|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **طرح نگهداشت و افزایش تولید 27 مخزن** | | | | | | | |
| **Calculation Note for Tank Foundation (TK-2301 A/B)**  **نگهداشت و افزایش تولید میدان نفتی بینک** | | | | | | | |
|  | |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |
| D02 | | FEB. 2024 | IFA | R.Berlouie | M.Fakharian | S.Faramarzpour |  |
| D01 | | OCT. 2023 | IFA | R.Berlouie | M.Fakharian | S.Faramarzpour |  |
| D00 | | SEP. 2023 | IFC | R.Berlouie | M.Fakharian | A.M.Mohseni |  |
| **Rev.** | | **Date** | **Purpose of Issue/Status** | **Prepared by:** | **Checked by:** | **Approved by:** | **CLIENT Approval** |
| **Class:2** | | | **COMPANY Doc. Number:** **F0Z-709122** | | | | |
| **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 |  |  | **66** |  |  |  |  |  |
| **2** | X | X | X |  |  | **67** |  |  |  |  |  |
| **3** | X | X |  |  |  | **68** |  |  |  |  |  |
| **4** | X |  |  |  |  | **69** |  |  |  |  |  |
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| **6** | X |  | X |  |  | **71** |  |  |  |  |  |
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| **13** | X |  | X |  |  | **78** |  |  |  |  |  |
| **14** | X |  |  |  |  | **79** |  |  |  |  |  |
| **15** | X |  |  |  |  | **80** |  |  |  |  |  |
| **16** | X |  | X |  |  | **81** |  |  |  |  |  |
| **17** | X |  | X |  |  | **82** |  |  |  |  |  |
| **18** | X |  |  |  |  | **83** |  |  |  |  |  |
| **19** | X |  |  |  |  | **84** |  |  |  |  |  |
| **20** | X |  |  |  |  | **85** |  |  |  |  |  |
| **21** | X |  |  |  |  | **86** |  |  |  |  |  |
| **22** | X |  | X |  |  | **87** |  |  |  |  |  |
| **23** | X |  |  |  |  | **88** |  |  |  |  |  |
| **24** | X |  |  |  |  | **89** |  |  |  |  |  |
| **25** |  | X |  |  |  | **90** |  |  |  |  |  |
| **26** |  | X |  |  |  | **91** |  |  |  |  |  |
| **27** |  | X |  |  |  | **92** |  |  |  |  |  |
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**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 design of Fire Water Storage Tanks (TK-2301A/B). The calculation of foundation is performed using “SAP” software.

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-GNRAL-PEDCO-000-ST-DC-0001 Structural Design Criteria
* BK-GNRAL-PEDCO-000-CV-SP-0004 Specification For Earth Work
* BK-GCS-PEDCO-120-GT-RT-0001 Geotechnical Investigation Report for Compressor Station

1. **Material properties**

Material properties are delivered in the following table.

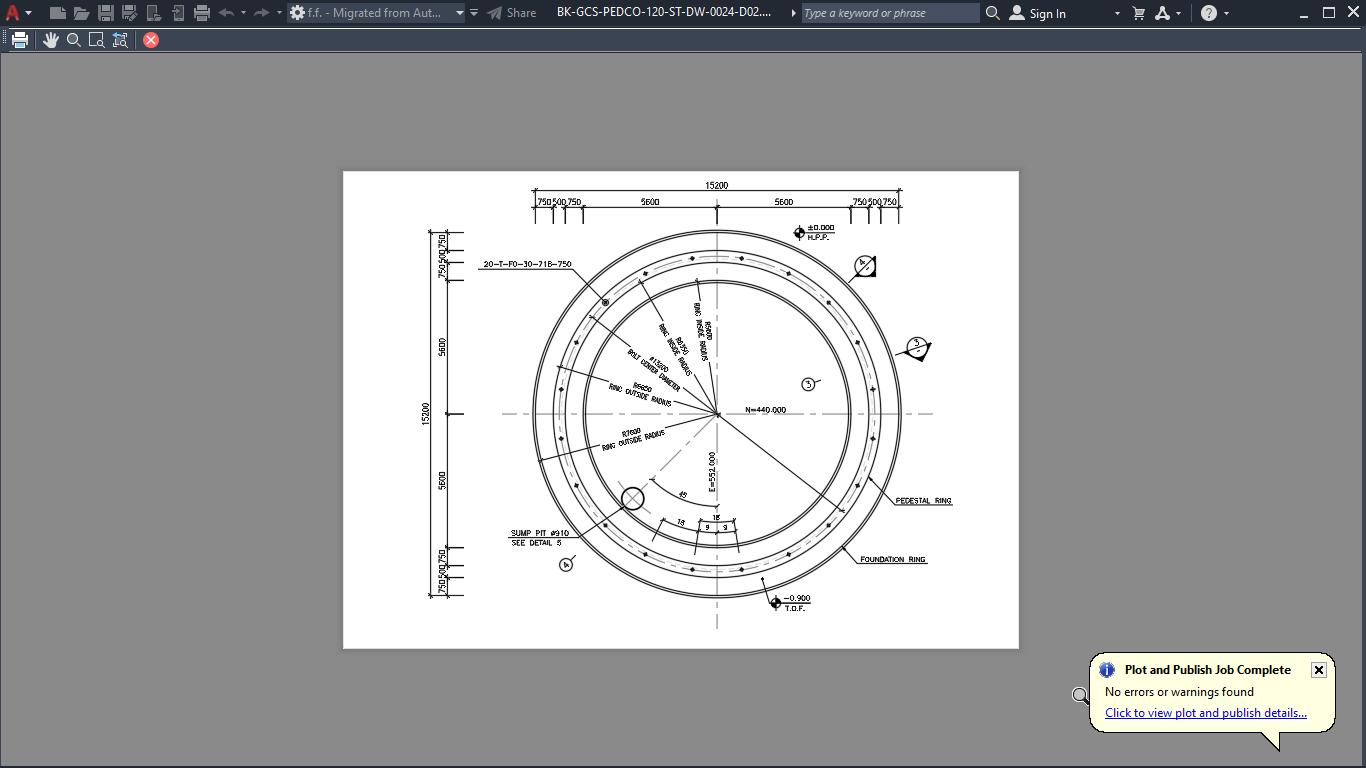
|  |  |
| --- | --- |
| Material properties | |
| Structure and Foundation concrete | F’c=300kg/cm²(28 days cylindrical sample) |
| Long. Reinforcement | Fy=4000 kg/cm² (AIII) |
| Trans. Reinforcement | Fy=4000 kg/cm² (AIII) |

1. **Computer software**

Computer’s Software, which is used in structure and foundation analysis and design, are defined in the following table.

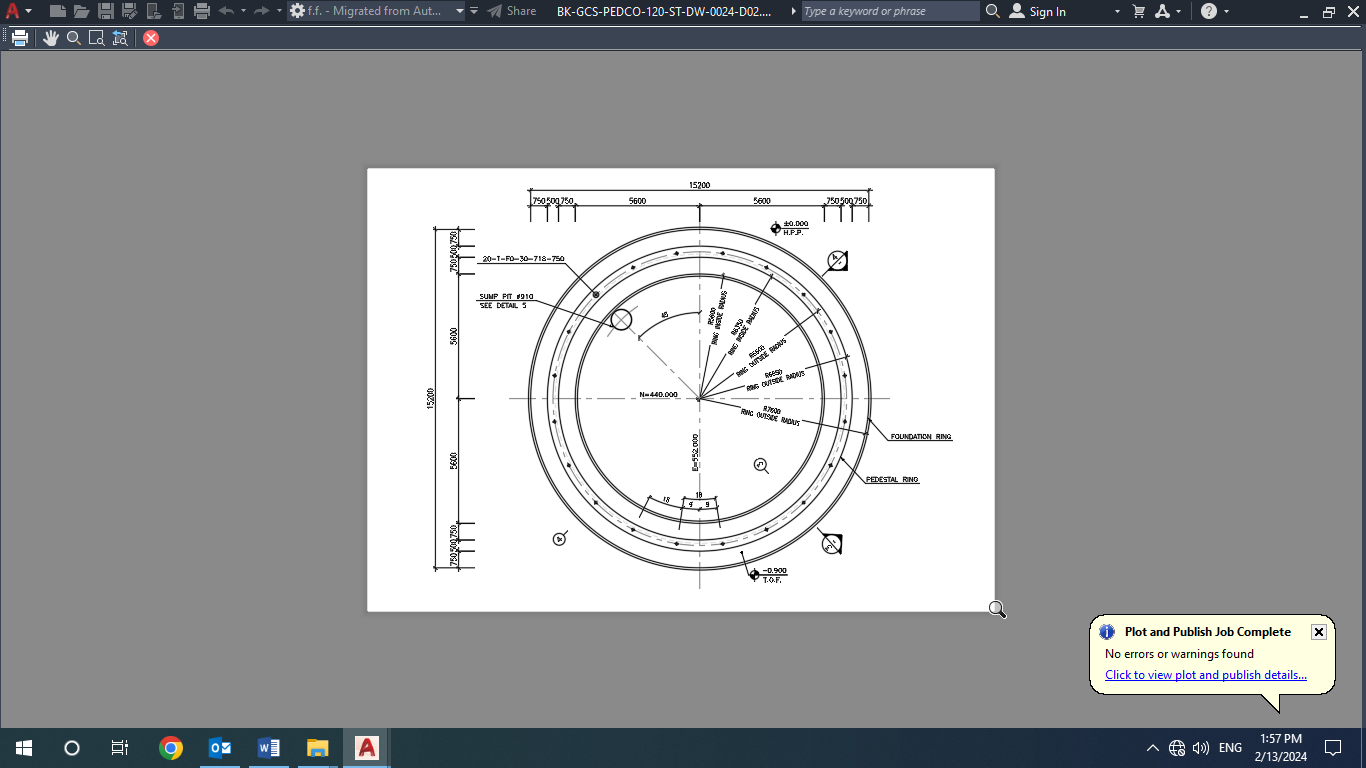
|  |  |
| --- | --- |
| Computer software | |
| analysis and design of structure and foundation | SAP 20.1.0 |

1. **Geometry**



D02

1. **foundation and pedestal plan for TK-2301-A**



1. **foundation and pedestal plan for TK-2301-B**
2. **DESIGN LOAD**
   1. Load case for tank foundation design

The loads that apply on the foundation, according to tank design report (annex I), are as following:

|  |  |
| --- | --- |
| **Empty Weight:** | **45283 kg** |
| **Operating Weight:** | **1085283 kg** |
| **Hydro test Weight:** | **1085283 kg** |
| **Wind Shear:** | **110468 N** |
| **Wind Moment:** | **716860 N.m** |
| **Seismic Shear:** | **1151613 N** |
| **Seismic Moment:** | **3679379 N.m** |

* 1. **Ds (Total Dead Load of Structure and Foundation & Soil overburden)**

Soil overburden:

Inside of Ring wall = 1.85 × 1.5 = 2.78 t/m²

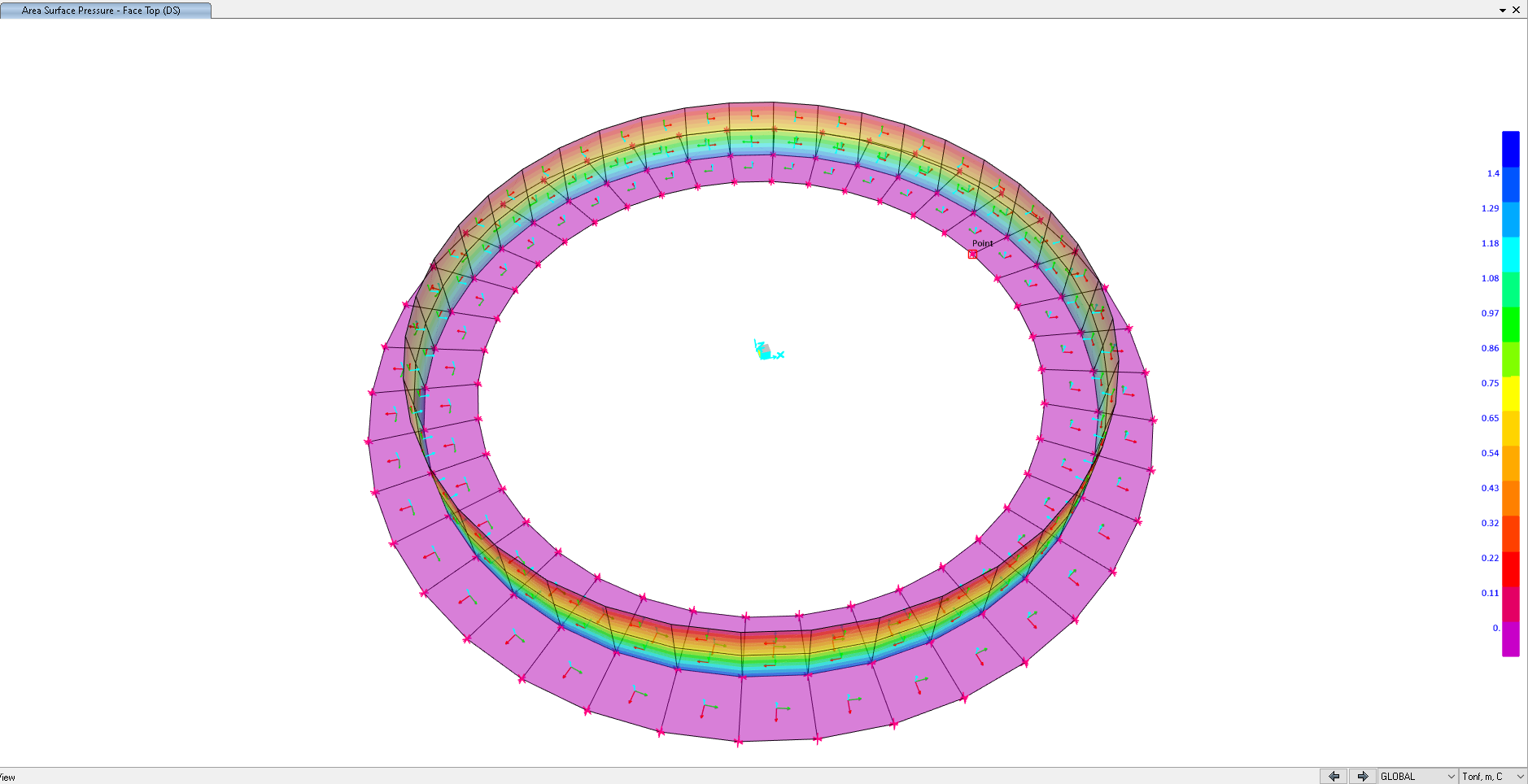
Outside of Ring wall = 1.85 × 0.9 = 1.67 t/m²

Top of Pedestal = +0.60

Top of Foundation= -0.90

Soil Pressure on Ring wall:

Ds = 0.5 × 1.85 × (1.5) = 1.40 ton/m²



1. **area surface pressure for ring wall (face top)**
   1. **De (Total dead load of tank)**

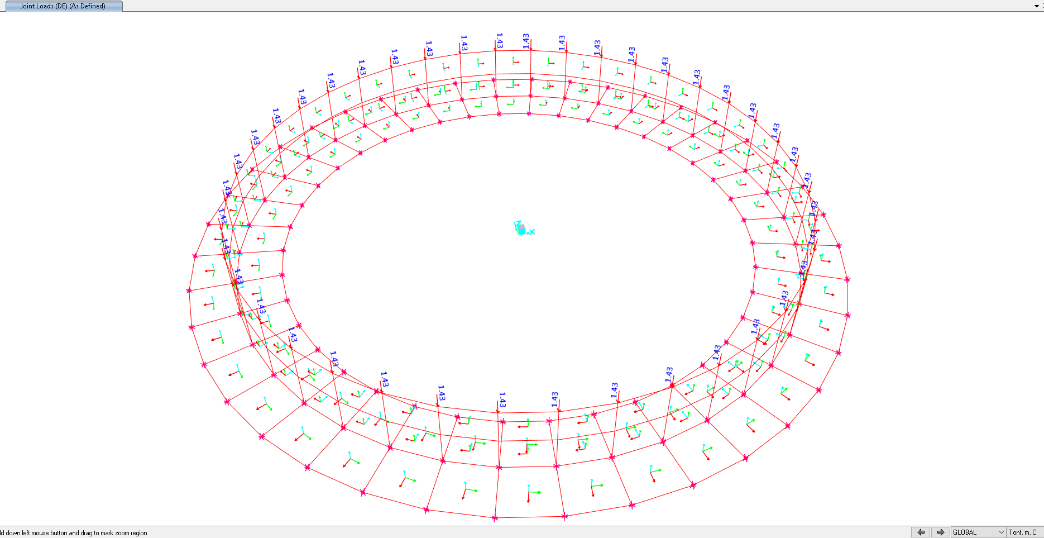
Weight of empty tank: 45.283 ton

Weight of bottom plate: 9.353 ton

Weight of roof plate: 11.98 ton

Weight of shell with roof: 45.283 + 11.98 = 57.265 ton

De = 57.265/40(joint) = 1.43 ton

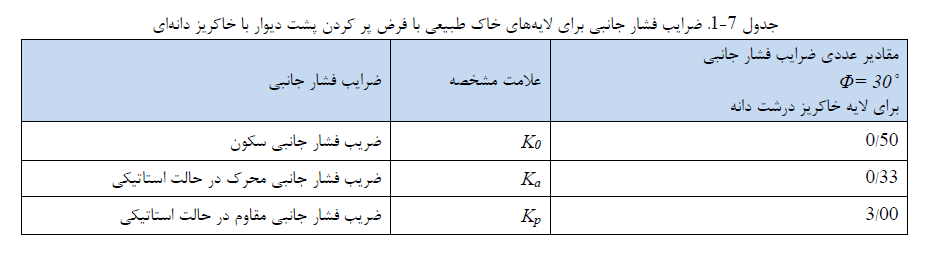


1. **joint load on ring wall** 
   1. **F (Normal Fluid Load)**

D02

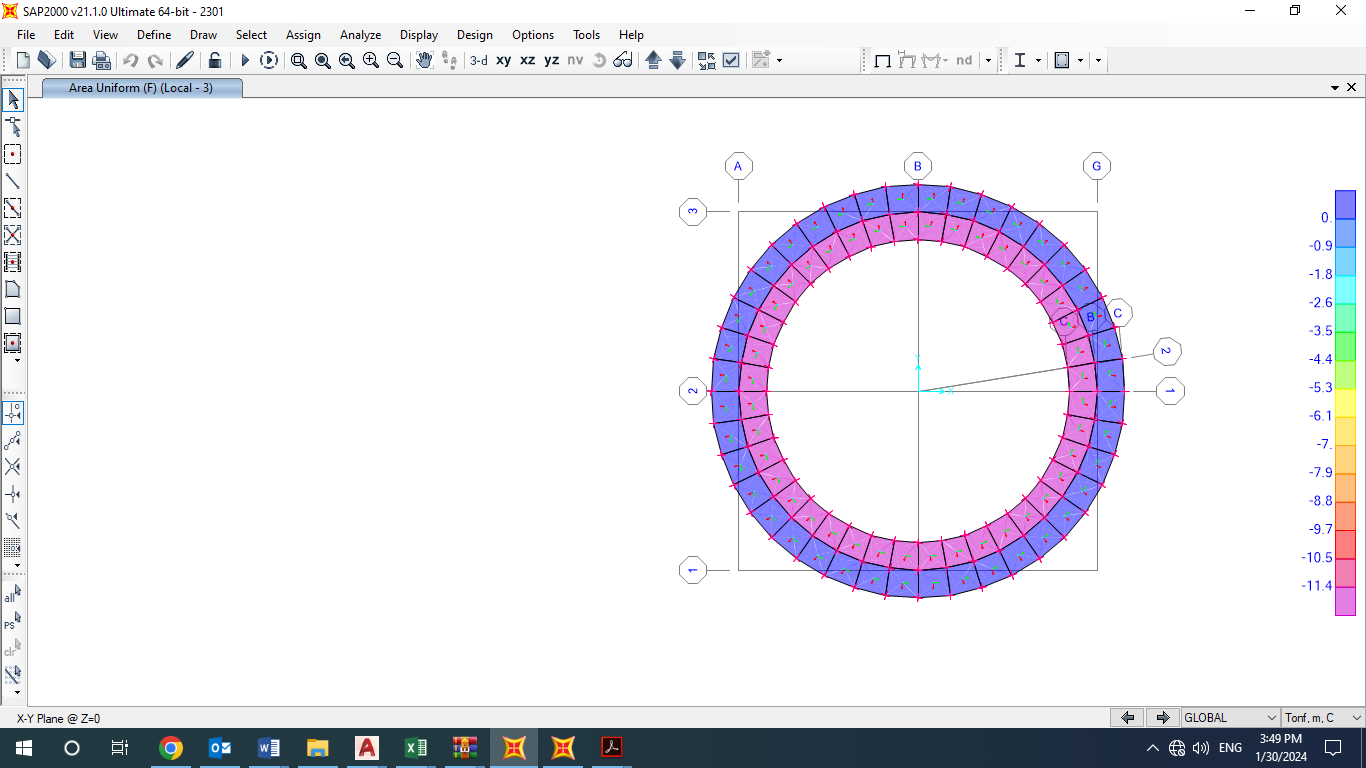
Normal Fluid Load on ring foundation:

F = Ope load / area of ring foundation → area of ring foundation: (𝜋 × 13²)/4- (𝜋 × 11²)/4 = 95 m2 → 1085283/ 95 = 11.42 ton/m²

