حنكه إس للإستشارات الهندسية
Henkah S Engineering Consulting

GATES STRUCTURE DESIGN REPORT

INTRO:

The report presents a comprehensive design proposal for the new landmark gates of the Four Seasons Hotel, located in the prestigious Red Sea Pride City, Jeddah. The design reflects both architectural excellence and functional efficiency, setting a new benchmark in elegance and modernity. These gates are envisioned not only as entry points, but also as iconic symbols that reinforce the hotel's distinguished presence within one of the region's most prominent destinations.

Ahmed Elhabashy
HENKA TECHNICAL MANAGER

1. SCOPE OF WORK

This report presents the structural design calculations for the proposed gates located at Entrances A, C, and D of the Four Seasons Hotel in Jeddah. The scope covers the full structural analysis and design of the gate frames, supporting members, and foundations, ensuring that the proposed structures are safe, serviceable, and consistent with the architectural design concepts. The calculations include determination of governing load cases, application of appropriate load combinations, structural member sizing, reinforcement detailing, and verification against applicable design codes.

2. Design Principles

The primary objective of structural design and construction design criteria is to guide the structural engineering design & developments to provide minimum loads, hazard levels, associated criteria, and intended performance goals for the buildings. It also aims to provide the basic requirements for:

2.1. Structural Safety

Structures must be able to withstand the loads acting on them during their design lifetime. This is accomplished first by careful selection of the structural system and a clear understanding of how that system will behave under loads. This involves identifying and considering possible failure modes during construction and during the life of the structure.

2.2. Strength and Stiffness

Buildings and other structures, and all parts thereof, shall be designed and constructed with adequate strength and stiffness to provide structural stability, protect nonstructural components and systems from unacceptable damage, to resist the applicable loads and meet the serviceability requirements.

Acceptable strength shall be demonstrated using one or more of the following procedures:

a. the strength procedures
b. the allowable stress procedures

2.3. Serviceability

In addition to having adequate strength, building structures must behave in a satisfactory manner in service. They should not deflect excessively or vibrate excessively. Structural systems, and members thereof, shall be designed under service loads to have adequate stiffness to limit deflections, lateral drift or any other deformations that adversely affect the intended use and performance of buildings and other structures based on requirements set forth in the applicable codes and standards, as specified in this design criteria.

2.4. Structural Analysis

Load effects on individual structural members shall be determined by methods of structural analysis that consider equilibrium, general stability, geometric compatibility. Members that tend to accumulate residual deformations under repeated service loads shall include in their analysis the added eccentricities expected to occur during their service life.

2.5. Structural Modeling:

An accurate and comprehensive three-dimensional structural model was developed in ETABS, reflecting the actual as-built geometry and member sizes of the building. This model incorporates the updated architectural layouts and structural configurations necessary for precise analysis.

2.6. Load Assessment:

Updated load conditions were applied in accordance with the new architectural floor plans. This included the reassignment of dead, live, super dead loads.

2.7. Design Verification

All structural members were checked against applicable design criteria, ensuring compliance with:

- ACI 318-19 – Structural Concrete Design
- SBC 301 – Load and Resistance Factor Design requirements
- AISC360 – Steel Design Specifications
- The design verification process ensures that all elements meet serviceability and strength requirements, accounting for both current and future usage of the facility.

3. Codes & Standards Followed

Reference specifications were based on the following specifications and standards and shall be applicable to the design of the permanent structural elements of the project. Unless specifically stated in the drawings, specifications, or other applicable documents.

The following are the governing structural codes and standards:

Structural Loads	
SBC 201 - CR, 2018	Saudi Building Code 2018 - General, Ch.16
SBC 301– CR, 2018	Saudi Loading Code 2018- Loads and Force Requirements
SBC 302 - E, 2018	Saudi Construction Code, Chapter 3
ASCE 7-10	Minimum Design loads and Associated Criteria for Buildings and Other Structures

Steel Construction	
SBC 201- CR, 2018	Saudi Building Code 2018 - General, Ch 22
SBC 306–CR, 2018	Saudi Steel Structures Code
AISC 360, latest Ed.	Specification for Structural Steel Buildings
AISC 341, latest Ed.	Seismic Provisions for Structural Steel Buildings
AWS D1.1	Structural Welding Code – Steel.

5. Units of Measurements

The modern metric System International (SI) will be applied.

6. Basis of Structural Design

6.1 Design Building Life

The design life term of the project shall be 50 years.

6.2 Stability

For all structures, a minimum FOS against sliding and overturning due to load combinations of gravity loads or with wind or seismic loads shall satisfy all code requirements according to items 7.4 & 8.6.5 in SBC 303 Soil and foundation.

6.3 Designated Occupancy Risk Category

The Structures' risk category shall be based on SBC 301-CR-2018 Table 1-2 and ASCE 7-10 Figure C1-1. It is recommended that all the buildings to be classified as Risk Category III.

Based on the structure risk category, an important factor shall be specified to enhance its resistance against the effect of lateral loads. In the structure's lateral loads analysis, the seismic analysis/ design importance factor shall consider Ie=1.25 for Risk Category II buildings.

7. Materials

Concrete grade fc`	=	**35**	**MPa**
Grade of Structural Steel Fy	=	**345**	**MPa**

8. Design Load Combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the load combinations.

Effects of one or more loads not acting shall be investigated. The most unfavorable effects from both wind and earthquake loads E (note on E: The same E from SBC 301 Section 12.4 is used for both SBC 301 Sections 2.3.2 and 2.4.1. Refer to SBC 301 Chapter 11 commentary for the Seismic Provisions.) shall be investigated, where appropriate, but they need not be considered to act simultaneously.

Refer to SBC 301 Section 12.4 for the specific details of the earthquake load effect E.

Symbols / Notations	
D	Dead load
L	floor live load greater than 1 kN/m^2
E	Static Earthquake load
W	Wind load

SDL	Super Dead Load (Screeds Finishing)

9.1 Load Combinations using Strength Design or LRFD Design & Using Allowable Stress Design.

Buildings and other structures, and portions thereof, shall be designed to resist the most critical effects resulting from the load combination specified in SBC 301-2018 Ch. 2.

9.2 Basic Combinations with Seismic Load Effects.

The seismic load combination for special cases or structural elements such as load transfer system (transfer beam/columns/shear walls) shall consider provisions of seismic loads (E) shown in SBC 301 Section 12.4.3.2 to 3.

ACI 318M-19 Ch. 18 provisions and requirements for the analysis, design and detailing do not apply to structure assigned to SDC A.

9.3 Load Combinations for Concrete Environmental Structures.

Durability factor, Sd shall be considered in accordance with ACI 350-06.

9.4 Load Combinations for General Structural integrity Loads.

Refer to SBC 301 Sections 1.5.8 through 1.5.11 and Section 1.5.7.1.

1.DL 2.DL+LL DEFLECTION 3.DL+0.75LL 4.DL+0.6WX 5.DL-0.6WX 6.DL+0.6WY 7.DL-0.6WY 8.DL+0.7EQX 9.DL-0.7EQX 10.DL+0.7EQY 11.DL-0.7EQY 12.0.6DL+0.6WX 13.0.6DL-0.6WX 14.0.6DL+0.6WY 15.0.6DL-0.6WY 16.0.6DL+0.7EQX 17.0.6DL-0.7EQX 18.0.6DL+0.7EQY 19.0.6DL-0.7EQY 20.0.9DL-WX	SBC 301 – CR -18

21.0.9DL-WY 22.0.9DL+WX 23.0.9DL+WY 24.1.2DL+1.6LL 25.1.2DL+LL-WX 26.1.2DL+LL-WY 27.1.2DL+LL+WX 28.1.2DL+LL+WY 29.1.2DL+LL-EQX 30.1.2DL+LL-EQY 31.1.2DL+LL+EQX 32.1.2DL+LL+EQY 33.1.4DL 35.1.2DL+1.6LL+1.2 POS TEMP 36.1.2DL+1.6LL+1.2 NEG TEMP	SBC 301 – CR -18

10. Structural Calculation / Analysis and Design Model

The analysis and design of the structural steel system shall be in accordance with the SBC 306 and AISC360-05 (LRFD) 13th edition Chapter C provisions and other related appendixes.

Slenderness of the steel structure elements shall be applicable to the requirements and provisions of AISC 360 Chapters D, E, and F.

Generally, the Direct Analysis Method in accordance with AISC will be used unless other analysis option is more appropriate or applicable.

Non-linear P-delta analysis will be performed as a requirement of the direct analysis method.

10.1 Seismic analysis procedure selection

For Seismic Design Category C, the following structural analysis types are permitted in accordance with SBC 301 chapter 12.

