طرح نگهداشت و افزایش تولید 27 مخزن

CALCULATION NOTE FOR SPECIAL PIPE SUPPORTS

نگهداشت و افزایش تولید میدان نفتی بینک

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Rev.	**Date**	**Purpose of Issue/Status**	**Prepared by:**	**Checked by:**	**Approved by:**	**CLIENT Approval**
Class:2		**COMPANY Doc. Number:F0Z-709131**				

Status:

IDC: Inter-Discipline Check
IFC: Issued For Comment
IFA: Issued For Approval
AFD: Approved For Design
AFC: Approved For Construction
AFP: Approved For Purchase
AFQ: Approved For Quotation
IFI: Issued For Information
AB-R: As-Built for CLIENT Review
AB-A: As-Built –Approved

REVISION RECORD SHEET

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CONTENTS

1.0 INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

2.0 SCOPE

This report covers the structure & foundation calculation report of the “Chemical injection and Storage Shelter”. The structure modelled by “SAP” software & the foundation modelled by “SAP” software too.

3.0 NORMATIVE REFERENCE

3.1 Local Codes and Standards

- INBC Part 6 “Iranian National Building Code
- INBC Part 7 “Iranian National Building Code
- INBC Part 9 “Iranian National Building Code
- INBC Part 10 “Iranian National Building Code
- Iranian Seismic Design Code for Petroleum Facilities(3rd edition)

3.2 International Codes and Standards

- ASCE 7-10 “Minimum Design Loads and Associated Criteria for Buildings and Other Structures-American Society of Civil Engineers”.
- ACI 318. “Building Code Requirements for Reinforced Concrete”, American Concrete Institute.
- AISC 358 “Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications.” American Institute of Steel Construction, Inc.
- AISC 360 - “Specification for Structural Steel Buildings”. American Institute of Steel Construction, Inc.

3.3 The Project Documents

- BK-GNRAL-PEDCO-000-ST-SP-0001 SPECIFICATION FOR CONCRETE WORK
- BK-GCS-PEDCO-120-ST-DW-0058 STRUCTURAL DRAWING FOR CHEMICAL INJECTION &

STORAGE SHELTER

5.2 BK-GNRAL-PEDCO-000-ST-DC-0001 STRUCTURAL DESIGN CRITERIA

5.3 BK-GNRAL-PEDCO-000-CV-SP-0004 SPECIFICATION FOR EARTH WORK

5.4 BK-GCS-PEDCO-120-GT-RT-0001 GEOTECHNICAL INVESTIGATION REPORT FOR COMPRESSOR STATION

4.0 MATERIAL PROPERTIES

Material properties are delivered in the following table.

TABLE 1 -MATERIAL PROPERTIES

Foundation Concrete	F'c = 30 Mpa(28- day cylindrical sample)
Long. reinforcement bar	Fy = 400 Mpa(AIII)
Trans. reinforcement bar	Fy = 400 Mpa(AIII)
Bolt Type	HV 8.8
Electrode Type	E 70
Structural Steel shapes and plates:	St 37(Fy=2400kg/cm2 , Fu=3700 kg/cm2)

5.0 STRUCTURE 'S SYSTEMS

The structure's system is Inverted pendulum.

TABLE 2 –STRUCTURAL SYSTEM

	SYSTEM	R	OMEGA	CD
X DIR	PENDULUM	2	2	2
Y DIR	PENDULUM	2	2	2

6.0 INPUT DATA

Structural elements stability and stress check have been performed considering the following load conditions:

LoadPat	DesignType	SelfWtMult	Notes
DL	Dead	1	Weight of the Structural members and permanent attachments or accessories
Test	Dead	0	The empty weight of the pipes plus the weight of the test medium
LL	Live	0	Live Load
OPR1	Dead	0	The weight of piping, piping insulation, cable tray, process equipment and vessels plus their contents (fluid load) in Thermal load. Operating Load=DLempty+LLop
EQX	Quake	0	Earthquake load is determined by equivalent static earthquake analysis at axis X
EQY	Quake	0	Earthquake load is determined by equivalent static earthquake analysis at axis Y
OCX	Quake	0	Pure seismic load of piping at axis X
TL	Other	0	Thermal loads are those forces caused by a change in temperature. Such forces shall include those caused by vessel or piping expansion or contraction.
OCY	Quake	0	Pure seismic load of piping at axis Y
FRX	Other	0	Friction loads due to thermal expansion of pipes axis X
FRY	Other	0	Friction loads due to thermal expansion of pipes axis Y
WX	Wind	0	Wind load axis X
WY	Wind	0	Wind load axis Y
EQZ	Quake	0	Vertical Earthquake load
TLst	Temperature	0	Temperature Load
NotionalX(DL)	Notional	0	Notional load derived from DL load at axis X
NotionalY(DL)	Notional	0	Notional load derived from DL load at axis Y
NotionalX(OPR)	Notional	0	Notional load derived from OPR load at axis X
NotionalY(OPR)	Notional	0	Notional load derived from OPR load at axis Y

