Finite Element Floating Roof Structure Calculation for Light Oil Tanks (TK-2050 A~D)

Rev	Status	Prepared	Checked	Approved	Date

Tabulation of Revised Pages

REV / PAGE	0	1	2	3					REV / PAGE	0	1	2	3					REV / PAGE	0	1	2	3				
1	X	X	X						43		X	X														
2	X	X	X						44		X	X														
3	X	X	X						45		X	X														
4	X	X	X						46		X	X														
5	X	X	X						47		X	X														
6	X	X							48		X	X														
7	X	X							49		X	X														
8	X	X							50		X	X														
9	X	X	X						51		X	X														
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11	X	X							53		X	X														
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18		X	X						60			X														
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26		X	X						68			X														
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35		X	X																							
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38		X	X																							
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1. Scope

In this document, mechanical strength of the floating roof structure is analyzed for the following cases using SAP2000:

- Maintenance case (Roof is seated on the bottom of the vessel)
- Floating case (Roof is seated on fluid)

2. Reference Documents

	Document No.	Document Title
1	A238-PV-00-DWG-251	General Arrangement Drawing for TK-2050
2	A238-PV-00-CSH-201	Mechanical Calculation Sheet for Light Oil Storage Tanks (TK-2050 A~D)
3	A238-PV-00-CSH-209	Buoyancy and Floating Structure Calculation for Light Oil Storage Tanks (TK-2050 A~D)

3. Applicable Codes and Standards

- API 650 - 2018 Edition

4. Design Data

4.1. Tank Description

Location	Asaluyeh
Service	Light Oil Storage
Tag	TK-2050 A~D
Roof Type	Internal Floating - Single Deck
Structure Position	Internal

4.2. Geometry

The floating roof type is selected ring pontoon roof with central deck. The pontoon roof is divided to watertight compartments. Within the ring pontoon some beams is welded for stiffening. The deck plate has been stiffened also by welded beams. The roof design criteria and calculation is based on API-650, App. "H". General view of the floating roof is shown in following figure :

Inside Diameter of Tank	ID	=	27500	mm
Shell Height	H_SH	=	19700	mm
Rim Gap	G_R	=	200	mm

Maximum Pontoon Height	H_P1	=	900	mm
Minimum Pontoon Height	H_P2	=	700	mm
Pontoon Width	W_P	=	3950	mm
Inside Radius of Inner Rim	R_IR	=	9600	mm
Outside Radius of Outer Rim	R_OR	=	13550	mm
Corrosion Allowance of wetted surface	CA	=	1.5	mm
Pontoon Top Plate Thickness	THK_PTP	=	5	mm
Pontoon Bottom Plate Thickness	THK_PBP	=	7	mm
Pontoon Inner Rim Plate Thickness	THK_PIR	=	20	mm
Pontoon Outer Rim Plate Thickness	THK_POR	=	7	mm
Pontoon Compartment Plate Thickness	THK_PCP	=	5	mm

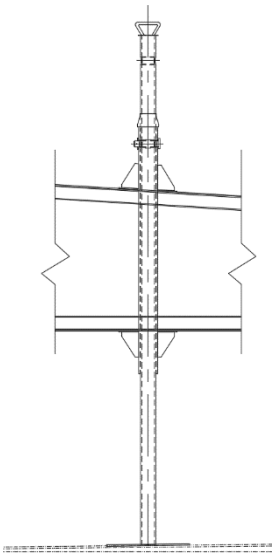


Figure 1: Floating Roof Support at Pontoons

Table 1:Number of Supports and Their Location

Leg Row	Nos.	Radius mm
1st	3	2000
2nd	6	5000
3rd	9	8000
4th	12	11000
5th	12	13250

4.3. Materials

Floating Roof Plate Material	Mat_R	=	SA-283 C	
Roof Plate Density	ρ_R	=	7861	kg/m3
Minimum Yield Stress of Roof Plate @ T_d (85°C)	Fy_R	=	2.109E+07	kg/m2
Roof Structure Material	Mat_SR	=	SA-36 / ST37	
Minimum Yield Stress of Roof Structure @ T_d (85°C)	Fy_SR	=	2.531E+07	kg/m2

4.4. Design Conditions

Design External Pressure	Pe_d	=	0.24	kPa

5. Design Considerations

5.1. Load Case Calculation

Following load cases are considered in the roof structure strength calculations based on API-650-Annex H:

5.1.1. Dead Loads

Roof plates has been modeled, and 10% of roof plates weight is considered as dead loads of attachments and distributed on central deck and peripheral pontoons.

5.1.2. Live Loads

Live load on the roof is as follows:

Live Load on the Roof	Lf1	=	0.24	kPa
Point Load of at least Two Men	Lf2	=	22	kN per point

5.1.3. Buoyancy Loads

In this analysis buoyancy loads are calculated using the liquid level height over the parts and applied to the model as hydrostatic pressures.

Standard acceleration of Gravity		=	g	=	9.8	m/s^2
Liquid Level Over Pontoon Bottom - Intact	(From buoyancy Calculation)	=	Hp	=	0.274	m
Liquid Level Over Deck Bottom - Intact	(From buoyancy Calculation)	=	Hd	=	0.127	m
Liquid Level Over Pontoon Bottom - Punctured	(From buoyancy Calculation)	=	Hp_pun	=	0.403	m
Density of the Product	(From buoyancy Calculation)	=	ρ	=	700	kg/m^3
Hydrostatic Pressure on Pontoon - Intact	=ρ *g*Hp	=	Pp	=	1880	N/m^2
Hydrostatic Pressure on Deck - Intact	=ρ *g*Hd	=	Pd	=	871	N/m^2
Hydrostatic Pressure on Pontoon - Punctured	=ρ *g*Hp_pun	=	Pp_pun	=	2765	N/m^2
Hydrostatic Pressure on Deck - Punctured		=	Pd_pun	=	0	N/m^2

