|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **طرح نگهداشت و افزایش تولید 27 مخزن** | | | | | | | |
| **CALCULATION NOTE FOR CHEMICAL INJECTION AND STORAGE SHELTER**  **نگهداشت و افزایش تولید میدان نفتی بینک** | | | | | | | |
|  | |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |
| D01 | | JUN. 2023 | IFC | R.Berlouie | M.Fakharian | A.M.Mohseni |  |
| D00 | | AUG. 2022 | IFC | R.Berlouie | M.Fakharian | M.Mehrshad |  |
| **Rev.** | | **Date** | **Purpose of Issue/Status** | **Prepared by:** | **Checked by:** | **Approved by:** | **CLIENT Approval** |
| **Class:2** | | | **COMPANY Doc. Number:F0Z-709141** | | | | |
| **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**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PAGE** | **D00** | **D01** | **D02** | **D03** | **D04** |  | **PAGE** | **D00** | **D01** | **D02** | **D03** | **D04** |
| **1** | X | X |  |  |  | **66** |  |  |  |  |  |
| **2** | X | X |  |  |  | **67** |  |  |  |  |  |
| **3** | X | X |  |  |  | **68** |  |  |  |  |  |
| **4** | X | X |  |  |  | **69** |  |  |  |  |  |
| **5** | X | X |  |  |  | **70** |  |  |  |  |  |
| **6** | X | X |  |  |  | **71** |  |  |  |  |  |
| **7** | X | X |  |  |  | **72** |  |  |  |  |  |
| **8** | X | X |  |  |  | **73** |  |  |  |  |  |
| **9** | X | X |  |  |  | **74** |  |  |  |  |  |
| **10** | X | X |  |  |  | **75** |  |  |  |  |  |
| **11** | X | X |  |  |  | **76** |  |  |  |  |  |
| **12** | X | X |  |  |  | **77** |  |  |  |  |  |
| **13** | X | X |  |  |  | **78** |  |  |  |  |  |
| **14** | X | X |  |  |  | **79** |  |  |  |  |  |
| **15** | X | X |  |  |  | **80** |  |  |  |  |  |
| **16** | X | X |  |  |  | **81** |  |  |  |  |  |
| **17** | X | X |  |  |  | **82** |  |  |  |  |  |
| **18** | X | X |  |  |  | **83** |  |  |  |  |  |
| **19** | X | X |  |  |  | **84** |  |  |  |  |  |
| **20** | X | X |  |  |  | **85** |  |  |  |  |  |
| **21** | X | X |  |  |  | **86** |  |  |  |  |  |
| **22** | X | X |  |  |  | **87** |  |  |  |  |  |
| **23** | X | X |  |  |  | **88** |  |  |  |  |  |
| **24** | X | X |  |  |  | **89** |  |  |  |  |  |
| **25** | X | X |  |  |  | **90** |  |  |  |  |  |
| **26** | X | X |  |  |  | **91** |  |  |  |  |  |
| **27** | X | X |  |  |  | **92** |  |  |  |  |  |
| **28** | X | X |  |  |  | **93** |  |  |  |  |  |
| **29** | X | X |  |  |  | **94** |  |  |  |  |  |
| **30** | X | X |  |  |  | **95** |  |  |  |  |  |
| **31** | X | X |  |  |  | **96** |  |  |  |  |  |
| **32** | X | X |  |  |  | **97** |  |  |  |  |  |
| **33** | X | X |  |  |  | **98** |  |  |  |  |  |
| **34** | X | X |  |  |  | **99** |  |  |  |  |  |
| **35** | X | X |  |  |  | **100** |  |  |  |  |  |
| **36** | X | X |  |  |  | **101** |  |  |  |  |  |
| **37** | X | X |  |  |  | **102** |  |  |  |  |  |
| **38** | X | X |  |  |  | **103** |  |  |  |  |  |
| **39** | X | X |  |  |  | **104** |  |  |  |  |  |
| **40** |  | X |  |  |  | **105** |  |  |  |  |  |
| **41** |  | X |  |  |  | **106** |  |  |  |  |  |
| **42** |  | X |  |  |  | **107** |  |  |  |  |  |
| **43** |  | X |  |  |  | **108** |  |  |  |  |  |
| **44** |  | X |  |  |  | **109** |  |  |  |  |  |
| **45** |  | X |  |  |  | **110** |  |  |  |  |  |
| **46** |  | X |  |  |  | **111** |  |  |  |  |  |
| **47** |  |  |  |  |  | **112** |  |  |  |  |  |
| **48** |  |  |  |  |  | **113** |  |  |  |  |  |
| **49** |  |  |  |  |  | **114** |  |  |  |  |  |
| **50** |  |  |  |  |  | **115** |  |  |  |  |  |
| **51** |  |  |  |  |  | **116** |  |  |  |  |  |
| **52** |  |  |  |  |  | **117** |  |  |  |  |  |
| **53** |  |  |  |  |  | **118** |  |  |  |  |  |
| **54** |  |  |  |  |  | **119** |  |  |  |  |  |
| **55** |  |  |  |  |  | **120** |  |  |  |  |  |
| **56** |  |  |  |  |  | **121** |  |  |  |  |  |
| **57** |  |  |  |  |  | **122** |  |  |  |  |  |
| **58** |  |  |  |  |  | **123** |  |  |  |  |  |
| **59** |  |  |  |  |  | **124** |  |  |  |  |  |
| **60** |  |  |  |  |  | **125** |  |  |  |  |  |
| **61** |  |  |  |  |  | **126** |  |  |  |  |  |
| **62** |  |  |  |  |  | **127** |  |  |  |  |  |
| **63** |  |  |  |  |  | **128** |  |  |  |  |  |
| **64** |  |  |  |  |  | **129** |  |  |  |  |  |
| **65** |  |  |  |  |  | **130** |  |  |  |  |  |

**CONTENTS**

[1.0 INTRODUCTION 5](#_Toc137036503)

[2.0 Scope 5](#_Toc137036504)

[3.0 NORMATIVE REFERENCE 5](#_Toc137036505)

[**3.1** **Local Codes and Standards** 5](#_Toc137036506)

[**3.2** **International Codes and Standards** 5](#_Toc137036507)

[**3.3** **The Project Documents** 5](#_Toc137036508)

[4.0 Material properties 6](#_Toc137036511)

[5.0 STRUCTURE ‘s systems 6](#_Toc137036512)

[6.0 DESIGN LOAD 6](#_Toc137036513)

[**6.1** **Dead load** 6](#_Toc137036514)

[**6.2** Live Loads 7](#_Toc137036515)

[**6.3** SNOW LOADS 8](#_Toc137036516)

[**6.4** **-Unbalanced SNOW LOADS** 9](#_Toc137036517)

[**6.5** **Seismic loads** 10](#_Toc137036520)

[**6.6** **CRANE load** 12](#_Toc137036521)

[**6.7** **WIND loads** 13](#_Toc137036522)

[**6.8** Thermal Load of structure (TLst) 16](#_Toc137036523)

[7.0 SAP loading table 16](#_Toc137036524)

[8.0 Load combinations 18](#_Toc137036525)

[9.0 STRUCTURE ANALYSIS AND DESIGN 19](#_Toc137036526)

[**9.1** **ANALYSIS** 19](#_Toc137036527)

[**9.2** **Flextural design of crane beam** 20](#_Toc137036528)

[**9.3** **Deflection control :** 21](#_Toc137036529)

[**9.4** **Drift control :** 22](#_Toc137036530)

[10.0 Structural Design Results 23](#_Toc137036531)

[**10.1** **Graphical output** 23](#_Toc137036532)

[11.0 STRUCTURE CONNECTIONS 23](#_Toc137036534)

[**11.1** **Intermediate moment frame** 23](#_Toc137036535)

[**11.2** **Description of Design Procedure & Parameters** 25](#_Toc137036537)

[**11.3** **Connection Force Calculation :** 27](#_Toc137036538)

[**11.4** **Beam Specification:** 27](#_Toc137036539)

[**11.5** **End plate thickness calculation :** 28](#_Toc137036540)

[**11.6** **End Plate Specification :** 28](#_Toc137036541)

[**11.7** **Determine Multiplier force of the flange :** 28](#_Toc137036542)

[**11.8** **Shear yield control of the end plate :** 28](#_Toc137036543)

[**11.9** **Shear rupture control of end plate** 29](#_Toc137036544)

[**11.10** **Control of shear rupture resistance of screws:** 29](#_Toc137036545)

[**11.11** **Continuty plate requirement** : 29](#_Toc137036546)

[**11.12** **local column web yielding control** : 29](#_Toc137036547)

[**11.13** **PURLIN DESIGN** 30](#_Toc137036548)

[11.13.1. Property of Purlin(Z180x2.5) 30](#_Toc137036549)

[11.13.2.Un deformed shape CONTROL: 31](#_Toc137036550)

[**11.14** Roof bracing Design 31](#_Toc137036551)

[**11.15** **Base Plate** 33](#_Toc137036552)

[**11.16** **General requirements of embedment in concrete**: 35](#_Toc137036607)

[12.0 FOUNDATION DESIGN 38](#_Toc137036632)

[**12.1** **Soil pressure and settlement** 38](#_Toc137036636)

[**12.2** **DESIGN** 39](#_Toc137036637)

[**12.3** **FOUNDATION DESIGN CONTROL** 40](#_Toc137036638)

[12.3.1Check of Stress for Foundation 40](#_Toc137036639)

[12.3.2. Check of Displacement for Foundation 44](#_Toc137036640)

[12.3.3 REINFORCING CONTROL 44](#_Toc137036641)

1. **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.

1. **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.