NotionalX(Test)	Notional	0	Notional load derived from Test load at axis X
NotionalY(Test)	Notional	0	Notional load derived from Test load at axis Y
Soil	Dead	0	Soil load

7.0 DESIGN LOAD

7.1 Dead load

The self-weight of structural elements (introduced Dead Load/DL in SAP) is automatically considered by SAP program.

7.2 OPERATION LOADS

Operation load of pipes according to piping documents assign in model.

7.3 HYDROTEST LOADS

Hydrotest load of pipes according to piping documents assign in model.

7.4 PURE SEISMIC WEIGHT OF PIPING (OCX & OCY)

Seismic loads of pipes according to piping documents assign in model. In some cases when the earthquake load is not provided by piping, the earthquake coefficient is calculated by Iranian seismic design code for Petroleum facilities (3rd edition). the same behavior as the inverted pendulum.

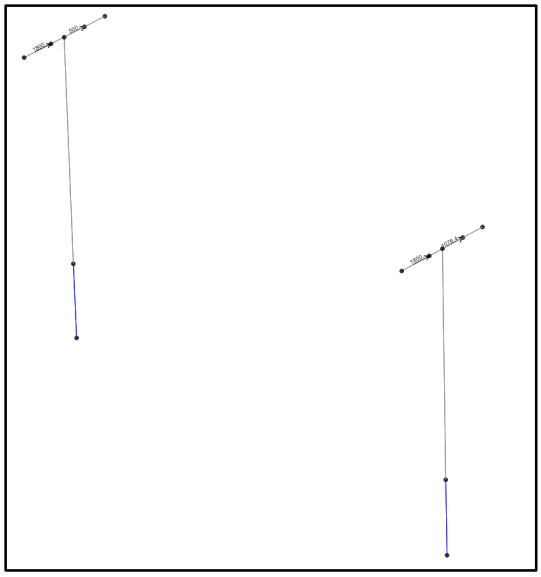

FIGURE 1. PURE SEISMIC WEIGHT OF PIPING (OCX)

7.5 SEISMIC LOAD (EQX,EQY)

All structures are in area with high risk zone of seismic and until finalizing of "Geotechnical Final Report" soil type consider is type II. Equivalent static method is used for calculation of seismic loads. Parameters which are used in calculation of earthquake force and seismic coefficient is presented in below According to Iranian seismic design code for Petroleum facilities (3rd edition). Structures with the same behavior as the inverted pendulum.

$$V = \frac{S_a}{R/I_e} \text{ W}$$

Where:

C_s = the seismic response coefficient from Equation below:

W = the effective seismic weight of the structure

$$C_s = \frac{S_a}{R/I_e}$$

Where:

Sa= mapped spectral response acceleration parameter (g), determined from hazard analysis.

$S_{DS} = 0.75$

$S_{D1} = 0.375$

R= the response modification factor for structure (Structures with the same behavior as the inverted pendulum)

I = the importance factor for structure:1.25

Ruy=2
Omega=2
Cd=2

$C_s = \frac{0.75 \times 1.25}{2}$=0.468

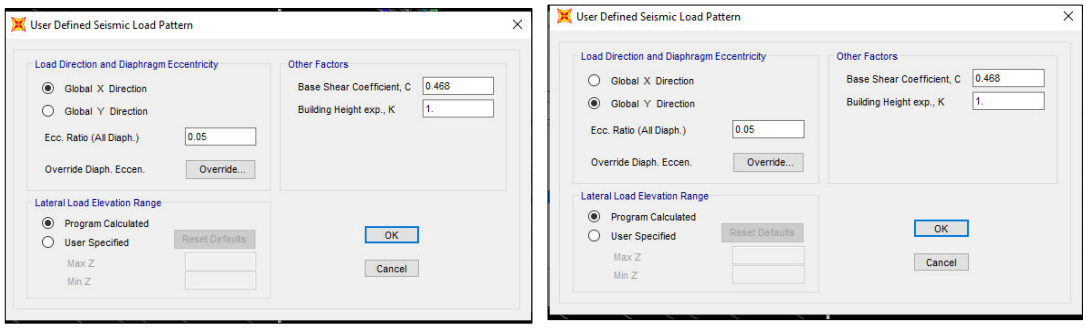

FIGURE 2. PERIOD IN X,Y DIRECTION

- **Vertical seismic component:**

The vertical seismic load effect, Ev, shall be determined in accordance with the following Equation 6):

$Ev = 0.2S_{DS}D$

S_{DS} = Design, 5% damped, spectral response acceleration parameter (g) at short periods (0.2 sec).