6. SAP Model

6.1. Geometry

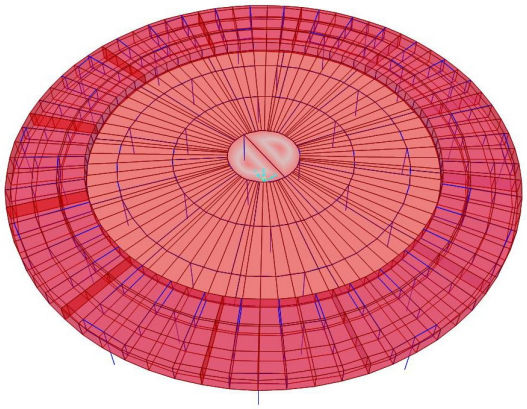


Figure 2:Floating Roof Geometry

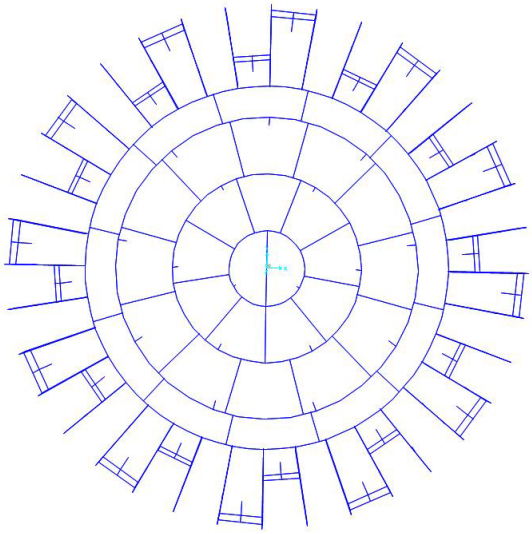


Figure 3:Frames Overview

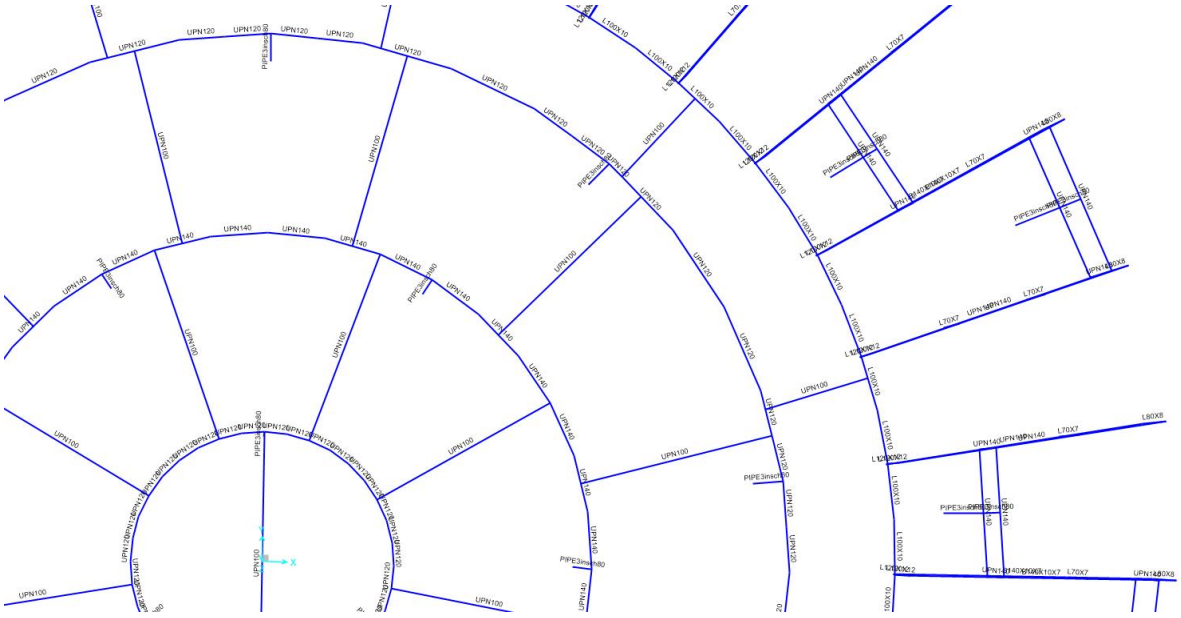
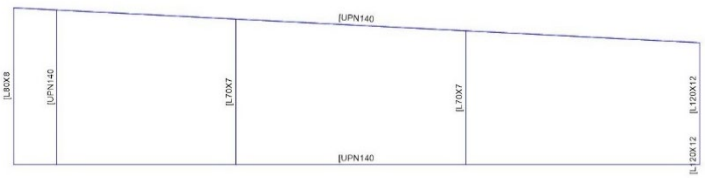


Figure 4:Deck Frame Plan

a	

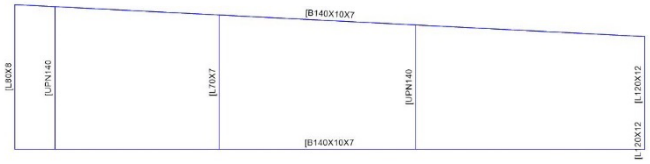
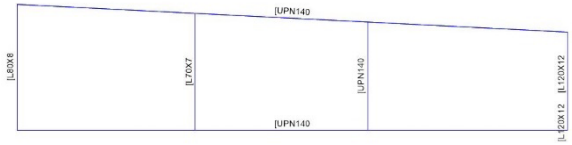
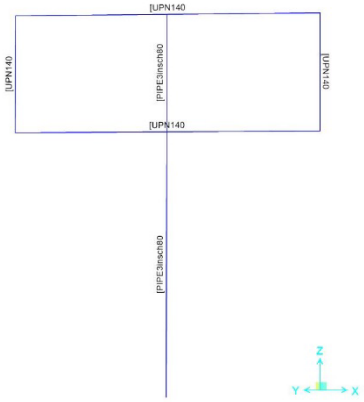
b	
c	
d	

Figure 5: Pontoon Frames a) Type1 b) Type2 c) Type3 d) Support to Pontoon Attachment

Table 2:Profile Section Properties

Section Name	Material	Shape	t3	t2	tf	tw
Text	Text	Text	mm	mm	mm	mm
B140X10X7	A36	Box/Tube	140	140	10	7
L100X10	A36	Angle	100	100	10	10
L120X12	A36	Angle	120	120	12	12
L70X7	A36	Angle	70	70	7	7
L80X8	A36	Angle	80	80	8	8
PIPE-3in-sch80	A53GrB	Pipe	88.9			7.62
UPN100	A36	Channel	100	50	8.5	6
UPN140	A36	Channel	140	60	10	7
DELETD						

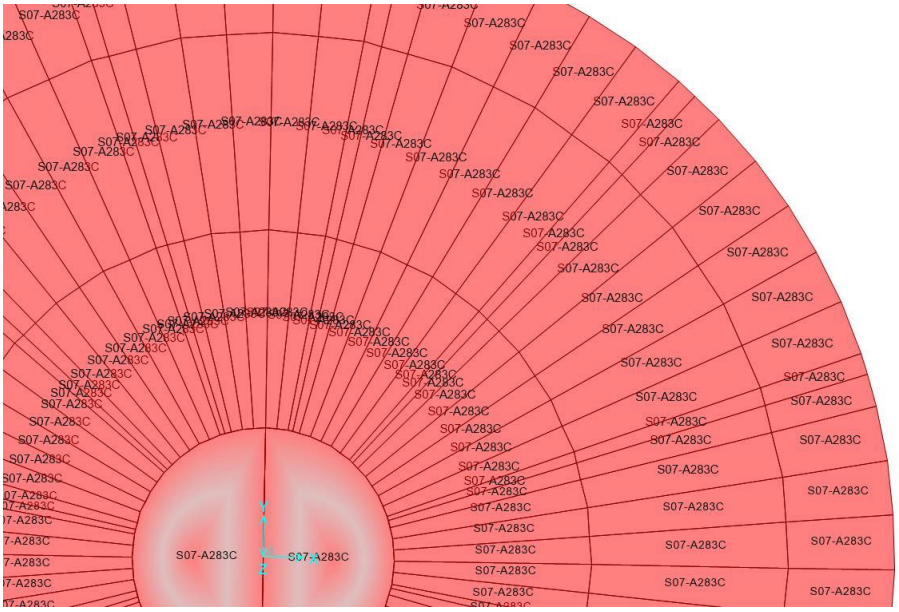


Figure 6:Deck Plate Plan

a	
b	

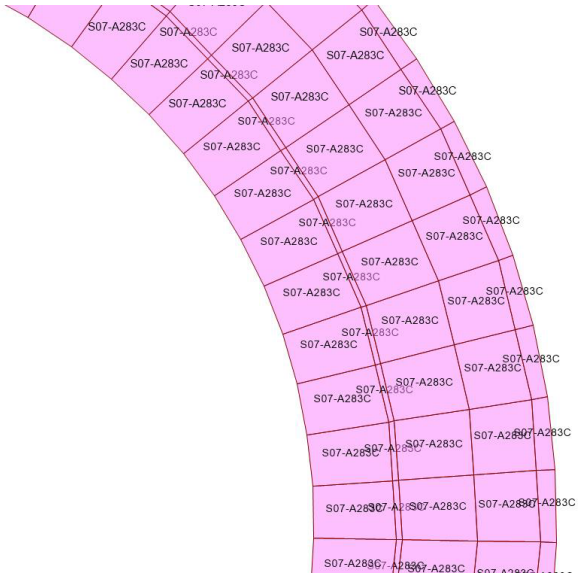
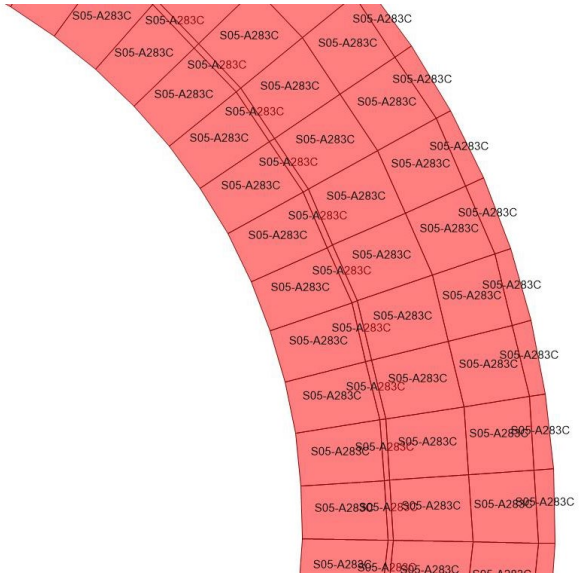
c	
d	