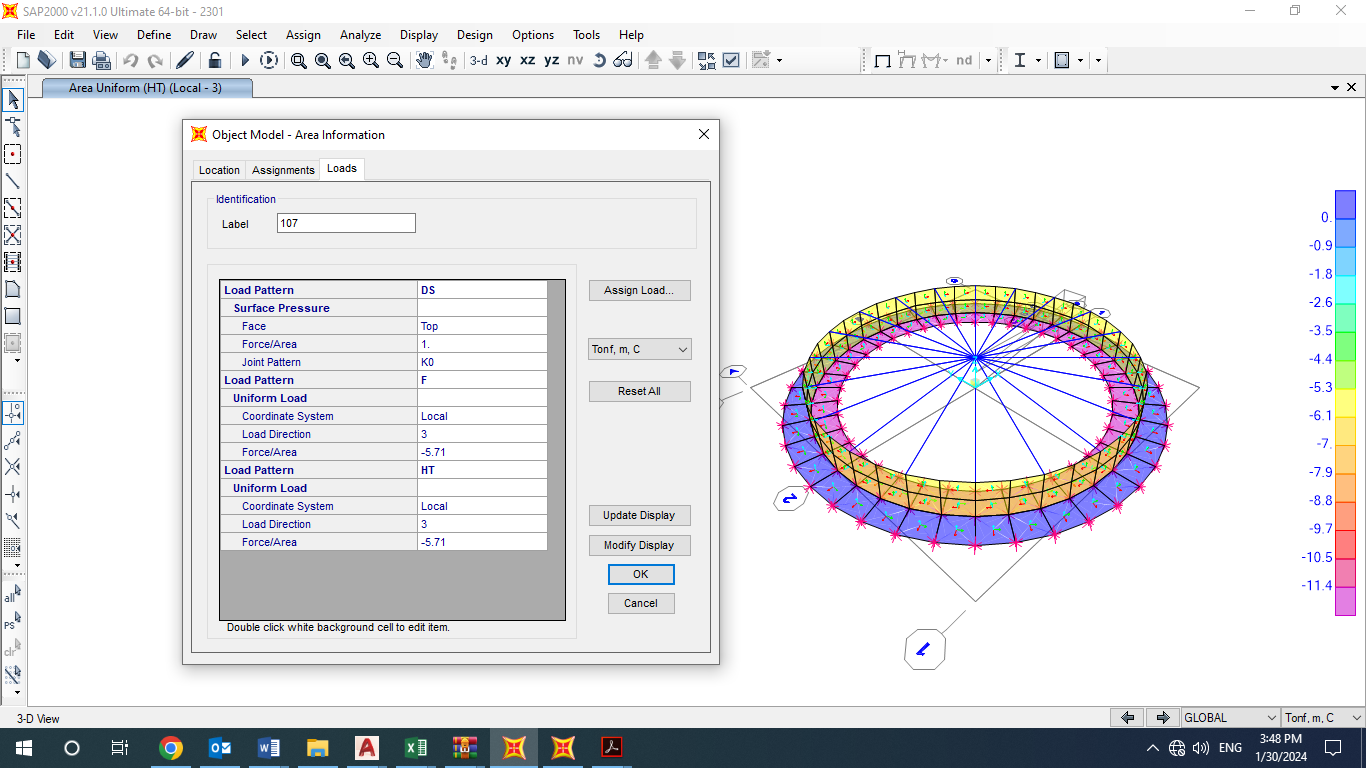


Soil Pressure Due to Normal Fluid Load on Ring wall:

F = 11.42 × (Kₒ = 0.5) = 5.71 t/m²



1. **Area uniform F load on the inside ring foundation**



1. **Area uniform F load on the ring wall** 
   1. **HT (Test Fluid Load)**

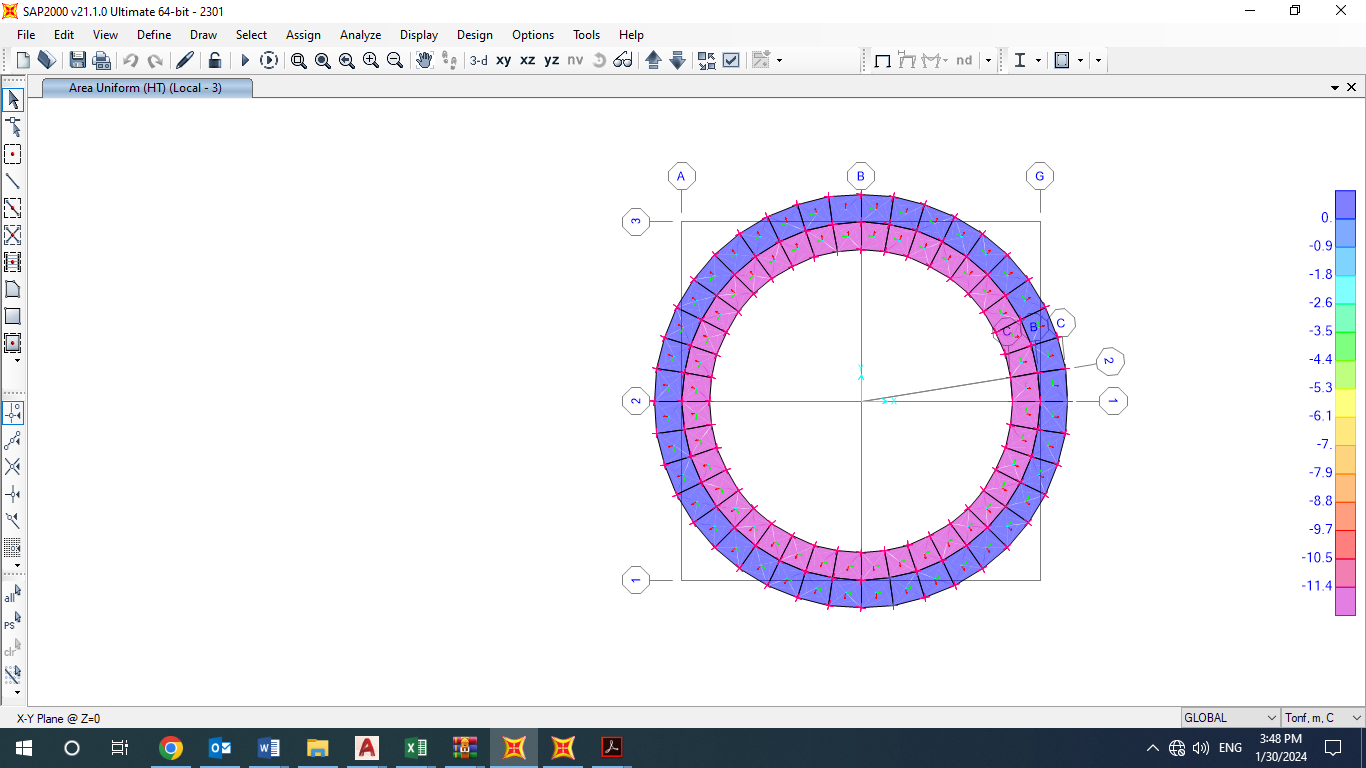
Test Load on ring foundation:

HT = Hydro test load / area of ring foundation → area of ring foundation: (𝜋 × 13²)/4- (𝜋 × 11²)/4 = 95 m2 → 1085283/ 95 = 11.42 ton/m²

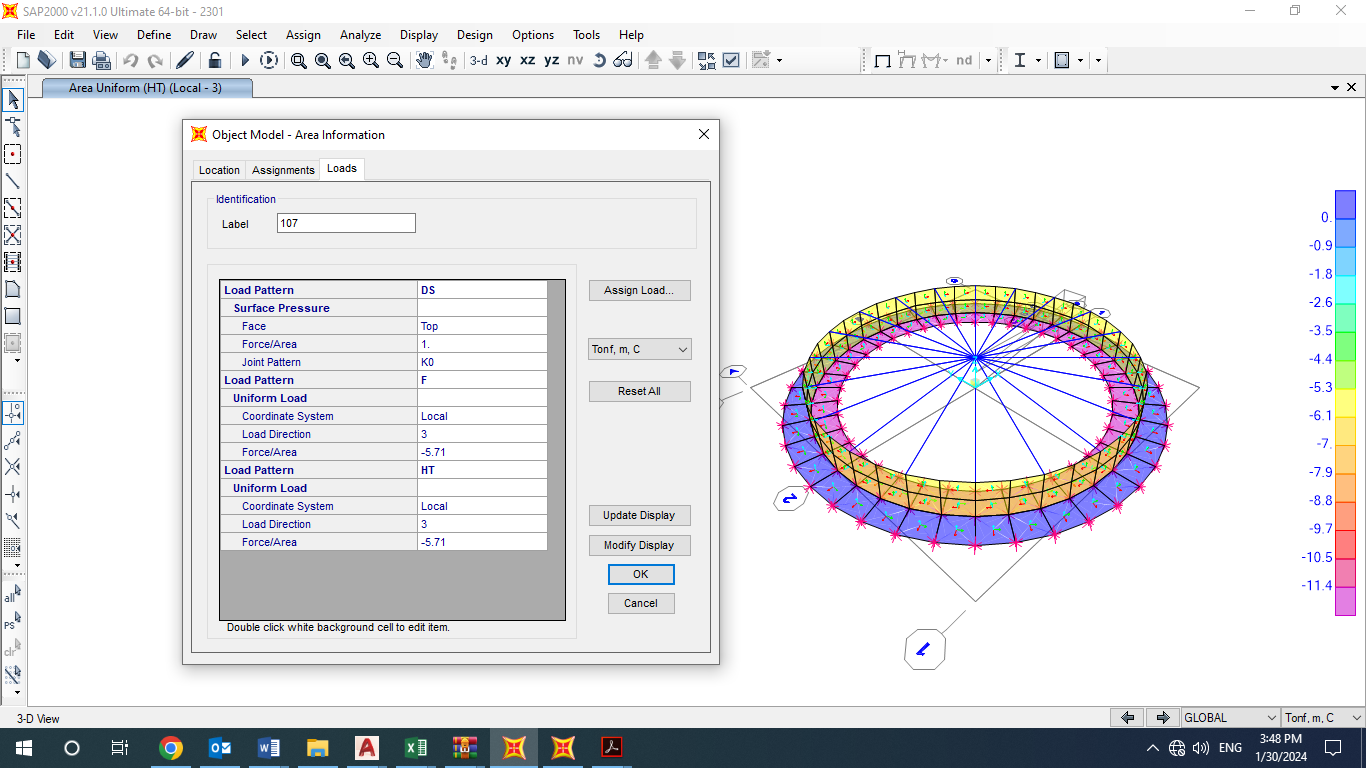
Soil Pressure Due to Test Fluid Load on Ring wall:

D02

HT = 11.42 × (Kₒ = 0.5) = 5.71 t/m²



1. **area uniform HT load on the inside ring foundation**



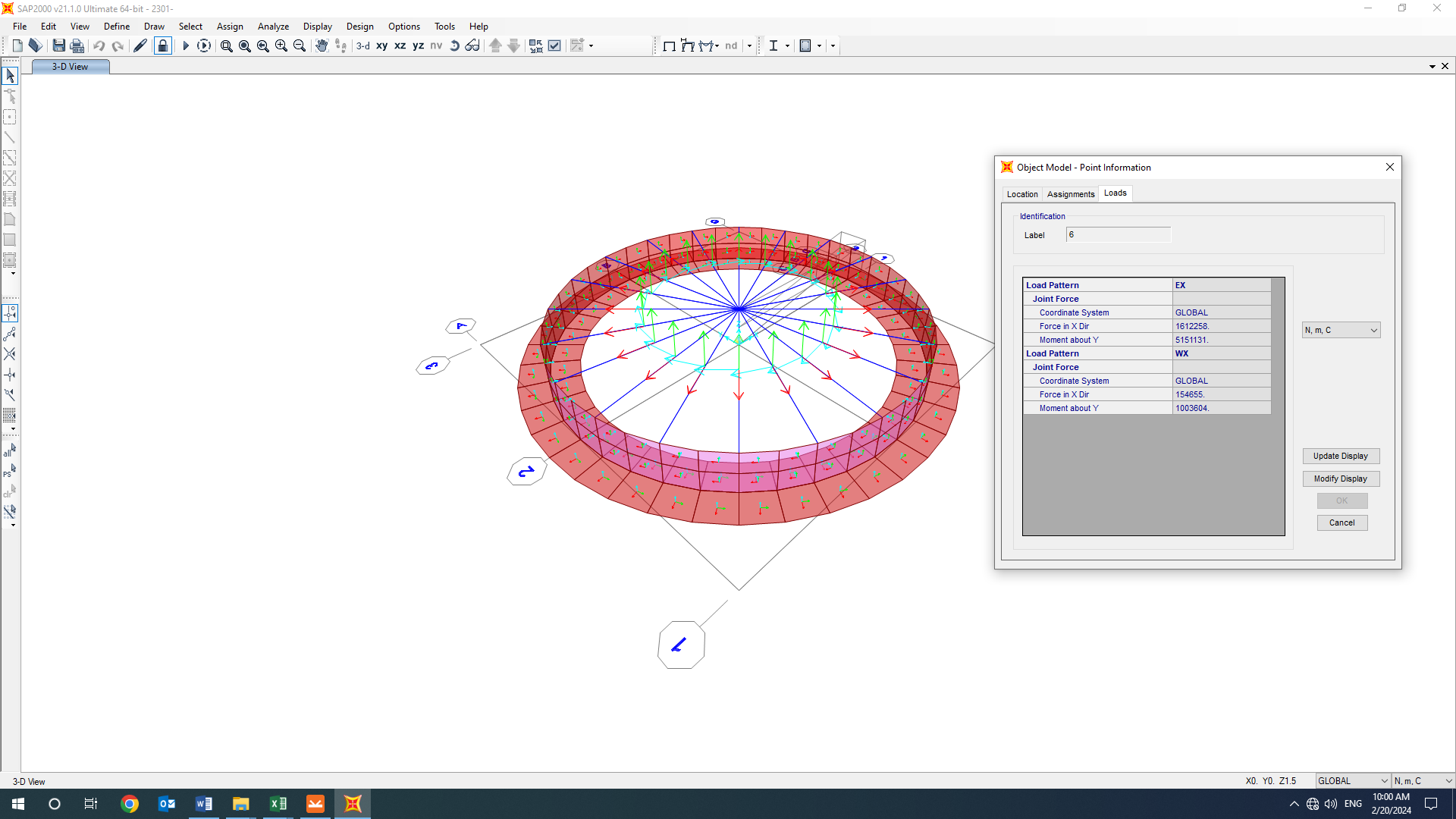
1. **area uniform HT load on the ring wall** 
   1. **E (Earthquake Load)**

Shear load = 1151613 N (based on Mechanical Data Sheet for fire water storage Tanks (TK-2301 A/B).

This shear is based on the datasheet, but we used API650 with ASD behavior coefficient so its value is multiplied by 1.4 → 1151613  1.4 = 1612258 N

Moment = 3679379 N.m (based on Mechanical Data Sheet for fire water storage Tanks (TK-2301 A/B).

This moment is based on the datasheet, but we used API650 with ASD behavior coefficient so its value is multiplied by 1.4 → 3679379  1.4 = 5151131 N.m



D02

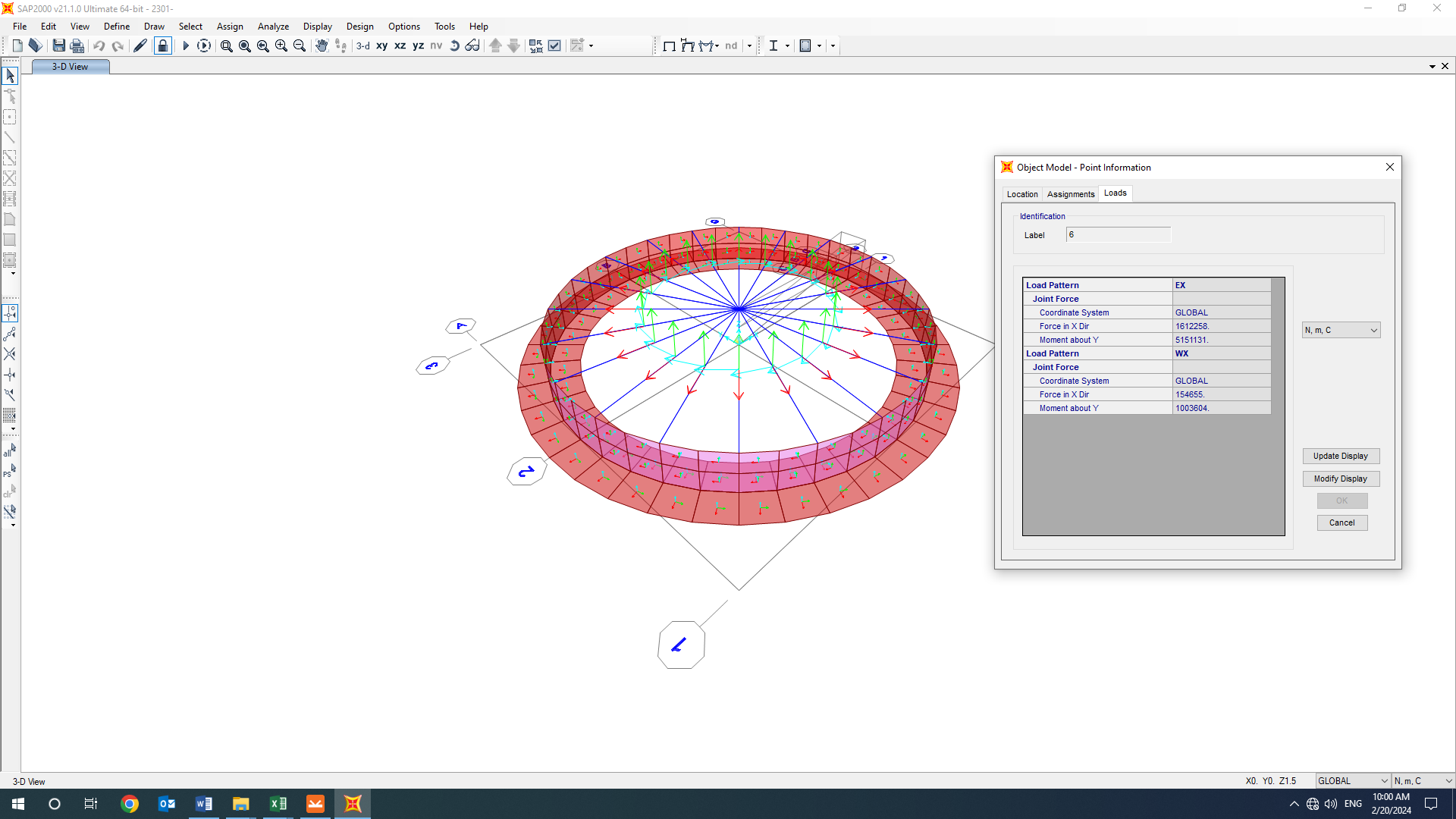
1. **Earthquake Load (EX)**
   1. **W (Wind Load)**

Shear load = 110468 N (based on Mechanical Data Sheet for fire water storage Tanks (TK-2301 A/B).

This shear is based on the datasheet, but we used API650 with ASD behavior coefficient so its value is multiplied by 1.4 → 110468  1.4 = 154655 N

Moment = 716860 N.m (based on Mechanical Data Sheet for fire water storage Tanks (TK-2301 A/B).

This moment is based on the datasheet, but we used API650 with ASD behavior coefficient so its value is multiplied by 1.4 → 716860  1.4 = 1003604 N.m