1. **NORMATIVE REFERENCE**
   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)
  1. **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.
  1. **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

1. **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 |

1. **STRUCTURE ‘s systems**

The Structure’s System is OMF in X direction and OCBF system in Y direction .Seismic Parameters according to Iranian Code of practice Fr Seismic resistant Design Of building StandardNo.2800 (4th edition)listed at below table.

table 2 –structural system

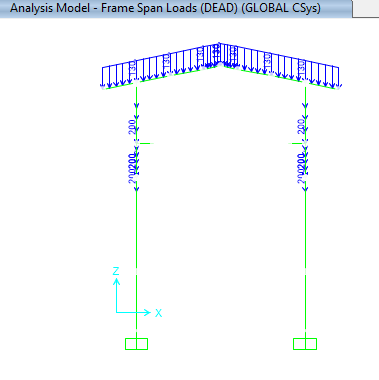
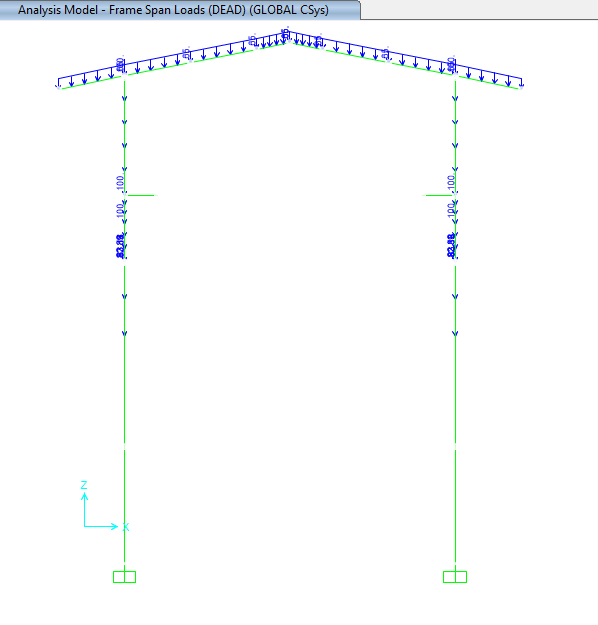
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | system | R | Omega | Cd |
| x dir | imf | 5 | 3 | 4 |
| y dir | ocbf | 3.5 | 2 | 3.5 |

1. **DESIGN LOAD**
   1. **Dead load**

Dead loads include the self-weight of the structure and all the permanent equipment which are supported by the structures

Roof weight is assigned in software 26 kg/m2.

* At ended frame :
* At middle frame :



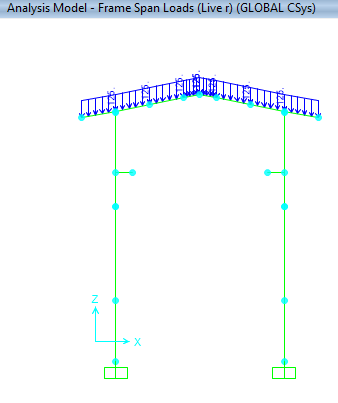
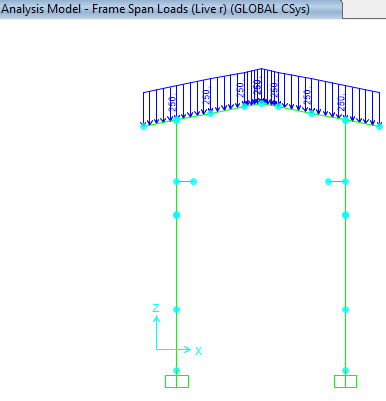
**Figure 1-applied Dead load on ended axe(1&3) (kg/m) Figure 2-applied Dead load on middle axe 2(kg/m)**

* 1. Live Loads

The design live load on an area shall be defined as the weight of all movable loads, including personnel, tools, and parts of dismantled equipment, cranes, hoist, and temporarily stored materials.

According to Iranian National Building code No.6 Live load in light slop roof is 50kg/m2 and assumed 1.3KN concentrated load has been applied at critical frame.

* At ended frame :
* At middle frame :



**Figure 3-Applied live Load on frame 2 (kg/m) Figure 4-Applied live Load on frame 1&3 (kg/m)**

* 1. **SNOW LOADS**

Snow load of this structure is calculated in accordance with Iranian National Building Code No.6 Latest edition.. Parameters which are used in calculation of snow force is presented in below:

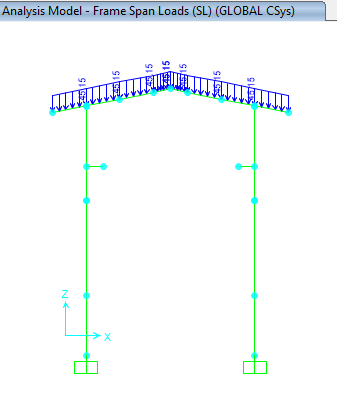
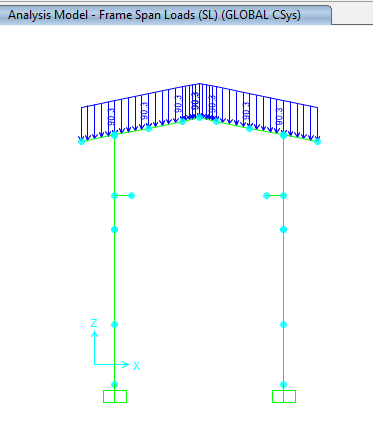
Ps=25 kg/m2 , Is=1

Cs= 0.91 (slope 11.31o)=1-

Ch=1

Cn=0.8

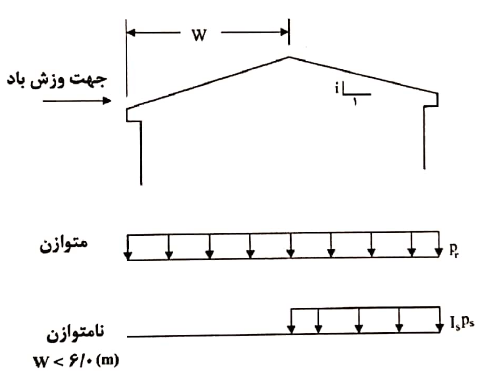
* At ended frame :
* At middle frame :

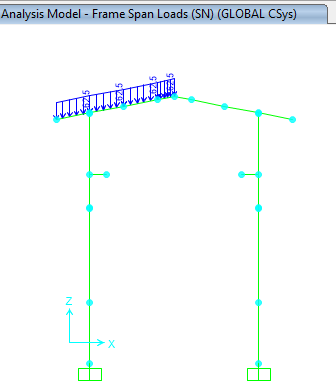
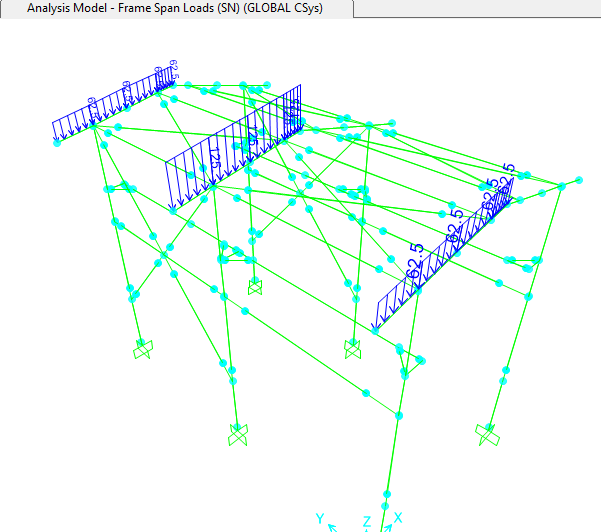
** **

**Figure 5-applied Snow load on ended axe(1&3) (kg/m) Figure 6-applied Snow load on middle axe 2(kg/m)**

* 1. **-Unbalanced SNOW LOADS**

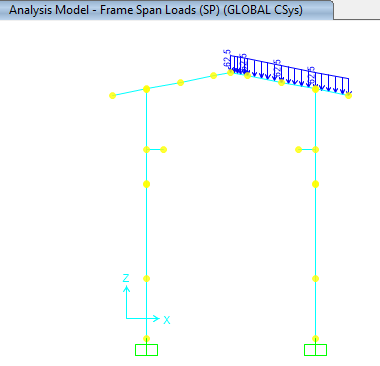
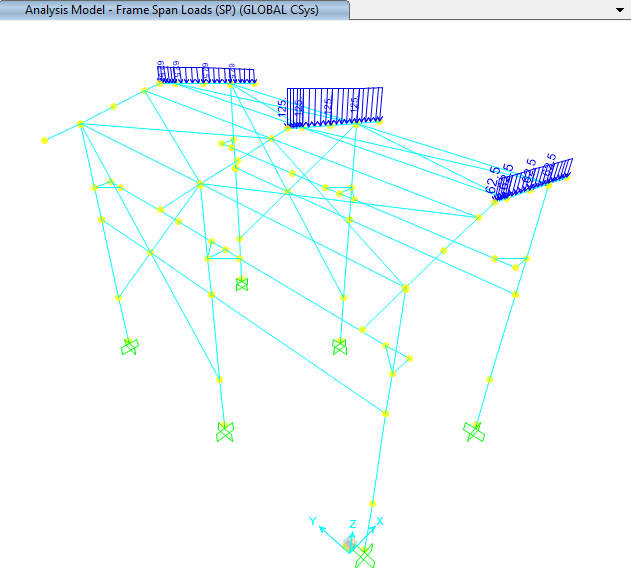
According to Iranian National Building Code No.6 (latest edition)) Unbalanced snow load have been considered for roof slope between 4%~60%..in this structure Calculation of this load represents as below:

****

` 

**Figure 7-applied unbalancexd Snow Load(SN)**

* At ended frame :
* At emiddle frame :

**Figure 8-applied unbalancexd Snow Load(SP)**

* 1. **Seismic loads**

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.