Figure 7:Pontoon Plate a) Inner Rim b) Outer Rim c) Bottom Plate d) Top Plate

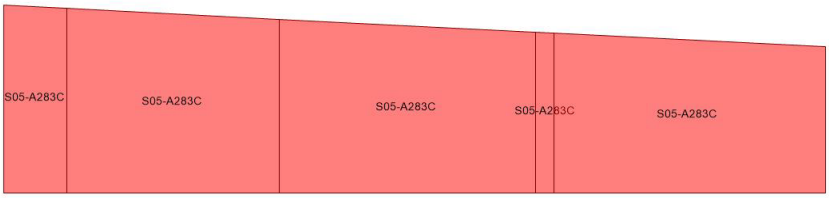


Figure 8: Compartment Plates

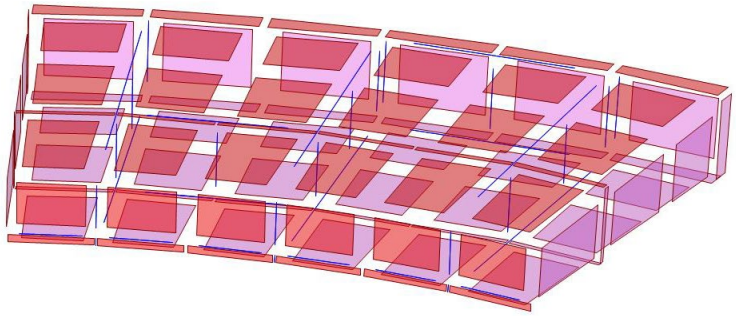


Figure 9: Exploded Parts of a Pontoon Compartment

Table 3: Properties of Plates

Section	Material	Area Type	Thickness	Bend Thick
Text	Text	Text	mm	mm
S05-A283	A283C	Shell	5	5
S07-A283C	A283C	Shell	7	7
S20-A283C	A283C	Shell	20	20

6.2. Boundary Conditions

Boundary conditions of roof structure are as follows:

6.2.1. Maintenance Case

Table 4: Roof Structure Boundary Conditions

Part	Considered?	Boundary Condition
Leg	Yes	Simply supported at the tank bottom

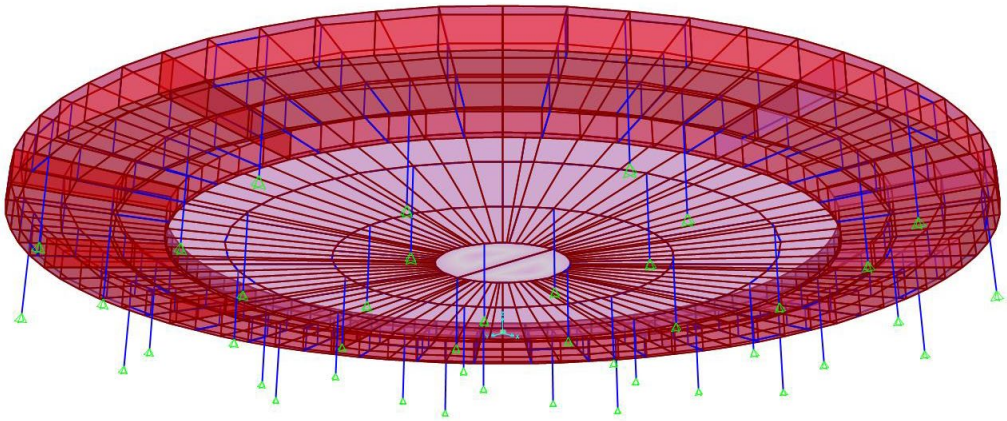


Figure 10: Roof Structure Boundary Conditions-Maintenance Case

6.3. Floating Case

When the roof is floating on the process fluid, the deck stays level with respect to the XY plane. Based on that, in order to bound the model in the Z direction, displacement of the deck

nodes are fixed in Z direction. On the other hand, since the outer rim of the pontoons is constrained by the roof seal to the shell, displacement of nodes on the outer rim are fixed in the X and Y directions

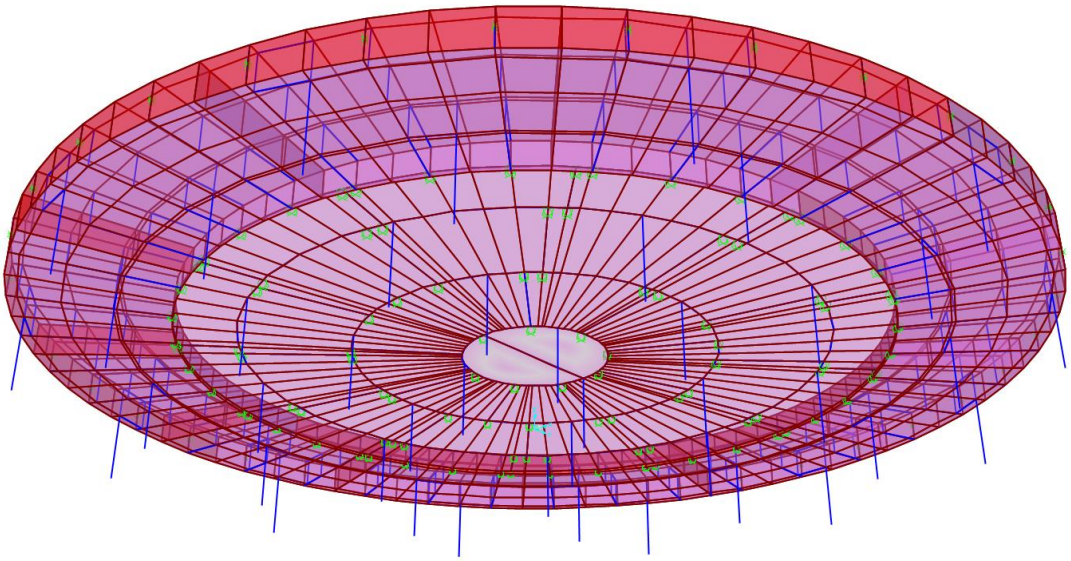


Figure 11: Roof Structure Boundary Conditions-Floating Case

6.4. Loads

6.4.1. Load Combinations for Analyzing the Supports

Following load combinations are considered in the calculation for floating roof support as per API-650-Annex H:

$$D_f + (the\ greater\ of) P_{fe}\ or\ L_{f1} or\ L_{f2}$$

D_f is the dead load of internal floating roof, including the weight of the flotation compartments, seal and all other floating roof and attached components;

L_{f1} is the internal floating roof uniform live load (0.6 kPa [12.5 lbf/ft2] if not automatic drains are provided, 0.24 kPa [5 lbf/ft2] if automatic drains are provided);

L_{f2} is the internal floating roof point load of at least two men walking anywhere on the roof. One applied load of 2.2 kN [500 lbf] over 0.1 m2 [1 ft2] applied anywhere on the roof addresses two men walking;

P_{fe} is the internal floating roof design external pressure (0.24 kPa [5 lbf/ft2] minimum).