1. Equivalent Lateral Force Analysis, in accordance with SBC 301 Section 12.8

11. Structural Design Methodology

11.1 Design Methods

All **steel structural members** are designed using the **Load and Resistance Factor Design (LRFD) Method**, in accordance with:

- **SBC 306** – Steel Structures.
- **AISC 360-16** – Specification for Structural Steel Buildings.
- **Base Plate Design - Eurocode 3 - 2005**

- Design parameters are selected to meet the structural integrity, serviceability, and safety requirements under:
    - Gravity loads (dead, live, super dead).
    - Environmental loads (wind and seismic).
- Structural members are checked for:
    - **Axial**, **bending**, and **shear** capacity.
    - **Deflection limits** under service loads.

12. ETABS Modeling:

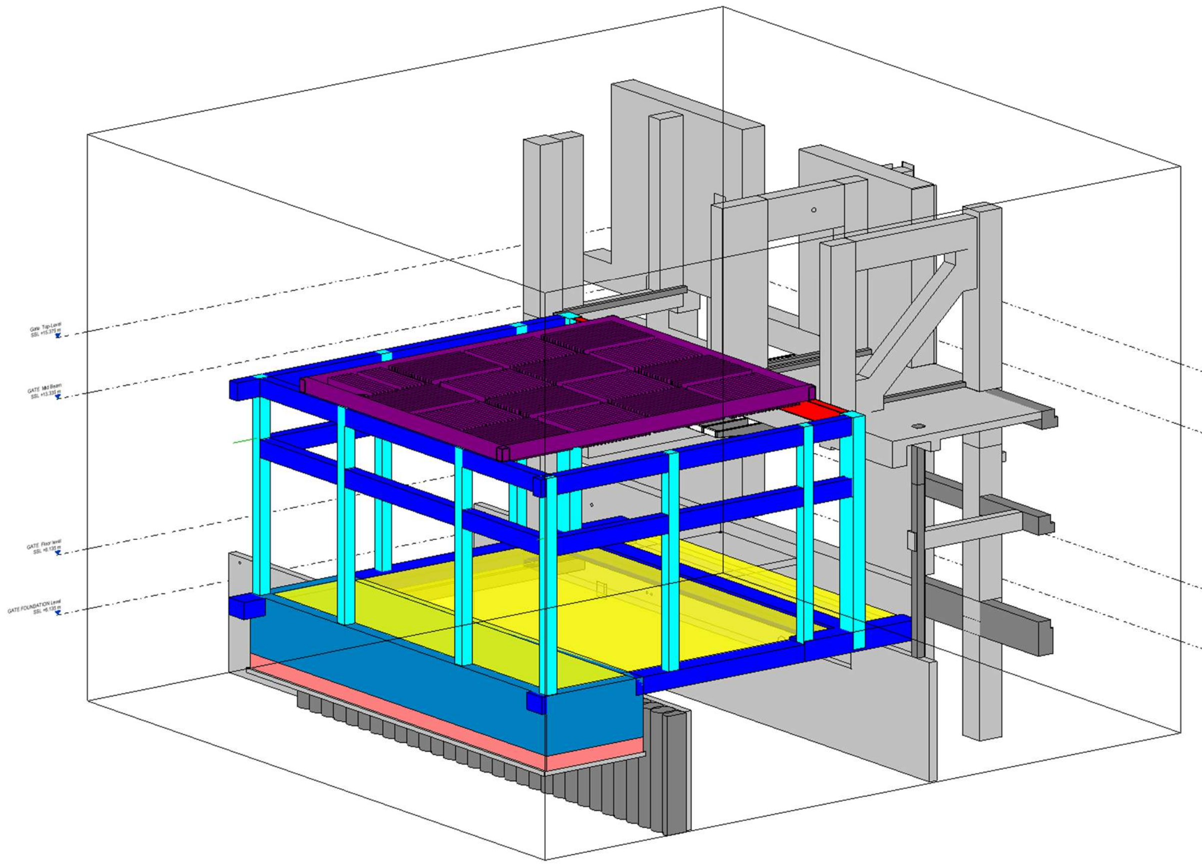
12.1 General Modeling

The analytical model was developed in ETABS to replicate the actual structural system based on as-built drawings and field verifications. The following steps were undertaken to ensure accuracy:

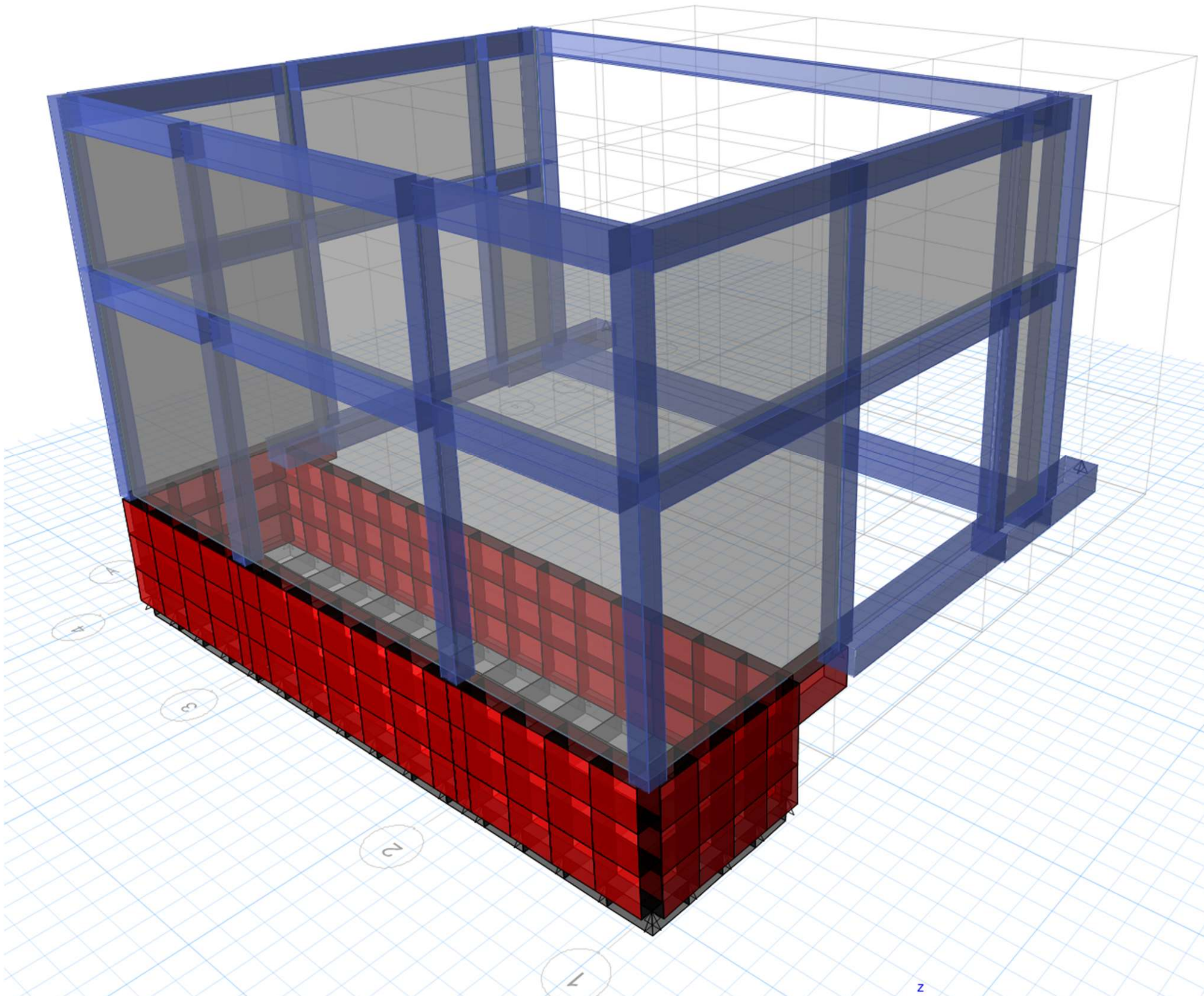
- **Grid Definition:**
  Structural grids were established as per the verified site measurements to match the actual layout of beams, columns, and the Revit model.

- **Validation:**
  The completed model was cross-checked against Revit structural model to confirm consistency before initiating analysis.