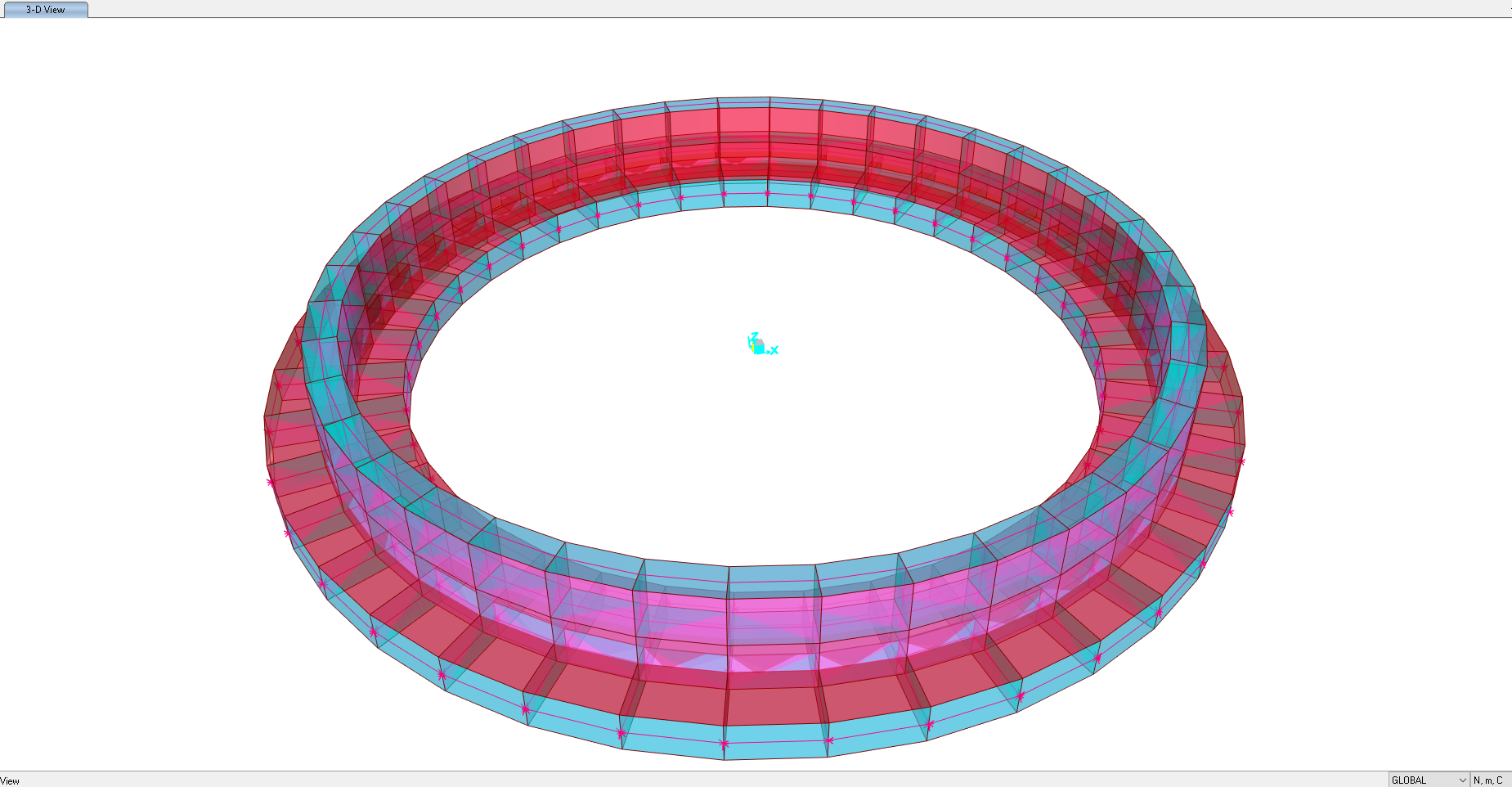


1. **Wind load (WX)**
2. **Design Load Combinations**

| **Load Assignments** | | | |
| --- | --- | --- | --- |
| **Case** | **LoadType** | **LoadName** | **LoadSF** |
| Text | Text | Text | Unitless |
| A.A.O.1-NL | Load pattern | DE | 1 |
| Load pattern | DL | 1 |
| Load pattern | DS | 1 |
| Load pattern | F | 1 |
| A.A.O.2-NL | Load pattern | DE | 1 |
| Load pattern | DL | 1 |
| Load pattern | DS | 1 |
| Load pattern | F | 1 |
| Load pattern | WX | 1 |
| A.B.T.1-NL | Load pattern | DL | 1 |
| Load pattern | DE | 1 |
| Load pattern | DS | 1 |
| Load pattern | HT | 1 |
| Load pattern | WX | 0.25 |
| A.B.T.2-NL | Load pattern | DL | 0.6 |
| Load pattern | DE | 0.6 |
| Load pattern | DS | 0.6 |
| Load pattern | HT | 0.6 |
| Load pattern | WX | 0.25 |
| A.C.E.1-NL | Load pattern | DL | 1 |
| Load pattern | DE | 1 |
| Load pattern | DS | 1 |
| Load pattern | WX | 1 |
| A.C.E.2-NL | Load pattern | DL | 0.6 |
| Load pattern | DE | 0.6 |
| Load pattern | DS | 0.6 |
| Load pattern | WX | 1 |
| A.D.E.1-NL | Load pattern | DL | 1 |
| Load pattern | DS | 1 |
| Load pattern | DE | 1 |
| Load pattern | F | 1 |
| Load pattern | EX | 0.7 |
| A.D.E.2-NL | Load pattern | DL | 0.6 |
| Load pattern | DS | 0.6 |
| Load pattern | DE | 0.6 |
| Load pattern | F | 0.6 |
| Load pattern | EX | 0.7 |
| S.A.O.1-NL | Load pattern | DL | 1.4 |
| Load pattern | DS | 1.4 |
| Load pattern | DE | 1.4 |
| Load pattern | F | 1.4 |
| S.A.O.2-NL | Load pattern | DL | 1.2 |
| Load pattern | DS | 1.2 |
| Load pattern | DE | 1.2 |
| Load pattern | F | 1.2 |
| Load pattern | WX | 1 |
| S.A.O.3-NL | Load pattern | DL | 0.9 |
| Load pattern | DS | 0.9 |
| Load pattern | DE | 0.9 |
| Load pattern | F | 0.9 |
| Load pattern | WX | 1 |
| S.B.T.1-NL | Load pattern | DL | 1.2 |
| Load pattern | DE | 1.2 |
| Load pattern | DS | 1.2 |
| Load pattern | HT | 1.2 |
| Load pattern | WX | 0.25 |
| S.B.T.2-NL | Load pattern | DL | 0.9 |
| Load pattern | DE | 0.9 |
| Load pattern | DS | 0.9 |
| Load pattern | HT | 0.9 |
| Load pattern | WX | 0.25 |
| S.C.E.1-NL | Load pattern | DE | 1.2 |
| Load pattern | DL | 1.2 |
| Load pattern | DS | 1.2 |
| Load pattern | WX | 1 |
| S.C.E.2-NL | Load pattern | DE | 0.9 |
| Load pattern | DL | 0.9 |
| Load pattern | DS | 0.9 |
| Load pattern | WX | 1 |
| S.D.E.1-NL | Load pattern | DE | 1.2 |
| Load pattern | DL | 1.2 |
| Load pattern | DS | 1.2 |
| Load pattern | F | 1.2 |
| Load pattern | EX | 1 |
| S.D.E.2-NL | Load pattern | DE | 0.9 |
| Load pattern | DL | 0.9 |
| Load pattern | DS | 0.9 |
| Load pattern | F | 0.9 |
| Load pattern | EX | 1 |

1. **Tank ANALYSIS AND DESIGN** 
   1. **Tank geometry**

As noted before, the structure has modelled and analysed by SAP2000. This figure shows a 3D view of the model in software.



1. **3D model** 
   1. **Tank Design Results**



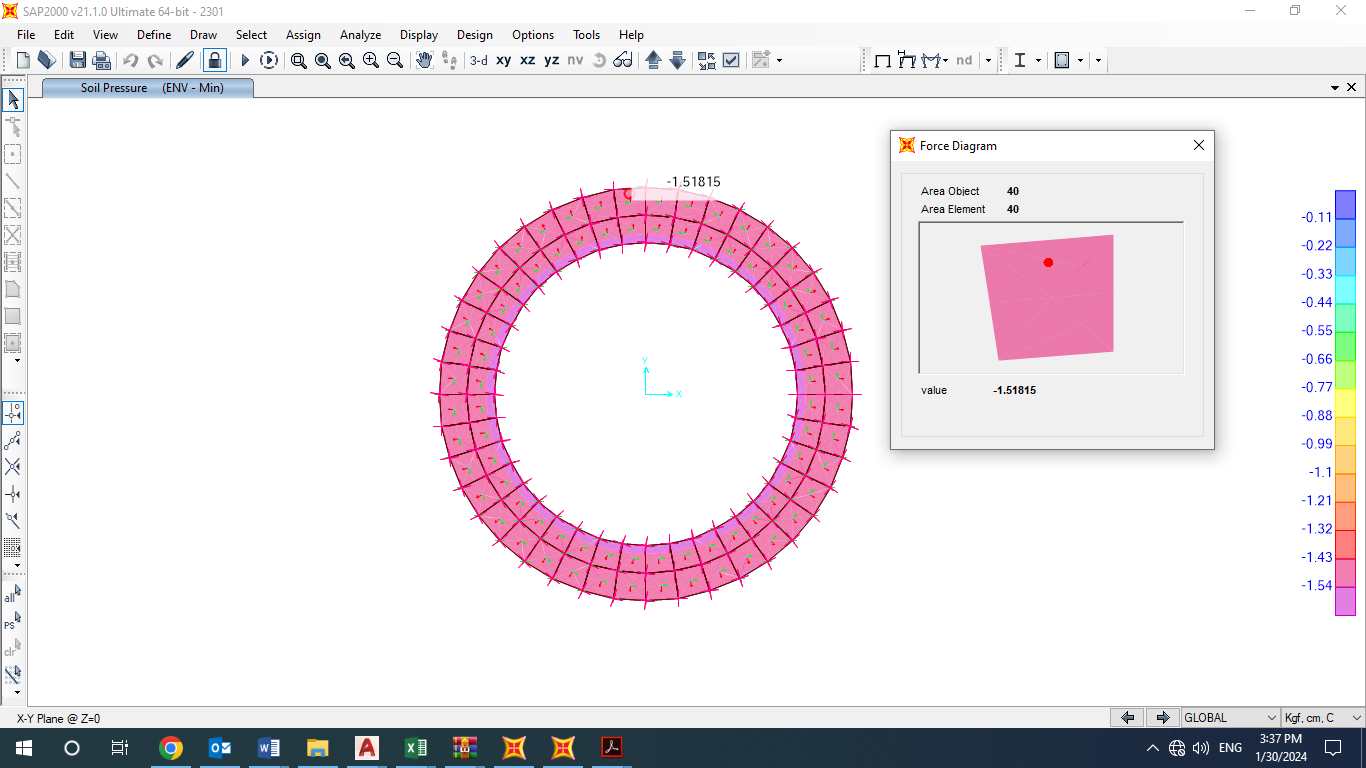




10. 2. 1. Soil Pressure Control

Soil pressures in different service load combinations should be checked by allowable value. The following figure is extracted from “SAP” model.

According to Geotechnical report Ks = 0.73 Kg/cm³ ,allowable settlement = 2.5 cm and Max soil pressure for this foundation is 2.00 Kg/cm², in this foundation maximum existing settlement is 1.64 cm and maximum existing stress is about 1.50 Kg/cm² .



1. Soil pressure

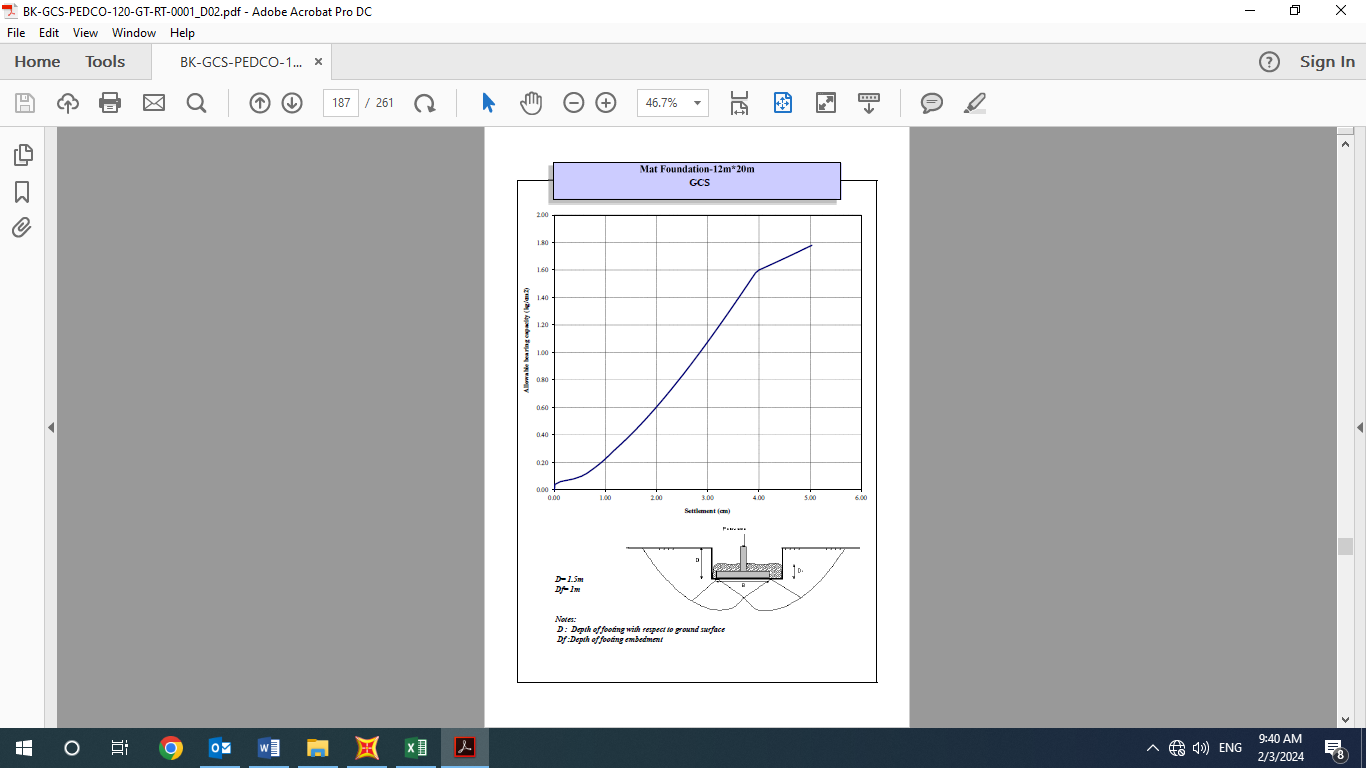
D02

According to Geotechnical report allowable soil pressure in mat foundation (middle of tank) is 0.88 Kg/cm²