Seismic loads are calculated according to Iranian Code Of Practice for seismic resistant design Of building Standard No.2800(4 th edition)

For IMF system (X direction)

Rux=5

Omega=3

Cd=4

For OCBF system (Y direction)

Ruy=3.5

Omega=2

Cd=3.5

Soil Type : Type II

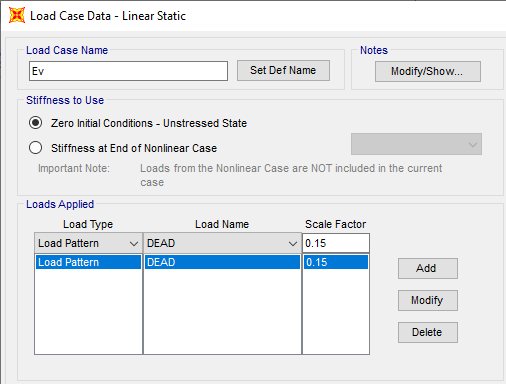
* **For X direction**

Soil type =II so T0=0.1 Ts=0.5 S=1.5 S0=1

N=1 B=B1N=(S+1)N=2.5

* **For Y direction:**

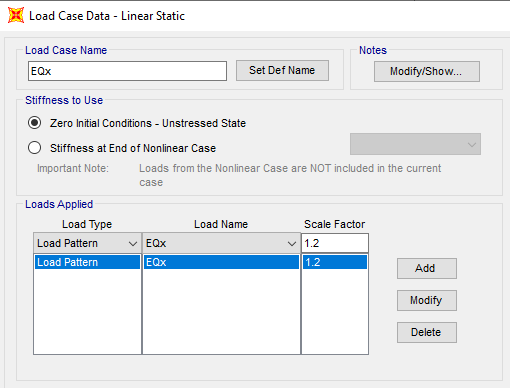
-Ev : Vertical seismic load applied at model:



**Figure 9-applied Ev load**

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

has been applied on earthquake load case cause of



**Figure 10 -applied coefficient**

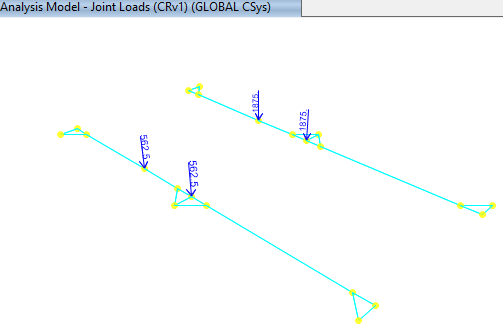
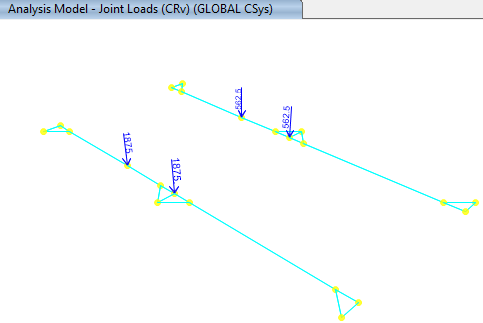
* 1. **CRANE load**

Distribution of crane load is as below :

Capacity : 2000 kg

At critical condition maximum force is 1500 and 450kg on each wheel of crane.

Kvs =1.25 (according to INBC no.6)

Mentioned load applied in two case (assumed critical condition on left & right side) 

**Figure11 -applied CRv & CRv1 load**

* 1. **WIND loads**

Wind loads are calculated according to Code No.6 and applied at model as below:

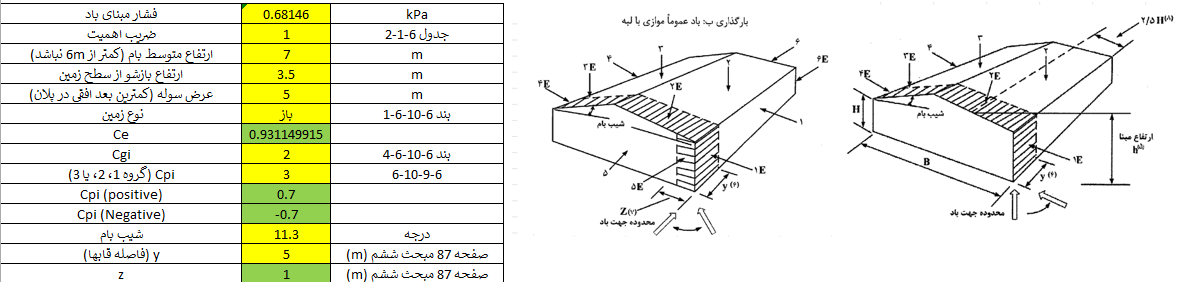
V=120 km/h(According to Iranian National Building Code No.6 last edition)

Mean

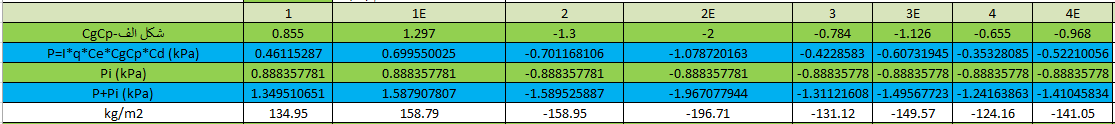
=0.93

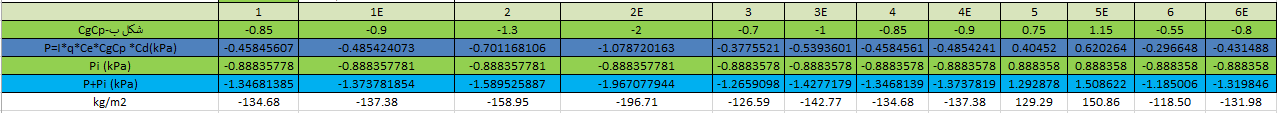
Cgi=2

Roof slope=11.3 degree

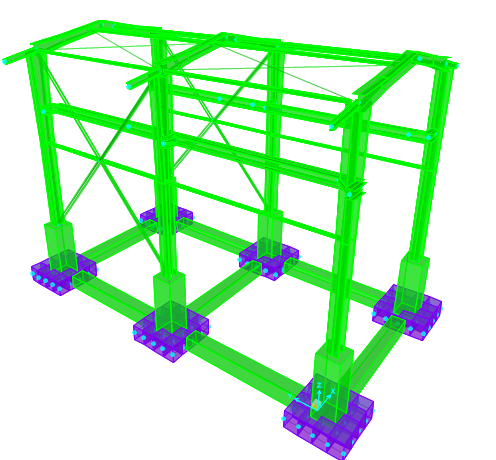
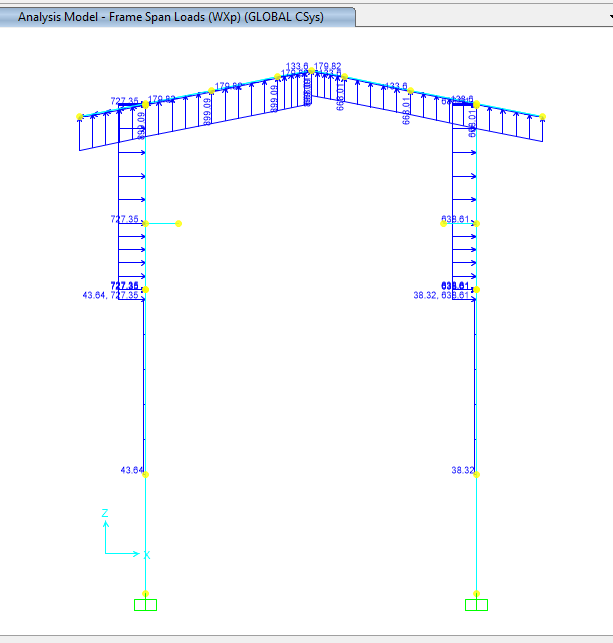


**Figure 12-Wind Load Direction**

****

****

* Element numbering for apply wind load is as below:

****

B4

B3

B6

B5

B2

B1

B4

B3

C6

C5

C2

C1

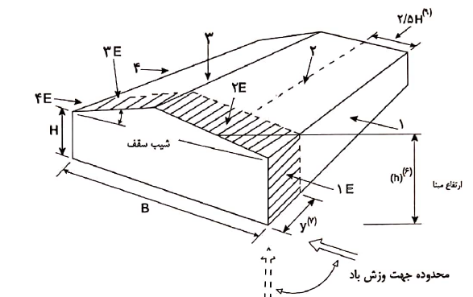
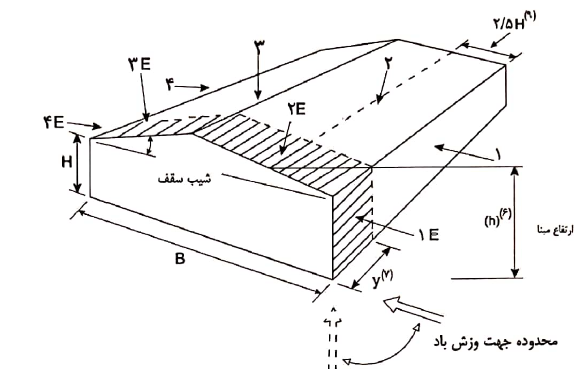
C4

C3

C5

C2

**Figure 13-Wind Load apply(Wxp)**

****

C2:

C5:

B3:

B4:

* 1. **Thermal Load of structure (TLst)**

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 of shelter.