13. GATE A:

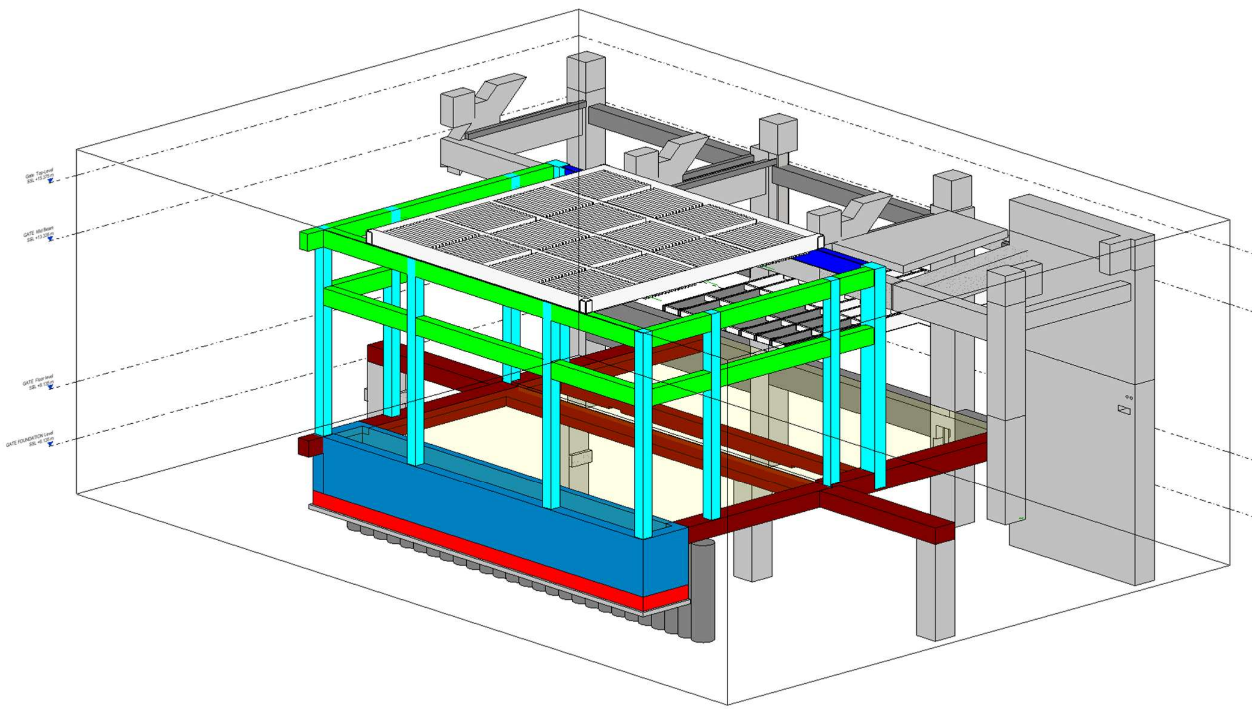


GATE A REVIT MODEL

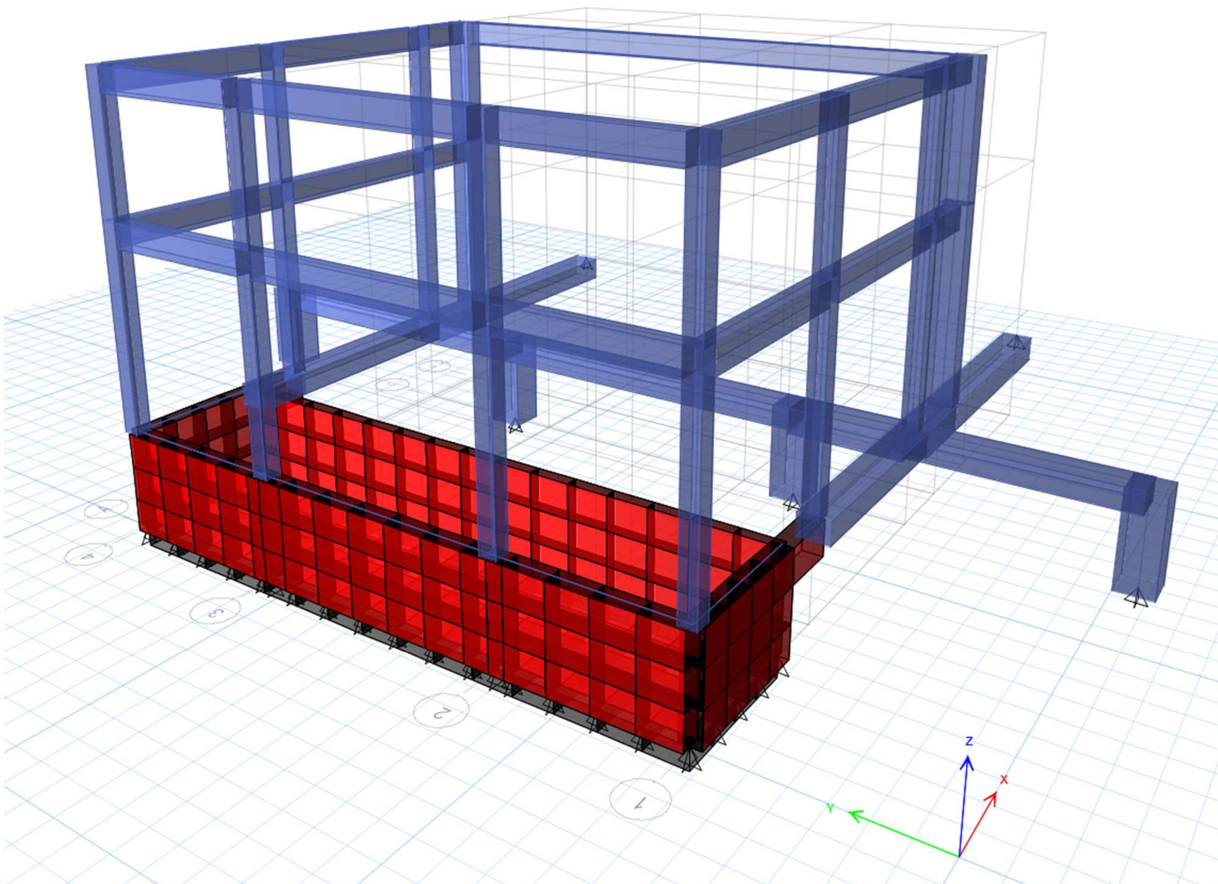


GATE A ETABS 3D MODEL

14. GATE C:

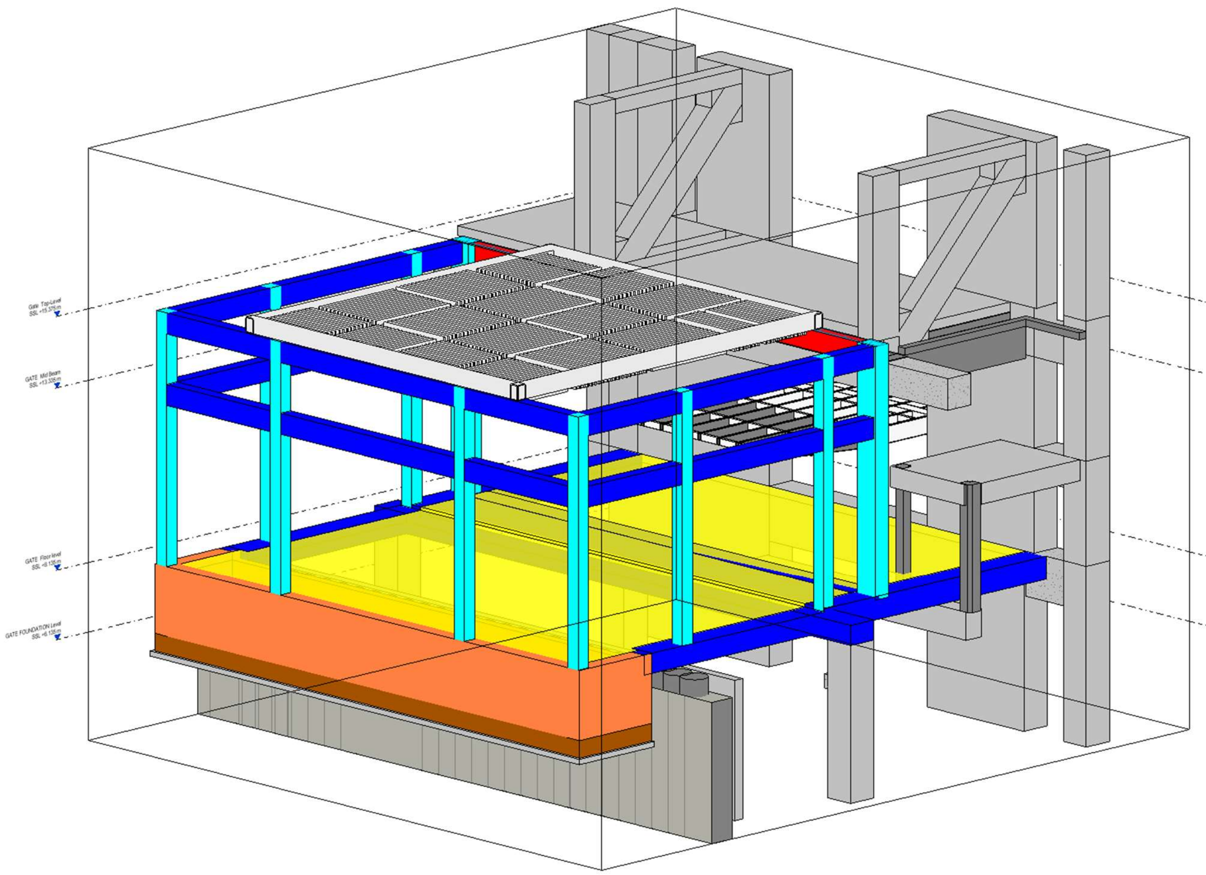


GATE C REVIT MODEL

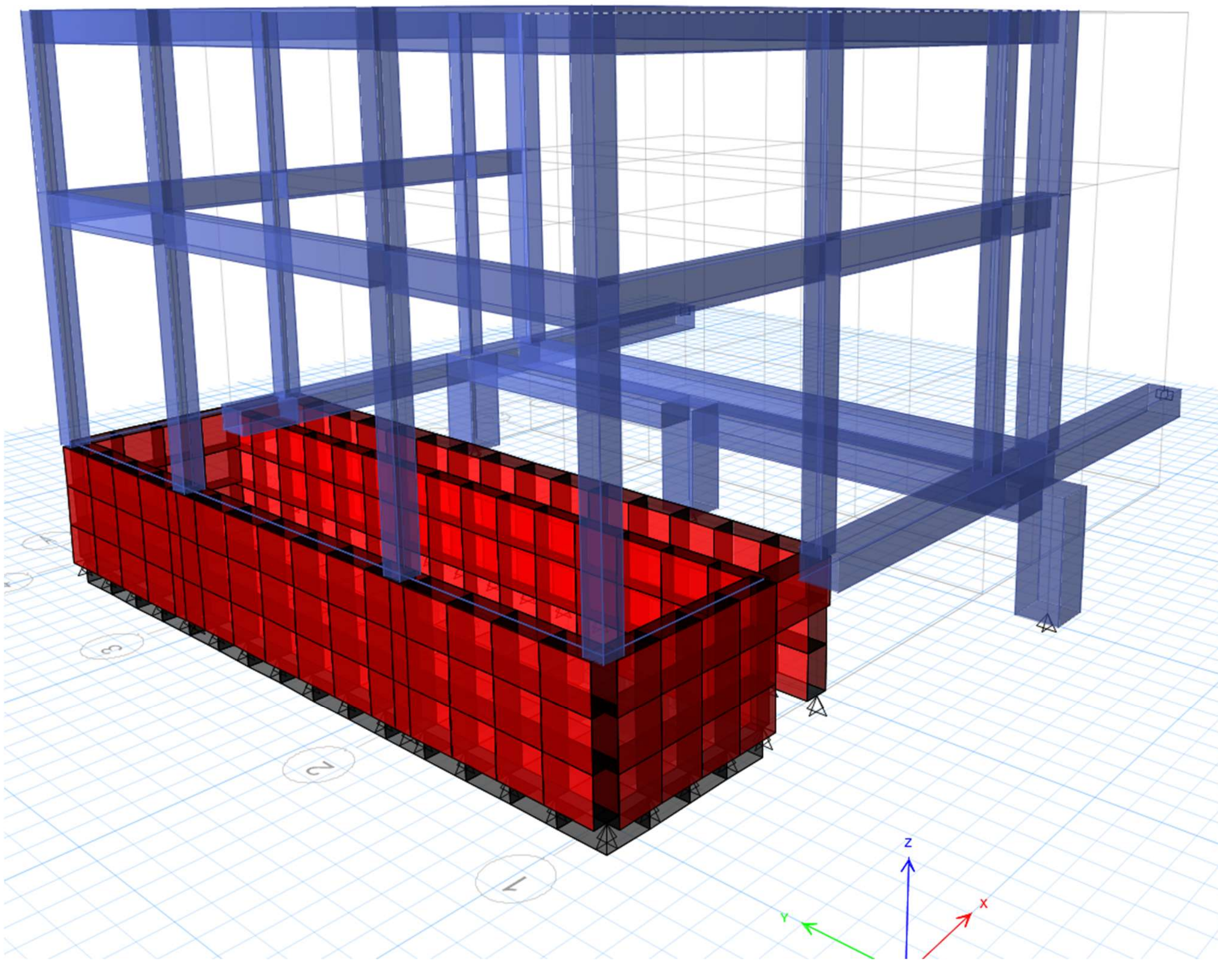


GATE C ETABS 3D MODEL

15. GATE D:



GATE D REVIT MODEL



GATE D ETABS 3D MODEL

16. Loads Assignments:

- **Dead Load (DL):**
  - **Owan weight**
- **SUPER DEAD LOADS:**
  - Steel Roof

    Weight = 120 kN

    Load per meter = 120 /(2x15.2) = 4.00 kN/m`
  - Walls

    Unite weight = 12 kN/m^3

