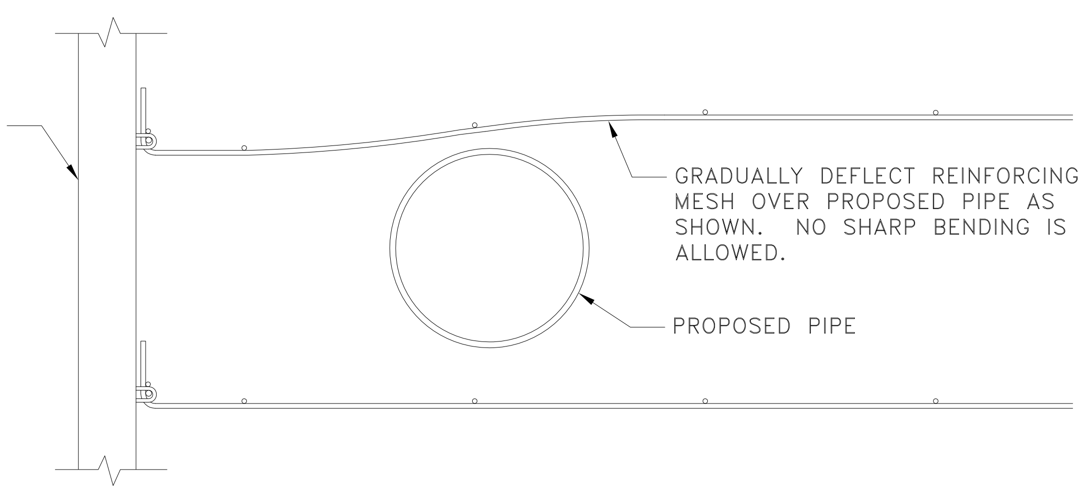
Section 2: ERS Design

2.1
Design Methodology

2.1.3 ERS Obstruction Design Detail



VERTICAL OBSTRUCTION SOIL REINFORCEMENT INSTALLATION DETAIL



HORIZONTAL OBSTRUCTION SOIL REINFORCEMENT SKEW DETAILS

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DRAWN BY: WM	01/24/22				
CHECK BY: FSH	01/24/22				
DESIGN BY: FSH	01/24/22				
CHECK BY: SR	01/24/22				
PROJ. ENGR: FSH		NO.	DATE	REVISION DESCRIPTION	BY

SOIL REINFORCEMENT SKEW DETAILS

MSE PLUS WALL SYSTEM
IDEA EVALUATION

Scale: NTS
Job:
Sheet:
Sheet of

2.2
Design Example

2.2.1 Design Problems

AASHTO 2017-2020
AASHTO LRFD 75 years

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title:	AASHTO LRFD 75 years
Project Number:	Problem 1 - Level Fill
Client:	
Designer:	FSH
Station Number:	

Description:

IDEA Evaluation, Strength 1

Company's information:

Name: SSL, LLC
Street: 4740 Scotts Valley Drive
Suite E
Scotts Valley, CA 95126
Telephone #: 831-430-9300
Fax #: 831-430-9340
E-Mail:

File path and name: C:\Users\fran\OneDrive - SSL\Documents\Technical submit.....
.....yrs H=30.0' LC1.BENp

Original date and time of creating this file: Wed Dec 14 13:52:17 2016

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL MATS/GRIDS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ 135.0 lb/ft ³

Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 120.0 lb/ft ³

Design value of internal angle of friction, ϕ 30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 120.0 lb/ft ³

Equivalent internal angle of friction, $\phi_{equiv.}$ 30.0 °

Equivalent cohesion, $c_{equiv.}$ 0.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)

Ka (external stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.

Bearing capacity factors (calculated by MSEW): Nc = 30.14 N γ= 22.40

SEISMICITY

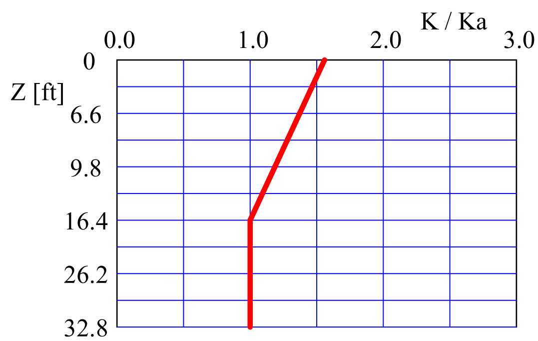
Not Applicable

INPUT DATA: Metal mats/grids
(Analysis)

D A T A	Metal mats type #1	Metal mats type #2	Metal mats type #3	Metal mats type #4	Metal mats type #5
Yield strength of steel, Fy [kips/in ²]	75.0	75.0	75.0	75.0	75.0
Gross width of grid, b [in]	24.0	32.0	40.0	24.0	24.0
Vertical spacing, Sv [ft]	Varies	Varies	Varies	Varies	Varies
Design cross section area, Ac [in ²]	0.32	0.40	0.48	0.63	0.32
Thickness of transverse element, t [in]	0.3	0.3	0.3	0.3	0.3
Distance between transverse bars, St [in]	18.0	30.0	36.0	30.0	12.0
Friction angle along reinforcement-soil interface,	ρ				
@ the top	34.00	34.00	34.00	34.00	34.00
@ 19.7 ft or below	34.00	34.00	34.00	34.00	34.00
Pullout resistance factor, F*					
@ the top	0.35	0.21	0.18	0.21	0.53
@ 19.7 ft or below	0.18	0.11	0.09	0.11	0.27
Scale-effect correction factor, α	1.00	1.00	1.00	1.00	1.00

Variation of Lateral Earth Pressure Coefficient With Depth (Coherent Mass)

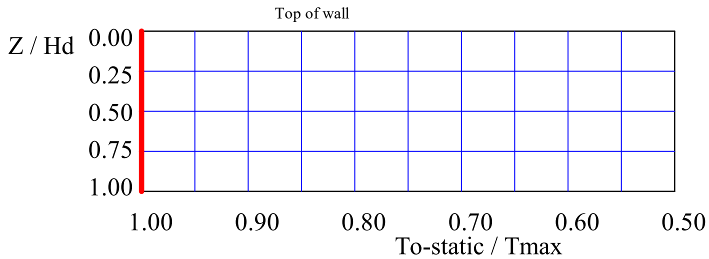
Z	K / Ka
0 ft	1.56
3.3 ft	1.47
6.6 ft	1.37
9.8 ft	1.28
13.1 ft	1.19
16.4 ft	1.09
19.7 ft	1.00



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
Average unit weight of panel is γ_f = 150.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	4W11x1.50..	5W11x2.50..	6W11x3.00..	4W20x2.50..	4W11x1.00..
Strength reduction at the connection, CRu = Fyc / Fy	0.98	0.98	0.98	0.98	0.98

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 30.00 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 30.00 ft }

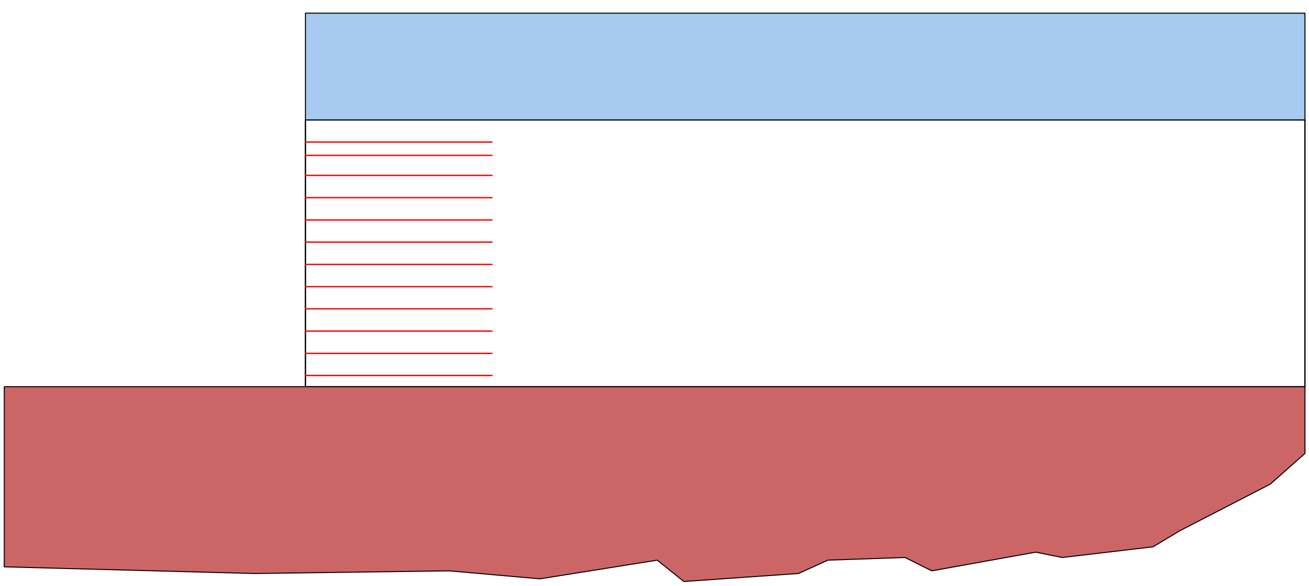
Soil in front of wall is Horizontal.

Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M   S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for Metal Mats pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV		Static		Combined Static/Seismic
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00
Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.90

ANALYSIS: CALCULATED FACTORS (Static conditions)

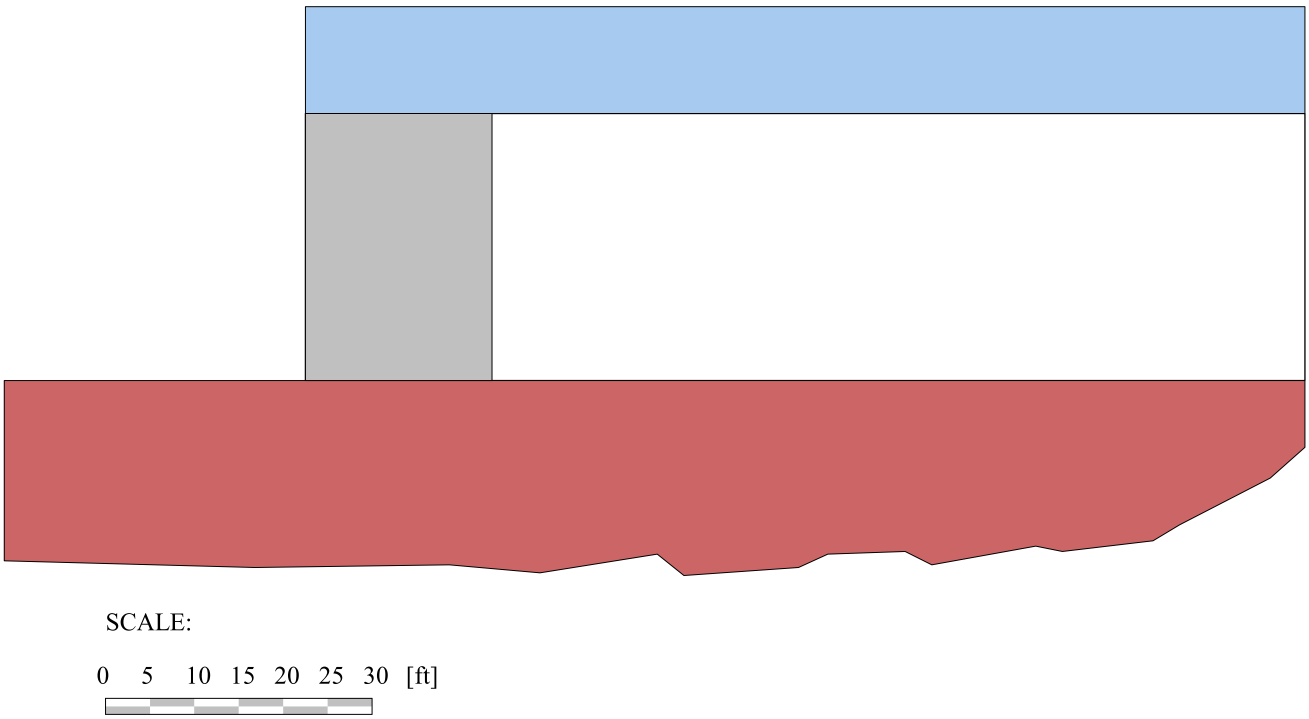
Bearing capacity, CDR = 1.71, factored bearing load = 7956 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.565, Eccentricity, e/L = 0.1879, CDR-overturning = 2.66

METAL MATS				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.25	21.00	4	1.15	1.17	1.172	1.139	1.896	0.1740	4W20x2.50W11
2	3.75	21.00	4	1.31	1.34	1.337	1.098	2.049	0.1479	4W20x2.50W11
3	6.25	21.00	3	1.13	1.15	1.153	1.445	2.228	0.1238	6W11x3.00W11
4	8.75	21.00	2	1.08	1.10	1.102	1.305	2.441	0.1019	5W11x2.50W11
5	11.25	21.00	2	1.21	1.24	1.236	1.223	2.700	0.0820	5W11x2.50W11
6	13.75	21.00	1	1.06	1.08	1.083	1.451	3.019	0.0643	4W11x1.50W11
7	16.25	21.00	1	1.18	1.20	1.203	1.423	3.425	0.0486	4W11x1.50W11
8	18.75	21.00	1	1.34	1.37	1.368	1.454	3.956	0.0350	4W11x1.50W11
9	21.25	21.00	1	1.58	1.61	1.610	1.450	4.683	0.0236	4W11x1.50W11
10	23.75	21.00	1	2.05	2.09	2.087	1.452	5.737	0.0142	4W11x1.50W11
11	26.00	21.00	1	3.31	3.37	3.375	1.605	7.193	0.0076	4W11x1.50W11
12	27.50	21.00	5	3.01	3.07	3.075	1.431	8.659	0.0041	4W11x1.00W11

BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	13618	N/A	[lb/ft ²]
Factored bearing load, σ_V	7955.7	N/A	[lb/ft ²]
Eccentricity, e	2.71	N/A	[ft]
Eccentricity, e/L	0.129	N/A	
CDR calculated	1.71	N/A	
Base length	21.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 90299.94 [lb/ft], L = 21.00, Unfactored e = 2.41 [ft], and Sigma = 5580.02 [lb/ft ²]



DIRECT SLIDING for GIVEN LAYOUT (for METAL MATS/GRIDS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.565

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	CDR Static	CDR Seismic	Metal Mats Type #	Product name
1	1.25	21.00	1.896	N/A	4	4W20x2.50W11
2	3.75	21.00	2.049	N/A	4	4W20x2.50W11
3	6.25	21.00	2.228	N/A	3	6W11x3.00W11
4	8.75	21.00	2.441	N/A	2	5W11x2.50W11
5	11.25	21.00	2.700	N/A	2	5W11x2.50W11
6	13.75	21.00	3.019	N/A	1	4W11x1.50W11
7	16.25	21.00	3.425	N/A	1	4W11x1.50W11
8	18.75	21.00	3.956	N/A	1	4W11x1.50W11
9	21.25	21.00	4.683	N/A	1	4W11x1.50W11
10	23.75	21.00	5.737	N/A	1	4W11x1.50W11
11	26.00	21.00	7.193	N/A	1	4W11x1.50W11
12	27.50	21.00	8.659	N/A	5	4W11x1.00W11

ECCENTRICITY for GIVEN LAYOUT (for Coherent Gravity Mass Method)

At interface with foundation: e/L static = 0.1879; Overturning: CDR-static = 2.66

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	e / L Static	e / L Seismic	Metal Mats Type #	Product name
1	1.25	21.00	0.1740	N/A	4	4W20x2.50W11
2	3.75	21.00	0.1479	N/A	4	4W20x2.50W11
3	6.25	21.00	0.1238	N/A	3	6W11x3.00W11
4	8.75	21.00	0.1019	N/A	2	5W11x2.50W11
5	11.25	21.00	0.0820	N/A	2	5W11x2.50W11
6	13.75	21.00	0.0643	N/A	1	4W11x1.50W11
7	16.25	21.00	0.0486	N/A	1	4W11x1.50W11
8	18.75	21.00	0.0350	N/A	1	4W11x1.50W11
9	21.25	21.00	0.0236	N/A	1	4W11x1.50W11
10	23.75	21.00	0.0142	N/A	1	4W11x1.50W11
11	26.00	21.00	0.0076	N/A	1	4W11x1.50W11
12	27.50	21.00	0.0041	N/A	5	4W11x1.00W11

RESULTS for STRENGTH [Note: Actual CDR = (Yield stress) / (Actual stress)] For Coherent Mass Method, Option A
Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	LTDS = Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	1.25	0.400	5.000	6171.8	5265.7	N/A	N/A	1.172	N/A	N/A
2	3.75	0.400	5.000	6171.8	4617.4	N/A	N/A	1.337	N/A	N/A
3	6.25	0.667	5.000	4660.5	4042.0	N/A	N/A	1.153	N/A	N/A
4	8.75	0.533	5.000	3883.4	3524.4	N/A	N/A	1.102	N/A	N/A
5	11.25	0.533	5.000	3883.4	3142.5	N/A	N/A	1.236	N/A	N/A
6	13.75	0.400	5.000	3107.3	2869.1	N/A	N/A	1.083	N/A	N/A
7	16.25	0.400	5.000	3107.3	2583.8	N/A	N/A	1.203	N/A	N/A
8	18.75	0.400	5.000	3107.3	2271.1	N/A	N/A	1.368	N/A	N/A
9	21.25	0.400	5.000	3107.3	1929.7	N/A	N/A	1.610	N/A	N/A
10	23.75	0.400	5.000	3107.3	1489.0	N/A	N/A	2.087	N/A	N/A
11	26.00	0.400	5.000	3107.3	920.7	N/A	N/A	3.375	N/A	N/A
12	27.50	0.400	5.000	3107.3	1010.5	N/A	N/A	3.075	N/A	N/A

RESULTS for PULLOUT
Live Load included in calculating Tmax
NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Metal Mats Elevation [ft]	Coverage Ratio Rc=b/Sh	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le (see NOTE)	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified seismic CDR	Actual seismic CDR
1	1.25	0.400	5265.7	N/A	20.25	0.75	5998.4	N/A	1.139	N/A	N/A	N/A
2	3.75	0.400	4617.4	N/A	18.75	2.25	5071.1	N/A	1.098	N/A	N/A	N/A
3	6.25	0.667	4042.0	N/A	17.25	3.75	5840.5	N/A	1.445	N/A	N/A	N/A
4	8.75	0.533	3524.4	N/A	15.75	5.25	4597.8	N/A	1.305	N/A	N/A	N/A
5	11.25	0.533	3142.5	N/A	14.25	6.75	3842.3	N/A	1.223	N/A	N/A	N/A
6	13.75	0.400	2869.1	N/A	12.75	8.25	4163.4	N/A	1.451	N/A	N/A	N/A
7	16.25	0.400	2583.8	N/A	12.00	9.00	3675.7	N/A	1.423	N/A	N/A	N/A
8	18.75	0.400	2271.1	N/A	12.00	9.00	3302.1	N/A	1.454	N/A	N/A	N/A
9	21.25	0.400	1929.7	N/A	12.00	9.00	2797.6	N/A	1.450	N/A	N/A	N/A
10	23.75	0.400	1489.0	N/A	12.00	9.00	2162.0	N/A	1.452	N/A	N/A	N/A
11	26.00	0.400	920.7	N/A	12.00	9.00	1478.0	N/A	1.605	N/A	N/A	N/A
12	27.50	0.400	1010.5	N/A	12.00	9.00	1446.2	N/A	1.431	N/A	N/A	N/A

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break		CDR Metal Mats strength		Product name
								Specified	Actual	Specified	Actual	
1	1.25	0.400	5.000	5266	0.98	6048	6172	N/A	1.15	N/A	1.17	4W20x2.50W11
2	3.75	0.400	5.000	4617	0.98	6048	6172	N/A	1.31	N/A	1.34	4W20x2.50W11
3	6.25	0.667	5.000	4042	0.98	4567	4661	N/A	1.13	N/A	1.15	6W11x3.00W11
4	8.75	0.533	5.000	3524	0.98	3806	3883	N/A	1.08	N/A	1.10	5W11x2.50W11
5	11.25	0.533	5.000	3142	0.98	3806	3883	N/A	1.21	N/A	1.24	5W11x2.50W11
6	13.75	0.400	5.000	2869	0.98	3045	3107	N/A	1.06	N/A	1.08	4W11x1.50W11
7	16.25	0.400	5.000	2584	0.98	3045	3107	N/A	1.18	N/A	1.20	4W11x1.50W11
8	18.75	0.400	5.000	2271	0.98	3045	3107	N/A	1.34	N/A	1.37	4W11x1.50W11
9	21.25	0.400	5.000	1930	0.98	3045	3107	N/A	1.58	N/A	1.61	4W11x1.50W11
10	23.75	0.400	5.000	1489	0.98	3045	3107	N/A	2.05	N/A	2.09	4W11x1.50W11
11	26.00	0.400	5.000	921	0.98	3045	3107	N/A	3.31	N/A	3.37	4W11x1.50W11
12	27.50	0.400	5.000	1011	0.98	3045	3107	N/A	3.01	N/A	3.07	4W11x1.00W11

AASHTO 2017-2020
AASHTO LRFD 75 years

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title: AASHTO LRFD 75 years
Project Number: Problem 2 - Sloping Fill
Client:
Designer: FSH
Station Number:

Description:

IDEA Evaluation, Strength 1

Company's information:

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E-Mail:

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.....yrs H=30.0' LC2.BENp

Original date and time of creating this file: Wed Dec 14 13:52:17 2016

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL MATS/GRIDS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	30.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	0.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.5365 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 30.14 N γ= 22.40

SEISMICITY

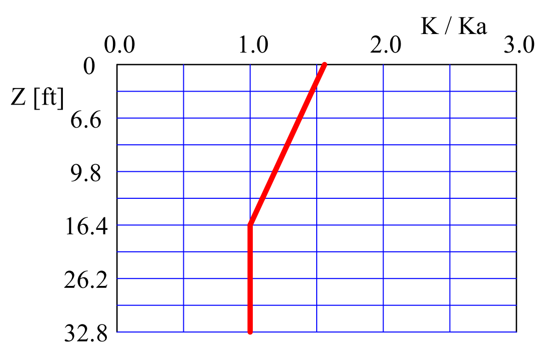
Not Applicable

INPUT DATA: Metal mats/grids (Analysis)

D A T A	Metal mats type #1	Metal mats type #2	Metal mats type #3	Metal mats type #4	Metal mats type #5
Yield strength of steel, Fy [kips/in ²]	75.0	75.0	75.0	75.0	75.0
Gross width of grid, b [in]	24.0	32.0	40.0	24.0	24.0
Vertical spacing, Sv [ft]	Varies	Varies	Varies	Varies	Varies
Design cross section area, Ac [in ²]	0.32	0.40	0.48	0.63	0.32
Thickness of transverse element, t [in]	0.3	0.3	0.3	0.3	0.3
Distance between transverse bars, St [in]	18.0	30.0	36.0	30.0	12.0
Friction angle along reinforcement-soil interface,	ρ				
@ the top	34.00	34.00	34.00	34.00	34.00
@ 19.7 ft or below	34.00	34.00	34.00	34.00	34.00
Pullout resistance factor, F*					
@ the top	0.35	0.21	0.18	0.21	0.53
@ 19.7 ft or below	0.18	0.11	0.09	0.11	0.27
Scale-effect correction factor, α	1.00	1.00	1.00	1.00	1.00

Variation of Lateral Earth Pressure Coefficient With Depth (Coherent Mass)

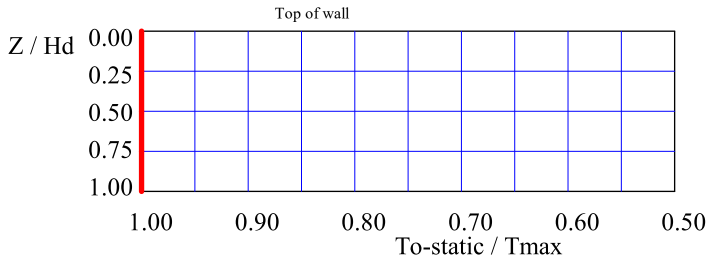
Z	K / Ka
0 ft	1.56
3.3 ft	1.47
6.6 ft	1.37
9.8 ft	1.28
13.1 ft	1.19
16.4 ft	1.09
19.7 ft	1.00



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
Average unit weight of panel is γ_f = 150.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	4W11x1.50..	5W11x2.50..	6W11x3.00..	4W20x2.50..	4W11x1.00..
Strength reduction at the connection, CRu = Fyc / Fy	0.98	0.98	0.98	0.98	0.98

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

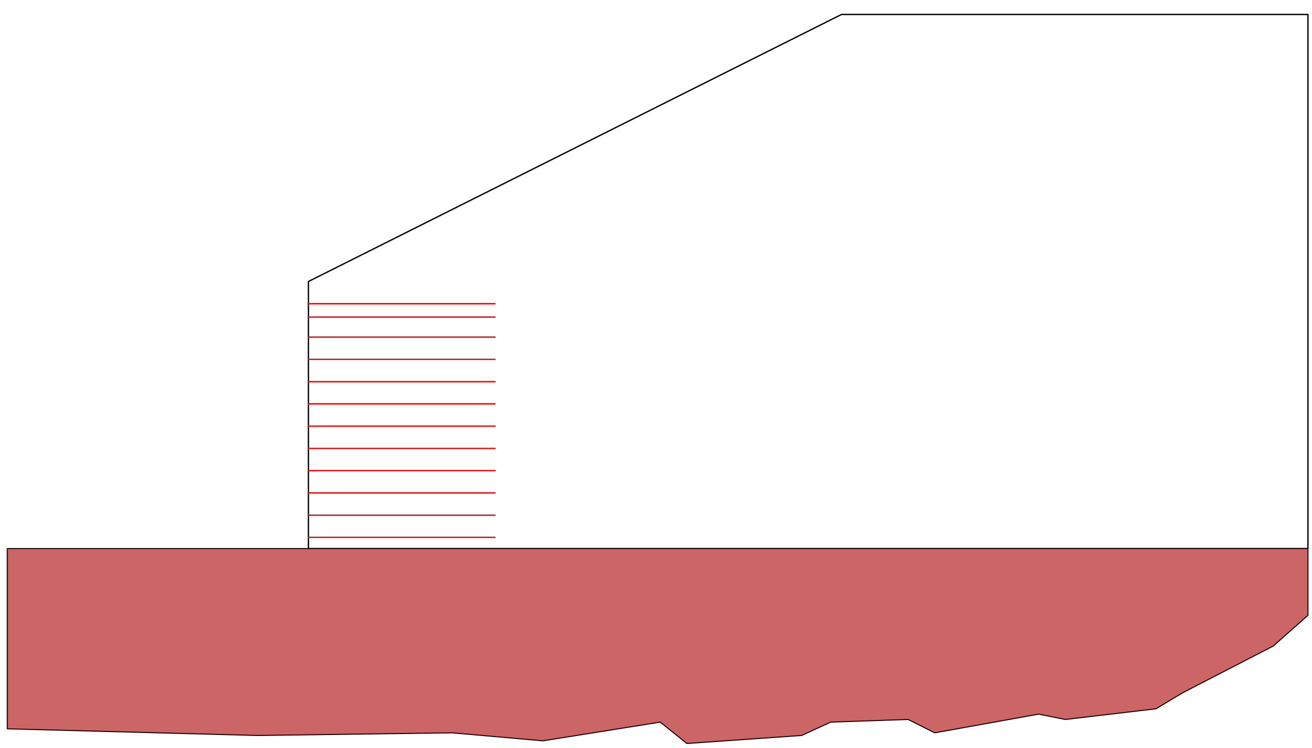
Design height, Hd 30.00 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 30.00 ft }

Soil in front of wall is Horizontal.

Batter, ω	0.0	[deg]	
Backslope, β	26.6	[deg]	
Backslope rise	30.0	[ft]	Broken back equivalent angle, I = 26.56° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ^{2}]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for Metal Mats pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV		Static		Combined Static/Seismic
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00
Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.90

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 1.15, factored bearing load = 11382 lb/ft².

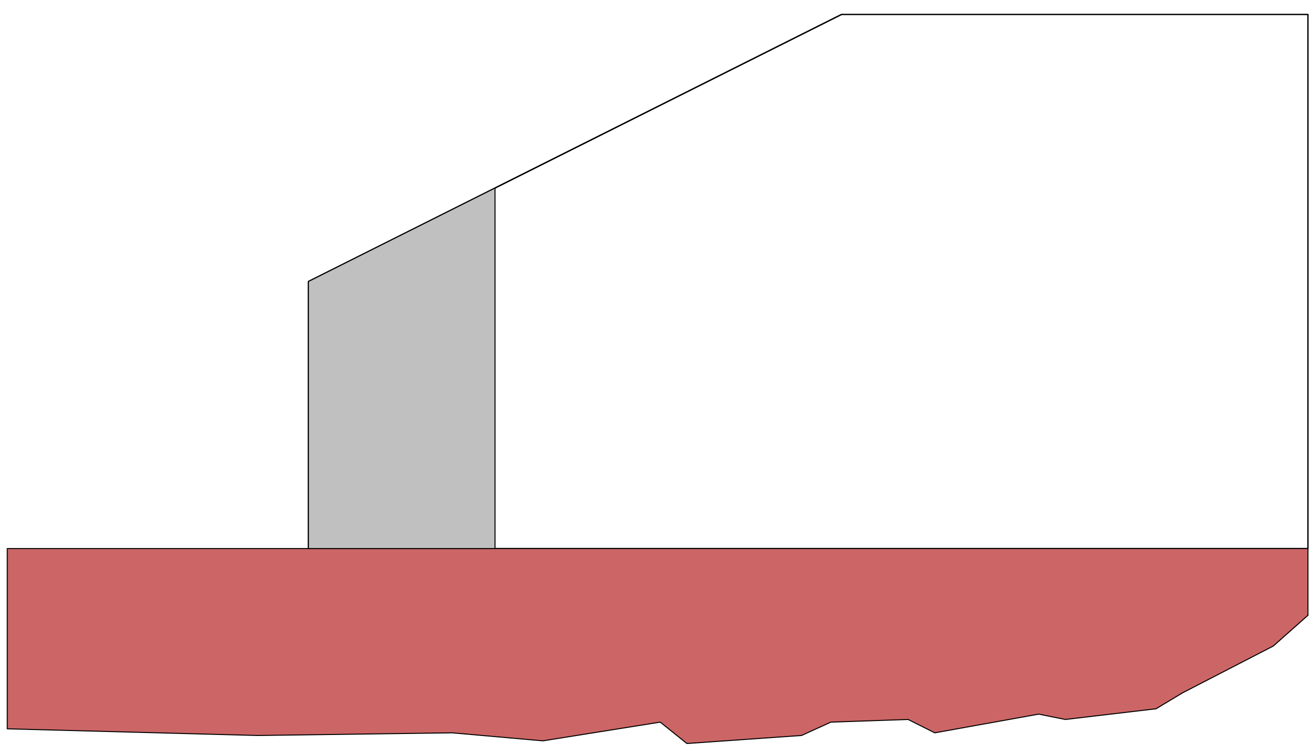
Foundation Interface: Direct sliding, CDR = 1.103, Eccentricity, e/L = 0.1873, CDR-overturning = 1.93

METAL MATS #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.25	21.00	4	1.02	1.04	1.039	1.201	1.314	0.1723	4W20x2.50W11
2	3.75	21.00	4	1.17	1.19	1.194	1.198	1.370	0.1432	4W20x2.50W11
3	6.25	21.00	3	1.02	1.04	1.037	1.637	1.432	0.1153	6W11x3.00W11
4	8.75	21.00	3	1.17	1.19	1.194	1.600	1.501	0.0885	6W11x3.00W11
5	11.25	21.00	2	1.13	1.15	1.152	1.562	1.579	0.0629	5W11x2.50W11
6	13.75	21.00	1	1.05	1.08	1.075	2.088	1.668	0.0382	4W11x1.50W11
7	16.25	21.00	1	1.21	1.24	1.236	2.137	1.768	0.0142	4W11x1.50W11
8	18.75	21.00	1	1.37	1.40	1.397	2.193	1.882	-0.0094	4W11x1.50W11
9	21.25	21.00	1	1.58	1.61	1.608	2.390	2.010	-0.0334	4W11x1.50W11
10	23.75	21.00	1	1.98	2.02	2.017	2.756	2.152	-0.0592	4W11x1.50W11
11	26.00	21.00	1	3.05	3.12	3.116	3.824	2.286	-0.0865	4W11x1.50W11
12	27.50	21.00	1	2.39	2.44	2.437	2.725	2.368	-0.1092	4W11x1.50W11

BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	13073	N/A	[lb/ft ²]
Factored bearing load, σ_V	11382.2	N/A	[lb/ft ²]
Eccentricity, e	3.02	N/A	[ft]
Eccentricity, e/L	0.144	N/A	
CDR calculated	1.15	N/A	
Base length	21.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 123535.85 [lb/ft], L = 21.00, Unfactored e = 2.73 [ft], and Sigma = 7951.69 [lb/ft ²]



SCALE:

0 5 10 15 20 25 30 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL MATS/GRIDS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.103

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	CDR Static	CDR Seismic	Metal Mats Type #	Product name
1	1.25	21.00	1.314	N/A	4	4W20x2.50W11
2	3.75	21.00	1.370	N/A	4	4W20x2.50W11
3	6.25	21.00	1.432	N/A	3	6W11x3.00W11
4	8.75	21.00	1.501	N/A	3	6W11x3.00W11
5	11.25	21.00	1.579	N/A	2	5W11x2.50W11
6	13.75	21.00	1.668	N/A	1	4W11x1.50W11
7	16.25	21.00	1.768	N/A	1	4W11x1.50W11
8	18.75	21.00	1.882	N/A	1	4W11x1.50W11
9	21.25	21.00	2.010	N/A	1	4W11x1.50W11
10	23.75	21.00	2.152	N/A	1	4W11x1.50W11
11	26.00	21.00	2.286	N/A	1	4W11x1.50W11
12	27.50	21.00	2.368	N/A	1	4W11x1.50W11

ECCENTRICITY for GIVEN LAYOUT (for Coherent Gravity Mass Method)

At interface with foundation: e/L static = 0.1873; Overturning: CDR-static = 1.93

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	e / L Static	e / L Seismic	Metal Mats Type #	Product name
1	1.25	21.00	0.1723	N/A	4	4W20x2.50W11
2	3.75	21.00	0.1432	N/A	4	4W20x2.50W11
3	6.25	21.00	0.1153	N/A	3	6W11x3.00W11
4	8.75	21.00	0.0885	N/A	3	6W11x3.00W11
5	11.25	21.00	0.0629	N/A	2	5W11x2.50W11
6	13.75	21.00	0.0382	N/A	1	4W11x1.50W11
7	16.25	21.00	0.0142	N/A	1	4W11x1.50W11
8	18.75	21.00	-0.0094	N/A	1	4W11x1.50W11
9	21.25	21.00	-0.0334	N/A	1	4W11x1.50W11
10	23.75	21.00	-0.0592	N/A	1	4W11x1.50W11
11	26.00	21.00	-0.0865	N/A	1	4W11x1.50W11
12	27.50	21.00	-0.1092	N/A	1	4W11x1.50W11

RESULTS for STRENGTH [Note: Actual CDR = (Yield stress) / (Actual stress)] For Coherent Mass Method, Option A
Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	LTDS = Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	1.25	0.400	5.000	6171.8	5940.7	N/A	N/A	1.039	N/A	N/A
2	3.75	0.400	5.000	6171.8	5168.7	N/A	N/A	1.194	N/A	N/A
3	6.25	0.667	5.000	4660.5	4495.9	N/A	N/A	1.037	N/A	N/A
4	8.75	0.667	5.000	4660.5	3901.7	N/A	N/A	1.194	N/A	N/A
5	11.25	0.533	5.000	3883.4	3370.5	N/A	N/A	1.152	N/A	N/A
6	13.75	0.400	5.000	3107.3	2890.4	N/A	N/A	1.075	N/A	N/A
7	16.25	0.400	5.000	3107.3	2513.3	N/A	N/A	1.236	N/A	N/A
8	18.75	0.400	5.000	3107.3	2224.2	N/A	N/A	1.397	N/A	N/A
9	21.25	0.400	5.000	3107.3	1932.2	N/A	N/A	1.608	N/A	N/A
10	23.75	0.400	5.000	3107.3	1540.4	N/A	N/A	2.017	N/A	N/A
11	26.00	0.400	5.000	3107.3	997.3	N/A	N/A	3.116	N/A	N/A
12	27.50	0.400	5.000	3107.3	1275.2	N/A	N/A	2.437	N/A	N/A

RESULTS for PULLOUT
Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage Ratio Rc=b/Sh	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified seismic CDR	Actual seismic CDR
1	1.25	0.400	5940.7	N/A	20.25	0.75	7132.6	N/A	1.201	N/A	N/A	N/A
2	3.75	0.400	5168.7	N/A	18.75	2.25	6193.8	N/A	1.198	N/A	N/A	N/A
3	6.25	0.667	4495.9	N/A	17.25	3.75	7361.8	N/A	1.637	N/A	N/A	N/A
4	8.75	0.667	3901.7	N/A	15.75	5.25	6244.5	N/A	1.600	N/A	N/A	N/A
5	11.25	0.533	3370.5	N/A	14.25	6.75	5263.2	N/A	1.562	N/A	N/A	N/A
6	13.75	0.400	2890.4	N/A	12.75	8.25	6035.8	N/A	2.088	N/A	N/A	N/A
7	16.25	0.400	2513.3	N/A	11.25	9.75	5371.3	N/A	2.137	N/A	N/A	N/A
8	18.75	0.400	2224.2	N/A	10.41	10.59	4876.6	N/A	2.193	N/A	N/A	N/A
9	21.25	0.400	1932.2	N/A	10.41	10.59	4618.2	N/A	2.390	N/A	N/A	N/A
10	23.75	0.400	1540.4	N/A	10.41	10.59	4246.1	N/A	2.756	N/A	N/A	N/A
11	26.00	0.400	997.3	N/A	10.41	10.59	3814.0	N/A	3.824	N/A	N/A	N/A
12	27.50	0.400	1275.2	N/A	10.41	10.59	3474.8	N/A	2.725	N/A	N/A	N/A

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal Mats strength Specified	CDR Metal Mats strength Actual	Product name
1	1.25	0.400	5.000	5941	0.98	6048	6172	N/A	1.02	N/A	1.04	4W20x2.50W11
2	3.75	0.400	5.000	5169	0.98	6048	6172	N/A	1.17	N/A	1.19	4W20x2.50W11
3	6.25	0.667	5.000	4496	0.98	4567	4661	N/A	1.02	N/A	1.04	6W11x3.00W11
4	8.75	0.667	5.000	3902	0.98	4567	4661	N/A	1.17	N/A	1.19	6W11x3.00W11
5	11.25	0.533	5.000	3371	0.98	3806	3883	N/A	1.13	N/A	1.15	5W11x2.50W11
6	13.75	0.400	5.000	2890	0.98	3045	3107	N/A	1.05	N/A	1.08	4W11x1.50W11
7	16.25	0.400	5.000	2513	0.98	3045	3107	N/A	1.21	N/A	1.24	4W11x1.50W11
8	18.75	0.400	5.000	2224	0.98	3045	3107	N/A	1.37	N/A	1.40	4W11x1.50W11
9	21.25	0.400	5.000	1932	0.98	3045	3107	N/A	1.58	N/A	1.61	4W11x1.50W11
10	23.75	0.400	5.000	1540	0.98	3045	3107	N/A	1.98	N/A	2.02	4W11x1.50W11
11	26.00	0.400	5.000	997	0.98	3045	3107	N/A	3.05	N/A	3.12	4W11x1.50W11
12	27.50	0.400	5.000	1275	0.98	3045	3107	N/A	2.39	N/A	2.44	4W11x1.50W11

AASHTO 2017-2020
AASHTO LRFD 75 years

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title:	AASHTO LRFD 75 years
Project Number:	Abutment on Piles
Client:	
Designer:	FSH
Station Number:	

Description:

Strength 1

Company's information:

Name: SSL, LLC
Street: 4740 Scotts Valley Drive
Suite E
Scotts Valley, CA 95126
Telephone #: 831-430-9300
Fax #: 831-430-9340
E-Mail:

File path and name: C:\Users\fran\OneDrive - SSL\Documents\Technical submit.....
.....utment on piles.BENp

Original date and time of creating this file: Wed Dec 14 13:52:17 2016

PROGRAM MODE: ANALYSIS
of a BRIDGE ABUTMENT
using METAL MATS/GRIDS as reinforcing material.

