1 Sample Engineering Report

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Company: ABC Engineering
Project: Bridge Analysis Project
Date: June 10, 2025

1.1 Executive Summary

This report presents the structural analysis and design recommendations for the proposed bridge structure. The analysis includes load calculations, member sizing, and safety factor verification.

1.2 Introduction

The purpose of this analysis is to evaluate the structural integrity of the proposed bridge design under various loading conditions including dead loads, live loads, and environmental factors.

1.3 Design Criteria

1.3.1 Loading Conditions

1. Dead Load: Self-weight of structure
2. Live Load: Traffic and pedestrian loads
3. Wind Load: Per ASCE 7 standards
4. Seismic Load: Site-specific seismic analysis

1.3.2 Material Properties

1. Concrete: f'c = 4000 psi
2. Steel: Fy = 50 ksi
3. Safety Factor: 2.0 minimum

1.4 Analysis Results

The structural analysis was performed using advanced finite element software. The key parameters include:

Maximum Moment: $M_{\max} = \frac{wL^2}{8} = \frac{1.5 \times 50^2}{8} = 468.75$ kN-m
Deflection Check: $\delta = \frac{5wL^4}{384EI} \leq \frac{L}{250}$
Where:

1. w = distributed load (kN/m)
2. L = span length (m)
3. E = modulus of elasticity (GPa)
4. I = moment of inertia (m^4)

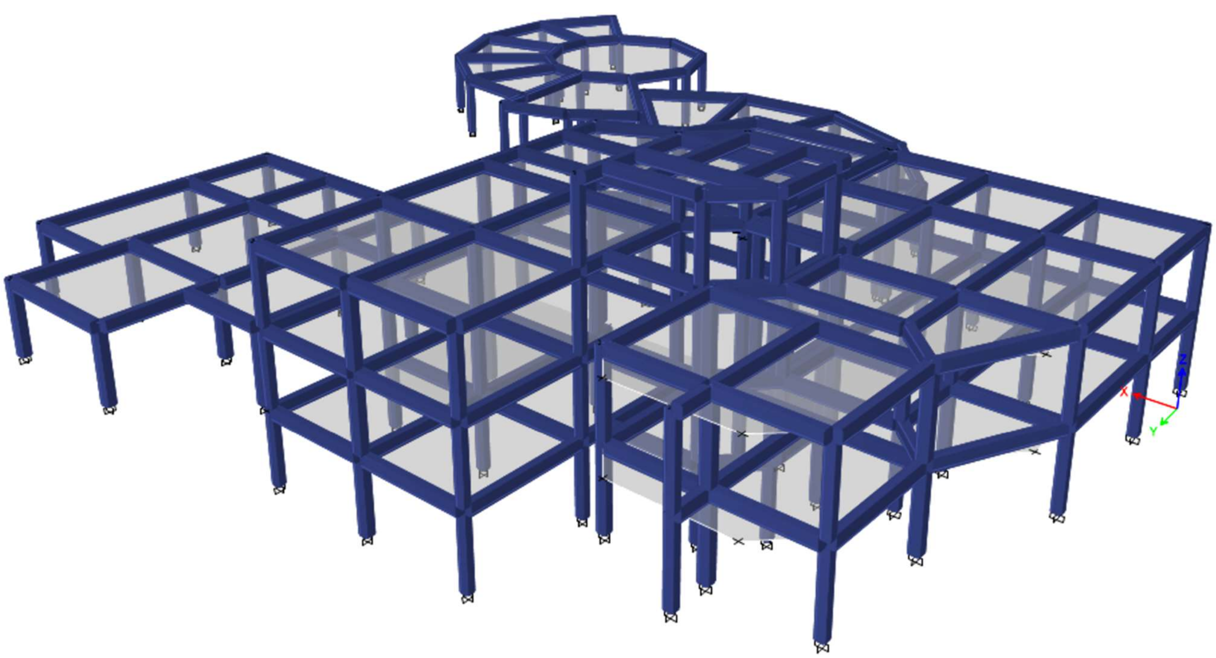
The detailed calculations and computer output are provided in the appendix.

STRUCTURAL DESIGN

SUMMARY CALCULATIONS REPORT

for

TRANSIT CENTER



BY: Eng. Ali Akbar Shaikhzadeh

DATE: 07 Oct 2018

Contents

PROJECT INFORMATION

Client	Norwegian Refugee Council
Type of project	Residential Building
Project Location	Nimrooz, Afghanistan
Type of main framing	Reinforced concrete beams & columns
Type of slabs	Reinforced concrete slabs
Type of foundation	Reinforced concrete strip foundation
Type of seismic resisting system	Intermediate moment frame
Loading design code (live, seismic, snow,...)	ASCE 7-16
Concrete design code	ACI 318-14
Steel design code	Not Applicable
Structural designer(s)	Eng. Ali Akbar Shaikhzadeh

STRUCTURAL LOADING CRITERIA

DEAD LOADS

Exterior Walls

Layer Material	Thickness (m)	Density (kg/m^3)	Weight/Area (kg/m^2)	Remarks
Brick	0.2	850	170	
Grout (Gypsum & soil) for inner face	0.02	1600	32	
Finishing (inner face)	0.005	1300	6.5	
Grout (cement) for outer face	0.04	2100	84	
Light Stone (outer face)	0.025	2500	62.5	
		Total Weight	**355**	

Interior Walls (Partitions)

Layer Material	Thickness (m)	Density (kg/m^3)	Weight/Area (kg/m^2)	Remarks
Brick	0.1	850	85	
Grout (Gypsum & soil) for inner face	0.02	1600	32	
Finishing (inner face)	0.005	1300	6.5	
Grout (Gypsum & soil) for outer face	0.02	1600	32	
Finishing (outer face)	0.005	1300	6.5	
		Total Weight	**162**	

Floor Slabs (without the concrete slab)

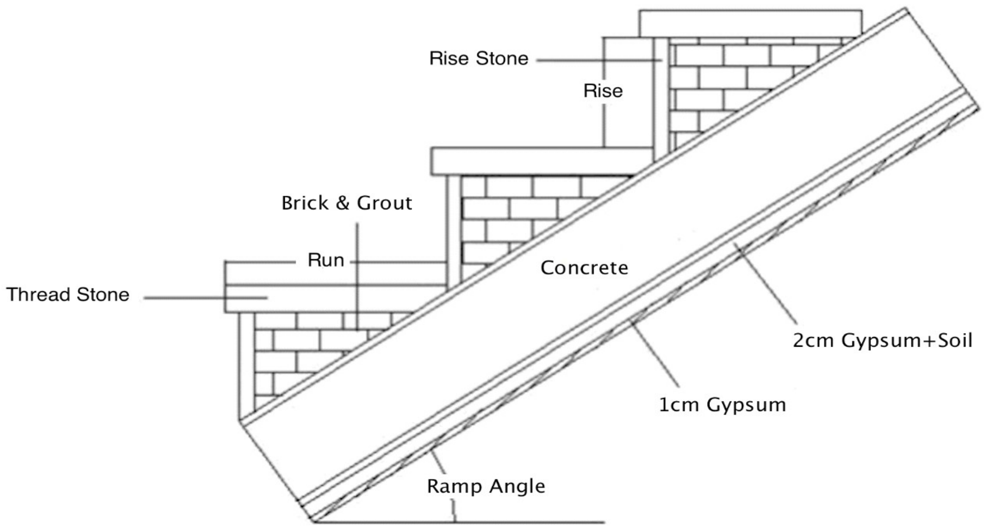
Layer Material	Thickness (m)	Density (kg/m^3)	Weight/Area (kg/m^2)	Remarks
Grout (cement) for top face	0.025	2100	52.5	
Ceramics	0.005	2100	10.5	
Grout (Gypsum & soil) for bottom face	0.02	1600	32	
Finishing (bottom face)	0.005	1300	6.5	
		Total Weight	**101.5**	

Roof Slab (without the concrete slab)

Layer Material	Thickness (m)	Density (kg/m^3)	Weight/Area (kg/m^2)	Remarks
Asphalt	0.03	2200	66	
Bitumen	-	-	15	
Grout (cement) for top face	0.02	2100	42	
Lightweight concrete (Grading)	0.15	2100	315	
Grout (Gypsum & soil) for bottom face	0.02	1600	32	
Finishing (bottom face)	0.005	1300	6.5	
		Total Weight	**476.5**	

Stairs

DEAD LOAD CALCULATIONS FOR RAMP OF STAIRS



Size of Run (m)	0.3
Size of Rise (m)	0.15
Angle of Ramp (deg.)	31

NOTE: Table calculations are for one step of the stairs and 1-m width (perpendicular to ramp direction) only.

Layer Material	Thickness (m)	Projected Plan Longitudinal Size (m)	Density (kg/m^3)	Weight/Length (kg/m)	Remarks
Thread stone	0.040	0.32	2500	32.0	
Rise stone	0.020	0.11	2500	5.5	
Grout under stones	0.020	0.37	2100	15.5	
Brick (average height used)	0.055	0.26	1850	26.5	
Concrete ramp	0.150	0.35	2500	131.2	
Gypsum & soil	0.020	0.35	1600	11.2	
Finishing (bottom face)	0.005	0.35	1300	2.3	
			Total Weight	**224.2**	

Weight per 1-meter length of ramp	**747.4**	kg/m
If we multiply by one meter width, the total weight in one square meter is obtained. Thus:		
Weight per 1-m^2 projected plan area of ramp	**747.4**	kg/m^2

DEAD LOAD CALCULATIONS FOR LANDING OF STAIRS

Layer Material	Thickness (m)	Projected Plan Longitudinal Size (m)	Density (kg/m^3)	Weight/Area (kg/m^2)	Remarks
Thread stone	0.040	-	2500	100.0	
Grout under stones	0.020	-	2100	42.0	
Concrete ramp	0.150	-	2500	375.0	
Gypsum & soil	0.020	-	1600	32.0	
Finishing (bottom face)	0.005	-	1300	6.5	
			Total Weight	**555.5**	

Weight per 1-m^2 of landing	**555.5**	kg/m^2

SUMMARY OF LOADS FOR STAIR

Weight per 1-m^2 projected plan area of ramp	**747.4**	kg/m^2
Weight per 1-m^2 of landing	**555.5**	kg/m^2
Live load per 1-m^2 of ramp & landing	**500.0**	kg/m^2

NOTES:

1- Using the tributary area of each beam supporting the stairs, the total dead and live loads on that beam is obtained.
2- Dividing by the beam length, the linear load on the beam can be calculated.
3- In calculation of the ramp tributary area on a supporting beam, the projected plan area of ramp is considered.

LIVE LOADS

Live loads has been selected based on ASCE 7-16 Table 4-1.