    Load per meter height

    Blocks = 0.2 x 12 = 2.40 kN/m`

    Plaster = 0.04 x 20 = 0.80 kN/m`

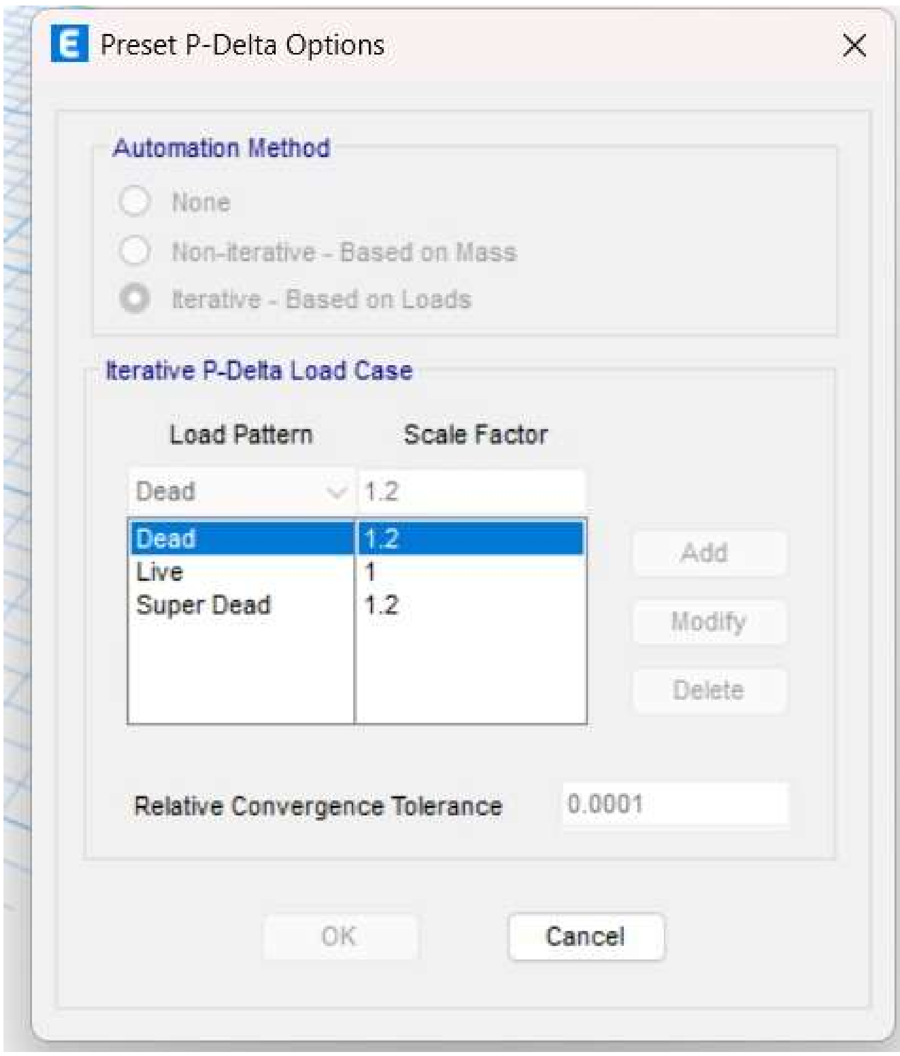
    Wall/m` = 3.20 kN/m`

- **Live Load (LL):**

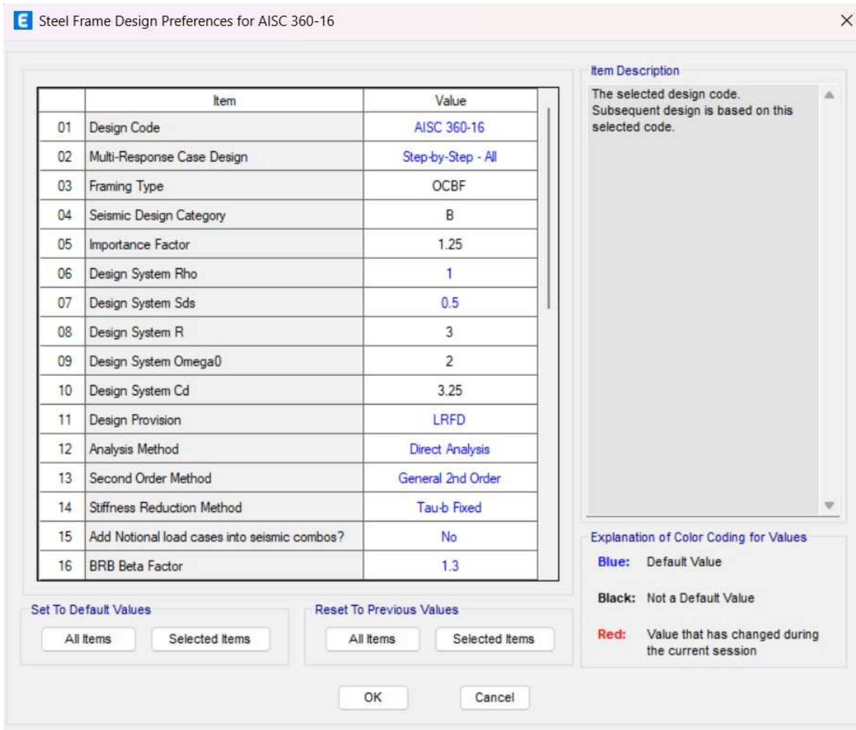
  NOT Accessible Live = 0Kn/m2

17. P-Delta:

P-Delta refers to the **secondary effects** in structures due to the combination of axial forces (P) and lateral displacements (Δ). It captures the additional moments and forces induced because the line of action of axial loads shifts when the structure deforms laterally.