SOIL DATA

Soil above reinforcement has the following properties:

Unit weight, γ		120.0 lb/ft ³
Design value of internal angle of friction,	ϕ	30.0 °

REINFORCED SOIL

Unit weight, γ		135.0 lb/ft ³
Design value of internal angle of friction,	ϕ	34.0 °

RETAINED SOIL

Unit weight, γ		120.0 lb/ft ³
Design value of internal angle of friction,	ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$		120.0 lb/ft ³
Equivalent internal angle of friction,	$\phi_{\text{equiv.}}$	30.0 °
Equivalent cohesion, $c_{\text{equiv.}}$		0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 13625.0 lb/ft².

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = N/A N γ= N/A

SEISMICITY

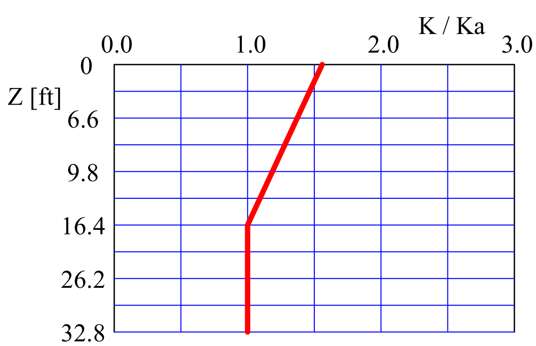
Not Applicable

INPUT DATA: Metal mats/grids
(Analysis)

D A T A	Metal mats type #1	Metal mats type #2	Metal mats type #3	Metal mats type #4	Metal mats type #5
Yield strength of steel, Fy [kips/in ²]	75.0	75.0	75.0	75.0	75.0
Gross width of grid, b [in]	24.0	24.0	24.0	24.0	24.0
Vertical spacing, Sv [ft]	Varies	Varies	Varies	Varies	Varies
Design cross section area, Ac [in ²]	0.32	0.46	0.46	0.46	0.63
Thickness of transverse element, t [in]	0.3	0.3	0.3	0.3	0.3
Distance between transverse bars, St [in]	12.0	12.0	18.0	24.0	18.0
Friction angle along reinforcement-soil interface,	ρ				
@ the top	34.00	34.00	34.00	34.00	34.00
@ 19.7 ft or below	34.00	34.00	34.00	34.00	34.00
Pullout resistance factor, F*					
@ the top	0.53	0.53	0.35	0.27	0.35
@ 19.7 ft or below	0.27	0.27	0.18	0.13	0.18
Scale-effect correction factor, α	1.00	1.00	1.00	1.00	1.00

Variation of Lateral Earth Pressure Coefficient With Depth (Coherent Mass)

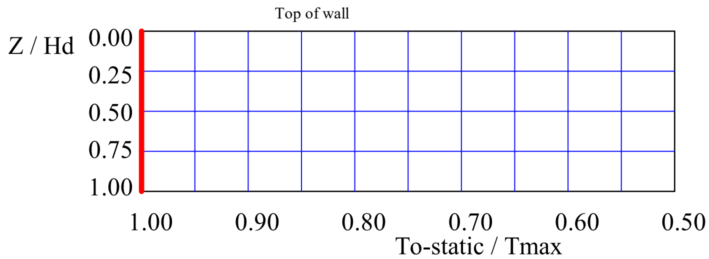
Z	K / Ka
0 ft	1.56
3.3 ft	1.47
6.6 ft	1.37
9.8 ft	1.28
13.1 ft	1.19
16.4 ft	1.09
19.7 ft	1.00



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
Average unit weight of panel is $\gamma_f = 150.00$ lb/ft ^{3}

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	4W11x1.00..	4W15x1.00..	4W15x1.50..	4W15x2.00..	4W20x1.50..
Strength reduction at the connection, CRu = Fyc / Fy	1.00	1.00	1.00	1.00	1.00

INPUT DATA: Geometry and Surcharge loads (of a BRIDGE ABUTMENT)

Design height, Hd 20.00 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 20.00 ft }

Soil in front of wall is Horizontal.

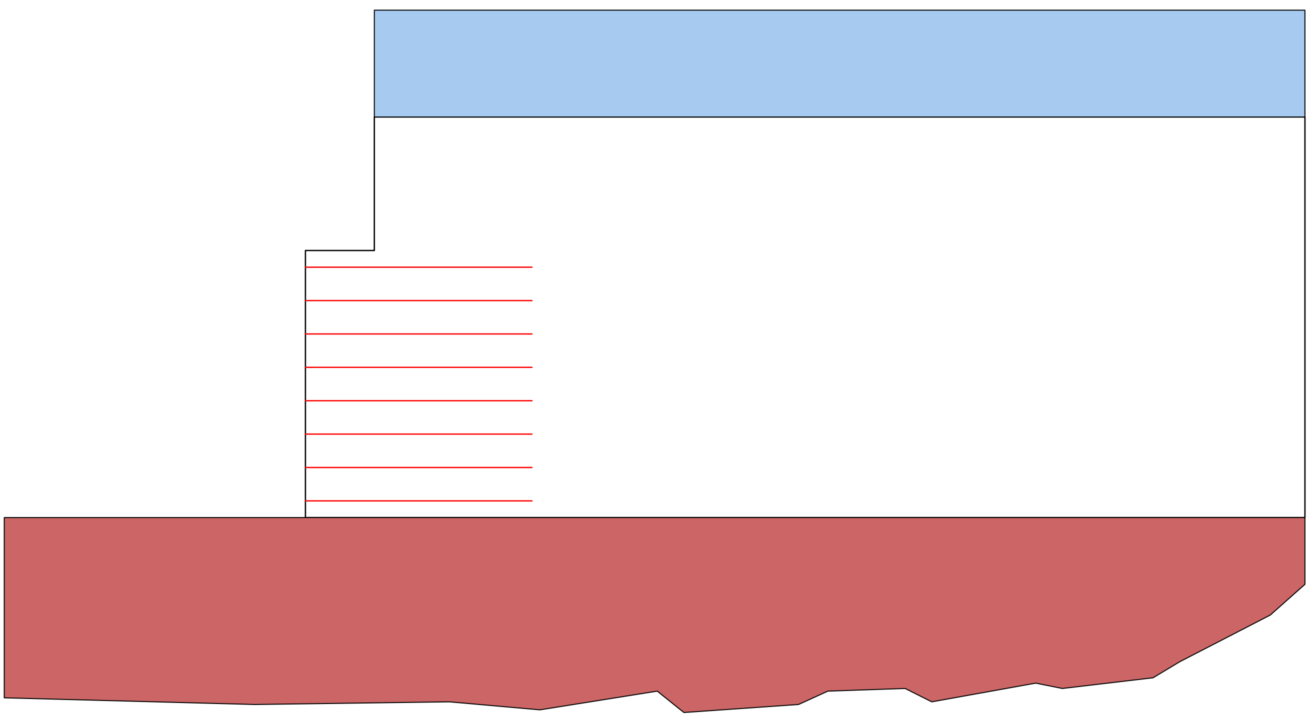
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ABUTMENT GEOMETRY (On pile foundation.)
2.17
Footing's dimension: height, h' = 10.00, width, b = 1.50, and thickness, t = 3.50 [ft].
Dimensions of bridge bearing plate: height, fh = 0.30, width, fw = 1.00 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for Metal Mats pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV		Static	Combined Static/Seismic	
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00
Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.90

ANALYSIS: CALCULATED FACTORS (Static conditions)

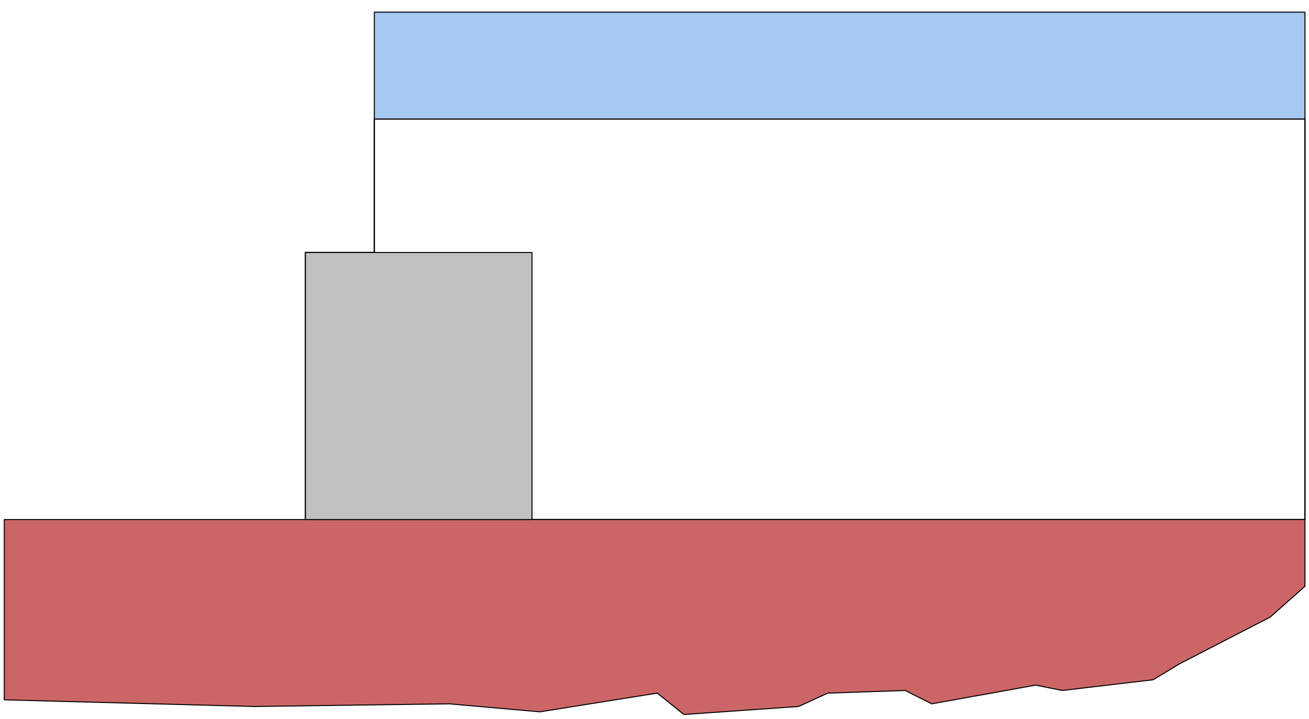
Bearing capacity, CDR = 1.10, factored bearing load = 8081 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.106, Eccentricity, e/L = 0.2926, CDR-overturning = 1.63

METAL MATS #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.25	17.00	5	1.06	1.06	1.060	1.302	1.332	0.2685	4W20x1.50W11
2	3.75	17.00	5	1.28	1.28	1.279	1.488	1.418	0.2221	4W20x1.50W11
3	6.25	17.00	3	1.11	1.11	1.108	1.668	1.514	0.1779	4W15x1.50W11
4	8.75	17.00	3	1.33	1.33	1.333	1.828	1.621	0.1355	4W15x1.50W11
5	11.25	17.00	3	1.43	1.43	1.426	1.640	1.741	0.0941	4W15x1.50W11
6	13.75	17.00	3	1.35	1.35	1.355	1.247	1.870	0.0525	4W15x1.50W11
7	16.25	17.00	3	1.31	1.31	1.306	1.001	2.003	0.0080	4W15x1.50W11
8	18.75	17.00	2	1.30	1.30	1.298	1.308	2.117	-0.0456	4W15x1.00W11

BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	8856	N/A	[lb/ft ²]
Factored bearing load, σ_V	8080.7	N/A	[lb/ft ²]
Eccentricity, e	3.16	N/A	[ft]
Eccentricity, e/L	0.186	N/A	
CDR calculated	1.10	N/A	
Base length	17.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 63053.46 [lb/ft], L = 17.00, Unfactored e = 2.75 [ft], and Sigma = 5479.30 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL MATS/GRIDS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.106

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	CDR Static	CDR Seismic	Metal Mats Type #	Product name
1	1.25	17.00	1.332	N/A	5	4W20x1.50W11
2	3.75	17.00	1.418	N/A	5	4W20x1.50W11
3	6.25	17.00	1.514	N/A	3	4W15x1.50W11
4	8.75	17.00	1.621	N/A	3	4W15x1.50W11
5	11.25	17.00	1.741	N/A	3	4W15x1.50W11
6	13.75	17.00	1.870	N/A	3	4W15x1.50W11
7	16.25	17.00	2.003	N/A	3	4W15x1.50W11
8	18.75	17.00	2.117	N/A	2	4W15x1.00W11

ECCENTRICITY for GIVEN LAYOUT (for Coherent Gravity Mass Method)

At interface with foundation: e/L static = 0.2926; Overturning: CDR-static = 1.63

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	e / L Static	e / L Seismic	Metal Mats Type #	Product name
1	1.25	17.00	0.2685	N/A	5	4W20x1.50W11
2	3.75	17.00	0.2221	N/A	5	4W20x1.50W11
3	6.25	17.00	0.1779	N/A	3	4W15x1.50W11
4	8.75	17.00	0.1355	N/A	3	4W15x1.50W11
5	11.25	17.00	0.0941	N/A	3	4W15x1.50W11
6	13.75	17.00	0.0525	N/A	3	4W15x1.50W11
7	16.25	17.00	0.0080	N/A	3	4W15x1.50W11
8	18.75	17.00	-0.0456	N/A	2	4W15x1.00W11

RESULTS for STRENGTH [Note: Actual CDR = (Yield stress) / (Actual stress)] For Coherent Mass Method, Option A
Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	LTDS = Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	1.25	0.400	5.000	6171.8	5822.0	N/A	N/A	1.060	N/A	N/A
2	3.75	0.400	5.000	6171.8	4826.1	N/A	N/A	1.279	N/A	N/A
3	6.25	0.400	5.000	4452.8	4017.4	N/A	N/A	1.108	N/A	N/A
4	8.75	0.400	5.000	4452.8	3341.4	N/A	N/A	1.333	N/A	N/A
5	11.25	0.400	5.000	4452.8	3123.0	N/A	N/A	1.426	N/A	N/A
6	13.75	0.400	5.000	4452.8	3286.3	N/A	N/A	1.355	N/A	N/A
7	16.25	0.400	5.000	4452.8	3408.5	N/A	N/A	1.306	N/A	N/A
8	18.75	0.400	5.000	4452.8	3430.1	N/A	N/A	1.298	N/A	N/A

RESULTS for PULLOUT
Live Load included in calculating Tmax
NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Metal Mats Elevation [ft]	Coverage Ratio Rc=b/Sh	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le (see NOTE)	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified seismic CDR	Actual seismic CDR
1	1.25	0.400	5822.0	N/A	16.25	0.75	7582.2	N/A	1.302	N/A	N/A	N/A
2	3.75	0.400	4826.1	N/A	14.75	2.25	7179.5	N/A	1.488	N/A	N/A	N/A
3	6.25	0.400	4017.4	N/A	13.25	3.75	6700.3	N/A	1.668	N/A	N/A	N/A
4	8.75	0.400	3341.4	N/A	11.75	5.25	6108.9	N/A	1.828	N/A	N/A	N/A
5	11.25	0.400	3123.0	N/A	10.25	6.75	5121.4	N/A	1.640	N/A	N/A	N/A
6	13.75	0.400	3286.3	N/A	8.75	8.25	4099.1	N/A	1.247	N/A	N/A	N/A
7	16.25	0.400	3408.5	N/A	8.00	9.00	3411.1	N/A	1.001	N/A	N/A	N/A
8	18.75	0.400	3430.1	N/A	8.00	9.00	4485.7	N/A	1.308	N/A	N/A	N/A

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal Mats strength Specified	CDR Metal Mats strength Actual	Product name
1	1.25	0.400	5.000	5822	1.00	6172	6172	N/A	1.06	N/A	1.06	4W20x1.50W11
2	3.75	0.400	5.000	4826	1.00	6172	6172	N/A	1.28	N/A	1.28	4W20x1.50W11
3	6.25	0.400	5.000	4017	1.00	4453	4453	N/A	1.11	N/A	1.11	4W15x1.50W11
4	8.75	0.400	5.000	3341	1.00	4453	4453	N/A	1.33	N/A	1.33	4W15x1.50W11
5	11.25	0.400	5.000	3123	1.00	4453	4453	N/A	1.43	N/A	1.43	4W15x1.50W11
6	13.75	0.400	5.000	3286	1.00	4453	4453	N/A	1.35	N/A	1.35	4W15x1.50W11
7	16.25	0.400	5.000	3409	1.00	4453	4453	N/A	1.31	N/A	1.31	4W15x1.50W11
8	18.75	0.400	5.000	3430	1.00	4453	4453	N/A	1.30	N/A	1.30	4W15x1.00W11

Section 3: CONSTRUCTION

3.1
Construction Procedures

3.1.2 ERS Construction Manual

INNOVATIVE CONSTRUCTION PRODUCTS

MSEPLUS™ PRECAST PANEL FACED MECHANICALLY STABILIZED EARTH WALL

INSTALLATION MANUAL

MSEPLUS RETAINING WALL SYSTEMS

PRECAST PANEL FACED
MECHANICALLY STABILIZED
EARTH (MSE) WALL
INSTALLATION MANUAL
STANDARD PANEL SIZES

SSL, LLC. SUPPLIES PRECAST CONCRETE PANELS, WELDED WIRE SOIL REINFORCEMENT AND ACCESSORIES TO BE USED IN CONJUNCTION WITH OTHER MATERIALS IN THE CONSTRUCTION OF MSE PLUS RETAINING WALLS. THESE WALLS ARE DETAILED IN THE SHOP DRAWINGS TO CONFORM TO THE REQUIREMENTS OF THE OWNER'S CONTRACT DOCUMENTS. THE MSE PLUS™ WALL INSTALLATION MANUAL FURNISHED HEREIN PROVIDES ONLY A GENERAL EXPLANATION OF THE SYSTEM.

THE CONTRACTOR IS SOLELY RESPONSIBLE TO DEVISE AND CARRY OUT A PLAN FOR ERECTION AND ASSEMBLY OF COMPONENTS, WHICH ARE PROJECT SPECIFIC. SAID PLAN SHALL PROVIDE FOR UNLOADING, HANDLING, PLACING, AND BRACING COMPONENT MATERIALS WITHOUT RELYING ON THE CONCEPTUAL DRAWINGS AND GUIDELINES PROVIDED BY SSL.

ACKNOWLEDGMENT OF THE RECEIPT AND REVIEW OF THE SSL WALL INSTALLATION MANUAL DOES NOT RELIEVE THE WALL CONTRACTOR OF RESPONSIBILITY TO COMPLY WITH THE PROJECT SPECIFICATIONS AND DRAWINGS OR STRICT COMPLIANCE WITH ALL FALL PROTECTION, LAWS, SAFETY STANDARDS, AND PROCEDURES DURING THE PERFORMANCE OF JOB SITE WORK. PRECAUTIONS SHALL BE TAKEN TO PROTECT INSPECTORS, SUPERVISORS AND TRADESMAN FROM INJURY DURING WALL ERECTION.

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List of Figures

List of References

American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications

AASHTO Interim Specifications for Highway Bridges

FHWA Design of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes

INTRODUCTION

The MSE*Plus*™ Precast Panel Faced Mechanically Stabilized Earth (MSE) Wall consists of soil reinforcing mesh, compacted soil, precast facing panels, bearing pads and a connection pin. MSE walls use reinforced soil, a term used when multiple layers of mesh act as reinforcement in soils placed as fill. MSE walls are cost-effective soil retaining structures that can tolerate much larger settlements than reinforced concrete walls. By placing tensile reinforcing elements (soil reinforcing mesh), the strength of the soil can be improved significantly such that the vertical face of the reinforced soil is essentially self-supporting. Use of a facing system (precast concrete panels) to prevent soil raveling between the reinforcing elements allows for very steep slopes and vertical walls to be constructed safely. The fascia panels may be cast with a texture such as fractured fin to provide a pleasing finished appearance. In addition, multiple finishes can be used for the fascia panels to create a larger pattern across the wall.

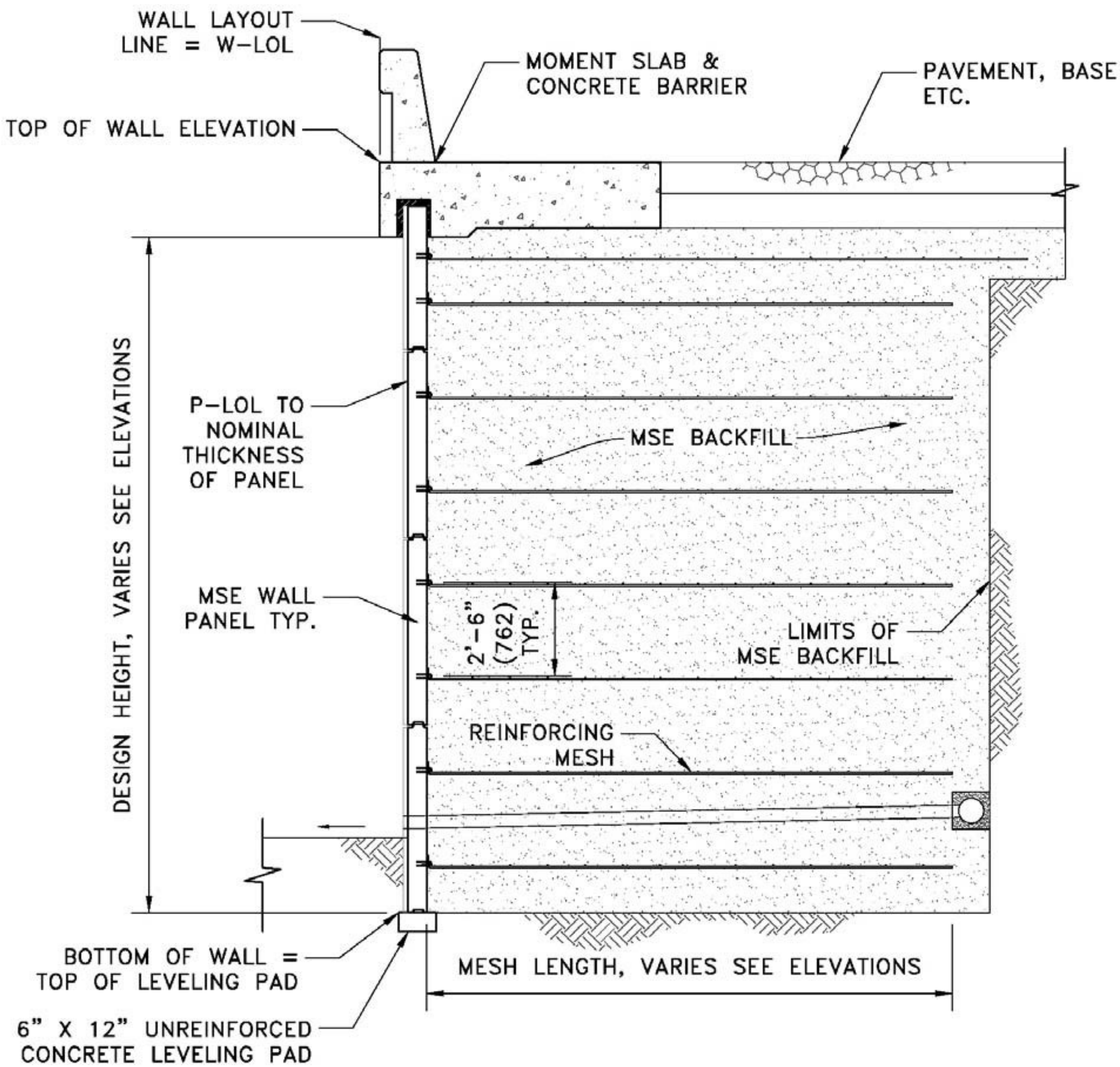

Figure 1: Typical Wall Cross Section

TERMINOLOGY

Bearing Pad – is a hard rubber or plastic pad placed in the horizontal joints between precast segmental panels.

Connection Pin – is a pin made of structural steel that is used to connect the soil reinforcing mesh to the concrete fascia panels.

Coping – is the reinforced concrete element at the top of the wall that typically overlaps the fascia panels and provides a finished appearance. Coping may be cast-in-place or it can be precast.

Embed Loops – are loops extending from the back face of a concrete fascia panel. The loops are used with the connection pin to join the soil reinforcing mesh to the concrete fascia panel.

Face Of Wall – is the front face of the MSE wall, typically the precast concrete panels.

Filter Fabric – is a geo-textile fabric that is placed along the horizontal and vertical joints on the fill side of the precast panels. The filter fabric prevents the erosion of soil from the MSE mass.

Finish Grade – is the material in front of the MSE wall, which should be graded to drain away from the wall. Typically 24" (610 mm) of material is used to protect the bottom of the wall from erosion and undercutting. For taller walls, the height of fill in front of the wall may be 10 percent of the overall height of the wall.

Formliner Finish – is the texture cast into the fascia panels with a concrete formliner. The fascia panels may be cast with a texture such as fractured fin or ashlar stone to provide a pleasing finished appearance. In addition, multiple finishes can be used for the fascia panels to create a larger pattern across the wall.

Leveling Pad – is the non-structural pad which provides a level surface at a given elevation for the placement of fascia panels. Typically leveling pads are poured concrete 6" (152 mm) high and 12" (305 mm) wide.

Level-Up Concrete – is the concrete poured along the top edge of the fascia panels to provide a uniform surface for the installation of precast coping.

Moment Slab – is a reinforced concrete slab along the top of the MSE wall that overlaps the top edges of the fascia panels. The moment slab acts as coping to provide a finished appearance along the top edge of the wall.

Panel Layout Line – is the line at the structural thickness of the panels along the front face that can be used as an aid during panel placement.

Precast Segmental Panel – is the reinforced concrete panel that is connected to the soil reinforcing mesh which forms the front face of the MSE wall. The panels are used to keep the front face of the MSE wall from raveling between the layers of soil reinforcing mesh and to provide an aesthetically pleasing fascia for the wall.

Prepared Foundation – is the bearing surface of the excavated area underneath the MSE wall. Typically the area should be proof-rolled.

Reinforced Soil/Fill – is the MSE structure consisting of successive layers of engineered fill, or select backfill, and soil reinforcement. Reinforced fill is also called select fill or structural fill.

Retained Fill – is the fill material located behind the MSE wall between the reinforced soil mass and the natural soil.

Soil Reinforcing Mesh – is a manufactured welded wire grid element with varying length, width and wire sizes, which reinforces the select fill.

Traffic Barrier – is the structural element to keep vehicles within the roadway and away from hazards. MSE walls supporting lanes of traffic often include a traffic barrier at the top of the wall. Traffic barriers may also be used at the base of an MSE wall where a roadway exists in front of the wall.

Vertical Panel Joint Pad – is a plastic pad which provides a buffer (in some states) during a seismic event. These pads are placed in the vertical joints between concrete fascia panels. Typically these pads are glued to each panel and installed with an air gap between the pad and the adjacent panel.

Wall Control Line – is the horizontal alignment of the MSE wall that is given in the contract plans. The location of the wall control line may be at the front face of the panels, the front face of the coping or barrier slab, or a different location.

GENERAL GUIDELINES

The erection of the MSE structure is relatively simple. The installation consists mainly of preparing the subgrade, pouring the leveling pad, setting the concrete fascia panels, placing and compacting backfill in normal lift operations, laying the soil reinforcing mesh, and installing the features at the top of the wall such as coping or barrier slab. The layers of soil reinforcing mesh and compacted soil are placed in layers with the reinforcing mesh attached to the concrete fascia panels at each level.

NOTE: The figures contained in this installation manual are for illustrative purposes only. Refer to the shop drawings for design criteria, wall geometry, geotechnical reports, project notes, sections, general details, part information, and information or installation instructions specific to your project.

NOTE: The procedures outlined below are intended to be general guidelines for the installation of the MSEPlus™ Precast Panel Faced MSE Wall. Each wall should be erected as shown in the shop drawings in accordance with the Owner's Contract Documents.

NOTE: It is the responsibility of the contractor or wall erector to establish and maintain proper on-site safety procedures relating to wall construction, including the protection of tradesmen, supervisors, inspectors, technical representatives, etc.

ACCEPTANCE OF MATERIAL

The contractor or erector should insure that proper equipment for unloading the material from trucks will be available when it arrives onsite. It is the responsibility of the contractor or erector to unload material without causing damage, delays, or incurring additional costs.

The material should be checked off the bill of lading as it arrives. The contractor should notify SSL within 24 hours in writing of any missing or damaged material. See the material handling procedures section of this manual and in the shop drawings. SSL recommends that the contractor or erector sort and store the concrete fascia panels and reinforcing mesh to best facilitate wall erection.

It is the responsibility of the contractor or erector to properly store the material so as to prevent damage. Proper sorting and storage of materials can also significantly aid the erection of the MSE structure(s). The contractor or erector should refer to the shop drawings for the location and placement of materials in the MSE structure and plan the storage and handling of materials accordingly.

STORAGE AND HANDLING OF PANELS

The panels should be stacked one-on-one, separated by non-staining dunnage. The width of dunnage between the panels should be greater than or equal to 2.5 inches (64 mm), or the height of the embed, whichever is greater. The number of panels per stack varies.

Dunnage should be aligned in the vertical direction. Care should be taken not to damage the edges or face of the panels during unloading, storage or setting. The panels may be unloaded supported by the provided pallets.

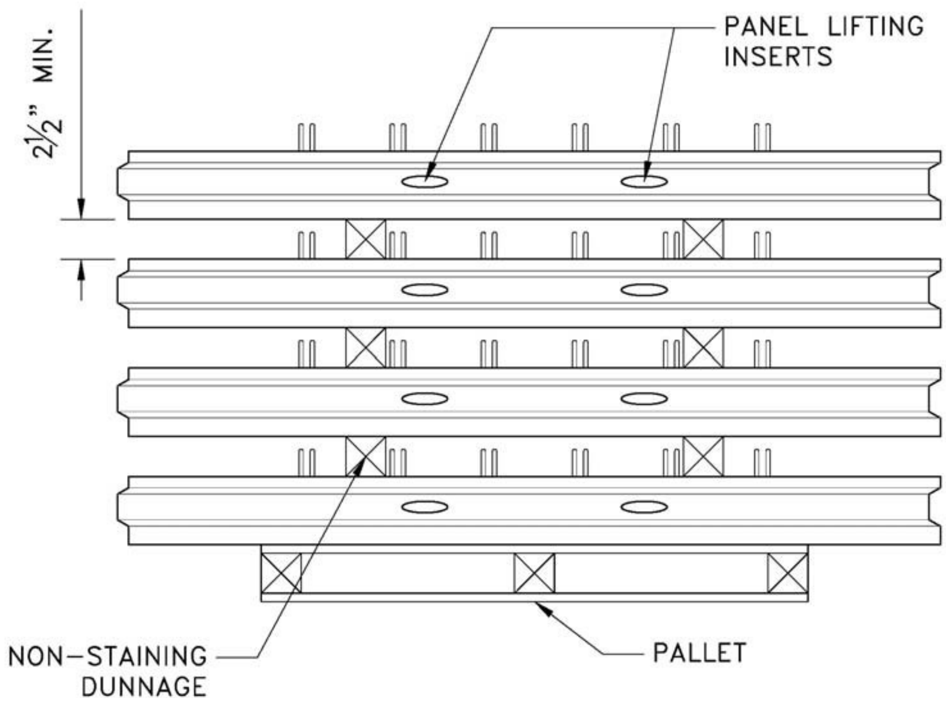

Figure 2: Panel Storage

During panel erection, panels shall be lifted and set by the use of the two lifting anchors located in the top of each panel. When lifting panels from the stack, make sure that an additional piece of dunnage is below the bottom edge of the panel to prevent damage when rotating panels from horizontal to vertical. The lifting line should be vertical to avoid damage to the panel.

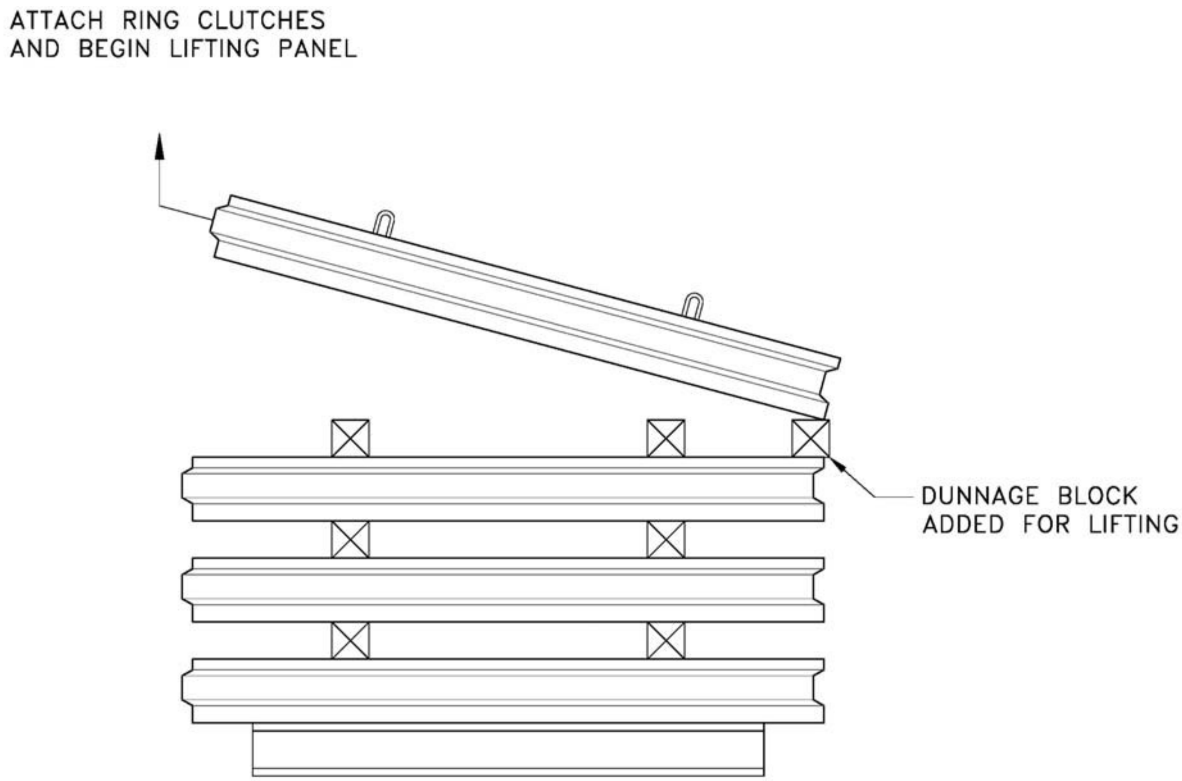

Figure 3: Panel Handling

STORAGE AND HANDLING OF REINFORCING MESH

Soil reinforcement arrives to the site on a flatbed truck with dunnage separating the different bundles of soil reinforcing. Off-load the soil reinforcing carefully, using at least two balanced pick points spaced no more than 7 feet (2.134 m) apart. The soil reinforcing should be placed on dunnage, not placed directly on the ground, with additional dunnage between bundles as needed.