In this foundation maximum soil pressure is:

Qliquid<Qall(Circular Mat)

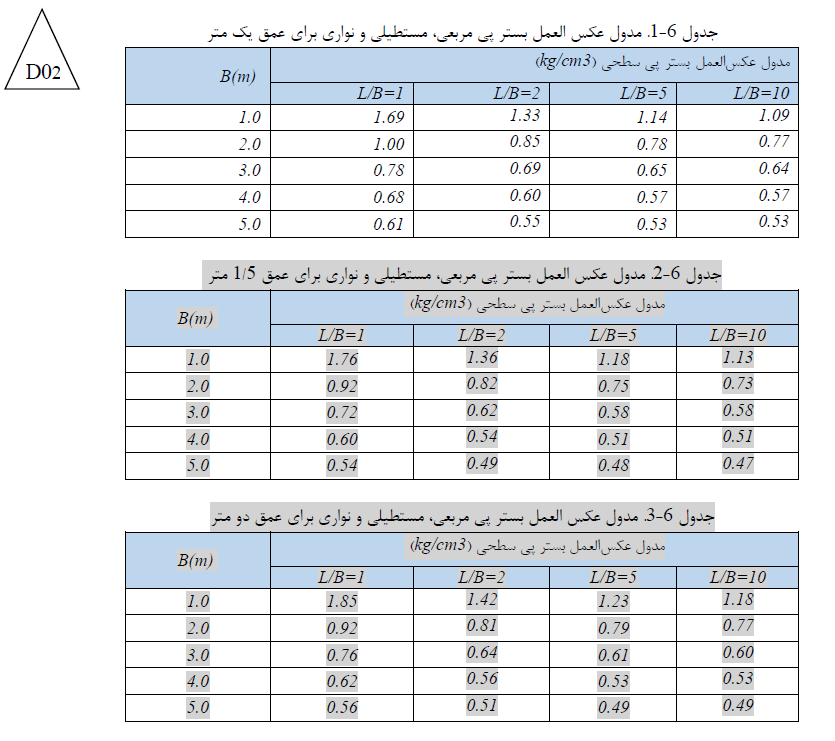
(Operation load / tank area) 1085283/ 1372587.32=0.79 Kg/cm² < 0.88 Kg/cm²



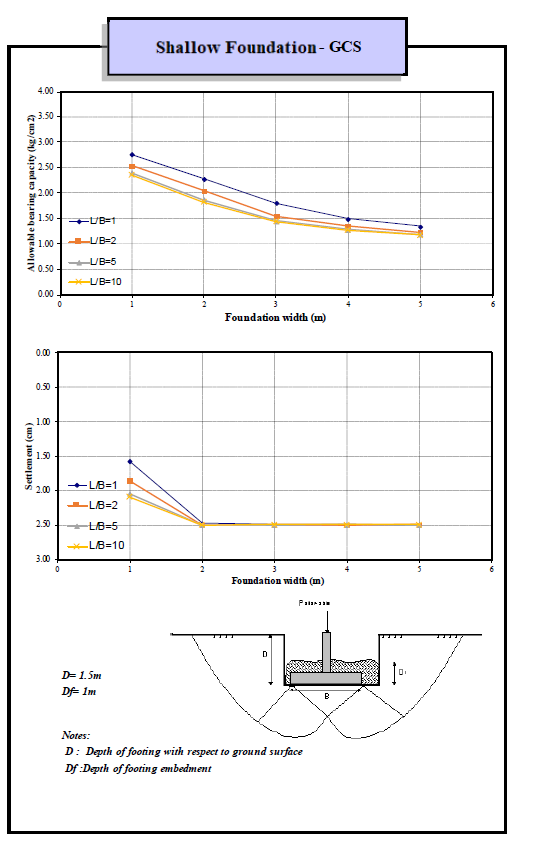
* + 1. Displacement check

Based on SAP2000 output the maximum deflection in foundation is 0.41 cm and the maximum drift is 1.64 cm.

| **TABLE: Joint Displacements** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Joint** | **OutputCase** | **CaseType** | **StepType** | **U1** | **U2** | **U3** |
| Text | Text | Text | Text | cm | cm | cm |
| 1 | ENV A | Combination | Max | 0 | 0 | -0.456155 |
| 1 | ENV A | Combination | Min | 0 | 0 | -1.425239 |
| 2 | ENV A | Combination | Max | 0 | 0 | -0.45562 |
| 2 | ENV A | Combination | Min | 0 | 0 | -1.424702 |
| 7 | ENV A | Combination | Max | 0 | 0 | -0.454027 |
| 7 | ENV A | Combination | Min | 0 | 0 | -1.423111 |
| 8 | ENV A | Combination | Max | 0 | 0 | -0.446368 |
| 8 | ENV A | Combination | Min | 0 | 0 | -1.427256 |
| 9 | ENV A | Combination | Max | 0 | 0 | -0.460501 |
| 9 | ENV A | Combination | Min | 0 | 0 | -1.417767 |
| 12 | ENV A | Combination | Max | 0 | 0 | -0.451417 |
| 12 | ENV A | Combination | Min | 0 | 0 | -1.420499 |
| 13 | ENV A | Combination | Max | 0 | 0 | -0.444266 |
| 13 | ENV A | Combination | Min | 0 | 0 | -1.425154 |
| 14 | ENV A | Combination | Max | 0 | 0 | -0.457409 |
| 14 | ENV A | Combination | Min | 0 | 0 | -1.414675 |
| 17 | ENV A | Combination | Max | 0 | 0 | -0.447852 |
| 17 | ENV A | Combination | Min | 0 | 0 | -1.416937 |
| 18 | ENV A | Combination | Max | 0 | 0 | -0.44139 |
| 18 | ENV A | Combination | Min | 0 | 0 | -1.422279 |
| 19 | ENV A | Combination | Max | 0 | 0 | -0.453176 |
| 19 | ENV A | Combination | Min | 0 | 0 | -1.410442 |
| 22 | ENV A | Combination | Max | 0 | 0 | -0.443422 |
| 22 | ENV A | Combination | Min | 0 | 0 | -1.412505 |
| 23 | ENV A | Combination | Max | 0 | 0 | -0.437821 |
| 23 | ENV A | Combination | Min | 0 | 0 | -1.41871 |
| 24 | ENV A | Combination | Max | 0 | 0 | -0.447925 |
| 24 | ENV A | Combination | Min | 0 | 0 | -1.405191 |
| 27 | ENV A | Combination | Max | 0 | 0 | -0.438235 |
| 27 | ENV A | Combination | Min | 0 | 0 | -1.407319 |
| 28 | ENV A | Combination | Max | 0 | 0 | -0.433637 |
| 28 | ENV A | Combination | Min | 0 | 0 | -1.414526 |
| 29 | ENV A | Combination | Max | 0 | 0 | -0.441768 |
| 29 | ENV A | Combination | Min | 0 | 0 | -1.399034 |
| 32 | ENV A | Combination | Max | 0 | 0 | -0.432419 |
| 32 | ENV A | Combination | Min | 0 | 0 | -1.401501 |
| 33 | ENV A | Combination | Max | 0 | 0 | -0.42895 |
| 33 | ENV A | Combination | Min | 0 | 0 | -1.409839 |
| 34 | ENV A | Combination | Max | 0 | 0 | -0.434871 |
|  |  |  |  |  | MAX | -1.427256 |