18. Design Preferences


Steel Frame Design Preferences for AISC 360-16

	Item	Value
01	Design Code	AISC 360-16
02	Multi-Response Case Design	Step-by-Step - All
03	Framing Type	OCBF
04	Seismic Design Category	B
05	Importance Factor	1.25
06	Design System Rho	1
07	Design System Sds	0.5
08	Design System R	3
09	Design System Omega0	2
10	Design System Cd	3.25
11	Design Provision	LRFD
12	Analysis Method	Direct Analysis
13	Second Order Method	General 2nd Order
14	Stiffness Reduction Method	Tau-b Fixed
15	Add Notional load cases into seismic combos?	No
16	BRB Beta Factor	1.3

13. Analysis Results

Based on the comprehensive structural analysis performed using the **ETABS software**, incorporating the updated architectural, mechanical, and structural loads, the following key observations were made:

13.1 **Overstressed Members:**

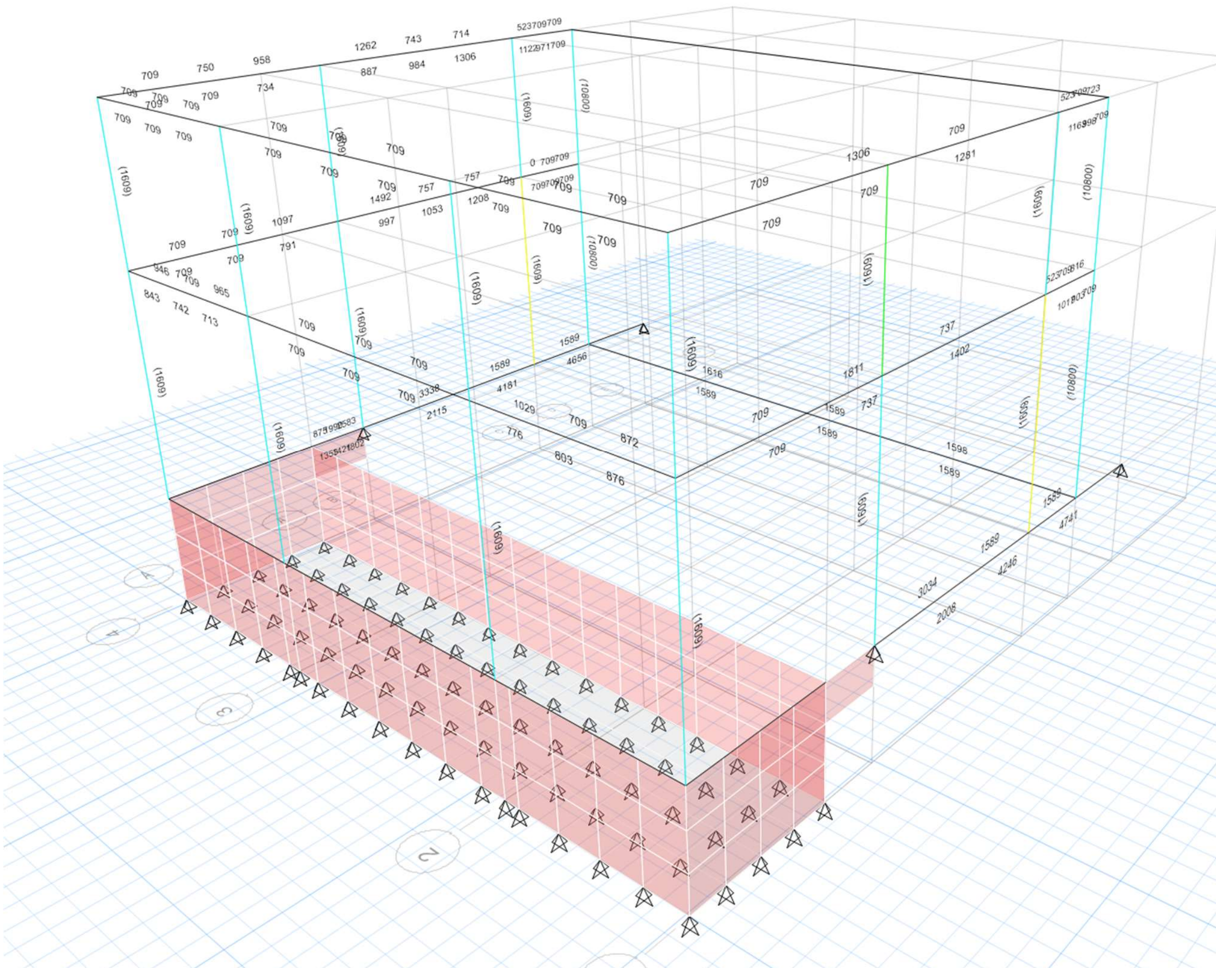
- All **primary structural elements** are in limits
- Flexural, shear, or axial capacity is sufficient under critical load combinations.

13.2 **Column Performance:**

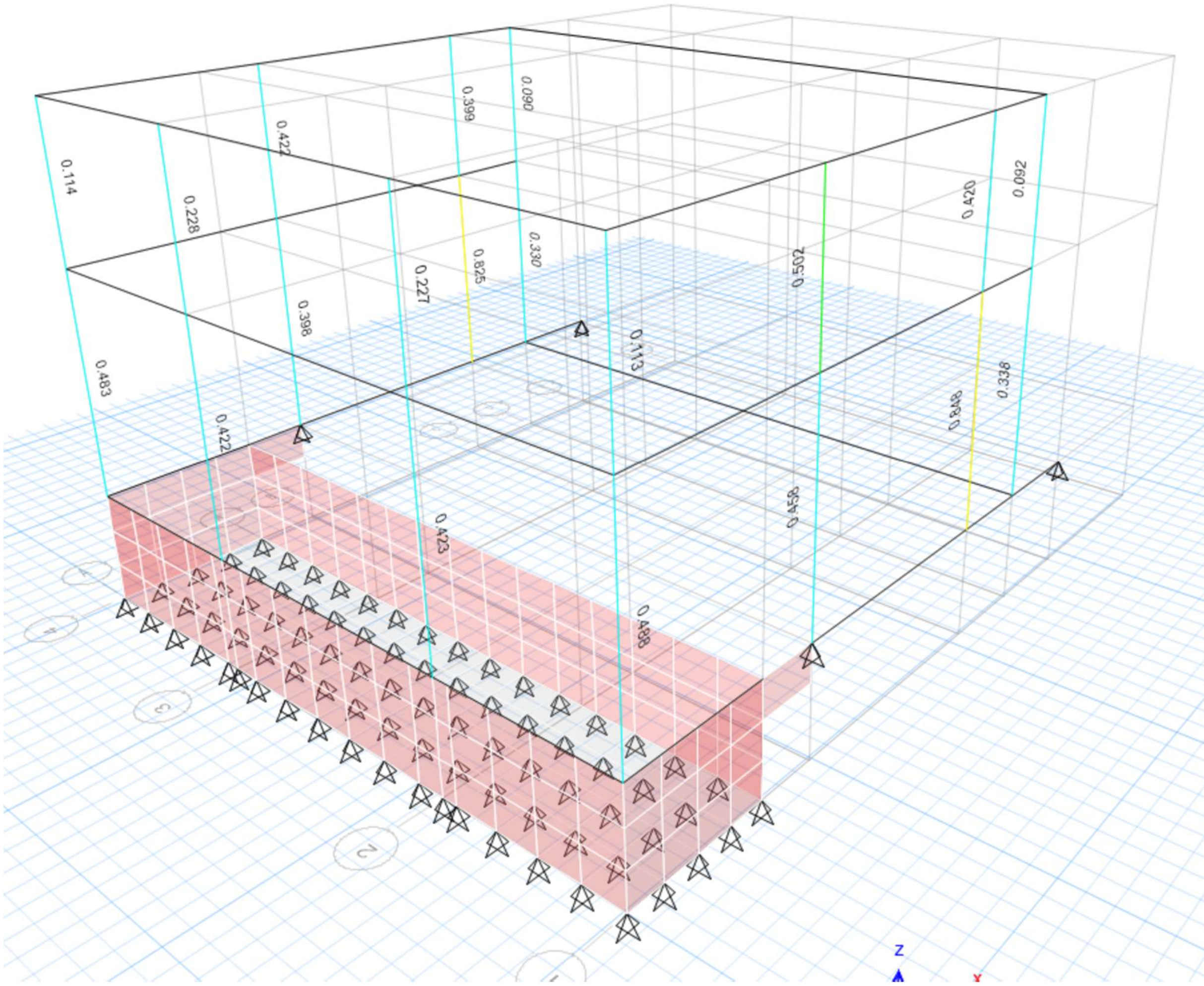
- All columns were assessed for **axial strength**, **moment resistance**, and **buckling**.