1. **SAP loading table**

* **Load pattern:**

|  |  |  |  |
| --- | --- | --- | --- |
| **LoadPat** | **DesignType** | **SelfWtMult** | **AutoLoad** |
|  |  |  |  |
| DEAD | Dead | 1 |  |
| Live r | Roof Live | 0 |  |
| EQx | Quake | 0 | USER COEFF |
| EQy | Quake | 0 | USER COEFF |
| WXp | Wind | 0 | None |
| WYp | Wind | 0 | None |
| SL | Snow | 0 |  |
| Live | Live | 0 |  |
| TL | Temperature | 0 |  |
| WXn | Wind | 0 | None |
| WYn | Wind | 0 | None |
| SP | Snow | 0 |  |
| SN | Snow | 0 |  |
| WXp1 | Wind | 0 | None |
| WYp1 | Wind | 0 | None |
| WYn1 | Wind | 0 | None |
| WXn1 | Wind | 0 | None |
| CRv | Live | 0 |  |
| FT | Live | 0 |  |
| FL | Live | 0 |  |
| CRv1 | Live | 0 |  |
| FT1 | Live | 0 |  |
| FL1 | Live | 0 |  |
| Ev | Dead | 0 |  |
| TLst | Temperature | 0 |  |
| DL empty | Dead | 0 |  |
| LLop | Live | 0 |  |
| FRx | Other | 0 |  |
| FRy | Other | 0 |  |
| ML | Other | 0 |  |
| Test | Dead | 0 |  |
| ER | Other | 0 |  |
| Soil | Dead | 0 |  |
| Notionalx(DL) | Notional | 0 |  |
| Notionaly(DL) | Notional | 0 |  |
| Notionalx(LL) | Notional | 0 |  |
| Notionaly(LL) | Notional | 0 |  |
| Notionalx(Lr) | Notional | 0 |  |
| Notionaly(Lr) | Notional | 0 |  |
| Notionalx(Lop) | Notional | 0 |  |
| Notionaly(Lop) | Notional | 0 |  |
| Notionalx(Test) | Notional | 0 |  |
| Notionaly(Test) | Notional | 0 |  |
| Notionalx(DLempty) | Notional | 0 |  |
| Notionaly(DLempty) | Notional | 0 |  |
| Notionalx(CR) | Notional | 0 |  |
| Notionaly(CR) | Notional | 0 |  |
| Notionalx(CR1) | Notional | 0 |  |
| Notionaly(CR1) | Notional | 0 |  |



1. **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:

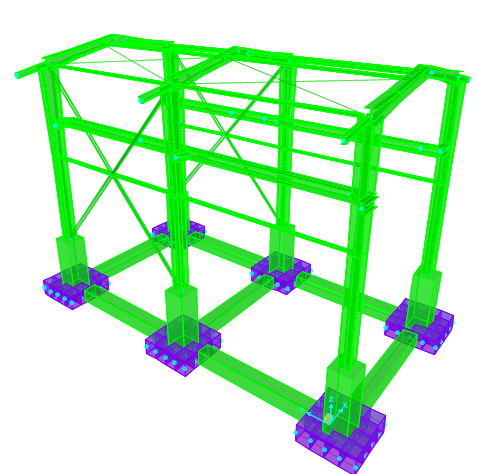
* 1.4(D)
* (1.2D) +1.6(L)+0.5(Lr/S/R)
* 1.2D+1.6(Lr/S/R) + (L/0.5W)
* 1.2D+1.0(W) + L+.5(Lr/S)
* 1.2D+1.0E+L+0.2S
* 0.9D+1.0W
* 0.9D+1.0E

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*

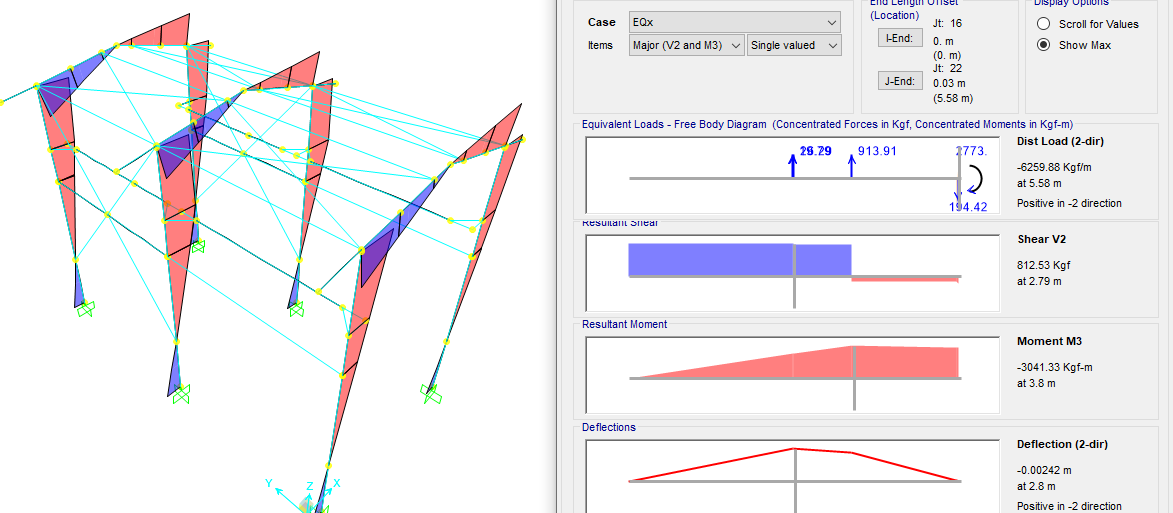
1. **STRUCTURE ANALYSIS AND DESIGN** 
   1. **ANALYSIS**

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

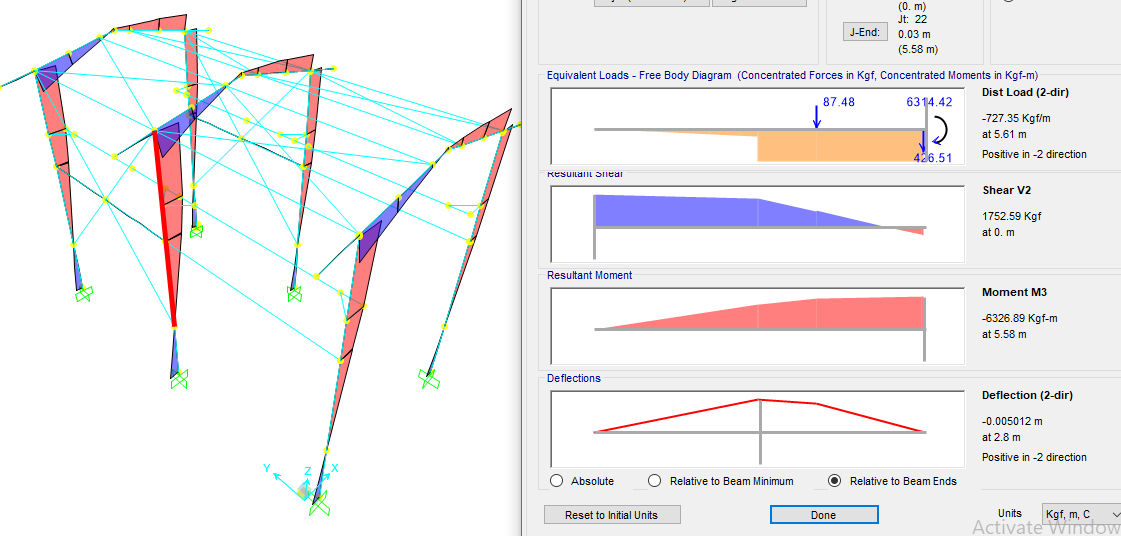


**Figure 14-3D view of SAP model**

:



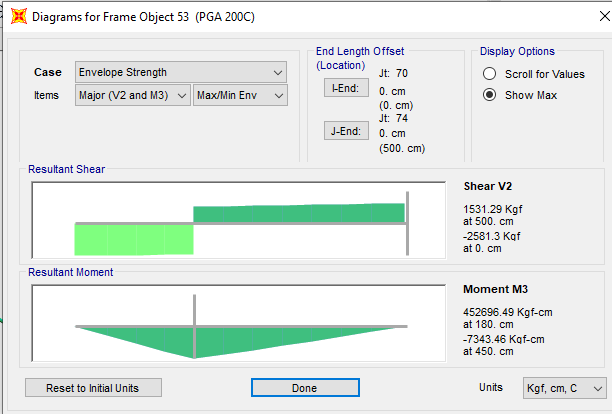
**Figure 15:** **Moment 3-3 under Ex load**



**Figure 16: Moment 3-3 Wx load**

* 1. **Flextural design of crane beam**

According to below output from sap software maximum crane beam moment under critical load combination is 452696.49 kg.cm :



**Figure 17: Moment 3-3 criticalload combination on crane beam**

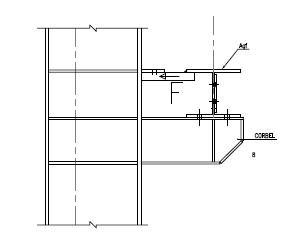
* 1. **Deflection control :**

Maximum beam deflection under crane live load is :

cm< 0.83 ok

* 1. **BEAM LATERAL RESTRAINT**

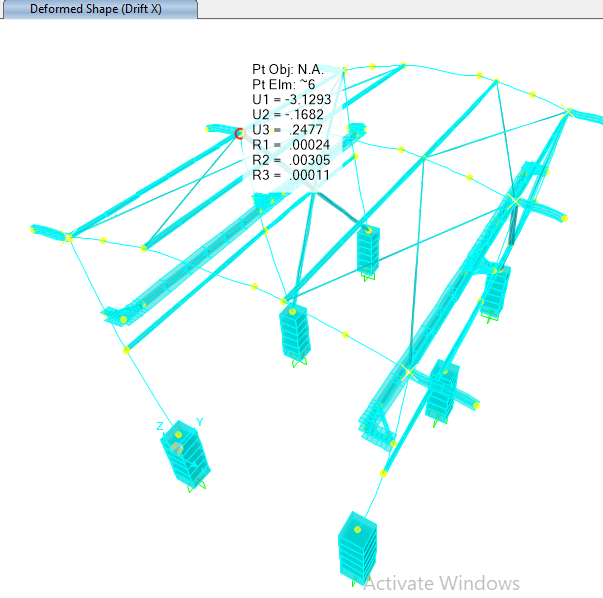
Beam lateral restraint should be designed for 0.02 of compressive flange capacity.