D02



1. Reinforcing

D02

* + 1. Hoop tension control

Ph=k0hQliquid+0.5k0Ɣh2=0.5\*2.1\*8.18+0.5\*0.5\*1.85\*2.12=10.62 T/m

T HOOP=PHD/2=10.62\*13/2=69 T

T HOOP=As Fy= As= THOOP /Fy =69000/4000=17.25 cm

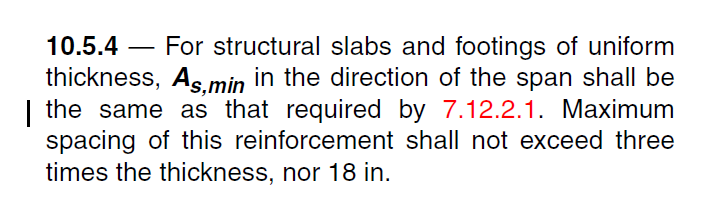
Use 10T16 As=20 OK

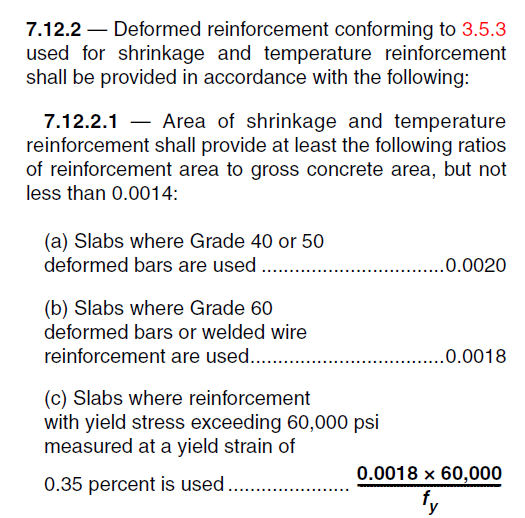
* + 1. Dowel reinforcement of ring wall

Use T16@200 As=20.00 OK

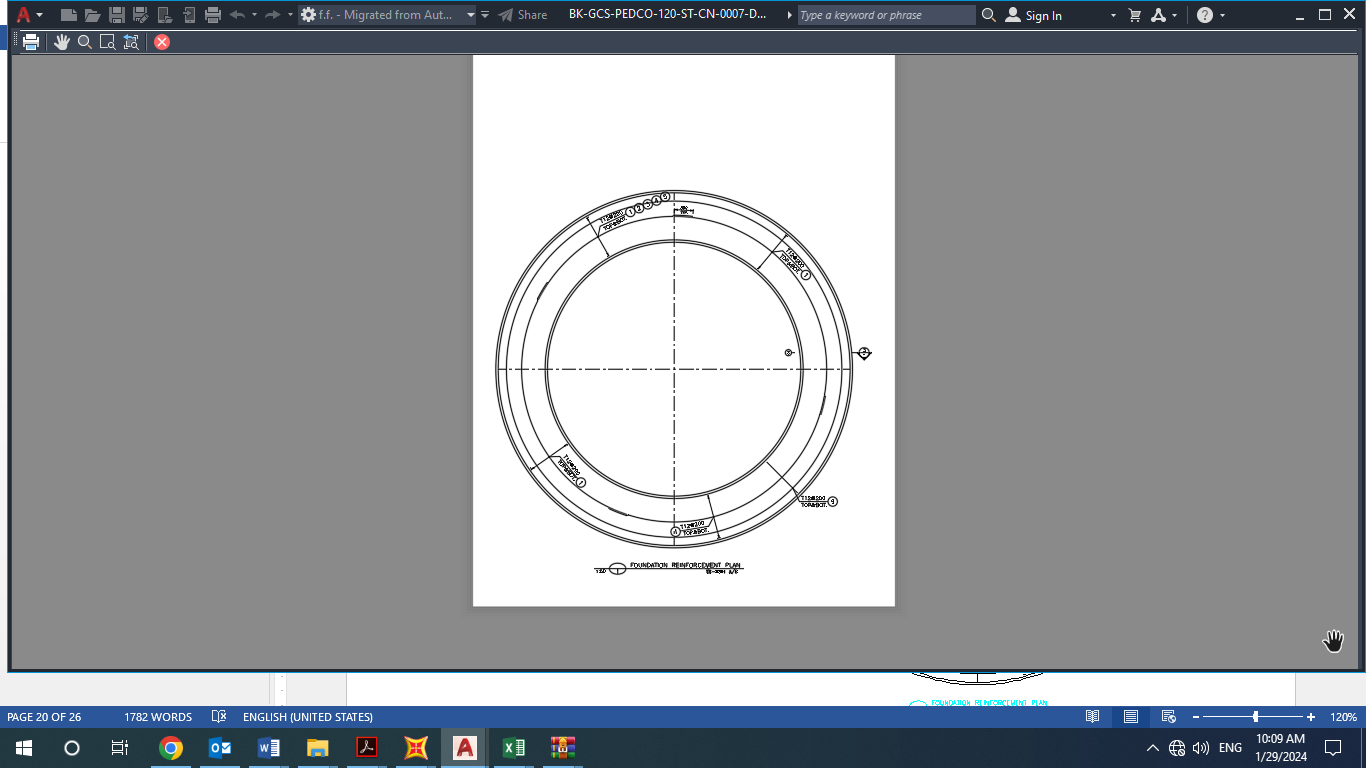
* + 1. Foundation reinforcement

According to ACI-318-08:

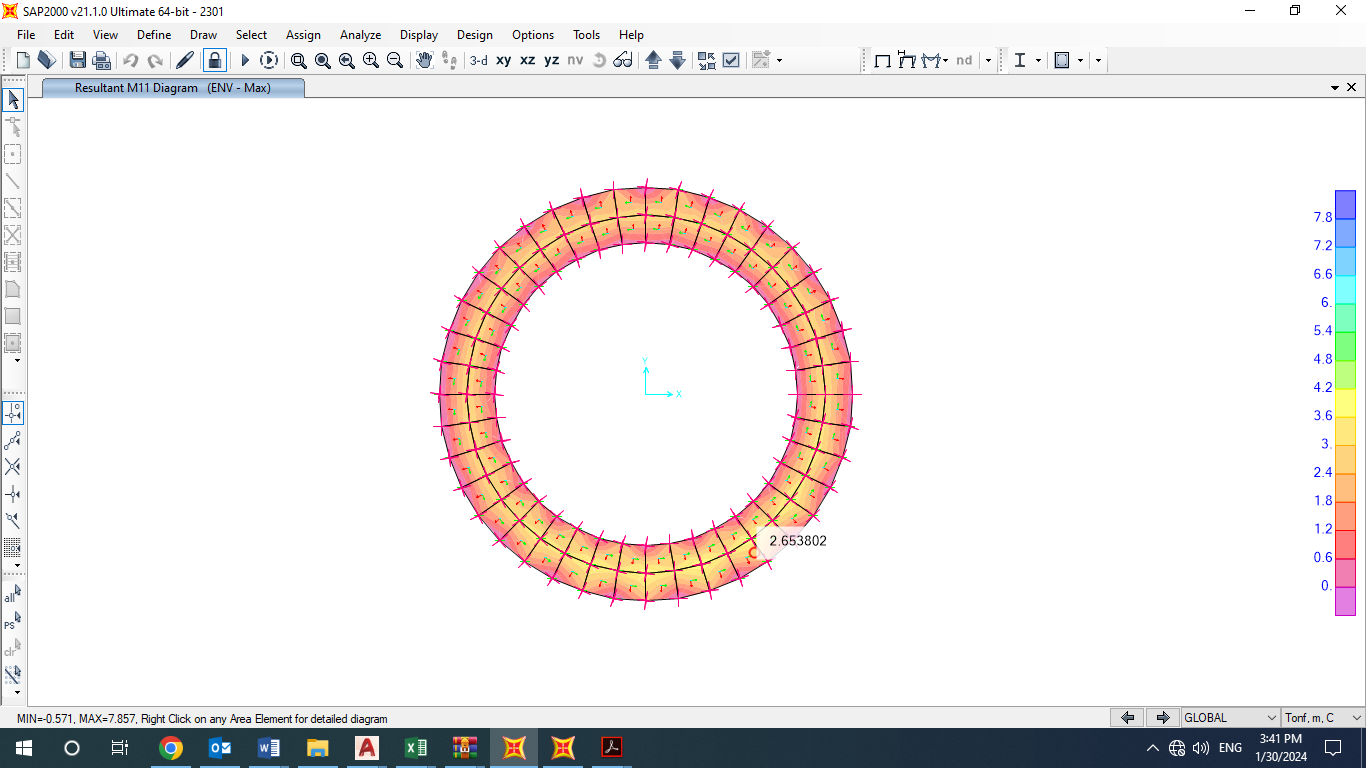




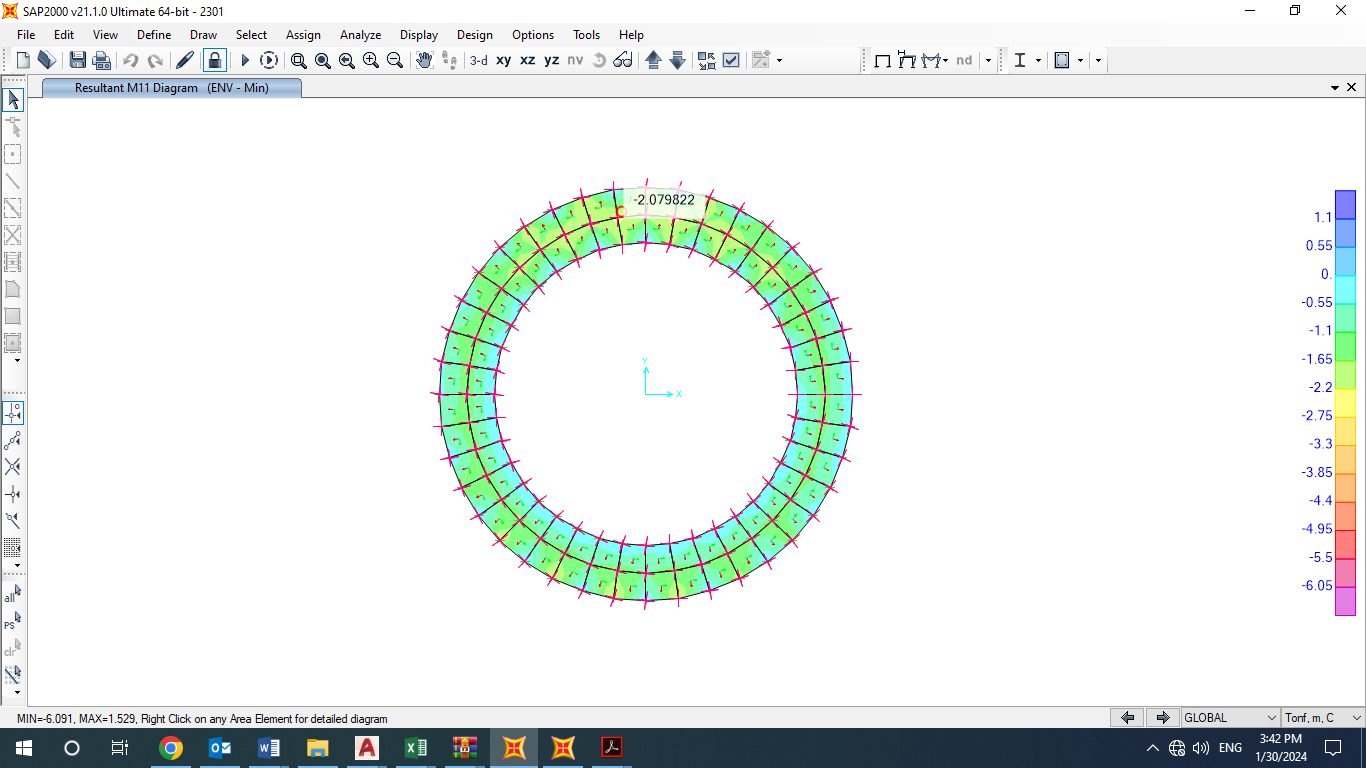
→ If use Φ 12@200 → A = 5.65cm² → 5.65 cm² ≤ 10.8/2 = 5.4 cm² → ok