Ensure that the dunnage under the stacked bundles of soil reinforcement are aligned vertically and are not spaced more 7 feet (2.134 m) apart horizontally. Note that the placement of the dunnage in the figure are shown for clarification purposes only. Dunnage may need to be added or removed based on the length of the soil reinforcement being placed into storage.

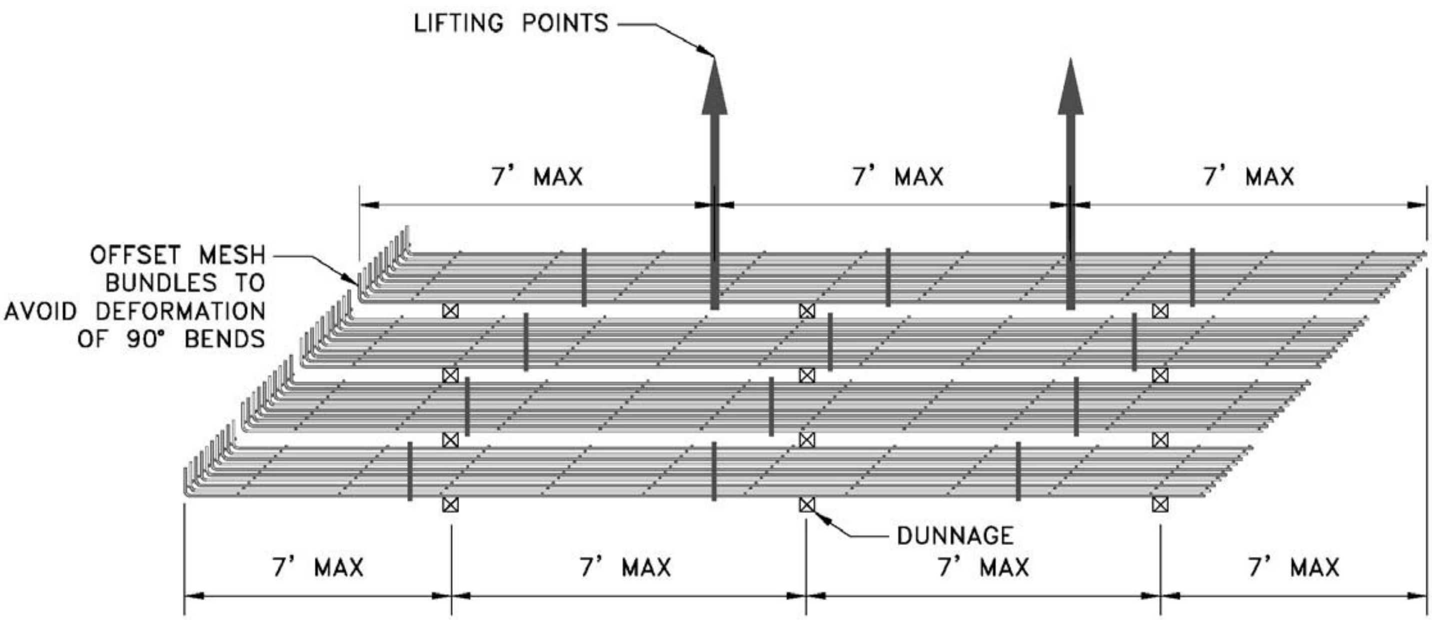

Figure 4: Mesh Handling

SITE PREPARATION

Properly preparing the area underneath the MSE structures is important to the overall performance and longevity of the wall(s). The foundation material must be capable of supporting the entire MSE structure and any additional loads upon each wall. The area should be grubbed and graded where reinforced fill will be placed, with additional area behind the soil reinforcement as required in the shop drawings and/or contract plans. Any unsuitable foundation material which may lead to settlement or other problems should be removed. Refer to the shop drawings and contract plans for any additional foundation remediation. Proper site preparation can also aid wall erection at not only the bottom of the wall but at the upper portions as well. Typically the foundation material is proof rolled and approved by the owner's engineer or geotechnical engineer.

LEVELING PAD

The leveling pad provides a smooth, level surface on which to set the precast concrete fascia panels. Though the leveling pad is not a structural element of the MSE wall, it is important to allow proper alignment and spacing of the bottom row of panels. Leveling pads are typically unreinforced concrete at least 6" (152 mm) high and 12" (305 mm) wide. Each pad is cast to the elevation and length shown in the shop drawings. Properly constructed leveling pads aid wall erection at not only the bottom of the wall but at the upper portions as well.

PRECAST CONCRETE PANELS

The fascia panels are cast to the dimensions and specifications in the shop drawings. The standard panel (usually Type A) can be 5' x 5', 5' x 6', 5' x 10' or 5' x 12'. An MSE wall usually includes several other types of panels to create the dimensions of the wall shown in the shop drawings. The naming of panels varies by project, but typically panel types used are A2 (half), L (left), R (right), T (top), TL (top-left), TR (top-right) and C (corner). Additional panels such as A1, A3 and A5 may be used at the bottom of the wall.

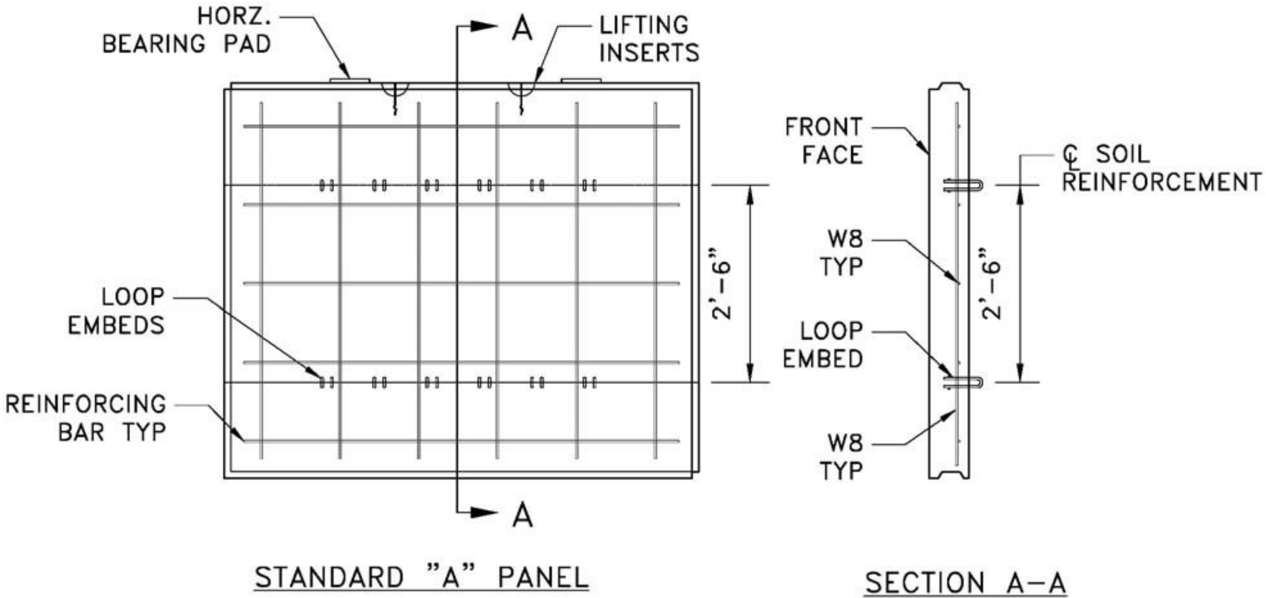

Figure 5: Standard 5' x 6' Precast Panel

SOIL REINFORCING MESH

The welded wire soil reinforcing mesh is manufactured in sheets to the specification and length shown in the shop drawings. Each sheet consists of longitudinal wires and crosswires, with a 90 degree bend at one end. The number of longitudinal wires, longitudinal wire gage, cross wire spacing, cross wire gage, and overall length vary as needed by design. The longitudinal wires are typically spaced at 8” (203 mm) on center and the spacing of the transverse wires varies from 6” to 48” (152 – 1219 mm) depending on the structural requirements of the system.

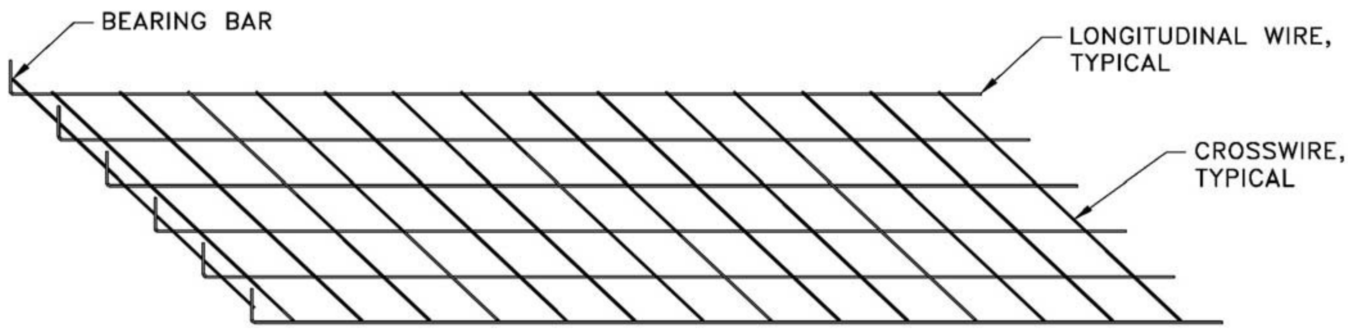

Figure 6: Typical Mesh Detail

The soil reinforcing mesh has a special bend at one end which is used to connect the concrete fascia panel to the mesh. Typically each sheet has only one bend, but the other end may be bent if individual sheets are to be joined together. This is usually the case if the required overall length of mesh exceeds 40 feet (12.195m).

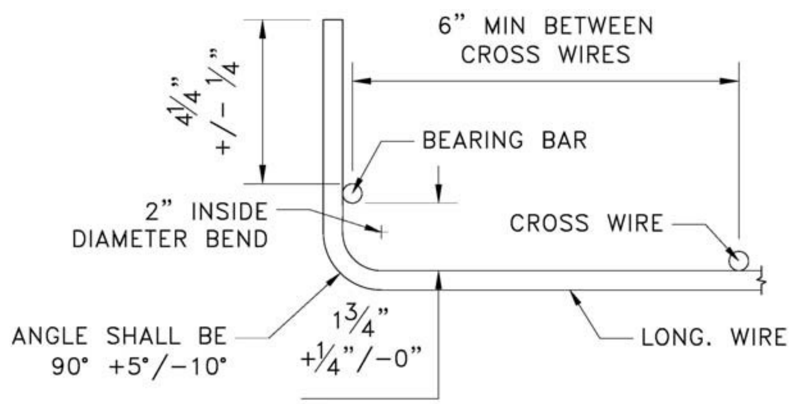

Figure 7: Typical Soil Reinforcing Bend Detail

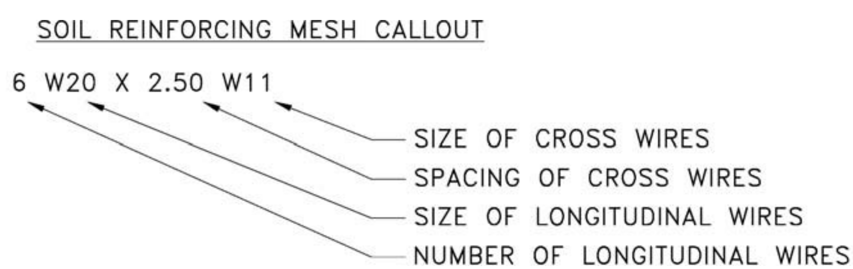

Figure 8: Mesh Callout Detail

The shop drawings and design tables give the mesh type and length to be used in each layer. The length is typically shown on a separate line of the design information. The type is detailed with a designated callout. This designation indicates the size and spacing of the welded wires for each sheet of mesh used in that section of the wall. The designation is ordered as the mesh is to be placed in the structure, with the bottom layers at the bottom and the top layers at the top.

NOTE: the contractor or erector must insure that the mesh is properly installed in the configuration shown in the shop drawings. As a check, typically the thicker longitudinal wire sizes occur at the bottom of the wall and the thinner longitudinal wire sizes occur at the top.

NOTE: where traffic barrier is used above the wall, the top one or two layers of soil reinforcement may have additional length, longitudinal wires, or crosswires.

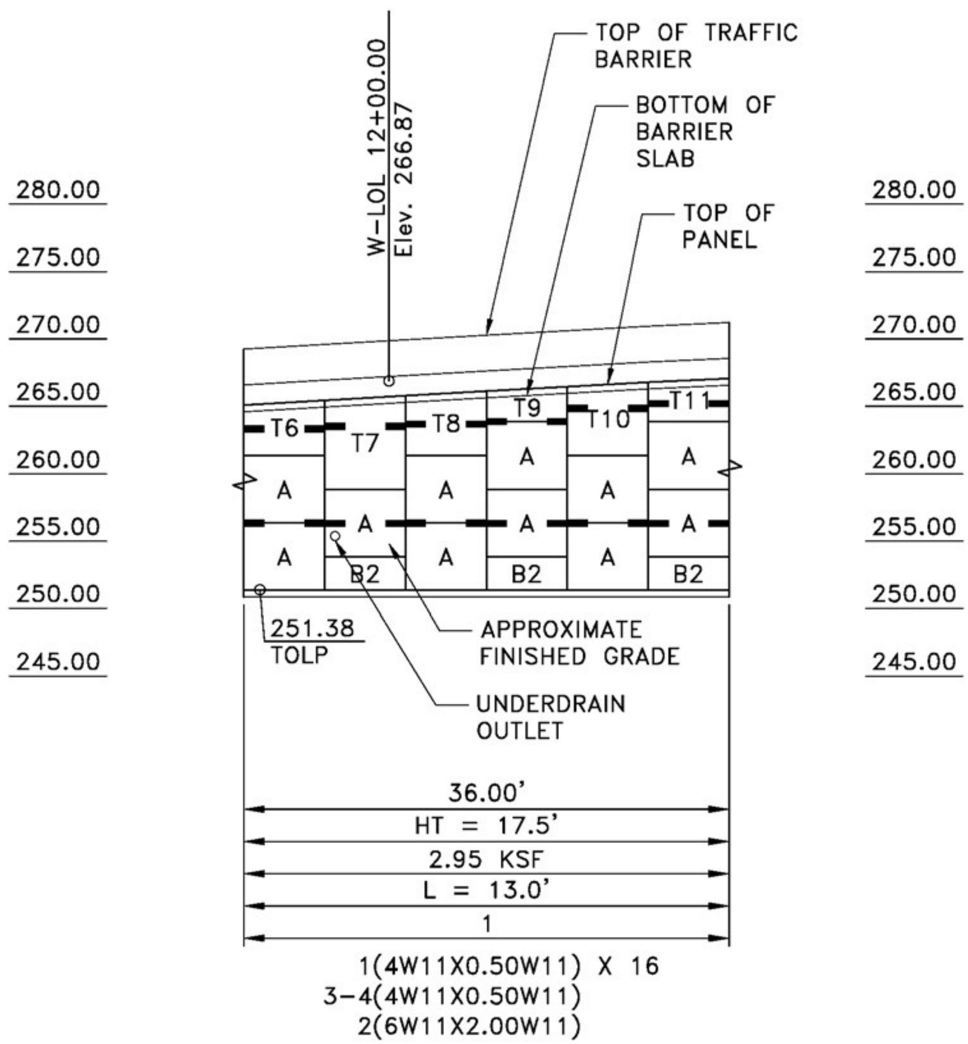

Figure 9: Typical Wall Elevation

The wall elevations in the shop drawings show the segmental panels along the front face of the wall. Mesh breaks are also shown, which indicate for each column of mesh where the mesh type changes. In the example shown, the mesh breaks correspond with the mesh callout. Note that the difference in mesh type between the bottom two layers, the middle layers and the top layer is indicated by both the mesh callout and the mesh breaks. Review the shop drawings for your project and notify SSL if any discrepancies exist between the mesh callouts, mesh breaks, or other information shown.

SETTING OF CONCRETE FASCIA PANELS

Precast concrete fascia panels are placed directly on the leveling pad, using shims where necessary to level the top edge of the panel. The panels are typically placed along a control line. Care should be taken in the setting of the bottom row of panels to achieve proper alignment and spacing. Proper placement of the bottom course of panels will facilitate the installation of the subsequent courses and improve the overall quality of the installation.

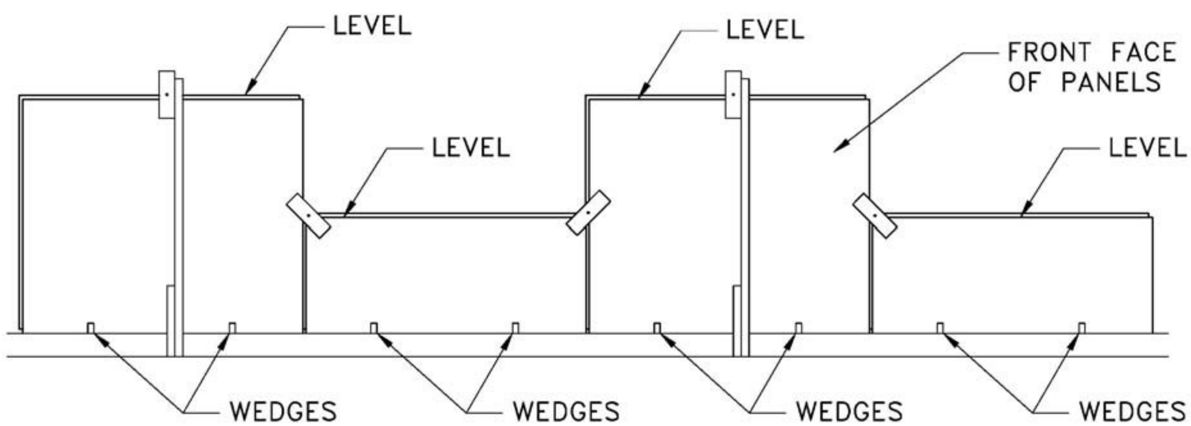

Figure 10: Bottom Row of Panels

The placement of the segmental panels begins with locating the control line(s). SSL recommends that the wall erector should use this information to establish a panel layout line, which is at the structural thickness of the panels at the front face. The offset distance between the panel layout line and the wall control line is shown in the typical cross section of the shop drawings. The panel layout line does not include the architectural finish, so no adjustment is necessary if the finish varies in thickness.

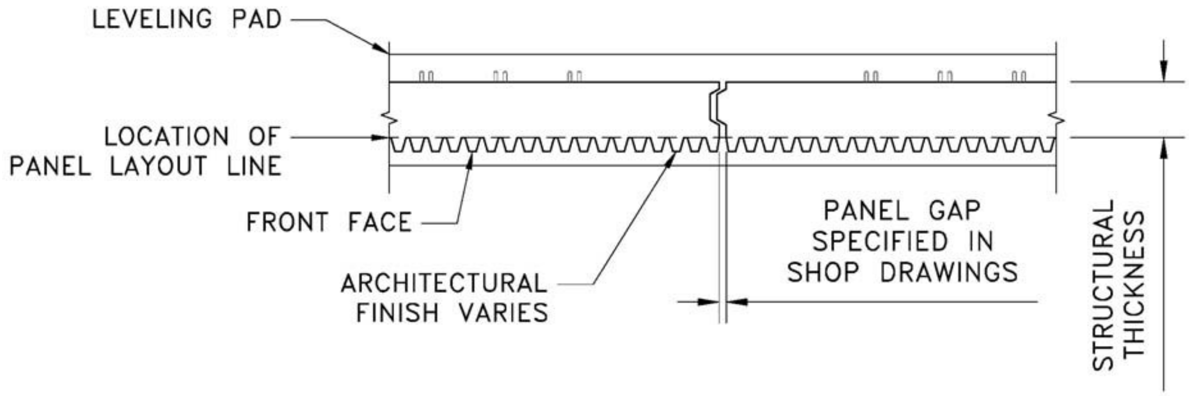

Figure 11: Panel Layout Line

The nominal width of the concrete fascia panels determines the correct spacing along the panel layout line. The nominal width is the actual width of the standard panels plus the width of the standard vertical panel gap. For example, if the standard panel width is 5'-11 1/4" (1810 mm) and the vertical panel gap is 3/4" (19 mm) then the nominal panel width is 6'-0" (1829 mm).

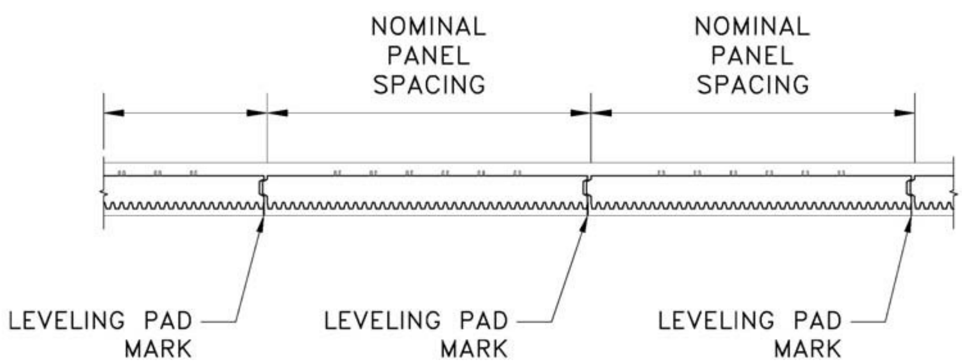

Figure 12: Nominal Panel Spacing

Where standard panels occur along the bottom of the wall, SSL recommends that the wall erector mark the leveling pad along the panel layout line at intervals equal to the nominal panel spacing. The spacing is adjusted at the ends of the wall, at corners, or wherever the width of the panels used is not the same as the standard width. Using the leveling pad marks will insure that long sections of wall will be set at the correct spacing and the wall will not "grow" or "shrink." The location of the marks can be the corner of each panel, the middle of the joint, or any point along the length of the panels. Each standard panel should be placed in the same position relative to the marks.

The wall control line(s) and panel layout line may include angles or curved sections. The shop drawings include details showing the placement of panels at the angle point. Typically the panel layout line will extend through the corner element.

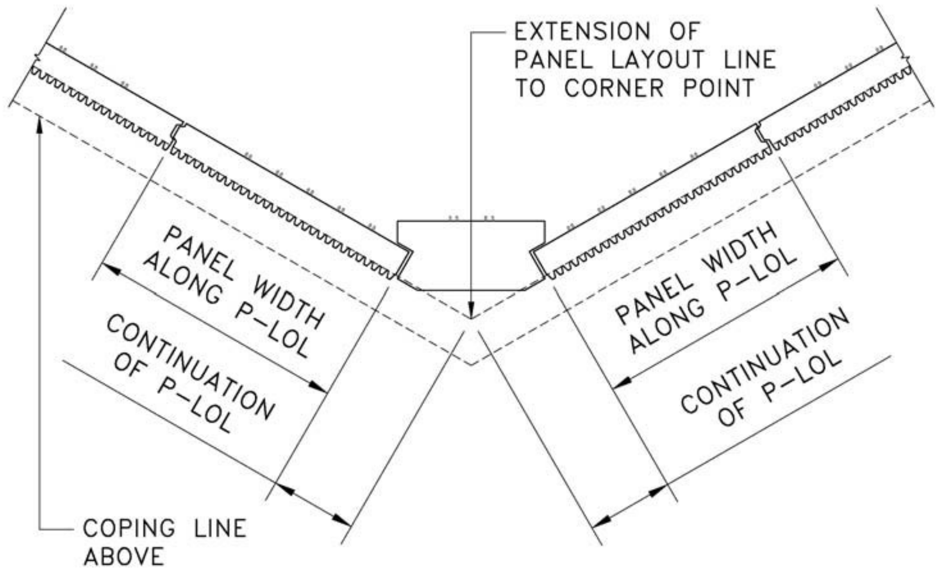

Figure 13: Corner Panel Layout

Where the panel layout line is curved, the spacing should be continued through the curved section. The panels should be placed at intervals equal to the nominal panel width along the curve. The panel gap should be measured along the panel layout line. At the back face of the segmental panels the spacing varies depending on the radius of the curve and whether the fill side of the wall is toward the center of the curve or away from it.

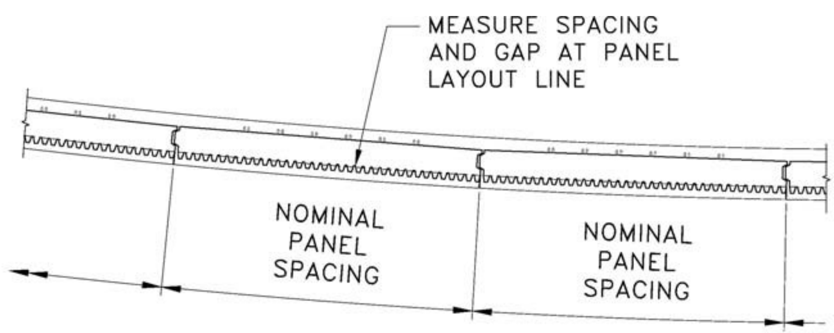

Figure 14: Curved Layout Line Panel Spacing

The segmental precast panels should be set with a batter to the fill side of the wall. The amount of batter depends on the type of select fill, the amount of compaction required near the face of the wall, and various construction methods. The shop drawings show a suggested amount of batter based on typical materials and construction methods.

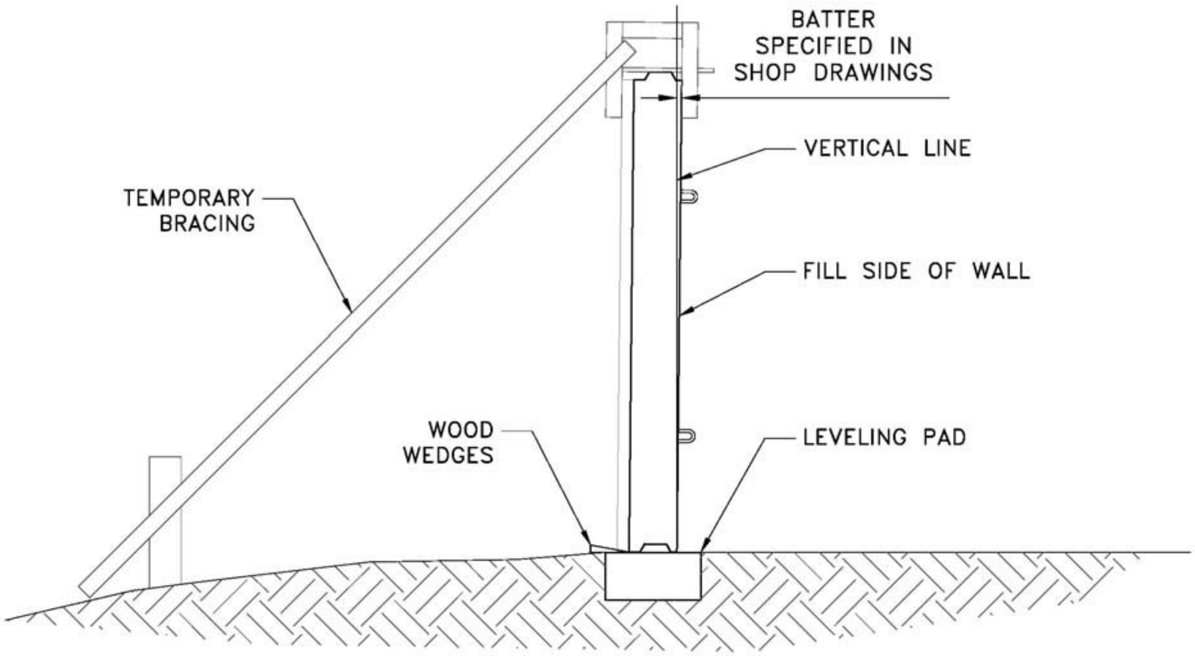

Figure 15: Panel Batter

NOTE: the recommended batter shown in the shop drawings is what is typically required in MSE wall installation. This batter will vary depending on the properties of the select fill, moisture content, compaction effort and other variables. Batter shall be monitored and maintained with each lift of soil reinforcing mesh installed by the erection contractor.

FILTER FABRIC

Prior to the placement of backfill, filter fabric should be attached to the back face of the concrete panels as shown in the shop drawings. The filter fabric should cover each of the panel gaps. This allows moisture to "weep" out from behind the panels. For this reason, "weep holes" are usually not necessary in the precast panels. The filter fabric is attached to the panels with a 1/4" (6 mm) bead of adhesive around the edges. Adjacent pieces of filter fabric should overlap the length shown in the shop drawings and/or contract documents.

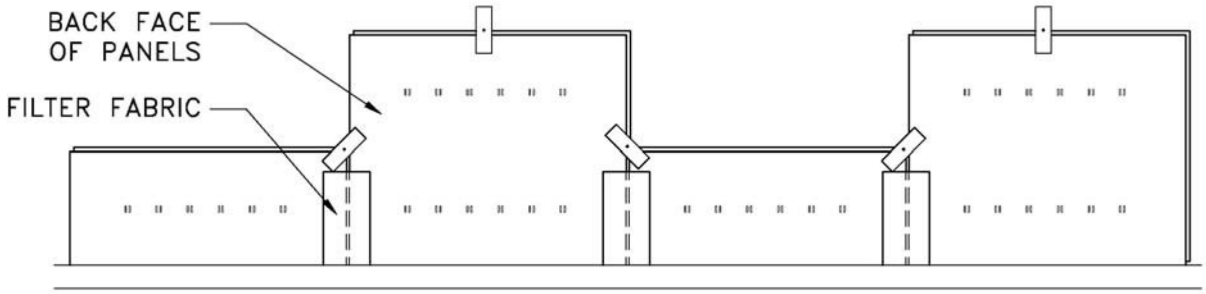

Figure 16: Filter Fabric Placement

INITIAL PLACEMENT OF BACKFILL

Refer to shop drawings, contract plans, and/or project specifications for the type of backfill to be used in the reinforced zone of the MSE wall. This backfill can be referred to as the "select fill," "structural fill" or the "reinforced fill." The depth of backfill to be placed for each "lift" is usually determined by the project specifications. Placement of the backfill close to the back of the precast panels shall be done with care to insure that the wall face remains in proper alignment during the initial placement of backfill. Each lift of backfill material should be compacted according to the shop drawings, contract plans, and/or project specifications.

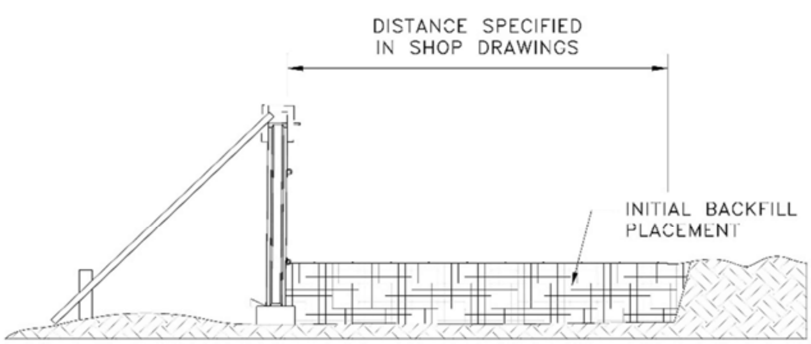

Figure 17: Initial Placement of Backfill

INSTALLATION OF SOIL REINFORCEMENT

The soil reinforcement should be installed perpendicular to the back face of the segmental panels. Each row of embed loops for each panel must have mesh attached. The soil reinforcing should be centered on the panel, or may be installed on alternating sides. For example, mesh with 2, 4, or 6 longitudinal wires should be centered in a standard embed loop configuration with 6 pairs of loops. If mesh with 3 or 5 longitudinal wires is connected to panels with 6 pairs of loops, it should be shifted to alternating sides as you go up. The bottom sheet would be placed on one side, the sheet above that would be placed on the other side, the third row of mesh placed above the first, etc.

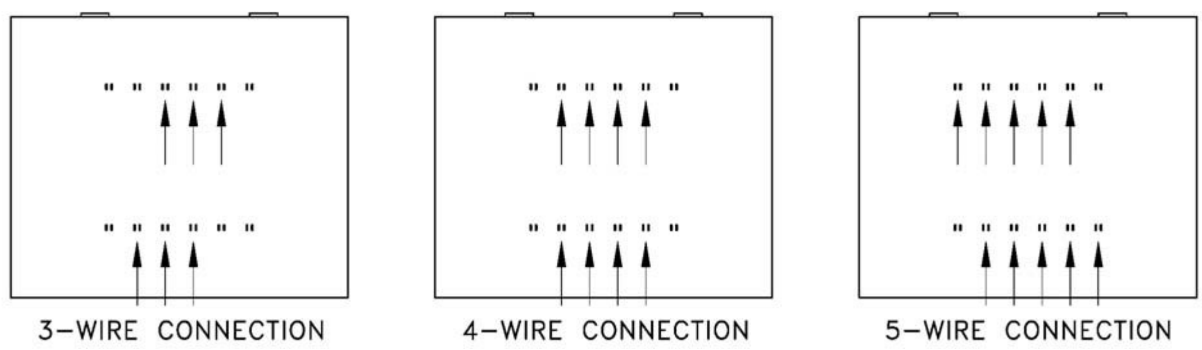

Figure 18: Mesh Connection by Wires

The mesh shown in the shop drawings is used for standard-width panels. Panels such as type "L," "R," "TL," "TR," and "C" may require mesh with fewer longitudinal wires than the standard panels. Typically, the panels will have fewer pairs of embed loops than the standard panels. The maximum number of longitudinal wires needed will be the same as the number of embed loop pairs. The extra longitudinal wires may be cut from the original sheet of mesh, or the mesh may be installed without the extra longitudinal wires attached to the fascia panels. Where the mesh is cut, the ends should be painted with a zinc-rich primer approved by the owner.

The connection is made by placing the mesh with the longitudinal wires between the pairs of embed loops on the panels. The "bearing bar" of the mesh should be resting on the top edge of the loops. Then the connection pin should be installed, typically one pin on each side of the row of loops. After the connection is made, the soil reinforcing mesh should be tensioned away from the fascia panels. One method is to install wedges between the soil reinforcing mesh and the back face of the panels. Another method is to use stakes to tension the mesh while backfill is spread above the soil reinforcement. Tension in the mesh can be maintained by placing the backfill near the panels and spreading it toward the ends of the soil reinforcement.

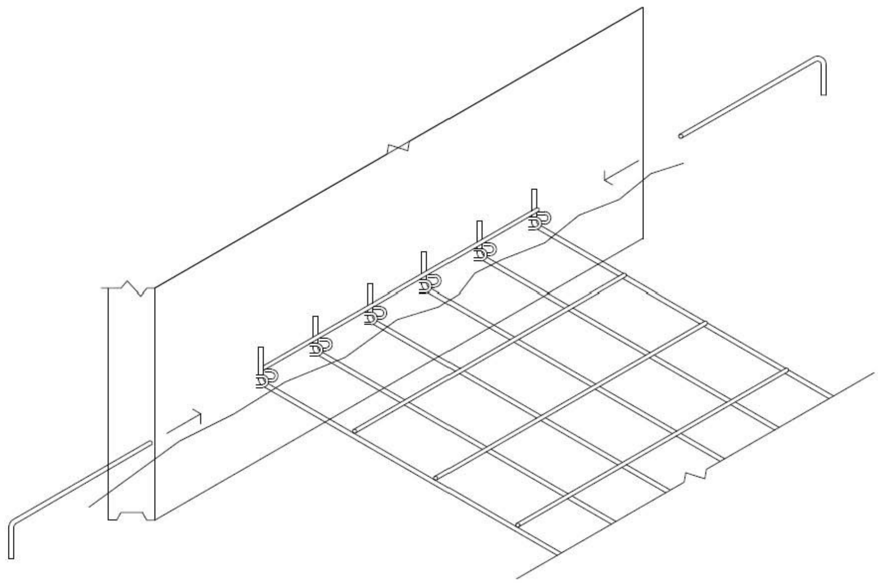

Figure 19: Mesh Connection Detail 1

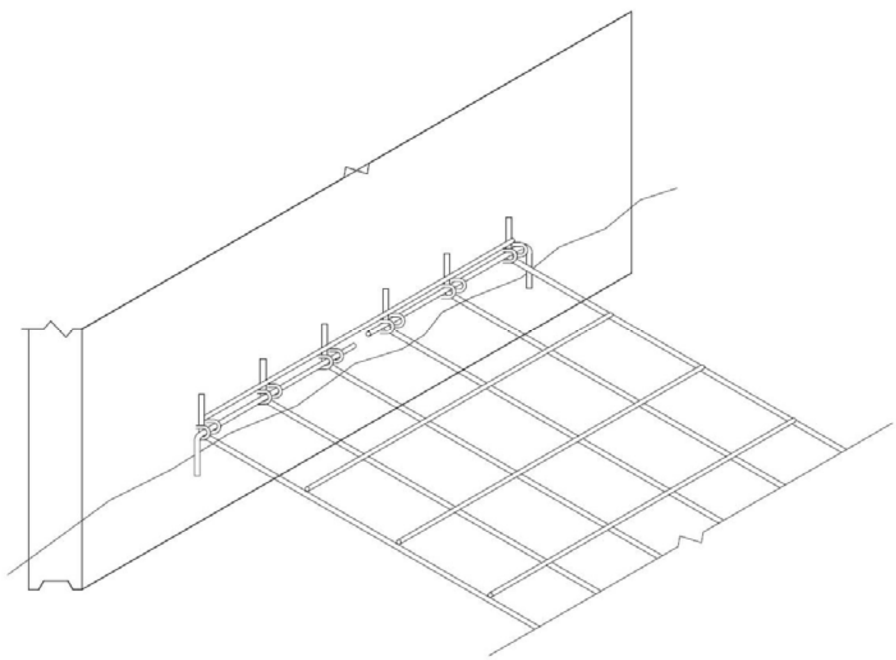

Figure 20: Mesh Connection Detail 2

BEARING PADS

Bearing pads are used on all horizontal joints between panels. Typically the pads are high density polyethylene preformed to be 3/4" (19 mm) high, 2 5/8" (67 mm) wide and 6" (152 mm) long. These pads provide a bearing surface between panels and control the width of horizontal panel joints. A minimum of two pads are required per joint. Additional pads may be required for taller walls or as shown in the shop drawings. Each pad must be temporarily glued to the surface of the panel.