Therefore, following load combinations are considered in the SAP model:

#	Load Combination
1	$D_f + L_{f1}$
2	$D_f + L_{f2}$
3	$D_f + P_{fe}$

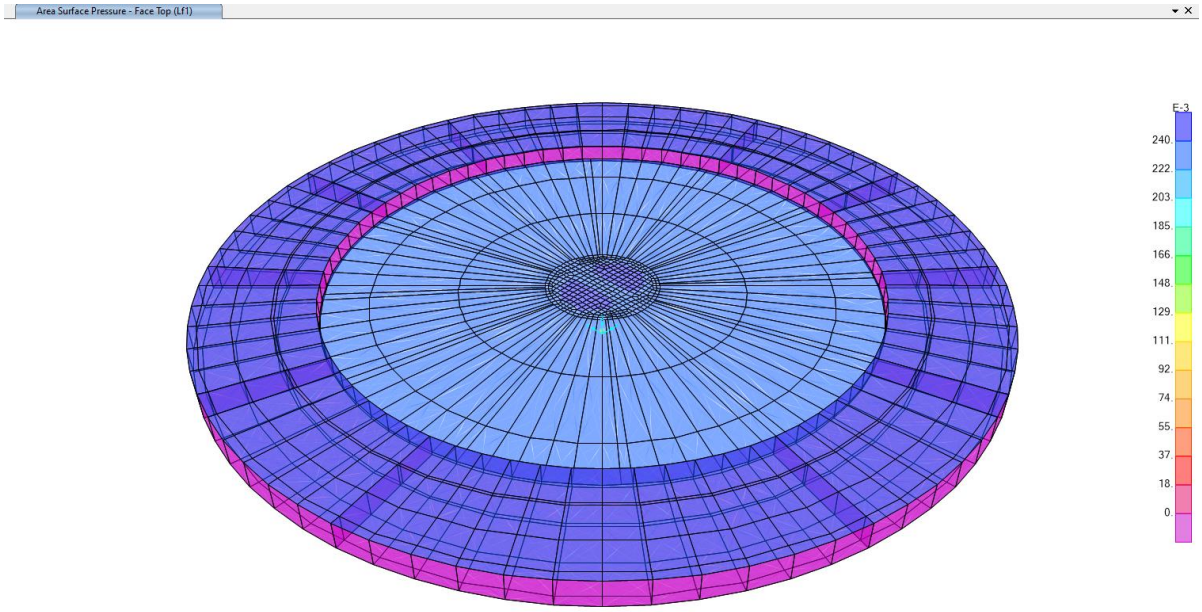


Figure 12: LF1 Load (kN/m2)

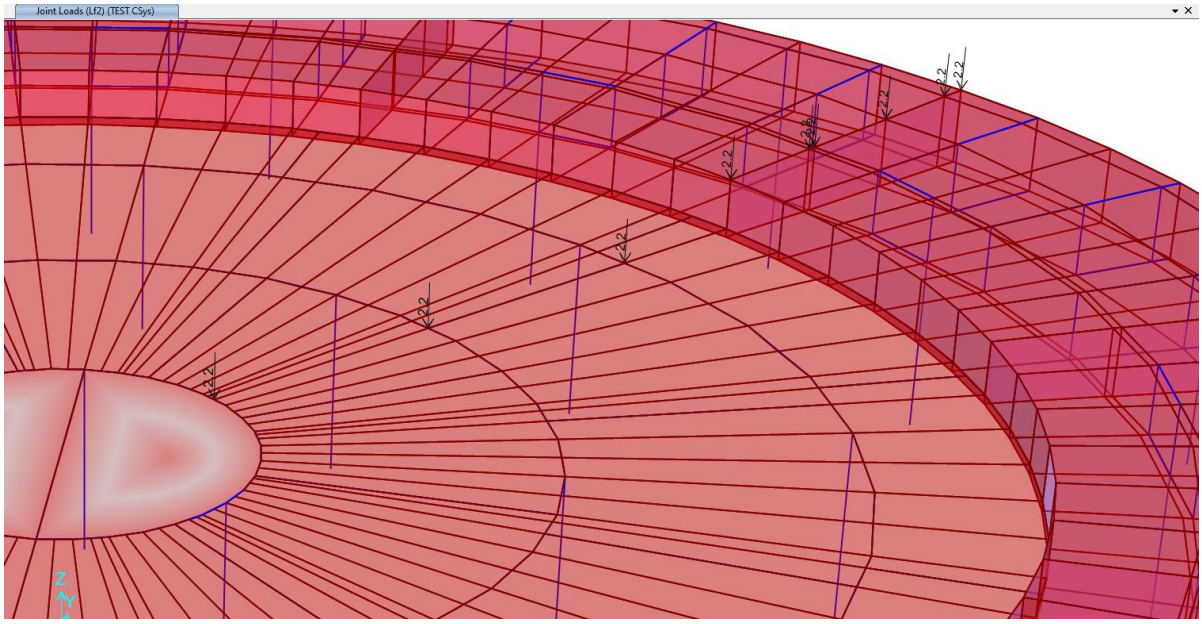


Figure 13:LF2 Load (kN)

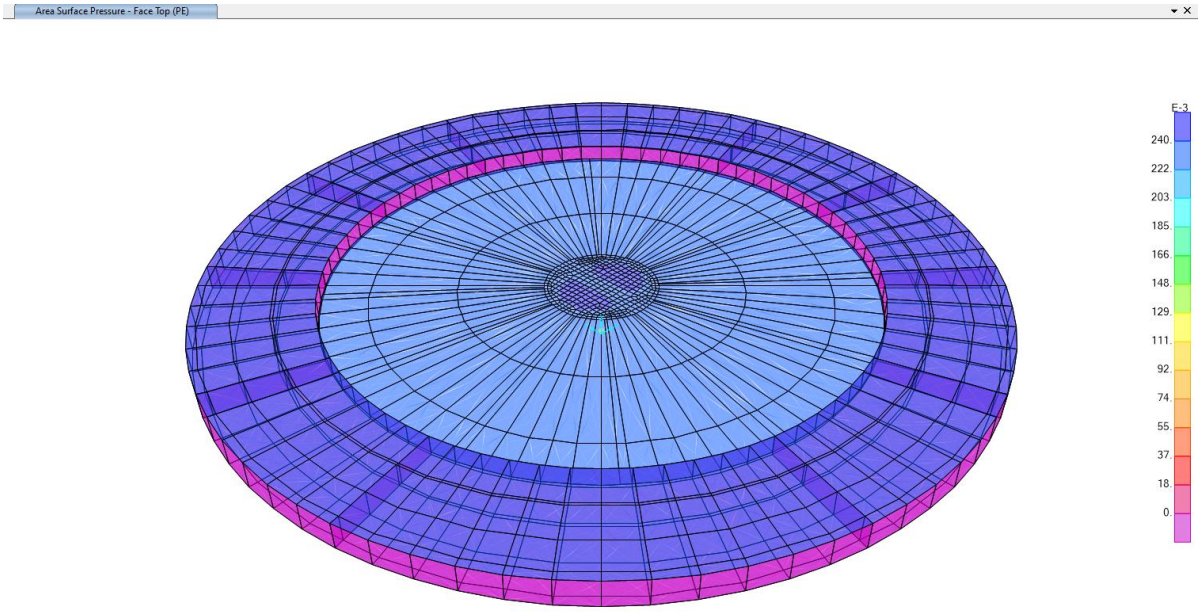


Figure 14: PE Load (kN/m2)