D = effect of dead load

Loads case name: EQZ=0.2×0.75×W=0.15×W

-Ev : Vertical seismic load applied at model:

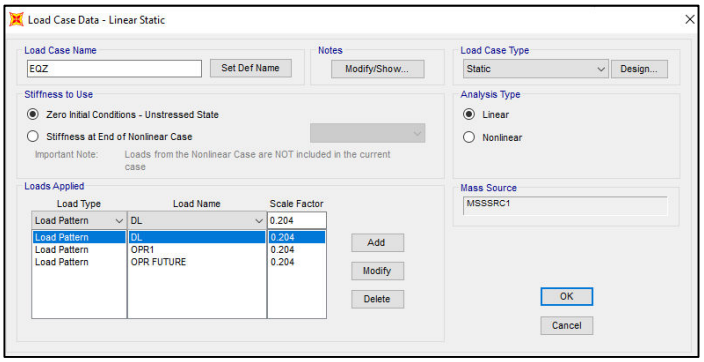

FIGURE 3. APPLIED EV LOAD

Ev applied at model as a portion of dead load as above.

7.6 FRICTION LOADS (FRX, FRY)

Based on design criteria on pipe racks and pipe supports with 3 or less lines the friction force shall be taken as 30% of the total pipe weight under operating condition.

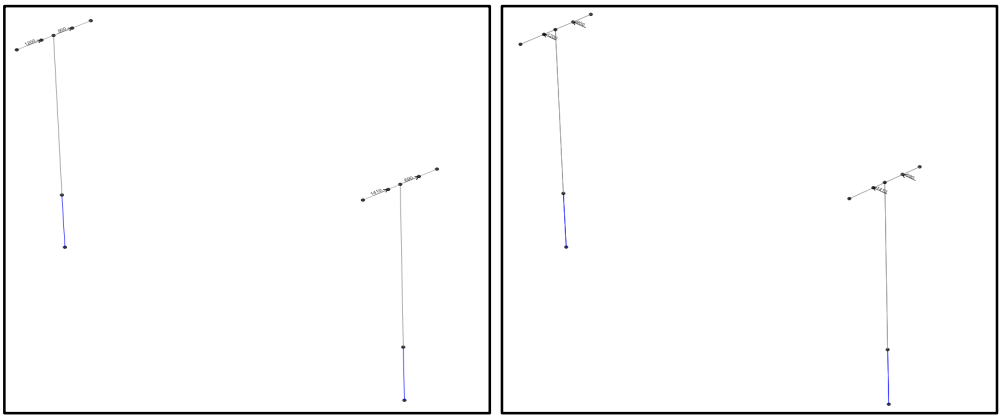

FIGURE 4. FRICTION LOADS (FRX, FRY)

7.7 THERMAL LOAD OF STRUCTURE (TLST)

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According to “Specification for Civil and Structural Design Criteria”. Maximum temperature of 28 ºC shall be considered for computing the thermal load in all components.

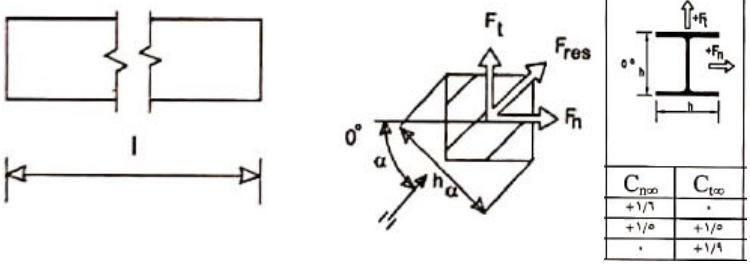
7.8 WIND LOAD

Wind loads are calculated according to Iranian National Building Code No.6 last edition and applied at model as below

- For columns wind load applied as below (according to INBC no.6)

$F_n = K \cdot C_{n\infty} \cdot q \cdot C_g \cdot C_e \cdot A \cdot l_w$

$F_t = K \cdot C_{t\infty} \cdot q \cdot C_g \cdot C_e \cdot A \cdot l_w$



$\alpha = 0 \quad C_{n\infty} = 1.6$

$\alpha = 90 \quad C_{t\infty} = 1.9$

$F_n = F_x = K.C_{n\infty}.q.Cq.Ce.A.Iw$

$F_t = F_x = K.C_{t\infty}.q.Cq.Ce.A.Iw$

$F_n = F_x = 0.75 \times 1.6 \times 0.681 \times 2 \times 0.941 \times 0.3 \times 1 = 0.4613KN = 46.13 \ kg$