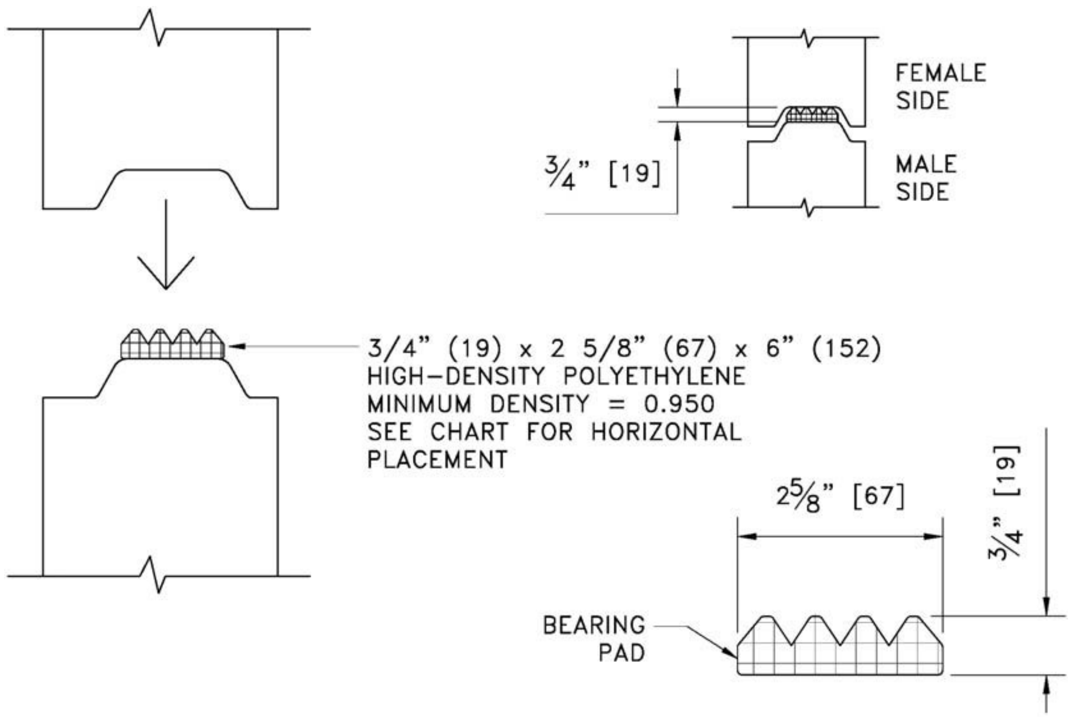

Figure 21: Bearing Pads

VERTICAL PANEL JOINT PAD

In some cases a pad is also provided for vertical panel joints. Typically these are molded plastic pads 3/8" (10 mm) high, 2 1/2" (64 mm) wide and 6 3/4" (171 mm) long. These provide protection during construction and under a seismic event. Each pad is attached with contact cement or adhesive. When vertical panel joint pads are required, they are usually attached to the panels by the precaster.

Note: Vertical panel joint pads are not used for all projects

Note: The vertical joint pad should not contact the adjacent panel

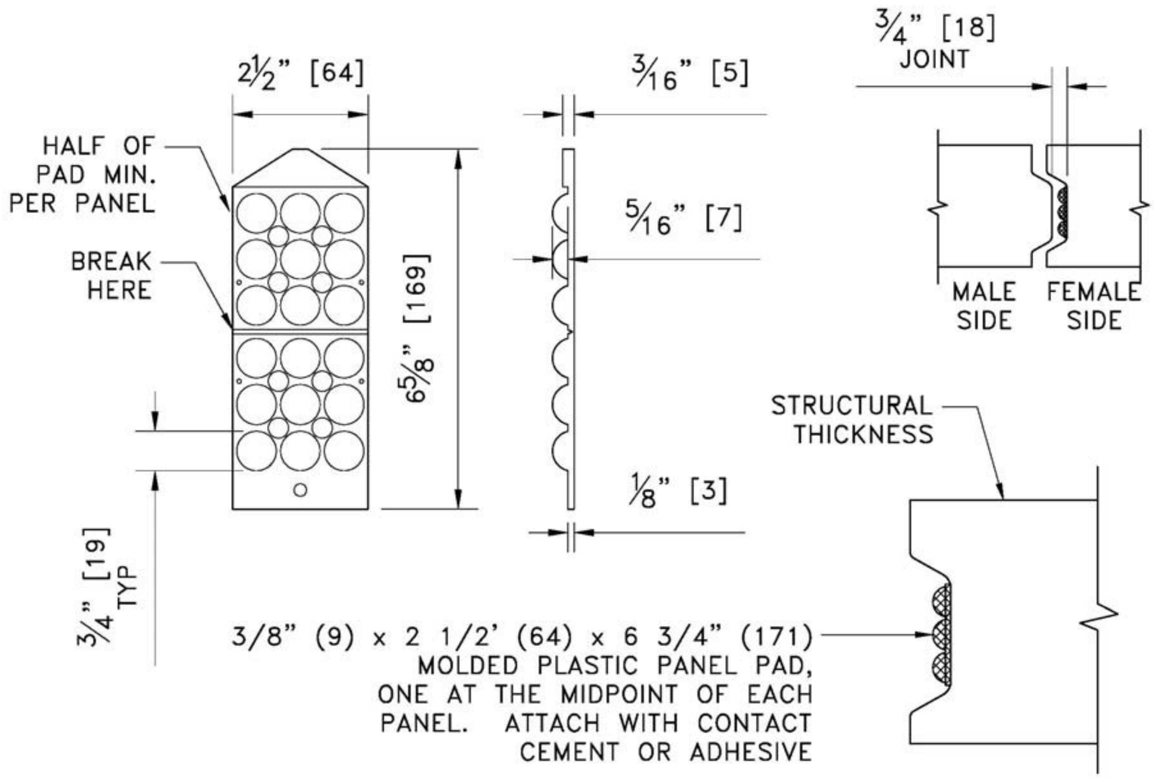

Figure 22: Vertical Joint Pads

ADDTIONAL PANEL PLACEMENT

Bearing pads should be glued to the top surface of the bottom row of panels. In many cases, two bearing pads are used spaced equally on top of the panels. Additional bearing pads may be used for tall walls. The upper panels are placed on top of the lower panels and attached with clamps. Filter fabric should be installed along the back face at each panel joint.

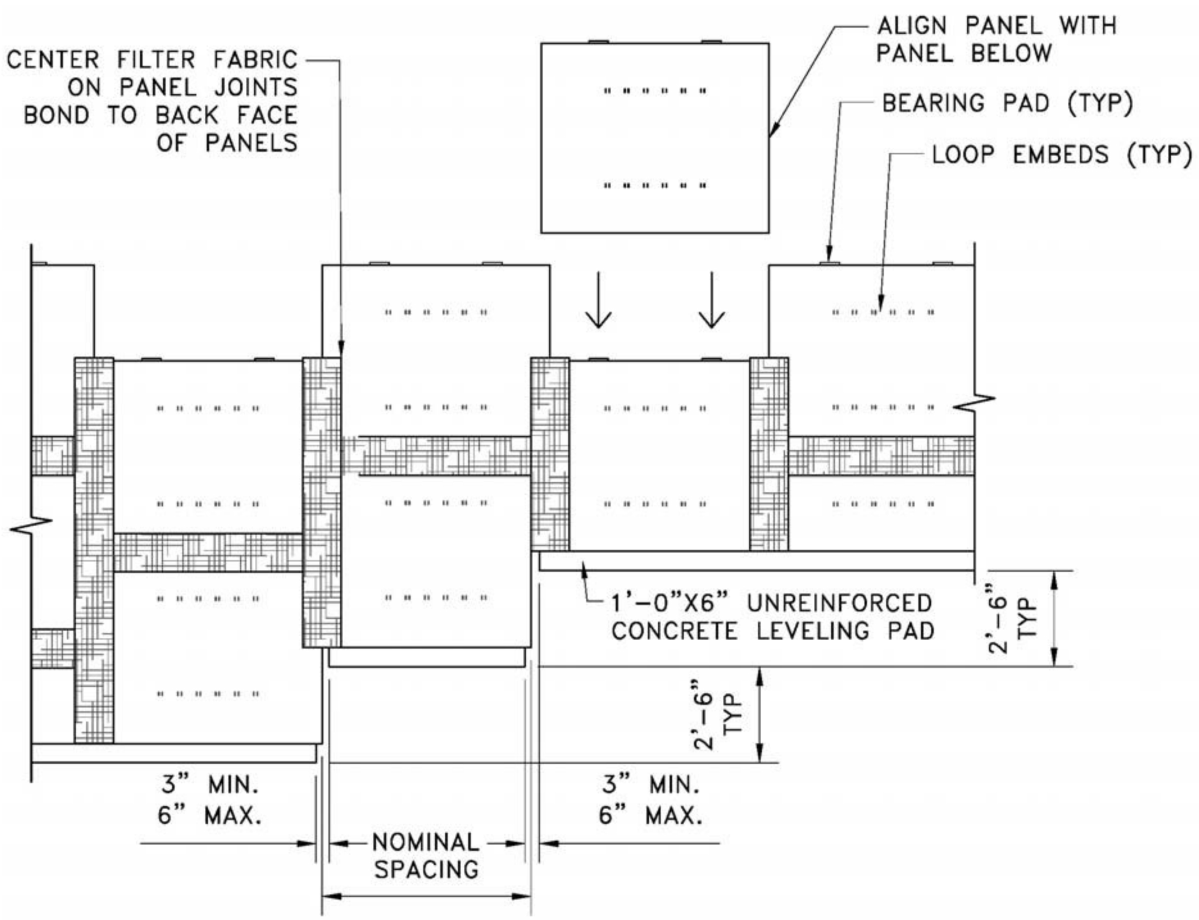

Figure 23: Installation of Upper Panels

ADDITIONAL BACKFILL PLACEMENT

Additional lifts of backfill material are placed and compacted over the initial lifts. The fill should be placed as described above. Each layer of soil reinforcing mesh is installed as described above.

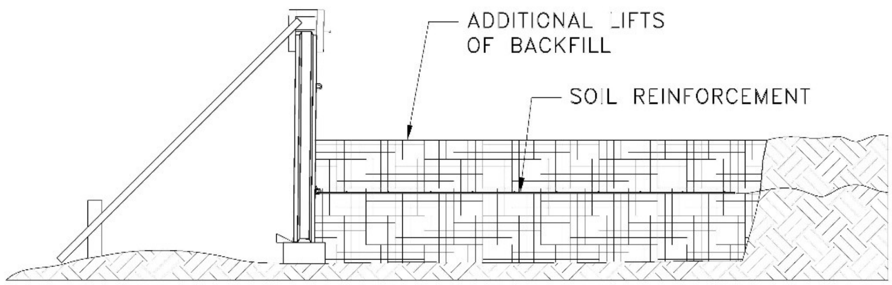

Figure 24: Additional Backfill Placement

The reinforced backfill should be compacted according to the shop drawings, contract plans, and/or project specifications, except within 3 feet (1 m) of the face of the wall. Due to the likelihood of causing distortion at the wall face, the fill within 3 feet (1 m) of the wall face should be placed manually. Great caution should be exercised during compaction efforts in this area. SSL recommends only minimal compaction effort be taken, and no compaction testing be done, within this 3 foot (1 m) zone.

The backfill material outside the 3 foot (1 m) zone from the face of the wall is typically compacted with equipment such as an 8-10 ton (88 kN) roller. SSL recommends smooth wheeled or rubber tire rollers but not grid type rollers. The compaction should be along the face of the wall working toward the tails of the mesh. Proper moisture content should be maintained during compaction. Refer to shop drawings, contract plans, and/or project specifications for the proper moisture content, compaction and compaction testing of the backfill material. SSL recommends that no compaction tests be performed within the 3 foot (1 m) zone of the face of the wall. The gradation of the reinforced fill should be checked periodically according to the shop drawings, contract plans, and/or project specifications. The contractor or wall erector should document all tests as they are performed. The vertical and horizontal alignment of the fascia panels should be checked periodically during compaction and wall erection.

OBSTRUCTIONS

The shop drawings for each MSE structure should include the locations of all obstructions to the soil reinforcing mesh. If additional obstructions are encountered, the contractor or wall erector should notify the Engineer of Record (EOR) and/or SSL. Refer to the shop drawings for general solutions or special details for each obstruction. These solutions may include cutting the crosswires of the soil reinforcing mesh to skew it away from the obstruction. The cut ends should be coated with a zinc-rich primer. Typically the skew angle does not exceed 15 degrees without additional calculations. The soil reinforcement should be bent gradually: abrupt bends could weaken the longitudinal wires and therefore should be avoided. SSL recommends that 6" (152 mm) of backfill material be maintained between soil reinforcement and obstructions. Where mesh is overlapping, SSL typically recommends 3" (76 mm) of backfill between the sheets. In some cases a structural frame may be necessary. For obstructions near the top of the wall, SSL recommends the use of a void former to block out space in the reinforced fill. This includes obstructions such as guardrail posts, which should not be driven into the reinforced fill. Driving posts into the reinforced fill after wall erection could damage the mesh and/or distort the wall face.

DRAINAGE

Proper drainage is essential to MSE structures. The contractor or wall erector must insure that the reinforced fill does not become over-saturated during or after wall erection. The reinforced fill should be sloped to provide drainage away from the face of the wall after each day of construction. Proper drainage should be maintained to prevent water intrusion from the front of the wall and the sides. Propagation of water in the backfill material may also alter the gradation by removing fines. Water intrusion or over-saturation will cause the MSE structure to become distorted or to destabilize and fail. Special care must be exercised during rain events to insure proper drainage and prevent erosion of the reinforced soil. Backfill material that becomes eroded or over-saturated should be replaced with new material conforming to the shop drawings, contract plans and/or contract specifications. SSL does not design drainage.

FINISH GRADE PLACEMENT

In most cases the bottom two feet or more of the MSE wall is buried below finish grade. The area in front of the wall is graded level with the bottom of the wall during construction, but should be filled in before wall erection reaches 20 feet (6.10 meters). Refer to the shop drawings, contract plans, and/or project specifications for additional requirements. Typically finish grade at the base of the wall should form a 4 foot (1.22 m) "bench" with a 2 percent minimum slope away from the wall. Proper drainage at the front of the wall should be maintained during and after wall erection to prevent the damage and/or failures described above. Special materials and/or measures may be required to prevent undercutting of the reinforced fill. After finish grade below the wall has been established, the contractor or wall erector should not proceed with any additional excavation in this area without permission in writing from the Engineer of Record (EOR) and/or SSL.

INSTALLATION SEQUENCE

STEP ONE

1. Excavate foundation to grades, lines and widths as shown on the project shop drawings.
2. Prepare foundation using proof-rolling or other means as specified in contract documents.
3. Pour leveling pad as shown on the project shop drawings (typical leveling pad shown).

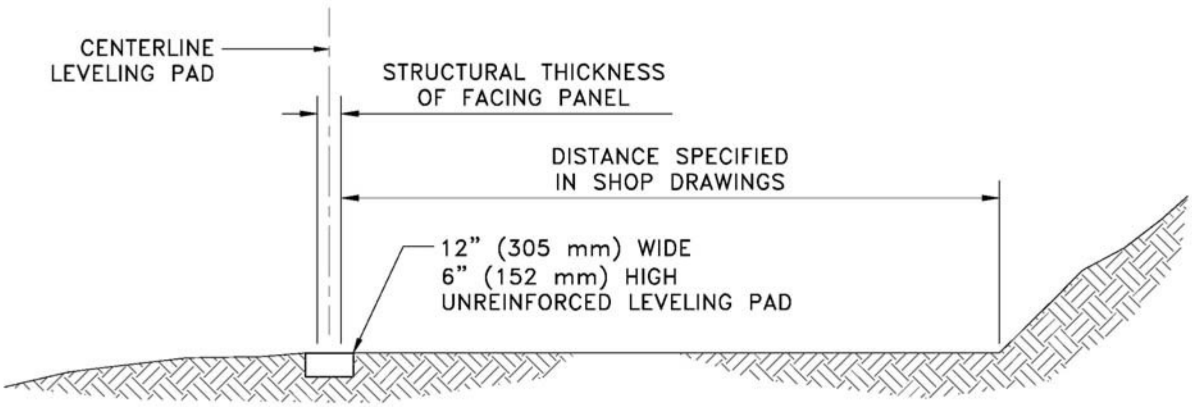

Figure 25: Installation Step One

STEP TWO

1. Place appropriate concrete fascia panels and align to the proper position.
2. Use wood wedges where necessary to level the top edge of panels and to batter panels.
3. Brace panels with temporary bracing as determined by contractor.
4. Attach filter fabric to the back face of panels at panel joints.

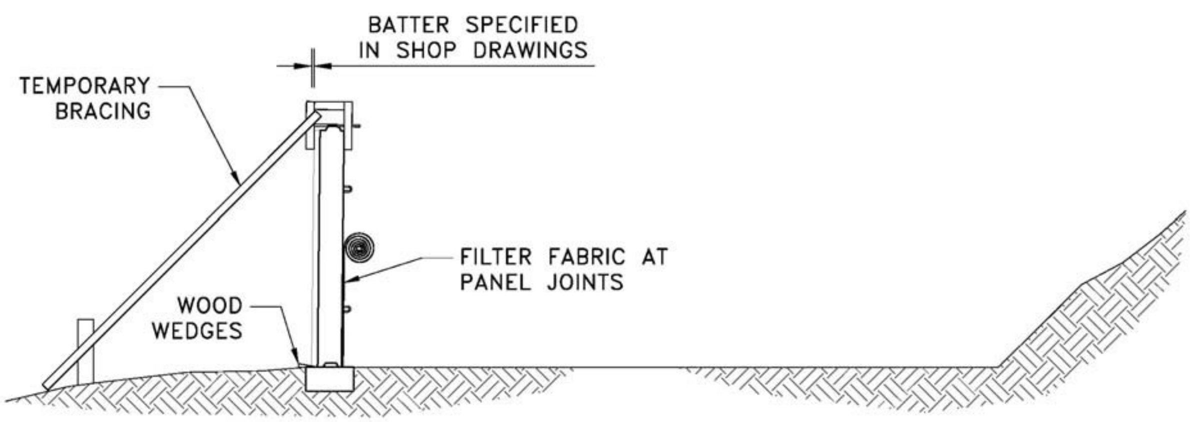

Figure 26: Installation Step Two

STEP THREE

1. Place the first lifts of select backfill.
2. Compact each lift of backfill according to project specifications.
3. Test backfill for compaction, gradation, etc. as directed by project specifications.
4. Continue backfill installation up to the level of the lowest embed loops of the facia panels.

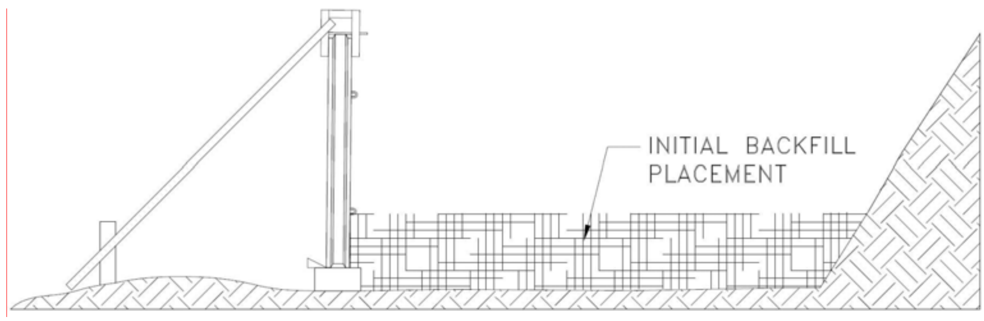

Figure 27: Installation Step Three

STEP FOUR

1. Select appropriate soil reinforcement for the bottom layer.
2. Modify mesh where necessary for non-standard width panels or obstructions.
3. Connect soil reinforcement to fascia panels with connection pin.
4. Tension mesh away from panels without distorting wall face.

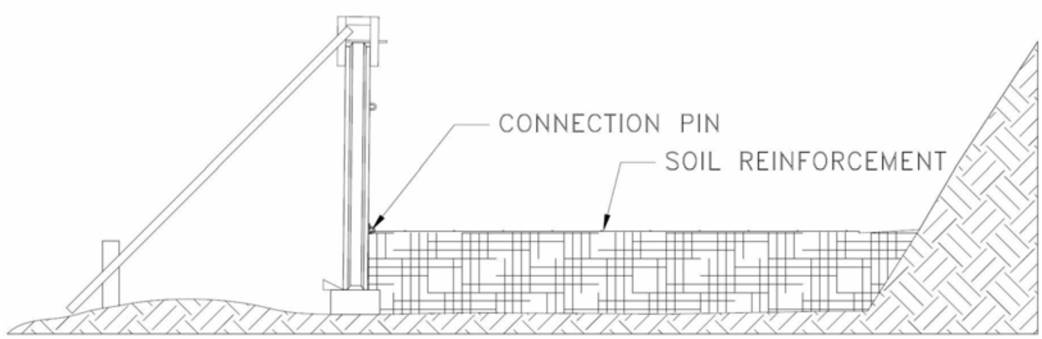

Figure 28: Installation Step Four

TOC – Appendix

STEP FIVE

1. Place additional lifts of select backfill to the elevation of the next layer of soil reinforcement.
2. Compact each lift of backfill according to project specifications.
3. Test backfill for compaction, gradation, etc. as directed by contract documents.
4. Continue installation of filter fabric.

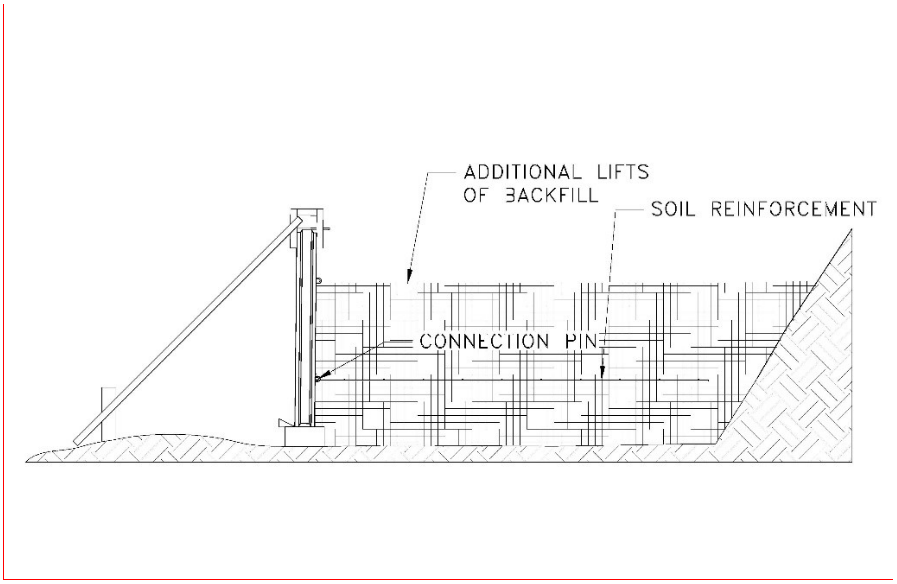

Figure 29: Installation Step Five

STEP SIX

1. Select appropriate soil reinforcement for the current layer.
2. Modify mesh where necessary for non-standard width panels or obstructions.
3. Connect soil reinforcement to fascia panels with connection pin.
4. Tension mesh away from panels without distorting wall face.

Note: Check to insure that the proper batter is maintained at the face of the wall

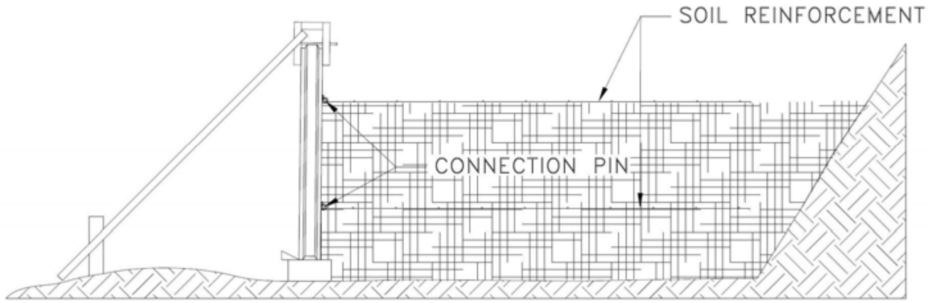

Figure 30: Installation Step Six

STEP SEVEN

1. Place additional lifts of select backfill to the elevation of the next layer of soil reinforcement. Leave void behind panels up to the second layer of mesh.
2. Compact each lift of backfill according to project specifications.
3. Test backfill for compaction, gradation, etc. as directed by contract documents.
4. Continue installation of filter fabric.

Note: Check to insure that the proper batter is maintained at the face of the wall

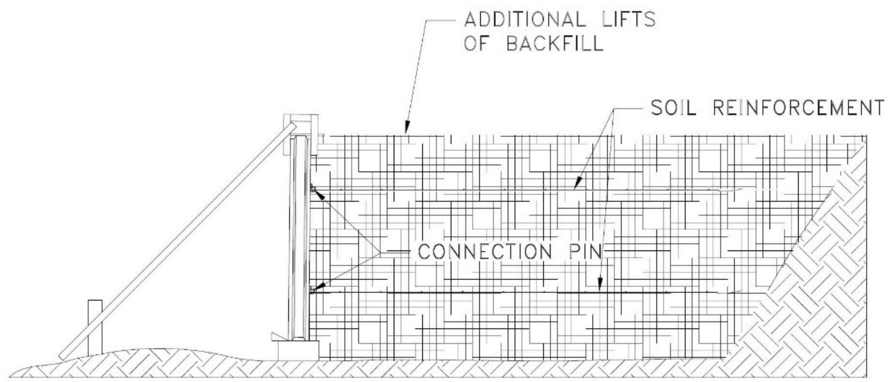

Figure 31: Installation Step Seven

STEP EIGHT

1. Glue bearing pads to top surface of bottom row of fascia panels. Refer to shop drawings for the number and placement of bearing pads.
2. Place appropriate panels above the first row.
3. Clamp panels to adjacent panels.
4. Remove temporary bracing only when backfill reaches top edge of bottom panels.

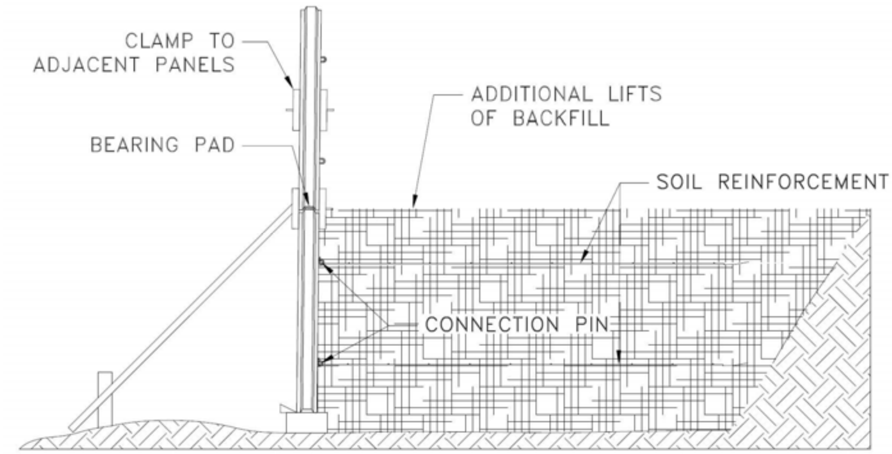

Figure 32: Installation Step Eight

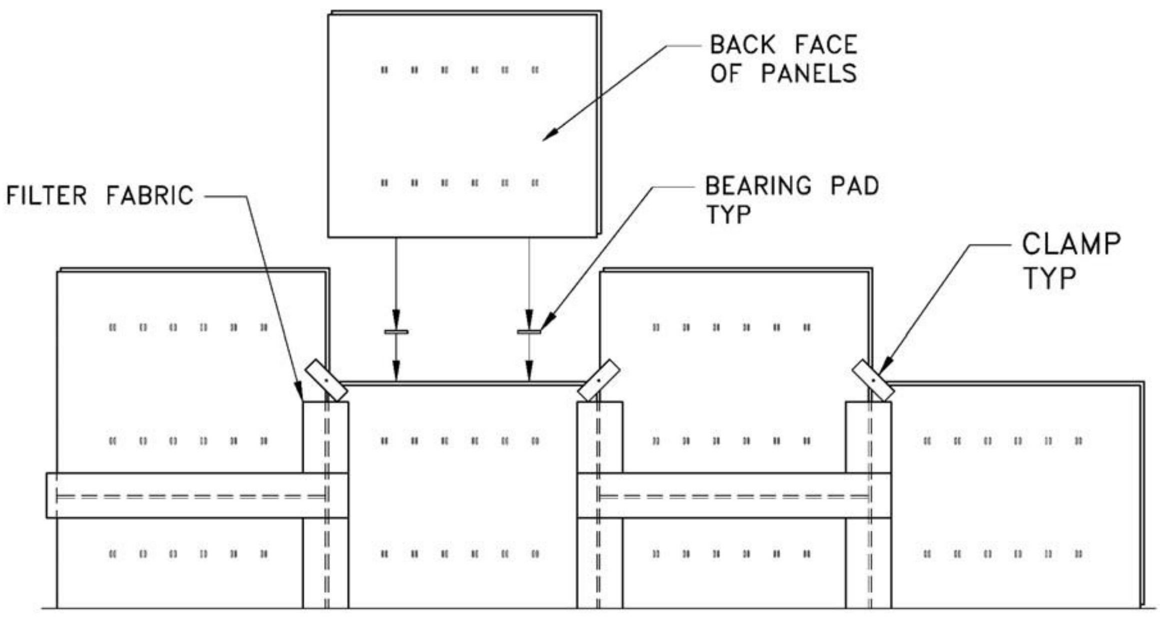

Figure 33: Installation Step Eight Back View

STEP NINE

1. Continue installation of backfill and soil reinforcement per steps 5-7.

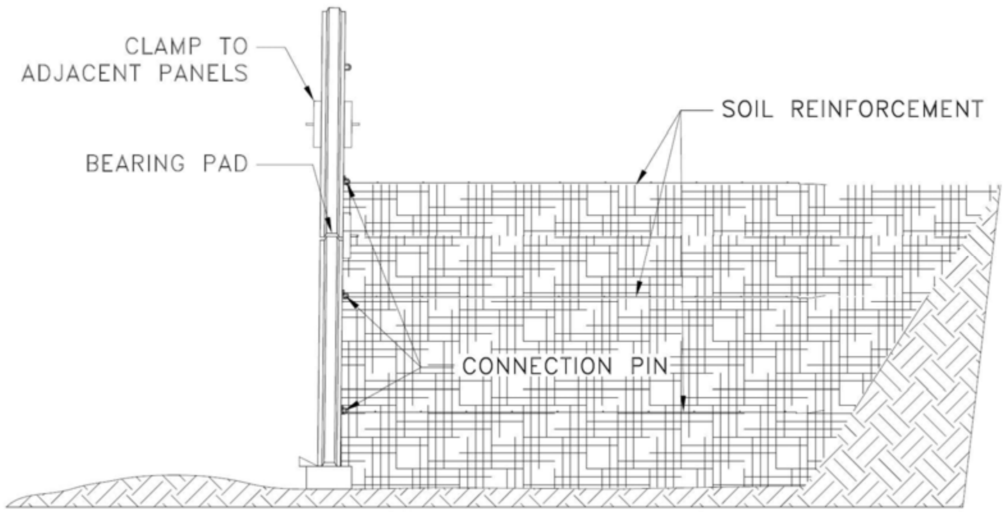

Figure 34: Installation Step Nine

Note: Insure that the proper batter has been achieved at the face of the wall

Note: Compaction within the 3' (1 m) zone of the wall face shall be compacted with at least 3 passes of a lightweight mechanical tamper, roller or vibratory system. Insure that proper compaction is achieved without distortions at the front face of the wall.

STEP TEN

1. Continue panel placement per step 8.
2. Monitor batter along wall as pressure of backfill pushes panels out.
3. At top of wall, install coping or barrier slab as directed by contract documents.

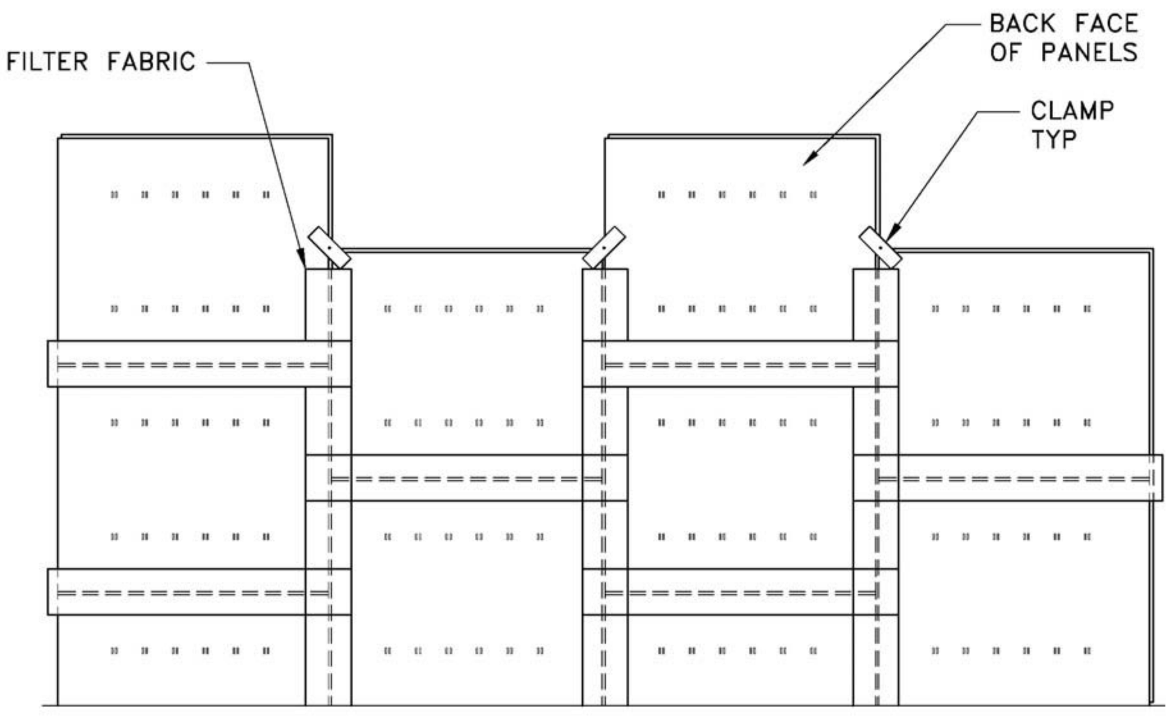

Figure 35: Installation Step Ten

Note: Insure that the proper batter has been achieved at the face of the wall

Note: Compaction tests should not be performed within the 3' (1 m) zone of the wall face.

WALL ERECTION CHECK LIST

1. Yes ☐ No ☐ Do you have an approved copy of shop drawings?

2. Yes ☐ No ☐ Do you have backfill test certifications?

3. Yes ☐ No ☐ Do you have material test certifications?

4. Yes ☐ No ☐ Does the wire mill have material manufactured and inspection certifications?

5. Yes ☐ No ☐ Does the galvanizer have galvanization certifications?

6. Yes ☐ No ☐ Is all material on site?

7. Yes ☐ No ☐ Is material stored properly to prevent onsite damage?

8. Yes ☐ No ☐ Has damaged material been recorded and a copy of rejected material given to suppliers?

9. Yes ☐ No ☐ Is the foundation excavated and proof rolled per the specifications and geotechnical report to the required width and elevation?

10. Yes ☐ No ☐ Has unsuitable material been compacted or removed and replaced?

11. Yes ☐ No ☐ Is the bottom row of panels properly placed, aligned and battered?

12. Yes ☐ No ☐ Is the first row of soil reinforcing mesh attached properly?

13. Yes ☐ No ☐ Are the required number of soil reinforcing mesh and the correct type being used?

14. Yes ☐ No ☐ Is the filter fabric being attached properly?

15 Yes ☐ No ☐ Are the bearing pads being placed properly between the panels? Are the correct number of pads used for each case?

16. Yes ☐ No ☐ Is the equipment being kept off of the grid until at least 6” of material is placed?

17. Yes ☐ No ☐ Is proper compaction being met in accordance with project specifications? Compaction to be minimum 95% of maximum density. Compaction to be 100% under bridge abutment spread footings.

18. Yes ☐ No ☐ Are obstructions to the soil reinforcement or other special situations met according to the details shown in the shop drawings?