>593.08 kg OK

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TABLE: Element Forces - Frames** | | | | | |
| **Frame** | **Station** | **OutputCase** | **CaseType** | **StepType** | **P** |
| Text | m | Text | Text | Text | Kgf |
| 42 | 0 | Envelope Strength | Combination | Max | 593.08 |
| 42 | 0.5 | Envelope Strength | Combination | Max | 593.03 |
| 42 | 0 | Envelope Strength | Combination | Min | -366.38 |
| 42 | 0.5 | Envelope Strength | Combination | Min | -366.41 |
|  |  |  |  | Max= | 593.08 |

* 1. **Drift control :**



**Figure 18: Deformed shape**

Maximum displacement according to above output from sap model under critical service load combination is about 1.62 cm which is less than allowable drift.

According to “Civil & Structural Design Criteria”, horizontal displacements shall not exceed H/180.

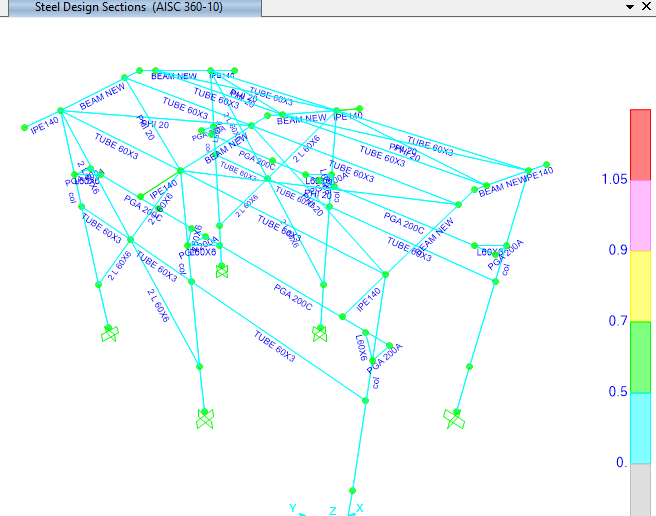
The maximum displacement is less than H/180, so the displacement values are acceptable.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **TABLE: Joint Displacements** | | | | | | |
| **Joint** | **OutputCase** | **CaseType** | **StepType** | **U1** | **allowable** | **result** |
| Text | Text | Text | Text | cm | h/180/0.8 |
| 19 | Drift X | Combination | Max | 2.849996 | 3.472 | ok |
| 19 | Drift X | Combination | Min | -3.004034 | 3.472 | ok |
| 20 | Drift X | Combination | Max | 3.02176 | 3.472 | ok |
| 20 | Drift X | Combination | Min | -2.846681 | 3.472 | ok |
| 22 | Drift X | Combination | Max | 2.974414 | 3.472 | ok |
| 22 | Drift X | Combination | Min | -3.135648 | 3.472 | ok |
| 24 | Drift X | Combination | Max | 3.152657 | 3.472 | ok |
| 24 | Drift X | Combination | Min | -2.969713 | 3.472 | ok |
| 26 | Drift X | Combination | Max | 2.868718 | 3.472 | ok |
| 26 | Drift X | Combination | Min | -3.02249 | 3.472 | ok |
| 28 | Drift X | Combination | Max | 3.037753 | 3.472 | ok |
| 28 | Drift X | Combination | Min | -2.862644 | 3.472 | ok |

1. **Structural Design Results**

All members designed by SAP2000, and code requirements have been checked accordingly. The following figures show the members ratios which are obtained from SAP2000 model analysis and design. All the acceptable ratios for beams & columns have been considered less than 1.0.

* 1. **Graphical output**

****

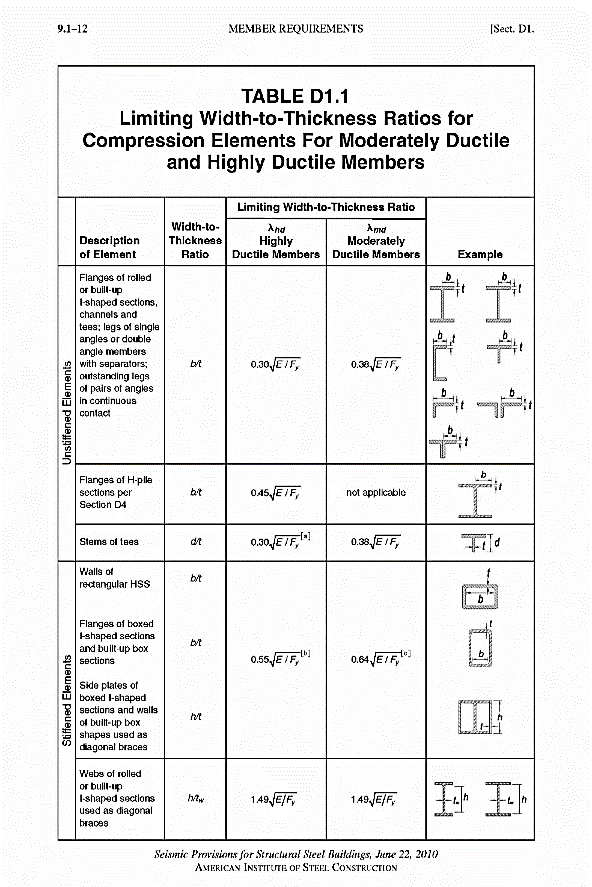
**Figure 19: Steel Design Output**

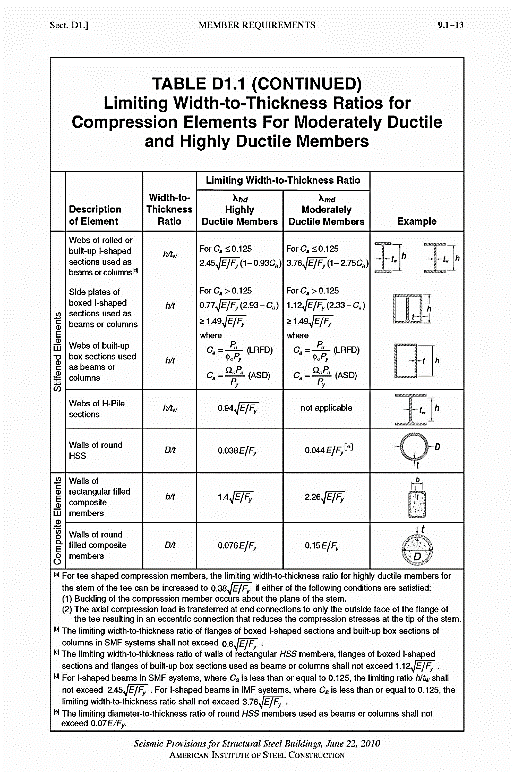
1. **STRUCTURE CONNECTIONS**
   1. **Intermediate moment frame**

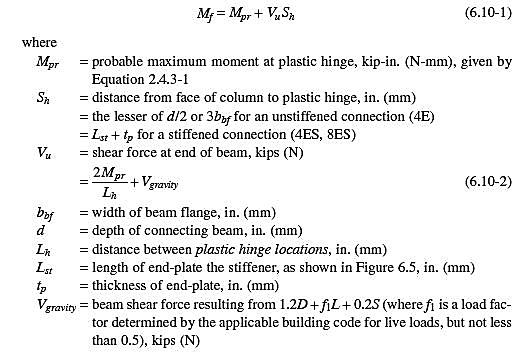
### -Beam to column

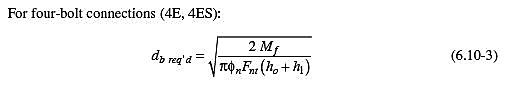
According to AISC 358-10 chapter 6, connection types 4ES and 8ES shall be used. Prequalified Special moment frame connections have been determined according to AISC 341- 10, Part 1, Section 10; AISC 358-10, Chapter 6 & AISC Design Guides 4, 13. Introductory figures & tables are attached. (Design procedure is mainly based on AISC 358 – 10 section 6.10)

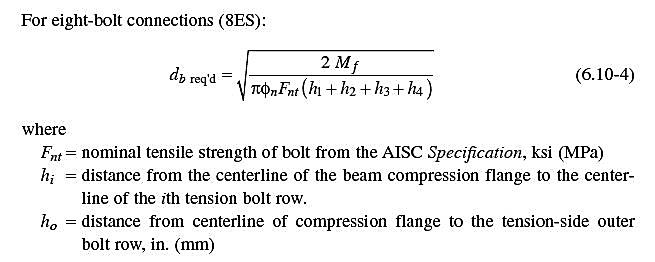
High pretension bolts, used are equivalent to HV8.8 with ultimate strength of Fu=8,000 kg/cm2. The units used in the above mentioned codes & based calculation are kg-cm.

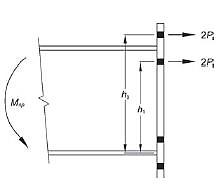












**Figure 20**: **4ES (four Extended Stiffened)**

* 1. **Description of Design Procedure & Parameters**

Compact sections shall be selected according to AISC 360-10.

bf, tf, hw and tw are sizes of girder.