6.4.2. Load Combinations for the Floating Case

For the floating case following load case is considered:

#	Load Combination
1	$D_f + BUO$

D_f is the dead load of internal floating roof, including the weight of the flotation compartments, seal and all other floating roof and attached components;

BUO is the hydrostatic pressure of the liquid which are calculated in section 5.1.3

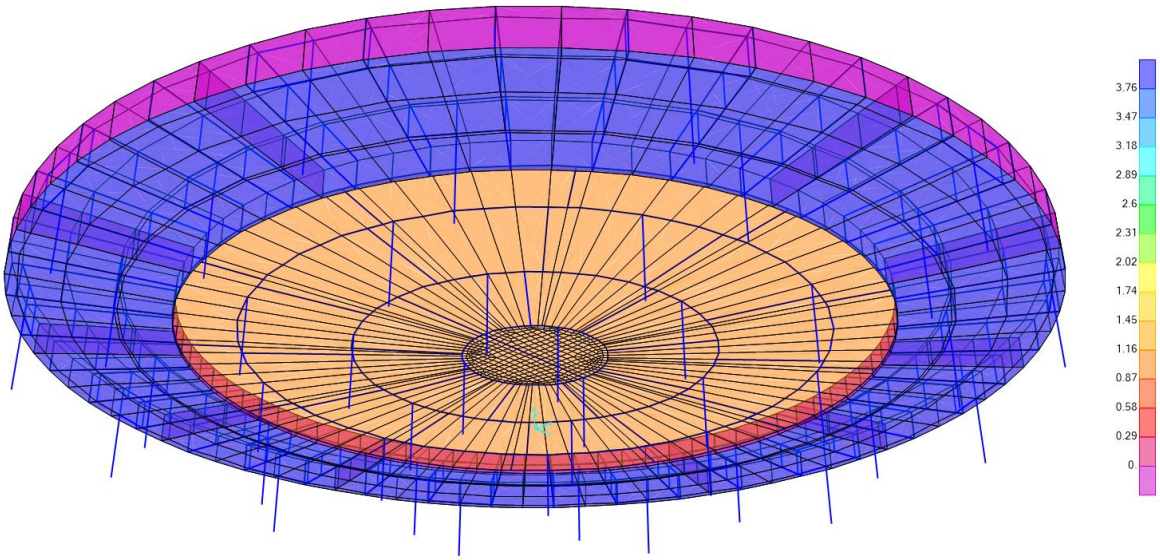


Figure 15: BUO Load - Intact (kN/m2)

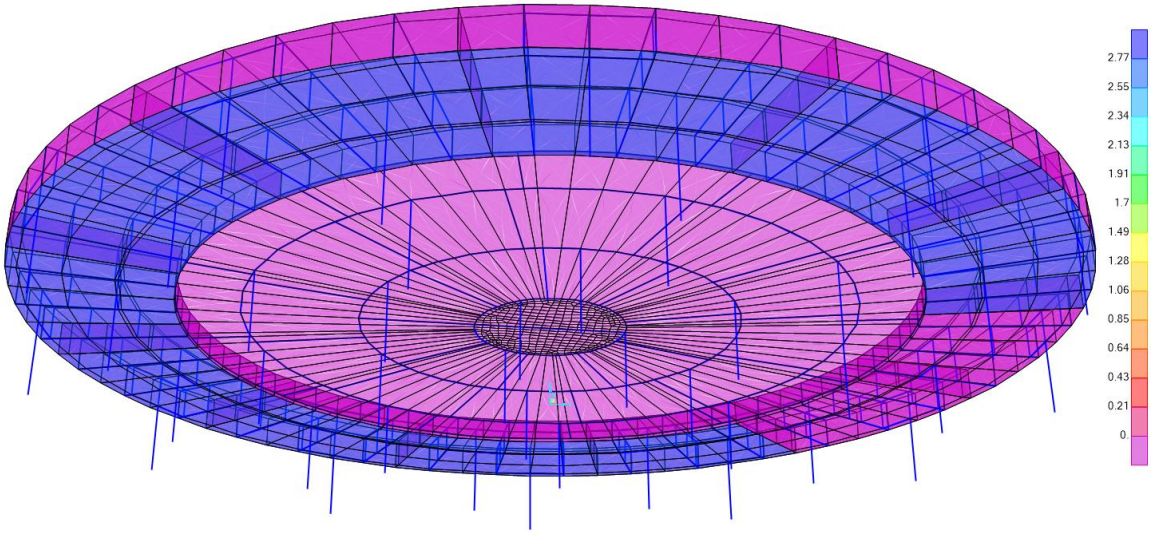


Figure 16: BUO Load - Punctured (kN/m2)

6.5. Section Design

Roof structure layout and sections design are done for optimum strength of the structure considering loads which are specified in section 6.4. In this regard sections are from commonly available profiles and following considerations are followed:

	Item	Value
1	Design Code	AISC 360-10
2	Multi-Response Case Design	Envelopes
3	Framing Type	OMF
4	Seismic Design Category	D
5	Importance Factor	1.25
6	Design System Rho	1.
7	Design System Sds	0.5
8	Design System R	8.
9	Design System Omega0	3.
10	Design System Cd	5.5
11	Design Provision	ASD
12	Analysis Method	Direct Analysis
13	Second Order Method	General 2nd Order
14	Stiffness Reduction Method	Tau-b Fixed
15	Omega(Bending)	1.67
16	Omega(Compression)	1.67
17	Omega(Tension-Yielding)	1.67
18	Omega(Tension-Fracture)	2.
19	Omega(Shear)	1.67
20	Omega(Shear-Short Webed Rolled I)	1.5
21	Omega(Torsion)	1.67
22	Ignore Seismic Code?	No
23	Ignore Special Seismic Load?	No

24	Is Doubler Plate Plug-Welded?	Yes
25	HSS Welding Type	ERW
26	Reduce HSS Thickness?	No
27	Consider Deflection?	Yes
28	DL Limit, L/	200.
29	Super DL+LL Limit, L/	200.
30	Live Load Limit, L/	200.
31	Total Limit, L/	200.
32	Total--Camber Limit, L/	200.
33	Pattern Live Load Factor	0.75
34	Demand/Capacity Ratio Limit	0.95