19. Yes ☐ No ☐ Is the vertical and horizontal alignment of the structure being checked periodically?

20. Yes ☐ No ☐ At the end of each days operation is the reinforced volume being protected from runoff and saturation?

SAMPLE INSTALLATION PHOTOS

Sample Installation Photo 1: Handling of Precast Panels

Sample Installation Photo 2: Connecting Soil Reinforcement

Sample Installation Photo 3: Completed Soil Reinforcement Connection

Sample Installation Photo 4: Placement of Reinforced Fill

Sample Installation Photo 5: Compaction of Reinforced Backfill

Sample Installation Photo 6: Nearly Complete Wall Installation

PROJECT NOTES

INNOVATIVE CONSTRUCTION PRODUCTS

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Section 4: QUALITY CONTROL

4.1
Manufacturing

4.1.1 Facing Unit QA/QC

Precast Solutions, Inc.

Quality Control Manual

Date of Issue: 9/07/06
Revision 1: 9/30/07
Revision 2: 12/12/07
Revision 3: 4/24/09
Revision 4: 2/24/12
Revision 5: 7/6/15
Revision 6: 12/10/15
Revision 7: 6/20/17
Revision 8: 6/18/18
Revision 9: 12/19/18
Revision 10: 7/24/19
Revision 11: 1/9/2020
Revision 12: 1/7/2021
Revision 13: 1/21/2022

PSI
Precast Solutions, Inc.

Prepared by: David C. Sweet

QUALITY CONTROL MANUAL

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1. PRECAST SOLUTIONS, INC. CONCRETE QUALITY POLICY STATEMENT:

To assure that the materials, fabrication and workmanship is satisfactory to our customers, the Owners, Management and Employees of ***PRECAST SOLUTIONS, INC. Precast Solutions, Inc.*** *shall comply with the requirements specified in this manual.*

1.a General Information, Key Contacts & Suppliers

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ocation:	Precast Solutions, Inc.
NPCA Member	6145 S. Indianapolis Road
	Whitestown, IN 46075
	Phone: 317-545-6557
	Fax: 317-545-6558
Main Contact Person:	Dave Sweet
Email Address:	dsweet@precastsolutions-inc.com
ACI Certified Technicians:	Alberto Teran Concrete Strength Testing Technician- Pending Test Results PQS-Level I- Signed up for class, pending start ACI- Field Testing Technician- Level I- Expires December 03, 2026
	Mike Sweet Concrete Strength Testing Technician- Pending Test Results PQS-Level I- Signed up for class, pending start ACI- Field Testing Technician- Level I- Taking Class February 2022
	Carmelo Franco PQS-Level I- Signed up for class, pending start ACI- Field Testing Technician- Level I- Taking Class February 2022
	Dave Sweet ID# Expires May 27, 2024 Concrete Strength Testing Technician
	Jose Sanchez Concrete Field Testing Technician- Grade 1, Taking Class February 2022
	Ben Winkles Concrete Field Testing Technician- Grade 1, Taking Class February 2022
PQS School Graduate:	David Sweet, John Davis, Britt Burtner, Bob Williams,
PCI Level I, 2 & III Graduate:	Dave Sweet
Products Manufactured:	Telephone Equipment Mounting Pads, MSE Wall, Box Culvert Flush to Grade Utility Vaults, Grease Traps, Fire Protection Vaults, Sound Walls, Architectural Precast Products, Lintels, Sills, Copings, Wall Caps, Stair Treads, Splash Blocks, A/C Pads, Custom Precast
Manufacturing Start- Up date:	October 1998
Concrete Batch Plant:	Mixer Systems

Ready-Mix Concrete Suppliers:	Bluestar Ready-Mix-Whitestown, IN Concrete Industries, Whitestown, IN Prairie Materials, Lebanon, IN
Testing Laboratory:	ATC Associates 7988 Centerpoint Dr., Ste 100 Indianapolis, IN 46256 Gordon Pickett, Manager PRECAST SOLUTIONS, INC. In-house testing ability

2. Organizational Responsibilities

John Davis
President/CEO
Corporate Secretary & Treasurer

Dave Sweet
Vice President of Operations
Engineering, Technical Services,
Specifications, Documentation and Certifications
Plant Safety & Quality

OPEN
Production/Shipping Manager

Alberto Teran
Quality Control Manager

Jose (Lalo) Sanchez
Production Supervisor

Reinforcing Steel Suppliers:	Harris Supply- a NUCOR Company 1700 7th. Avenue Suite 2100 Seattle, WA 98101 Liberty Steel and Wire Peoria, IL
Aggregates:	Prairie Materials- Indianapolis, IN Martin Marietta- Carmel, IN
Chemical Admixtures:	BASF Products
Certifications:	Material Test reports and/or certificates of compliance

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3. DE… OF RESPONSIBILITIES FOR QC PERSONNEL

3.0 QC Personnel consist of a Quality Assurance Manager (responsible for scope of QC program), Quality Control Technician, Production Manager (manages QC plan in precast), Production Supervisor (executes QC program in precast), Product Manager (specifies products), Concrete Testing Technicians (QC testers).

4. DESCRIPTION OF TRAINING REQUIREMENTS FOR QC PERSONNEL, PRODUCTION STAFF, FORKLIFT OPERATORS AND DRIVERS.

4.0 The QC Manager will attend and pass the National Precast Concrete Association Production and Quality Precast School as well as the ACI Concrete Field Testing Technician, Grade 1 School and Concrete Strength Testing Technician Course.

4.1 The Testing Technician(s) will maintain the ACI Concrete Field Testing Technician, Grade 1 and The PQS Level 1 School.

4.2 The Plant Production Supervisor will review Forklift Safety Practices with the personnel who are driving forklifts in our plant. Safety meetings will be held monthly to address other equipment and procedural safety issues.

5. HOUSEKEEPING PLAN

5.0 Precast Solutions, Inc. will keep the plant clean by sweeping daily, to keep the floors clear from aggregate and concrete mix. Tools and molds will all be assigned storage spaces and are to be kept in those spaces when not in use. Walking areas will be kept neat and free from hazards.

The personnel will keep parts and tools in their assigned storage spaces to eliminate tripping hazards and ensure tools are readily found when needed.

Forklifts will be parked with forks on the ground, with gas canisters turned off. At the end of the day, forklift keys will be removed and put in the lockbox.

6. PRODUCTION PRE, POST AND FINAL INSPECTION PROCEDURES

6A. PRE-POUR CHECKLIST

6A.0 The Production Manager will confirm the production schedules. The schedule will be updated daily on the project production board displayed in the production area.

6A.1 The Production Supervisor will use the daily schedule (Exhibit #3) to verify that pre- pour inspection checkpoints are assured and note and correct any deficiencies. Each checkpoint will be verified with a checkmark on each day's production. Quality Control will review the checklist and discuss any deficiencies found with setup personnel to insure problems are minimized. Proper rebar placement will be checked on one piece daily.

6A.2 Checklists will be returned to the Q. C. Manager weekly. This document will become part of the production file that is maintained in the Q. C. Manager's office.

6B. POST-POUR CHECKLIST

6B.0 Post-pour checklist is included on the same document as the pre-pour checklist. Issue and completion is the same as the pre-pour checklist.

6B.1 If deficiencies are found, they will be noted on the "Post-pour Checklist (Exhibit 3). The Q.C. Tech/Product Manager will confirm all repairs are completed satisfactorily.

The product is removed from the form and is inspected. If this is not part of a group/lot (same part, same formula and to be shipped on the same pallet) it will be identified with date and/or name. If the item is part of a group to be added to an existing order of like products, the pallet of like parts will be identified with the project name or a color code for the entire pallet. Some short run parts may be added to Precast Solutions, Inc. inventory as a normally stocked item; these will not be marked. After the visual quality inspection and tolerance check (if not previously verified), the product will be transported to a temporary storage location.

6C. FINAL INSPECTION

6C.0 As products are wrapped and strapped for shipping, a final inspection will take place to be sure the products are free of defects and are stacked for safe shipping. If defects are found, that item will be removed from the pallet and set aside for repair or replacement. The QC Technician and/or Plant Manager will perform the final inspection.

7. PLANT CURING PROCEDURES FOR ALL SEASONS

7.0 During warm weather months, concrete shall be covered overnight, then placed outside after stripping from its mold.

7.1 During cold weather months, concrete shall be covered (to hold heat and moisture, with winter blankets if needed) and left overnight indoors, when feasible, then placed outside after stripping from molds and achieving a minimum strength. If outside overnight temperatures are to be below 20 degrees F or over 80 degrees F, additional time will be added with the product covered and kept inside before moving product outside to insure adequate initial strength.

7.2 If outside temperature appears to be too high or low for standard curing procedures, as noted in 7.1, we will verify overnight in plant curing temperature to determine if products should be removed from molds. This temperature is recorded by Quality Control personnel each morning as the plant is opened.

8. MINIMUM STRENGTH REQUIREMENTS FOR STRIPPING AND SHIPPING PRODUCT

8.0 Unless instructed otherwise by specific customer requirements, a minimum of 1500 psi is required before stripping and 2500 psi is required before shipping products.

9. PRODUCT REPAIR POLICY AND PROCEDURES

9.0 If the needed repair is purely cosmetic, defect will be corrected during the stripping process. If it is structural, the production supervisor and/or product manager will determine the repair approach and see that it is performed. A customer may request specific repair materials to be used on their manufactured products.

10. PRODUCT TOLERANCES

10.0 All products shall be manufactured within tolerances specified on shop drawings and/or blueprints supplied by the customer.

11. FORM TOLERANCES AND MAINTENANCE POLICY

11.0 During the stripping process, forms will be visually checked for defects and if found, noted on the Post-pour portion of the Daily Production Status Report form (Exhibit 3) and/ or taken directly to the shop for the required repair or possible replacement.

11.1 Forms shall be cleaned thoroughly after each use to ensure that release agents will not build up and that joints between form parts will remain sealed. Forms that will not be soon used again will be stored (upside down if possible) in a designated area.

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12. M[illegible]UALIFICATION AND TESTING PROCEDURES

12.0 Concrete mix is supplied by the batch plant equipment or by a local approved ready-mix plant. Cement shall be type I or III and shall conform to the requirements of AASHTO M-85. Concrete mix for INDOT shall have a compressive strength at twenty-eight (28) days of 4000 psi. The concrete for ODOT shall have a compressive strength of 4500 psi at twenty-eight (28) days.

12.1 Compressive strength testing shall be performed as required for production lots. Documented mix designs from Precast Solutions, Inc. or supplied by local ready-mix plant technicians are maintained by the Production manager and are available upon request. The appropriate mix design shall be submitted to the State DOT or authorized representatives for approval, when required, prior to the start of any project.

Precast Solutions, Inc. Batch Plant utilizes formulas appropriate for specific customers and products, with compressive strengths from 4000 psi to 9000 psi.

12.2 During the batch plant mixing cycle, a plastic properties test shall be conducted to determine the slump, air content, and temperature and will be executed near the point of placement, to assure the concrete meets applicable specifications. Data recorded by Q.C. technician will include the following:

a) Slump: 3” - 8” or job specific.
b) Concrete temperature: 50 min. – 90 max.
c) Air Content: 3-8% or job specific

12.3 All of the above data is captured once each day for each formula used in the batch plant. It is recorded on the Precast Solutions, Inc. Concrete Testing Report form (Exhibit 2) and turned in to the Quality Control Manager upon form completion.

12.4 Entrained air testing shall be performed with a type “B” pressure meter according to AASHTO T-152/ASTM C-231. Equipment shall be calibrated quarterly and records maintained in the calibration file.

Testing personnel shall maintain an ACI Concrete Field Testing Technician – Grade 1 Certification.

Air Specifications by state are as follows:

1) INDOT - 6 ½% ± 1 ½%
2) OHDOT - 6 % ±2 %
3) PENDOT – 6% ± 2%
4) WVDOT – 7% ± 2 ½%
5) SCDOT - 3% - 5%
6) KYDOT – 6% -± 2%
7) NCDOT – 4 ½% ± 1 ½%
8) VDOT - 6 ½% ± 1 ½%
9) MDDOT - 5% - 8%
10) IDOT - 5-8%

Note: Specifications are after aggregate correction factor

Formula - 6000	**6000 psi**		
Ingredient	Cu. Yard	u/m	
Cement Type III	658	lb	
Coarse Pea Gravel	1800	lb	
Fine sand	1165	lb	

Water	262	lb	
Air (AE260)	3.45	oz	
Super (SP - MNC)	110	oz	
	Super is 16 oz per 100 weight cement		
Formula - 4000	**4000 psi**		
Ingredient	Cu Yd	u/m	
Cement Type III	517	lb	
Coarse Pea Gravel	1676	lb	
Fine sand	1550	lb	
Water	215	lb	
Air (AE260)	2.6	oz	
Super (SP - MNC)	60	oz	
Fiber	1 lb	27 cu ft	

12.4 CONCRETE SAMPLING

12.4a All samplings will be obtained at the discharge end of the chute or concrete hopper.

12.4b ACI and ASTM Specifications require fresh concrete and compression testing every 150 yd³ for each mix design. PSI's requirement is every 50 yd³ for each mix design.

12.4c Cylinders will be 6" X 12" if required for DOT jobs if necessary, and 4" X 8" for other precast jobs, prepared in accordance with AASHTO T-141 or ASTM C31/C31M-03a.

12.4d Acceptance of the concrete products, with respect to compressive strength, shall be determined on the basis of production mix design.

12.4e PSI will obtain compressive strength sampling and testing for each production mix design. A strength report will be supplied by PSI or ATC.

12.4f A set of compressive strength samples shall consist of a minimum of 4 (four) cylinders. This allows samples to be tested at several intervals. Box culverts require 6 cylinders minimum.

12.4g Compressive strength cylinders shall be cured in the same manner as the products.

12.5 COMPRESSIVE STRENGTH CRITERIA

12.5a Compressive strength tests shall be performed on test cylinders in a size driven by customer requirements. Currently six (4) inch diameter by twelve (8) inch tall cylinders are approved by INDOT when prepared in accordance with AASHTO T-23. Other jobs may only require (4) four by ght cylinders, with the same testing procedure. Some jobs may also have different strength requirements and will be tested as requested by client or customer.

12.5b The initial strength of the concrete at seven (7) days will be determined by compressive strength testing in accordance with AASHTO T-22. The samples must meet or exceed the mix design strength on or before twenty-eight (28) days. Minimum strength shall be 4000 p.s.i. (27.6Mpa) for DOT projects (IDOT requires 4500 psi). Each quarter, PSI will complete 1-day strength testing, to confirm de-molding strength in that season is appropriate.

Compressive strength shall be established by a two (2) cylinder average at each testing. PSI will prepare cylinders for compressive strengths utilizing concrete test specimens based on ASTM C 172 and ASTM C31. These test samples will then be taken to: ATC Associates Inc. testing lab (Indianapolis, IN) for compressive strength testing, or tested in-house with CGM compressive strength testing equipment.

12.5c For DOT strength testing requirements, if the initial strength test result indicates a compressive strength greater than or equal to 4000 psi (or 4500 psi for IDOT), then this test result will be utilized as the compressive strength test result for that production mix design and the requirements for additional testing will be waived. A twenty-eight day break will still be made unless previous tests have met our customer's strength requirements.

12.5d Acceptance of a production mix design will be made if compressive strength test result is greater than or equal to the requirements of our customer. The average of both tested cylinders must exceed the minimum required design strength.

13. RAW MATERIAL TESTING POLICY AND PROCEDURES

13.0 Raw materials, such as gravel and sand, will be checked visually and mill certificates will be collected and filed in the materials records book.

13.1 All materials used for fabrication shall meet the requirements specified by the contract documents and approved drawings submitted for fabrication by customers/clients of Precast Solutions, Inc.. Materials not conforming to contract documents shall not be used without the written consent of the designated State or project authority.

13.2 Reinforcing steel shall meet the requirements of ASTM A-615 or A-706 Grade 60 as required by customer. All reinforcing bar is purchased from one or more of the approved Certified Reinforcing Bar Producers from the IDOT list dated 10-5-07. Steel shall be purchased from suppliers listed in Section 1 of this manual. Rebar size and details shall be determined by approved drawings or requests of customers. Standard rebar jigs may be used to insure the consistent conformity of rebar mats. Material certification shall be maintained in the project file in the Quality Control Manager's office and available upon request. Epoxy or fiberglass rebar is used as requested per project specification.

13.3 Moisture testing for fine aggregates: We follow the standard test method outlined by ASTM Designation: C566 – 97. This approach allows for a sample from the discharge area of the bulk fine aggregate storage bin of a known quantity to be weighed, heated (we use a hot plate) and weighed again to determine the percentage difference from the moisture removal. We determine the mass of the dried sample to the nearest 1% after it has cooled sufficiently. This new moisture percentage is then factored into the plant batching for that particular day unless a different aggregate source is introduced. If the aggregate source changes, we will retest for current moisture content.

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14. E[illegible] CALIBRATION POLICY AND PROCEDURES

14.0 Certificates of Calibration will be kept in the Quality Control Manager's office.

Testing equipment to be calibrated:

Annually shall include-

a) Compressive Strength Test Machine
b) Unit weight Scales (*DigiWeigh* model DW-65, digital scales)
c) Reference Thermometer (*Instant Read* model #46430, Digital Thermometer)
d) Admixture Dosing Equipment (BASF)

Quarterly shall include-

a) Air Meter (Forney LA-0316) shall be calibrated every three (3) months per ASTM C231 Section A1.9, type "B" Air Meter and documented on Air Meter Calibration Record (Exhibit #12)

Checked visually daily shall include-

a) Slump Cone (ELE model EI34-0108) – visual check for dents & out of round
b) Single Use Plastic cylinder molds – visual check each time used

*Please see attached Precast Solutions, Inc QC Performance Timeline for additional requirements.

15. PRODUCT PERFORMANCE TEST POLICY AND PROCEDURES

15.0 Precast concrete products shall meet all requirements for function, dimension(s), design, color (if specified) and strength to meet customer's order request.

15.1 The mold shall be checked in detail after its construction and before the first unit is made. A complete check of the first product from the mold is further verification of the adequacy of the mold. Checking correlating product inspection of appearances and dimensional tolerances to the form is only feasible where an element can positively be identified with the specific form in which it was cast.

16. EXAMPLES OF ALL DOCUMENTATION AND FORMS USED BY PLANT TO RECORD QC AND PRODUCTION PROCESSES

EXHIBIT NO.	TABLE OF CONTENTS - DESCRIPTION
1	Batch Manufacturing Schedule – Daily plan and mix sizes
2	Precast Solutions, Inc. Concrete Testing Report – testing data
3	Precast Solutions, Inc. Daily Production Status Report – pre-pour, post-pour inspection
4	Precast Solutions, Inc. Unit Weight & Yield of Concrete Report – test data
5	Precast Solutions, Inc. Aggregate Moisture Record
6	Bill of Lading – Short Form

17. DOCUMENTATION OF PRODUCTS MANUFACTURED UNDER FRANCHISE AGREEMENTS, INCLUDING ALL DESIGN SPECIFICATIONS AND DRAWINGS.

17.0 At present, we do not have any franchise agreements. When applicable, they will be filed with design specifications and drawings for easy reference, with an additional set of drawings available to plant supervision personnel.

17.1 Control of product drawings, when provided, shall be maintained by the Product Manager. Master copies are maintained in the project file. Drawings are dated and marked upon receipt. Drawing transmittals are maintained in the project file. New release or revised drawings are hand-carried to affected personnel and outdated drawings are removed and destroyed. Product Manager will VOID the old master set, marking as such, and maintain VOID drawings with project records. All project records will be stored and maintained for a period of three (3) years unless requested to do otherwise.

18. FORMS PREPARATION

18.0 Forms shall be thoroughly cleaned and free from dirt, debris and concrete scale. Once accomplished, the inner portion (all interior surfaces) that will be in contact with the concrete mix, shall be applied with an evenly distributed, uniform coat of release agent, while minimizing any puddling on the form face. This will assist with the stripping process and facilitate the production of a defect-free concrete surface, while improving the working condition of the form. All block-outs are made of a rigid, non-absorptive material that will not harm concrete and will be held firmly in place during the casting and curing process. Block-outs will be made to customers' specific tolerances, if required.

18.1 After cleaning, each form will be set up to meet the specific product demand. This includes the placement and securing of headers to create special parts, cable block-outs, placement of the rebar, positioning of lifting inserts and location devices to locate attachment hardware. Care shall be taken, by the use of rebar chairs, to insure there is no contact with the release agent to the reinforcing steel. The supervisor will complete the Pre-pour checklist (Exhibit 3) for all molds included in each day's casting. Products with specified rebar placement will be checked for proper installation of rebar sticks or cage. Cages will utilize rebar ties or welding, whichever is appropriate for the particular job, or detailed in the product plans and drawings. If epoxy-coated rebar is used, care will be taken that the bars are repaired with patching material,

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poxy become damaged or removed due to cutting and bending. Referral to the reference manual, "Placing reinforcing Bars" by by Concrete Reinforcing Steel Institute (CRSI), will clarify rebar placement. All special product demands and materials will be clearly illustrated on the approved shop drawings and will be available to the person who is charged with setting up that particular form. The approved production drawings are issued by the Product manager.

19. CONCRETE PLACEMENT/FINISHING/CURING/MARKING

19.0 The concrete mix will be batched at the Precast Solutions, Inc. batch plant or at a local ready-mix plant (if truck delivered). The ready time is approximately 10 minutes for Precast Solutions, Inc. plant or approximately 30 minutes for ready-mix.

19.1 The concrete mix will be deposited into the forms directly from the bucket or chute at close proximity. The concrete shall be placed via use of shovel, trowel or scoop to insure proper concrete volume, as required to fill remaining voids within each respective mold.

19.2 As a form is being filled, or immediately afterwards, the concrete will be consolidated via the use of vibration. Vibration shall be continued until proper consolidation has occurred. The vibration will be minimized to prevent possible segregation of aggregates.

19.3 The exposed back surface of the precast item will be vibrated to level or rough floated to remove any remaining high or low surfaces, if required.

19.4 If required, upon concluding the vibration/ troweling operation, each item shall be marked on the exposed concrete surface with the cast date. On certain parts a surface description may be required; if so, we will place marking on an area out of view during final placement of concrete part. This part marking will insure the proper tracking of the product.

19.5 After any required identification markings, a curing method will be used to meet any applicable project specifications. Covering products with blankets, or use of curing compound(s) are available.

19.6 The cast products will remain in the form for a minimum of fifteen (15) hours. One (1) day compressive strength cylinders shall be made and tested once every quarter to document stripping strength. Minimum acceptable stripping strength is 1500 p.s.i.

19.7 Proper rebar placement is required. For products with specified reinforcement, plans will be followed. Where no customer specifications are required, but reinforcement will be used as a precaution against breakage, we will use Grade # 60, #4 rebar straights placed at least ½" below concrete finishing surface. Rebar length will be at least 2" shorter than the length or width of the mold. Care will be taken to keep end of rebar from the side of the mold. Typically 2 rebar straights will be placed into sills and or wall caps, depending on their size.

19.8 Embedded items will be placed per job drawings, unless they are placed for ease of de-molding, in which case they will be centered in the most useful way. Either templates or measuring will determine proper placement.

20. STRIPPING/STONING/REPAIRING/STORING

20.0 The following morning, after the previous day's pour, the forms will be stripped. After the product is removed from the form, it will be visually inspected for any voids or defects. If any deficiencies are identified, the piece will be tagged or set aside and a repair will be made during that production day. Supervisors will complete a "Post-pour Checklist" (Daily Production Status Report, Exhibit 3 of this manual). Any repair failing to satisfy our quality inspection will be marked as a reject and taken to the reject storage area. A replacement will be cast timely, as not to interfere with shipping schedule commitments. Rejected pieces will be indicated as such on the project documentation.

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ual quality inspection and tolerance checks, the product will be stoned with rubbing bricks and any small holes filled. These parts will then be loaded on a pallet and moved to a temporary storage area or if the pallet is complete, it will then be first wrapped and strapped and then moved to the storage area.

21. HANDLING, STORAGE, SHIPPING

21.0 All products shall be handled, stored and shipped in such a manner as to minimize the danger of chipping, cracks, fractures, and excessive bending stresses. All products shall be stored on pallets unless otherwise directed by customer. Any product that is to be stacked will utilize wood or foam spacers. This "spaced" stacking may not apply to small items. A designated staging area at Precast Solutions, Inc. extends along the south edge of our fenced property. This paved area is used to accumulate all parts for specific shipments. Additional long term storage is provided on the graveled, level areas of the yard.

21.1 Three forklifts (8,000, 8,000 and 10,000 lbs.) are on-site to move all products safely inside and outside of the plant. There are also a number of overhead cranes/hoists to assist with the safe lifting of pre-cast products. Lifting equipment is visually checked each time before use. Maintenance records are filed in the office.

22. ACCEPTANCE PACKAGE TRANSMITTAL

22.0 We will provide the following project information as a packet upon request:

a) Mix Design
b) Reinforcing Steel Certifications
c) Attachment Hardware Certifications
d) Cement Certifications
e) Aggregate Report – Coarse (pea gravel)
f) Aggregate Report – Fine (#23 sand)
g) Compressive Strength Report
h) Daily Production Report

23. SHIPMENTS/SHIPPING DOCUMENTS

23.0 Precast products will be shipped by a commercial freight line as requested by client or customer. If no method of shipping is provided, PSI will seek the most competitive professional means of shipping each product, given size and time requirements. We employ the use of proven commercial LTL and flatbed carriers. Shipping records and "bills of lading" records, which are attached to customer invoices, will be kept in files at PSI for a minimum of one year.

Batch Manufacturing Schedule 2021

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Thursday, November 11, 2021

Production	QTY	WT	YDS	QC	NOTES	CODE	PRIORITY
MSE							
21-4010 - NORTH SPLIT - SSL 5X10	24	99,063	24.46				
21-4010 - corner North Split no slag							
21-4010 Coping Superior no slag		0	0.00				
21-4012 Milestone step liner with slag	1	4,536	1.12				
21-4013 Milestone step liner	7	22,964	5.67				
21-4012 Milestone slick liner							
21-4013 Walsh stone with slag	6	28,188	6.96				
21-4013 Walsh Corner with slag							
21-4012 Coping Walsh with slag		0	0.00				
		0					
						38	38.21
UTILITY							
21-6083 Man Hole Riser 2"	3	81	0.02		QTY 29		
21-6083 Man Hole Riser 4"	1	81	0.02		18		
Stock - 4" riser square	1	203	0.05				
21-6082 - WESTHAVEN TREAD	2	405	0.10		QTY 192 Penetron		
21-6033 - RW MARKERS	5	1,316	0.33		QTY 200		
20-6052 - PORSCHE							
20-6011 30" KO Box	1	2,025	0.50				
20-6011 42" KO Box	1	3,038	0.75				
21-6083 - Propane tank pads	20	1,215	0.30		250 required		
VAULT							
21-2104 BHI Base slab	1	8,796	2.20				
21-2104 BHI Lid							
Strip Popeye's 1500 GT- Walls	0	11,376	2.80				
Strip Popeye's 1500 GT- Lid		0					
Strip Airport Walkway Base & Walls		0					
Frito Lay Lid- strip		0					
BOX CULVERT							
Strip 21-3017-1 Box Culvert							
21-3017-2 Box Culvert - Tippecanoe County PrePro Set up	1	40,905	10.10		10 pcs 10.1 yds each		
ARCHITECTURE							
Organize foam							
Clean outside south side outside carpenter bay							

	Plan	Actual	% Goal
Total pieces-----	73		0%
Total Weight-----	183,286		0%
Total Yards-----	55		0%
Work Orders Generated-----			
Work Orders Completed-----			

Batch Breakout	
In House Standard-----	
In House Slag-----	
Blue Star-----	
Staffing	
Total Team Members-----	
Total Man Hours-----	
Man Hours Per Yard-----	

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Solutions, Inc. Concrete Testing Report 2021

Date : ____________

7 days

Average | Product | Average

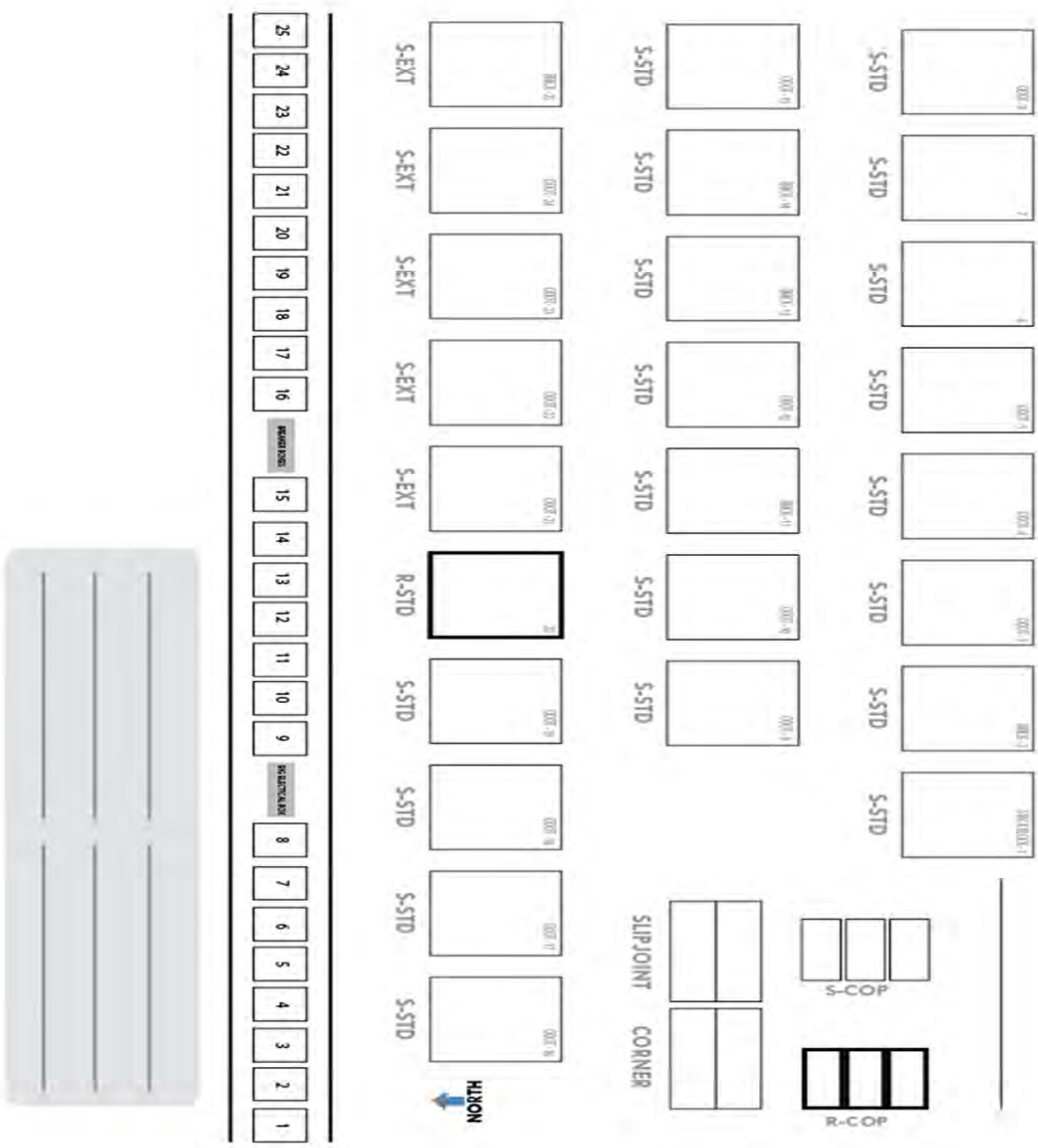
1

2

3

4

Product or mix : ____________	**Product or mix** : ____________
VSI - ________ %	WH temp - ________ C temp - ________ Spread ________ Slump - ________ Air - ________ UW - ________ Time - ________ Tester - ____________ VSI - ________ %
Product or mix : ____________	**Product or mix** : ____________
VSI - ________ %	WH temp - ________ C temp - ________ Spread ________ Slump - ________ Air - ________ UW - ________ Time - ________ Tester - ____________ VSI - ________ %


S-STD
S-EXT
R-STD
SLIPJOINT
CORNER
S-COP
R-COP
NORTH
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Precast Solutions, Inc. - Unit Weight and Yield of Concrete Report

Producer:	Date:
Test no.	Project:

Batch Weight in Pounds

(A) Cement			
Water			
Fine Aggregate			
Coarse Aggregate			
(B) Total Weight of Batch			

Weight of Concrete in Pounds per Cubic Foot

Weight of Container Full of Concrete			
Weight of Container			
(C) Net Weight of Concrete			
(D) Container Factor			
(E) Weight per Cubic Foot (C X D)			

Batch Volume Produced and Cement Factor

Specified Minimum Cement Factor (cwt/cy)			
(F) Batch Volume Produced (B/E)			
(G) Yield (F/27)			
Actual Cement Factor (.01A/G) cwt/cy			

Comments:

Precast Solutions, Inc. Unit Weight & Yield Report Exhibit 4

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Precast Solutions, Inc. Aggregate Moisture Record

Date	Aggregate	Sample Size Bin #	Pre-Test Weight	Post-Test Weight	Percent Change (free water)	Meter Reading		
			KEPT IN MIXER AREA					

SHIPPING TICKET

Precast Solutions, Inc.

SHIP FROM	Bill of Lading Number:
Precast Solutions, Inc. 6145 S. Indianapolis Road Whitetown, In 46075	
SHIP TO	**Carrier Name:**
[Name] [Street Address] [City, ST ZIP Code] CID No.:	Trailer number: Serial number(s):
THIRD PARTY FREIGHT CHARGES BILL TO	
[Name] [Street Address] [City, ST ZIP Code]	
Special Instructions:	**Freight Charge Terms** (Freight charges are prepaid unless marked otherwise): Prepaid ❑ Collect ❑ 3rd Party ❑
	❑ Master bill of lading with attached underlying bills of lading.

CUSTOMER ORDER INFORMATION

Customer Order No.	# of Packages	Weight	Pallet/Slip (circle one)		Additional Shipper Information
			Y	N	
			Y	N	
			Y	N	
			Y	N	
Grand Total					

CARRIER INFORMATION

Handling Unit		Package					LTL Only	
Qty	Type	Qty	Type	Weight	HM (X)	**Commodity Description** Commodities requiring special or additional care or attention in handling or stowing must be so marked and packaged as to ensure safe transportation with ordinary care. See Section 2(e) of NMFC item 360	NMFC No.	Class

Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property as follows: "The agreed or declared value of the property is specifically stated by the shipper to be not exceeding _______________ per _______________.	**COD Amount: $** ______________________ Fee terms: Collect ❑ Prepaid ❑ Customer check acceptable ❑

Note: Liability limitation for loss or damage in this shipment may be applicable. See 49 USC § 14706(c)(1)(A) and (B).

Received, subject to individually determined rates or contracts that have been agreed upon in writing between the carrier and shipper, if applicable, otherwise to the rates, classifications, and rules that have been established by the carrier and are available to the shipper, on request, and to all applicable state and federal regulations.	The carrier shall not make delivery of this shipment without payment of charges and all other lawful fees. **Shipper Signature** ____

Shipper Signature/Date	Trailer Loaded:	Freight Counted:	Carrier Signature/Pickup Date
______________________________ This is to certify that the above named materials are properly classified, packaged, marked, and labeled, and are in proper condition for transportation according to the applicable regulations of the DOT.	❑ By shipper ❑ By driver	❑ By shipper ❑ By driver/pallets said to contain ❑ By driver/pieces	______________________________ Carrier acknowledges receipt of packages and required placards. Carrier certifies emergency response information was made available and/or carrier has the DOT emergency response guidebook or equivalent documentation in the vehicle. Property described above is received in good order, except as noted.

Precast Solutions, Inc. Testing, Inspection and Investigation
Compression Test

Date Poured: ________ No. of cylinders made: ________

Mix: Air Content: Slump: Temperature of mix:

Required Strength: Admixture: Concrete Supplier: Concrete Supplier

Client: Project Job#

Qty of Cu Yds represented by cylinders: Sampled By

Comments:

No	Crushing Load lbs	Crushing Str PSI	Age to be tested	Date Tested	Cylinder Measurement	Type of Break	Initials of tester

size	divide by	rate of load
4" X 8"	12.57	770-900
6" X 12"	28.27	1000-1500

CGM Compression Break Card Testing Info 9-06.xls

Precast Solutions, Inc. Testing, Inspection and Investigation
Compression Test

Date Poured: ________ No. of cylinders made: ________

Mix: Air Content: Slump: Temperature of mix:

Required Strength: Admixture: Concrete Supplier: Concrete Supplier

Client: Project Job#

Qty of Cu Yds represented by cylinders: Sampled By

Comments:

No	Crushing Load lbs	Crushing Str PSI	Age to be tested	Date Tested	Cylinder Measurement	type of break	Initials of tester

size	divide by	rate of load
4" X 8"	12.57	770-900
6" X 12"	28.27	1000-1500

Post Pour Inspection Form-Grease Traps/Vaults

Product or Job: - Vault Base Date:____________________

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	Mon	Tue	Wed	Thu	Fri	Sat
Casting Date:						
Inspection Date:						
Product Type						
Stripping Strength (psi)						
Casting Finish- CS 1800 2 coats- -SIDES & BOTTOM						
Coating Finish- Black Roll On						
Cast Length (ft/in)						
Cast Width (ft/in)						
Cast Depth (ft/in)						
Wall Thickness						
Cracks or Spalls						
Honeycombing / Bugholes						
Exposed reinforcement						
Lifting Devices						
Ht of 2 Opposite Sides- Length						
Ht of 2 Opposite Sides- Width						
Block out #1- 24" x 24" x 1" for sump in Floor						
Block out #2- Sump Pit- floor						
This will get a sloped floor						

Comments:____

____

QC Inspector: _______________________________________ Date: _________________

Customer Complaint Form

Report Date: ____

Product or Job: _______________________________________

Number of Units: _______________________________________

Casting / Unit Type: _______________________________________

Nature of

Complaint:____
____
____
____
____

Corrective Action/Follow

Up:____

____

____

____

____

____

____

Person Performing Follow Up: _________________________Date: ___________________

Person Performing Corrective Action: _______________________ Date: ___________________

QC Inspector: ____ Date: ___________________

Tank Watertightness Testing Form

Date T TOC – Appendix ___________________

Location of Test: ___________________

Product Tested: ___________________

Product Serial # ___________________

TEST SPECIFICATIONS

Test Requested By: ___________________________________

Test Performed By: ___________________________________

Test Witnessed By: ___________________________________

Description of Test: __*see C-1613-10.9.1.2 Hydrostatic Testing below___

Product Tested To: __ASTM C-1613-10.9.1.2 Performance test methods___

Additional Comments: ____

Water level reading: Start: _________" End: _________" Time: _____ Min.