- For pipe wind load applied as below (according to INBC no.6)

$d\sqrt{qC_e}$		
<۰/۱۶۷	≥ ۰/۱۶۷	
۱/۲	۰/۵	○
۱/۲	۰/۷	○
۱/۲	۰/۹	
۱/۳	۱/۱	

$C_f \quad \rightarrow \quad \text{if} \quad d\sqrt{qC_e} \geq 0.167 = 0.5$

$F = C_f.q.C_g.C_e.A.I_w = 0.5x0.681x2x0.941x0.25x1 = 0.16 \ kN/m = 16kg/m$

1.1 SAP LOADING TABLE

✓ **Load pattern:**

TABLE: Load Pattern Definitions				
LoadPat	**DesignType**	**SelfWtMult**	**AutoLoad**	**NotBasePat**
Text	Text	Unitless	Text	Text
DL	Dead	1		
OPR1	Dead	0		
FRX	Other	0		
FRY	Other	0		
EQX	Quake	0	USER COEFF	
EQY	Quake	0	USER COEFF	
EQZ	Quake	0	None	
TL	Temperature	0		
L	Live	0		
Test	Dead	0		
Soil	Dead	0		
OCX	Quake	0	None	

TABLE: Load Pattern Definitions				
LoadPat	**DesignType**	**SelfWtMult**	**AutoLoad**	**NotBasePat**
Text	Text	Unitless	Text	Text
OCY	Quake	0	None	
NotionalX(DL)	Notional	0		DL
NotionalY(DL)	Notional	0		DL
NotionalX(OPR)	Notional	0		OPR1
NotionalY(OPR)	Notional	0		OPR1
NotionalX(Test)	Notional	0		Test
NotionalY(Test)	Notional	0		Test
OCZ	Quake	0	None	
WX	Wind	0	None	
WY	Wind	0	None	

8.0 Load combinations

According to code INBC No.60(4 th edition) structures, components, and foundations shall be designed, so that their design strength equals or exceeds that effect of factored loads in the following combination:

- 1.4(D)
- (1.2D) +1.6(L)+0.5(Lr/S/R)
- 1.2D+1.6(Lr/S/R) + (L/0.5W)
- 1.2D+1.0(W) + L+.5(Lr/S)
- 1.2D+1.0E+L+0.2S
- 0.9D+1.0W
- 0.9D+1.0E

Load listed herein shall be considered to act in the following combinations; whichever produces the most unfavorable effect considering soil reactions.

- *D*
- *D+L*
- *D+(Lr/S/R)*
- *D+0.75(L)+0.75(Lr/R/S)*
- *D+(0.6W or 0.7E)*
- *D+0.75L+0.75(0.6W)+0.75(Lr/S/R)*
- *D+0.75L+0.75(0.7E)+0.75S*
- *0.6D+0.6W*
- *0.6D+0.7E*

9.0 STRUCTURE ANALYSIS AND DESIGN

9.1 ANALYSIS

Structural analysis is done by SAP2000 software. In model loads are applied, some graphical outputs from model are shown as follows.

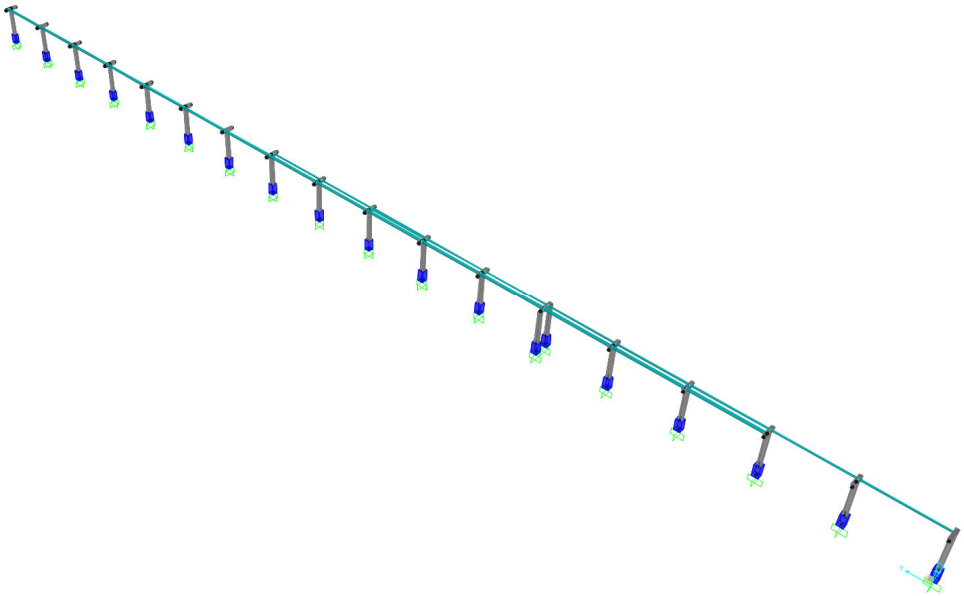


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FIGURE 5. 3D VIEW OF SAP MODEL

9.2 DRIFT CONTROL:

According to “Civil & Structural Design Criteria”, horizontal displacements for shelter shall not exceed H/200.

