|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **طرح نگهداشت و افزایش تولید 27 مخزن** | | | | | | |
| **CALCULATION NOTE FOR COMPRESSOR AREA MAIN SLEEPERS**  **نگهداشت و افزایش تولید میدان نفتی بینک** | | | | | | |
| D04 | MAR.2024 | AFD | R.Berlouie | M.Fakharian | S.Faramarzpour |  |
| D03 | JUN.2023 | AFD | R.Berlouie | M.Fakharian | A.M.Mohseni |  |
| D02 | MAY.2023 | IFA | R.Berlouie | M.Fakharian | M.Mehrshad |  |
| D01 | MAR.2023 | IFA | R.Berlouie | M.Fakharian | M.Mehrshad |  |
| D00 | JAN.2023 | IFC | R.Berlouie | M.Fakharian | M.Mehrshad |  |
| **Rev.** | **Date** | **Purpose of Issue/Status** | **Prepared by:** | **Checked by:** | **Approved by:** | **CLIENT Approval** |
| **Class:2** | | **CLIENT Doc. Number:F0Z-709129** | | | | |
| **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 | X | X | **66** |  |  |  |  |  |
| **2** | X |  | X | X | X | **67** |  |  |  |  |  |
| **3** | X |  | X | X |  | **68** |  |  |  |  |  |
| **4** | X |  | X |  |  | **69** |  |  |  |  |  |
| **5** | X | x | X |  |  | **70** |  |  |  |  |  |
| **6** | X |  | X |  |  | **71** |  |  |  |  |  |
| **7** | X |  | X |  |  | **72** |  |  |  |  |  |
| **8** | X |  | X |  |  | **73** |  |  |  |  |  |
| **9** | X | **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 |  | X | **80** |  |  |  |  |  |
| **16** |  | **x** | X |  | X | **81** |  |  |  |  |  |
| **17** |  | **x** | X |  | X | **82** |  |  |  |  |  |
| **18** |  | **x** | X |  | X | **83** |  |  |  |  |  |
| **19** |  | **x** | X |  | X | **84** |  |  |  |  |  |
| **20** |  | **x** | X |  | X | **85** |  |  |  |  |  |
| **21** |  | **x** | 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 | X | **92** |  |  |  |  |  |
| **28** |  |  |  |  |  | **93** |  |  |  |  |  |
| **29** |  |  |  |  |  | **94** |  |  |  |  |  |
| **30** |  |  |  |  |  | **95** |  |  |  |  |  |
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| **41** |  |  |  |  |  | **106** |  |  |  |  |  |
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| **43** |  |  |  |  |  | **108** |  |  |  |  |  |
| **44** |  |  |  |  |  | **109** |  |  |  |  |  |
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| **46** |  |  |  |  |  | **111** |  |  |  |  |  |
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| **53** |  |  |  |  |  | **118** |  |  |  |  |  |
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| **55** |  |  |  |  |  | **120** |  |  |  |  |  |
| **56** |  |  |  |  |  | **121** |  |  |  |  |  |
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| **59** |  |  |  |  |  | **124** |  |  |  |  |  |
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| **61** |  |  |  |  |  | **126** |  |  |  |  |  |
| **62** |  |  |  |  |  | **127** |  |  |  |  |  |
| **63** |  |  |  |  |  | **128** |  |  |  |  |  |
| **64** |  |  |  |  |  | **129** |  |  |  |  |  |
| **65** |  |  |  |  |  | **130** |  |  |  |  |  |

**CONTENTS**

[1.0 INTRODUCTION 4](#_Toc136182057)

[2.0 Scope 5](#_Toc136182058)

[3.0 NORMATIVE REFERENCES 5](#_Toc136182059)

[- Local Codes and Standards 5](#_Toc136182060)

[- International Codes and Standards 5](#_Toc136182061)

[- The Project Documents 5](#_Toc136182062)

[- ENVIRONMENTAL DATA 5](#_Toc136182063)

[- Order of Precedence 5](#_Toc136182064)

[4.0 MATERIALS 6](#_Toc136182065)

[5.0 DESIGN INFORMATION 7](#_Toc136182066)

[5.1 LOCATION OF SLEEPERS 7](#_Toc136182067)

[6.0 PIPING weigh 8](#_Toc136182069)

[7.0 SOIL PARAMETERS 10](#_Toc136182070)

[8.0 LOADING 11](#_Toc136182071)

[- Dead Load 11](#_Toc136182072)

[- Live Load 11](#_Toc136182073)

[- Seismic Load 11](#_Toc136182074)

[- Wind Load 11](#_Toc136182075)

[- LOAD COMBINITION FOR DESIGN 11](#_Toc136182076)

[9.0 FOUNDATION ANALYsis 15](#_Toc136182077)

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.

As a part of the Project, a New Gas Compressor Station (adjacent to existing Binak GCS) shall be constructed to gather of 15 MMSCFD (approx.) associated gases and compress & transfer them to Siahmakan GIS.

**GENERAL DEFINITION**

The following terms shall be used in this document.

|  |  |
| --- | --- |
| CLIENT: | National Iranian South Oilfields Company (NISOC) |
| PROJECT: | Binak Oilfield Development – Surface Fcilities; New Gas Compressor Station |
| EPD/EPC CONTRACTOR (GC): | Petro Iran Development Company (PEDCO) |
| EPC CONTRACTOR: | Joint Venture of : Hirgan Energy – Design & Inspection (D&I) Companies |
| VENDOR: | The firm or person who will fabricate the equipment or material. |
| EXECUTOR: | Executor is the party which carries out all or part of construction and/or commissioning for the project. |
| THIRD PARTY INSPECTOR (TPI): | The firm appointed by EPD/EPC CONTRACTOR (GC) and approved by CLIENT (in writing) for the inspection of goods. |
| SHALL: | Is used where a provision is mandatory. |
| SHOULD: | Is used where a provision is advisory only. |
| WILL: | Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR. |
| MAY: | Is used where a provision is completely discretionary. |

1. **Scope**

This report covers the Sleeper Pipe Supports foundation Design . The structure modeled by “SAP” software.

1. **NORMATIVE REFERENCES**

## Local Codes and Standards

* INBC Part 9 Iranian National Building Code, Part 9 (4th Edition)
* Iranian Standard No.2800 Iranian Code of Practice for Seismic Resistant Design of Buildings (4th Edition)

## International Codes and Standards

* ACI 315 Manual of Standard Practice for Detailing Reinforced Concrete
* ACI 318-14 Building Code Requirements for Reinforced Concrete
* ASCE7-10 Minimum Design Loads and Associated Criteria for Buildings and Other Structures-American Society of Civil Engineers
* ISDC-038 Iranian Seismic Design Code for Petroleum Facilities(3rd edition)

## The Project Documents

* BK-GCS-PEDCO-120-GT-RT-0001 Geotechnical Investigation Report for Compressor Station
* BK-GNRAL-PEDCO-000-ST-DC-0001 Structural Design Criteria

## ENVIRONMENTAL DATA

Refer to "Process Basis of Design; Doc. No. BK-GNRAL-PEDCO-000-PR-DB-0001".

## Order of Precedence

In case of any conflict between the contents of this document or any discrepancy between this document and other project documents or reference standards, this issue must be reported to the CLIENT. The final decision in this situation will be made by CLIENT.

1. **MATERIALS**

Material properties are delivered in the following table.

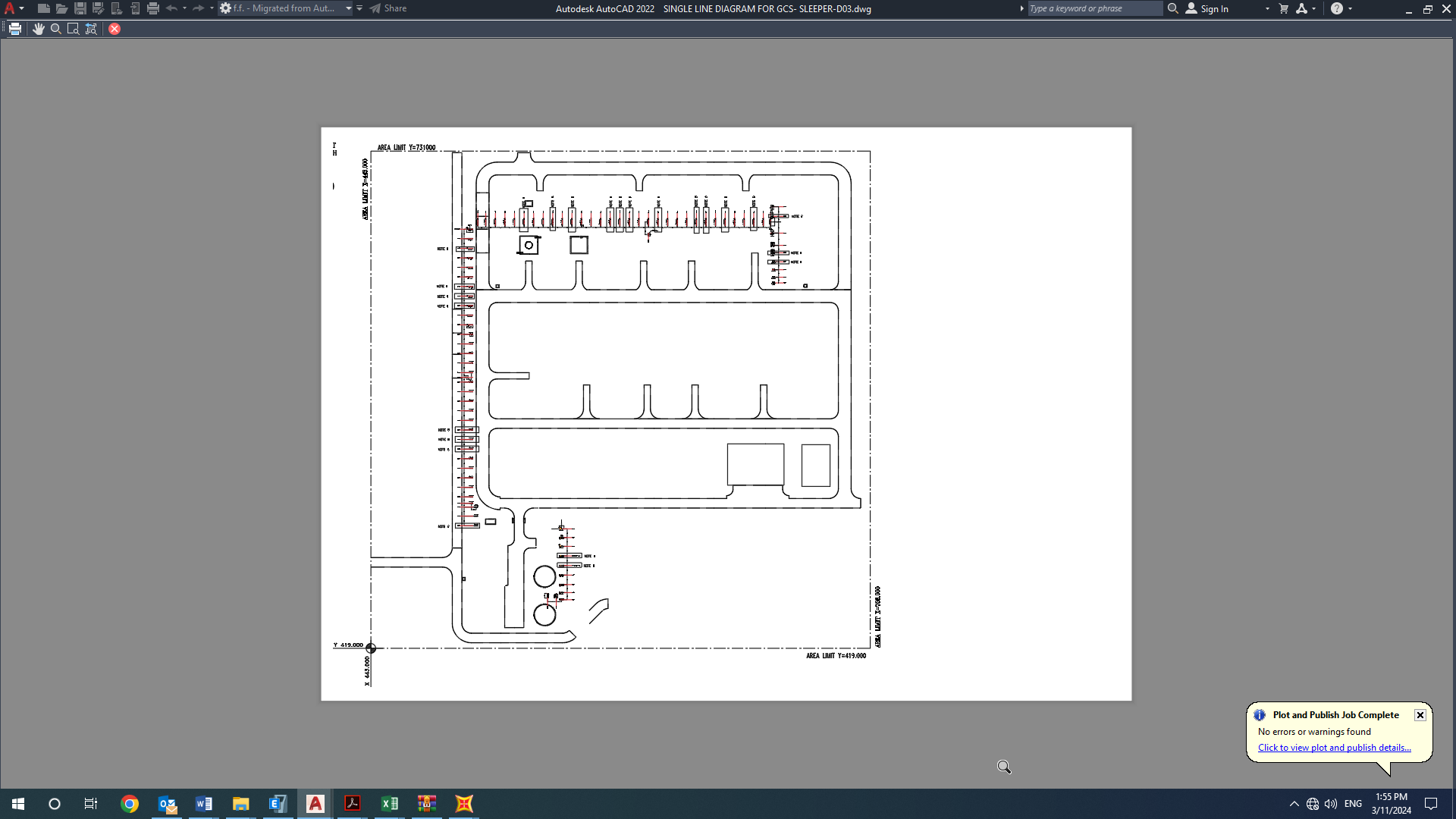
**Table 1- Material Properties**

|  |  |
| --- | --- |
| Foundation Concrete | f'c = 300 kg/cm2 (28- day cylindrical sample) |
| Long. reinforcement bar | Fy = 4000 kg/cm2 (AIII) |
| Trans. reinforcement bar | Fy = 4000 kg/cm2 (AIII) |