Start: _________" End: _________" Time: _____ Min.

(Allow the tank to stabilize before beginning the timed test. Refer to the latest edition of ASTM C 1613 for requirements.)
**"C-1613-10-9.1.2 Hydrostatic Testing-Seal the tank, fill with water to operational lever, let stand for 8-10 hours. If there is a measurable drop in water surface elevation, let stand for another 8-10 hours There shall be no further measurable drop in the water surface elevation. Tank shall not be rejected for damp spots on exterior concrete surface. If water is dripping in a steady stream, the tank shall be repaired and retested"*

1st Attempt: Final Attempt if needed:

Pass _________ Fail __________ Pass _________ Fail __________

Signature: ____ Date:___________
Mark Schuhler, Q.C. Manager

Signature: ____ Date:_____________
Dave Sweet, VP of Operations

This is to certify that the quality control procedures of

Precast Solutions Inc.

6145 S. Indianapolis Road
Whitestown, IN 46075-9526

were audited during an on-site plant inspection on June 6, 2019 and have met the

Precast Concrete Requirements

stated in the (14th Edition 2-7-19 of the NPCA Quality Control Manual for Precast Concrete Plants

Renewal Granted on December 31, 2019

Participation in the NPCA Plant Certification program affirms an ongoing commitment to producing quality precast concrete products to recognized standards of the *American Association of State Highway and Transportation Officials* (AASHTO), the American Concrete Institute (ACI), the ASTM International (ASTM), the American Welding Society (AWS), the Precast Prestressed Concrete Institute (PCI), and the Concrete Reinforcing Steel Institute (CRSI).

This renewal certificate is valid through December 31, 2020.

NPCA CERTIFIED PLANT

ANSI

Jon Ohmes, Chairman of the Board

Frederick H. Grubbe, NPCA President

Philip B. Cutler, P.E., Director of Quality Assurance Programs

NPCA | 1320 City Center Drive, Suite 200 | Carmel, IN 46032
This document shall be reproduced in its entirety

Latest NPCA Plant Audit is available and located in the Hard copy of the Plant QC Manual.

Latest NPCA Plant Audit response to deficiencies is available and located in the Hard copy of the Plant QC Manual.

Ambient Temperature Log

Date	Temp Out	Temp In	Initials
1/2/2018			
1/3/2017			
1/4/2017			
1/5/2017			
1/6/2017			
1/9/2017			
1/10/2017			
1/11/2017			
1/12/2017			
1/13/2017			
1/16/2017			
1/17/2017			
1/18/2017			
1/19/2017			
1/20/2017			
1/23/2017			
1/24/2017			
1/25/2017			
1/26/2017			
1/27/2017			
1/30/2017			
1/31/2017			
2/1/2017			
2/2/2017			
2/3/2017			
2/6/2017			
2/7/2017			
2/8/2017			
2/9/2017			
2/10/2017			
2/13/2017			
2/14/2017			
2/15/2017			
2/16/2017			
2/17/2017			
2/20/2017			
2/21/2017			
2/22/2017			
2/23/2017			
2/24/2017			

Precast Solutions,Inc. Annual form Precast Solutions, Inc. Inspection and Inventory Sheet

Steps			
Location	Model	Size	Qty
1A	MG	39 x 12 x 2.5	18
	MI	36 x 12 x 2.25	15
	BY	39 x 11 x 2.5	3
2A	Copper Commons	42 x 11.5 x 2	2
1B	717B	48 x 12.5 x 2	1
	718A	48 x 11.5 x 2	1
	600B-R1	43.5 x 11 x 2	1
	718B	48 x 12.125 x 2	1
	600 B	42 x 11 x 2	1
		47 x 11.25 x 2	2
		53.75 x 15 x 2	2
	107C	48 x 17 x 2	2
	107B	48 x 16 x 2	1
		35.625 x 15 x 2	2
	600C	47.375 x 15 x 2	4
	600A	44.375 x 11 x 2	5
	610A		7
		41.5 x 10.675 x 2.5	20
	516C		5
2A	2A 600A	35.75 x 11 x 2	11
		35 x 12 x 2.25	10
		40 x 10.75 x 2	3
2B	610c		6
	510 A		6
	518A		2
	600B		1
	512A		2
	516A		5
	717A	48 x 11 x2	3
	718C	45.75 x 11 x 2	1
	Spring Mill	39 x 12 x 2.25	5
		48 x 18.5 x 2	1
2C		48 x 12 x 2	1
	Chicago	45 x 12 x 3	2
	Chicago	41.5 x 12 x 3	3
	Chicago	48 x 10 x 3.5	5
	Anson		7

Pool Coping			
Location	Model	Size	Qty
1D			
Box Culvert			
Location	Model	Size	Qty
K/O Box			
Location	Model	Size	QTY

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Bay 2 M		36”	1
Bay 2 Mid	2x2	Block-out for 24” Box	1
Bay 2 Mid	2x2x4”	4” Riser	1
Bay 2 Mid	2x2x6”	6” Riser	1
Sills			
Location	Model	Size	Qty
3A	CU	42 x 5 x 5.5 x 4.5	6
	AW7		10
	B		
	AU	3.625 x 4.625	10
	KS		9
	KR		3
	KG		
		31 x 5.25 x 4.5 x 4	1
3B	6F	47.625 x	8
	KG	48 x	8
	IO		12
	LB		3
	MF		4
	JU		4
	HI		3
4A	IT		20
	GO		8
	GO		2
	GY		4
	H2		2
	HJ		9
4C	GK		10
	CA		4
	LD		1
	ML		2
	KP		2
	KP		3
	M2		1
		60 x 10 x 3.5 x 2.5	1
4D	FU	36 x 4 x 4.5 x 16	3
	FV	36 x 4 x 4.5 x 20	3
	FT	36 x 4 x 4.5 x 12	7
		47.5 x 5 x 3.5 x 3.25	2
4C	3M Masonry	x 7.625 x 9.5 x 6.25	1
	BO		6
5A	J4		8
	MC		8

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			4
	IC		3
	JE		2
	MB		4
	MA		1
	6M		3
Sills			
Location	Model	Size	Qty
5B	BX		7
	MI		2
	KO		3
	JD		2
	HT		3
5C		43.75 x 11.5 x 3.75	1
		40 x 11.5 x 3.75	
	KB		5
	LK		2
	LG		2
	KT		3
	LA		3
	JK		4
	GO		2
5D	MM		5
	NC		1
	CV		16
5E	6W		2
	BO		7
	BV		4
6A	IC		2
	IB		2
	6V		3
	JC		3
	GT		2
	G2		1
6B	BL		8
	AF		9
6C	HA		4
	I2		4
	GE		2
	K2		3
	EB		2
	HH		2
6D	CA		15
	3722		1

	5		1
	HS-SH		
	FG		3
Sills			
Location	Model	Size	Qty
7A	KH		3
	KU		1
	KU		1
	HO		2
	2		1
	3		3
	4		7
	5		4
	6L		1
	HI		1
	GU		1
	HL		1
Park Stop			
Location	Model	Size	QTY
Bay 2 Mid	5 gang	6’	3
Bay 2 Shelf	Trk- Single	8’	12
24” Riser			
Location	Model	Size	Qty
Bay 2 Mid	Gang Mold	24” i.d.	1
34” Riser CEG			
Location	Model	Size	Qty
Bay 2 Mid	CEG 2”	2” x 34” i.d.	3

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Pier Caps			
Location	Model	Size	Qty
8A	2V		2
	KA		3
	FD		5
	3628		6
	EX		1
	FB		1
	DX		1
	HM-WH		1
	FC		1
8B	HN		1
	HC		2
	HE		1
	HD		1
	HR		1
		32 x32	1
	FW		2
	F		
	6P/HQ CORNER		1
		25.5 x 25.5	1
		24 x 24	1
		34 x 17.5	1
	JG		2
9A	A		4
	4		3
9B	R Corner		7
	E		5
10A	FI		2
	FH		1
		8" Radius Cap x 7.125	
	FM		
	3654		2
		48 x 12 X 3.5 x 3.75	2
10B	AC	48 x 10	

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Wall Caps			
Location	Model	Size	Qty
10B	FF		
11A	CL		9
11B	B		10
	6C		8
	9"		6
	CN	8"	12
	CK		15
	AD		5
12A	AN		3
	AM		4
	AP		3
12B	IF		3
	AO		5
	MH		2
	MK		1
12C	AE		2
	JI		6
		48 x 8 x 4	4
	LH		3
	KX		1
12D	BR		3
	AO		6
12E	HY		3
12F	HZ		2
	IZ		1
	6D		1
	FK		1
	FL		2
	IN		1
	IH		1
	IG		1
	CA		1
	KI		1

			1
	AI		1
13A	DE		3
		36 x 16.5 splash block	4
	JT		4
13B	St. Marys	48 x20	1
	JM		1
	KC		3
13C		14" Wall Cap	3
	AL	34" x 18	6
MISC			
Location	Model	Size	Qty
13D	AS	16 x 16 Column Cap	1
		24 x 24 Column Cap	1
	A{	26 x 18 Column Cap	9
14A	Fireplace Kit		
	Picnic Table Legs		
	JB		1
	ID	40 x 18 x 2	1
	Bench Seats		2
	CI	36 x 36 x 4	1
	6G		
	Wieland Molds		1
		Bench Legs	2
		Columns Molds	1
	FY		1
	Rollins	Community Hospital	1
	J2		1
	Tombstone		1
	Dog Bone		53
	30"		2
	48" Splash Block		2
	20 x 48 x 2 Step		1
	60 x 20 x 2 Step		1
	67 x 10.25 x 2 Step		3
	67 x 8 x 2 Step		1
	Indiana Grand A		3
	Indiana Grand B		3
	60 x 18 x7		2
	67.75 x 11.5 x 3.75		2
	63.75 x 63,75 x 3.75		2
	64 x 11.5 x 3.75		2
	44.5 x 23.5 x 3		7

15A			4
	GP		4
			1
		34.5 x 26.5 x Pier Cap	2
2A1		34.5 x 18.5	4
		18.5 x 18.5	2
EG		18.25 x 18.25 x 3	1
		33 x38	3
PADS			
Location	Model	Size	Qty
16A	ADTRV4		1
17A	ADTRMC500WES		3
17B	VEE		
17C	VF/VG		
17D	VDS		
17E	VC		
17F	NET 22		
Production Floor			
Location	Model	Size	Qty
	AC Pad	42 x 42	2
	24" Splash Block		
	29" Splash Block		
	35" Splash Block		
	Propane Pads		
	36" AC Pad	36 x 36	
	24" AC Pad	24 x 24	8

Precast Solutions, Inc.

QC Performance Timeline

DAILY QC TASKS

1. Break strip cylinders
2. Log Outdoor and Indoor Ambient Temperatures
3. Post Pour Inspections- From previous day pour
4. Pre-Pour Inspections – Today's pour
5. Final Inspection- Prior to loading-STOCK and NON-STOCK Precast Materials
6. Concrete Tests on each mix type
7. Break 7 and 28 day cylinders
8. Log Cylinder Breaks
9. Batch tickets into book- these need to be printed every load, every day.
10. Pre and Post Pour sheets filed properly
11. Fill out Daily Quality Report in Computer prior to 11 a.m.
12. Fill out Work Orders, Copy and give to Plant Manager

WEEKLY QC TASKS

1. Weekly Curing Ambient Temperature Charting
2. Check for new Mill Certs on Aggregates, Cement, Admixtures & Reinforcing, place in Materials Book

MONTHLY QC TASKS

1. Safety Toolbox Talks
2. Monthly QC meeting

FIRST QUARTER QC TASKS

1. Compression Machine Calibration (Ohio Requirement)
2. Bench Scale Calibration (Ohio Requirement)
3. Air Meter Calibration (Ohio Requirement)
4. Unit Weight Bucket (Ohio Requirement)
5. Thermometers, 25 ° - 125° F Calibration/Replacement (Ohio Requirement)
6. Slump Cone Calibration (Ohio Requirement)
7. Quarterly QC Meeting

BI-ANNUAL & SECOND QUARTER QC TASKS

1. Bi-Annual QC meetings
2. Aggregate Bin Scale Load Cell Calibration (Ohio Requirement)
3. Cement Scale Load Cell Calibration (Ohio Requirement)
4. Admixture Dispensers Calibration (Ohio Requirement)
5. Compression Machine Calibration (Ohio Requirement)
6. Bench Scale Calibration (Ohio Requirement)
7. Air Meter Calibration (Ohio Requirement)
8. Unit Weight Bucket (Ohio Requirement)
9. Thermometers, 25 ° - 125° F Calibration/Replacement (Ohio Requirement)
10. Slump Cone Calibration (Ohio Requirement)

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Precast Solutions, Inc.
QC Performance Timeline

THIRD QUARTER QC TASKS

1. Compression Machine Calibration (Ohio Requirement)
2. Bench Scale Calibration (Ohio Requirement)
3. Air Meter Calibration (Ohio Requirement)
4. Unit Weight Bucket (Ohio Requirement)
5. Thermometers, 25 ° - 125° F Calibration/Replacement (Ohio Requirement)
6. Slump Cone Calibration (Ohio Requirement)
7. Quarterly QC Meeting

FOURTH QUARTER QC TASKS

1. Compression Machine Calibration (Ohio Requirement)
2. Bench Scale Calibration (Ohio Requirement)
3. Air Meter Calibration (Ohio Requirement)
4. Unit Weight Bucket (Ohio Requirement)
5. Thermometers, 25 ° - 125° F Calibration/Replacement (Ohio Requirement)
6. Slump Cone Calibration (Ohio Requirement)
7. Quarterly QC Meeting

ANNUAL QC TASKS

1. GT Watertightness Testing (1 of each size, 1000 gal, 2000 gal, etc.)
2. Bi-Annual QC Meetings
3. Check Boots, Profile Gaskets, mastic for Conformance to Standards on Manufacturers Websites
4. Annual Safety Refresher Course for OSHA topics
5. Check Dimensional Tolerances of Forms
6. Vibrator Training Course

4.1.2 Soil Reinforcing QA/QC

SSL Quality Control Manual
Revision 7
10/18/2013

Quality Control Manual

SSL Retaining Walls
4740 Scotts Valley Drive, Suite E
Scotts Valley, CA

Prepared By:
Steve Ruel, P.E.
Fransiscus Hardianto, P.E.
Scott Thompson Jr.

REGISTERED PROFESSIONAL ENGINEER
FRANSISCUS S HARDIANTO
C 60215
EXP. 6-30-18
CIVIL
STATE OF CALIFORNIA

SSL Quality Control Manual
Revision 7
10/18/2013

Table of Contents

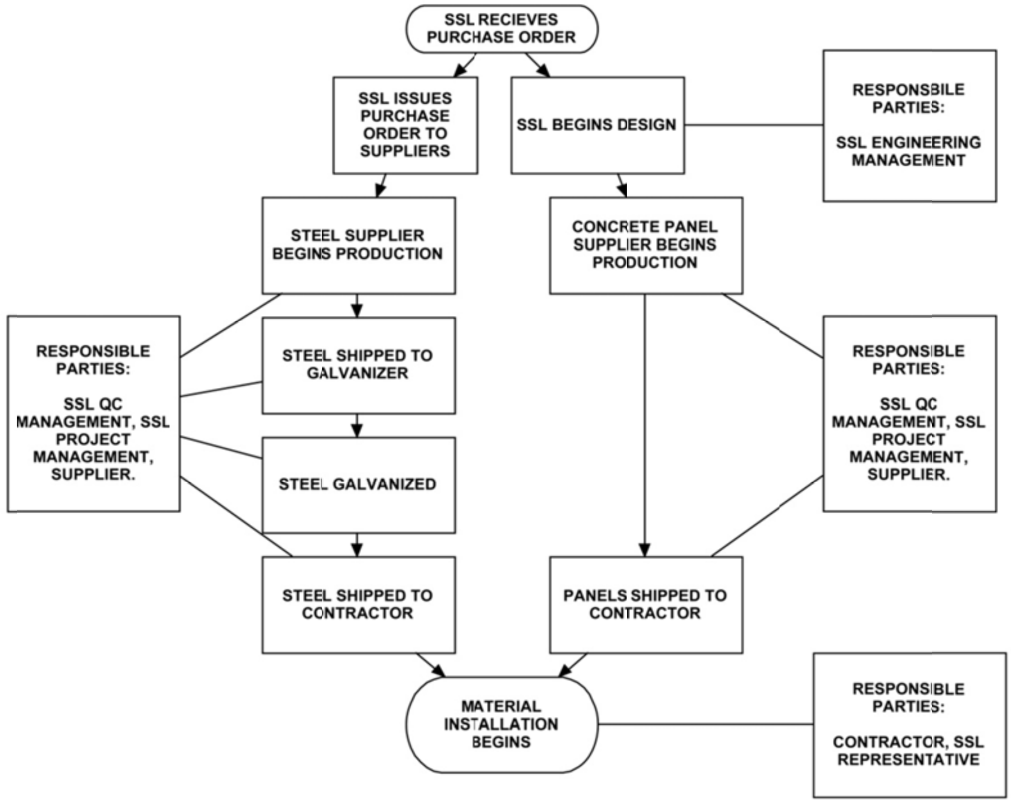
1. INTRODUCTION

SSL is an engineering design firm involved in the design and supply of Mechanically Stabilized Earth retaining walls. SSL's products employ welded wire mesh as soil reinforcement combined with a facing element that will either be precast concrete panels or welded wire mesh panels. The production of the welded wire mesh and precast concrete elements is performed by supplier organizations that specialize in those materials. SSL has coordinated and implemented an extensive Quality Control Program that will provide our customers with a superior product that meets or exceeds all applicable standards and specifications including those set forth by the American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing Materials (ASTM) and the Buy America Act.

This manual will outline the Quality Control procedures in place at SSL along with the procedures in place at our suppliers. The Quality Control measures required by SSL of the Contractor are listed in the Standard Details of our Shop Drawings. The Quality Control Program in its entirety is intended to provide several check points at which any potential production or manufacturing problems will become evident. Should any problems arise, the program is intended to isolate and correct the production process responsible.

SSL's Quality Control Program was developed with input from industry experts and reflects the latest in design and testing methods. Any changes to the Quality Control Program will be detailed in a numbered revision to the Quality Control Manual which will be re-submitted to Caltrans for review.

2. PRODUCTION PROCESS AND RESPONSIBLE PARTIES



3. SUPPLIER RESPONSIBILITES

Upon acceptance of SSL's purchase order, the material supplier agrees to perform all Quality Control procedures put forth in this manual and any others that may be required by the project Owner's specifications or the American Society for Testing Materials (ASTM). No welded wire soil reinforcement or precast concrete panels will be shipped to the jobsite without a Certificate of Compliance signed by a California Licensed PE from SSL.

Steel suppliers must ensure that all material is produced and fabricated according to ASTM guidelines (ASTM-A82 and ASTM-A185) along with any other requirements of the project Owner's specifications. All material must be properly identified and tagged. Steel suppliers shall provide *wire coupons* (wire rod samples, 1 from each spool) for *production go-ahead testing* prior to mesh fabrication, which will not proceed until wire coupons achieve a satisfactory result. *Production go-ahead testing* shall be performed by a qualified third party testing agency[1]. Steel suppliers shall provide *mesh coupons*

[1] Testing agency certified in accordance with ISO 17025, NADCAP AC-7101 or similar.

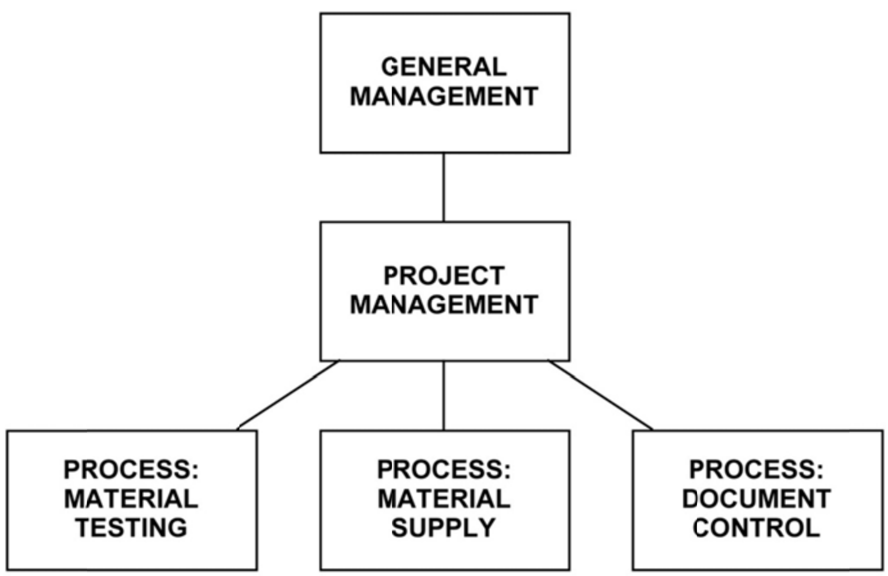
(fabricated mesh samples, 1 per change in wire size or change number of longitudinal wires per sheet) to be galvanized and sent to the contractor as a control lot.

Steel galvanizers must ensure that all material is coated according to ASTM-A123 guidelines and tested according to ASTM-A143, along with any other requirements of the project Owner's specifications. All material must be properly identified and tagged to ensure proper installation at the jobsite.

Concrete panel suppliers must ensure that all material is produced according to the project Owner's approved Quality Control procedure along with any other requirements of the project Owner's specifications. Concrete panel supplier's Quality Control Manager must complete and sign the Precast Quality Control Checklist included in Section 10.

For complete details, please see Section 10 containing the current Quality Control Programs for; Concrete Reinforcements, Inc; and AZZ Galvanizing Inc. An individual Quality Control Program for concrete panel suppliers has not been included because concrete suppliers are selected on a job by job basis. The individual Quality Control Program of the selected supplier will be subject to review and will comply with SSL's Quality Control Program.

4. SSL PERSONNEL RESPONSIBILITIES



General Management: The general managers are responsible for developing a Quality Control Policy that will ensure that each element of the product supplied to customers meets or exceeds all applicable standards. The general managers are responsible for allocating a sufficient amount of time and resources to the development and implementation of a Quality Control Program that will reflect the Quality Control Policy.

Project Management: The Project Managers are responsible for the implementation and management of SSL's Quality Control Policy, this includes making material suppliers aware of the program and proficient with all aspects. The project managers will ensure each material supplier has their own Quality Control Program in place and that it reflects SSL's own Quality Control Policy. The project managers will provide a Certificate indicating Compliance (COC) with SSL's Quality Control Program for each load of material delivered to the jobsite, the COC must be signed by a Professional Engineer Licensed in the State of California. When specified, the project managers will coordinate with the contractor's Quality Control Manager.

Material Supply: At the direction of project management, the production and delivery of materials will be coordinated with the material supplier. Project management must ensure that all material is being produced in accordance with SSL's Quality Control Program and attain verification that all material is being produced in accordance with each supplier's own Quality Control Program. Project management may at any time in the production process, request changes to the supplier's Quality Control Program or request additional Quality Control or testing procedures to be performed by the supplier.

Document Control: At the direction of project management, any and all necessary or requested material compliance certifications and testing logs will be collected from material suppliers. All records will be stored on a project specific basis such that information can be quickly and easily verified or distributed as needed.

Material Testing and Inspection: At the direction of project management, specific material components or elements of the entire system may be tested by SSL's material testing personnel. Testing may be performed as proof of design concept or as production compliance verification. Inspection may be performed at the job-site or at each material supplier's location.

5. MATERIAL TESTING AND INSPECTION PERFORMED BY SSL

SSL personnel have the option to perform different testing and inspection methods on the material elements of the system at any stage of production or installation. These tests are in addition to those required by ASTM and AASHTO. These tests were designed to reflect those prescribed by ASTM but modified to allow for on-site testing performed outside of a lab. When specified, SSL will coordinate with a qualified third party[2] to perform additional testing. A report detailing any results will be distributed to the parties involved.

[2] Testing agency with expertise in metallurgy, galvanization or precast concrete.

The list below contains methods that are currently being employed, SSL is not limited to these methods and may adopt others at any point in time. If other methods are employed at a later date, SSL will revise the Quality Control Program to reflect the changes. SSL will determine which tests will be employed and the frequency of testing on a project specific basis, a summary and outline of the project specific program will be included in Shop Drawings that are submitted for approval at the beginning of the project.

Connection Test: SSL has developed a test procedure that verifies the load capacity of the concrete panel to soil reinforcement connection elements. Please see the attached Test Procedure for more details. This test will be performed for System Qualification and for evaluation of Steel Suppliers.

Bend Test: A bend test verifies the ductile strength of the steel and identifies embrittlement. This test can be performed either on single wire coupons both before and after the galvanizing process, and on welded-wire mesh after fabrication. This test may be performed at any point in the production process or on samples selected from material that has been shipped and is ready for installation. Questionable results will require further evaluation and may be cause for rejection of material. SSL may submit questionable material to a qualified independent testing laboratory for further evaluation.

If the wire has not been bent during mesh fabrication, a single wire is isolated and restrained by a vice or clamps, the wire is bent (max 1 inch bend radius) through 90˚ and back so that the straightened piece will be examined. The steel must complete the bend test without exhibiting any visible cracking at the bend.

If the wire has been bent during mesh fabrication, a single wire is isolated and restrained by a vice or clamps leaving the bent portion free. Using a minimum 3' long section of 1" metal pipe, the wire is bent to straight so that the straight piece is examined. The steel must complete the bend test without any visible cracking occurring at the bend.

Production Go-Ahead Testing: The bend test discussed above will be performed at a rate of 1 sample per wire spool for all wire produced. Samples will be taken from a recently drawn spool, galvanized and bend tested prior to mesh fabrication. Mesh fabrication will not proceed without satisfactory results.

Unsatisfactory results will require that the material in question be removed from production pending further evaluation.

Impact Test: An impact test is performed at room temperature on steel samples that have been bent then galvanized and is intended to identify embrittlement.

This test will be performed once for each project during site-visits by SSL personnel, and may also be performed at any time during the production or installation process. Questionable results will be cause for further evaluation.

As detailed in Figure 1 below, a single wire is isolated and restrained by a vice or clamp. Using a small metal mallet or hammer (20 oz or larger), the wire sample is struck up to three times directly on the bent portion: The first strike will be a light tap with the swing initiated at the Tester's wrist, if no cracking occurs continue on to the second strike; The second strike will be stronger and initiated at the Tester's elbow, if no cracking occurs repeat the strike with the same strength. The steel must complete the impact test without any visible cracking occurring at the bend.

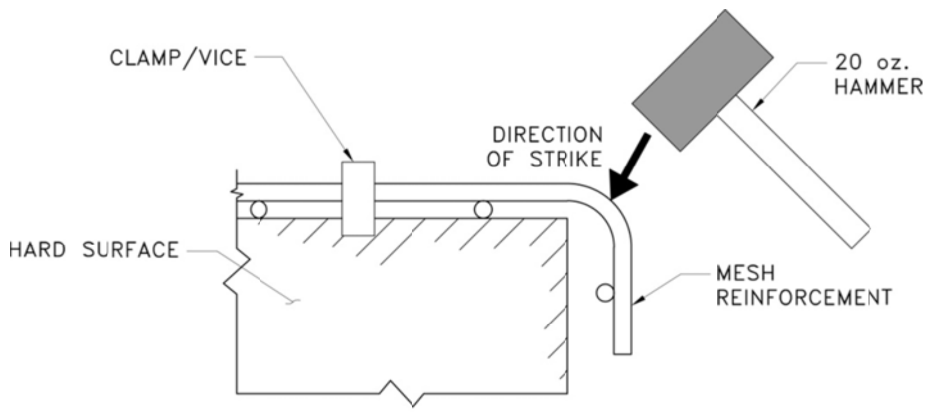


FIGURE 1

Visual Inspection at Jobsite: A thorough visual inspection of any SSL supplied material on site is performed during SSL 's onsite technical representation or by the contractor. The inspection is intended to verify that no deformations or broken bends or welds are visibly present in the reinforcing mesh. This test will only identify those issues that are readily apparent as some of the material is typically obscured by packaging or not accessible.

In the absence of an SSL representative, any material found by the Contractor to be out of SSL tolerances shall be tagged and removed from the installation process. The contractor shall notify SSL immediately for further evaluation of the questionable material.

The steel identification tags attached by the galvanizer are checked against actual sizes and styles of reinforcing mesh. If discrepancies exist, the actual size and styles of the reinforcing mesh can be determined by the contractor by measuring the wire size, longitudinal wire quantity and the distance of transverse wire spacing. Proper identification labels should be attached to ensure proper installation.

If any broken wires or welds are present they will be flagged and the mesh sheet will be evaluated by an SSL engineer for integrity. If SSL determines that the integrity of the mesh sheet is compromised, the sheet will be removed from the installation process and tagged.

Process Audit at Steel Supplier: SSL personnel may elect at any time during the production process to perform an on-site inspection of the entire production process at each steel supplier's location. *Process Audits will take place a quarterly (minimum of four times a year)*. The inspection is intended to verify that the production process is in compliance with all aspects of both SSL's and the Supplier's QCP. SSL personnel may decide to include as an agent, an industry expert not affiliated with the supplier in the inspection to provide an independent opinion. A detailed report of the audit will be generated by SSL and kept as a record by SSL and the reinforcement supplier facility. A copy will be supplied to Caltrans upon request.

If SSL's personnel or agent determines that changes to the production process are necessary, the Supplier in question will implement the necessary changes without any delays to the production process.

First-Article Inspection and Process Audit at Precast Supplier: For Quality Validation, SSL personnel will perform at least four First-Article Inspection and Process-Audits per year and at the start of production for a specific project if required by the Project Specifications. SSL may also elect at any time during the production process to perform an on-site inspection of the any aspects of the entire production process at the concrete panel supplier's location.

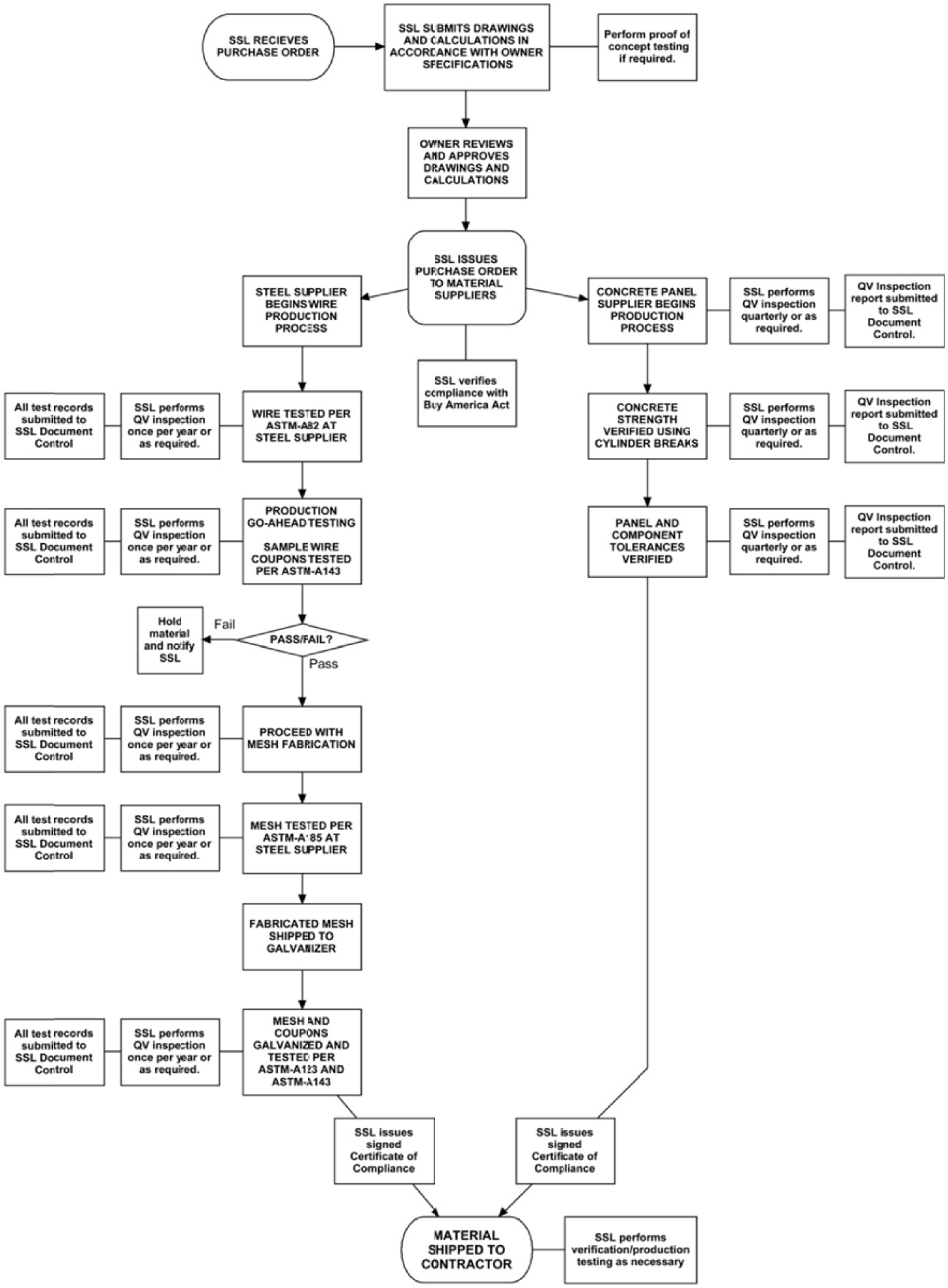
The inspection will involve an examination of the casting and testing process for one representative panel from each potential type of panel for the manufacturing period or project (e.g. “A” panels, “X” panels, top-panels, L/R panels or corner-panels) and any unique product/architectural finish as well. The inspection will focus on the following items: embed loop clearance and spacing, panel identification and tracking, verification of concrete strength, process documentation and general condition of formwork. The inspection is intended to verify that the production process is in compliance with all aspects of both SSL's and the Supplier's QCP and that the Supplier can produce material in accordance with SSL Shop Drawings and Project Specifications.

A report of the inspection will be kept on file at the precast facility and submitted along with the Certificate of Compliance (COC) that accompanies the material to the jobsite (see sample First Article Inspection and Process Audit Report in). A copy will be supplied to Caltrans upon request.

SSL personnel may decide to include as an agent, an industry expert not affiliated with the supplier in the inspection to provide an independent opinion. If SSL's personnel or agent determines that changes to the production process are necessary, the Supplier in question will implement the necessary changes without any delays to the production process.

6. QUALITY CONTROL PROGRAM FLOWCHART

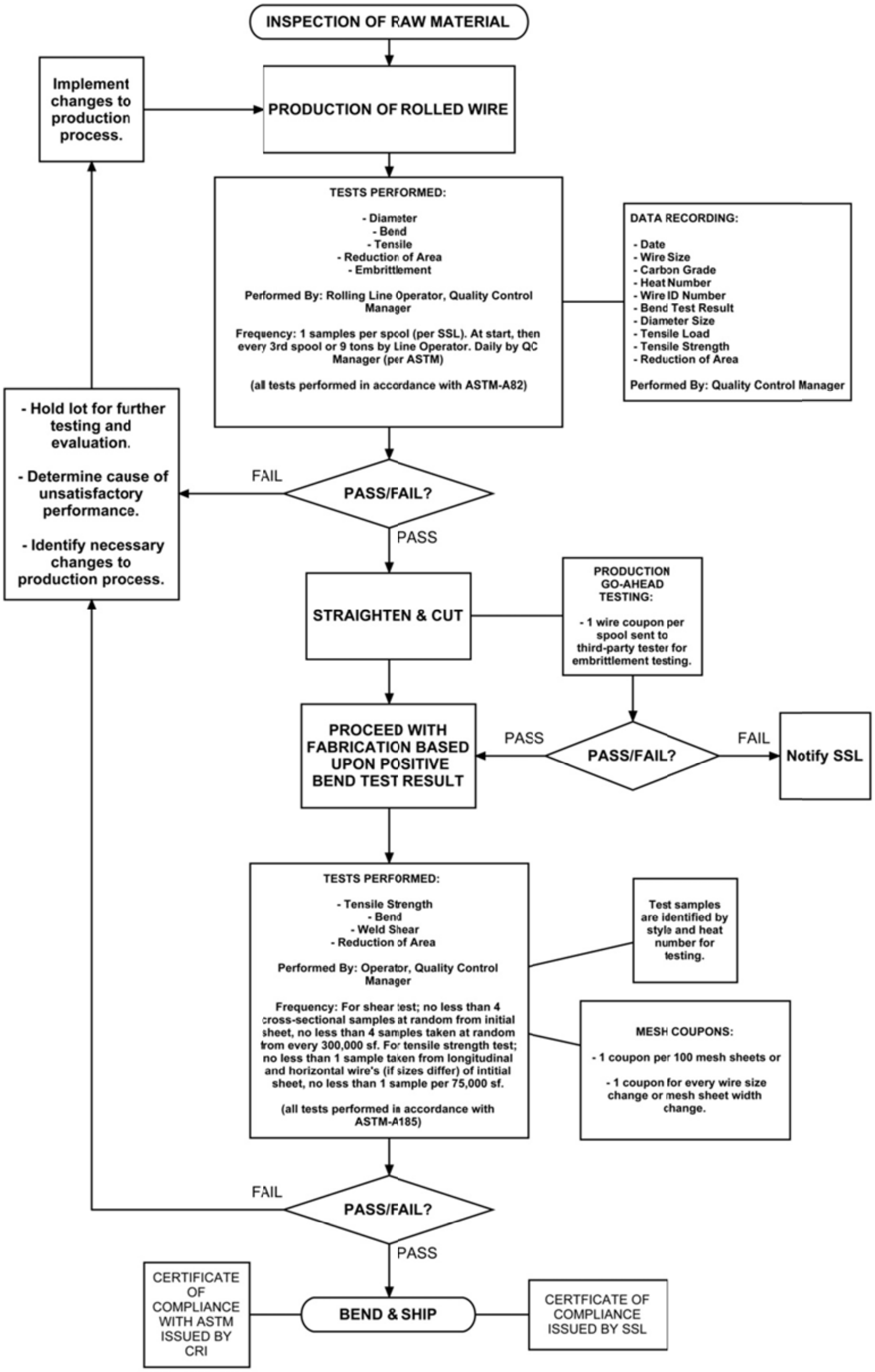
Below is a flowchart summarizing the entire QC process as required by SSL's QCP and the individual QCP's of the material suppliers. This chart combines the steps taken by SSL along with the steps taken at each supplier's location. For detailed flowcharts that cover the procedures of the material suppliers, please see Section 7.