7. Results

7.1. Maintenance case

7.1.1. Overall View

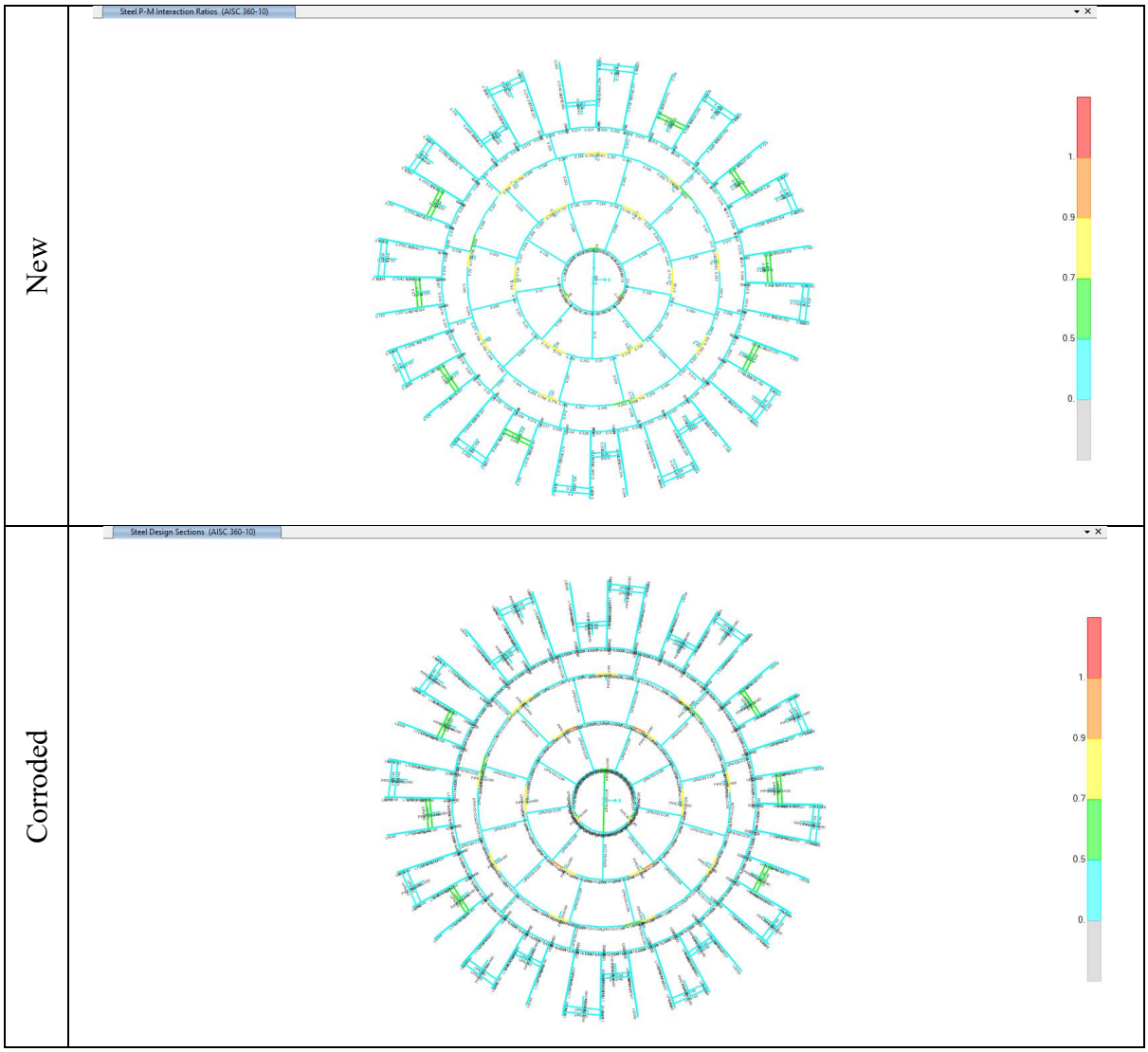


Figure 17:P-M Ratio of the Roof Structure – Maintenance case

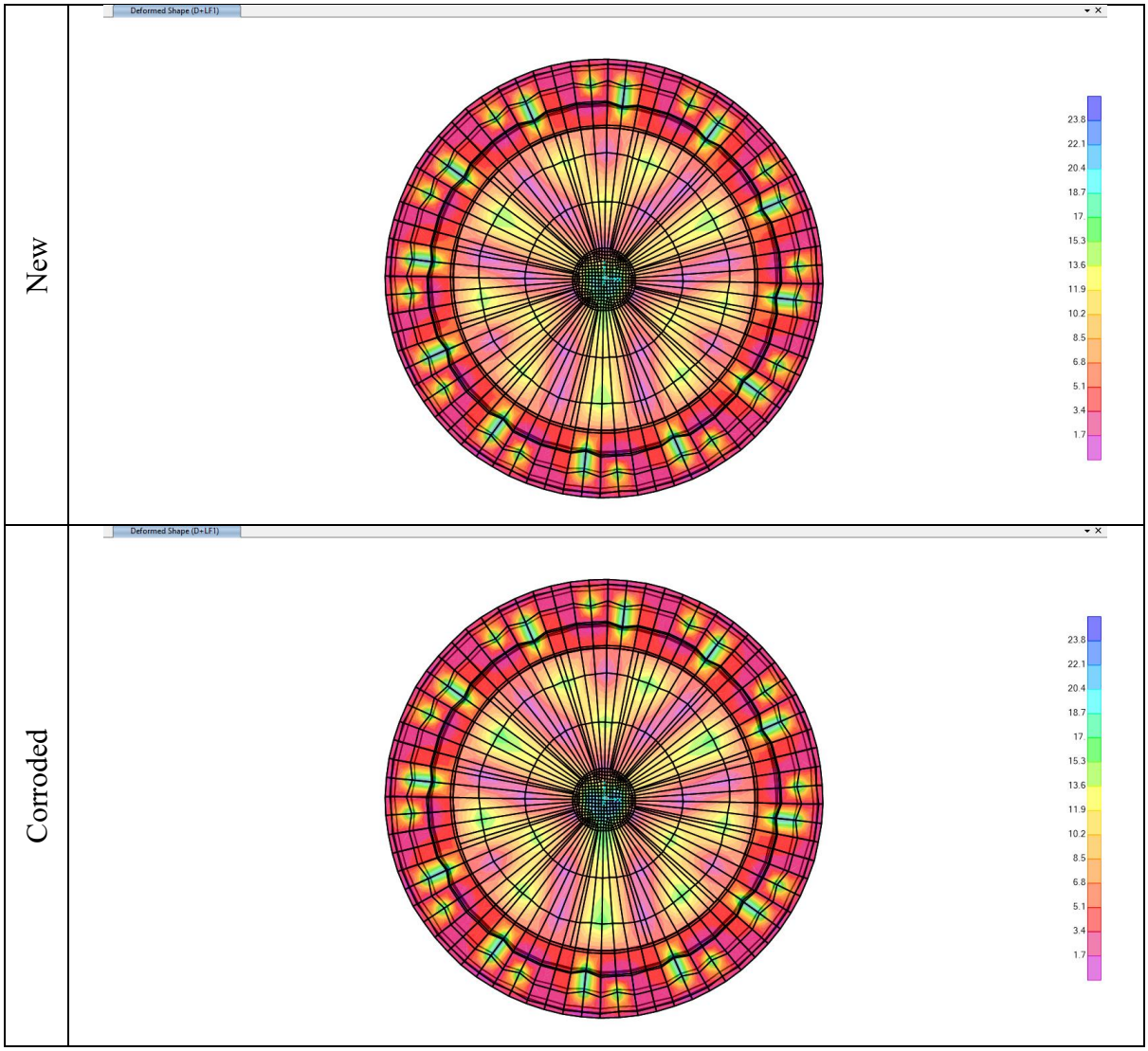
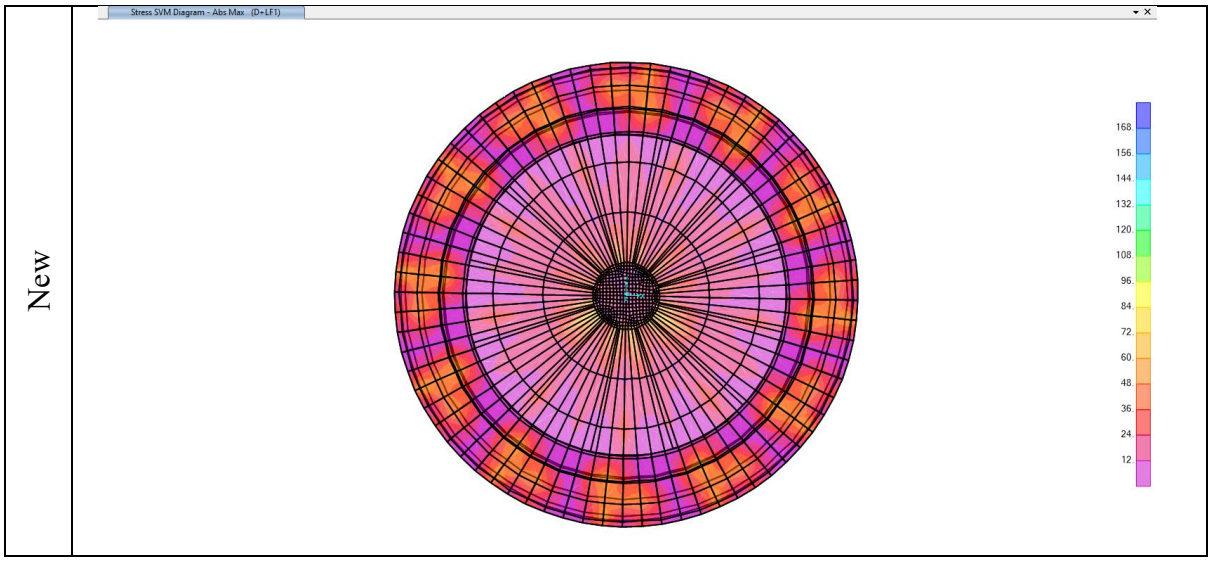


