Spectrum Structural Engineering, Inc.
Solutions to the spectrum of structural engineering concerns SM

516 Sixteenth Street, Oakland, CA 94612 | T: 415.519.1820 | www.SpectrumSE.net

July 25, 2023

David Heinzerling, PE
Principal
Taylor Engineers
1080 Marina Village Parkway
Alameda, CA 94501

Subject: Report of findings

Project: Structural Evaluation of Roof Slab for Proposed Heat Pumps Installation
1537 Webster Street
Oakland, California 94612
Spectrum Structural Engineering Project 23028

Dear Mr. Heinzerling:

At your request and pursuant to Spectrum Structural Engineering's (SSE's) proposal dated May 31, 2023, SSE has evaluated by calculation the roof slab of the existing building located at 1537 Webster Street in Oakland. The purpose for the evaluation is to assess the roof slab's structural adequacy to accommodate the weight of four new rooftop heat pumps that are slated to replace four existing rooftop air-conditioning units. This report presents SSE's evaluation methodology and findings.

Executive Summary

Four new heat pumps are proposed on the roof of the existing building to replace four existing air-condition units. The proposed heat pumps will be located essentially in the same location as those slated for removal. The existing roof structure is a two-way reinforced concrete slab constructed circa the 1920s. Structural Calculations indicate the existing roof slab is structurally adequate to accommodate the weights of the proposed heat pumps.

Project Scope Description

Presently four rooftop air-conditioning units serve the building. Their individual weights range from approximately 800 pounds to 1,300 pounds. The project you contemplate will remove the four units and install four new heat pumps in the same locations to limit roofing patching work scope. The proposed heat pumps' approximate weights and approximate overall dimensions are listed below as follows:

Tag	Weight	Width	Length	Height
AC-01	3,800 lbs	77 in	162 in	83 in
AC-02	1,400 lbs	67 in	87 in	41 in
AC-03	1,400 lbs	67 in	87 in	41 in
AC-04	600 lbs	49 in	74 in	44 in

The proposed heat pumps' sizes and weights are comparable to those of the existing air-conditioning units slated for removal.

The proposed heat pumps' locations are illustrated in Figure 1 in the appendix.

Building Description

You and Mr. Cooper stated the building shell's original design drawings are not known to exist.

I visited the building on May 23, 2023 and July 24, 2023 with Ben Cooper of Stop Waste, the building's tenant. The purpose for the visits was to perform a cursory, visual survey of present conditions on the roof and at the underside of the roof slab. Mr. Cooper and I toured the roof, and I observed the underside of the roof slab from the second floor. Much of the roof slab is visible from the second floor, but ceiling finish conceals some areas.

I reviewed drawings dated 03-13-06 prepared by Komorous-Towey Architects, OLMM Structural Engineers, Rumsey Mechanical Engineers, and Integrated Design Electrical Engineers. The drawings illustrate a tenant improvements work scope that generally includes interior finishes alterations, a new interior stair, a new skylight above the stair, seismic rehabilitation of the primary structural system, and improvements to mechanical, electrical and plumbing systems.

The building stands two stories and is rectangular shaped in plan. The original structural system is constructed of cast-in-place, reinforced concrete as follows: two-way roof and second floor slabs with drop panels at interior columns, and perimeter walls. It is estimated the building was originally erected in the 1920s based on the appearance of the concrete formboards and the use of square shaped reinforcing bars, which are visible in some areas at the roof slab underside.

The 2006 tenant improvement project added a reinforced shotcrete shear wall at the south wall, and two structural steel braced frames founded on micro-pile foundations, one frame at the front stair and a second frame at the rear (west) wall.

The roof slab's cross section is visible at the skylight. The 2006 tenant improvement project included cutting an opening in the roof slab for the skylight. The slab cross section was reviewed from a ladder at the July 24 site visit. The slab measures 8 inches thick, and ½-inch by ½-inch square, ribbed steel reinforcing bars were observed near the slab's top and bottom surfaces and spaced approximately 8 inches on center. 26-inch diameter interior columns with

66-inch diameter capitals and 4-inch by 8 feet by 8 feet drop panels vertically support the roof slab. Construction phase photos in a written narrative[1] about the tenant improvement project corroborate the foregoing observations.

Methodology

SSE evaluated the structural adequacy of the roof slab by calculation. The commercially available software SAP2000 is used to perform the structural analysis. The software mathematically models the roof structure's geometric and mechanical properties. The new heat pumps' weights and the roof assembly's weight are applied to the model. A 20 pounds per square foot building code prescribed live load is also applied to the model in the areas between heat pumps to represent the weight of incidental loading.

The mechanical properties of the concrete and steel reinforcing bars are not definitively known, but based on the building's circa 1920s estimated vintage, the properties can be reasonably estimated. The evaluation assumes a 2,500 pounds per square inch concrete compressive strength and a 33,000 pounds per square inch steel reinforcing bar yield strength.[2]

The roof slab's available strength is determined applying the methodology prescribed in *Building Code Requirements for Structural Concrete and Commentary*, ACI 318-19, a standard adopted by the 2022 California Building Code. According to the methodology, structural components are deemed adequate when their available strength exceeds the required strength that corresponds to the applied loads described above.

Findings

Calculations indicate the existing reinforced concrete roof slab is structurally adequate to accommodate the weight of the proposed heat pumps. This finding is based on the heat pumps weights and locations described in this report.

Changes to the weights, dimensions, locations or quantity of heat pumps described in this report could alter the conclusions in this report. SSE should be consulted if changes to any of these parameters are contemplated before acting on such intentions.

No significant distress in the roof slab or the walls and columns that support the roof slab was observed during the visual surveys performed on May 23 and July 24.

Limitations

The findings in this report are based on the stipulations described herein. SSE has relied on information furnished to it by others for the purposes of preparing this report. SSE has not independently verified the information provided. If circumstances differ from those

[1] *1537 Webster Street – A Green Renovation in Downtown Oakland*, November 2016, by Stop Waste.
[2] *Seismic Evaluation and Retrofit of Existing Buildings*, published by the American Society of Civil Engineers, Standard 41-17.

summarized above, please notify SSE. Circumstances other than those assumed could invalidate the findings in this report.

The field surveys SSE performed on May 23 and July 24, 2023 were limited to cursory, visual reviews of conditions readily observable. Instruments that detect concealed conditions were not employed.

The findings in this report are based on calculations. Physical, in situ load testing was not employed.