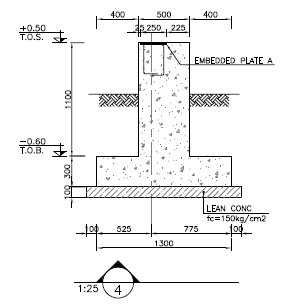
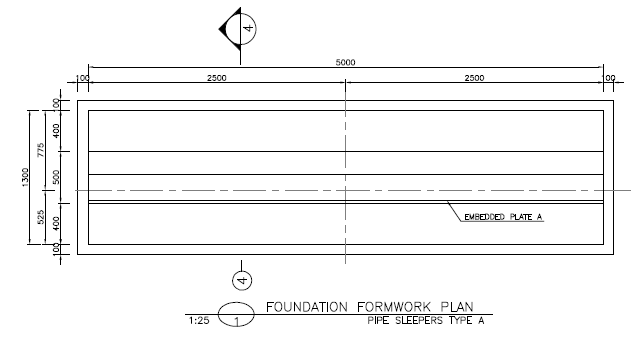
|  |  |  |  |
| --- | --- | --- | --- |
| **TABLE: Material Properties 01 - General** | | | |
| **Material** | **Type** | **SymType** | **TempDepend** |
| Text | Text | Text | Yes/No |
| A416Gr270 | Tendon | Uniaxial | No |
| A615Gr60 | Rebar | Uniaxial | No |
| C30 | Concrete | Isotropic | No |
| C0 | Concrete | Isotropic | No |
| ST37 | Steel | Isotropic | No |

1. **DESIGN INFORMATION**

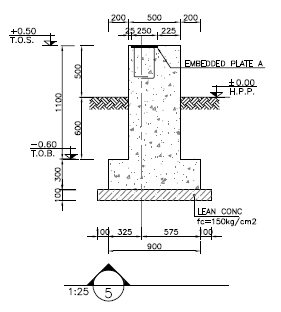
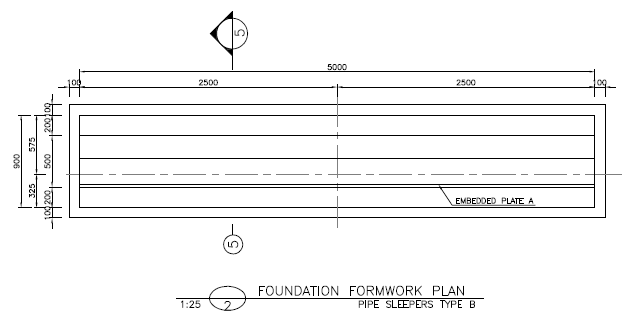
**5.1 LOCATION OF SLEEPERS**



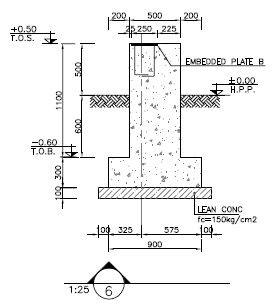
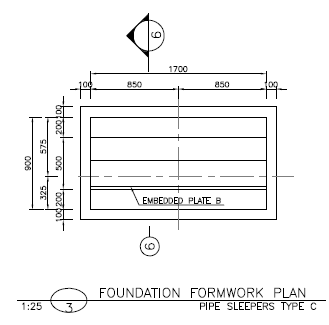
1. Location of sleepers According to Piping SLD



1. Sleeper Type A

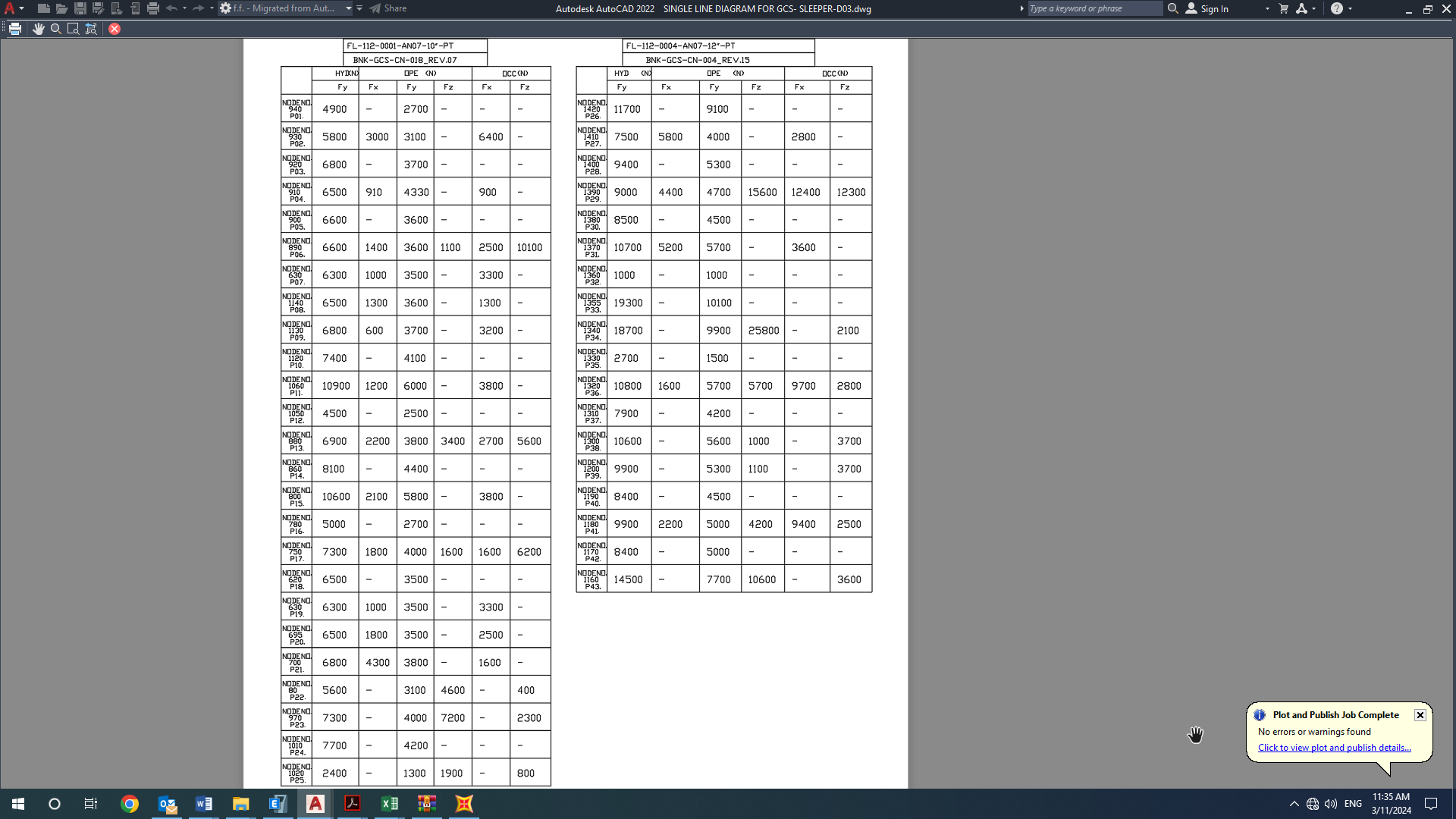


1. Sleeper type B



1. Sleeper type C
2. **PIPING weigh**

Data Received from Piping is as single lines and loading table for each point as bellow:



\*Note:

Lateral & axial Friction loads for uniform loads=0.3\*vertical load

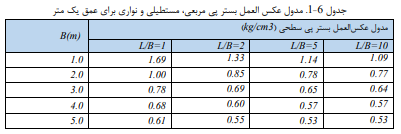
Lateral & axial seismic load for uniform loads = 0.4\* vertical load

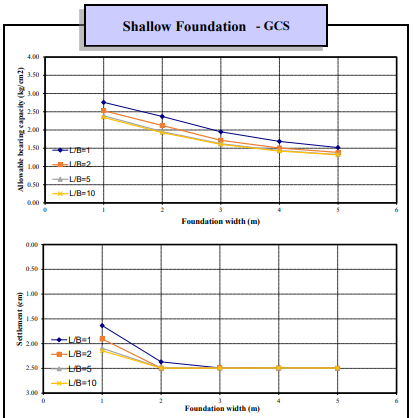
Lateral seismic& friction loads for anchor sleepers =0.4\*Vertical Load

Axial seismic & friction loads for anchor sleepers = 0.8\* vertical load

1. **SOIL PARAMETERS**

According to Soil Investigation Report, prepared by BKP soil parameters shows as below:





1. Soil Parameters
2. **LOADING**

## Dead Load

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

## Live Load

Live load (operation) of Equipment according to piping documents assign in model.

## Seismic Load

Seismic load (occasional) of Equipment according to piping documents assign in model.

## Wind Load

Wind load is not applicable for pipe support foundation.

## LOAD COMBINITION FOR DESIGN

According to ASCE07-10 structures, components, and foundations shall be designed, so that their design strength equals or exceeds that effect of factored loads in the following combination

\*\*

Vertical seismic load applied at combinations with load combination with coefficient of 0.15\*dead load.