WIND LOADING PRAMETERS

Parameter	Value	Remarks
Structure type (enclosed, partially enclosed, or open)	Partially Enclosed	
Roof type	Flat	
Basic wind speed	140 km/h	
Risk category	II	
Directionality factor, k_d	0.85	
Topographical factor, k_{zt}	1	
Exposure category	C	
Gust effect factor	0.85	
Topography significant? (Y/N)	No	
Design method (directional, envelope, C&C)	Directional	

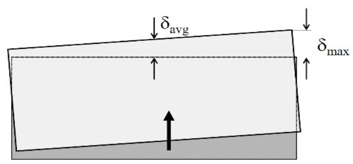
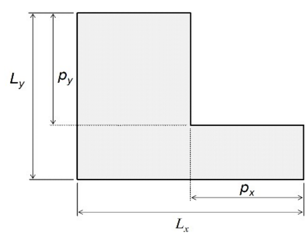
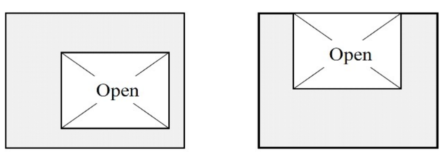
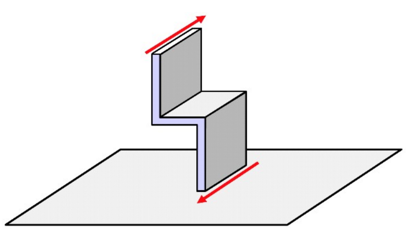
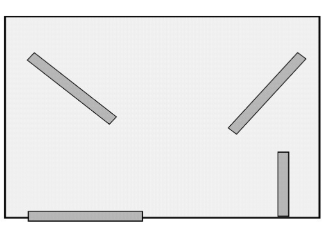
SEISMIC LOADING PARAMETERS

Parameter	Value	Remarks
Site class (section 11.4.2)	D	
Mapped spectral acceleration parameter S_s	0.60 g	
Mapped spectral acceleration parameter S_1	0.30 g	
Risk category	II	
Seismic design category (Table 11.6-1 & 11.6-2)	D	
Lateral load resisting system	Intermediate moment frame	
Long-period transition period	8 sec	
Response modification factor, R	5	
System overstrength, omega	3	
Deflection amplification factor, C_d	4.5	
Occupancy importance, I	1	

STRUCTURAL CONTROL FROM ANALYSIS RESULTS

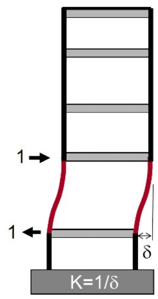
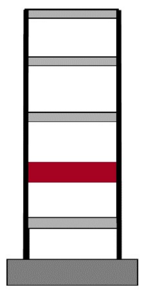
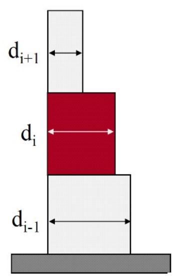
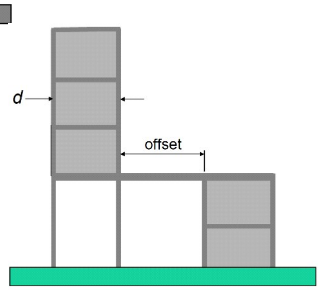
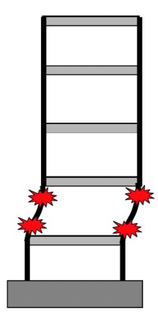
HORIZONTAL IRREGULARITIES (ASCE 12.3.2.1)

HORIZONTAL STRUCTURAL IRREGULARITIES

Figure	Description	Type (ASCE)
	$\delta_{max} < 1.2\delta_{ave}$ No irregularity $1.2\delta_{ave} \le \delta_{max} \le 1.4\delta_{ave}$ Irregularity $\delta_{max} > 1.4\delta_{ave}$ Extreme irregularity	**1a & 1b** Torsional Irregularity
	Irregularity exists if: $p_y > 0.15L_y$ and $p_x > 0.15L_x$	**2** Reentrant Corner Irregularity
	Irregularity exists if open area > 0.5 times floor area OR if effective diaphragm stiffness vaires by more than 50% from one story to the next. NOTE: The provisions are not specific on how effective diphragm stiffness is to be computed.	**3** Diphragm Discontinuity Irregularity
	The out-of-plane offset should be avoided.	**4** Out-of- Plane Offset
	Nonparallel system Irregularity exists when the vertical lateral force resisting elements are not parallel to or symmetric about the major orthogonal axes of the seismic force resisting system.	**5** Nonparallel System Irregularity

VERTICAL IRREGULARITIES (ASCE 12.3.2.2)

VERTICAL STRUCTURAL IRREGULARITIES

Figure	Description	Type (ASCE)
 Exception: Irregularity does not exist if no story drift ratio is greater than 1.3 times drift ratio of story above. Irregularity 1b is NOT PERMITTED in SDC E or F.	Irregularity (1a) exists if stiffness of any story is less than 70% of the stiffness of the story above or less than 80% of the average stiffness of the three stories above. An extreme irregularity (1b) exists if stiffness of any sotry is less than 60% of the stiffness of the story above or less than 70% of the average stiffness of the three stories above.	**1a & 1b** Stiffness (Soft Story) Irregularity
	Irregularity exists if the effective mass of any story is more than 150% of the effective mass of an adjacent story. Exception: Irregularity does not exist if no story drift ratio is greater than 1.3 times drift ratio of story above.	**2** Weight (Mass) Irregularity
	Irregularity exists if the dimensions of the lateral resisting system at any story is more than 130% of that for any adjacent story.	**3** Vertical Geometric Irregularity
	Irregularity exists if the offset is greater than the width (*d*) or there exists a reduction in stiffness of the story below.	**4** In-Plane Discontinuity Irregularity
	Irregularity (5a) exists if the lateral strength of any story is less than 80% of the strength of the story above. An extreme irregularity (5b) exists if the lateral strength of any story is less than 65% of the strength of the story above. Irregularities 5a and 5b are NOT PERMITTED in SDC E or F. Irregularity 5b not permitted in SDC D.	**5a & 5b** Strength (Weak Story) Irregularity

BASEMENT RETAINING WALL ANALYSIS & DESIGN

RETAINING WALL ANALYSIS

In accordance with International Building Code 2015

Retaining wall details

Stem type;	Propped cantilever pinned at the base
Stem height;	h_{stem} = **2500** mm
Prop height;	h_{prop} = **2500** mm
Stem thickness;	t_{stem} = **200** mm
Angle to rear face of stem;	α = **90** deg
Stem density;	γ_{stem} = **24** kN/m^3
Toe length;	l_{toe} = **1000** mm
Base thickness;	t_{base} = **500** mm
Base density;	γ_{base} = **24** kN/m^3
Height of retained soil;	h_{ret} = **2300** mm
Angle of soil surface;	β = **0** deg
Depth of cover;	d_{cover} = **0** mm

Retained soil properties

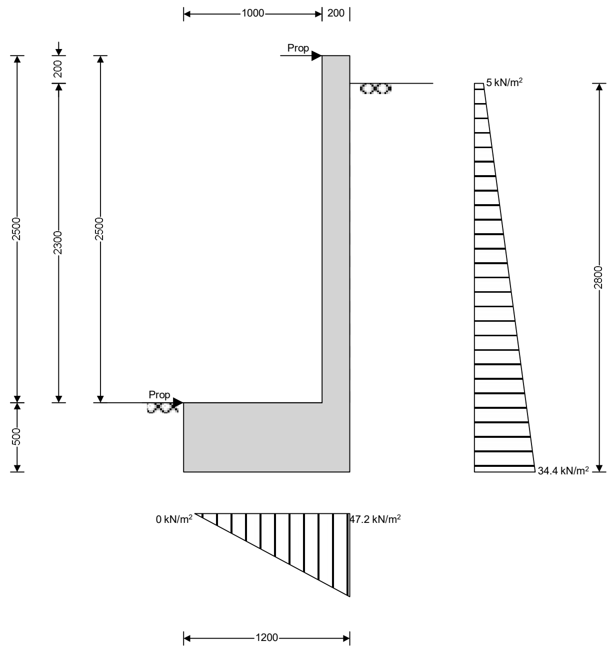
Soil type;	Medium dense well graded sand
Moist density;	γ_{mr} = **21** kN/m^3
Saturated density;	γ_{sr} = **23** kN/m^3
Effective angle of internal resistance;	ϕ_r = **30** deg
Effective wall friction angle;	δ_r = **0** deg

Base soil properties

Soil type;	Medium dense well graded sand
Soil density;	γ_b = **18** kN/m^3
Cohesion;	c_b = **0** kN/m^2
Effective angle of internal resistance;	ϕ_b = **30** deg
Effective wall friction angle;	δ_b = **15** deg
Effective base friction angle;	δ_{bb} = **30** deg
Allowable bearing pressure;	$P_{bearing}$ = **96** kN/m^2

Loading details

Dead surcharge load;	$Surcharge_D$ = **5** kN/m^2
Live surcharge load;	$Surcharge_L$ = **5** kN/m^2



General arrangement

Calculate retaining wall geometry

Base length;	$l_{base} = l_{toe} + t_{stem} = \mathbf{1200}$ mm
Moist soil height;	$h_{moist} = h_{soil} = \mathbf{2300}$ mm
Length of surcharge load;	$l_{sur} = l_{heel} = \mathbf{0}$ mm
- Distance to vertical component;	$x_{sur\_v} = l_{base} - l_{heel} / 2 = \mathbf{1200}$ mm
Effective height of wall;	$h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{2800}$ mm
- Distance to horizontal component;	$x_{sur\_h} = h_{eff} / 2 = \mathbf{1400}$ mm
Area of wall stem;	$A_{stem} = h_{stem} \times t_{stem} = \mathbf{0.5}$ m^2
- Distance to vertical component;	$x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{1100}$ mm
Area of wall base;	$A_{base} = l_{base} \times t_{base} = \mathbf{0.6}$ m^2
- Distance to vertical component;	$x_{base} = l_{base} / 2 = \mathbf{600}$ mm

Using Rankine theory

At rest pressure coefficient;	$K_0 = 1 - \sin(\phi_r) = \mathbf{0.500}$
Passive pressure coefficient;	$K_P = (1 + \sin(\phi_b)) / (1 - \sin(\phi_b)) = \mathbf{3.000}$

From IBC 2015 cl.1807.2.3 Safety factor

Load combination 1;	1.0 × Dead + 1.0 × Live + 1.0 × Lateral earth

Bearing pressure check

Vertical forces on wall

Wall stem;	$F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{12}$ kN/m
Wall base;	$F_{base} = A_{base} \times \gamma_{base} = \mathbf{14.4}$ kN/m
Total;	$F_{total\_v} = F_{stem} + F_{base} = \mathbf{26.4}$ kN/m

Horizontal forces on wall

Surcharge load; $F_{sur\_h} = K_0 \times (Surcharge_D + Surcharge_L) \times h_{eff} = \mathbf{14}$ kN/m

Moist retained soil; $F_{moist\_h} = K_0 \times \gamma_{mr} \times h_{eff}^2 / 2 = \mathbf{41.2}$ kN/m

Base soil; $F_{pass\_h} = -K_P \times \gamma_b \times (d_{cover} + h_{base})^2 / 2 = \mathbf{-6.7}$ kN/m

Total; $F_{total\_h} = F_{moist\_h} + F_{pass\_h} + F_{sur\_h} = \mathbf{48.4}$ kN/m

Moments on wall

Wall stem; $M_{stem} = F_{stem} \times x_{stem} = \mathbf{13.2}$ kNm/m

Wall base; $M_{base} = F_{base} \times x_{base} = \mathbf{8.6}$ kNm/m

Total; $M_{total} = M_{stem} + M_{base} + M_{sur} = \mathbf{21.8}$ kNm/m

Check bearing pressure

Distance to reaction; $\bar{x} = M_{total} / F_{total\_v} = \mathbf{827}$ mm

Eccentricity of reaction; $e = \bar{x} - l_{base} / 2 = \mathbf{227}$ mm

Loaded length of base; $l_{load} = 3 \times (l_{base} - \bar{x}) = \mathbf{1118}$ mm

Bearing pressure at toe; $q_{toe} = \mathbf{0}$ kN/m^2

Bearing pressure at heel; $q_{heel} = 2 \times F_{total\_v} / l_{load} = \mathbf{47.2}$ kN/m^2

Factor of safety; $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = \mathbf{2.033}$;