SSL RECIEVES PURCHASE ORDER
SSL SUBMITS DRAWINGS AND CALCULATIONS IN ACCORDANCE WITH OWNER SPECIFICATIONS
Perform proof of concept testing if required.
OWNER REVIEWS AND APPROVES DRAWINGS AND CALCULATIONS
SSL ISSUES PURCHASE ORDER TO MATERIAL SUPPLIERS
SSL verifies compliance with Buy America Act
STEEL SUPPLIER BEGINS WIRE PRODUCTION PROCESS
WIRE TESTED PER ASTM-A82 AT STEEL SUPPLIER
SSL performs QV inspection once per year or as required.
All test records submitted to SSL Document Control
PRODUCTION GO-AHEAD TESTING
SAMPLE WIRE COUPONS TESTED PER ASTM-A143
PASS/FAIL?
Fail
Hold material and notify SSL
Pass
PROCEED WITH MESH FABRICATION
MESH TESTED PER ASTM-A185 AT STEEL SUPPLIER
FABRICATED MESH SHIPPED TO GALVANIZER
MESH AND COUPONS GALVANIZED AND TESTED PER ASTM-A123 AND ASTM-A143
CONCRETE PANEL SUPPLIER BEGINS PRODUCTION PROCESS
SSL performs QV inspection quarterly or as required.
QV Inspection report submitted to SSL Document Control.
CONCRETE STRENGTH VERIFIED USING CYLINDER BREAKS
PANEL AND COMPONENT TOLERANCES VERIFIED
SSL issues signed Certificate of Compliance
MATERIAL SHIPPED TO CONTRACTOR
SSL performs verification/production testing as necessary

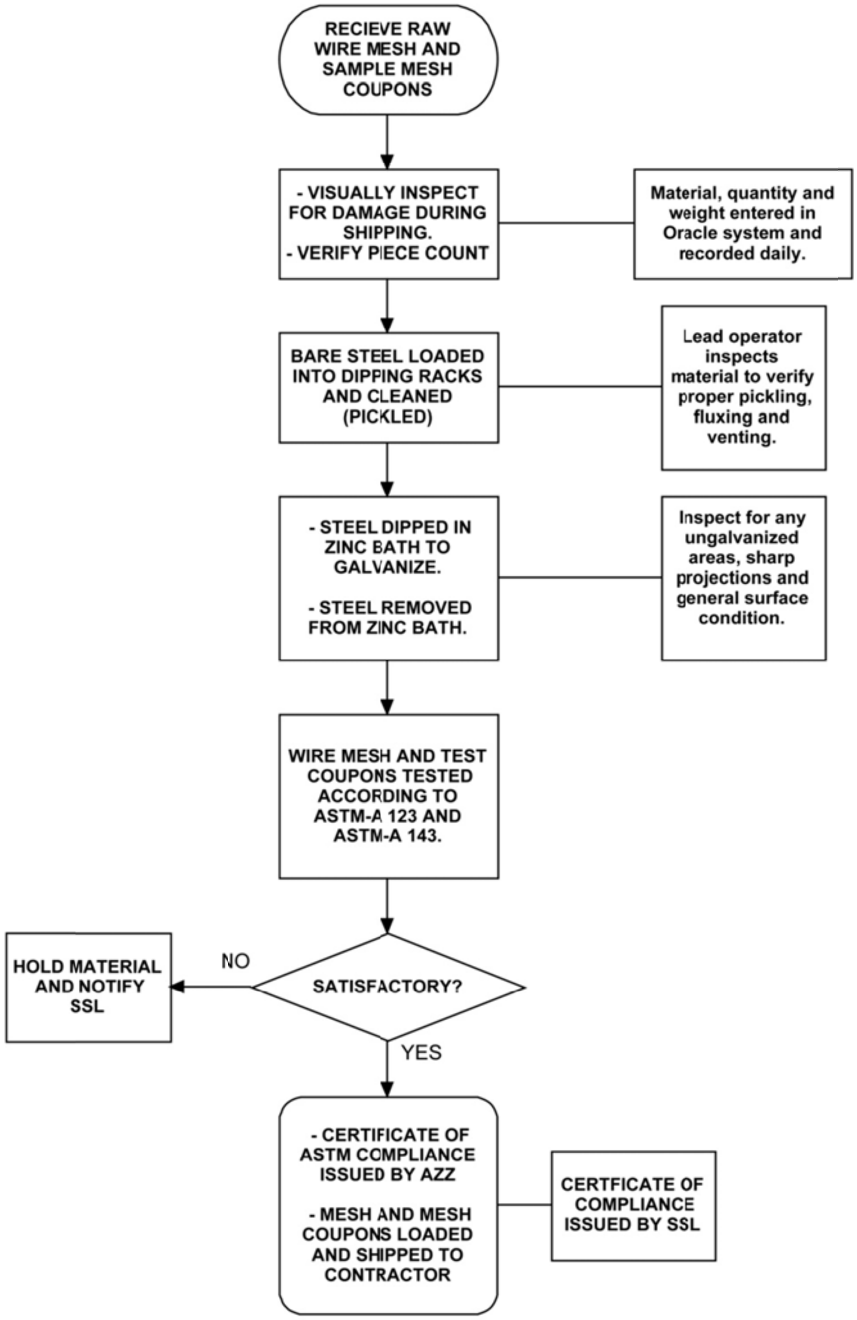
7. MATERIAL TESTING AND INSPECTION PERFORMED BY SUPPLIERS

Below are the QC Procedure Flowcharts for two of SSL's Suppliers, they reference the attached individual QC Programs in place at those Suppliers and are made part of SSL's QC Program. Should SSL elect to use a different supplier as a substitute, SSL will examine their QC program and perform the necessary QV inspections to ensure that it meets or exceeds the requirements laid out below.

Concrete Reinforcements, Inc: QC Process Flowchart for SSL Soil Reinforcing



AZZ Galvanizing Services: QC Process Flowchart for SSL Soil Reinforcing



8. CONCLUSION

SSL feels that our QCP in conjunction with the QCP's in place at our Material Suppliers, will ensure that the products we provide meet or exceed all applicable standard and specifications. If after review, any aspects of our QCP or the individual QCP's of our Material Suppliers are found to be insufficient, SSL will make any necessary changes to our QCP and notify our Material Suppliers of any necessary changes. Should SSL become aware of any additional requirements, SSL's and the individual QCP's of our Material Suppliers will be revised to reflect those requirements.

Concrete Reinforcements, Inc.

13450 W. Peoria Ave. Surprise, Az. 85379 Ph. 623-975-2970 Fax. 623-975-2790

3/7/2012

Scott Thompson Jr.
SSL LLC
4740 Scotts Valley Dr. STE E
Scotts Valley, CA. 95066

Regarding: Increase Quality Practices for SSL Soil Reinforcing Mesh

Mr. Scott Thompson

Attached is Concrete Reinforcements General Quality Plan as well an Enhanced Quality Plan designed for production of SSL Soil Reinforcing Mesh. This plan was implemented February 2012.

Best Regards,

JT Wright
Concrete Reinforcements, Inc.

Raw Material Inspection for Wire Rod

Purpose: This Raw Material Inspection is designed to verify materials strength and dimensional properties as well as verifying the chemical properties are within specification.

Frequency: One sample for every different heat number from the steel mill

Method:

1. As a shipment is received, verify that Mill Certificates have been provided for each heat number that has been delivered.
2. Obtain one sample (approx. 12") for each different heat number for testing the diameter. Refer to ASTM A510 Table 8 for diameter conformance. Refer to ASTM A510 Section 11 if material does not meet the requirements. Otherwise, proceed to step 3.
3. Using the same sample from the diameter test, test the tensile strength per ASTM A370. Verify it to be within the range specified on the Mill Cert
4. Verify that the chemical composition of each heat is within the parameters required by A510 using Table 3. Material ½" or greater must be Grade 1010. Material less than ½" will either be 1010 or 1008.

If the tests and inspections are within limits, all material within the heat shall be tagged with a color code. If anything is out of limit, the material shall be put through further processing tests to verify it will meet ASTM Standards for welded wire reinforcing as well as passing the galvanized embrittlement per ASTM A143

Recorded Data:

1. Material Tensile noted on Mill Cert
2. Chemical verification signed off
3. Diameter noted on Mill Cert

CRI

Rolled Wire Inspection - SSL Specific Requirements

Purpose: This inspection is designed to verify material conformance to ASTM A82 and A143 for Embrittlement

Frequency: One sample (approx 2 ft) per spool.
Note: additional samples may be requested for outside testing

Method:

1. Check the diameter around the entire wire using Venier Calipers to verify the wire is within range according to ASTM A82 Table 4 & section 6
2. Perform a Bend Test on each sample per A82 section 5.2
3. Perform a Tension Test on each sample per A82 section 5.1
4. Perform a Reduction of Area Test Per A82 section 5.3
5. Label the bent portion of each sample with the Heat Number, Wire Size & Date and submit them to the galvanizer for the appropriate Embrittlement Test. Wire sizes that do not get bent prior to galvanizing are not required to be tested for Embrittlement.

If the tests and inspections are within limits, material may be staged and tagged for the Straighten and Cut Process. If anything is out of limit, the material shall be placed in a non-conforming area and may not be used for SSL Soil Reinforcing unless additional testing validates the quality of the finished product

Recorded Data:

1. Date of Rolling
2. Diameter Min & Max
3. Rod Size & Heat Number
4. Carbon Content
5. Wire Size
6. Lbs on spool
7. Bend Test Verification
8. Reduction of Area
9. Tensile Strength
10. Embrittlement Test Verification / Certification

Weld Shear and Tensile Test Across Welds - SSL Specific Requirements

Purpose: This test is designed to verify weld shear integrity and tensile strength of wire that has been welded

Frequency: One sample sheet for every different width and/or wire size.

Method:

1. Before each style change (width, wire size or machine positioning) weld a replica test sample of the sheets to be succeeded by this test.
2. Perform a Weld Shear Test per ASTM A185 Section 7 & 10 for each intersection across the width of the test sample
3. Perform a Tensile Test across the welded intersections per ASTM A185 Section 7.1 for every different wire size or 75,000 square feet. If the fractured section is of sufficient distance from the weld to measure diameter, perform a reduction of area test per A185 Section 7.2
4. Bend the remaining portion of the replica sample in the same manner as its job requires. Tag it accordingly and ship it with the order in which it corresponds. (this is intended for further process testing if required by the purchaser)

If the tests and inspections are within limits, material may be staged for bending. If anything is out of limit, the material shall be placed in a non-conforming area and may not be used for SSL Soil Reinforcing unless additional testing validates the quality of the finished product

Recorded Data:

1. Date of Weld
2. Job Number and Styles Tested
3. Wire Size
4. Weld Shear Ultimate PSI
5. Tensile Ultimate PSI

Bend Setup Inspection

Purpose: The purpose of this inspection is to verify accuracy of the bender setup according to the job requirement

Frequency: Once for each bend diagram provided with each job.

Method:

1. Check the vertical and horizontal dimensions to ensure the jig pins adjusted correctly.
2. Verify Mandrel size is correct
3. Verify the angle adjustment is correct

If any of the preceding inspections are incorrect, make the necessary adjustments before proceeding

Recorded Data: N/A

Concrete Reinforcements Inc.

QUALITY CONTROL PLAN
(IMPLEMENTED 11/98)

ROLLED WIRE:

1. FREQUENCY OF SAMPLING AND TESTING

A. Each rolling line operator will initially cut a 12" sample coupon from the start of the rolling process and continue to every third spool of wire produced of the same size to ensure it meets all weight, deformation and tensile spec's required. Operators will repeat the same process after each change over to a different wire size's to meet all required specifications.

2. TESTING SMOOTH WIRE SAMPLES

   A. Smooth wire is tested in accordance with ASTM-A82. The following tests are performed.
      - Diameter
      - Bend Test
      - Tensile
      - Reduction of Area

3. RECORDED DATA OF SMOOTH WIRE

   A. Sample coupons are tested daily by Quality Control to ensure all wire samples conform to ATMS-A82 steel welded wire specification for yield, weight and tensile.

   B. Internal data recorded is as follows:
      - Date
      - Wire Size
      - Carbon Grade
      - Heat Number
      - Bend Test

Concrete Reinforcements Inc.

- Wire ID Number
- Diameter Size
- Tensile Load
- Tensile Strength
- Reduction of Area

4. SAMPLE TESTING OF DEFORMED WIRE

A. Deformed wire is tested in accordance with ASTM-A 496.

B. Tests performed are as follows:
- Weight per Linear Foot
- Tensile
- Bend Test
- Height of Deformations

5. RECORDED DATA OF DEFORMED WIRE SAMPLES

A. Sample coupons are tested daily by Quality Control to ensure all wire samples conform to ASTM A-496 steel welded wire specification for yield, weight and tensile and filed.

B. Data recorded is as follows:
- Date
- Wire Size
- Heat Number
- Bend Test
- Tag Number
- Weight per Foot
- Tensile Load
- Tensile Strength
- Deformation Height

Concrete Reinforcements Inc.

WELDED WIRE FABRIC

1. FREQUENCY OF TESTING WELDED WIRE FABRIC

A. Shear testing of welded wire fabric will constitute of no less than four cross sectional welded samples cut out staggered through out the initial sheet to ensure welded consistency is achieved. No less than four test samples are taken for every 300,000 square feet to conform to the weld shear strength requirements for the welded wire fabric to conform to A-497.

B. Tensile testing of welded wire fabric will constitute a minimum of one sample taken from the longitudinal and horizontal wire's if differs in wire sizes from welded fabric being tested. Testing of samples will be taken at intervals of no less than $75{,}000^2$ of welded fabric to conform to ASTM A-497 & A185.

C. The samples are identified by style, order number, and tested in accordance with ASTM-A185 or A497.

D. Test performed are as follows:

- Tensile Strength
- Bend
- Wels Shear
- Reduction of Areas (Smooth Fabric Only)

2. RECORDED DATA OF DEFORMED WIRE SAMPLES

A. Sample coupons are tested daily by Quality Control to ensure all wire samples conform to ATMS-A82 496 and 497 steel welded wire specification for yield, weight and tensile.

B. Data recorded is as follows:

- Customer
- Mesh Style
- Date
- Bend Test
- Tensile Strength

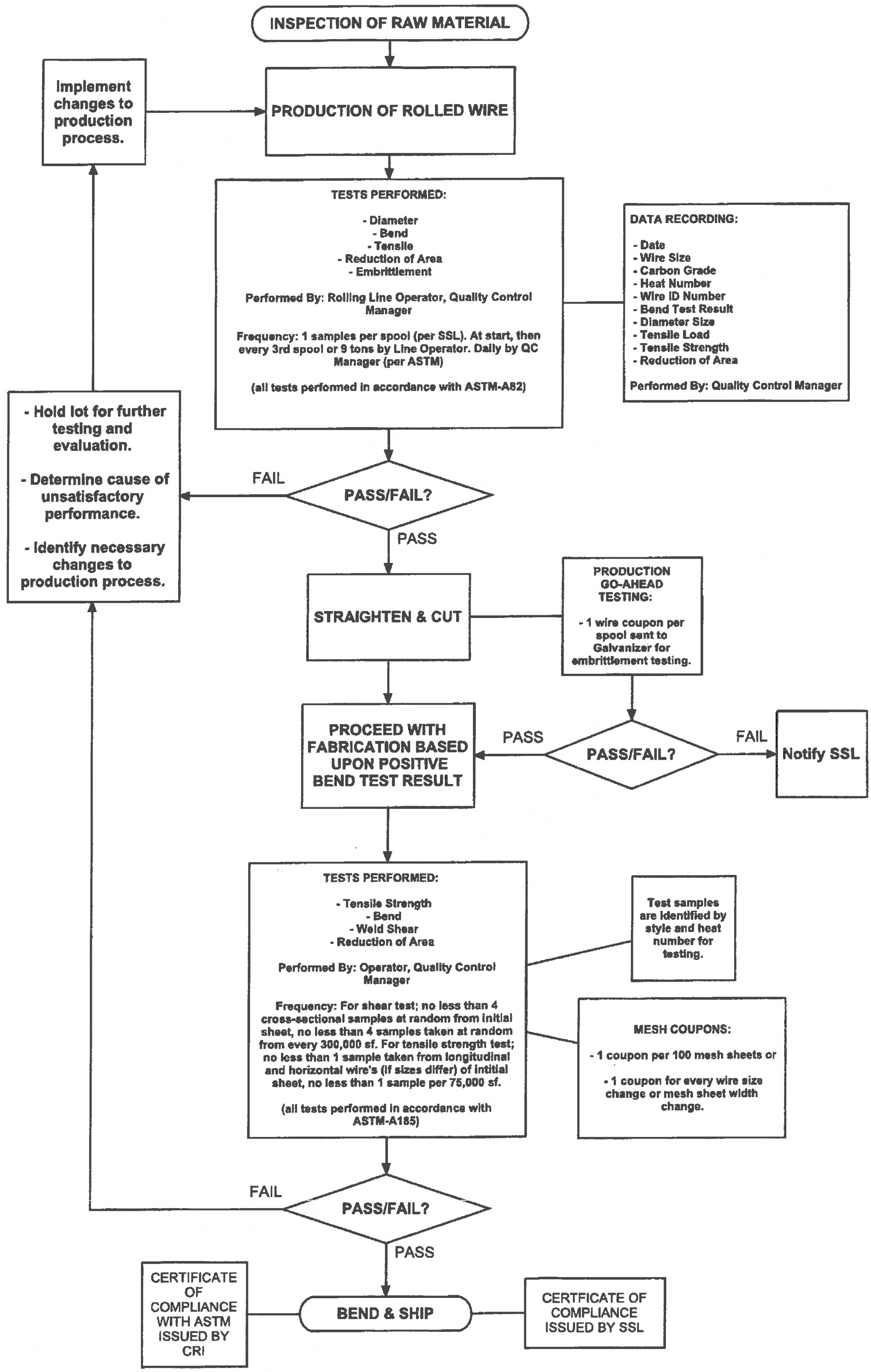
Concrete Reinforcements Inc.

- Pass Value of Weld Shear Test
- Weld Shear Load
- Reduction of Area (Smooth Wire Fabric Only)

3. FINAL CERTIFICATION

Final job order certifications are signed only by the Quality Control Manager, certifying the material ordered adheres to the designated ASTM specification, and domestic origin.

13450 West Peoria Avenue Surprise, Arizona 85379
Phone: 623-975-2970 Fax: 623-975-1278


INSPECTION OF RAW MATERIAL
Implement changes to production process.
PRODUCTION OF ROLLED WIRE
TESTS PERFORMED:
- Diameter
- Bend
- Tensile
- Reduction of Area
- Embrittlement
Performed By: Rolling Line Operator, Quality Control Manager
Frequency: 1 samples per spool (per SSL). At start, then every 3rd spool or 9 tons by Line Operator. Daily by QC Manager (per ASTM)
(all tests performed in accordance with ASTM-A82)
DATA RECORDING:
- Date
- Wire Size
- Carbon Grade
- Heat Number
- Wire ID Number
- Bend Test Result
- Diameter Size
- Tensile Load
- Tensile Strength
- Reduction of Area
Performed By: Quality Control Manager
- Hold lot for further testing and evaluation.
- Determine cause of unsatisfactory performance.
- Identify necessary changes to production process.
FAIL
PASS/FAIL?
PASS
STRAIGHTEN & CUT
PRODUCTION GO-AHEAD TESTING:
- 1 wire coupon per spool sent to Galvanizer for embrittlement testing.
PROCEED WITH FABRICATION BASED UPON POSITIVE BEND TEST RESULT
PASS
PASS/FAIL?
FAIL
Notify SSL
TESTS PERFORMED:
- Tensile Strength
- Bend
- Weld Shear
- Reduction of Area
Performed By: Operator, Quality Control Manager
Frequency: For shear test; no less than 4 cross-sectional samples at random from initial sheet, no less than 4 samples taken at random from every 300,000 sf. For tensile strength test; no less than 1 sample taken from longitudinal and horizontal wire's (if sizes differ) of intitial sheet, no less than 1 sample per 75,000 sf.
(all tests performed in accordance with ASTM-A185)
Test samples are identified by style and heat number for testing.
MESH COUPONS:
- 1 coupon per 100 mesh sheets or
- 1 coupon for every wire size change or mesh sheet width change.
FAIL
PASS/FAIL?
PASS
CERTIFICATE OF COMPLIANCE WITH ASTM ISSUED BY CRI
BEND & SHIP
CERTFICATE OF COMPLIANCE ISSUED BY SSL

Quality Management System
Quality Manual

FACILITIES:

CROWLEY
200 NORTH BEVERLY
CROWLEY, TX

JACKSON
125 AZTEC DR
RICHLAND, MS

HOUSTON
7407 CE KING PKWY
HOUSTON, TX

MOSS POINT
4212 DUTCH BAYOU RD.
MOSS POINT, MS

ARKANSAS
998 ESCUE DRIVE
PRAIRIE GROVE, AR

WASKOM
990 E. TEXAS AVE
WASKOM, TX

MOBILE
17640 INDUSTRIAL PARK
CITRONELLE, AL

HOBSON
2402 ENGINEERS RD
BELLE CHASSE, LA

ARIZONA
15775 ELWOOD ST
GOODYEAR, AZ

BEAUMONT
5898 INDUSTRIAL RD.
BEAUMONT, TX

WESTSIDE
3520 S. RIVERVIEW
PORT ALLEN, LA

CINCINNATI
4454 STEEL PLACE
CINCINNATI, OH

MUNCIE
2415 S. WALNUT ST
MUNCIE, IN

DIXON
310 E. PROGRESS DRIVE
DIXON, IL

CHELSEA
6022 S INDUSTRIAL RD
CHELSEA, OK

PLYMOUTH
2631 JIM NEU DR
PLYMOUTH, IN

PEORIA
6718 PLANK RD
PEORIA, IL

HAMILTON
7825 HOMESTEAD DR
HAMILTON, IN

JOLIET
625 MILLS RD
JOLIET, IL

WINSTED
800 6TH ST
WINSTED, MN

BRISTOL
14871 INDUSTRIAL PARK RD
BRISTOL, VA

PILOT
MANILA CREEK RD
POCA, WV

DENVER
4400 EAST 61ST AVE.
COMMERCE, CO

TULSA
1800 W. 21ST ST
TULSA, OK

CANTON
1723 CLEVELAND AVE. S.W.
CANTON, OH

HOUSTON WEST
9103 FAIRBANKS N HOUSTON RD
HOUSTON, TX

ST. LOUIS
1461 KIN ARK CT
ST. LOUIS, MO

RSI - CATOOSA
5101 BIRD CREEK
PORT OF CATOOSA, OK

NASHVILLE
200 32ND AVE. N.
NASHVILLE, TN

LOUISVILLE
6310 KENJOY DR.
LOUISVILLE, KY

HURST
625 W. HURST BLVD
HURST, TX

KANSAS CITY
7700 E. 12TH ST.
KANSAS CITY, MO

WHEELING
748 MCMECHEN ST SUITE 11
BENWOOD, WV

Contents

0.0 Introduction

AZZ Galvanizing Services is committed to a policy of conformance to quality requirements for each function and product of the organization. The policy has been instituted to ensure client confidence, that its services and products are as requested and meet the rigorous specification requirements. This policy is enhanced with an added degree of excellence attributed to the inclusion of substantial control on the administration, procurement, engineering, operation and quality functions of the organization.

The policy is implemented with the adoption of a Quality Management System (QMS) which ensures the organizational structure, responsibilities, processes and resources consistently provide product meeting customer, statutory and regulation requirements. If procedures are found to be in need of improvement, measures will be initiated to revise officially the anomaly to an acceptable level of clarity and resolution.

AZZ Galvanizing Services has planned for the long-term, a strategy utilizing continuous quality improvement, combined with responsive, near-term actions to enable it as an organization, to be a quality leader.

1.0 Duties of Personnel

Senior Vice President and Chief Operating Officer, Galvanizing Services
The Senior Vice President and COO of Galvanizing is responsible for the overall operation of the Galvanizing Services segment. The Senior Vice President and COO of Galvanizing has been assigned the overall responsibility to plan, implement and maintain the Quality Management System.

Vice President of Operations
The Galvanizing Vice President of Operations is responsible for administration, customer relations, safety and quality of the plant under their division.

Galvanizing Regional Manager
The Galvanizing Regional Manager is responsible for administration, customer relations, safety and quality of the plant under their region.

Plant Manager
The Galvanizing Plant Manager is responsible for administration, customer relations, production, maintenance, safety, and quality of service and coating. The Plant Manager is responsible for seeing that all materials are galvanized in accordance with the applicable specifications.

Office Manager
The Office Manager analyzes, organizes and implements office procedures involving accounting payroll, human resources, information management, filing systems, requisition of supplies and other clerical services.

Plant Supervisor
The Plant Supervisor is responsible for production, maintenance and quality of products produced under shift supervision.

Maintenance Supervisor
The Maintenance Supervisor analyzes and resolves work and production problems, performs preventative maintenance, and troubleshoots equipment failures.

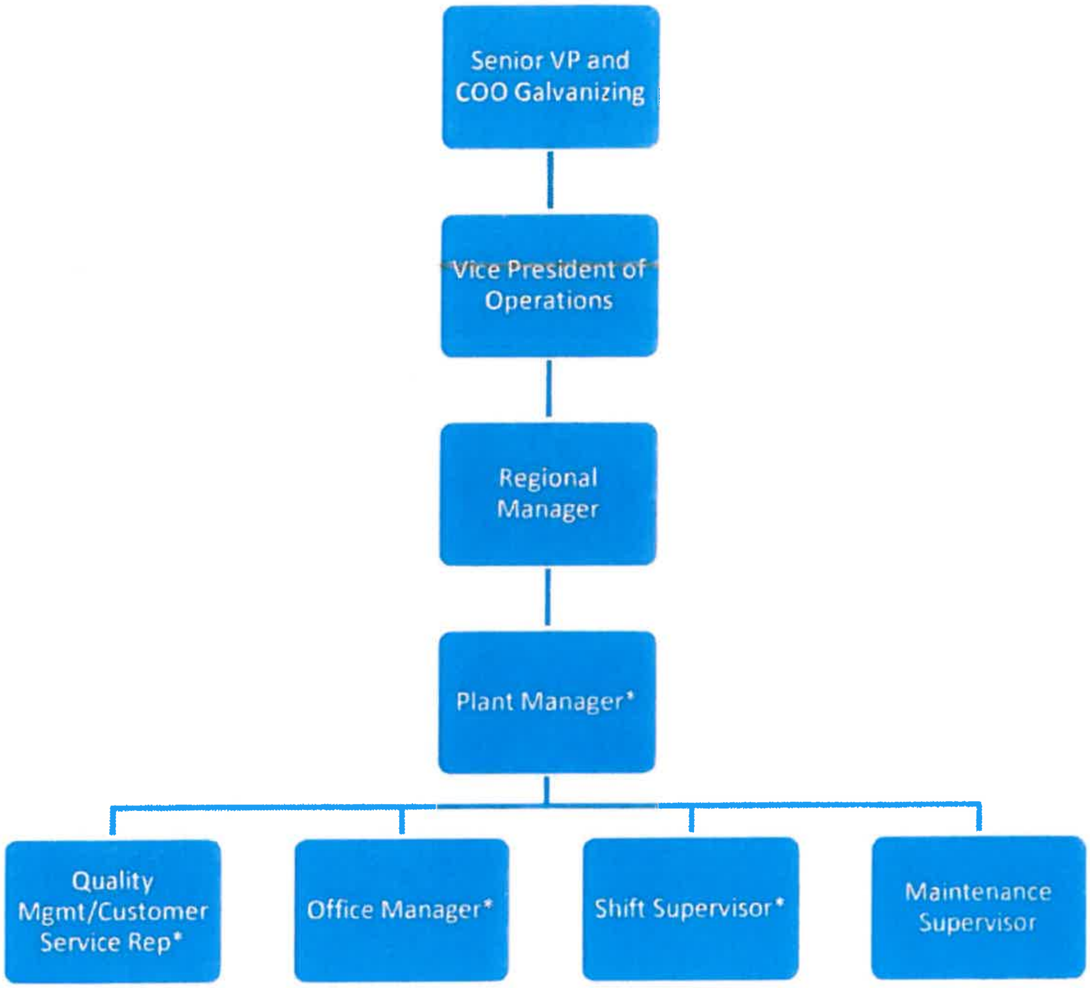
Quality Management/Customer Service Representative
The Quality Management/Customer Service Representative is responsible for proper quality training, document control, document review and adherence monitoring.

2.0 Quality Management

The AZZ Galvanizing Services Quality Manual addresses the requirements of the quality standard and defines the company Quality Management System (QMS). This is the overall responsibility of the Quality Management/Customer Service Representative with input and help from all Quality Management team members, and overseen by the Plant Manager.

2.1 Quality Management Team

This chart is an example of the plant management organization. Actual organization and number of employees may vary at each plant.



*Quality Management Team

2.2 General Requirements

The Quality Management Team implements and maintains the effectiveness and efficiency of the organization's performance by considering the needs of customers through the following steps:

a. Determine the processes needed for the QMS and their application throughout the organization.
b. Determine the sequence and interaction of these processes.
c. Determine criteria and methods needed to ensure that both the operation and control of these processes are effective.

d. Ensure the availability of resources and information necessary to support the operation and monitoring of these processes.
e. Monitor, measure where applicable, and analyze these processes.
f. Implement actions necessary to achieve planned results and continual improvement of these processes. Through the use of the Quality Management Team, all quality related issues are resolved in a timely and efficient manner.

The Quality Management Team directs the Quality Management System. It establishes and reviews all quality policies and is the main policy setting body within the plant. The team interprets the quality policy, and develops quality system objectives, and measures quality performance and institutes corrective action when necessary. The Quality Management Team also controls manufacturing resources and ensures the Quality Management System is in compliance with required regulatory standards.

When chosen to outsource any process that affects product conformity to requirements control over such processes will be ensured. Control of such processes will be identified within the Quality Management System by request for quote, quotation, purchase request, and purchase order. Any required sketches, drawings, specifications, explanations, or standards, will be included with the communications for the outsourced vendor.

2.3 Document Control

The Quality Program Manual and all documents and records required by the manual are controlled and are to be maintained and retained by the appropriate Plant Manager or Vice President, as defined by the manual.

The Quality Program Manual is prepared and distributed by the Manufacturing Engineer Galvanizing Services.

- All controlled manuals will be numbered prior to distribution.
- Controlled in-company distribution of quality manuals will include the Senior Vice President Galvanizing Services, Vice President of Operations, Director of Engineering, Manufacturing Engineer, Galvanizing Marketing Manager, Galvanizing Sales Manager, Galvanizing Regional Manager, Galvanizing Plant Manager, and Sales Manager, each of whom will acknowledge receipt by signature of record to the Senior Vice President.
- Distribution outside the company will be as appropriate and necessary, with receipt acknowledged by signature to the Plant Manager. Manuals distributed outside of the company are considered uncontrolled copies of the Plant Manager's Quality Manual.
- The Plant Manager will maintain records of the distribution of all uncontrolled manuals and receipt signatures.

Revisions of the Quality Program Manual will originate with the Vice President of Operations, and be distributed with a revised contents page to each manual holder of record.

- In-company receipt of revisions will be acknowledged by signature after discussions of the revisions with the Vice President of Operations and return of superseded pages.
- Uncontrolled manuals held outside the company will be acknowledged by signature and return of superseded pages to the Plant Manager.

3.0 Management Responsibility

The Quality Management Team implements the Quality Management System and continually improves its effectiveness by:

a) Communicating the importance of meeting customer and regulatory requirements.

b) Establishing the quality policy.

c) Ensuring that quality objectives are established.

d) Conducting management reviews as necessary.

e) Ensuring the availability of resources.

The Quality Policy, Quality Objectives/Goals and the Quality Management Team support the development, management and continuous improvement in effectiveness of the Quality Management System.

3.1 Management Commitment

The Quality Management Team will formally review the QMS at a minimum of once per year to ensure its continuing suitability and assess opportunity improvements.

3.2 Customer Focus

AZZ Galvanizing Services depends on its customers and focuses to understand current and future customer needs. To that end, customer requirements are determined and fulfilled with the aim of enhancing customer satisfaction.

3.2.1 Customer Requirements

Upon receiving the customer's material, the receiving supervisor or designee will review the customer designated requirements. If customer requirements surpass specifications by statutory or regulatory standards such as ASTM A123 and/or ASTM A153, it is the Plant Manger's responsibility to review these requirements with the customer prior to plant commitment to perform any galvanizing service.

3.3 Quality Policy

AZZ Galvanizing is committed to continually improve the effectiveness of the Quality Management System. This commitment is expressed by:

- Absolute Quality Provider
- Zero Injuries
- Zero Customer Complaints

3.3.1 Quality Policy Communication and Framework for Quality Objectives

The Quality Policy provides the framework for the company Quality Objectives. This Quality Policy is communicated and understood throughout the organization. The policy is posted on bulletin boards, posted at work stations, posted in the offices, posted in the lunchroom and reception area.

3.4 Quality Planning

The Quality Management/Customer Service Representative manages and develops quality objectives, measures quality performance and institutes corrective action when quality objectives are not consistent with the quality policy. The Quality Management Team manages manufacturing resources and ensures that quality objectives, including those needed to meet requirements for product are established at relevant functions and levels within the organization.

The quality objectives are measurable and consistent with the quality policy:

- Pounds shipped
- External/Internal Rework
- Customer Complaints
- Pounds per man hour
- OSHA Accidents
- Sales per month

- Lifts per hour
- Kettle Analysis

4.0 Product Specification

The drive for continual improvement of the organization's performance focuses on the improvement of the effectiveness and efficiency of processes, to achieve increased benefits, increased customer satisfaction, improved use of resources and reduction of waste. The standard specification is in accordance with ASTM A123 unless otherwise specified.

4.1 Planning of Product Specification

In planning of product specification, the Quality Management Team plans and develops the processes needed for product realization and evaluates planning of product specification to be consistent with the requirements of the other processes of the Quality Management System.

In planning product specification, the organization shall determine the following, as appropriate:

- Quality objectives and requirements for the product.
- The need to establish processes, document and provide product specific resources.
- Required verification, validation, monitoring, inspection and test activities specific to the product and the criteria for product appearance.

4.2 Customer-Related Processes

The Quality Management Team shall have a full understanding of the process requirements of the customer before initiating its action to comply.

4.2.1 Determination of Requirements Related to the Product

It is a combined effort between AZZ Galvanizing Services and the customer to determine product requirements:

- There are requirements specified by customer including packing and shipping instructions plus delivery instructions.
- The requirements not stated by customer but necessary for specific products to be processed with the required zinc thickness and appearance such as ASTM A123 standards.

- Statutory and regulatory requirements related to the products and processes.
- Any additional requirements determined by AZZ Galvanizing Services

4.2.2 Review of Requirements Related to the Product

Prior to the AZZ Galvanizing Services' commitment to supply a product to the customer, the review process of requirements related to the product, includes verification of:

- Product requirements are defined.
- Contract or order requirements differing from those previously expressed are resolved.
- That AZZ Galvanizing has the ability to meet the defined requirements.

Where the customer provides no documented statement of requirement, AZZ Galvanizing confirms the customer requirements before acceptance as default to ASTM A123. Changed requirements are identified during review process and evaluated in order to understand the effect on other processes and the needs and expectations of customers. This understanding and its impact need to be mutually acceptable. Relevant documents are amended and relevant personnel are made aware of the changed requirements.

4.3 Customer Communication

The Quality Management Team determines and implements ways for communicating to the customer in relation to:

- Product information.
- Inquiries, contracts or order handling, including amendments.
- Customer feedback, including customer complaints.

Customer communications include quotes, purchase orders, phone calls, fax documents, e-mails, visits, letters, bill of ladings and packing slips.