In combinations with earthquake load

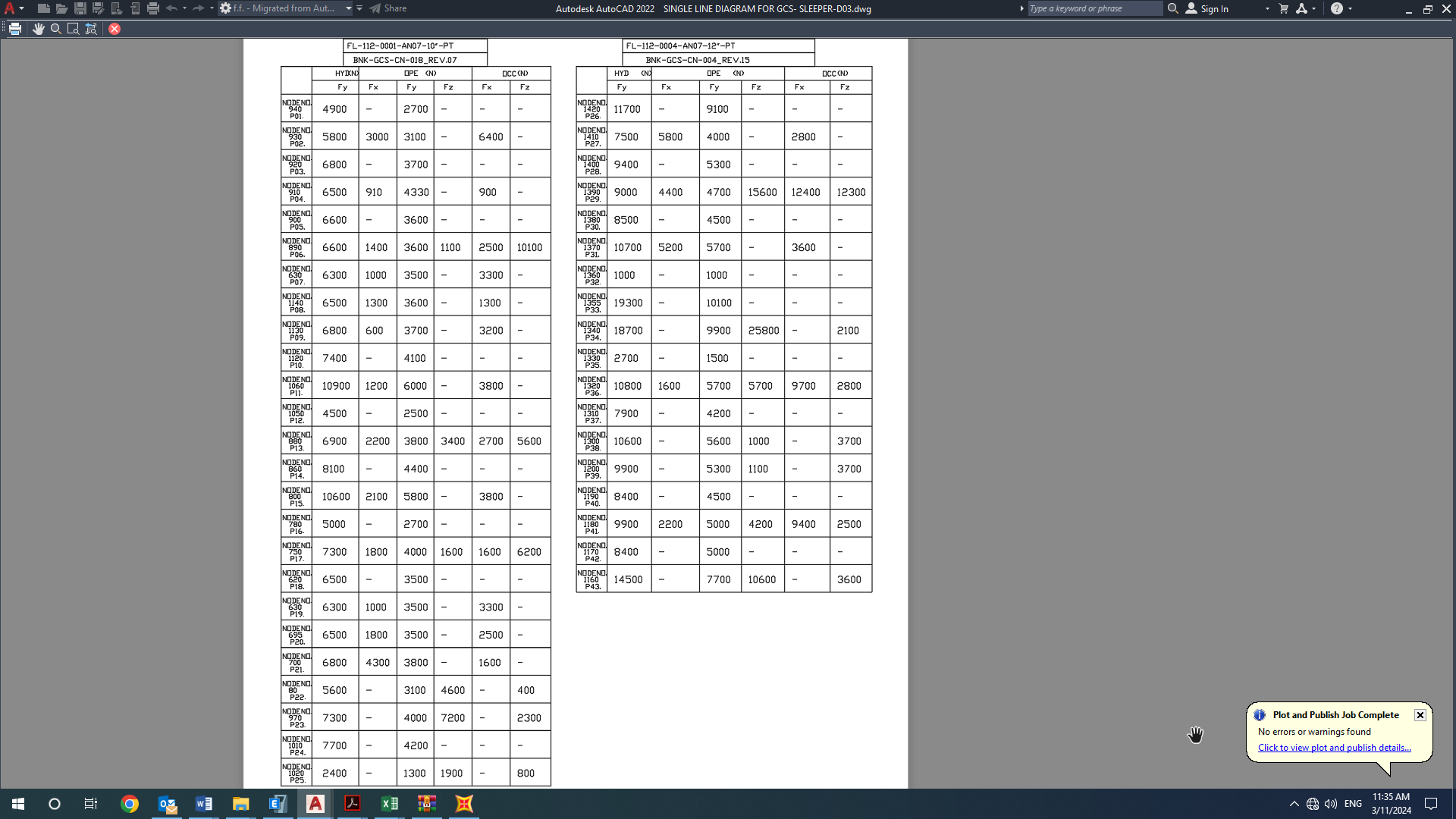
|  |  |  |  |
| --- | --- | --- | --- |
| **TABLE:** | | | |
| **LoadPat** | **DesignType** | **SelfWtMult** | **AutoLoad** |
|  |  |  |  |
| SUS | Dead | 1 |  |
| OPE | Live | 0 |  |
| OCCX | Quake | 0 | None |
| OCCY | Quake | 0 | None |
| HYD | Dead | 0 |  |
| LIVE | Live | 0 |  |
| FRX | Other | 0 |  |
| FRY | Other | 0 |  |
| Ev | Quake | 0 | None |
| H | Other | 0 |  |

| **TABLE:** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **ComboName** | **ComboType** | **AutoDesign** | **CaseName** | **ScaleFactor** | **SteelDesign** |
| D+L+FR | Linear Add | No | SUS | 1 | Strength |
| D+L+FR |  |  | FRx | 1 |  |
| D+L+FR |  |  | OPE | 1 |  |
| HYD+FR | Linear Add | No | HYD | 1 | None |
| HYD+FR |  |  | FRx | 1 |  |
| 1.4D | Linear Add | No | SUS | 1.4 | None |
| 1.35D+L+EX+FR+1.6H | Linear Add | No | SUS | 1.35 | Strength |
| 1.35D+L+EX+FR+1.6H |  |  | OCCX | 1 |  |
| 1.35D+L+EX+FR+1.6H |  |  | OPE | 1 |  |
| 1.35D+L+EX+FR+1.6H |  |  | FRx | 1 |  |
| 1.35D+L+EX+FR+1.6H |  |  | FRY | 1 |  |
| 1.35D+L+EX+FR+1.6H |  |  | H | 1.6 |  |
| 1.35D+L-EX+FR+1.6H | Linear Add | No | SUS | 1.35 | Strength |
| 1.35D+L-EX+FR+1.6H |  |  | OCCX | -1 |  |
| 1.35D+L-EX+FR+1.6H |  |  | OPE | 1 |  |
| 1.35D+L-EX+FR+1.6H |  |  | FRx | 1 |  |
| 1.35D+L-EX+FR+1.6H |  |  | FRY | 1 |  |
| 1.35D+L-EX+FR+1.6H |  |  | H | 1.6 |  |
| 1.35D+L+EY+FR+1.6H | Linear Add | No | SUS | 1.35 | Strength |
| 1.35D+L+EY+FR+1.6H |  |  | OCCY | 1 |  |
| 1.35D+L+EY+FR+1.6H |  |  | FRx | 1 |  |
| 1.35D+L+EY+FR+1.6H |  |  | OPE | 1 |  |
| 1.35D+L+EY+FR+1.6H |  |  | FRY | 1 |  |
| 1.35D+L+EY+FR+1.6H |  |  | H | 1.6 |  |
| 1.35D+L-EY+FR+1.6H | Linear Add | No | SUS | 1.2 | Strength |
| 1.35D+L-EY+FR+1.6H |  |  | OCCY | -1 |  |
| 1.35D+L-EY+FR+1.6H |  |  | FRx | 1 |  |
| 1.35D+L-EY+FR+1.6H |  |  | OPE | 1 |  |
| 1.35D+L-EY+FR+1.6H |  |  | FRY | 1 |  |
| 1.35D+L-EY+FR+1.6H |  |  | H | 1.6 |  |
| 0.9D+Ex+1.6H | Linear Add | No | SUS | 0.9 | Strength |
| 0.9D+Ex+1.6H |  |  | OCCX | 1 |  |
| 0.9D+Ex+1.6H |  |  | H | 1.6 |  |
| 0.9D-Ex+1.6H | Linear Add | No | SUS | 0.9 | Strength |
| 0.9D-Ex+1.6H |  |  | OCCX | -1 |  |
| 0.9D-Ex+1.6H |  |  | H | 1.6 |  |
| 0.9D-Ey+1.6H | Linear Add | No | SUS | 0.9 | Strength |
| 0.9D-Ey+1.6H |  |  | OCCY | -1 |  |
| 0.9D-Ey+1.6H |  |  | H | 1.6 |  |
| 0.9D+Ey+1.6H | Linear Add | No | SUS | 0.9 | Strength |
| 0.9D+Ey+1.6H |  |  | OCCY | 1 |  |
| 0.9D+Ey+1.6H |  |  | H | 1.6 |  |
| 1.2D+1.6L+1.6FR+1.6H | Linear Add | No | SUS | 1.2 | Strength |
| 1.2D+1.6L+1.6FR+1.6H |  |  | OPE | 1.6 |  |
| 1.2D+1.6L+1.6FR+1.6H |  |  | FRx | 1.6 |  |
| 1.2D+1.6L+1.6FR+1.6H |  |  | FRY | 1.2 |  |
| 1.2D+1.6L+1.6FR+1.6H |  |  | H | 1.6 |  |
| 0.75D-Ex | Linear Add | No | SUS | 0.75 | Strength |
| 0.75D-Ex |  |  | OCCX | -1 |  |
| 0.75D-Ey | Linear Add | No | SUS | 0.75 | Strength |
| 0.75D-Ey |  |  | OCCY | -1 |  |
| 0.75D+Ey | Linear Add | No | SUS | 0.75 | Strength |
| 0.75D+Ey |  |  | OCCY | 1 |  |
| 0.75D+Ex | Linear Add | No | SUS | 0.75 | Strength |
| 0.75D+Ex |  |  | OCCX | 1 |  |
| Envelope Strength | Envelope | No | 1.4D | 1 | None |
| Envelope Strength |  |  | 1.35D+L+EY+FR+1.6H | 1 |  |
| Envelope Strength |  |  | 1.35D+L+EX+FR+1.6H | 1 |  |
| Envelope Strength |  |  | 1.35D+L-EY+FR+1.6H | 1 |  |
| Envelope Strength |  |  | 1.35D+L-EX+FR+1.6H | 1 |  |
| Envelope Strength |  |  | 1.2D+1.6L+1.6FR+1.6H | 1 |  |
| Envelope Strength |  |  | 0.9D+Ey+1.6H | 1 |  |
| Envelope Strength |  |  | 0.9D+Ex+1.6H | 1 |  |
| Envelope Strength |  |  | 0.9D-Ey+1.6H | 1 |  |
| Envelope Strength |  |  | 0.9D-Ex+1.6H | 1 |  |
| Envelope Strength |  |  | 0.75D-Ex | 1 |  |
| Envelope Strength |  |  | 0.75D-Ey | 1 |  |
| Envelope Strength |  |  | 0.75D+Ey | 1 |  |
| Envelope Strength |  |  | 0.75D+Ex | 1 |  |
| D+L+H | Linear Add | No | SUS | 1 | None |
| D+L+H |  |  | OPE | 1 |  |
| D+L+H |  |  | H | 1 |  |
| D+0.7OCCX+H | Linear Add | No | SUS | 1 | None |
| D+0.7OCCX+H |  |  | OCCX | 0.7 |  |
| D+0.7OCCX+H |  |  | H | 1 |  |
| D-0.7OCCX+H | Linear Add | No | SUS | 1 | None |
| D-0.7OCCX+H |  |  | OCCX | -0.7 |  |
| D-0.7OCCX+H |  |  | H | 1 |  |
| D+0.7OCCY+H | Linear Add | No | SUS | 1 | None |
| D+0.7OCCY+H |  |  | OCCY | 0.7 |  |
| D+0.7OCCY+H |  |  | H | 1 |  |
| D-0.7OCCY+H | Linear Add | No | SUS | 1 | None |
| D-0.7OCCY+H |  |  | OCCY | -0.7 |  |
| D-0.7OCCY+H |  |  | H | 1 |  |
| D+0.75L+0.75OCCX+H | Linear Add | No | SUS | 1 | None |
| D+0.75L+0.75OCCX+H |  |  | OPE | 0.75 |  |
| D+0.75L+0.75OCCX+H |  |  | OCCX | 0.75 |  |
| D+0.75L+0.75OCCX+H |  |  | H | 1 |  |
| D-0.75L-0.75OCCX+H | Linear Add | No | SUS | 1 | None |
| D-0.75L-0.75OCCX+H |  |  | OPE | 0.75 |  |
| D-0.75L-0.75OCCX+H |  |  | OCCX | -0.75 |  |
| D-0.75L-0.75OCCX+H |  |  | H | 1 |  |
| D+0.75L+0.75OCCY+H | Linear Add | No | SUS | 1 | None |
| D+0.75L+0.75OCCY+H |  |  | OPE | 0.75 |  |
| D+0.75L+0.75OCCY+H |  |  | OCCY | 0.75 |  |
| D+0.75L+0.75OCCY+H |  |  | H | 1 |  |
| D-0.75L-0.75OCCY+H | Linear Add | No | SUS | 1 | None |
| D-0.75L-0.75OCCY+H |  |  | OPE | 0.75 |  |
| D-0.75L-0.75OCCY+H |  |  | OCCY | -0.75 |  |
| D-0.75L-0.75OCCY+H |  |  | H | 1 |  |
| D+H | Linear Add | No | H | 1 | None |
| D+H |  |  | SUS | 1 |  |
| Envelope allowable | Envelope | No | D+L+H | 1 | None |
| Envelope allowable |  |  | HYD+FR | 1 |  |
| Envelope allowable |  |  | D+L+FR | 1 |  |
| Envelope allowable |  |  | D+H | 1 |  |
| Envelope allowable |  |  | D+0.7OCCY+H | 1 |  |
| Envelope allowable |  |  | D+0.7OCCX+H | 1 |  |
| Envelope allowable |  |  | D+0.75L+0.75OCCY+H | 1 |  |
| Envelope allowable |  |  | D+0.75L+0.75OCCX+H | 1 |  |
| Envelope allowable |  |  | D-0.75L-0.75OCCX+H | 1 |  |
| Envelope allowable |  |  | D-0.75L-0.75OCCY+H | 1 |  |
| Envelope allowable |  |  | 0.75D+Ey | 1 |  |
| Envelope allowable |  |  | 0.75D+Ex | 1 |  |
| Envelope allowable |  |  | 0.75D-Ex | 1 |  |
| Envelope allowable |  |  | 0.75D-Ey | 1 |  |