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

<u>RETAINING WALL DESIGN</u>

In accordance with ACI 318-14

Tedds calculation version 2.9.02

Concrete details

Compressive strength of concrete; $f'_c = \mathbf{28}$ N/mm^2

Concrete type; Normal weight

Reinforcement details

Yield strength of reinforcement; $f_y = \mathbf{420}$ N/mm^2

Modulus of elasticity or reinforcement; $E_s = \mathbf{199948}$ N/mm^2

Cover to reinforcement

Front face of stem; $c_{sf} = \mathbf{40}$ mm

Rear face of stem; $c_{sr} = \mathbf{50}$ mm

Top face of base; $c_{bt} = \mathbf{50}$ mm

Bottom face of base; $c_{bb} = \mathbf{75}$ mm

From IBC 2015 cl.1605.2.1 Basic load combinations

Load combination no.1; 1.4 × Dead

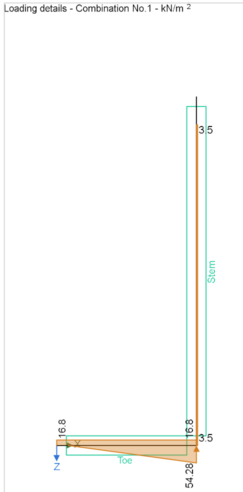
Load combination no.2; 1.2 × Dead + 1.6 × Live + 1.6 × Lateral earth

Load combination no.3; 1.2 × Dead + 1.0 × Earthquake + 1.0 × Live + 1.6 × Lateral earth

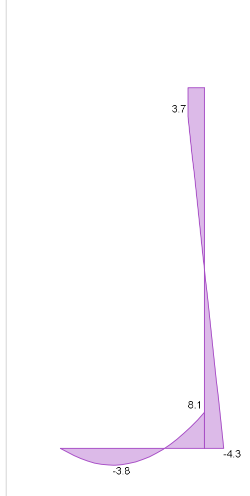
Load combination no.4; 0.9 × Dead + 1.0 × Earthquake + 1.6 × Lateral earth

Towsea Shahr Construction Company	*Project* Transit Center		*Job Ref.* ---
	Section --		*Sheet no./* 13
	Calc. by E. Ali Akbar Shaikhzadeh	*Chk'd by* ---	*Date* 4/8/2016

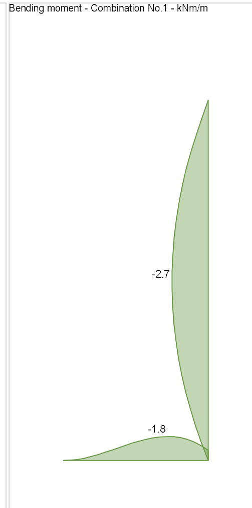
Loading details - Combination No.1 - kN/m²



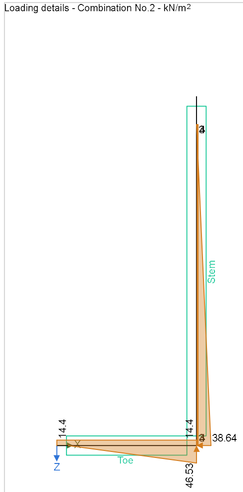
Shear force - Combination No.1 - kN/m



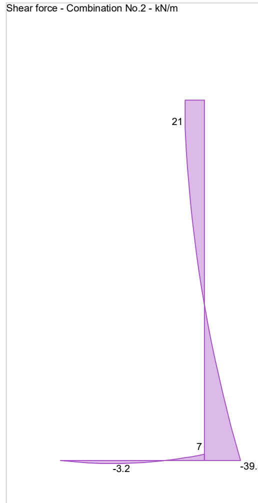
Bending moment - Combination No.1 - kNm/m



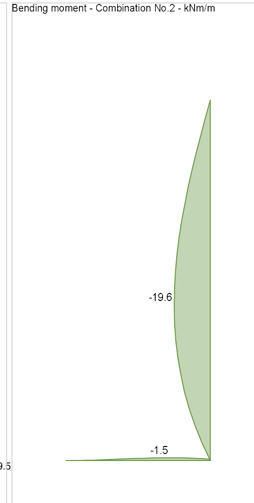
Loading details - Combination No.2 - kN/m²



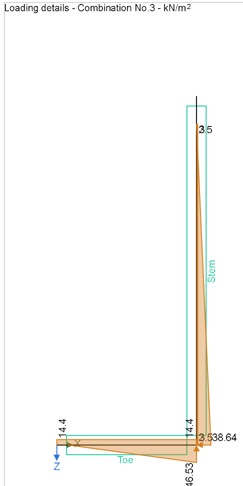
Shear force - Combination No.2 - kN/m



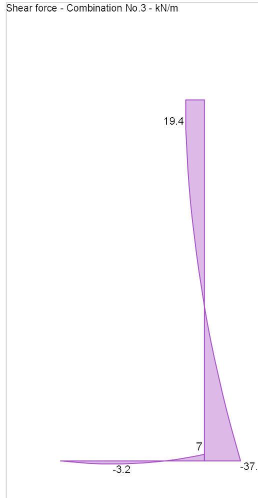
Bending moment - Combination No.2 - kNm/m



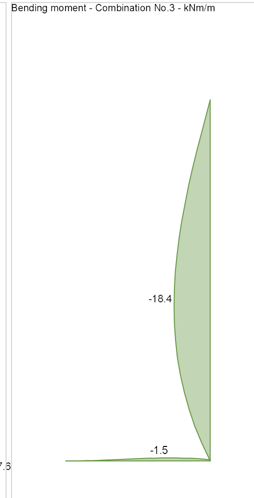
Loading details - Combination No.3 - kN/m²

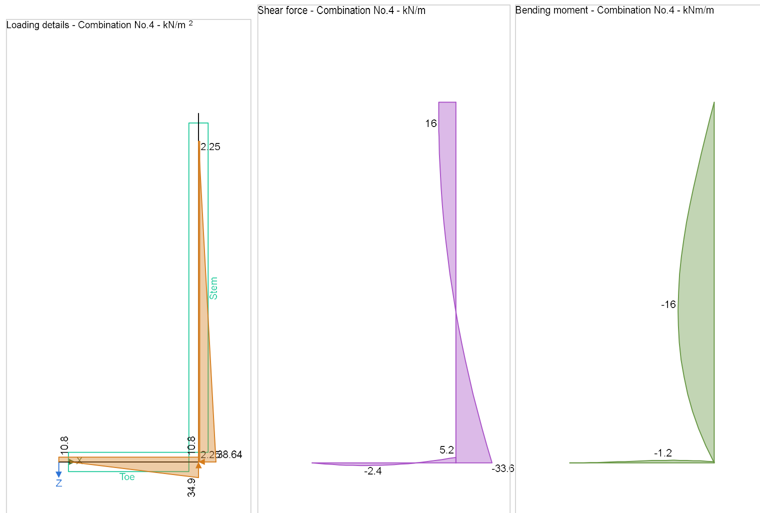


Shear force - Combination No.3 - kN/m



Bending moment - Combination No.3 - kNm/m





Check stem design at 1080 mm

Depth of section; h = **200** mm

Rectangular section in flexure - Section 22.3

Design bending moment combination 2; M = **19.6** kNm/m

Depth of tension reinforcement; $d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2$ = **136** mm

Compression reinforcement provided; 16 mm dia bars @ 250 mm c/c

Area of compression reinforcement provided; $A_{srM.prov} = \pi \times \phi_{srM}^2 / (4 \times s_{srM})$ = **804** mm^2/m

Tension reinforcement provided; 16 mm dia bars @ 250 mm c/c

Area of tension reinforcement provided; $A_{sfM.prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM})$ = **804** mm^2/m

Maximum reinforcement spacing - cl.11.7.2; s_{max} = min(18 in, 3 × h) = **457** mm

PASS - Reinforcement is adequately spaced

Depth of compression block; $a = A_{sfM.prov} \times f_y / (0.85 \times f'_c)$ = **14** mm

Neutral axis factor - cl.22.2.2.4.3; β_1 = min(max(0.85 - 0.05 × (f'$_c$ - 28 N/mm^2) / 7 N/mm^2, 0.65), 0.85) = **0.85**

Depth to neutral axis; $c = a / \beta_1$ = **17** mm

Strain in reinforcement; $\varepsilon_t = 0.003 \times (d - c) / c$ = **0.021435**

Section is in the tension controlled zone

Strength reduction factor; ϕ_f = min(max(0.65 + (ε_t - 0.002) × (250 / 3), 0.65), 0.9) = **0.9**

Nominal flexural strength; $M_n = A_{sfM.prov} \times f_y \times (d - a / 2)$ = **43.5** kNm/m

Design flexural strength; $\phi M_n = \phi_f \times M_n$ = **39.2** kNm/m

$M / \phi M_n$ = **0.499**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis; $A_{sfM.des}$ = **391** mm^2/m

Minimum area of reinforcement - cl.9.6.1.2; $A_{sfM.min}$ = max(0.25 × √(f'$_c$ × 1 N/mm^2), 1.4 N/mm^2) × d / f$_y$ = **453** mm^2/m

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Check stem design at base of stem

Depth of section; h = **200** mm

Rectangular section in shear - Section 22.5

Design shear force; $V = \mathbf{39.5}$ kN/m

Concrete modification factor - cl.19.2.4; $\lambda = \mathbf{1}$

Nominal concrete shear strength - eqn.22.5.5.1; $V_c = 0.17 \times \lambda \times \sqrt{(f'_c \times 1 \text{ N/mm}^2)} \times d = \mathbf{122.3}$ kN/m

Strength reduction factor; $\phi_s = \mathbf{0.75}$

Design concrete shear strength - cl.11.5.1.1; $\phi V_c = \phi_s \times V_c = \mathbf{91.8}$ kN/m

$V / \phi V_c = \mathbf{0.431}$

PASS - No shear reinforcement is required

Check stem design at prop

Depth of section; $h = \mathbf{200}$ mm

Rectangular section in shear - Section 22.5

Design shear force; $V = \mathbf{21}$ kN/m

Concrete modification factor - cl.19.2.4; $\lambda = \mathbf{1}$

Nominal concrete shear strength - eqn.22.5.5.1; $V_c = 0.17 \times \lambda \times \sqrt{(f'_c \times 1 \text{ N/mm}^2)} \times d = \mathbf{122.3}$ kN/m

Strength reduction factor; $\phi_s = \mathbf{0.75}$

Design concrete shear strength - cl.11.5.1.1; $\phi V_c = \phi_s \times V_c = \mathbf{91.8}$ kN/m

$V / \phi V_c = \mathbf{0.229}$

PASS - No shear reinforcement is required

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.11.6.1; $A_{sx.req} = 0.002 \times t_{stem} = \mathbf{400}$ mm²/m

Transverse reinforcement provided; 16 mm dia @ 200 mm c/c each face

Area of transverse reinforcement provided; $A_{sx.prov} = 2 \times \pi \times \phi_{sx}^2 / (4 \times s_{sx}) = \mathbf{2011}$ mm²/m

PASS - Area of reinforcement provided is greater than area of reinforcement required

Rectangular section in shear - Section 22.5

Design shear force; $V = \mathbf{8.1}$ kN/m

Concrete modification factor - cl.19.2.4; $\lambda = \mathbf{1}$

Nominal concrete shear strength - eqn.22.5.5.1; $V_c = 0.17 \times \lambda \times \sqrt{(f'_c \times 1 \text{ N/mm}^2)} \times d = \mathbf{122.3}$ kN/m

Strength reduction factor; $\phi_s = \mathbf{0.75}$

Design concrete shear strength - cl.7.6.3.1; $\phi V_c = \phi_s \times V_c = \mathbf{91.8}$ kN/m