$allowable\ drift\ is\ \frac{h}{200} = \frac{300}{200} = 1.5cm$

The maximum displacement is less than H/200, so the displacement values are acceptable.

TABLE: Joint Displacements						
Joint	OutputCase	CaseType	StepType	U1	U2	U3
Text	Text	Text	Text	cm	cm	cm
67	ENV-Allowable	Combination	Max	1.59	0.91	0.55

32	ENV-Allowable	Combination	Max	1.51	0.91	0.53
46	ENV-Allowable	Combination	Max	1.49	0.91	0.52
25	ENV-Allowable	Combination	Max	1.48	0.91	0.52
18	ENV-Allowable	Combination	Max	1.39	0.91	0.50
60	ENV-Allowable	Combination	Max	1.36	1.12	0.50
82	ENV-Allowable	Combination	Max	1.69	0.56	0.49
53	ENV-Allowable	Combination	Max	1.24	0.91	0.45
74	ENV-Allowable	Combination	Max	1.25	0.12	0.45
81	ENV-Allowable	Combination	Max	1.67	1.35	0.43
54	ENV-Allowable	Combination	Max	1.27	1.46	0.43
26	ENV-Allowable	Combination	Max	1.51	1.46	0.38
19	ENV-Allowable	Combination	Max	1.42	1.46	0.35
68	ENV-Allowable	Combination	Max	1.61	1.46	0.34
33	ENV-Allowable	Combination	Max	1.54	1.46	0.33
47	ENV-Allowable	Combination	Max	1.51	1.46	0.30
124	ENV-Allowable	Combination	Max	0.59	0.51	0.28
11	ENV-Allowable	Combination	Max	0.63	0.83	0.28
88	ENV-Allowable	Combination	Max	0.66	0.99	0.28
61	ENV-Allowable	Combination	Max	1.39	1.47	0.27
P22	ENV-Allowable	Combination	Max	1.26	0.87	0.26
4	ENV-Allowable	Combination	Max	0.55	0.83	0.26
110	ENV-Allowable	Combination	Max	0.50	0.51	0.25
96	ENV-Allowable	Combination	Max	0.49	0.51	0.25
123	ENV-Allowable	Combination	Max	0.58	0.76	0.24
P09	ENV-Allowable	Combination	Max	1.60	0.29	0.24
116	ENV-Allowable	Combination	Max	0.52	0.76	0.23
P26	ENV-Allowable	Combination	Max	1.51	0.87	0.23
P15	ENV-Allowable	Combination	Max	1.52	0.12	0.23
P13	ENV-Allowable	Combination	Max	1.50	0.19	0.23
P16	ENV-Allowable	Combination	Max	1.49	0.32	0.23
84	ENV-Allowable	Combination	Max	1.68	0.71	0.23
102	ENV-Allowable	Combination	Max	0.48	0.76	0.22

9.3 Base Plate

Current Date: 2/27/2024 1:21 PM
Units system: Metric
File name: C:\ProgramData\Bentley\Engineering\RAM Connection\13.7.0\Data\Base Plate Examples.rcnx

Steel connections

Results

Connection name : Pinned BP
Connection ID : 1

Family: Column - Base (CB)
Type: Base plate
Description: DG1 LRFD - Example 4.1
Design code: AISC 360-05 LRFD, ACI 318-08

DEMANDS

Description	Pu [T]	Mu22 [T*m]	Mu33 [T*m]	Vu2 [T]	Vu3 [T]	Load type
DC1	-25.00	0.00	0.00	5.00	3.00	Design

Design for major axis
Base plate (AISC 360-05 LRFD)

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Base plate						
Distance from anchor to edge	[cm]	5.80	0.64	--	✓	
Weld size	[1/16in]	7	3	--	✓	table J2.4