1. **FOUNDATION ANALYsis**

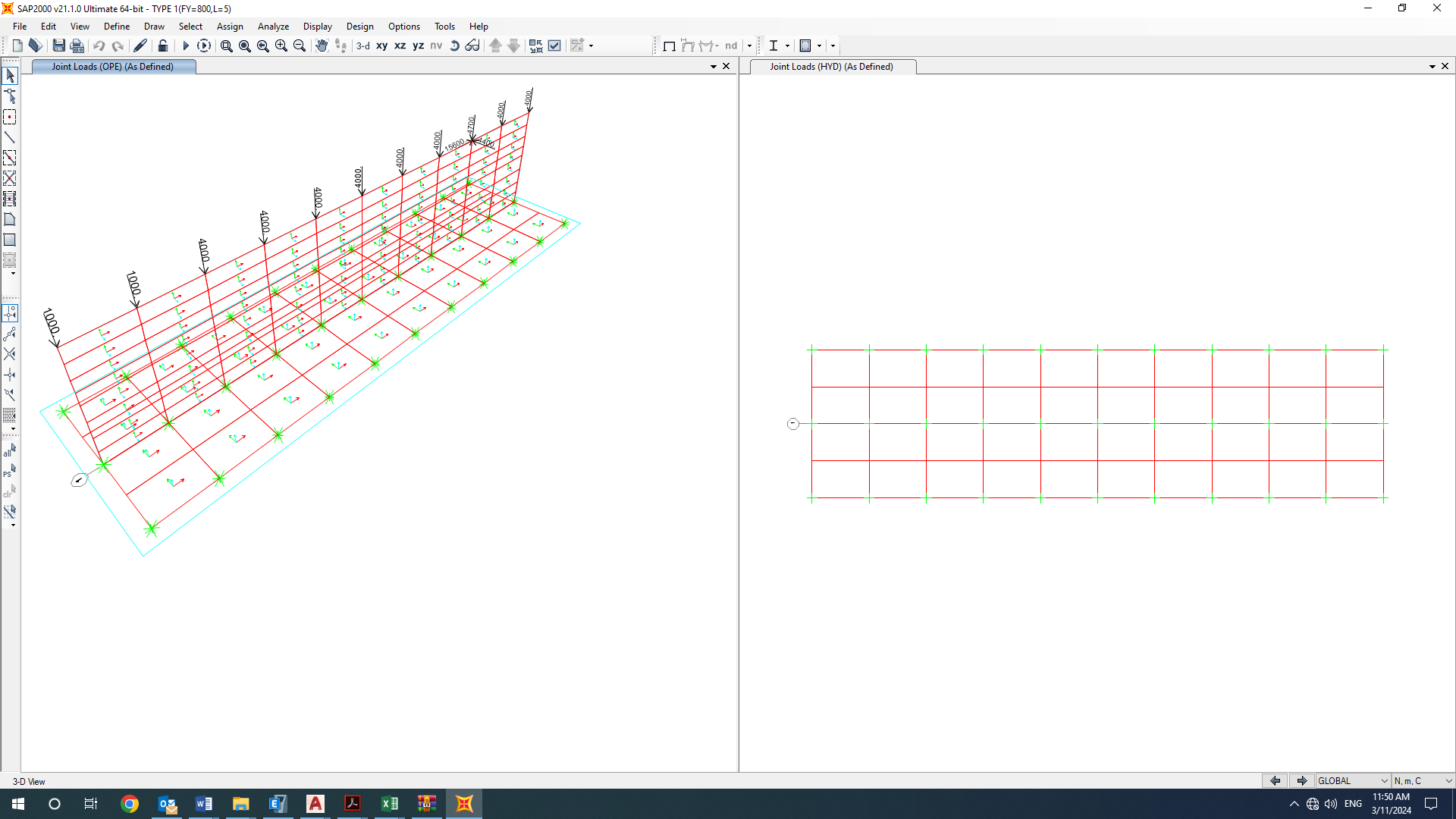
## sleeper type A

## piping load data



9.1.1.Operating weight of Pipng

This type of loading is operating weight of pipes that are considered by Piping and illustrated in tables and is equal to OPR for each point.

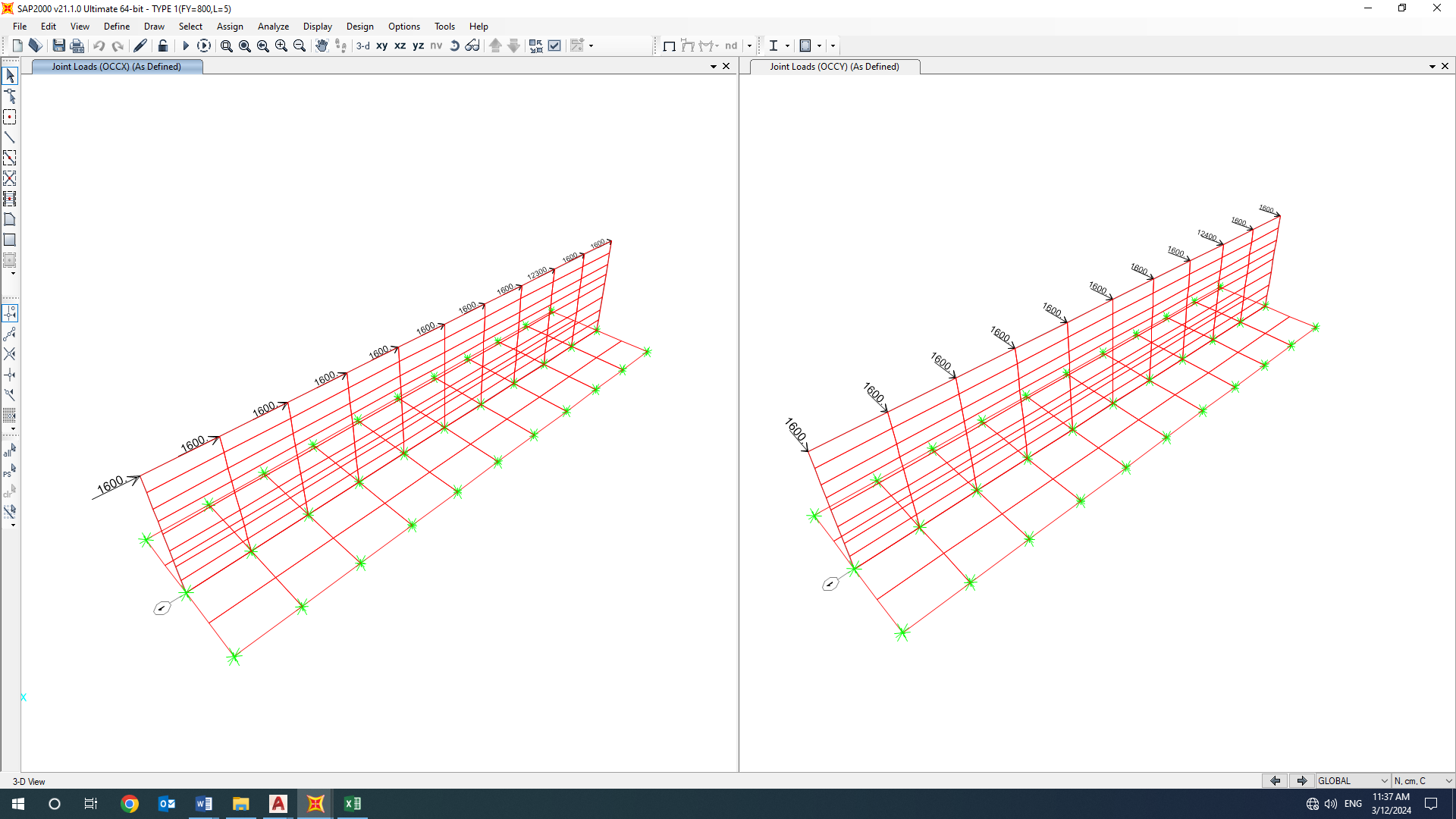


1. OPE Points Loads on sleeper (N)
   * 1. PURE SEISMIC WEIGHT OF PIPING (OCCX & OCCY)

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 as follow:

Lateral & axial seismic load for uniform loads = 0.4\* vertical load

Lateral & axial friction loads for anchor sleepers = 0.8\* vertical load

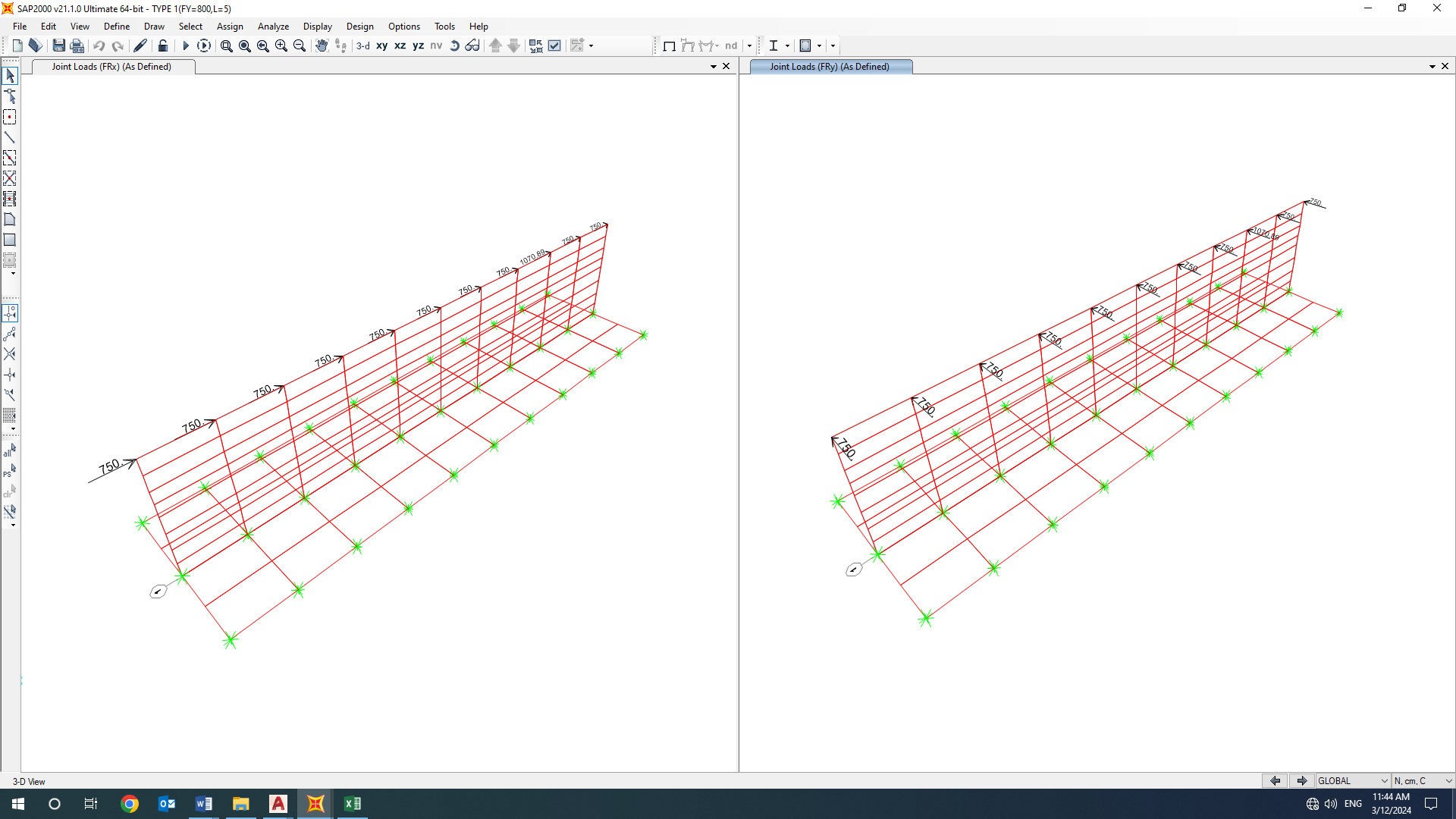


1. OCCX,Y Points Loads on sleeper (N)
   * 1. Friction Load (FRX & FRY)

Thermal displacement due to Operating condition and the friction between pipes and the sleepers, causes lateral forces according to piping documents assign in model. In some cases when the Friction load is not provided by piping, the Friction coefficient is calculated as follow:

Lateral & axial Friction loads for uniform loads=0.3\*vertical load

Lateral & axial loads for anchor sleepers = 0.8\* vertical load



1. FRx,y Points Loads on sleeper
   * 1. Vertical seismic load

The vertical seismic load effect, 𝐸𝑣, shall be determined in accordance with the following Equation ASCE7-16 Eq. (12.14-6):

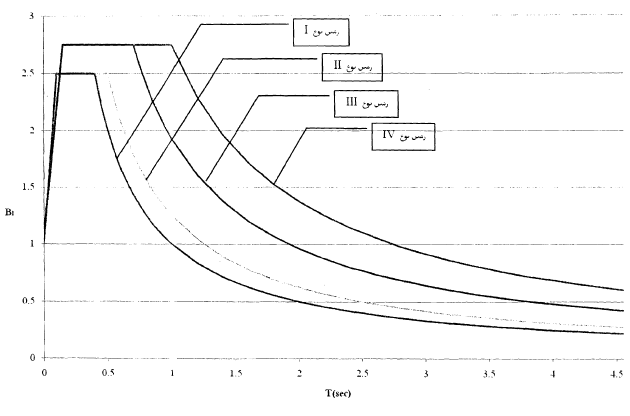
𝐸𝑣 = 0.2𝐷 (ASCE7/ Eq. 12.14-6)

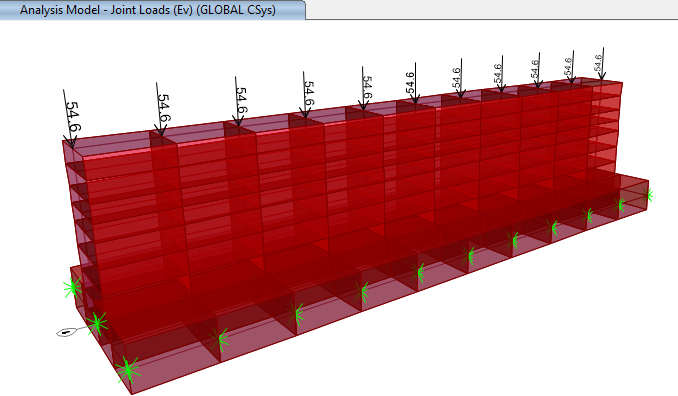
= Design, 5% damped, spectral response acceleration parameter (g) at short periods (0.2 sec).

D = effect of dead load

Loads case name: EQZ=0.2\*AB\*W=0.15\*W (where W=DL+OPR1+OPR FUTURE)

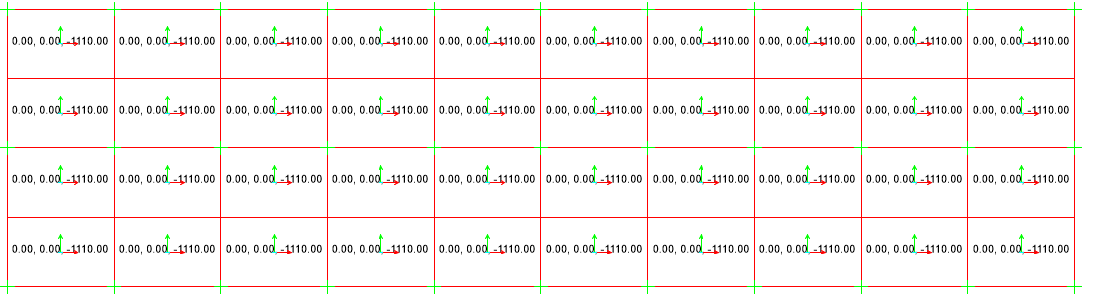
A=0.3g, B=2.5(according to code 2800 4th)





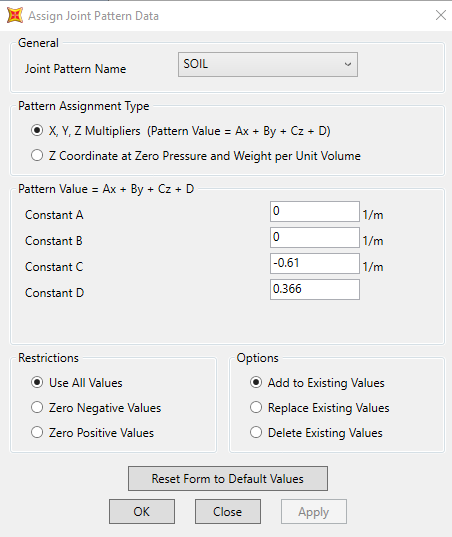
1. Ev Points Loads on sleeper =0.15\*SUS(Kg)
   * 1. Soil load on foundation