13.5 **Member Utilization Ratios:**

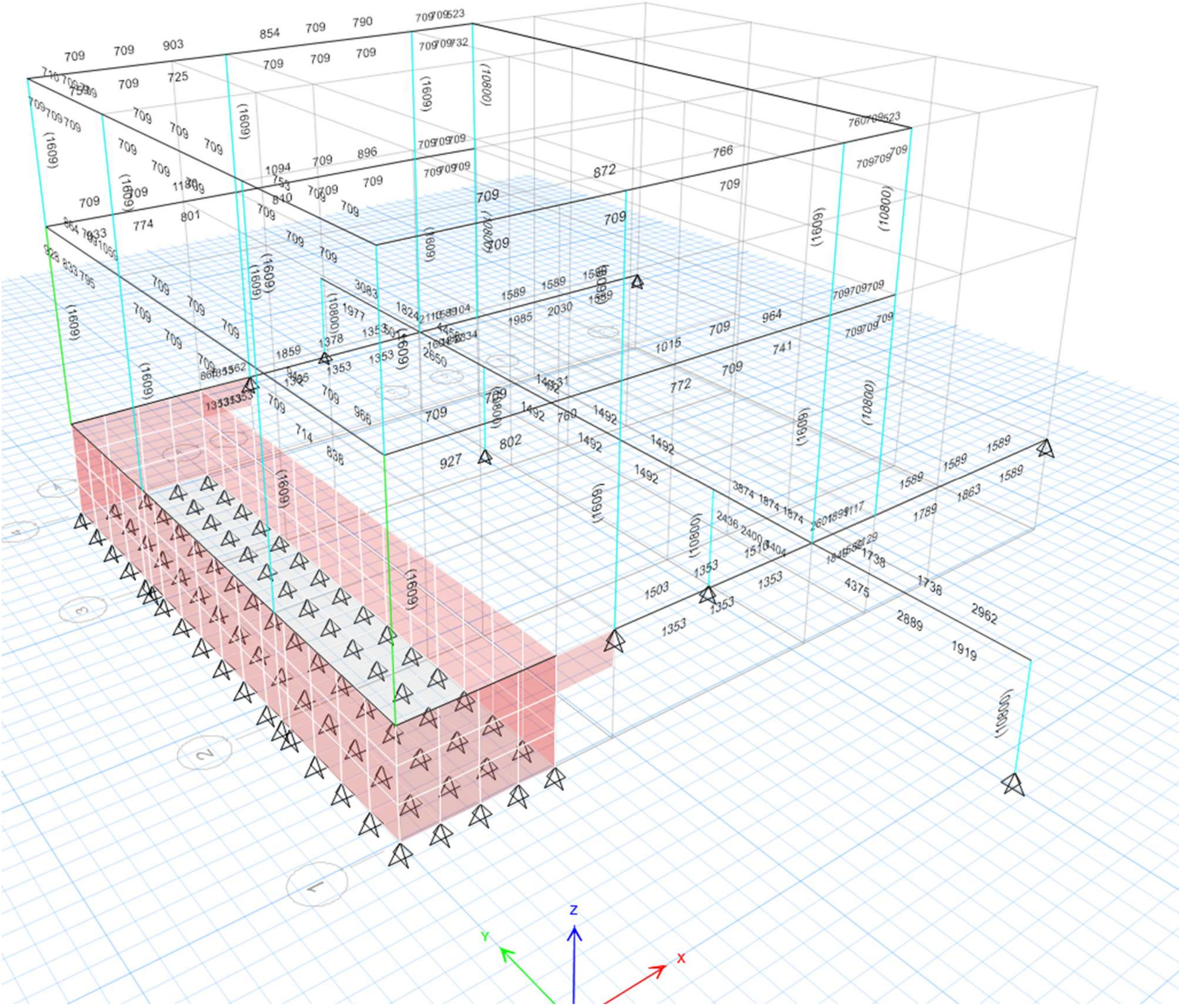
- Elements exceeding **1.0** utilization ratio are flagged unsafe.