This report is intended for the sole use of Taylor Engineers, its client, Stop Waste, and the local authority having jurisdiction for building code enforcement at the subject location under the circumstances described herein. Any other party that relies on the findings of this report without the express, written consent of SSE assumes sole responsibility for any and all circumstances that arise or may arise from such unauthorized use of this report, and that party agrees to indemnify, defend and hold harmless SSE, its officers, employees, heirs, successors and assigns against all damages, liabilities, claims, or costs, including attorneys' fees.

This report has been prepared using the degree of care and skill ordinarily exercised by reputable engineers acting under similar circumstances at the same time and in the same or similar locality. SSE makes no warranty, express or implied, as to the findings in this report or SSE's services.

Please do not hesitate to contact me if you have any questions.

Sincerely,

Jeffrey E. Taner, S.E.
Principal

7-25-2023

Attachments:

- Figure 1 (1 page)
- Structural calculations dated July 25, 2023 (17 pages)

Appendix

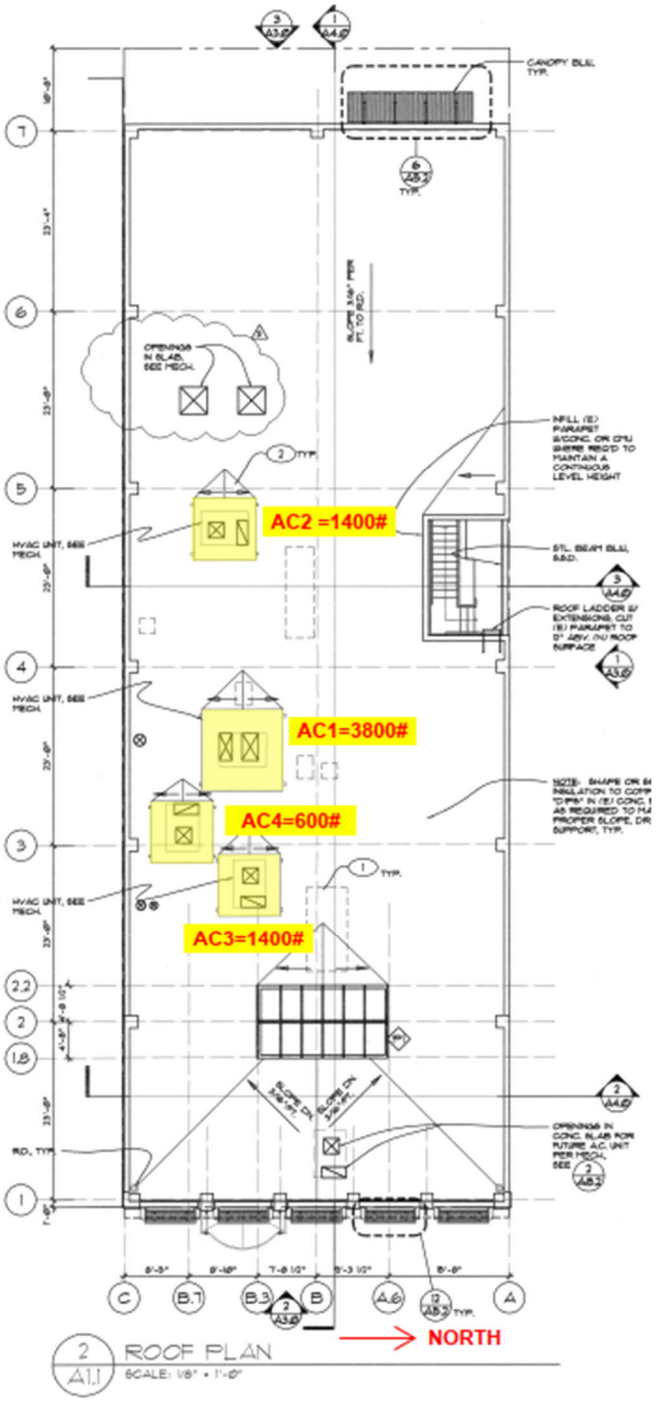

Figure 1 – Roof Plan & Heat Pump Layout

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STRUCTURAL EVALUATION
OF
EXISTING ROOF SLAB TO SUPPORT ROOFTOP HEAT PUMPS

Existing Building
1537 Webster Street
Oakland, California 94612

Prepared for: Taylor Engineers
1080 Marina Village Parkway
Alameda, California 94501

Prepared by: Spectrum Structural Engineering, Inc.
516 Sixteenth Street
Oakland, CA 94612
Spectrum Project 23028

July 25, 2023

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Index

END Index

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Project description:

The scope of these calculations is limited to structural evaluation of the existing reinforced concrete roof slab's structural adequacy to accommodate the weight of four proposed rooftop heat pumps. The heat pumps will replace four existing air-conditioning units. The heat pumps will be installed at the same locations where the air-conditioning units are removed.

Seismic anchorage design for the proposed heat pumps is outside the scope of these calculations.

All other project components not described above are outside the scope of these calculations.

Address:

1537 Webster Street
Oakland, California 94612

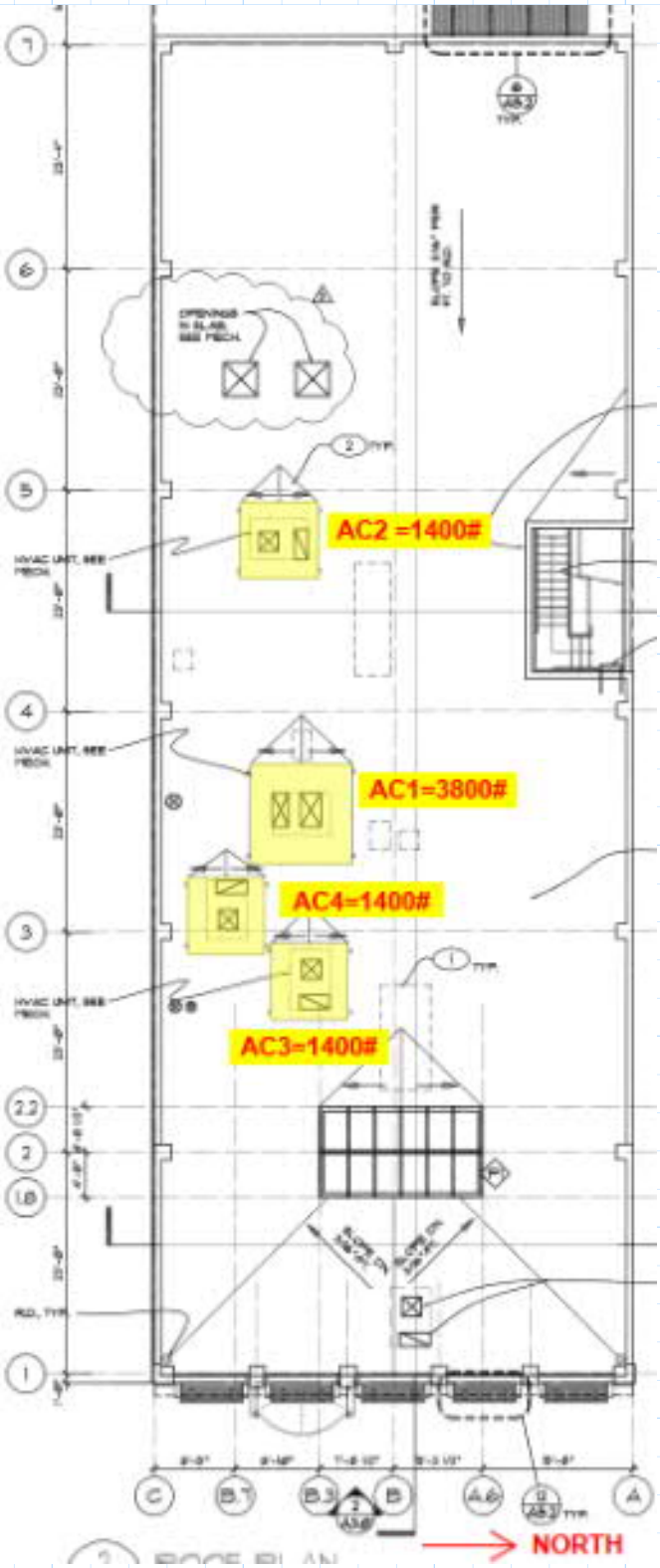
Structural evaluation criteria:

Applicable loads and permissible materials stresses the 2022 California Building Code and 2022 California Existing Building Code prescribe.

Limitations:

These calculations are intended solely for use by Spectrum Structural Engineering, Inc. (SSE) and the authority having jurisdiction for building code enforcement. Use by any other party without the prior, express, written consent of SSE is prohibited. Any party other than the foregoing that relies on these calculations assumes sole responsibility for any and all consequences that arise or may arise from such unauthorized use, and that party agrees to defend, indemnify and hold harmless SSE, its officers, employees, heirs, assigns and successors against all claims.

Key Plan - Rooftop Mechanical Units



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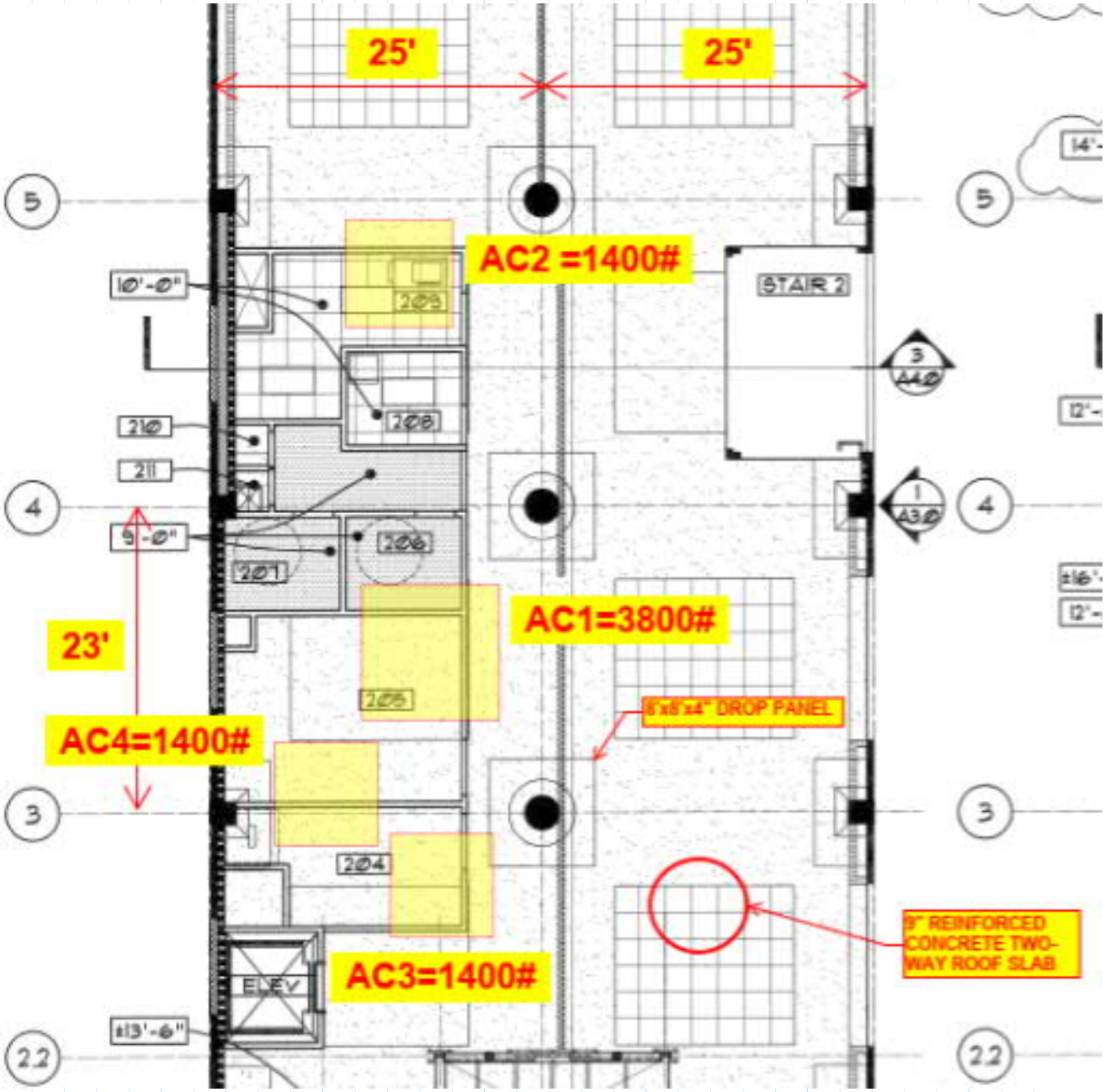
Partial Roof Framing Plan