$V / \phi V_c = \mathbf{0.089}$

PASS - No shear reinforcement is required

Check base design at toe

Depth of section; $h = \mathbf{500}$ mm

Rectangular section in flexure - Section 22.3

Design bending moment combination 1; $M = \mathbf{1.8}$ kNm/m

Depth of tension reinforcement; $d = h - c_{bt} - \phi_{bt} / 2 = \mathbf{442}$ mm

Compression reinforcement provided; 16 mm dia bars @ 200 mm c/c

Area of compression reinforcement provided; $A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb}) = \mathbf{1005}$ mm²/m

Tension reinforcement provided; 16 mm dia bars @ 200 mm c/c

Area of tension reinforcement provided; $A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt}) = \mathbf{1005}$ mm²/m

Maximum reinforcement spacing - cl.7.7.2.3; s_{max} = min(18 in, 3 × h) = **457** mm

PASS - Reinforcement is adequately spaced

Depth of compression block; $a = A_{bt.prov} \times f_y / (0.85 \times f'_c)$ = **18** mm

Neutral axis factor - cl.22.2.2.4.3; β_1 = min(max(0.85 - 0.05 × (f'_c - 28 N/mm^2) / 7 N/mm^2, 0.65), 0.85) = **0.85**

Depth to neutral axis; $c = a / \beta_1$ = **21** mm

Strain in reinforcement; $\varepsilon_t = 0.003 \times (d - c) / c$ = **0.060532**

Section is in the tension controlled zone

Strength reduction factor; ϕ_f = min(max(0.65 + (ε_t - 0.002) × (250 / 3), 0.65), 0.9) = **0.9**

Nominal flexural strength; $M_n = A_{bt.prov} \times f_y \times (d - a / 2)$ = **182.9** kNm/m

Design flexural strength; $\phi M_n = \phi_f \times M_n$ = **164.6** kNm/m

$M / \phi M_n$ = **0.011**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis; $A_{bt.des}$ = **11** mm^2/m

Minimum area of reinforcement - cl.7.6.1.1; $A_{bt.min} = 0.0018 \times h$ = **900** mm^2/m

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

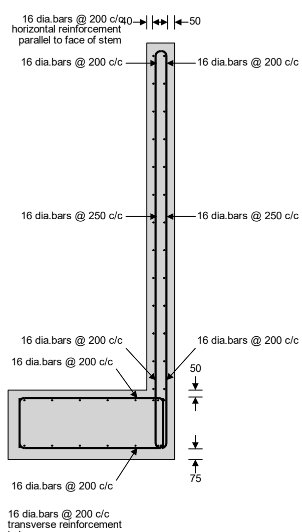
Transverse reinforcement parallel to base

Minimum area of reinforcement - cl.76.1.1; $A_{bx.req} = 0.0018 \times t_{base}$ = **900** mm^2/m

Transverse reinforcement provided; 16 mm dia @ 200 mm c/c each face

Area of transverse reinforcement provided; $A_{bx.prov} = 2 \times \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **2011** mm^2/m

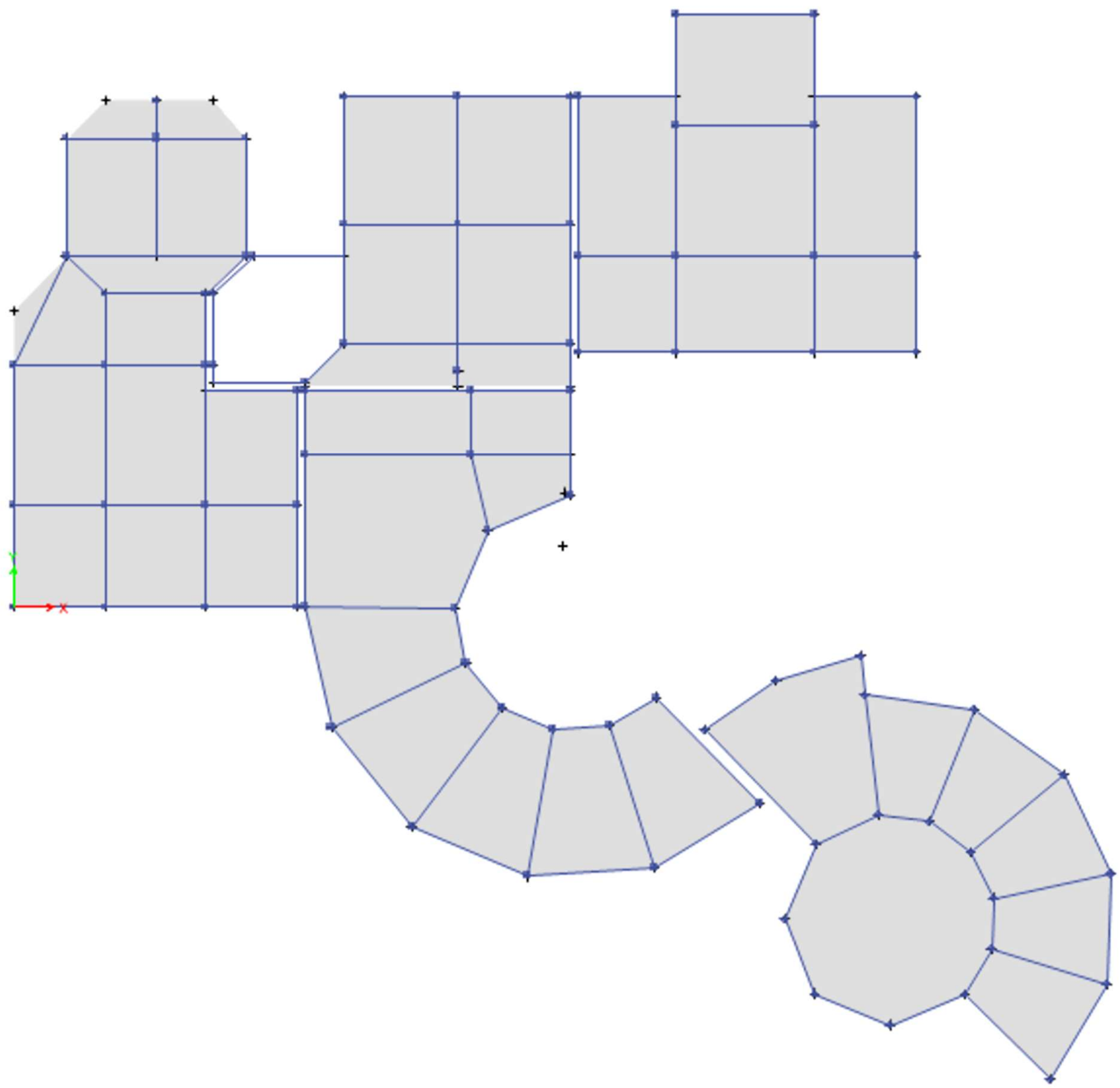
PASS - Area of reinforcement provided is greater than area of reinforcement required



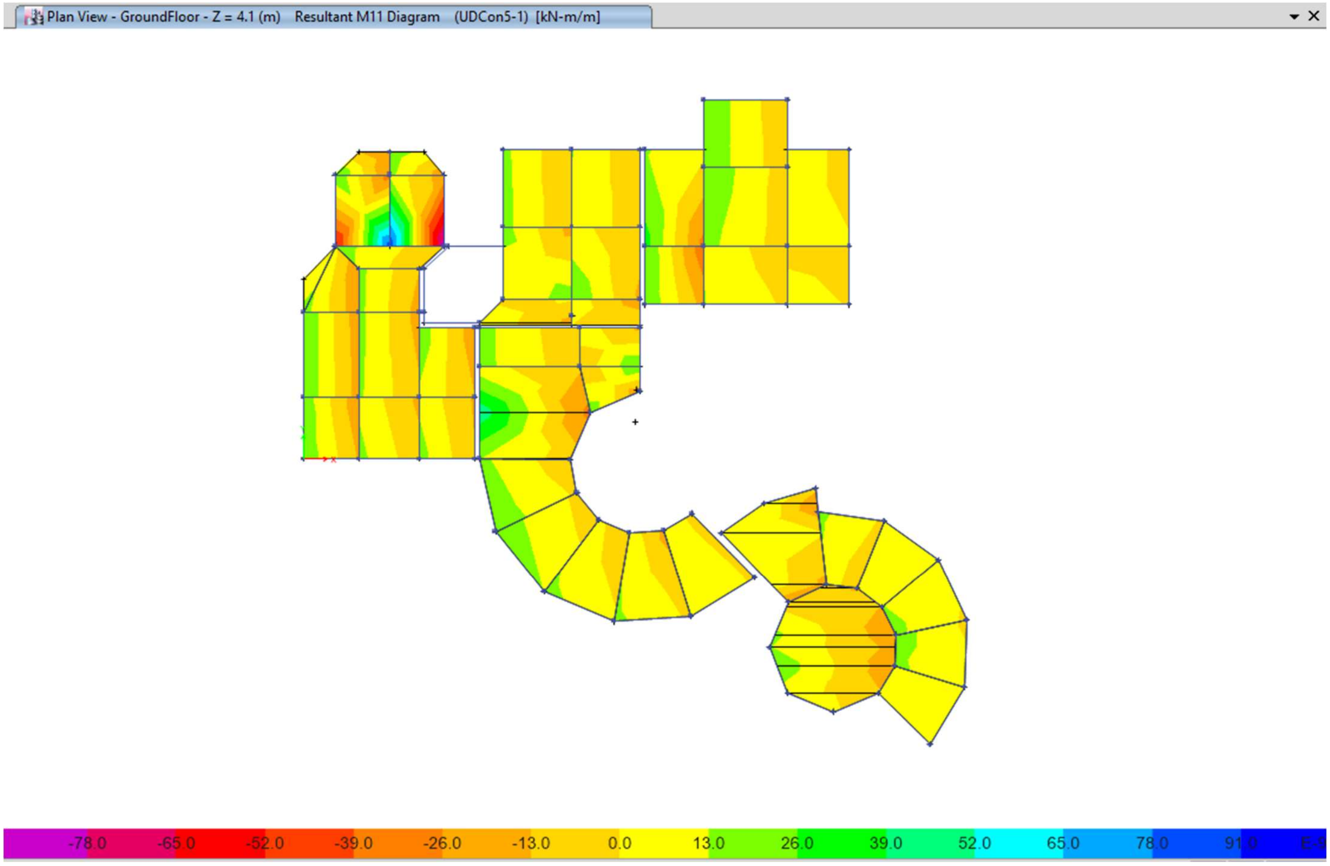
Reinforcement details

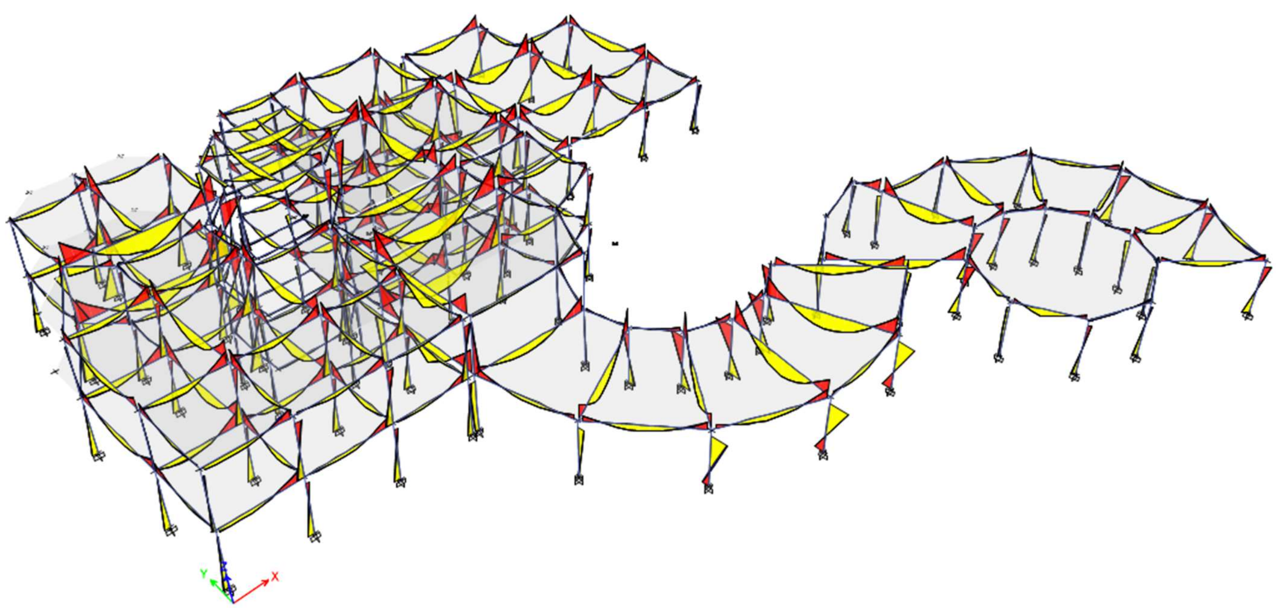
FRAME DESIGN

The frame of the building has been analysed and designed in ETABS software. Some figures of the model are shown below. However, due to the lengthy calculations and tables, the software complete report has not been added here and will be sent upon request.