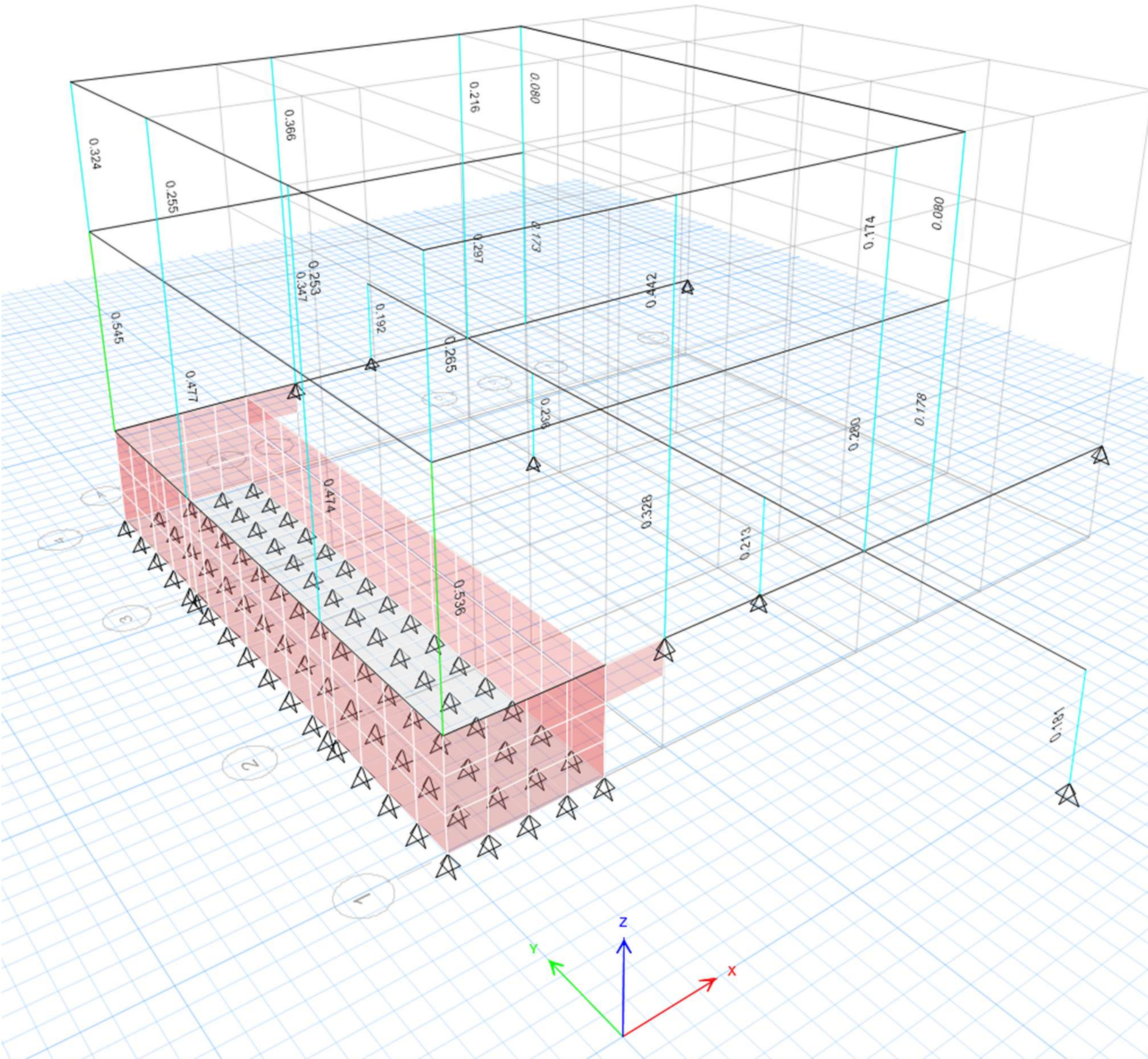
Gate A BEAM RFT



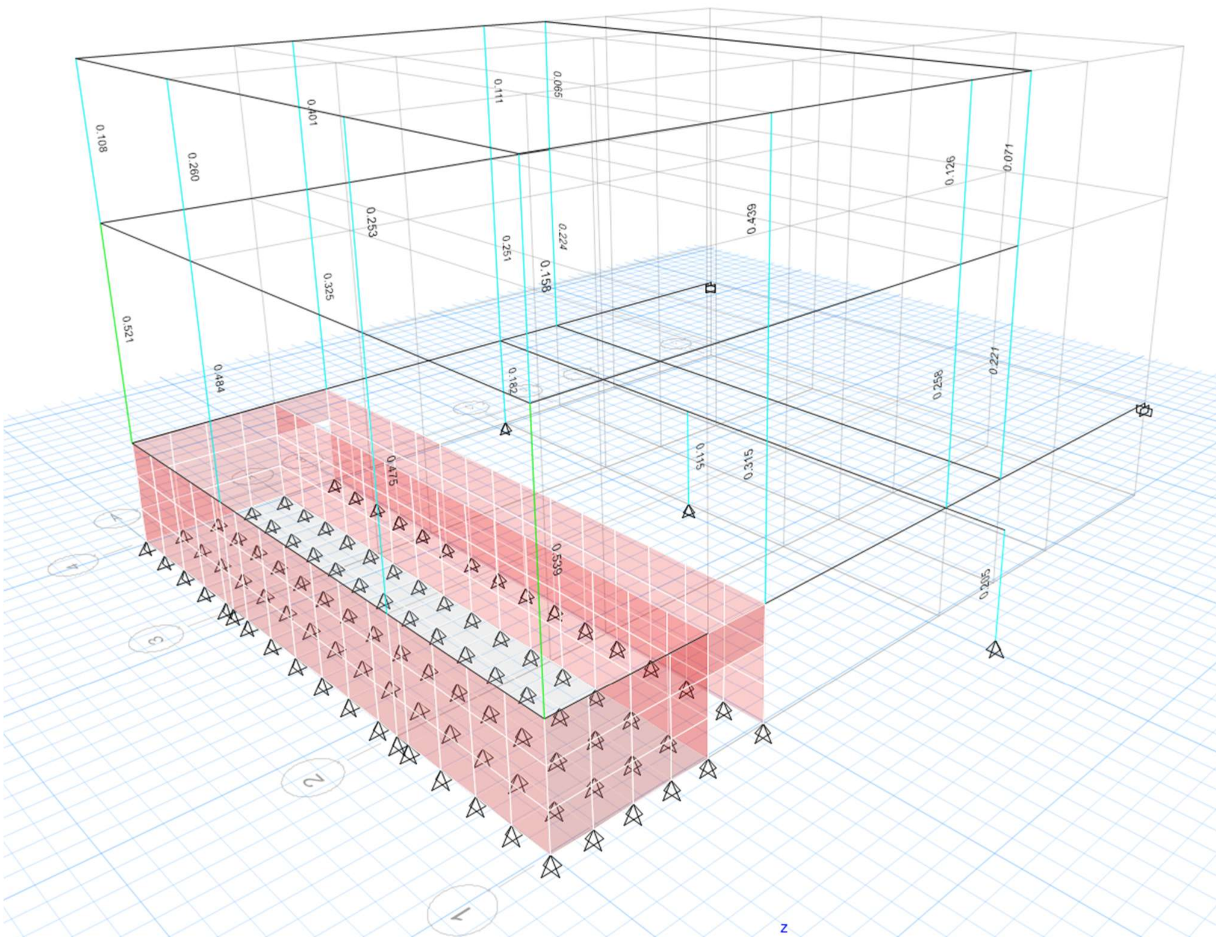
Gate A COLUMN PM-M RATIO RFT



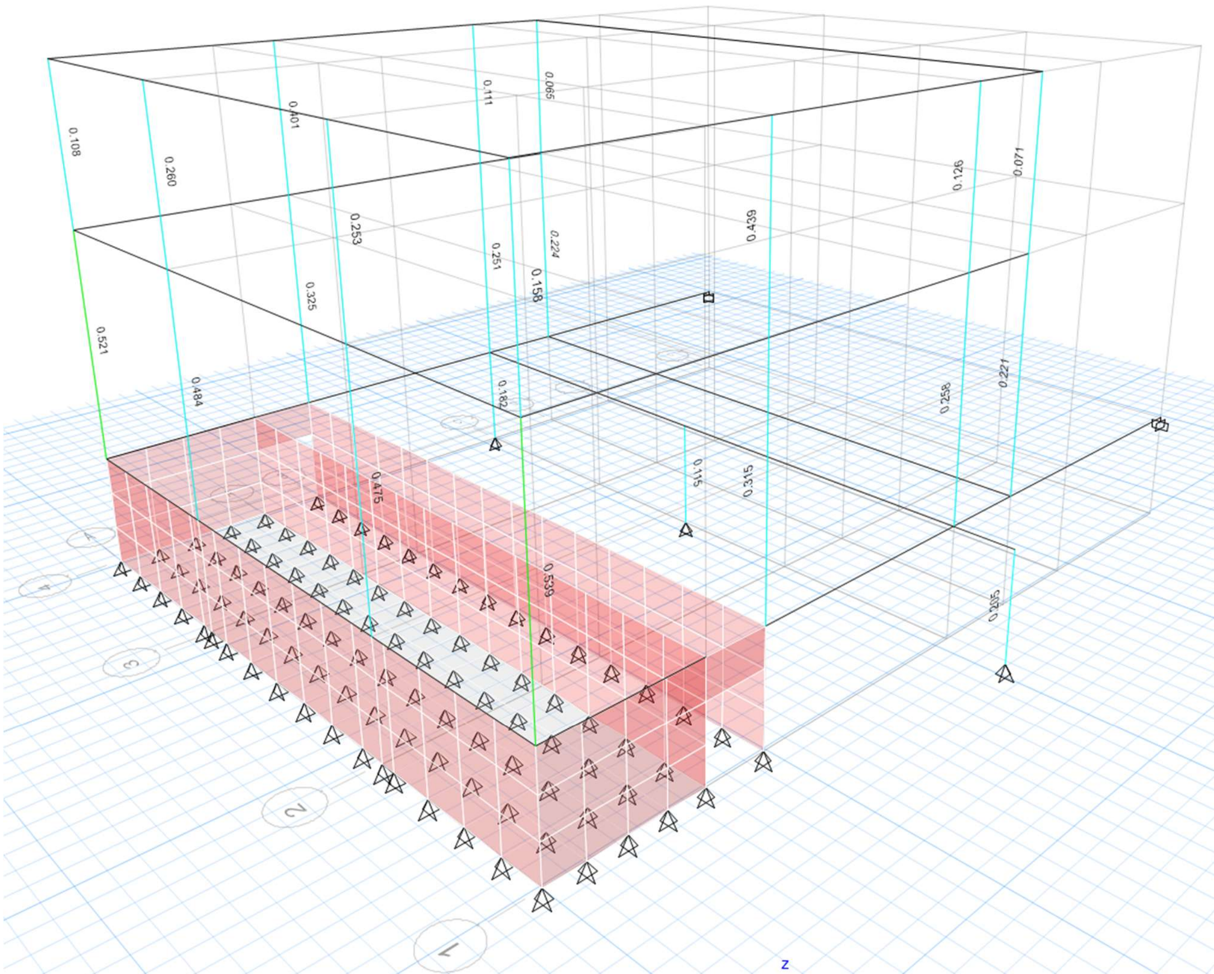
Gate C BEAM RFT



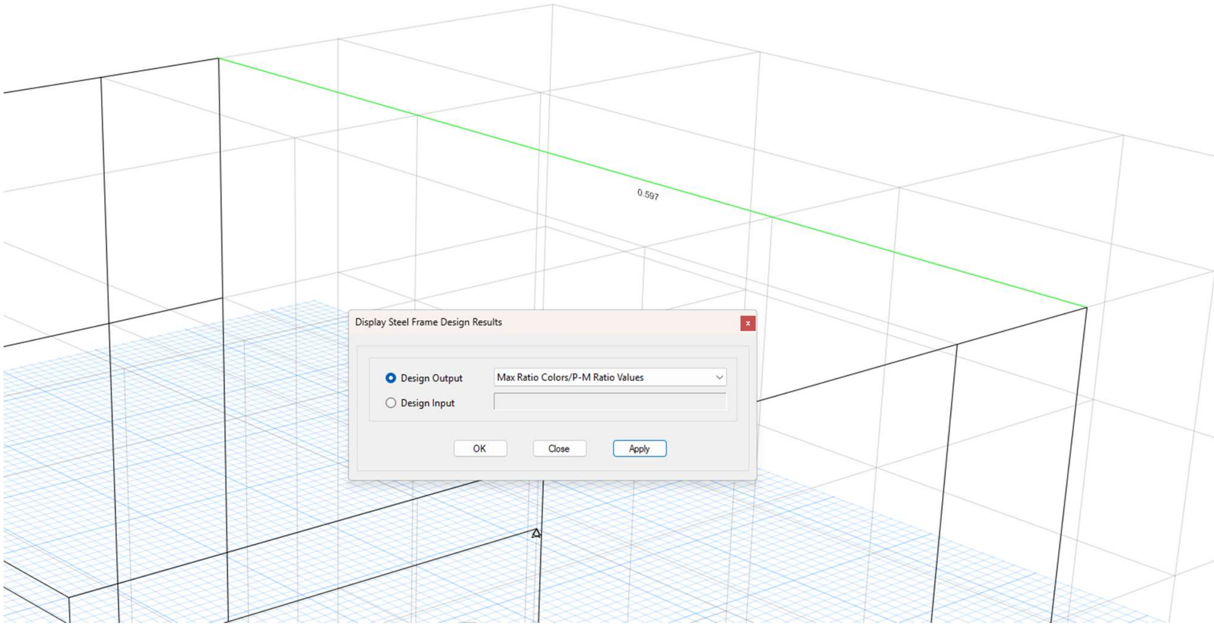
Gate C COLUMN PM-M RATIO RFT



Gate D BEAM RFT

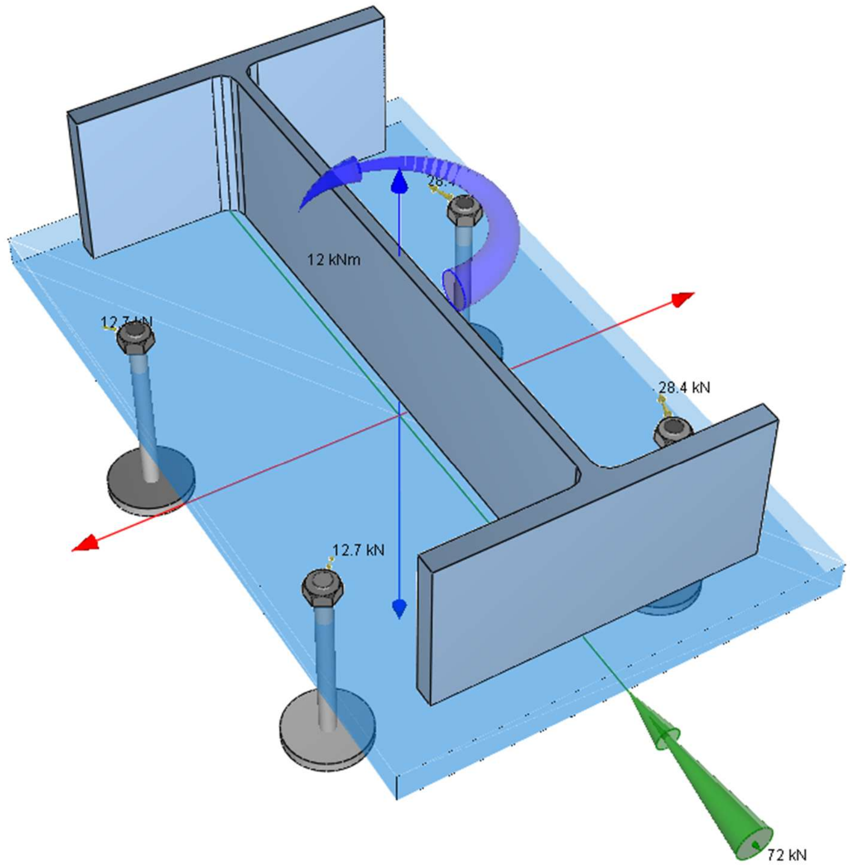


Gate C COLUMN PM-M RATIO RFT



STEEL BEAM UB 610 PM-M RATIO

19. Connection Design



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PROKON			
Your details here	Job Number 12030		Sheet 1
	Job Title FOURE SEASONE HOTEL		
	Client MIDAD		
	Calcs by AHMED ELHABASHY	Checked by	Date 9/30/2025

Base Plate Design - Eurocode 3 - 2005

Material Strength Properties

fcu : 25 MPa
Bolt Grade : 8.8
Bolt fy : 640 MPa
Bolt fu : 800 MPa
fy Baseplate : 355 MPa
fu Baseplate : 355 MPa
fy Column : 355 MPa
fu Column : 355 MPa
tu Weld : 500 MPa

Column Section

I1 610x305x149

Base Plate Design Data:

Plate Shape : Rectangular
Height : 700 mm
Breadth : 415 mm
Thickness : 30 mm

Weld Properties

Size : 10 mm Fillet Weld

Bolt Properties

Diameter : 16 mm
Anchor Length : 150 mm
Compression not allowed in bolts

Bolt End Plate Properties

End Type : Circular Plate
Diameter : 80 mm
Thickness : 10 mm

Bolt Resistance Forces

Bolt Netto Cross Section

$$A_n = \frac{0.75 \cdot \pi \cdot d^2}{4}$$

$$= \frac{0.75 \times \pi \times 16^2}{4}$$

$$= 150.796 \text{ mm}^2$$

Tension Resistance — Table 3.4

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	Job Title FOURE SEASONE HOTEL			
	Client MIDAD			
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$$T_r = \frac{k_1 \cdot A_n \cdot f_u}{Y_{m2} \cdot 1000}$$

$$= \frac{.9 \times 150.8 \times 800}{1.25 \times 1000}$$

$$= 86.861 \text{ kN}$$

Tension Resistance Concrete DD_CEN_TS_1992-4-2 — 6.2.5(1)

$$N_{Rk} = \frac{k_{cr} \cdot \sqrt{f_{ck}} \cdot h_{ef}^{1.5}}{1000}$$

$$= \frac{7.7 \times \sqrt{25} \times 150^{1.5}}{1000}$$

$$= 70.729 \text{ kN}$$

$$N_{Rk} = \frac{6 \cdot (A\_end - A\_bolt) \cdot f_{ck} \cdot Y_{ucr}}{1000}$$

$$= \frac{6 \times (5\,026.5 - 201.06) \times 25 \times 1}{1000}$$

$$= 723.816 \text{ kN}$$

Shear Resistance — Table 3

$$V_r = \frac{0.6 \cdot A_n \cdot f_u}{Y_{m2} \cdot 1000}$$