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Mechancial Equipment Properties

AC-1:

$W_1 := 3800\ lbf$

$D_1 := \frac{W_1}{w_1 \cdot d_1} = 44\ psf$

$w_1 := 77\ in = 6.42\ ft$

$d_1 := 162\ in = 13.5\ ft$

$h_1 := 83\ in = 6.92\ ft$

AC-2:

$W_2 := 1400\ lbf$

$D_2 := \frac{W_2}{w_2 \cdot d_2} = 35\ psf$

$w_2 := 67\ in = 5.58\ ft$

$d_2 := 87\ in = 7.25\ ft$

$h_2 := 41\ in = 3.42\ ft$

AC-3:

$W_3 := 1400\ lbf$

$D_3 := \frac{W_3}{w_3 \cdot d_3} = 35\ psf$

$w_3 := 67\ in = 5.58\ ft$

$d_3 := 87\ in = 7.25\ ft$

$h_3 := 41\ ft = 41\ ft$

AC-4:

$W_4 := 600\ lbf$

$D_4 := \frac{W_4}{w_4 \cdot d_4} = 24\ psf$

$w_4 := 49\ in = 4.08\ ft$

$d_4 := 74\ in = 6.17\ ft$

$h_4 := 44\ in = 3.67\ ft$

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Slab Boundary Condition Rotational Stiffness

$h := 8\ in$: Slab thickness

$f'_c := 2500\ psi$

$E_c := 57 \cdot \sqrt{\frac{f'_c}{1\ psi}} \cdot 1\ ksi = 2850\ ksi$

$I_{cr} := \frac{0.3 \cdot 12\ in \cdot h^3}{12} = 154\ in^4$: 0.3 factor for cracked section

$L := 23\ ft$: Slab span

Slab rotational stiffness

$K_\theta := \frac{4 \cdot E_c \cdot I_{cr}}{L} = 6344\ \frac{kip \cdot in}{rad}$

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Roof Slab Unit Loads

Roof Dead Load

Roofing =
8" concrete slab =
MEP distribution =
Suspended ceiling =
Misc =

$$D_{Slabi} := \begin{bmatrix} 3\ psf \\ 150\ pcf \cdot 8\ in \\ 1\ psf \\ 2\ psf \\ 1\ psf \end{bmatrix} = \begin{bmatrix} 3 \\ 100 \\ 1 \\ 2 \\ 1 \end{bmatrix} psf$$

$$D_{Slab} := \sum D_{Slabi} = 107\ psf$$

$$D_{Super} := D_{Slab} - 150\ pcf \cdot 8\ in = 7\ psf$$

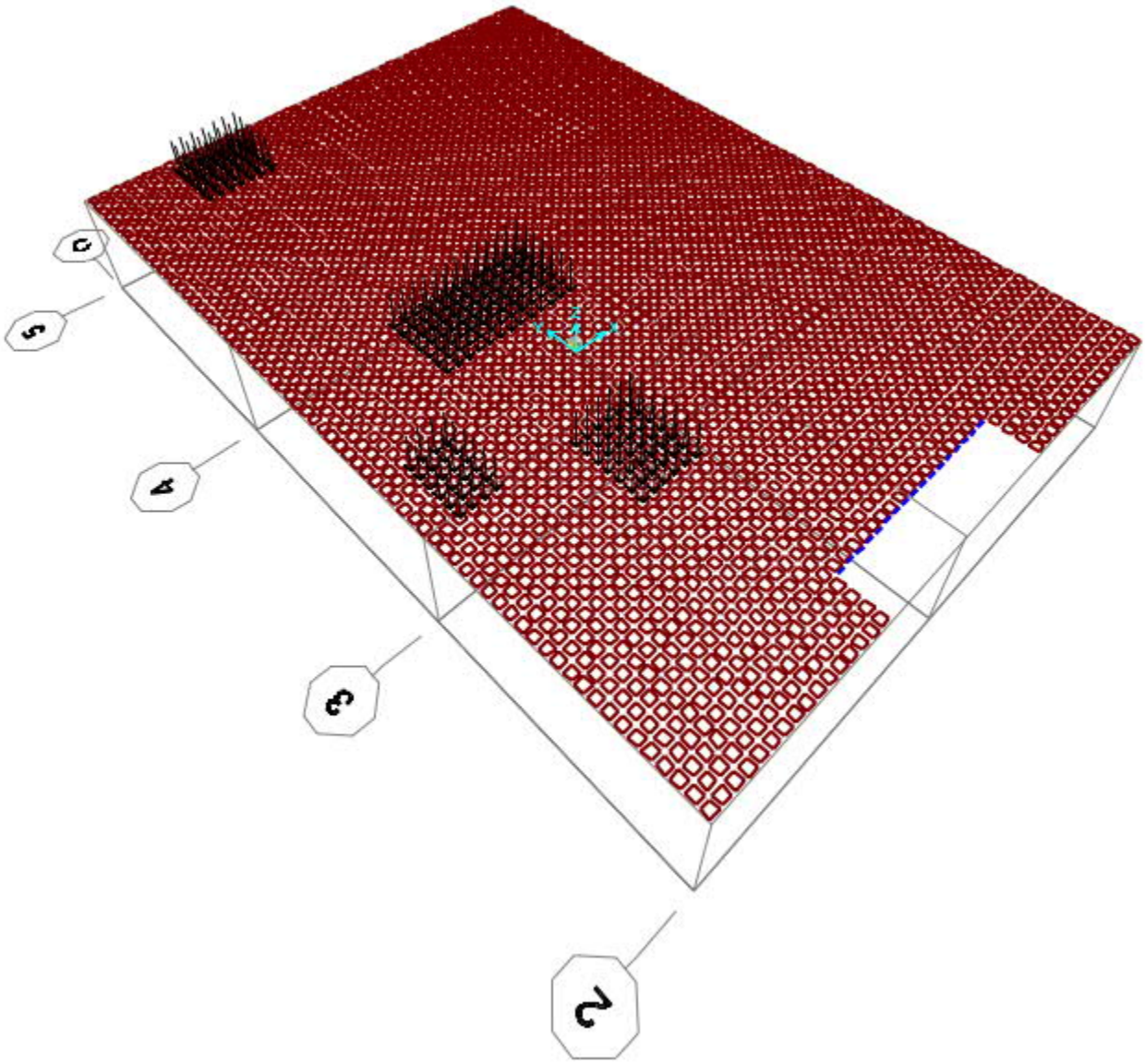
Live Load:

$$L_{Slab} := 20\ psf$$

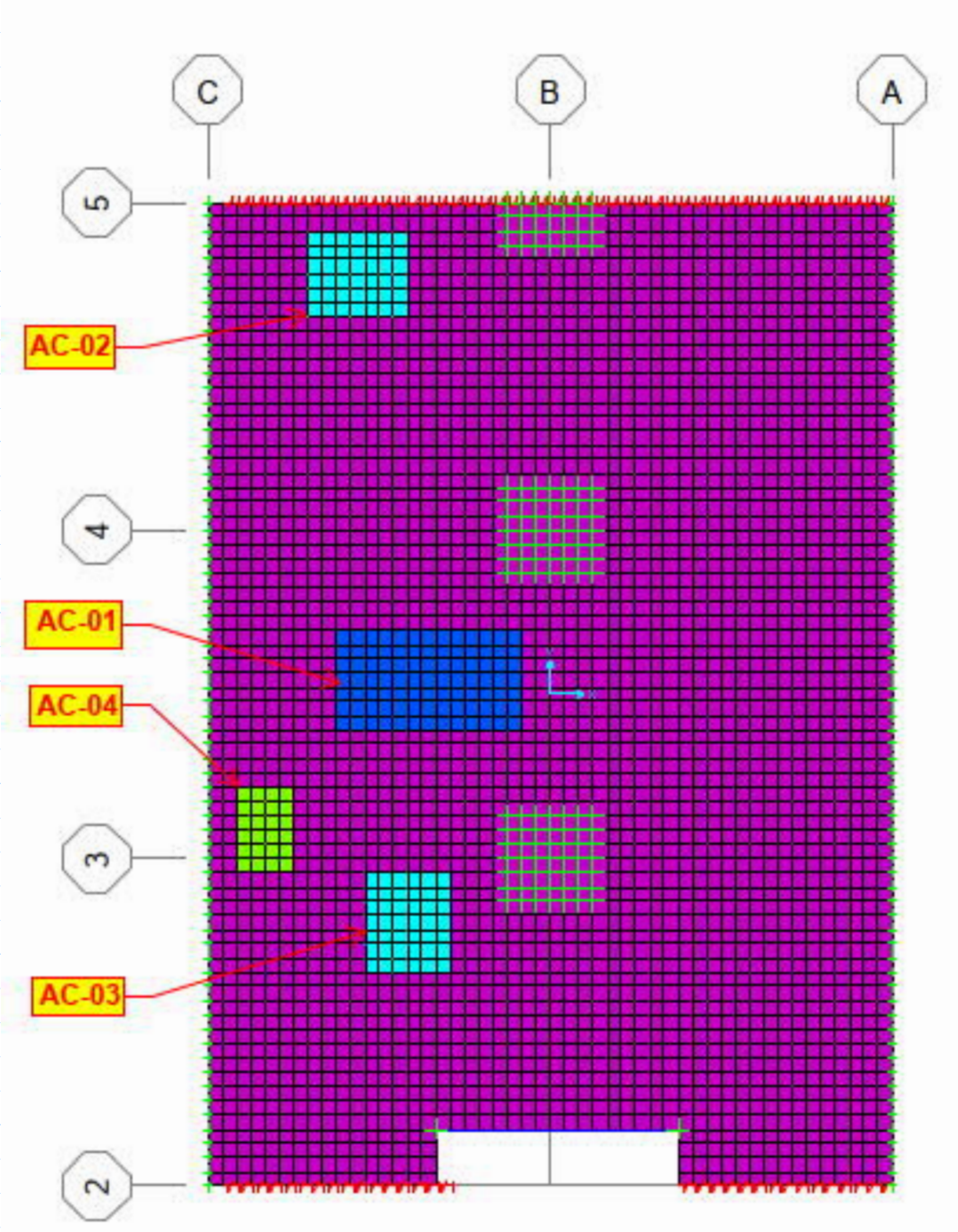
Load Combinations - LRFD

1. Combination 1: 1.4 Roof Dead + 1.4 Head Pump Weight
2. Combination 2: 1.2 Roof Dead + 1.2 Heat Pump Weight + 1.6 Roof live load of 20 psf