Project		Job Ref.
Transit Center		---
Section		Sheet no./
--		18
Calc. by	Chk'd by	Date
E. Ali Akbar Shaikhzadeh	---	4/8/2016

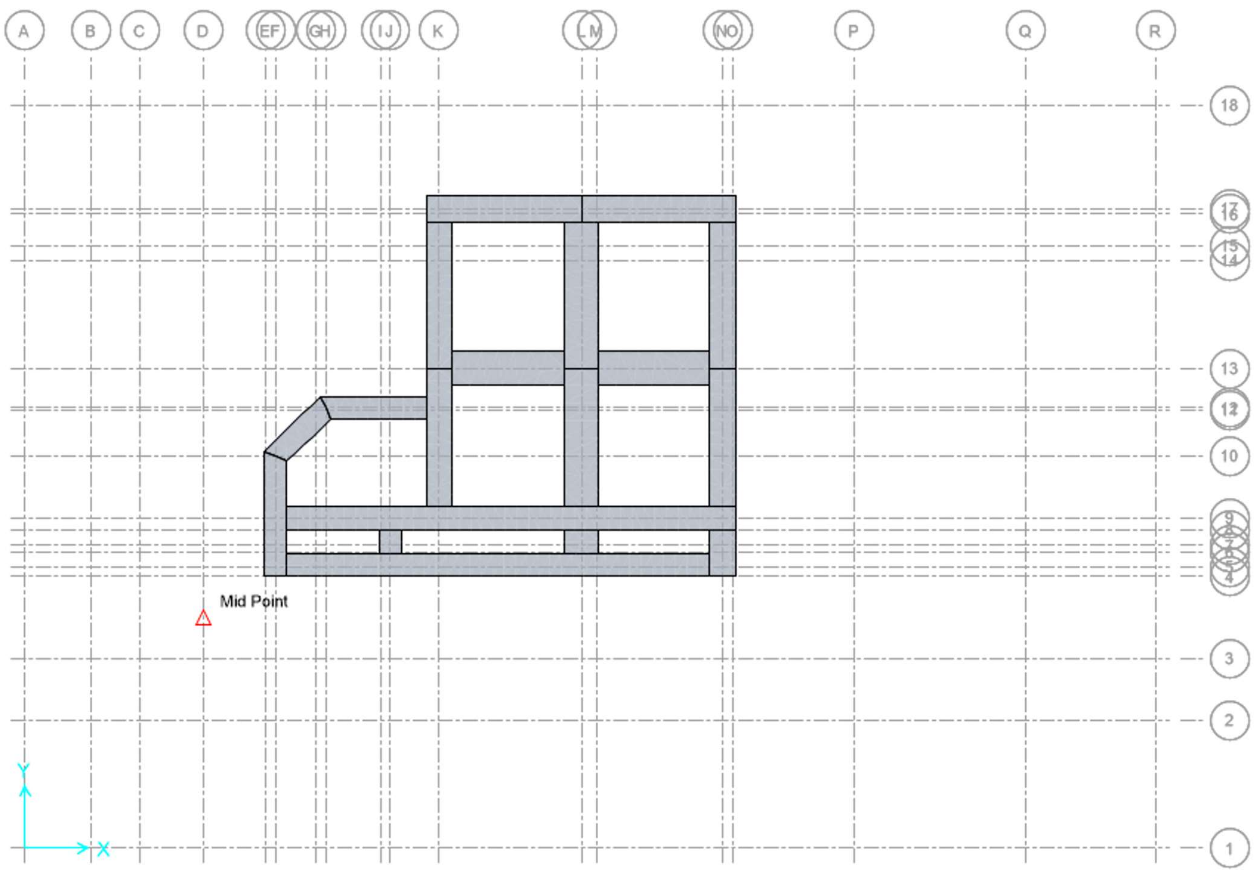




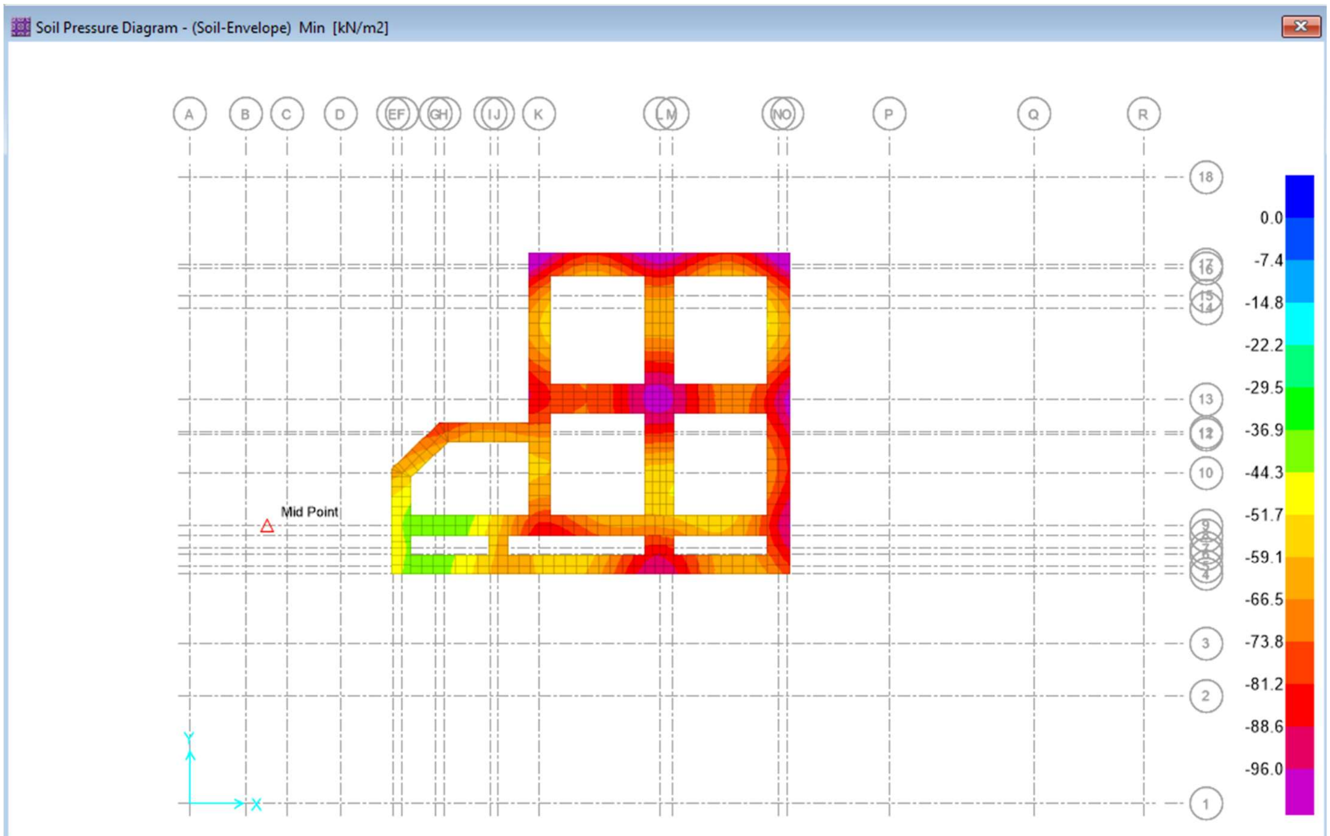
FOUNDATION & SLABS DESIGN

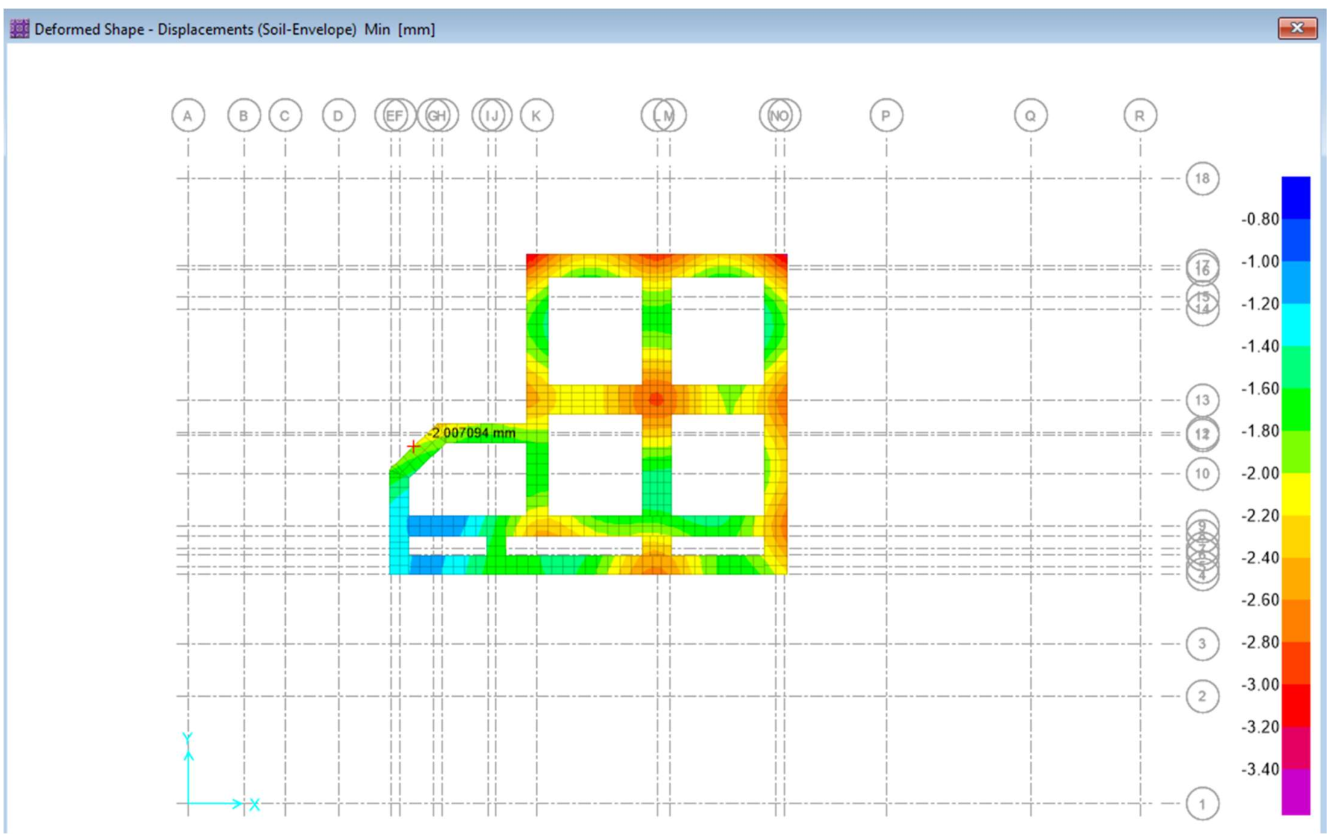
The foundation and slabs of the building has been designed in SAFE 2016 software. Some figures of the model are shown below. However, due to the lengthy calculations and tables, the software report has not been added here and will be sent upon request.