Soil load weight has been applied on foundation as below

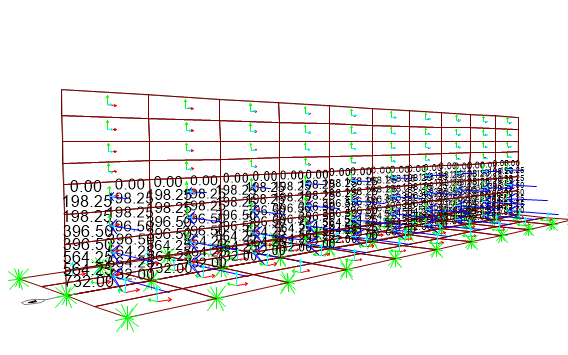


1. applied soil load on foundation (Kg)
   * 1. Soil Pressure on wall of sleepert

According to drawings approximately 0.6m is under ground that horizontal pressure applied on model as below :



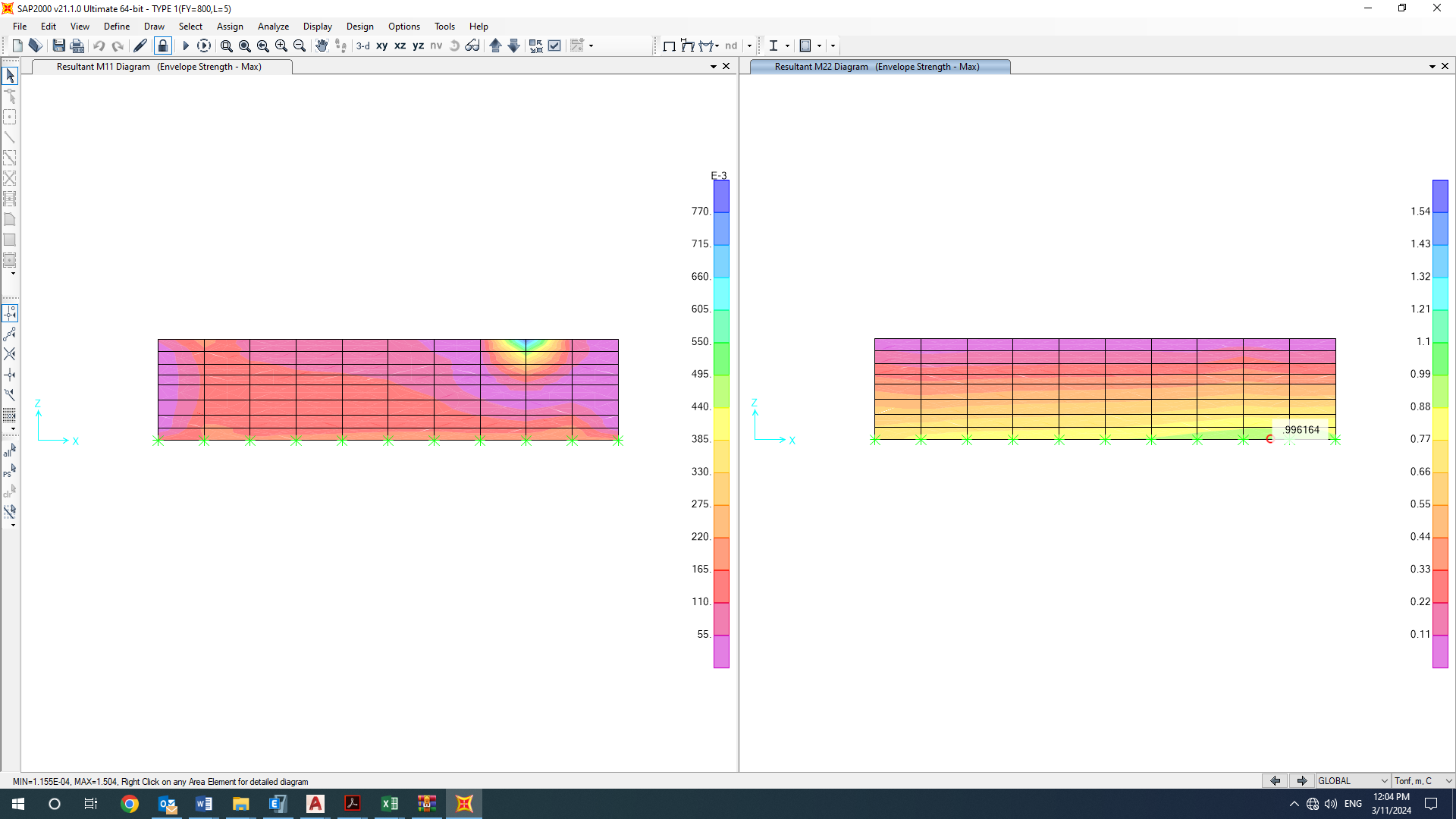
1. Define joint Pattern



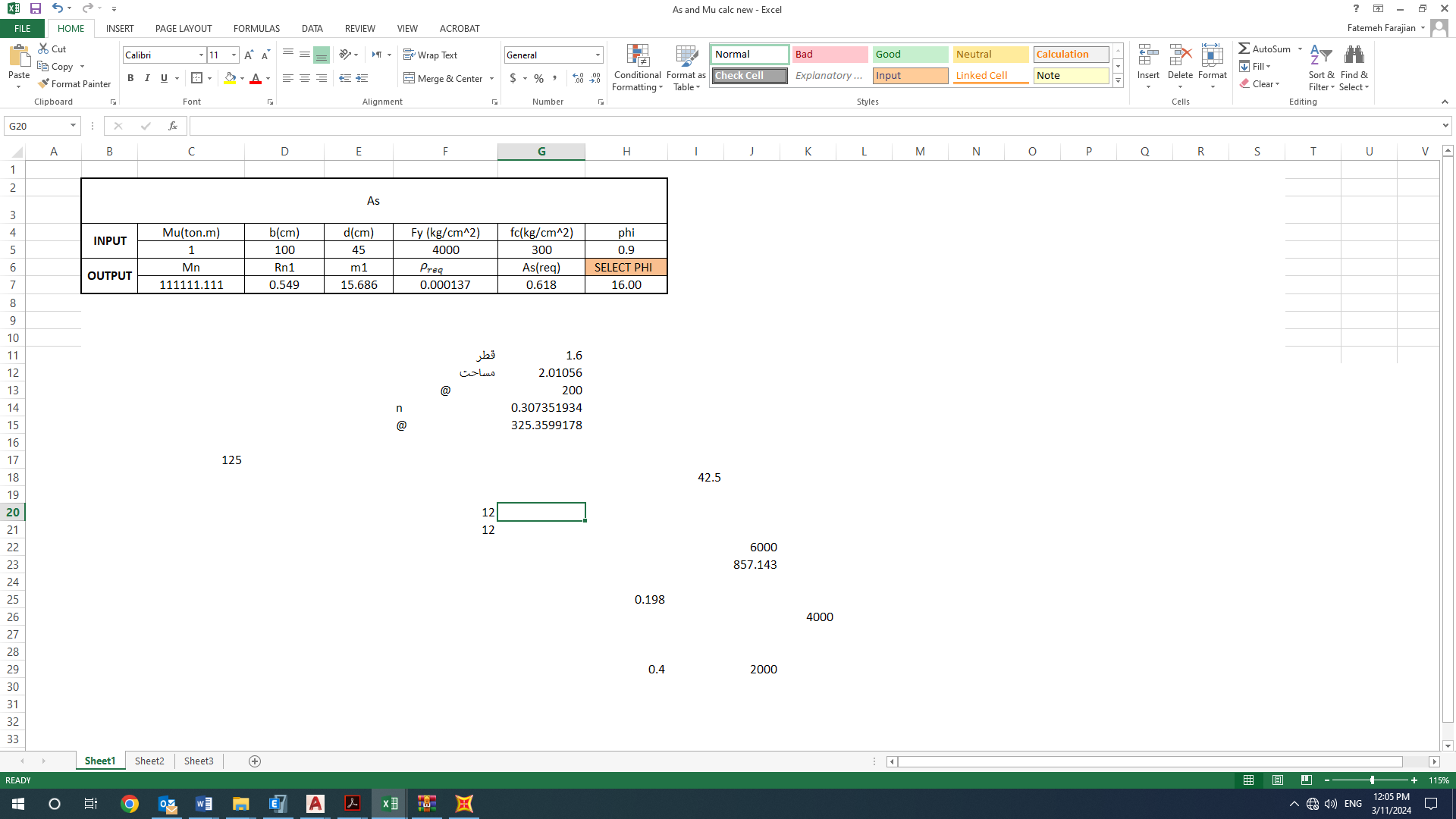
1. -applied soil pressure load

## 9.2. wall design

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