Figure 18:Deflection of Plates (mm) – Maintenance case



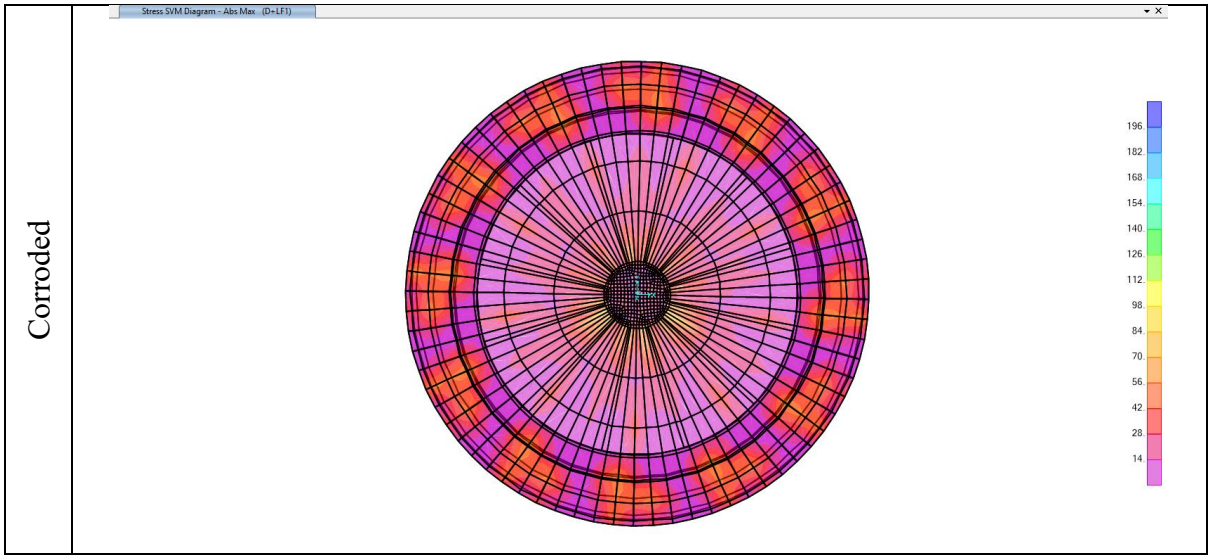
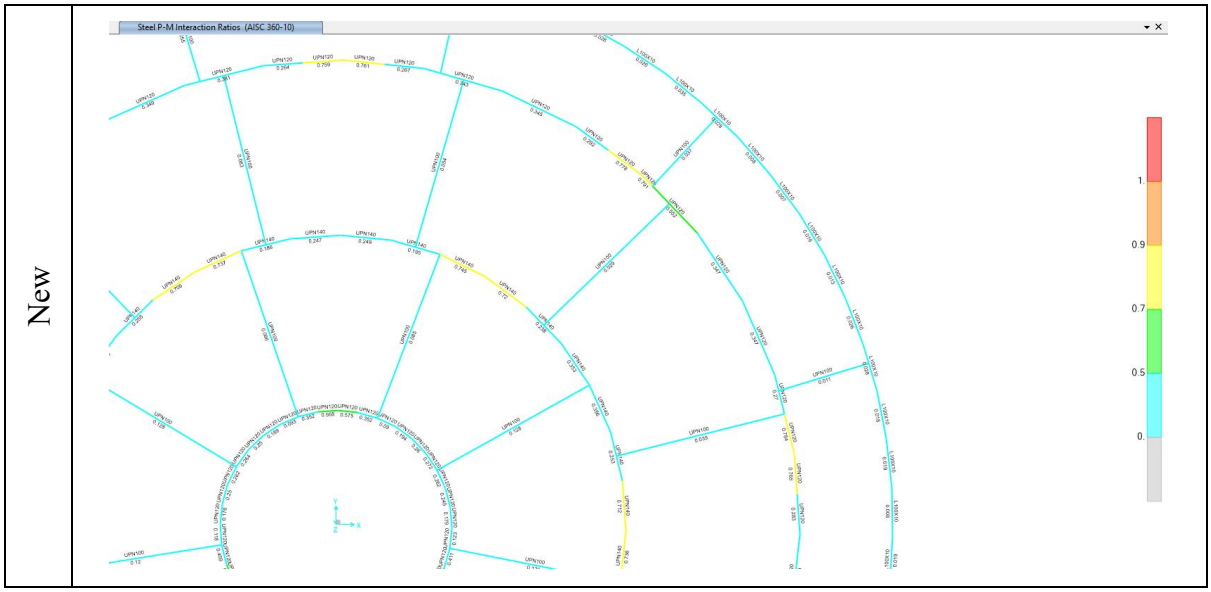


Figure 19:Shell SVM Stress (MPa) – Maintenance case

7.1.2. Deck Structure



Corroded

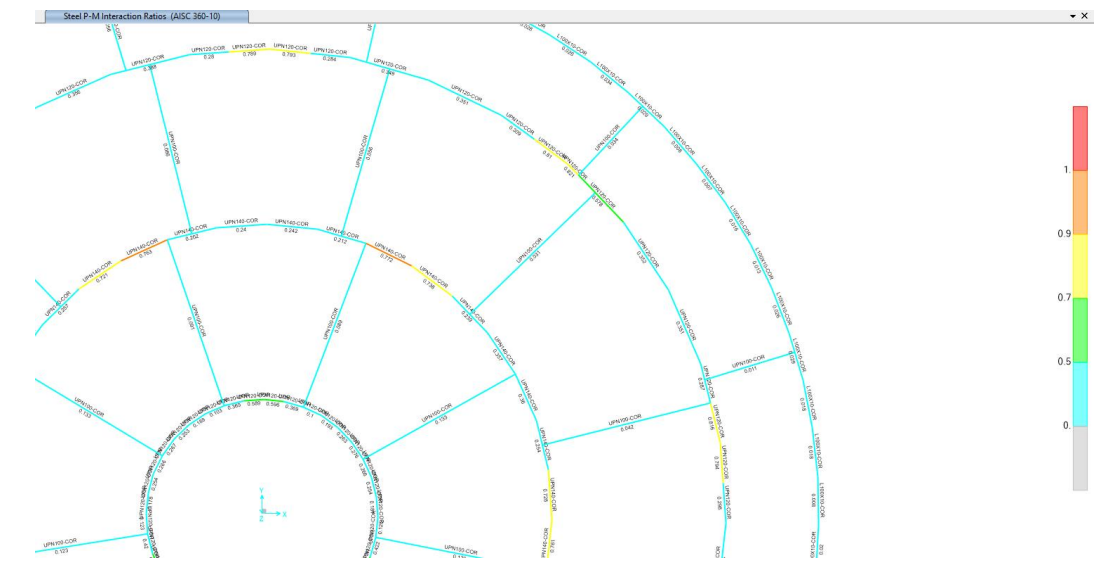
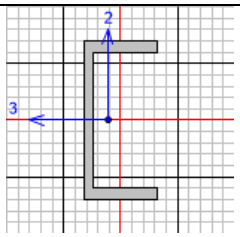