Ry is the ratio of expected to specified structural steel yield strength.

probable maximum moment at plastic hinge (according to AISC358- 10).

distance from the face of column to plastic hinge (according to AISC358- 10).

Length of the end-plate stiffener.

end-plate thickness.

distance between plastic hinges.

moment at the face of te column (according to AISC358- 10).

Shear force at the end of the beam (according to AISC358- 10).

since amplified moment is allowed to be used for Special frame connections. It is extracted from the load combination using ().

bolt ultimate strength (HV8.8).

nominal tensile strength of bolt.

non-ductile resistance factor (according to AISC358-10).

distance from the centerline of the beam compression flange to the centerline of ith tension bolt row.

required bolt dimension (according to AISC358-10)

selected bolt diameter

phi Rn 4S = bolt shear rupture strength of the connection (according to AISC358-10)

bolt stress according to flexural < phi Fnt.

phi Rn yield = local column web yielding strength at beam flanges (according to AISC358-10).

phi Rn buck. = unstiffened column web buckling strength at beam compression flange (according to AISC358-10).

phi Rn cripp. = unstiffened column web crippling strength at beam compression flange (according to AISC358-10).

overall depth of column.

column web thickness including doubler plates with plug weld.

Astiff = calculated required continuity plates area.

thickness of end-plate calculated according to plate theories formulas regarding plate boundary conditions. (it submits exactly the same amount using AISC 358 formulas).

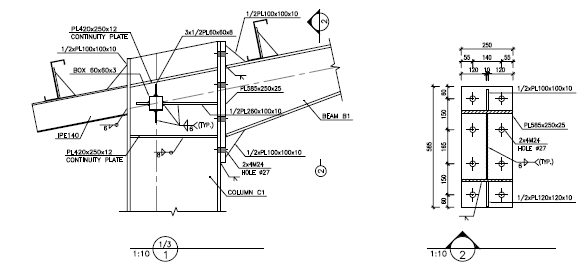


Figure 21: BEAM TO COLUMN CONNECTION

* 1. **Connection Force Calculation :**
  2. **Beam Specification:**
  3. **End plate thickness calculation :**

Mu=42 ton.m

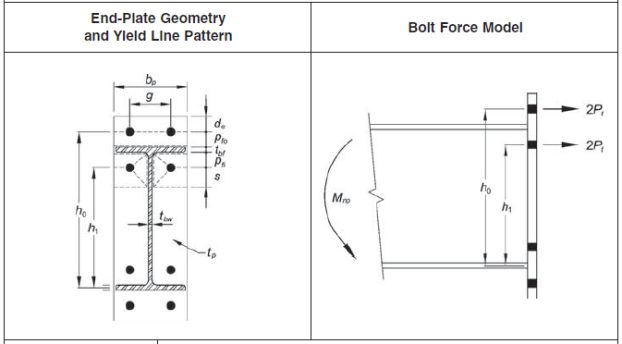
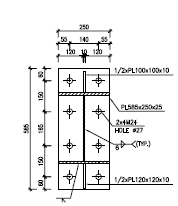
9.35 cm

[

We Used Plate 25

* 1. **End Plate Specification :**

|  |  |
| --- | --- |
| bp(cm) | 25 |
| tp(cm) | 2.5 |
| g(cm) | 14 |
| s | 9.35 |
| pfi | 6 |
| pfo | 6 |



* 1. **Determine Multiplier force of the flange :**
  2. **Shear yield control of the end plate :**
  3. **Shear rupture control of end plate**
  4. **Control of shear rupture resistance of screws:**
  5. **Continuty plate requirement** :

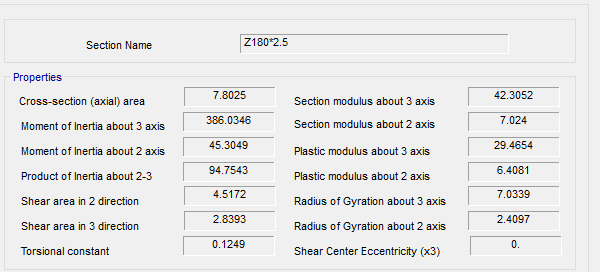
Column flange design force:

* 1. **local column web yielding control** :

Continuty plate is needed. According to above calculation Ffu>

* 1. **PURLIN DESIGN**

## 11.13.1. Property of Purlin(Z180x2.5)



**Figure 22-Section Property Of Purlin**

According to above table :

FOR Z 180 :

### 11.13.2.Un deformed shape CONTROL:

* 1. **Roof bracing Design**

According to INBC No.10 section 10-2-3-4 for tensile member :

Roof brace =

According to sap model maximum tensile force is 773 kg & it’s OK.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TABLE: Element Forces - Frames** | | | | |
| **Frame** | **Station** | **OutputCase** | **StepType** | **P** |
| Text | m | Text | Text | Kgf |
| 43 | 0 | Envelope Strength | Max | 686.66 |
| 43 | 2.7 | Envelope Strength | Max | 686.23 |
| 43 | 5.4 | Envelope Strength | Max | 685.8 |
| 43 | 0 | Envelope Strength | Min | -549.84 |
| 43 | 2.7 | Envelope Strength | Min | -550.27 |
| 43 | 5.4 | Envelope Strength | Min | -550.7 |
| 44 | 0 | Envelope Strength | Max | 538.46 |
| 44 | 2.7 | Envelope Strength | Max | 538.91 |
| 44 | 5.4 | Envelope Strength | Max | 539.36 |
| 44 | 0 | Envelope Strength | Min | -636.9 |
| 44 | 2.7 | Envelope Strength | Min | -636.45 |
| 44 | 5.4 | Envelope Strength | Min | -636 |
| 47 | 0 | Envelope Strength | Max | 585.28 |
| 47 | 2.7 | Envelope Strength | Max | 585.7 |
| 47 | 5.4 | Envelope Strength | Max | 586.13 |
| 47 | 0 | Envelope Strength | Min | -423.5 |
| 47 | 2.7 | Envelope Strength | Min | -423.07 |
| 47 | 5.4 | Envelope Strength | Min | -422.64 |
| 48 | 0 | Envelope Strength | Max | 689.36 |
| 48 | 2.7 | Envelope Strength | Max | 688.91 |
| 48 | 5.4 | Envelope Strength | Max | 688.46 |
| 48 | 0 | Envelope Strength | Min | -296.22 |
| 48 | 2.7 | Envelope Strength | Min | -296.67 |
| 48 | 5.4 | Envelope Strength | Min | -297.12 |
| 49 | 0 | Envelope Strength | Max | 690.06 |
| 49 | 2.7 | Envelope Strength | Max | 690.52 |
| 49 | 5.4 | Envelope Strength | Max | 690.98 |
| 49 | 0 | Envelope Strength | Min | -338.73 |
| 49 | 2.7 | Envelope Strength | Min | -338.12 |
| 49 | 5.4 | Envelope Strength | Min | -337.51 |
| 50 | 0 | Envelope Strength | Max | 772.13 |
| 50 | 2.7 | Envelope Strength | Max | 772.71 |
| 50 | 5.4 | Envelope Strength | Max | 773.29 |
| 50 | 0 | Envelope Strength | Min | -551.51 |
| 50 | 2.7 | Envelope Strength | Min | -551.07 |
| 50 | 5.4 | Envelope Strength | Min | -550.63 |
| 52 | 0 | Envelope Strength | Max | 605.02 |
| 52 | 2.7 | Envelope Strength | Max | 604.44 |
| 52 | 5.4 | Envelope Strength | Max | 603.85 |
| 52 | 0 | Envelope Strength | Min | -480.24 |
| 52 | 2.7 | Envelope Strength | Min | -480.82 |
| 52 | 5.4 | Envelope Strength | Min | -481.41 |
| 55 | 0 | Envelope Strength | Max | 600.58 |
| 55 | 2.7 | Envelope Strength | Max | 599.97 |
| 55 | 5.4 | Envelope Strength | Max | 599.35 |
| 55 | 0 | Envelope Strength | Min | -665.7 |
| 55 | 2.7 | Envelope Strength | Min | -666.32 |
| 55 | 5.4 | Envelope Strength | Min | -666.93 |
|  |  |  | max= | 773.29 |

* 1. **Base Plate**

**Design force :**

**Shear check in transverse direction :**

According to INBC No.10 section 10-2-6-2-1

then

**Shear check in longitudinal direction :**

According to INBC No.10 section 10-2-6-7-2

According to above acalculation The column section is ok for shear check .

**Bolt control in shear**

**For ordinary & critical load combination**

**Tension Strength control of anchor bolts :**

**Shear control of Anchor Bolts:**

* 1. **General requirements of embedment in concrete**:

**According to ACI318 appendix D:**

Concrete breakout strength of anchor in tension : the nominal concrete breakout strength Ncbg shall not exceed

Concrete strength to withstand against tension in braced frame column under combination with Ω factor is acceptable.

**Concrete breakout of anchor in shear :**

The nominal concrete breakout strength Vcbg in shear shall not exceed :

### -REQUIRED THICKNESS

Maximum Axial Load according to SAP2000 model is about 8.13 ton Under critical load combination:

=11.7cm used th=2 cm

==117

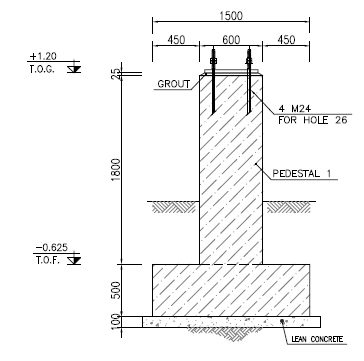
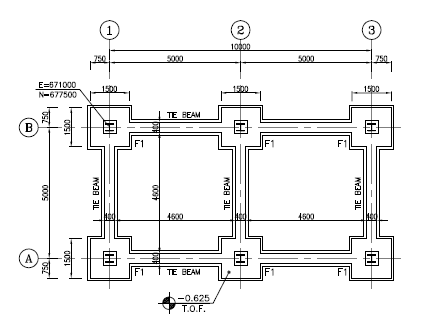
==150

L=max(m,n,λn)=117

1. **FOUNDATION DESIGN**

SAP2000 has been used in order to modeling, analyses and design of this foundation.