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Pedestal						
Axial bearing	[Ton/cm2]	0.17	0.01	DC1	0.04	DG1 3.1.1;
Base plate						
Flexural yielding (bearing interface)	[Ton*m/m]	3.56	1.06	DC1	0.30	DG1 Eq. 3.3.13
Flexural yielding (tension interface)	[Ton*m/m]	3.56	0.00	DC1	0.00	DG1 Eq. 3.3.13
Column						
Weld capacity	[Ton/m]	261.03	0.00	DC1	0.00	p. 8-9, Sec. J2.5, Sec. J2.4
Elastic method weld shear capacity	[Ton/m]	174.02	8.33	DC1	0.05	p. 8-9, Sec. J2.5, Sec. J2.4
Elastic method weld axial capacity	[Ton/m]	261.03	0.00	DC1	0.00	p. 8-9, Sec. J2.5, Sec. J2.4
Ratio	**0.30**					

Major axis
Anchors

GEOMETRIC CONSIDERATIONS

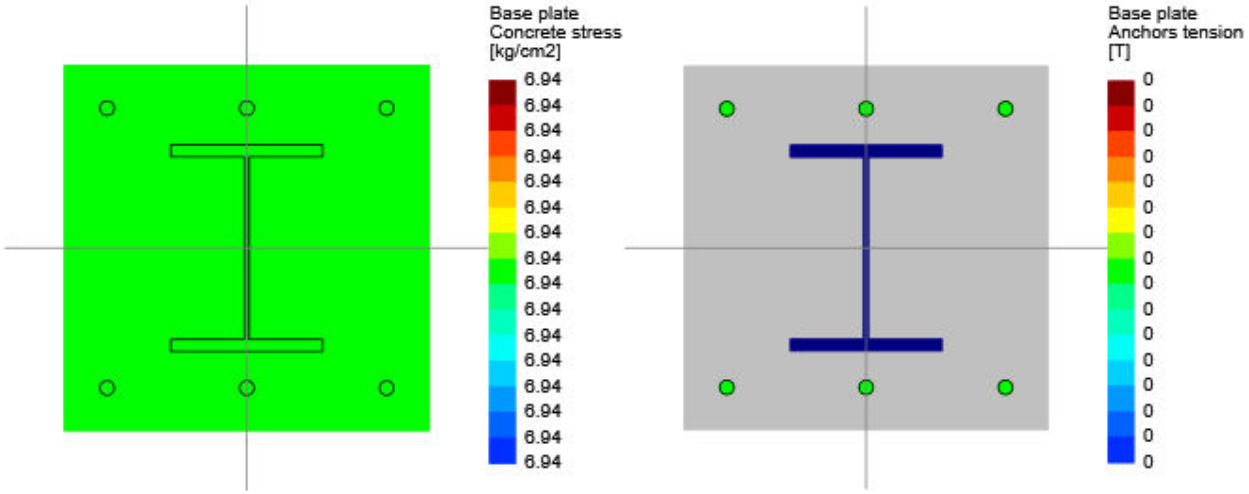
Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Anchors						

Anchor spacing	[cm]	23.00	9.60	--	✓	Sec. D.8.1
Concrete cover	[cm]	13.30	5.08	--	✓	Sec. 7.7.1
Effective length	[cm]	51.56	--	138.44	✓	

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Anchor tension	[Ton]	10.80	0.00	DC1	0.00	Eq. D-3
Breakout of anchor in tension	[Ton]	12.34	0.00	DC1	0.00	Eq. D-4, Sec. D.4.1.1
Pullout of anchor in tension	[Ton]	15.77	0.00	DC1	0.00	Sec. D.4.1.1
Side-face blowout of anchor in tension	[Ton]	9.66	0.00	DC1	0.00	Sec. D.5.4.1, Sec. D.4.1.1
Anchor shear	[Ton]	4.49	0.83	DC1	0.19	Eq. D-20, Sec. D.6.1.3
Breakout of anchor in shear	[Ton]	3.06	0.83	DC1	0.27	Sec. D.4.1.1
Breakout of group of anchors in shear	[Ton]	10.76	5.00	DC1	0.46	Sec. D.4.1.1
Pryout of anchor in shear	[Ton]	24.68	0.83	DC1	0.03	Eq. D-4, Sec. D.4.1.1
Ratio	**0.46**					
Global critical strength ratio	**0.46**					

Major axis
Maximum compression and tension (DC1)



Maximum bearing pressure	6.94	[kg/cm2]
Minimum bearing pressure	6.94	[kg/cm2]
Maximum anchor tension	0.00	[T]
Minimum anchor tension	0.00	[T]
Neutral axis angle	0.00	[deg]
Bearing length	1E32	[cm]