$$= \frac{0.6 \times 150.8 \times 800}{1.25 \times 1000}$$

$$= 57.907 \text{ kN}$$

Shear Resistance — 6.2.2 (7)

$$V_r = \frac{(0.44 - 0.0003 \cdot f_{yb}) \cdot f_{ub} \cdot A_s}{Y_{m2} \cdot 1000}$$

$$= \frac{(0.44 - 0.0003 \times 640) \times 800 \times 150.8}{1.25 \times 1000}$$

$$= 23.935 \text{ kN}$$

Compression Resistance — 13.3.1

$$C_r = \frac{0.9 \cdot A_n \cdot f_u}{1000}$$

$$= \frac{0.9 \times 150.8 \times 516.13}{1000}$$

$$= 70.049 \text{ kN}$$

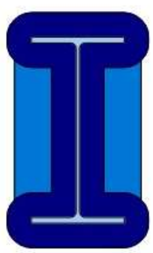
Find Effective Compression Area

Effective Distance from Edge of Section

$$c_{Max} = t_p \cdot \sqrt{\frac{f_{yp}}{3 \cdot \frac{2}{3} \cdot f_{ck} \cdot Y_{m0}}}$$

$$= 30 \times \sqrt{\frac{355}{3 \times \frac{2}{3} \times 25 \times 1}}$$

$$= 79.937 \text{ mm}$$



Calculation Sheet for Load Case : 1

Factored loads

Vz : 72 kN

Torsion : 12 kNm

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	Job Title FOURE SEASONE HOTEL	
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Find Equilibruim

The actual number of Grid Point used for calculation is 1112

Moment balancing

Sum Of Moments around X-axis = 0.0 kNm
Sum Of Moments around Y-axis = 0.0 kNm

Axial Force balancing

Sum Of Forces in Y-direction = 0.0 kN

The Shear Resistance in the Bolts Resists the Following Forces:

Forces in X-direction
Moments around Y-axis
Forces in Z-direction

Calculating Factors of Safety in Critical Bolt

Shear in Bolts
Critical Bolt Shear

PROKON Your details here	Job Number 12030	Sheet 5
	Job Title FOURE SEASONE HOTEL	
	Client MIDAD	
	Calcs by AHMED ELHABASHY	Checked by	Date 9/30/2025

$$FOS = \frac{V_r}{Shear}$$

$$= \frac{57.906}{28.429}$$

$$= 2.037$$

Welds

Since unit values are used for the length and size of the weld, the capacity of this layout is given in kN/mm

Design shear strength 4.4

$$f_{w.d} = \frac{f_u}{\sqrt{3} \cdot \beta_w \cdot \gamma_{M2}}$$

$$= \frac{355}{\sqrt{3} \times .80333 \times 1.25}$$

$$= 204.110 \text{ MPa}$$

Design resistance per unit length 4.3

$$F_{w.Rd} = \frac{f_{w.d} \cdot a \cdot Size}{1000}$$

$$= \frac{204.11 \times .707 \times 10}{1000}$$

$$= 1.443 \text{ kN/mm}$$

Capacity of 10mm weld is 1.443kN/mm

$$FOS = \frac{Resistance}{Force}$$

$$= \frac{1.443}{.07477}$$

$$= 19.299$$