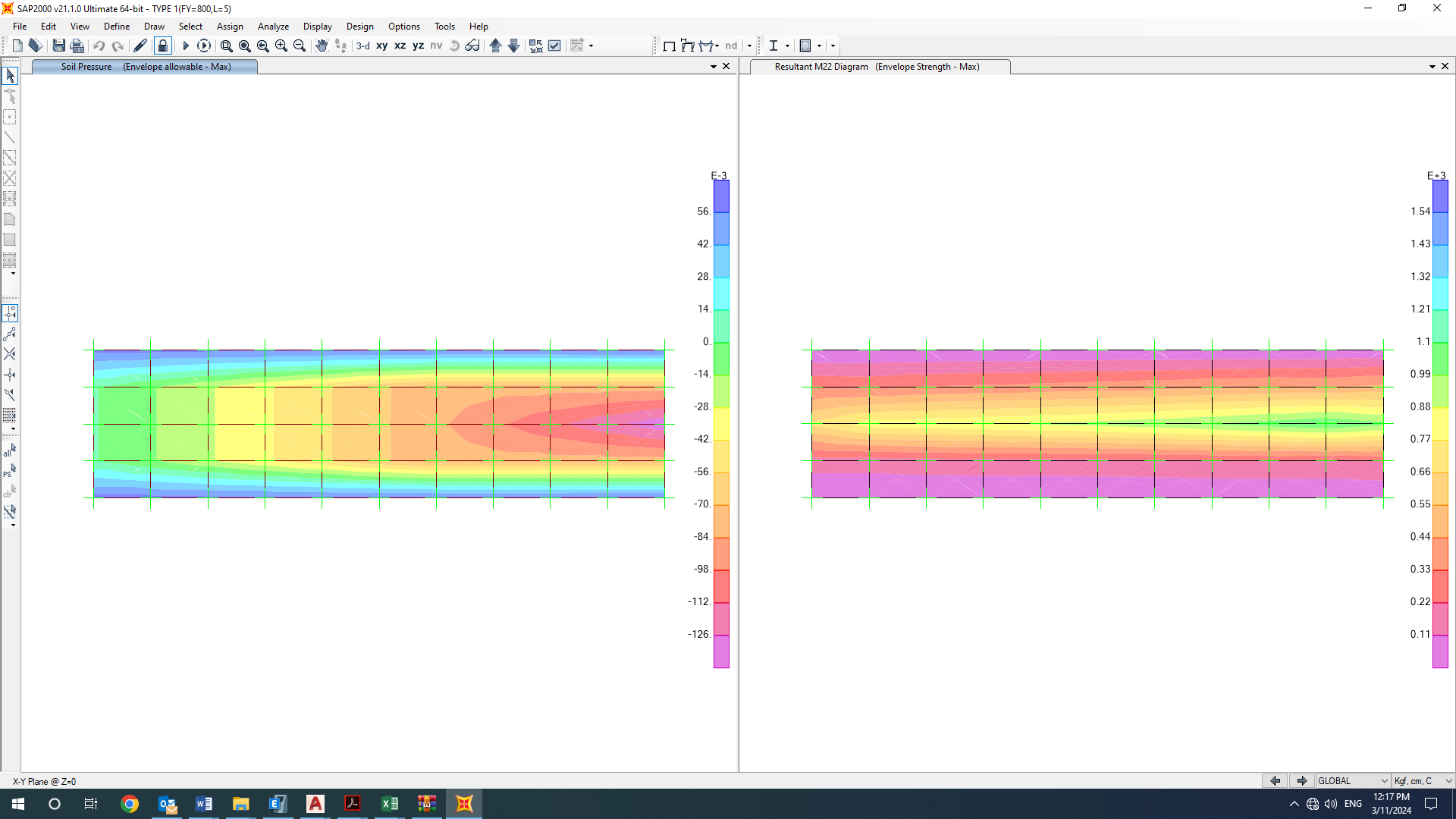
1. -Graphical output of Mmax(ton-m)



According to above output max Moment is about 100000 kg-cm

=0.618 cm2 << : uses Ø16@200 As=10.05cm2 ok

## 9.3 check of stress & settlement for foundation (500x130x30)



1. .stress diagram for foundation

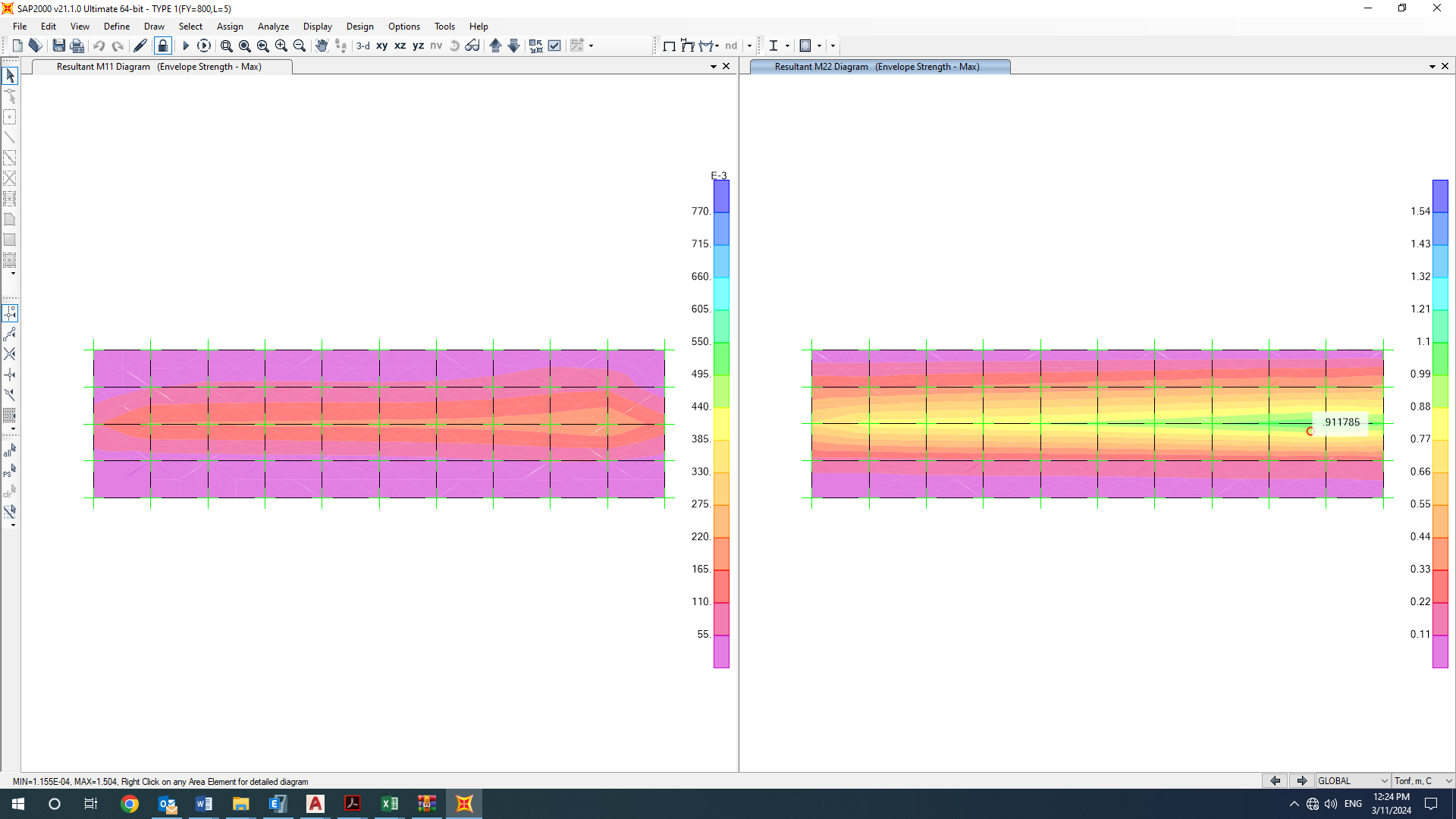
According to Sap results, the maximum soil stress under the foundation in combination ENV-Allowable is:

Foundation joints displacement under load combinations is as below:

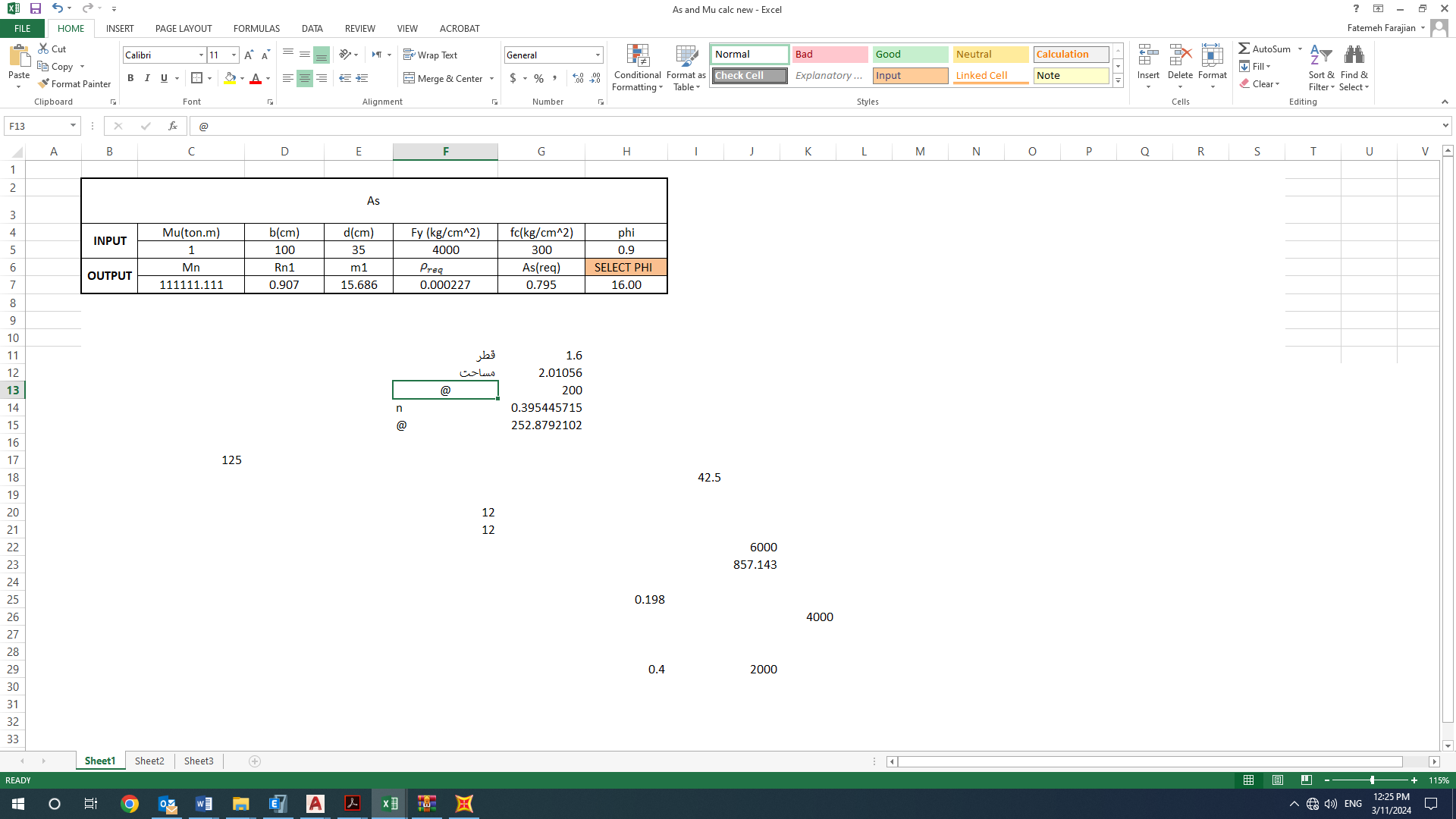
| **TABLE: Joint Displacements** | | | | |
| --- | --- | --- | --- | --- |
| **Joint** | **OutputCase** | **CaseType** | **StepType** | **U3** |
| Text | Text | Text | Text | cm |
| 1 | Envelope allowable | Combination | Max | 0.001352 |
| 1 | Envelope allowable | Combination | Min | -0.4161 |
| 2 | Envelope allowable | Combination | Max | -0.170046 |
| 2 | Envelope allowable | Combination | Min | -0.551104 |
| 5 | Envelope allowable | Combination | Max | -0.015787 |
| 5 | Envelope allowable | Combination | Min | -0.417207 |
| 13 | Envelope allowable | Combination | Max | -0.032925 |
| 13 | Envelope allowable | Combination | Min | -0.418319 |
| 18 | Envelope allowable | Combination | Max | -0.050061 |
| 18 | Envelope allowable | Combination | Min | -0.419431 |
| 23 | Envelope allowable | Combination | Max | -0.067196 |
| 23 | Envelope allowable | Combination | Min | -0.425989 |
| 28 | Envelope allowable | Combination | Max | -0.084332 |
| 28 | Envelope allowable | Combination | Min | -0.440615 |
| 33 | Envelope allowable | Combination | Max | -0.101468 |
| 33 | Envelope allowable | Combination | Min | -0.462689 |
| 38 | Envelope allowable | Combination | Max | -0.118608 |
| 38 | Envelope allowable | Combination | Min | -0.484777 |
| 43 | Envelope allowable | Combination | Max | -0.135751 |
| 43 | Envelope allowable | Combination | Min | -0.506877 |
| 48 | Envelope allowable | Combination | Max | -0.152896 |
| 48 | Envelope allowable | Combination | Min | -0.528987 |
| 56 | Envelope allowable | Combination | Max | 0.076759 |
| 56 | Envelope allowable | Combination | Min | -0.623787 |
| 57 | Envelope allowable | Combination | Max | 0.07708 |
| 57 | Envelope allowable | Combination | Min | -0.692865 |
| 58 | Envelope allowable | Combination | Max | 0.07708 |
| 58 | Envelope allowable | Combination | Min | -0.78599 |
| 59 | Envelope allowable | Combination | Max | 0.076759 |
| 59 | Envelope allowable | Combination | Min | -0.675953 |
| 60 | Envelope allowable | Combination | Max | 0.076774 |
| 60 | Envelope allowable | Combination | Min | -0.623797 |
| 61 | Envelope allowable | Combination | Max | 0.076774 |
| 61 | Envelope allowable | Combination | Min | -0.686926 |
| 62 | Envelope allowable | Combination | Max | 0.0768 |
| 62 | Envelope allowable | Combination | Min | -0.62382 |
| 63 | Envelope allowable | Combination | Max | 0.0768 |
| 63 | Envelope allowable | Combination | Min | -0.697911 |
| 64 | Envelope allowable | Combination | Max | 0.076834 |
| 64 | Envelope allowable | Combination | Min | -0.623854 |
| 65 | Envelope allowable | Combination | Max | 0.076834 |
| 65 | Envelope allowable | Combination | Min | -0.708906 |
| 66 | Envelope allowable | Combination | Max | 0.076875 |
| 66 | Envelope allowable | Combination | Min | -0.626875 |
| 67 | Envelope allowable | Combination | Max | 0.076875 |
| 67 | Envelope allowable | Combination | Min | -0.719907 |
| 68 | Envelope allowable | Combination | Max | 0.07692 |
| 68 | Envelope allowable | Combination | Min | -0.637864 |
| 69 | Envelope allowable | Combination | Max | 0.07692 |
| 69 | Envelope allowable | Combination | Min | -0.730915 |
| 70 | Envelope allowable | Combination | Max | 0.076967 |
| 70 | Envelope allowable | Combination | Min | -0.648857 |
| 71 | Envelope allowable | Combination | Max | 0.076967 |
| 71 | Envelope allowable | Combination | Min | -0.741931 |
| 72 | Envelope allowable | Combination | Max | 0.07701 |
| 72 | Envelope allowable | Combination | Min | -0.659856 |
| 73 | Envelope allowable | Combination | Max | 0.07701 |
| 73 | Envelope allowable | Combination | Min | -0.75295 |
| 74 | Envelope allowable | Combination | Max | 0.077045 |
| 74 | Envelope allowable | Combination | Min | -0.670858 |
| 75 | Envelope allowable | Combination | Max | 0.077045 |
| 75 | Envelope allowable | Combination | Min | -0.763968 |
| 76 | Envelope allowable | Combination | Max | 0.077067 |
| 76 | Envelope allowable | Combination | Min | -0.68186 |
| 77 | Envelope allowable | Combination | Max | 0.077067 |
| 77 | Envelope allowable | Combination | Min | -0.774979 |
| 108 | Envelope allowable | Combination | Max | -0.015784 |
| 108 | Envelope allowable | Combination | Min | -0.485873 |
| 109 | Envelope allowable | Combination | Max | 0.001353 |
| 109 | Envelope allowable | Combination | Min | -0.478664 |
| 110 | Envelope allowable | Combination | Max | -0.015784 |
| 110 | Envelope allowable | Combination | Min | -0.532374 |
| 111 | Envelope allowable | Combination | Max | 0.001353 |
| 111 | Envelope allowable | Combination | Min | -0.521404 |
| 112 | Envelope allowable | Combination | Max | -0.03292 |
| 112 | Envelope allowable | Combination | Min | -0.496846 |
| 113 | Envelope allowable | Combination | Max | -0.03292 |
| 113 | Envelope allowable | Combination | Min | -0.543352 |
| 114 | Envelope allowable | Combination | Max | -0.050054 |
| 114 | Envelope allowable | Combination | Min | -0.507821 |
| 115 | Envelope allowable | Combination | Max | -0.050054 |
| 115 | Envelope allowable | Combination | Min | -0.554333 |
| 116 | Envelope allowable | Combination | Max | -0.067187 |
| 116 | Envelope allowable | Combination | Min | -0.518798 |
| 117 | Envelope allowable | Combination | Max | -0.067187 |
| 117 | Envelope allowable | Combination | Min | -0.565318 |
| 118 | Envelope allowable | Combination | Max | -0.08432 |
| 118 | Envelope allowable | Combination | Min | -0.529777 |
| 119 | Envelope allowable | Combination | Max | -0.08432 |
| 119 | Envelope allowable | Combination | Min | -0.576308 |
| 120 | Envelope allowable | Combination | Max | -0.098278 |
| 120 | Envelope allowable | Combination | Min | -0.540762 |
| 121 | Envelope allowable | Combination | Max | -0.098278 |
| 121 | Envelope allowable | Combination | Min | -0.587304 |
| 122 | Envelope allowable | Combination | Max | -0.098256 |
| 122 | Envelope allowable | Combination | Min | -0.551753 |
| 123 | Envelope allowable | Combination | Max | -0.098256 |
| 123 | Envelope allowable | Combination | Min | -0.598305 |
| 124 | Envelope allowable | Combination | Max | -0.098238 |
| 124 | Envelope allowable | Combination | Min | -0.562749 |
| 125 | Envelope allowable | Combination | Max | -0.098238 |
| 125 | Envelope allowable | Combination | Min | -0.60931 |
| 126 | Envelope allowable | Combination | Max | -0.098227 |
| 126 | Envelope allowable | Combination | Min | -0.573747 |
| 127 | Envelope allowable | Combination | Max | -0.098227 |
| 127 | Envelope allowable | Combination | Min | -0.620312 |
| 128 | Envelope allowable | Combination | Max | -0.098221 |
| 128 | Envelope allowable | Combination | Min | -0.58475 |
| 129 | Envelope allowable | Combination | Max | -0.098221 |
| 129 | Envelope allowable | Combination | Min | -0.631319 |
|  |  |  | Max | 0.07708 |
|  |  |  | Min | -0.78599 |

According to above sap 2000 results, the maximum soil displacement under the foundation in combination ENV-COMB is:

## 9.4. foundation REINFORCING CONTROL



1. stress diagram for foundation



=0.892cm2 << : uses Ø16@200 As=10.05cm2 ok

## 9.5. OVERTURNING and sliding CONTROL CALCULATION

|  |  |  |  |
| --- | --- | --- | --- |
| **input data** | | | |
| foundation | L | 5 | length(m) |
| B | 1.3 | width(m) |
| t | 0.4 | Th.(m) |
| wall | L | 5 | length(m) |
| t | 0.5 | Th.(m) |
| H | 1.1 | height(m) |
| soil & concrete parameter | y | 1.85 | soil density(ton/m30 |
| kp | 3 |  |
| ka | 0.33 |  |
| v | 0.35 | poisson |
|  | 0.35 | friction Coe.(soil-con) |
| |  | | --- | | Fc | | 300 | kg/cm2 |
|  | 2.5 | concrete density(ton/m3) |
| h | 0.6 | soil height on foundation(m) |
| loading parameter | x | 0 | SUS(ton) |
| y | 0 |
| z | 0 |
| x | 1.56 | OPE(ton) |
| y | 0.44 |
| z | 0.47 |
| x | 0 | OCC(ton) |
| y | 1.24 |
| z | 1.23 |

|  |  |  |  |
| --- | --- | --- | --- |
| **output data** | | | |
| foundation weight | Wf | 6.50 | ton |
| wall weight (ton) | Ww | 6.88 | ton |
| soil weight on foundation(ton) | Ws | 4.44 | ton |
| passive pressure ( y direction | Pp | 16.10 | ton |
| passive pressure ( x direction | Pp | 0.58 | ton |
| active | Pa | 0.00 | ton |
| total ope load (Z) on wall | DL | 0.47 | ton |
| overturning arm in side 1 | L1 | 2.50 | m |
| overturning arm in side 2 | L2 | 0.65 | m |
| D+L | Fx | 1.56 | ton |
| Fy | 0.44 | ton |
| D+0.75L+0.75E | Fx | 1.56 | ton |
| Fy | 2.49 | ton |
| M resistance | Mx | 17.25 | ton.m |
| My | 45.79 | ton.m |
| M assigned | Mx | 3.74 | ton.m |
| My | 2.34 | ton.m |
| Overturning Control (X Dir) |  | 19.57 | OK |
| Overturning Control (Y Dir) |  | 4.62 | OK |
| Sliding Control (X Dir) |  | 4.47 | OK |
| Sliding Control (Y Dir) |  | 9.03 | OK |