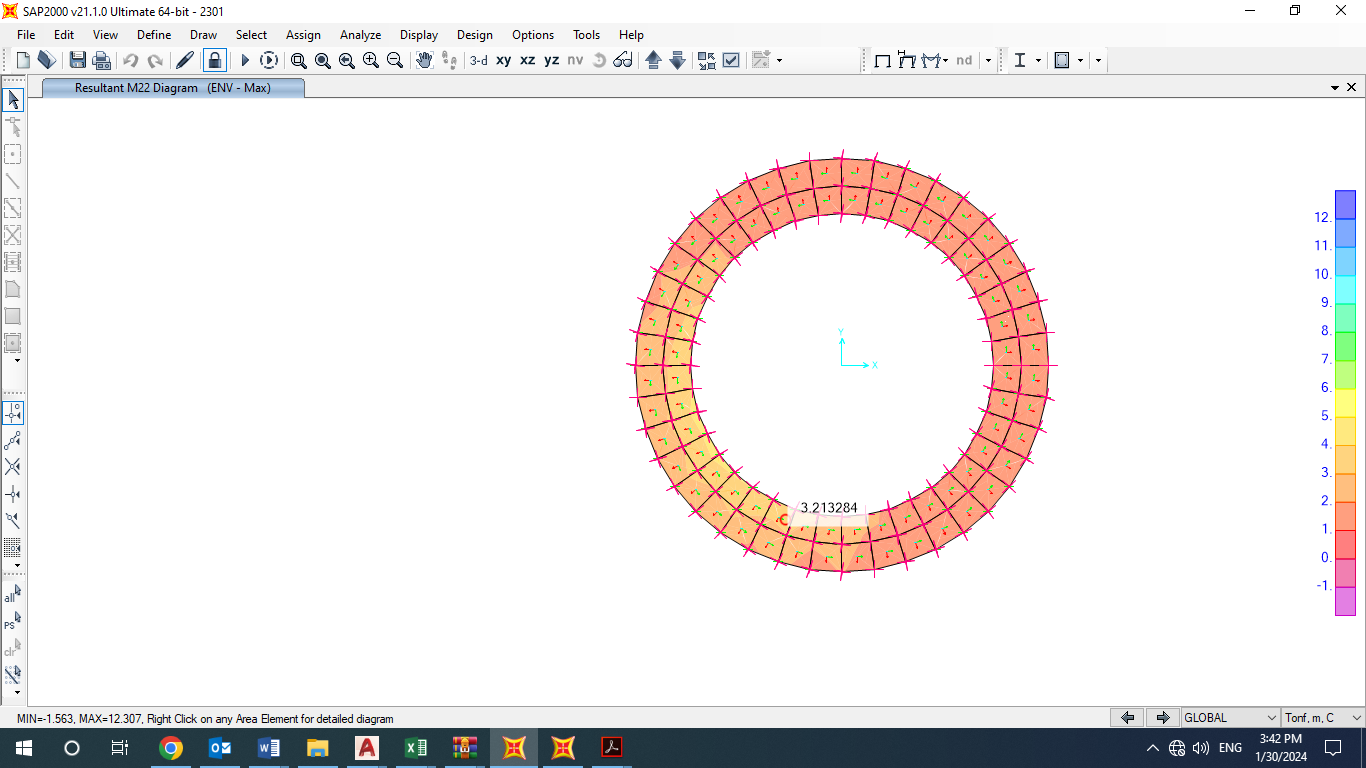
1. Foundation reinforcement plan



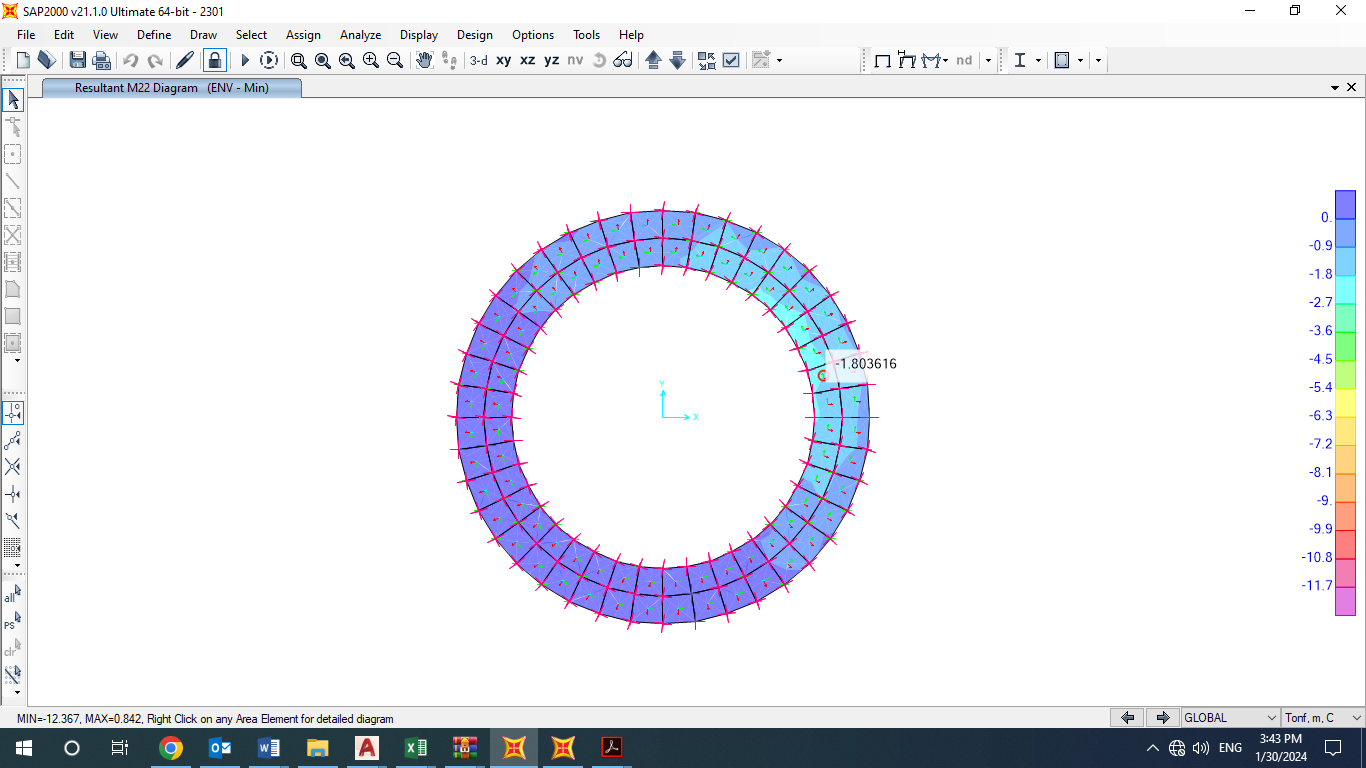
1. **M11 Max**



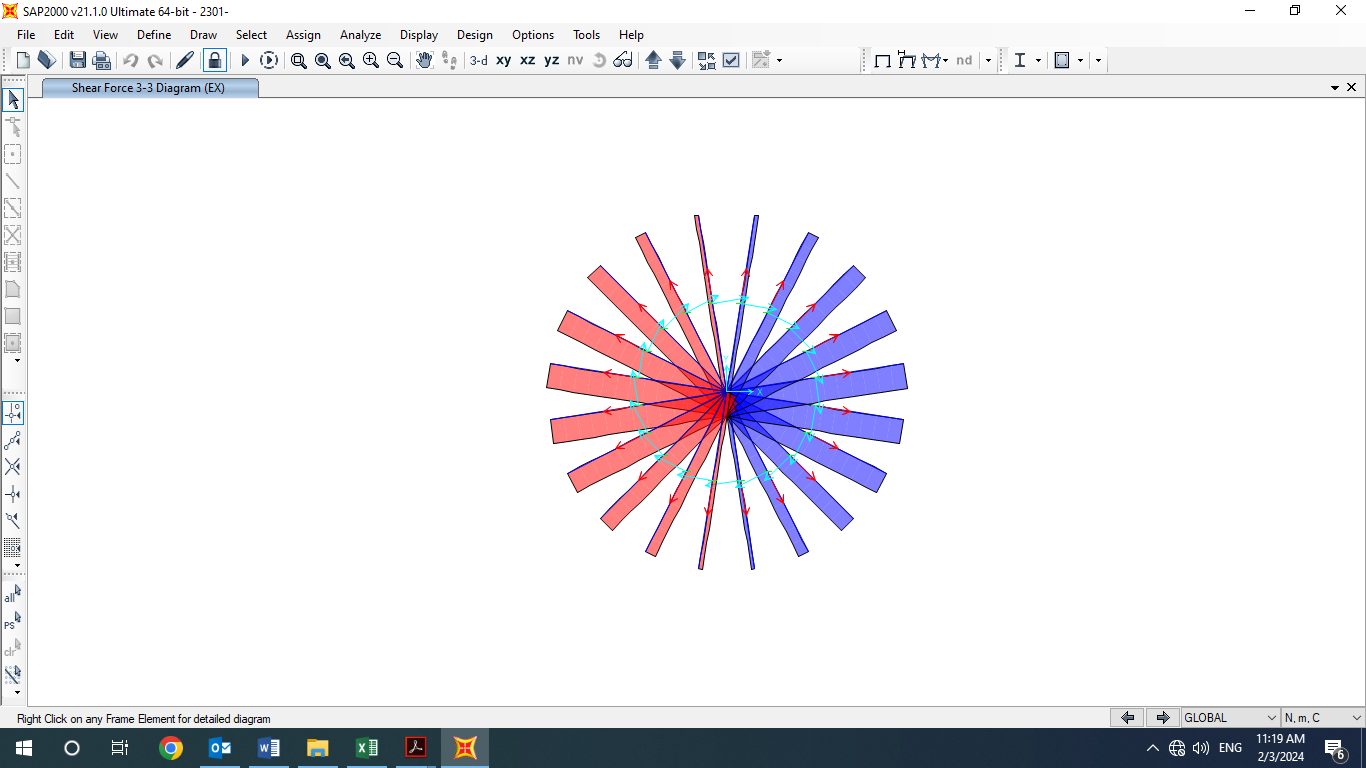
1. **M11 Min**



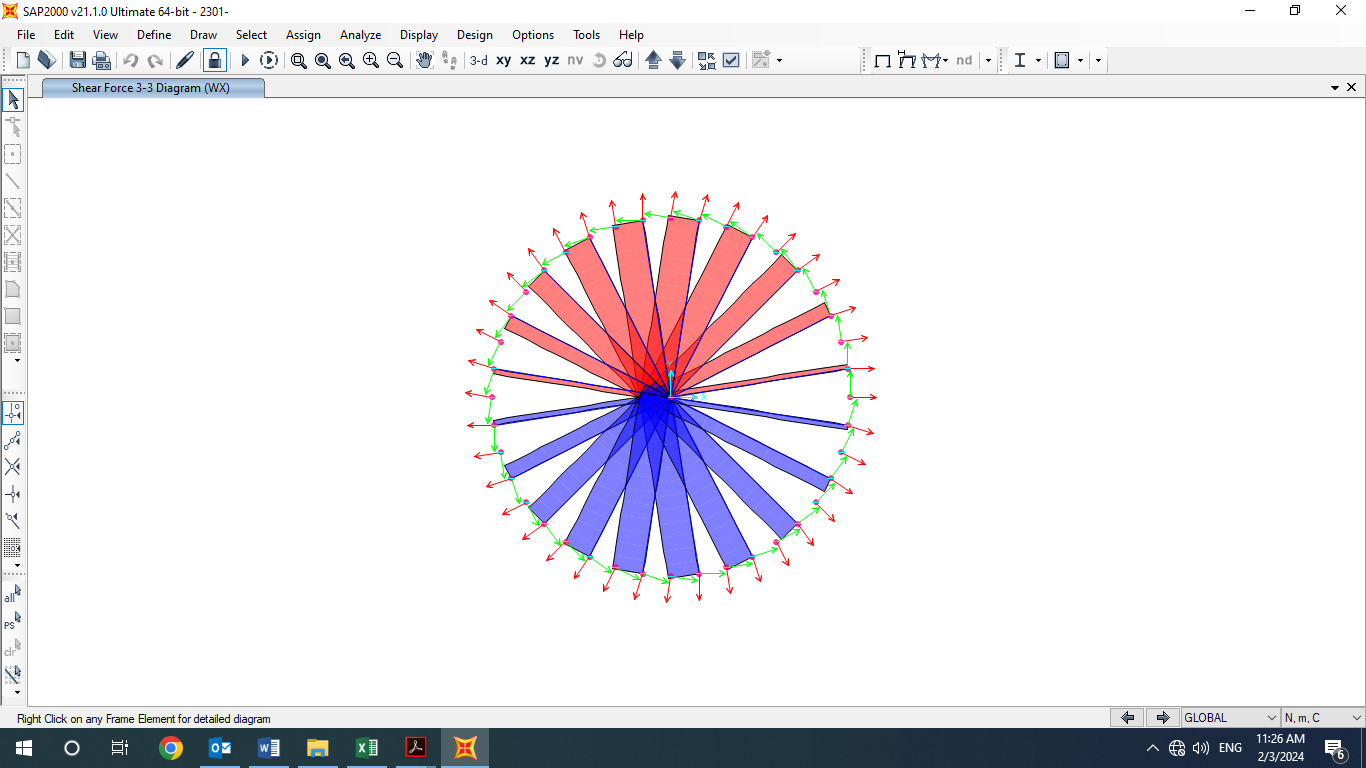
1. **M22 Max**



1. **M22 Min**



1. **V3-3 EX**



1. **V3-3 WX**
2. **ATTACHMENTS** 
   1. **SOWFTWARE FILE**

“SAP” software file is attached.

* 1. **MECHANICAL DATA SHEET**

Mechanical data sheet is attached.

* 1. **MECHANICAL CALCULATION**

Mechanical calculation file is attached.