4.4 Purchasing

4.4.1 Purchasing Process

Products will be purchased from approved vendors unless it is a one-time only purchase. The Quality Management Representative or the Plant Manager must approve one-time-only purchases.
Selection criteria for approved vendors are based on:

- Cost
- Product/Service quality

- Availability/Delivery
- Terms
- Recommendations
- Reputation

Records of approved vendors will be maintained on the approved vendor list.

Approved Vendor Lists exist for

- Bath Metals and Tank Chemicals

4.4.2 Purchasing Information

Purchasing information will describe the product to be purchased.
The purchasing process is:

- Fill out purchasing order requisition form and/or update purchase order log regarding items to be purchased.
- Plant Manager or designee must approve the purchase order.
- Once the order is placed a copy is given to the requestor and the original is filed in purchasing A/P files.

4.5 Production and Service Provisions

4.5.1 Control of Production and Service Provisions

Controlled conditions for production and service provisions include:

- Availability of information that describe the product characteristics.
- Use of suitable process equipment.
- Control of process equipment by monitoring and measurement equipment where applicable.
- Availability and use of monitoring and measuring devices.
- Implementation of release, delivery and post-delivery activities.

4.5.2 Customer Property

Care will be exercised when handling customer-supplied product. Incoming material will be checked visually for damage in transit. The customer will be notified of any damage prior to unloading damaged material. Permission from the customer to unload damaged material must be confirmed and documented. Digital pictures shall be taken prior to unloading damaged material and kept on file. If customer property is lost, damaged or otherwise found unsuitable for use, this will be reported to the customer and records maintained.

4.6 Control of Monitoring and Measuring Equipment

Each Galvanizing Plant Manager is responsible for all testing equipment and all records relating to testing equipment.

4.6.1 Instruments

Thickness gauge

- Gauge will be calibrated and/or tested for accuracy according to the manufacturer's recommendations against standards traceable to the National Institute of Standards and Technology (NIST).

The zinc bath temperature probes will be checked for accuracy and/or calibrated annually.

Weight scales will be checked for accuracy and/or calibrated annually.

5.0 Measurement, Analysis and Improvement

The Quality Management Team ensures that an effective and efficient monitoring, measurement, collection, analysis, improvement and validation of data are in place, to ensure that AZZ Galvanizing Services' performance achieves satisfaction of customer by:

- Demonstrating conformity of the product.
- Ensuring conformity of the QMS.
- Continually improve the effectiveness of the QMS.

5.1 Monitoring and Measurement

5.1.1 Customer Satisfaction

It is the responsibility of the Plant Manager to ensure customer satisfaction. The Quality Management Team monitors information related to customer perception of having needs met.

Appropriate actions are to be taken to correct any complaints and to guard against in the future.

5.2 Internal Audit

Internal audits are conducted at planned intervals to determine whether the QMS conforms to planned arrangements in product realization and is effectively implemented and maintained.

The internal audit program is planned on the basis of the status and importance of the processes and areas to be audited, as well as the results of the previous audit (except for the initial audit). The audit criteria, scope frequency and methods are defined. Selection of auditors and performance of audits will ensure the objectivity and impartiality of the audit process. Auditors shall not audit their own work.

The Quality Management Team is responsible to ensure that actions are taken without undue delay to eliminate detected nonconformities and their causes. Follow-up activities will include the verification of the actions taken and the reporting of the verification results.

5.3 Control of Nonconforming Product

Product that does not conform to requirements is identified and controlled to prevent its unintended use or delivery..

Nonconforming product is managed by one or more of the following ways:

- By taking action to eliminate the nonconformity.
- By authorizing its use, release or acceptance under concession by the Plant Manager and where applicable customer consent.
- By taking action to prohibit its original intended use or application, unless authorized by the customer.
- Records of the nature of the nonconformities and any subsequent action taken, including concession obtained, are maintained.
- When nonconforming product is corrected it will be re-verified to demonstrate conformity to requirements.
- When nonconforming product is detected after delivery or use has started, actions will be taken appropriate to the effects, or potential effect, of the nonconformity.

5.4 Improvement

5.4.1 Continual Improvement

The Quality Management Team continually seeks to improve the effectiveness of the Quality Management System through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions and management review.

5.4.2 Corrective Action

In order to prevent reoccurrence of nonconformities, the following actions are taken to eliminative nonconformities:

- Reviewing nonconformities (including customer complaints).
- Determining the causes of the nonconformities.
- Evaluating the need for action to ensure that nonconformities do not reoccur.
- Determining and implementing action needed.
- Records of the results of action taken.
- Reviewing the effectiveness of corrective action taken.

5.4.3 Preventive Action

Preventive action is taken to eliminate the causes of potential nonconformities in order to prevent their occurrence. The preventive action requirements are:

- Determining potential nonconformities and their causes.
- Evaluating the need for action to prevent the occurrence of nonconformities.
- Determining and implementing action needed.
- Reviewing the effectiveness of the preventive action taken.

6.0 Work Instruction

6.1 Receiving

Incoming material will be checked visually for damage in transit. The customer will be notified of any damage prior to unloading damaged material. Permission from the customer to unload damaged material must be confirmed and documented. Digital pictures should be taken prior to unloading damaged material and kept on file.

Incoming paperwork will be checked for customer identification. Piece counts will be verified when deemed feasible by the Plant Manager.

Material will be removed carefully from the trucks with forklifts or cranes.

Material is inspected for drainage provisions and mounting holes. If these items are not properly addressed the customer will be called and arrangements made to correct the materials.

The material, number of pieces and weights are entered into the Oracle computer system and recorded on daily shipping and receiving sheets.

Any special galvanizing instructions or requests for fast turnaround times are communicated to the Plant Manager and/or Production Supervisor.

6.2 Racking

Bare steel is loaded into pickle baskets or affixed to a fixture via wire, brackets, chains, pins, hooks, etc.

Products are to be oriented in such that they will gravity drain liquids when removed from the different baths. A lead person or supervisor must be contacted for instruction if products are noticed without drainage provisions.

6.3 Pickling

All tanks are to be monitored per the SOP for temperature and chemical strength. Records of temperature, chemical strength and remedial action will be kept per the SOP.

Alkaline cleaning tank or Acid Degreasing tank - when required, material will be immersed in the cleaning solution to remove oils, greases and paints.

Acid Tank

Material may be chemically cleaned in either:

Hydrochloric Acid (or)

Sulfuric Acid

Material is submerged until all scale, rust or coatings are removed.

Abrasive cleaning may be used as an alternative cleaning method to acid cleaning.

Rinse tanks for the removal of cleaning chemicals will contain water.

Pre-flux tank (zinc ammonium chloride) to prevent oxidation until material is galvanized

Hoisting Procedure:

- Material is lowered slowly into tanks.
- Material is moved onto the next tank only after a minimum amount of drips are present falling from the lowest point of the load.

6.4 Galvanizing

- The zinc bath temperature will be maintained per the SOP and may be varied to meet the requirement of products being galvanized.
- Kettle lead person will inspect material to verify proper pickling, fluxing, and venting, prior to its entering the kettle.
- All material will remain in the kettle zinc bath until it reaches the temperature of the bath.
- All material will be withdrawn from the zinc bath in a manner that will minimize ash inclusion.
- Major uncoated areas are cause for rejection and return to pickling for regalvanizing if the bare spots are larger than 1 inch in the narrowest dimension (ASTM A123). Minor uncoated areas, one inch or less in the narrowest dimension, will be repaired according to ASTM A780 (latest revision). See the *Inspection of Products Hot Dip Galvanized After Fabrication* (published by American Galvanizers Association).

6.5 Control and De-racking

- Operators remove materials from fixtures or baskets while inspecting for ungalvanized areas, sharp projections and or surface condition.
- If needed, materials are cleaned using files or grinders, and any needed repairs are conducted in accordance to the ASTM A123 standards.
- Product is weighed and the weights recorded.

6.6 Shipping

- Product is prepared for shipment and thoroughly banded and or shrink wrapped if applicable.
- Final product count, identification, weighing, orientation etc must be checked for compliance with customer specifications.
- Customer is contacted for pickup.
- Materials should be loaded as they were received unless noted not feasible.
- Careful loading and tight bundling is important.

- Carrier is responsible for product once it is loaded and must inspect the load.

PRECAST QUALITY CONTROL CHECKLIST

SUPPLIER:

PROJECT:

DATE:

WALL NO:

CASTING DATES:

RELEASE DATE:

PANEL QTY:

Quality Control Checklist Included?

Concrete Strength Test Results Included?

Quality Control Manager:____

Signature:____

PRE-POUR
DATE:
PROJECT/WALL ID:
INSPECTOR:

POST-POUR
DATE:
INSPECTOR:

PANEL ID	COMMENTS	READY TO CAST?	CASTING	COMMENTS	READY TO SHIP?

*For a panel to be ***READY TO CAST*** it must be checked for the following:
Length, width, square, level, clean, oil, rebar size, rebar qty, cover, lifting inserts, embed size, embed placement, embed clearance.

*For a panel to ***CAST*** properly it must be witnessed that the concrete is placed, finished, vibrated and cured per all applicable Specifications.

*For a panel to be ***READY TO SHIP*** it must be checked for the following:
Front and back finish, cracks, spalls, broken edges, lifting inserts, embed placement, length, width, square.

4.1.3 Miscellaneous Component QA/QC

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TESTING ENGINEERS, INC.

Quality Assurance Services
Materials Consulting
Since 1954

Laboratory No. N208A

MECHANICAL TESTS

Report Date: 3/25/2021
Test Date: 3/24/2021

Client No. SSL000

P.O. No.: Verbal

Project : SSL
Plastic Pad Compression

Description or Mark No.	CAV-1A	CAV-2A	CAV-2B		Specified Requirements
Length x Width, Ins.	5.978 x 2.647	5.972 x 2.646	5.964 x 2.644		
Height, Ins.	0.766	0.769	0.761		
Displacement at 40,000 lbf, in	0.1449	0.1281	0.1138		
Failure Mode	Minimal flattening of ends.	Minor flattening of ends.	Minor flattening of ends.		
Mass, g	135.7	136.1	133.3		

Test Equipment: Instron 5985 SN B17048 and 6" Fowler SN TE0601. Tested at 0.05 in/min.
Scale: Torbal AD500 S/N 105001062

Remarks: Graphs are presented in Figures 1, 2, and 3. Photograph of specimens before and after test are presented in Figure 4.
Displacement at max load was calculated based on zero displacement at 30 lbf.
Results Reported To: SSL

TESTING ENGINEERS,INC.

By Colin Subasa 3/25/21

Colin Subasa, Materials Testing Technician

Corporate Office – 2811 Teagarden Street – San Leandro, California 94577 – (510) 835-3142 – FAX (510) 834-3777
www.Testing-Engineers.com

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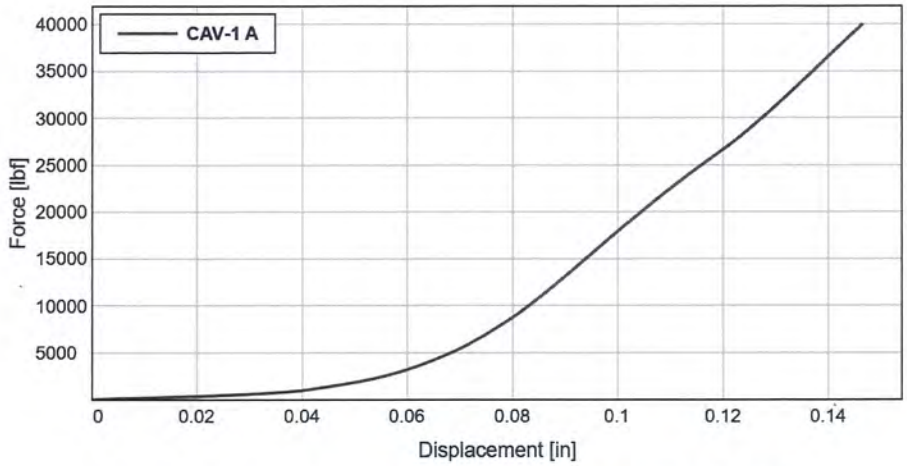


Figure 1. Load-displacement graph of Specimen CAV-1 A.

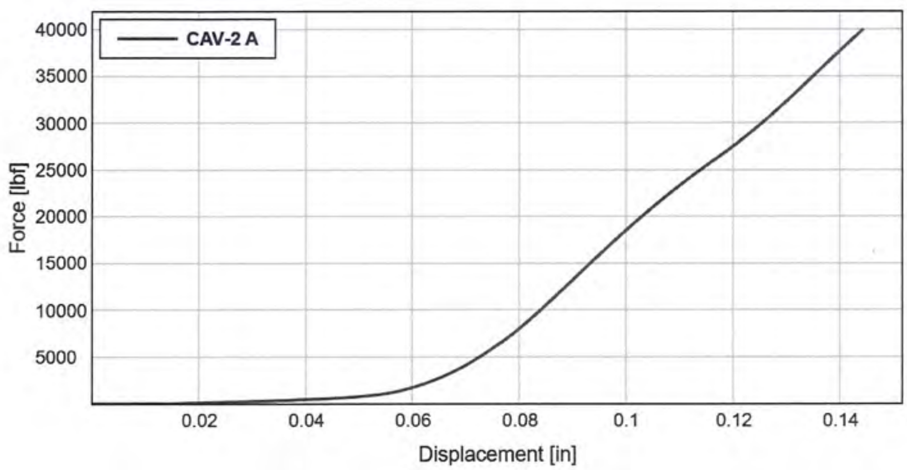


Figure 2. Load-displacement graph of Specimen CAV-2 A.

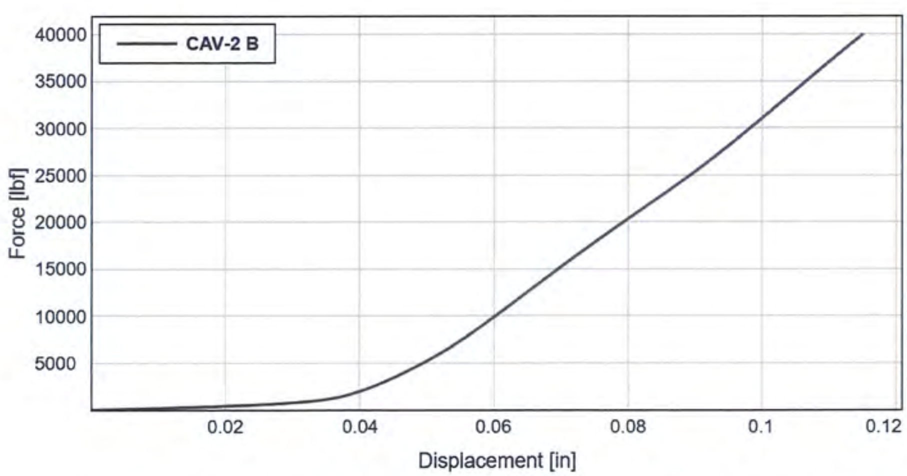
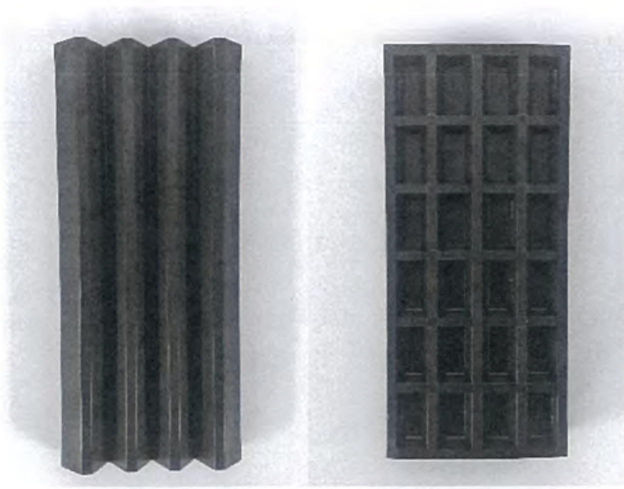
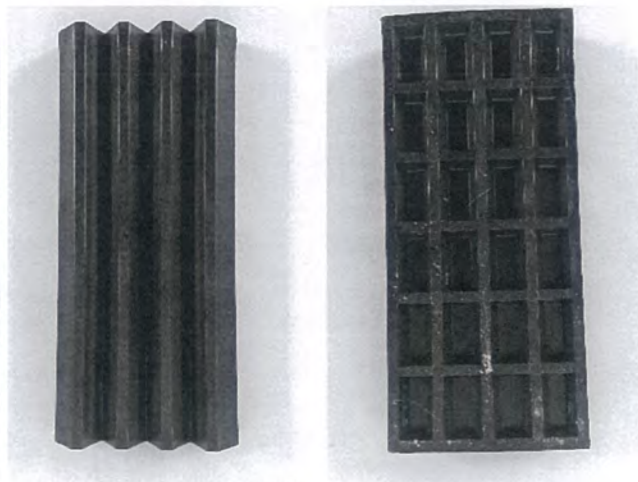


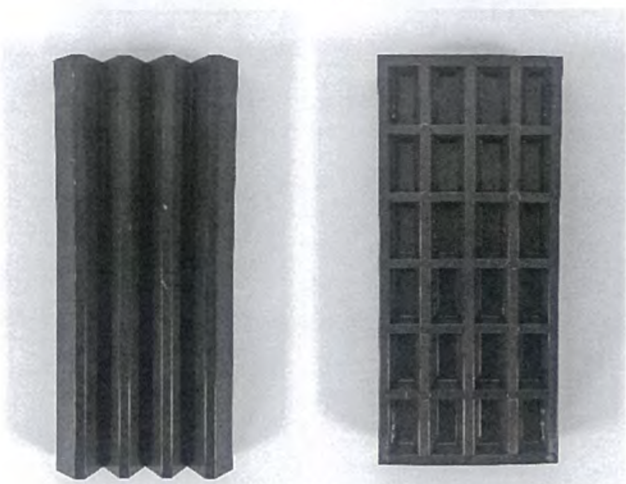
Figure 3. Load-displacement graph of Specimen CAV-2 B.



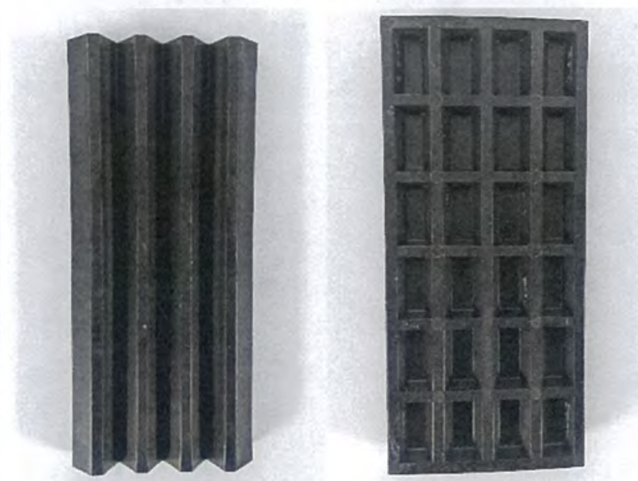
CAV-1 A Before Test



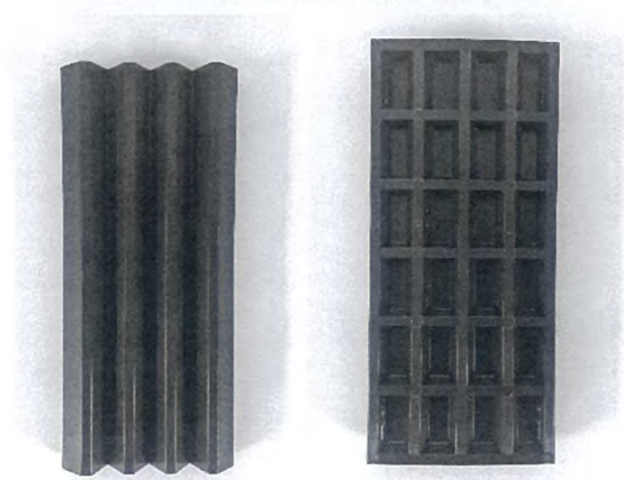
CAV-1 A After Test



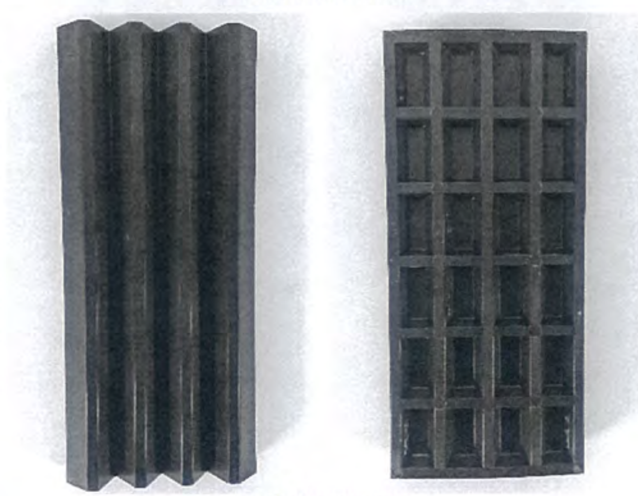
CAV-2 A Before Test



CAV-2 A After Test



CAV-2 B Before Test



CAV-2 B After Test

Figure 4. Photographs of CAV-1 A, CAV-2 A, and CAV2-B before and after testing.

Section 5: PERFORMANCE

5.3
Performance History

5.1.4 System Approval by User

MSE Plus System Approval by State

State	Approved	Letter Dated	Contact	Position	Phone
Alabama	Y	28-Aug-2006	B.E. Cox Jr, P.E.	Geotechnical Engineer, AK DOT	(334) 206-2270
Alaska	Y	Letter not issued	Kieth Korri	Materials and Testing Headquarters, AK DOT	(907) 269-6243
Arizona	Y	13-Jul-1998	Muhannad M.A. Zubi, P.E.	Product Evaluation Engineer, AZ DOT	(602) 407-3134
Arkansas	Y	27-Sep-2001	Jim Gee	Materials Engineer, AR DOT	(501) 569-2400
California	Y	14-Aug-2012	Kathryn Griswell	Earth Retaining System Specialist, Caltrans	(916) 227-7330
Colorado	Y	Letter not issued	David Kotzer	Product Evaluation Coordinator	(303) 757-9421
Connecticut	N				
Delaware	Y	Letter not issued	John V Eustis Jr.	Competitively Bid Contracts Manager	(302) 760-2030
Florida	Y	10-Dec-2012	Barry Smith	Product Evaluation Administrator	(850) 414-4353
Georgia	N		Brennan Roney	New Product Evaluation Engineer, GA DOT	(404) 608-4816
Hawaii	Y	Letter not issued	Clarence Miyashiro	Highways Division, Materials Testing, HI DOT	(808) 832-3409
Idaho	Y	22-Dec-1998	Jon Ingram	Geotechnical Engineer, Headquarters Construction/Materials	(208) 334-8436
Illinois	Y	17-Sep-1999	Ralph E Anderson	Engineer of Bridges and Structures, IL DOT	(217) 785-1462
Indiana	Y	31-Aug-2020	Aamir Turk, PE	Geotechnical Engineer, IN DOT	(317) 522-9728
Iowa	N				
Kansas	Y	10-Oct-2000	Lon S Ingram, P.E.	Chief, Bureau of Materials and Research, KS DOT	(785) 296-3008
Kentucky	Y	Letter not issued	William H Phillips	T.E. Specialist, Division of Bridge Design, KY DOT	(502) 564-4560
Louisiana	N				
Maine	N				
Maryland	N				
Massachusetts	Y	Letter not issued	Richard Carpenito	Technical Services Engineer, Mass DOT	(617) 951-1348
Michigan	Y	Letter not issued	Rich Endress	Office of Construction & Technology	(517) 322-1207
Minnesota	Y	Letter not issued			
Mississippi	N				
Missouri	Y	Letter not issued	Judy Kempker	Executive Director, Division of Professional Registration, MO DOT	(573) 751-0047
Montana	Y	Letter not issued	Robert Tholt	Administrator, Geotechnical Section, MT DOT	(406) 444-6008
Nebraska	Y	24-Apr-2008	Omar A Qudus, P.E.	Geotechnical Engineer, Materials & Tests Division, NE DOT	(402) 471-4567
Nevada	Y	17-Feb-2000	Alan R Hilton	Research Division Chief, NV DOT	(775) 888-7220
New Hampshire	N				
New Jersey	Y	1-Jun-2008	Robert F Baker	Project Engineer, New Technologies & Products, NJ DOT	(609) 530-5290
New Mexico	Y	20-Jul-2011			(505) 476-3116
New York	N				
North Carolina	N		Scott Hidden	Geotechnical Engineering Unit	(919) 707-6856
North Dakota	Y	Letter not issued	Paul Murdoff		(701) 328-2569
Ohio	Y	15-Nov-2006	Tim Keller, P.E.	Administrator, Office of Structural Engineering, OH DOT	(614) 728-2057
Oklahoma	Y	15-Apr-2002	Robert J. Rusch, P.E.	Bridge Engineer, OK DOT	(405) 521-2606
Oregon	Y	21-Nov-2012	Jon Guido, P.E., G.E.	State Bridge Engineer, Bridge Engineering Section, OR DOT	(503) 986-3993
Pennsylvania	N		Michael McGonagle	New Products Coordinator, PennDOT	(717) 214-4035
Rhode Island	N				
South Carolina	N				
South Dakota	Y	3-Jan-2002	Lawrence L. Weiss	Chief Engineer, Division of Engineering, SD DOT	(605) 773-3174
Tennessee	Y	19-Jun-2002	Edward P Wasserman	Civil Engineering Director, Division of Structures, TN DOT	(615) 741-3351
Texas	Y	3-Nov-2000	Mark P McClelland, P.E.	Geotechnical Branch Manager, Bridge Design Section, TX DOT	(512) 416-2226
Utah	Y	6-Oct-2004	Jim McMinimee P.E.	Project Development Director, UT DOT	(801) 965-4000
Vermont	N				
Virginia	Y	14-Mar-2008	D. Ashton Lawler, P.E.	Program Manager, Geotechnical Design of Structures, VA DOT	(804) 786-2355
Washington	Y	5-Aug-2013	Monique Pawelka, P.E.	Division of Bridge and Structure Design, WA DOT	(360) 705-7754
West Virginia	Y	17-Apr-2002	Barney C. Stinnett, P.E.	Director, Materials Control, Soils and Testing Division, WV DOT	(304) 558-3505
Wisconsin	Y	5-Feb-2004	Lee J Schuchardt, P.E.	Bridge Research and Automation Engineer, WI DOT	(608) 266-8494
Wyoming	Y	Letter not issued	B. Patrick Collins, P.E.	Bridge Program, WY DOT	(307) 777-4427

Appendix C4
Initial Technical Evaluation Checklist for Precast Concrete Panel Paired with Inextensible Reinforcement

Guidelines for the Applicant to use this checklist:

1. Provide your submittal in Adobe portable document format (i.e. PDF).

2. Organize the submittal based on the numbered outline shown in the checklist below. Use the numbered outline for a table of contents (TOC). Provide the response for each item in your report. Create *links* between the items in the TOC and the items in the report and appendices.

3. If reports, drawings or calculations are requested for a section, provide them in the appendix tabbed for that section. For example, design calculations are required for Item 2.3.1. They should be included in Appendix 2.3.1.

4. Mark the checklist at each item to indicate "yes" you have included the relevant information. If you must check "no", please provide a brief explanation if appropriate.

Section 1: ERS Components

1.1	Facing Unit		
1.1.1	Yes	No	Item
	☐	☒	Does the wall system contain what you consider to be an innovation that is related to the facing unit? If yes, please describe the innovation briefly. As items below apply to the innovation, please describe the innovation in further detail.
1.1.2	☒	☐	List each type of facing unit.
1.1.3	☒	☐	Provide specifications for each facing unit.
1.1.4	☒	☐	Provide standard dimensions, tolerances and typical steel reinforcement schedule (if any is used) for each type of unit (e.g. standard, crest, corner, base, etc.) in plan and section drawings.
1.1.5	☒	☐	Provide the target 28-day minimum compressive strength.
1.1.6	☐	☒	Provide the target percent air range.
1.1.7	☒	☐	Producers will change mix design to accommodate state requirements.
1.1.8	☒	☐	Describe with text any unit shear, alignment or bearing devices. Provide specifications and detail drawings.
1.1.9	☒	☐	Describe with text any filter which is used to prevent migration of fill soil through wall face. Provide specifications.
1.1.10	☒	☐	Describe with text the aesthetic facing options that are available. Provide photos, drawings and brochures as appropriate.
1.1.11	☒	☐	Describe any limits on the facing units that are created by curved wall sections and corners.

1.2	Inextensible Reinforcement

Appendix C4
Initial Technical Evaluation Checklist for Precast Concrete Panel Paired with Inextensible Reinforcement

	Yes	No	Item
1.2.1	☐	☒	Does the wall system contain what you consider to be an innovation that is related to the reinforcement? If yes, please describe the innovation briefly. As items below apply to the innovation, please describe the innovation in further detail.
1.2.2	☒	☐	List each reinforcement type that is to be used with the facing system.
1.2.3	☒	☐	For each type provide physical property specifications. Address ultimate and yield strengths as well as welds if they are applicable.
1.2.4	☒	☐	For each reinforcement type describe corrosion protection measures. If coatings or galvanization are used, provide minimum thickness for 75-year design life (based on the electrochemical requirements listed in AASHTO).
1.2.5	☒	☐	For each reinforcement type provide sacrificial steel thickness for 75 and 100-year design life.
1.2.6	☐	☒	For each reinforcement type provide the results of any corrosion tests that have been performed.
1.2.7	☒	☐	For each reinforcement type provide detail drawings that show dimensional tolerances.
1.2.8	☒	☐	Describe with text and drawing details how the reinforcement connects to facing units.
1.2.9	☒	☐	List each connection device that is used to connect the facing unit and reinforcement.
1.2.10	☒	☐	For each connection device provide physical property specifications. Address ultimate and yield strengths as well as welds if they are applicable.
1.2.11	☒	☐	For each connection device describe corrosion protection measures and provide specifications. If coatings or galvanization are used, provide minimum thickness for 75-year design life (based on the electrochemical requirements listed in AASHTO).
1.2.12	☒	☐	For each connection device provide sacrificial steel thickness for 75 and 100 year design life.
1.2.13	☐	☒	For each connection device provide the results of any corrosion tests that have been performed.
1.2.14	☒	☐	For each connection device provide detail drawings that show dimensional tolerances.
1.2.15	☒	☐	List facing unit-reinforcement connection strength tests performed, provide test results and strength envelopes the Applicant recommends for design.
1.2.16	☐	☒	List reinforcement pullout (ASTM D6706) tests performed and provide results. Provide test soil properties, corresponding pullout friction factors (F*) and scale effect correction factors (α) Applicant recommends for design (it is recognized that for inextensible reinforcement the value of α may be 1.0). Discuss how test results support these recommendations based on Appendix B at FHWA-NHI-10-025. If no tests have been performed, list the default values that should be used based on FHWA-NHI-10-024/025

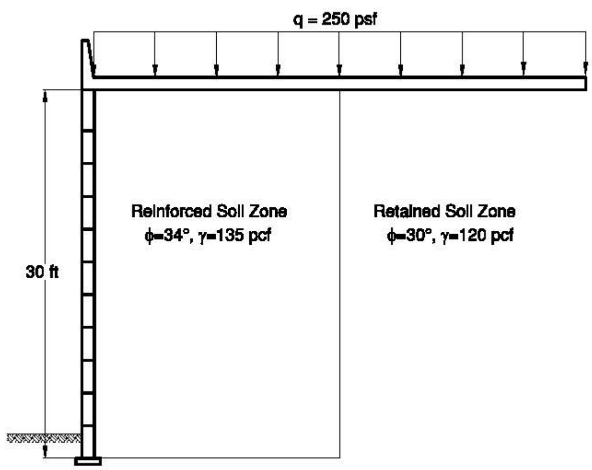
1.2.17	☐	☒	List soil-reinforcement interface shear (ASTM D5321) tests performed and provide results. List interface friction angle (□) Applicant recommends for design. Discuss how test results support these recommendations. If no tests have been performed, list the default values that should be used based on FHWA-NHI-10-024/025.

1.3	Other Components		
	Yes	No	Item
1.3.1	☐	☒	Does the wall system contain what you consider to be an innovation that is related to a wall component? If yes, please describe the innovation briefly. As items below apply to the innovation, please describe the innovation in further detail.
1.3.2	☐	☒	Reinforced Soil - Provide the standard Atterberg Limits range, grain-sized distribution range, minimum effective internal angle of friction and limiting electrochemical properties. Are these soil parameters consistent with current AASHTO requirements?
1.3.3	☒	☐	Drainage - Describe with text any internal and external drainage measures that are inherent in the wall system. That is, they are not optional measures such as blanket and chimney drains or drainage swales, but are built-into wall components.
1.3.4	☒	☐	Coping – Describe with text standard coping that may be used with the wall system, not including the previously described cap units. Provide typical dimensions, and plan and section view drawings.
1.3.5	☒	☐	Traffic Barriers – describe with text traffic barriers (i.e. moment slab, post and beam or other) that may be used with the system and any limitations that may apply. Provide typical plan and section view drawings.
1.3.6	☒	☐	Slip Joints – describe with text how slip joints are made to accommodate potential differential settlement. Provide typical plan and elevation view drawings.

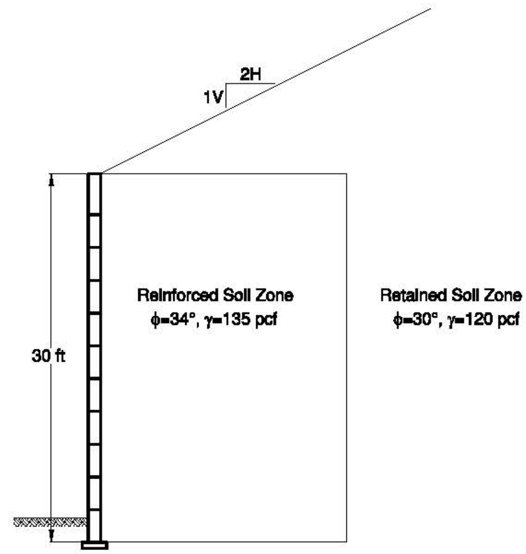
Section 2: ERS Design

2.1	Design Methodology		
	Yes	No	Item
2.1.1	☐	☒	Does the wall system contain what you consider to be an innovation that is related to the design methodology? If yes, please describe the innovation briefly. As items below apply to the innovation, please describe the innovation in further detail.
2.1.2	☒	☐	Describe the design methodology thoroughly, and provide references to supporting literature as appropriate.
2.1.3	☒	☐	Describe how and provide typical plan and section detail drawings of the facing and reinforcement to handle vertical and horizontal obstructions in the reinforced zone.

Appendix C4
Initial Technical Evaluation Checklist for Precast Concrete Panel Paired with Inextensible Reinforcement



Problem 1
Design Life 75 Years



Problem 2
Design Life 75 Years

2.2	Design Example		
	Yes	No	Item
2.2.1	☒	☐	Problems 1 and 2—provide complete calculations for both problems using MSEW. If the design is performed with software that is not commercially available or is proprietary, please provide sample calculations with references to support the analysis.

Section 3: Construction

3.1	Construction Procedures		
	Yes	No	Item
3.1.1	☐	☒	Does the wall system contain what you consider to be an innovation that is related to the construction procedures? If yes, please describe the innovation briefly. As items below apply to the innovation, please describe the innovation in further detail.
3.1.2	☒	☐	Provide the construction manual for the wall system and at a minimum they should include the following items.
3.1.3	☒	☐	Describe any limitations of facing unit installation at inside and outside curved sections of the wall and at corners as well as any modifications that are required to be made to the facing unit.
3.1.4	☒	☐	Describe procedures to install earth reinforcement at curved sections of the wall and at corners. Specifically address any measures that are to be taken at intersection or overlapping panels of reinforcement.
3.1.5	☒	☐	Describe measures that are required to maintain the design vertical and horizontal alignment of the wall face.
3.1.6	☒	☐	Describe the procedures to install soil in the reinforced soil zone.

3.1.7	☒	☐	Describe measures that are required to prevent erosion behind and in front of the wall during construction.
3.1.8	☒	☐	Describe experience or other special qualifications that are required of the wall construction contractor.
3.1.9	☒	☐	Describe the procedures to install soil in the reinforced soil zone.

Section 4: Quality Control

4.1	Manufacturing		
	Yes	No	Item
4.1.1	☒	☐	Describe the quality control measures that are required for the manufacturing of facing units. You may do this by providing a manufacturing QC manual.
4.1.2	☒	☐	Describe the quality control measures that are required for the manufacturing of earth reinforcement components. You may do this by providing a manufacturing QC manual.
4.1.3	☒	☐	Describe the quality control measures that are required for the manufacturing of any shear, alignment, bearing or connection devices. You may do this by providing a manufacturing QC manual.

4.2	Construction		
	Yes	No	Item
4.2.1	☒	☐	Describe the quality control measures that are required during construction of the wall system. If these measures are described in the system's construction manual then state that they are so included and refer the reviewer to the appropriate section of the submittal.

5: Performance

5.1	Performance History		
	Yes	No	Item
5.1.1	☒	☐	Provide a description of the system's development and usage history. Then describe the following:
5.1.2	☒	☐	The oldest three structures.
5.1.3	☒	☐	The tallest three structures.
5.1.4	☒	☐	Provide a list of private- and public sector users who have approved the use of the system. Also provide the contact information for a person at the user agency who may be contacted regarding the wall system's performance.

6: Other

6.0	Other Information		
6.1	☐	☒	In this section, please include anything you think will better help a reviewer understand your ERS that has not been adequately address in the previous questions.