DETAILS” property of piles has been shown in the following FIG:

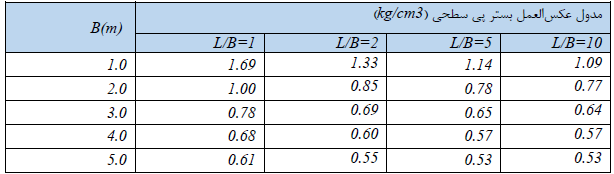


**Figure 23-Foundation Plan**

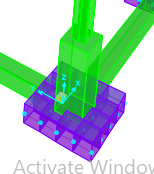
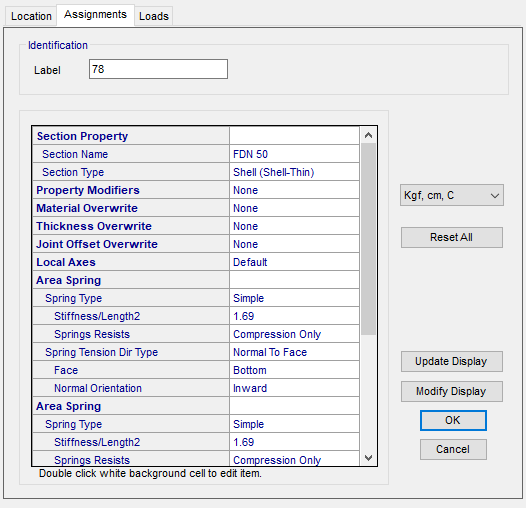
* 1. **Soil pressure and settlement**

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



**Figure 24-Subgrade Modulus**

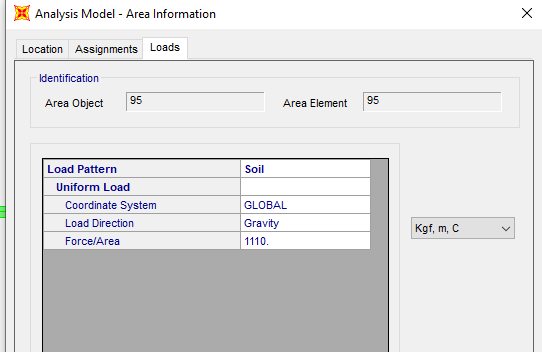
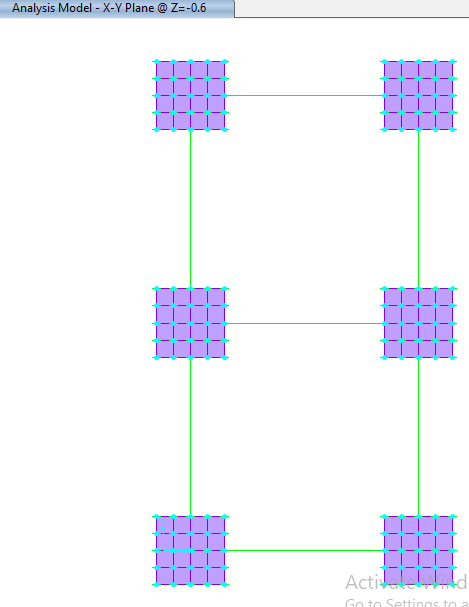


**Figure 25-Assign Spring to Foundation**

* 1. **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.

Soil load applied on model as below:



**Figure 26-Applied soil load on Foundation**

Soil dead load is

* 1. **FOUNDATION DESIGN CONTROL**

### 12.3.1 Check of Stress for Foundation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TABLE: Joint Displacements** | | | | | |
| **Joint** | **OutputCase** | **CaseType** | **U1** | **U2** | **U3** |
| Text | Text | Text | cm | cm | cm |
| 7 | vertical def | Combination | -0.000006628 | -0.000014 | -0.126788 |
| 9 | vertical def | Combination | 0.000006629 | -0.000014 | -0.126782 |
| 11 | vertical def | Combination | -0.000011 | 0.000055 | -0.138285 |
| 13 | vertical def | Combination | 0.000011 | 0.000055 | -0.138284 |
| 15 | vertical def | Combination | -0.000028 | -0.000041 | -0.223485 |
| 17 | vertical def | Combination | 0.000028 | -0.000041 | -0.223485 |
| 32 | vertical def | Combination | 0 | 0 | -0.098266 |
| 42 | vertical def | Combination | 0 | 0 | -0.210027 |
| 45 | vertical def | Combination | 0 | 0 | -0.177358 |
| 46 | vertical def | Combination | 0 | 0 | -0.065466 |
| 47 | vertical def | Combination | 0 | 0 | -0.154923 |
| 48 | vertical def | Combination | 0 | 0 | -0.081722 |
| 49 | vertical def | Combination | 0 | 0 | -0.121888 |
| 50 | vertical def | Combination | 0 | 0 | -0.193943 |
| 61 | vertical def | Combination | 0 | 0 | -0.210027 |
| 62 | vertical def | Combination | 0 | 0 | -0.098266 |
| 63 | vertical def | Combination | 0 | 0 | -0.065465 |
| 64 | vertical def | Combination | 0 | 0 | -0.177358 |
| 65 | vertical def | Combination | 0 | 0 | -0.154923 |
| 78 | vertical def | Combination | 0 | 0 | -0.193942 |
| 79 | vertical def | Combination | 0 | 0 | -0.121886 |
| 81 | vertical def | Combination | 0 | 0 | -0.081721 |
| 82 | vertical def | Combination | 0 | 0 | -0.011303 |
| 86 | vertical def | Combination | 0 | 0 | -0.127777 |
| 90 | vertical def | Combination | 0 | 0 | -0.241088 |
| 92 | vertical def | Combination | 0 | 0 | -0.124796 |
| 93 | vertical def | Combination | 0 | 0 | -0.069744 |
| 94 | vertical def | Combination | 0 | 0 | -0.06813 |
| 95 | vertical def | Combination | 0 | 0 | -0.183513 |
| 96 | vertical def | Combination | 0 | 0 | -0.184926 |
| 97 | vertical def | Combination | 0 | 0 | -0.127772 |
| 98 | vertical def | Combination | 0 | 0 | -0.011296 |
| 99 | vertical def | Combination | 0 | 0 | -0.12479 |
| 100 | vertical def | Combination | 0 | 0 | -0.241084 |
| 101 | vertical def | Combination | 0 | 0 | -0.069738 |
| 102 | vertical def | Combination | 0 | 0 | -0.184921 |
| 103 | vertical def | Combination | 0 | 0 | -0.183508 |
| 104 | vertical def | Combination | 0 | 0 | -0.068123 |
| 105 | vertical def | Combination | 0 | 0 | -0.193487 |
| 106 | vertical def | Combination | 0 | 0 | -0.293677 |
| 107 | vertical def | Combination | 0 | 0 | -0.251922 |
| 108 | vertical def | Combination | 0 | 0 | -0.151782 |
| 109 | vertical def | Combination | 0 | 0 | -0.245597 |
| 110 | vertical def | Combination | 0 | 0 | -0.171579 |
| 111 | vertical def | Combination | 0 | 0 | -0.203945 |
| 112 | vertical def | Combination | 0 | 0 | -0.271989 |
| 113 | vertical def | Combination | 0 | 0 | -0.293677 |
| 114 | vertical def | Combination | 0 | 0 | -0.193487 |
| 115 | vertical def | Combination | 0 | 0 | -0.151782 |
| 116 | vertical def | Combination | 0 | 0 | -0.251922 |
| 117 | vertical def | Combination | 0 | 0 | -0.245597 |
| 118 | vertical def | Combination | 0 | 0 | -0.271989 |
| 119 | vertical def | Combination | 0 | 0 | -0.203945 |
| 120 | vertical def | Combination | 0 | 0 | -0.171579 |
| 123 | vertical def | Combination | 0.0000016 | 0.000014 | -0.126683 |
| 124 | vertical def | Combination | 0.000002964 | 0.000013 | -0.118063 |
| 125 | vertical def | Combination | 0.000000687 | 0.000005241 | -0.089756 |
| 126 | vertical def | Combination | -0.000004081 | 0.000013 | -0.110116 |
| 127 | vertical def | Combination | -0.000002513 | 0.000021 | -0.146033 |
| 128 | vertical def | Combination | -0.000008319 | 0.000015 | -0.102111 |
| 129 | vertical def | Combination | -0.000006269 | 0.000006298 | -0.073715 |
| 130 | vertical def | Combination | -0.000003825 | 0.000015 | -0.093803 |
| 131 | vertical def | Combination | -0.000002445 | 0.000021 | -0.1303 |
| 132 | vertical def | Combination | -0.000003863 | 0.000015 | -0.182381 |
| 133 | vertical def | Combination | -0.000008326 | 0.000015 | -0.173878 |
| 134 | vertical def | Combination | -0.000004081 | 0.000013 | -0.165983 |
| 135 | vertical def | Combination | -0.000006273 | 0.00000626 | -0.201735 |
| 136 | vertical def | Combination | 0.000002971 | 0.000013 | -0.15798 |
| 137 | vertical def | Combination | 0.000001638 | 0.000014 | -0.149619 |
| 138 | vertical def | Combination | 6.915E-07 | 0.000005203 | -0.185759 |
| 139 | vertical def | Combination | 0.000003863 | 0.000015 | -0.182381 |
| 140 | vertical def | Combination | 0.000008325 | 0.000015 | -0.173878 |
| 141 | vertical def | Combination | 0.000006273 | 0.00000626 | -0.201734 |
| 142 | vertical def | Combination | 0.000004081 | 0.000013 | -0.165982 |
| 143 | vertical def | Combination | 0.000002513 | 0.000021 | -0.146032 |
| 144 | vertical def | Combination | -0.000002971 | 0.000013 | -0.157979 |
| 145 | vertical def | Combination | -6.915E-07 | 0.000005203 | -0.185758 |
| 146 | vertical def | Combination | -0.000001638 | 0.000014 | -0.149618 |
| 147 | vertical def | Combination | 0.000002445 | 0.000021 | -0.130299 |
| 148 | vertical def | Combination | -0.0000016 | 0.000014 | -0.126683 |
| 149 | vertical def | Combination | -0.000002964 | 0.000013 | -0.118063 |
| 150 | vertical def | Combination | 0.000004081 | 0.000013 | -0.110115 |
| 151 | vertical def | Combination | -0.000000687 | 0.000005241 | -0.089755 |
| 152 | vertical def | Combination | 0.000008318 | 0.000015 | -0.10211 |
| 153 | vertical def | Combination | 0.000003825 | 0.000015 | -0.093802 |
| 154 | vertical def | Combination | 0.000006269 | 0.000006298 | -0.073714 |
| 155 | vertical def | Combination | -0.000001352 | -0.00000401 | -0.040603 |
| 156 | vertical def | Combination | -0.000003079 | -0.000004129 | -0.069139 |
| 157 | vertical def | Combination | -0.000002614 | -0.000001786 | -0.039791 |
| 158 | vertical def | Combination | -0.000002562 | -0.00000323 | -0.097528 |
| 159 | vertical def | Combination | -0.000001511 | -0.000005241 | -0.098346 |
| 160 | vertical def | Combination | -2.829E-07 | -0.000002757 | -0.125775 |
| 161 | vertical def | Combination | -8.906E-07 | -0.000001122 | -0.096385 |
| 162 | vertical def | Combination | -4.49E-08 | -0.000003165 | -0.154246 |
| 163 | vertical def | Combination | -0.000001602 | -0.000005241 | -0.154943 |
| 164 | vertical def | Combination | 5.331E-09 | -0.000003159 | -0.098728 |
| 165 | vertical def | Combination | -2.735E-07 | -0.000002748 | -0.127326 |
| 166 | vertical def | Combination | -0.000002562 | -0.000003138 | -0.155724 |
| 167 | vertical def | Combination | -8.846E-07 | -0.000001072 | -0.156419 |
| 168 | vertical def | Combination | -0.000003089 | -0.000004119 | -0.183888 |
| 169 | vertical def | Combination | -0.000001403 | -0.000004004 | -0.212209 |
| 170 | vertical def | Combination | -0.00000262 | -0.000001736 | -0.212923 |
| 171 | vertical def | Combination | -5.255E-09 | -0.000003159 | -0.098722 |
| 172 | vertical def | Combination | 2.737E-07 | -0.000002748 | -0.127321 |
| 173 | vertical def | Combination | 8.848E-07 | -0.000001072 | -0.156415 |
| 174 | vertical def | Combination | 0.000002563 | -0.000003138 | -0.155719 |
| 175 | vertical def | Combination | 0.000001511 | -0.000005241 | -0.09834 |
| 176 | vertical def | Combination | 0.000003089 | -0.00000412 | -0.183883 |
| 177 | vertical def | Combination | 0.000002621 | -0.000001736 | -0.212919 |
| 178 | vertical def | Combination | 0.000001403 | -0.000004004 | -0.212204 |
| 179 | vertical def | Combination | 0.000001602 | -0.000005241 | -0.154938 |
| 180 | vertical def | Combination | 0.000001352 | -0.00000401 | -0.040597 |
| 181 | vertical def | Combination | 0.000003079 | -0.000004129 | -0.069132 |
| 182 | vertical def | Combination | 0.000002563 | -0.00000323 | -0.097522 |
| 183 | vertical def | Combination | 0.000002615 | -0.000001786 | -0.039784 |
| 184 | vertical def | Combination | 2.831E-07 | -0.000002757 | -0.125769 |
| 185 | vertical def | Combination | 4.498E-08 | -0.000003165 | -0.154241 |
| 186 | vertical def | Combination | 8.908E-07 | -0.000001122 | -0.096379 |
| 187 | vertical def | Combination | -0.000005018 | -0.000013 | -0.219822 |
| 188 | vertical def | Combination | -0.000011 | -0.000013 | -0.208676 |
| 189 | vertical def | Combination | -0.00001 | -0.000005728 | -0.182383 |
| 190 | vertical def | Combination | -0.000011 | -0.000009627 | -0.197896 |
| 191 | vertical def | Combination | -0.000006606 | -0.000016 | -0.234242 |
| 192 | vertical def | Combination | -0.000002889 | -0.000007487 | -0.187438 |
| 194 | vertical def | Combination | -9.103E-07 | -0.000009045 | -0.178099 |
| 195 | vertical def | Combination | -0.000006603 | -0.000016 | -0.212801 |
| 196 | vertical def | Combination | -0.000000912 | -0.000009046 | -0.269787 |
| 197 | vertical def | Combination | -0.00000289 | -0.000007488 | -0.258579 |
| 198 | vertical def | Combination | -0.000011 | -0.00000963 | -0.247708 |
| 199 | vertical def | Combination | -0.00000482 | -0.000002914 | -0.282636 |
| 200 | vertical def | Combination | -0.000011 | -0.000013 | -0.237321 |
| 201 | vertical def | Combination | -0.000005016 | -0.000013 | -0.228019 |
| 202 | vertical def | Combination | -0.00001 | -0.00000573 | -0.261491 |
| 203 | vertical def | Combination | 9.119E-07 | -0.000009046 | -0.269787 |
| 204 | vertical def | Combination | 0.00000289 | -0.000007488 | -0.258579 |
| 205 | vertical def | Combination | 0.000004819 | -0.000002914 | -0.282636 |
| 206 | vertical def | Combination | 0.000011 | -0.00000963 | -0.247708 |
| 207 | vertical def | Combination | 0.000006606 | -0.000016 | -0.234242 |
| 208 | vertical def | Combination | 0.000011 | -0.000013 | -0.237321 |
| 209 | vertical def | Combination | 0.00001 | -0.00000573 | -0.261492 |
| 210 | vertical def | Combination | 0.000005016 | -0.000013 | -0.228019 |
| 211 | vertical def | Combination | 0.000006602 | -0.000016 | -0.212801 |
| 212 | vertical def | Combination | 0.000005018 | -0.000013 | -0.219822 |
| 213 | vertical def | Combination | 0.000011 | -0.000013 | -0.208676 |
| 214 | vertical def | Combination | 0.000011 | -0.000009627 | -0.197896 |
| 215 | vertical def | Combination | 0.00001 | -0.000005729 | -0.182382 |
| 216 | vertical def | Combination | 0.000002889 | -0.000007488 | -0.187438 |
| 217 | vertical def | Combination | 9.102E-07 | -0.000009046 | -0.178099 |
| 218 | vertical def | Combination | 0.000004819 | -0.000002912 | -0.161263 |
|  |  |  |  | min | -0.293677 |
|  |  |  |  | max | -0.011296 |

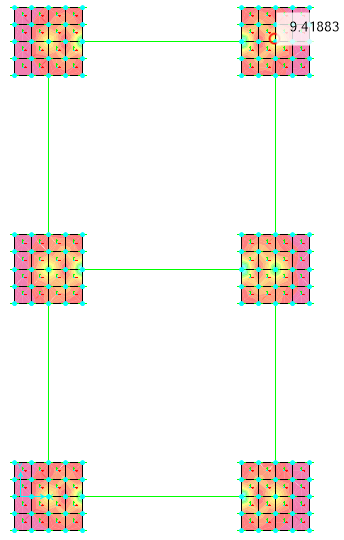
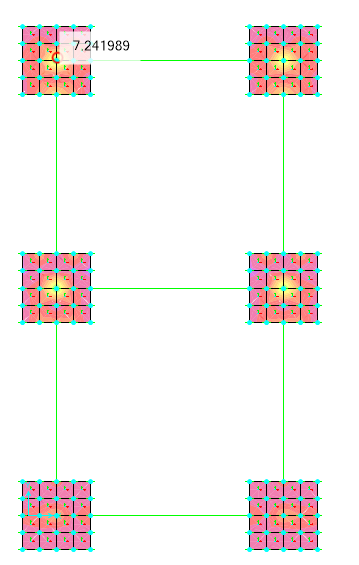
According to above output, Max soil pressure under the foundation is:

### 12.3.2. Check of Displacement for Foundation

According to above outputs, Max soil displacement under the foundation is:

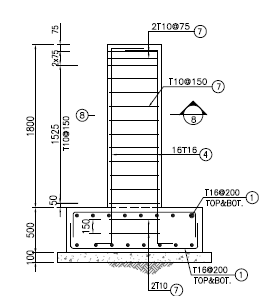
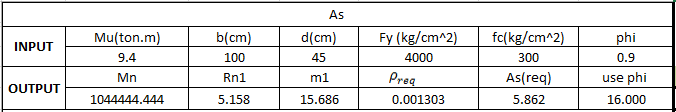
### 12.3.3 REINFORCING CONTROL

Minimum rebar for foundation:



**Figure 27-M11 & M22 result**

According to above figures max Moment is about 9.41 ton.m= 941000 kg-cm



**Figure 28-reinforcement(**