Basement foundation



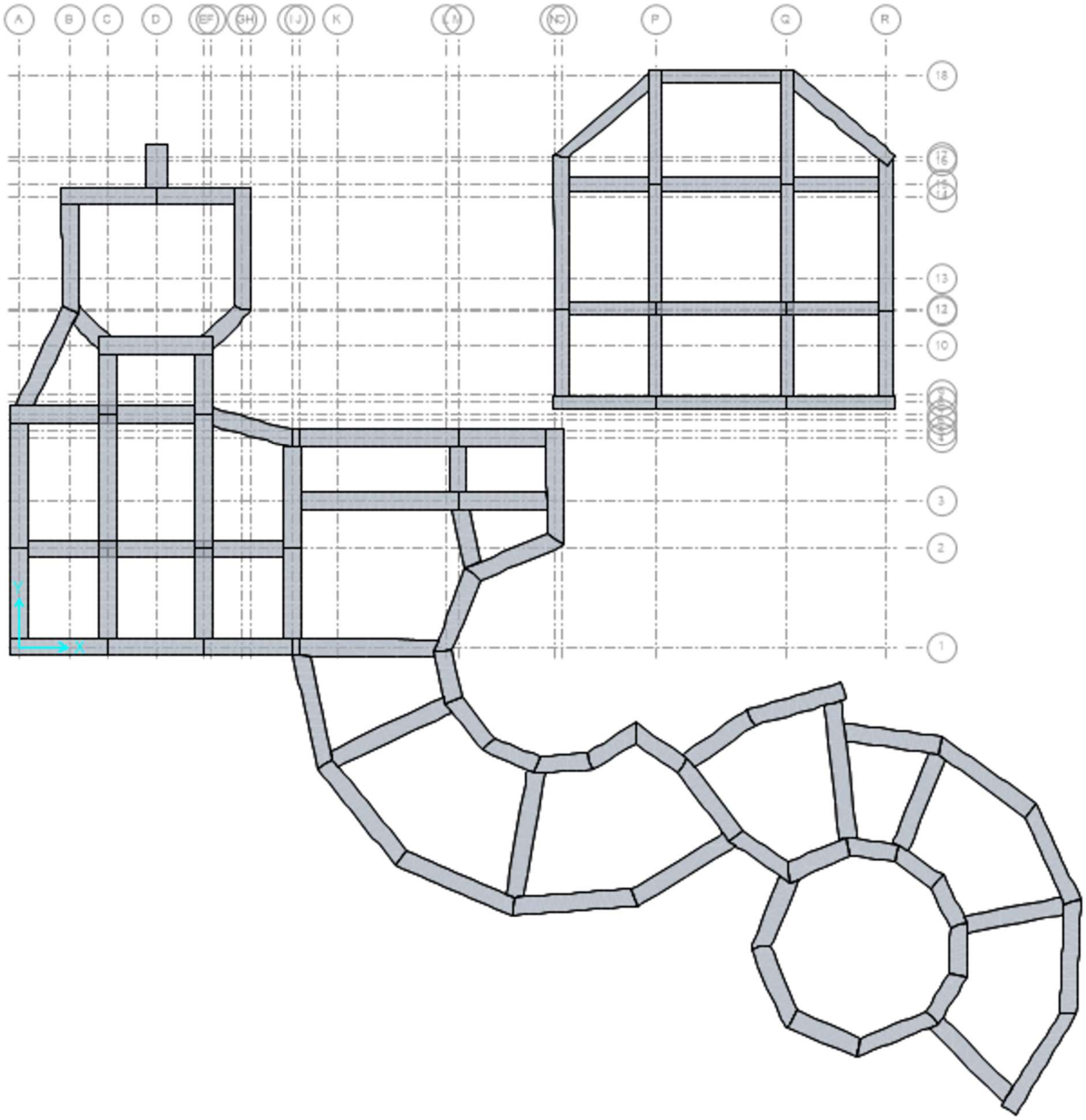
Towsea Shahr Construction Company	Project: Transit Center		Job Ref.: ---
	Section: --		Sheet no./ 20
	Calc. by: E. Ali Akbar Shaikhzadeh	Chk'd by: ---	Date: 4/8/2016





Ground Floor Foundation

Towsea Shahr Construction Company	*Project* Transit Center		*Job Ref.* ---
	Section --		*Sheet no./* 21
	Calc. by E. Ali Akbar Shaikhzadeh	*Chk'd by* ---	*Date* 4/8/2016