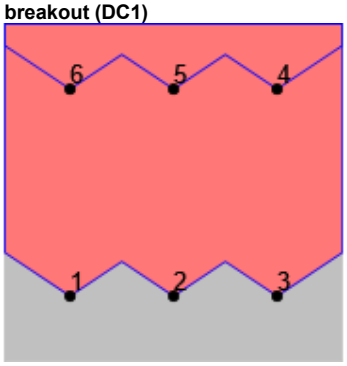
Anchors tensions

Anchor	Transverse [cm]	Longitudinal [cm]	Shear [T]	Tension [T]
1	-23.00	-23.00	0.83	0.00
2	0.00	-23.00	0.83	0.00

3	23.00	-23.00	0.83	0.00
4	23.00	23.00	0.83	0.00
5	0.00	23.00	0.83	0.00
6	-23.00	23.00	0.83	0.00

Major axis

Results for shear breakout (DC1)



Group	Area [cm2]	Shear [T]	Anchors
1	6806.25	5.00	1, 2, 3, 4, 5, 6
2	1631.25	2.50	4, 5, 6

10.0 FOUNDATION DESIGN

SAFE has been used in order to modeling, analyses and design of this foundation.

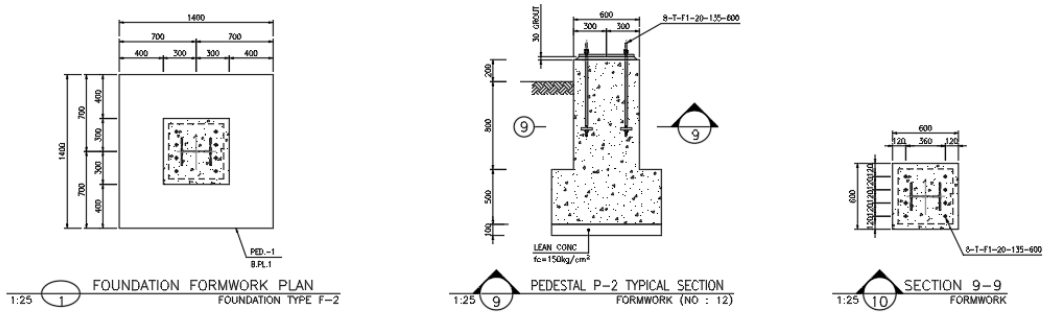


FIGURE 6. FOUNDATION PLAN

10.1 Soil pressure and settlement

Until finalize of geotechnical report for this area we consider => qa= 2kg/cm2

Based on geotechnical report for subgrade modulus is => Ks = 1.69 kg/cm3

B(m)	مدول عکس‌العمل بستر پی سطحی (kg/cm3)			
	L/B=1	L/B=2	L/B=5	L/B=10
1.0	1.69	1.33	1.14	1.09
2.0	1.00	0.85	0.78	0.77
3.0	0.78	0.69	0.65	0.64
4.0	0.68	0.60	0.57	0.57
5.0	0.61	0.55	0.53	0.53

FIGURE 7. SUBGRADE MODULUS

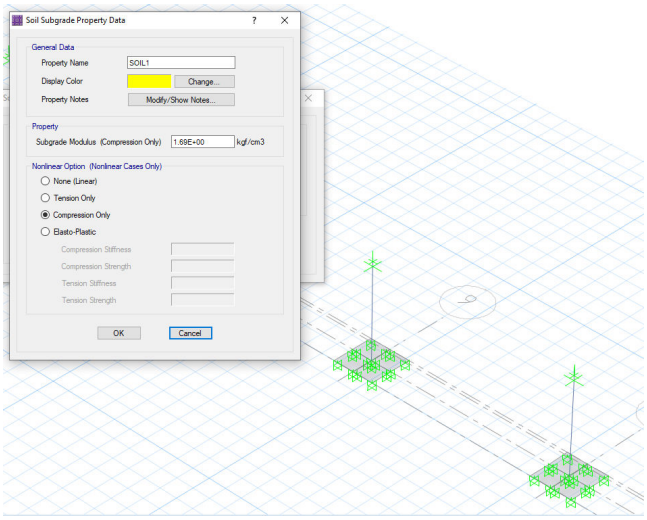


FIGURE 8. ASSIGN SPRING TO FOUNDATION

10.2 DESIGN

Concrete Foundation are designed according to ACI 318-14. Required loads are derived from SAP data, and design process will be done according to ACI code based on ultimate strength procedure.