Mathematical Model of Slab

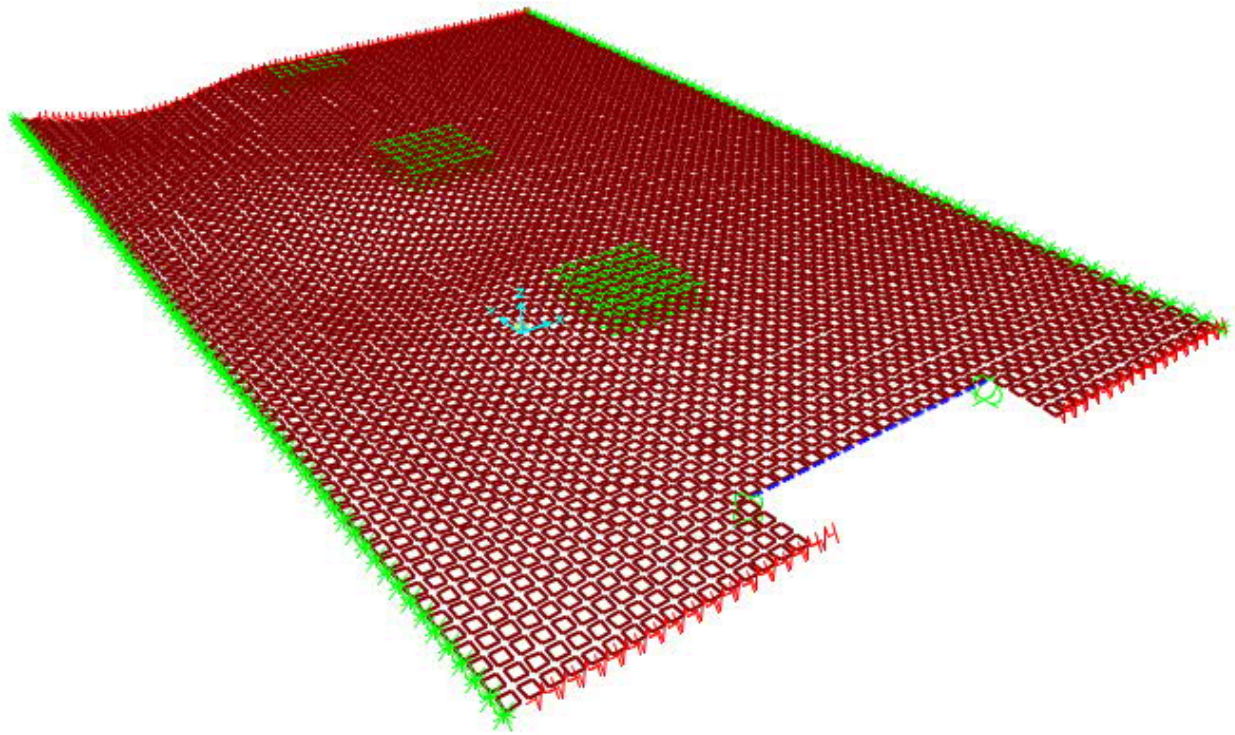


Slab 3D View

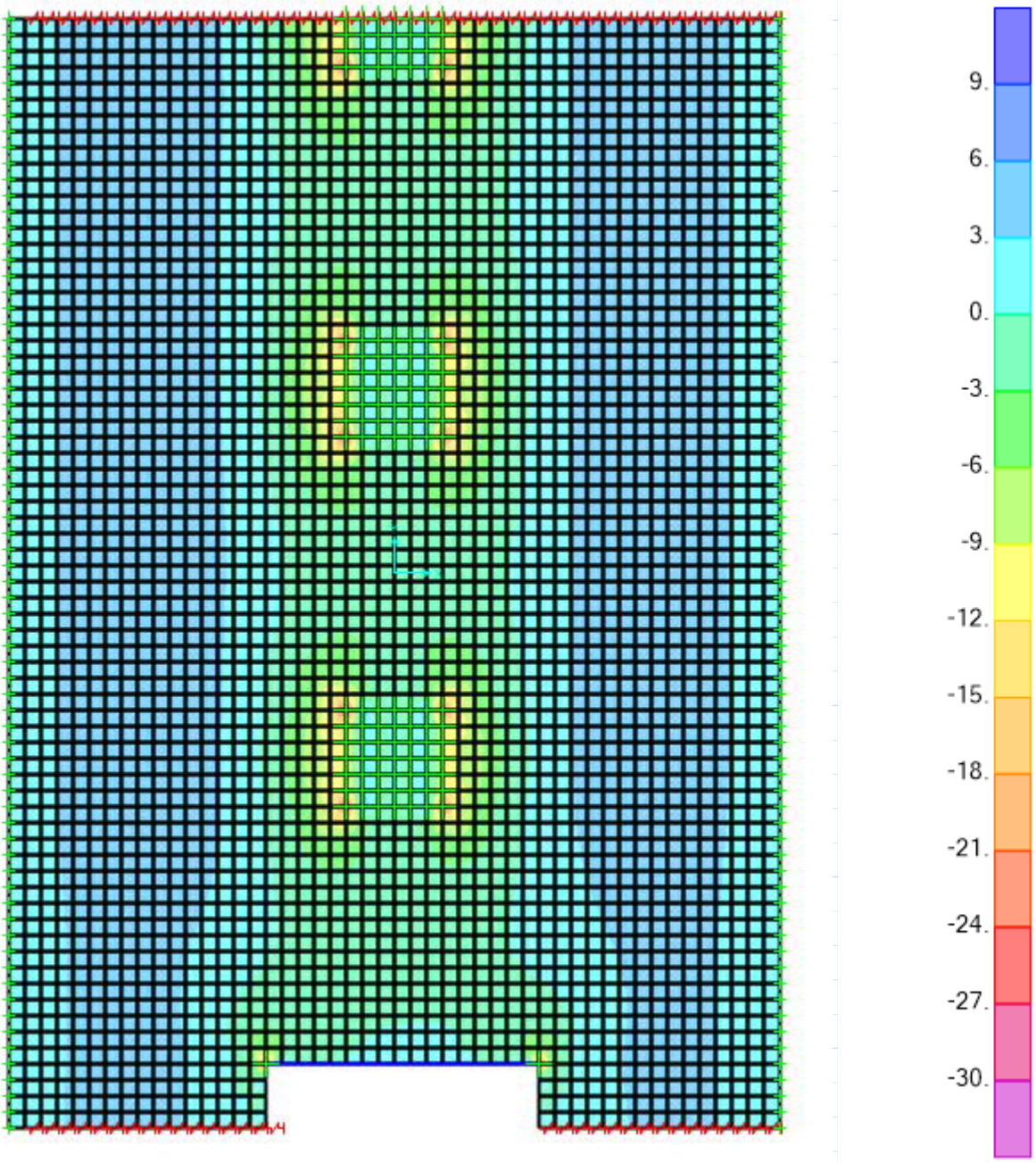


Slab Plan View

Slab Deformed Shape

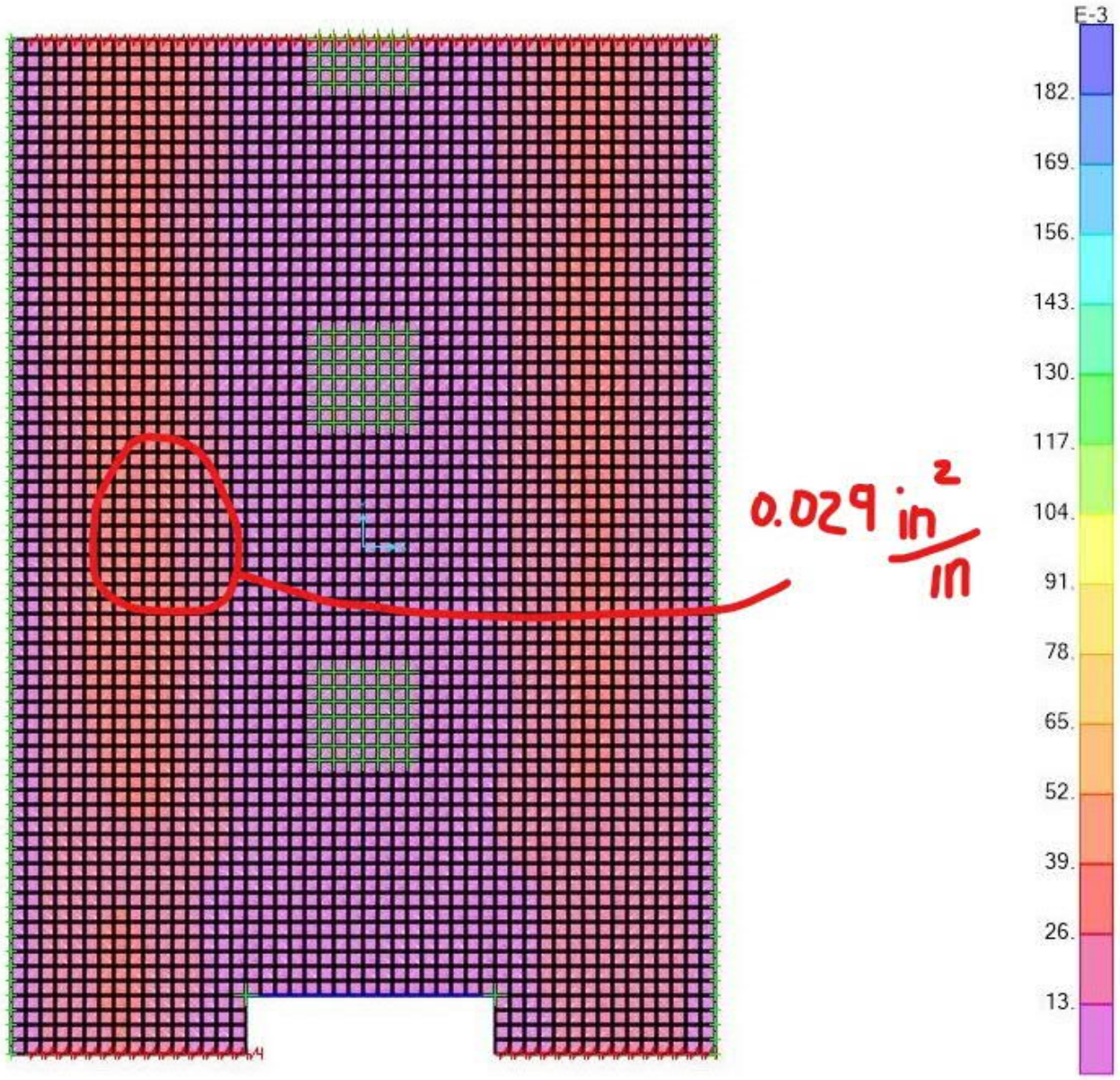


Slab Force Analysis

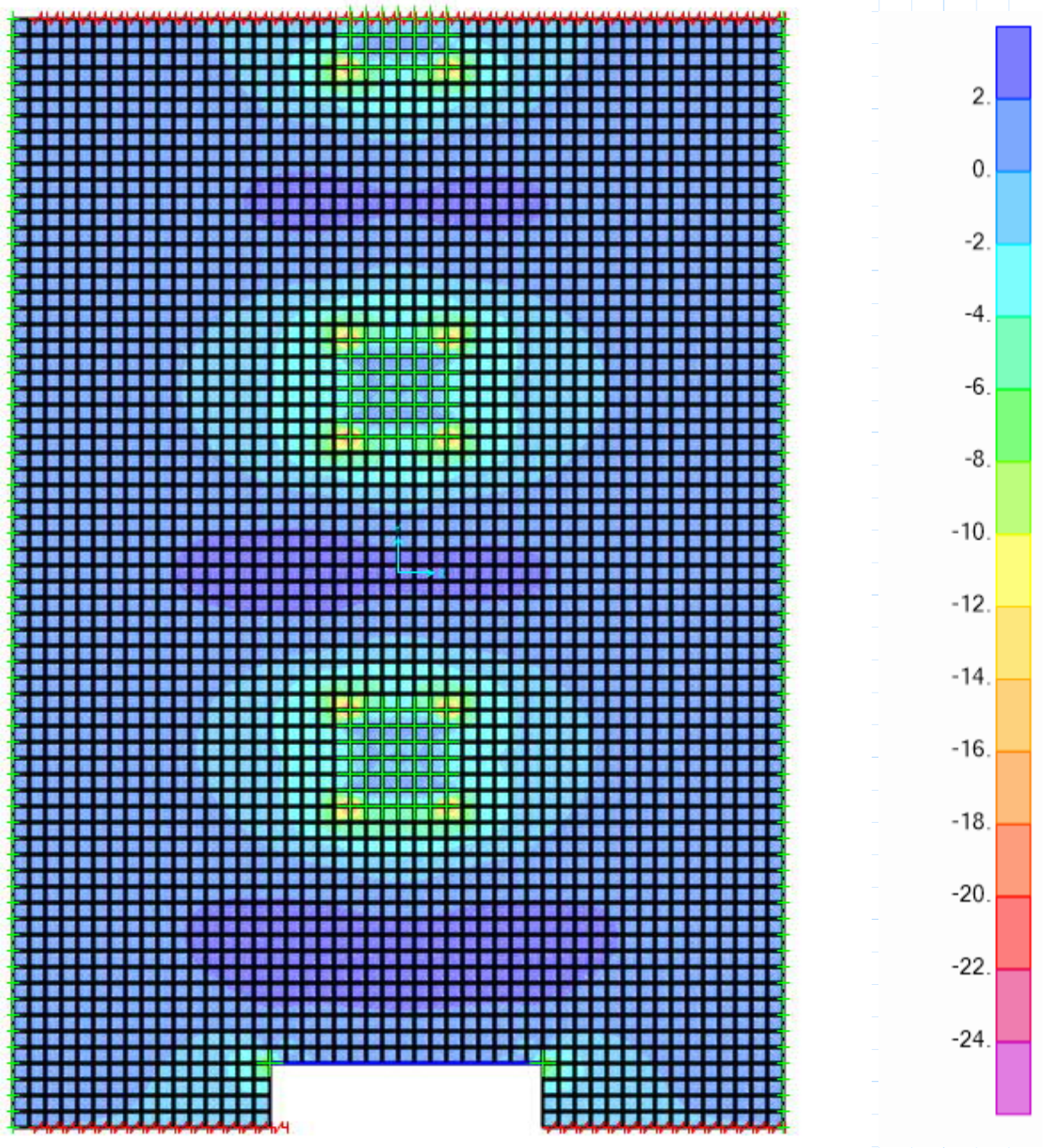


kip-in/in

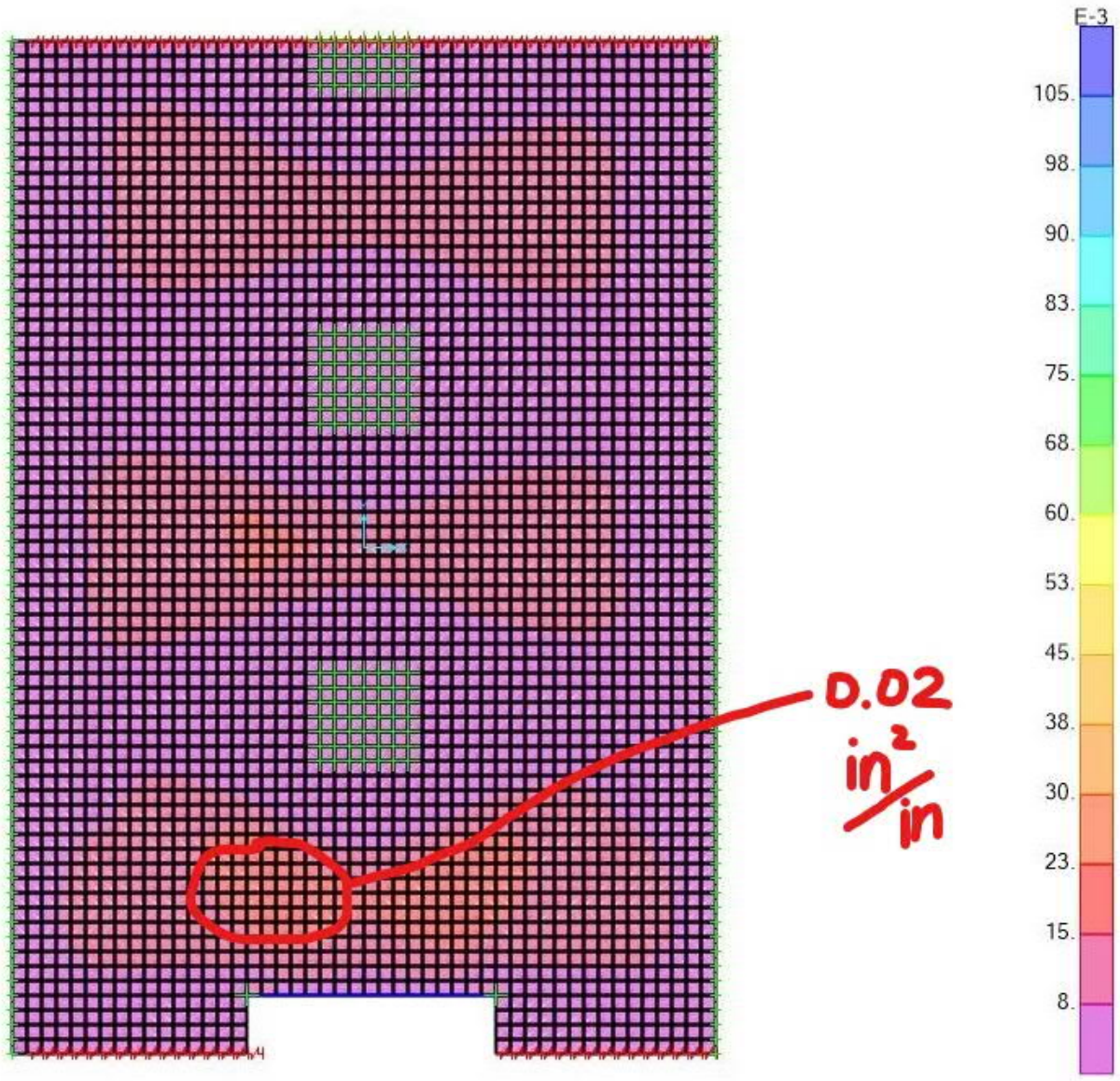
$M_{uX} := 5.3 \ \frac{kip \cdot in}{in} = 63.6 \ \frac{kip \cdot in}{ft}$: Maximum X-direction required moment strength



Required bottom steel area in left-right (X) direction (in^2 / in)



$M_{uY} := 2.8 \frac{kip \cdot in}{in} = 33.6 \frac{kip \cdot in}{ft}$: Maximum Y-direction required moment strength



Required bottom steel area in up-down (Y) direction (in^2 / in)