	Project		Job Ref.
Towsea Shahr Construction Company	Transit Center		---
	Section --		Sheet no./ 22
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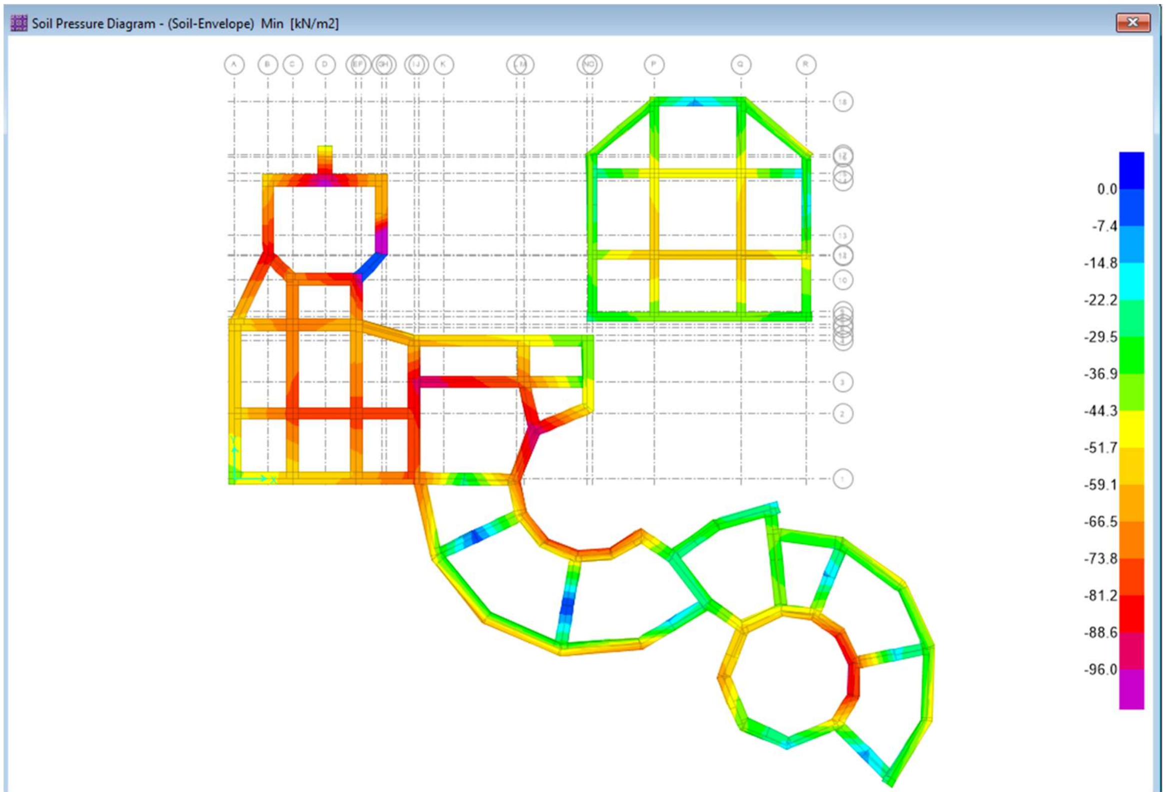
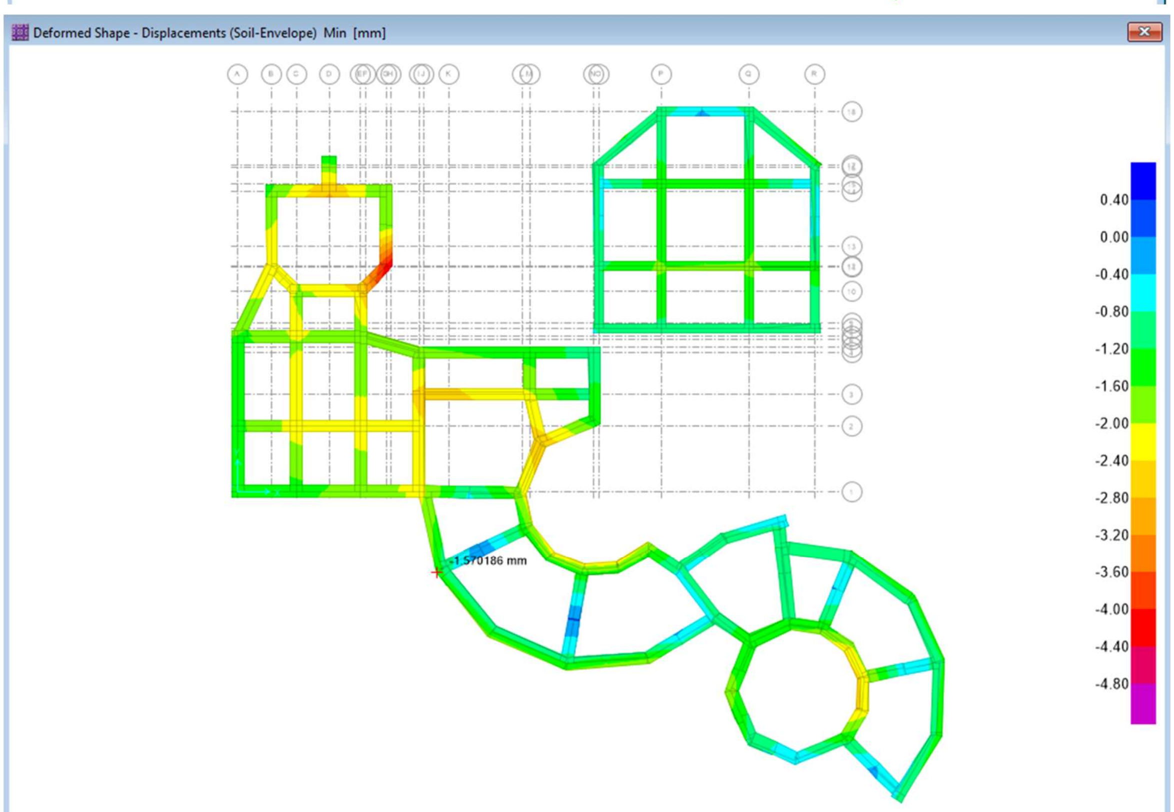
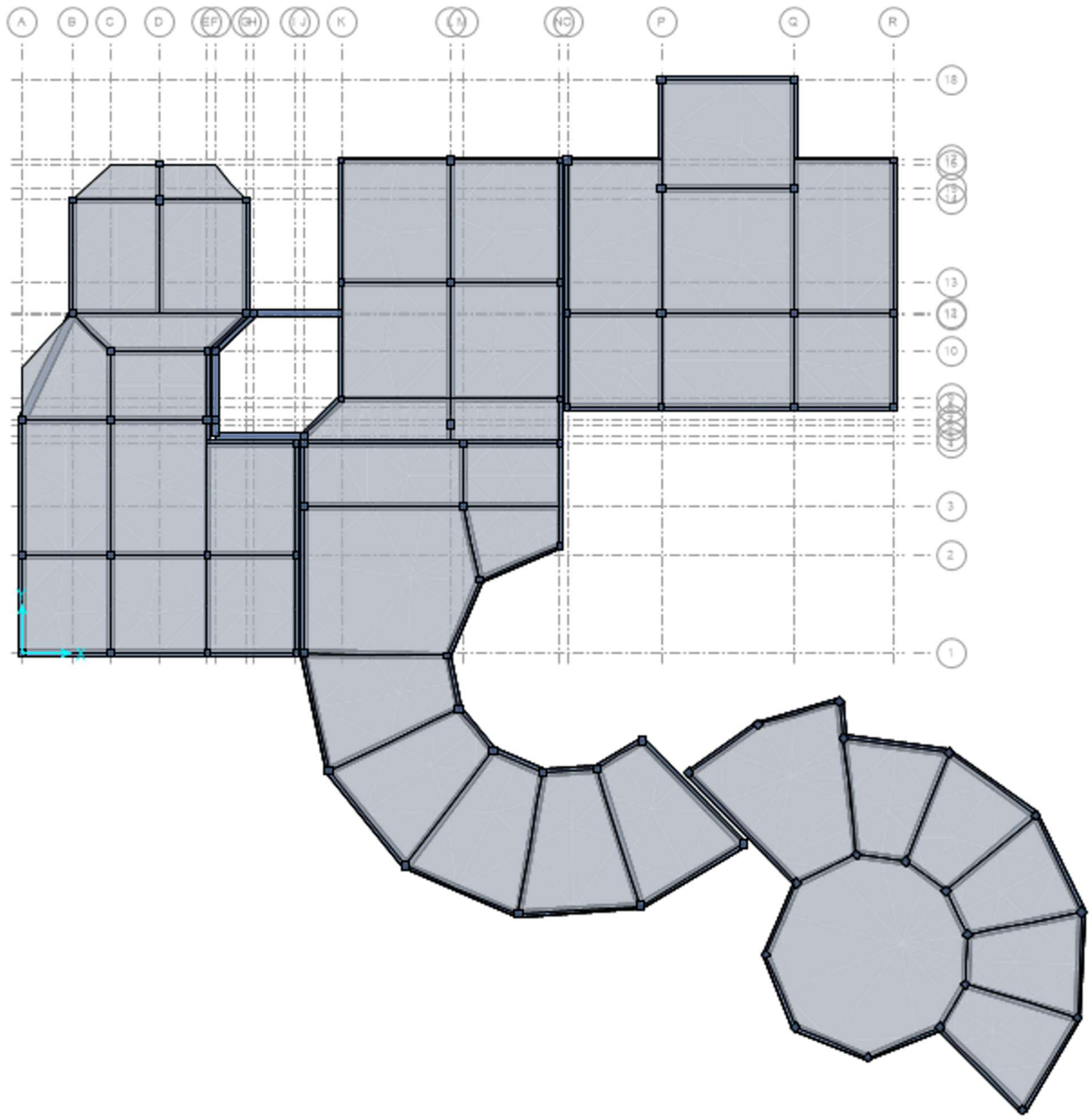
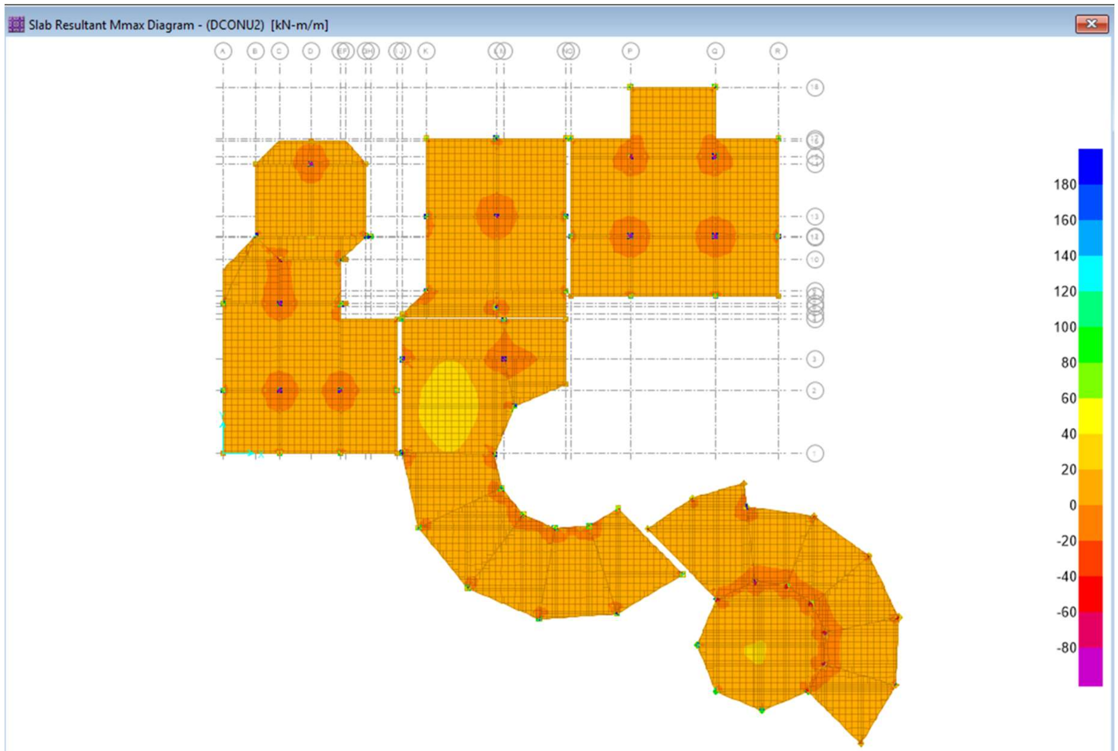