$f'_c = 30\text{Mpa}$ $f_y = 400\text{Ma}$

Soil load applied on model as below:

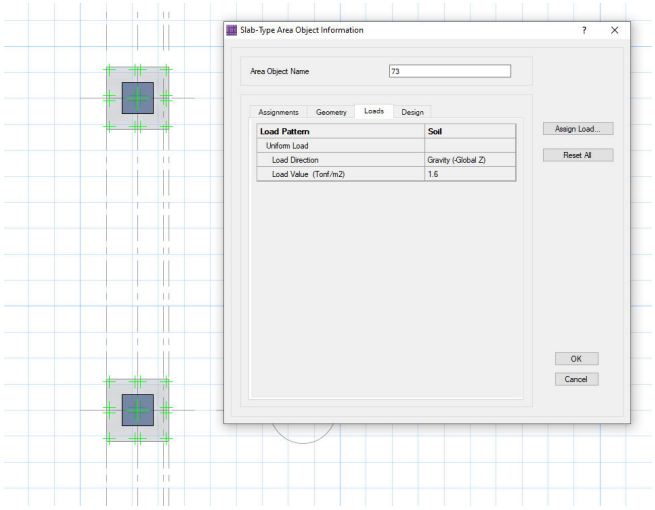


FIGURE 9. APPLIED SOIL LOAD ON FOUNDATION

Soil dead load is $\gamma h = 1.85 * 0.6 = 1.11 \frac{ton}{m2} = 1110 \frac{kg}{m2}$

10.3 FOUNDATION DESIGN CONTROL

12.3.1 CHECK OF STRESS FOR FOUNDATION

TABLE: Nodal Displacements					
Point	OutputCase	CaseType	Ux	Uy	Uz
71	COMB11	Combination	0	0	-0.12303
239	COMB11	Combination	0	0	-0.12303
71	ENV	Combination	0	0	-0.12303
239	ENV	Combination	0	0	-0.12303
119	COMB11	Combination	0	0	-0.1227
119	ENV	Combination	0	0	-0.1227
118	COMB11	Combination	0	0	-0.12267
123	COMB11	Combination	0	0	-0.12267
118	ENV	Combination	0	0	-0.12267
123	ENV	Combination	0	0	-0.12267
117	COMB11	Combination	0	0	-0.12264
117	ENV	Combination	0	0	-0.12264
121	COMB11	Combination	0	0	-0.12264
124	COMB11	Combination	0	0	-0.12264
121	ENV	Combination	0	0	-0.12264
124	ENV	Combination	0	0	-0.12264
116	COMB11	Combination	0	0	-0.12258
122	COMB11	Combination	0	0	-0.12258

TABLE: Nodal Displacements					
Point	OutputCase	CaseType	Ux	Uy	Uz
116	ENV	Combination	0	0	-0.12258
122	ENV	Combination	0	0	-0.12258
22	COMB11	Combination	0	0	-0.11921
232	COMB11	Combination	0	0	-0.11921
22	ENV	Combination	0	0	-0.11921
232	ENV	Combination	0	0	-0.11921
51	COMB11	Combination	0	0	-0.1189
51	ENV	Combination	0	0	-0.1189
52	COMB11	Combination	0	0	-0.11886
56	COMB11	Combination	0	0	-0.11886
52	ENV	Combination	0	0	-0.11886
56	ENV	Combination	0	0	-0.11886
49	COMB11	Combination	0	0	-0.11884
55	COMB11	Combination	0	0	-0.11884
49	ENV	Combination	0	0	-0.11884
55	ENV	Combination	0	0	-0.11884
				MAX	-0.12303

According to above output, Max soil pressure under the foundation is:

$$q_n = 0.123 \times 1.69 = 0.200\ \text{kg/cm}^2 \ < \ 2\ \ \text{kg/cm}^2 \ \ \text{ok}$$

12.3.3 REINFORCING CONTROL

Minimum rebar for foundation:

$$A_{s\,min} = 0.0018bh$$

$$A_{smin} = \frac{1}{2}0.0018\ bh = \frac{1}{2}0.0018 \times 100 \times 50 = 4.5 \quad \text{cm}^2/\text{m}$$

$$A_{s\,used} = \text{Ø}16@200 = 10.05\text{cm}^2$$

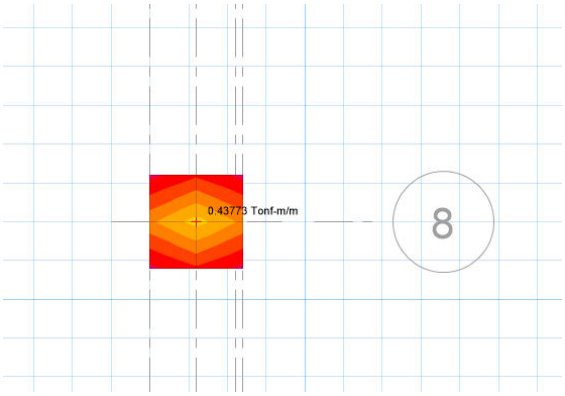


FIGURE 10. M22 RESULT