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Existing Slab Properties

Concrete density = 150 pcf

$f'_c := 2.5\ ksi$

$f_y := 33\ ksi$

$A_s := \frac{0.5\ in \cdot 0.5\ in}{8\ in} = 0.031\ \frac{in^2}{in}$: 1/2"X1/2" square bars @ 8" oc

$A_s = 0.38\ \frac{in^2}{ft}$: 1/2"X1/2" square bars @ 8" oc

$d := 8\ in - 0.75\ in - 0.25\ in = 7\ in$: Effective depth

$b := 12\ in$

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Existing Slab Force Evaluation

Flexure:

$M_{uX} = 5.3 \ \frac{kip \cdot in}{in}$: Maximum X-direction required moment strength

$M_{uY} = 2.8 \ \frac{kip \cdot in}{in}$: Maximum Y-direction required moment strength

$M_u := \max\left(M_{uX}, M_{uY}\right) = 5.3 \ \frac{kip \cdot in}{in}$

$\phi M_n := \left(0.9 \cdot \left(A_s \cdot 1 \ ft\right) \cdot f_y \cdot d \cdot \left(1 - \left(\left(A_s \cdot 1 \ ft\right) \cdot f_y\right) \div \left(b \cdot d \cdot 1.7 \cdot f'_c\right)\right)\right) \div 1 \ ft = 6.3 \ \frac{kip \cdot in}{in}$

$\phi M_n = 75.3 \ \frac{kip \cdot in}{ft}$

$\frac{M_u}{\phi M_n} = 0.85$ < 1.0 ∴ conforms

Shear:

$V_u := 0.37 \ \frac{kip}{in}$

$\phi V_c := 0.75 \cdot 2 \cdot \sqrt{\frac{f'_c}{1 \ psi}} \cdot 12 \ in \cdot d \cdot \frac{1 \ lbf}{1 \ in^2} \cdot \frac{1}{1 \ ft} = 6.3 \ \frac{kip}{ft}$

$DCV_{Slab} := \frac{V_u}{\phi V_c} = 0.7$ < 1.0 ∴ conforms