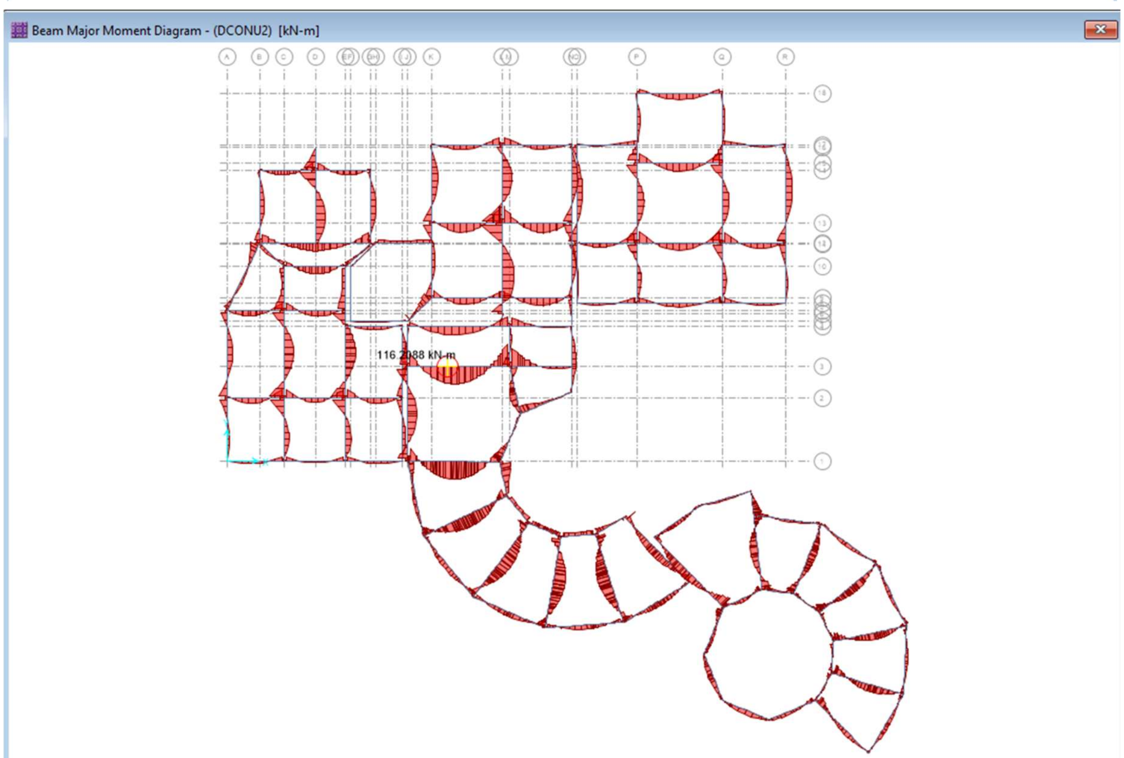


Ground Floor Slab



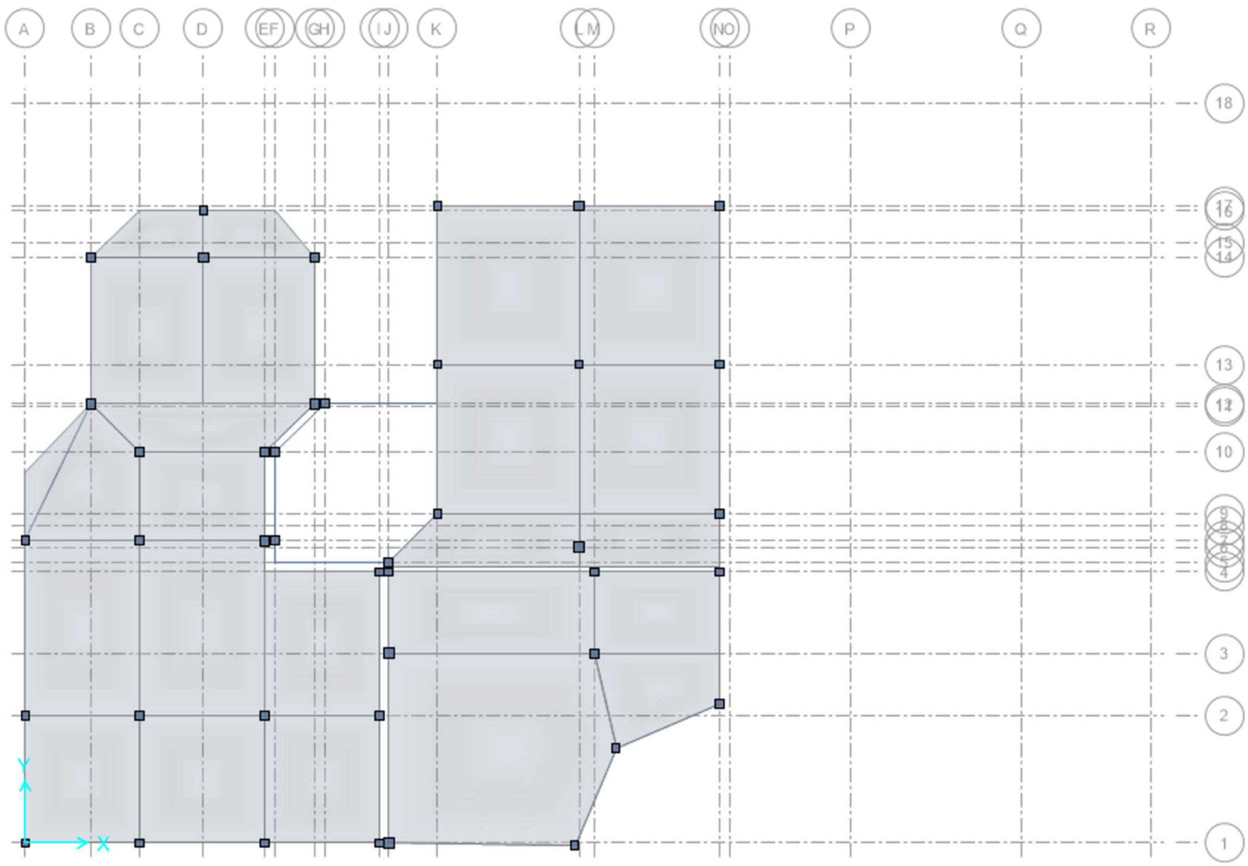


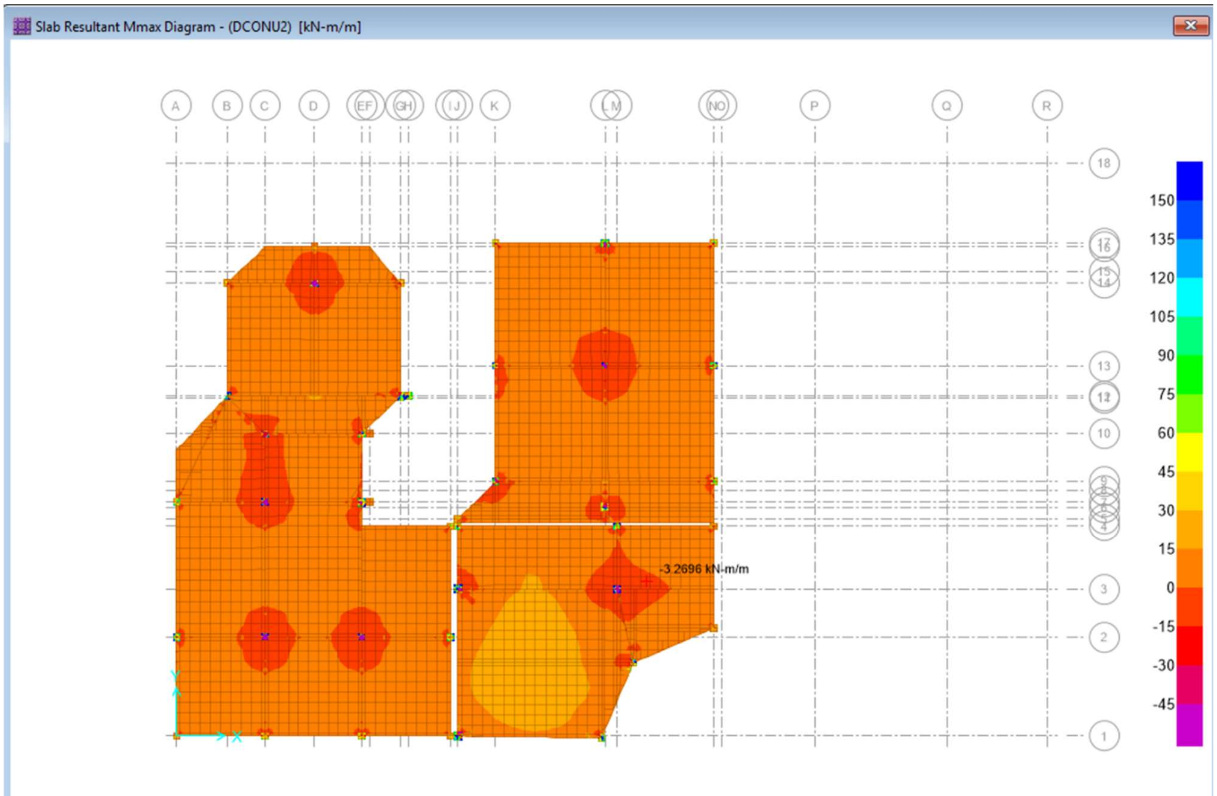
Slab Resultant Mmax Diagram - (DCONU2) [kN-m/m]
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80



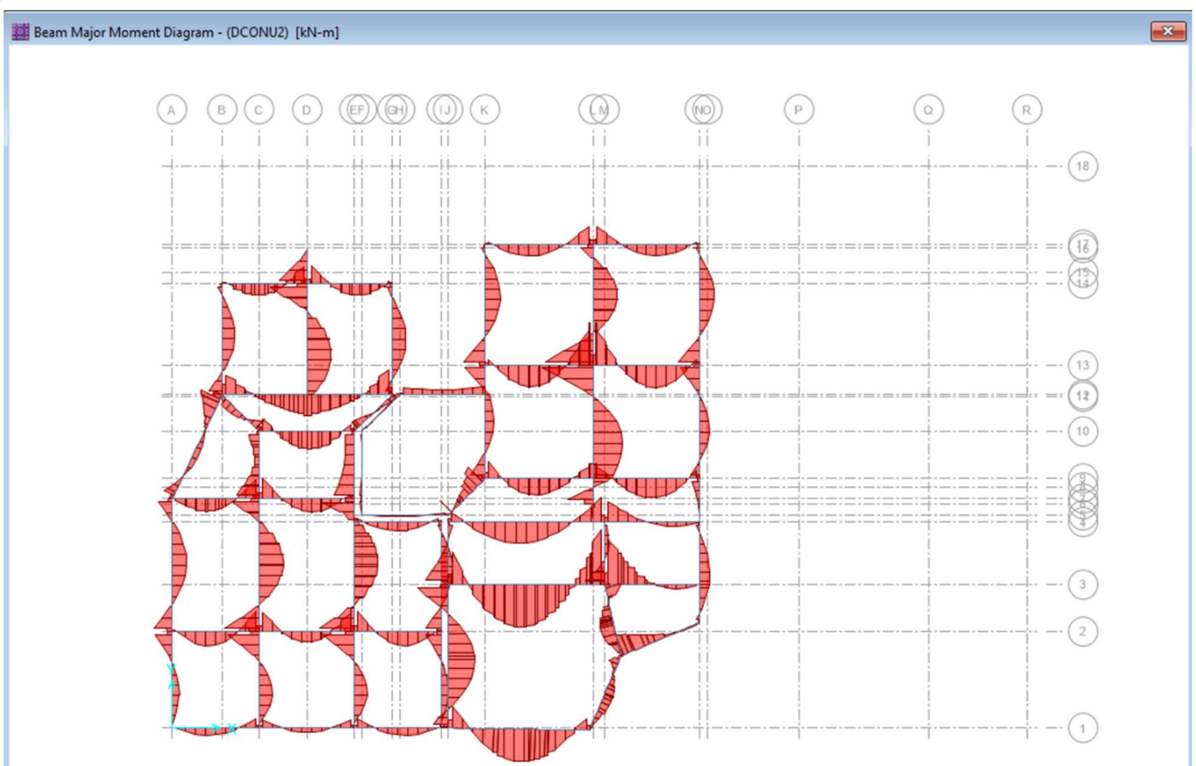
Beam Major Moment Diagram - (DCONU2) [kN-m]
116.2088 kN-m

Roof Slab





Slab Resultant Mmax Diagram - (DCONU2) [kN-m/m]
-3.2696 kN-m/m
150
135
120
105
90
75
60
45
30
15
0
-15
-30
-45



Beam Major Moment Diagram - (DCONU2) [kN-m]

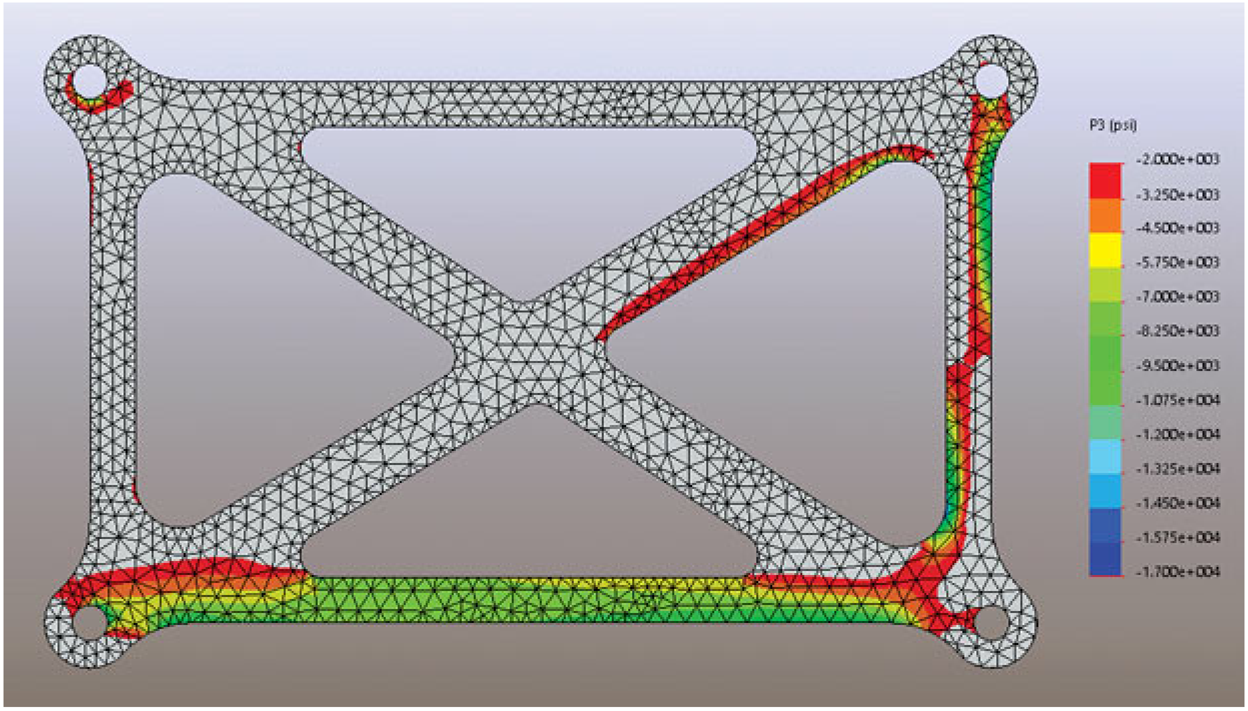


Figure 1: Stress in FEA: Part 3

Figure 1: Stress distribution diagram from finite element analysis

1.5 Member Design

1.5.1 Beam Design

The main girders were designed for the maximum moment and shear forces determined from the analysis.

Design Equation: $f_b = \frac{M}{S} \leq F_b$

Where the section modulus is: $S = \frac{I}{c}$

1.5.2 Column Design

Columns were designed for axial load plus bending moment combinations.

Interaction Formula: $\frac{P}{P_n} + \frac{M}{M_n} \leq 1.0$

1.6 Safety Verification

All structural members have been verified to meet or exceed the required safety factors:

1. Beam capacity utilization: 85% maximum
2. Column capacity utilization: 78% maximum
3. Connection capacity utilization: 92% maximum

1.7 Recommendations

Based on the analysis results, the following recommendations are made:

1. Proceed with construction using the proposed design
2. Implement regular inspection schedule post-construction
3. Monitor deflections during initial loading phases

1.8 Conclusion

The proposed bridge design meets all applicable codes and standards. The structure provides adequate safety margins for the intended loading conditions.

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