Figure 20:P-M Ratio of the Roof Structure– Maintenance case

P-M Ratio for the worst case - NEW



AISC 360-10 STEEL SECTION CHECK (Summary for Combo and Station)
Units : N, mm, C

Frame : 617 X Mid: -7840.212 Combo: ENV Design Type: Beam
Length: 277.873 Y Mid: 1524.558 Shape: UPN120 Frame Type: OMF
Loc : 277.873 Z Mid: 2100. Class: Compact Princpl Rot: 0. degrees

Provision: ASD Analysis: Direct Analysis
D/C Limit=0.95 2nd Order: General 2nd Order Reduction: Tau-b Fixed
AlphaPr/Py=0.002 AlphaPr/Pe=7E-05 Tau_b=1. EA factor=0.8 EI factor=0.8

OmegaB=1.67 OmegaC=1.67 OmegaTY=1.67 OmegaTF=2.
OmegaV=1.67 OmegaV-RI=1.5 OmegaVT=1.67

A=1704. I33=3675168. r33=46.441 S33=61252.8 Av3=990.
J=35132.17 I22=491416.592 r22=16.982 S22=13084.785 Av2=840.
E=199947.979 Fy=248.211 Ry=1.5 z33=73152. Cw=1053471116.3
RLLF=1. Fu=399.896 z22=23668.

STRESS CHECK FORCES & MOMENTS (Combo ENV)

Location	Pr	Mr33	Mr22	Vr2	Vr3	Tr
277.873	540.315	-8656405.8	4283.484	10101.974	-30.212	-18231.683

PMM DEMAND/CAPACITY RATIO (H1.2,H1-1b)
D/C Ratio: 0.799 = 0.001 + 0.796 + 0.001
= (1/2)(Pr/Pc) + (Mr33/Mc33) + (Mr22/Mc22)

AXIAL FORCE & BIAXIAL MOMENT DESIGN (H1.2,H1-1b)

Factor	L	K1	K2	B1	B2	Cm
Major Bending	1.	1.	1.	1.	1.	1.
Minor Bending	1.	1.	1.	1.	1.	1.

	Lltb	Kltb	Cb
LTB	1.	1.	1.148

	Pr	Pnc/Omega	Pnt/Omega
	Force	Capacity	Capacity
Axial	540.315	247721.312	253264.687

	Mr	Mn/Omega	Mn/Omega	Mn/Omega
	Moment	Capacity	No LTB	Cb=1
Major Moment	-8656405.8	10872546.02	10872546.02	10872546.02
Minor Moment	4283.484	3111656.215		

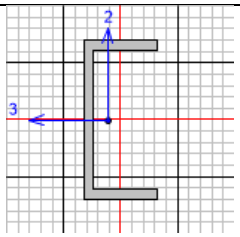
SHEAR CHECK

	Vr	Vn/Omega	Stress	Status
	Force	Capacity	Ratio	Check
Major Shear	10101.974	74909.274	0.135	OK
Minor Shear	30.212	88285.93	0.	OK

CONNECTION SHEAR FORCES FOR BEAMS

	VMajor	VMajor
	Left	Right
Major (V2)	10025.437	10101.974

P-M Ratio for the worst case - CORRODED



AISC 360-10 STEEL SECTION CHECK (Summary for Combo and Station)
Units : N, mm, C

Frame : 617 X Mid: -7840.212 Combo: ENV Design Type: Beam
Length: 277.873 Y Mid: 1524.558 Shape: UPN120-COR Frame Type: OMF
Loc : 277.873 Z Mid: 2100. Class: Compact Princpl Rot: 0. degrees

Provision: ASD Analysis: Direct Analysis
D/C Limit=0.95 2nd Order: General 2nd Order Reduction: Tau-b Fixed
AlphaPr/Py=0.002 AlphaPr/Pe=8E-05 Tau_b=1. EA factor=0.8 EI factor=0.8

OmegaB=1.67 OmegaC=1.67 OmegaTY=1.67 OmegaTF=2.
OmegaV=1.67 OmegaV-RI=1.5 OmegaVT=1.67

A=1520.25 I33=3240189.703 r33=46.167 S33=54686.746 Av3=882.75
J=26062.086 I22=419237.177 r22=16.606 S22=11436.793 Av2=740.625
E=199947.979 Fy=248.211 Ry=1.5 z33=64917.844 Cw=887457854.8
RLLF=1. Fu=399.896 z22=20710.048

STRESS CHECK FORCES & MOMENTS (Combo ENV)

Location	Pr	Mr33	Mr22	Vr2	Vr3	Tr
277.873	563.836	-7973103.6	4071.128	9049.732	-27.581	-13086.075

PMM DEMAND/CAPACITY RATIO (H1.2,H1-1b)
D/C Ratio: 0.829 = 0.001 + 0.826 + 0.001
= (1/2)(Pr/Pc) + (Mr33/Mc33) + (Mr22/Mc22)

AXIAL FORCE & BIAXIAL MOMENT DESIGN (H1.2,H1-1b)

Factor	L	K1	K2	B1	B2	Cm
Major Bending	1.	1.	1.	1.	1.	1.
Minor Bending	1.	1.	1.	1.	1.	1.

	Lltb	Kltb	Cb
LTB	1.	1.	1.144

	Pr	Pnc/Omega	Pnt/Omega
	Force	Capacity	Capacity
Axial	563.836	220783.559	225954.015

	Mr	Mn/Omega	Mn/Omega	Mn/Omega
	Moment	Capacity	No LTB	Cb=1
Major Moment	-7973103.6	9648707.397	9648707.397	9648707.397
Minor Moment	4071.128	2719751.96		

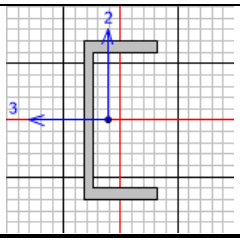
SHEAR CHECK

	Vr	Vn/Omega	Stress	Status
	Force	Capacity	Ratio	Check
Major Shear	9049.732	66047.239	0.137	OK
Minor Shear	27.581	78721.621	0.	OK

CONNECTION SHEAR FORCES FOR BEAMS

	VMajor	VMajor
	Left	Right
Major (V2)	8981.447	9049.732

Deflection for the worst case - NEW



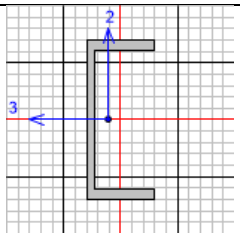
AISC 360-10 STEEL SECTION CHECK (Deflection Details)
Units : N, mm, C

Frame : 394 X Mid: 1632.224 Combo: def(D+LF2) Design Type: Beam
Length: 348.144 Y Mid: -1142.603 Shape: UPN120 Frame Type: OMF
Loc : 0. Z Mid: 2100. Class: Slender Princpl Rot: 0. degrees

DEFLECTION CHECK (Combodef(D+LF)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	0.542	1.741	0.312	OK
Super DL+LL	Yes	1.107	1.741	0.636	OK
Live Load	Yes	1.107	1.741	0.636	OK
Total Load	Yes	1.65	1.741	0.948	OK
Total-Camber	Yes	1.65	1.741	0.948	OK

Deflection for the worst case - CORRODED



AISC 360-10 STEEL SECTION CHECK (Deflection Details)
Units : N, mm, C

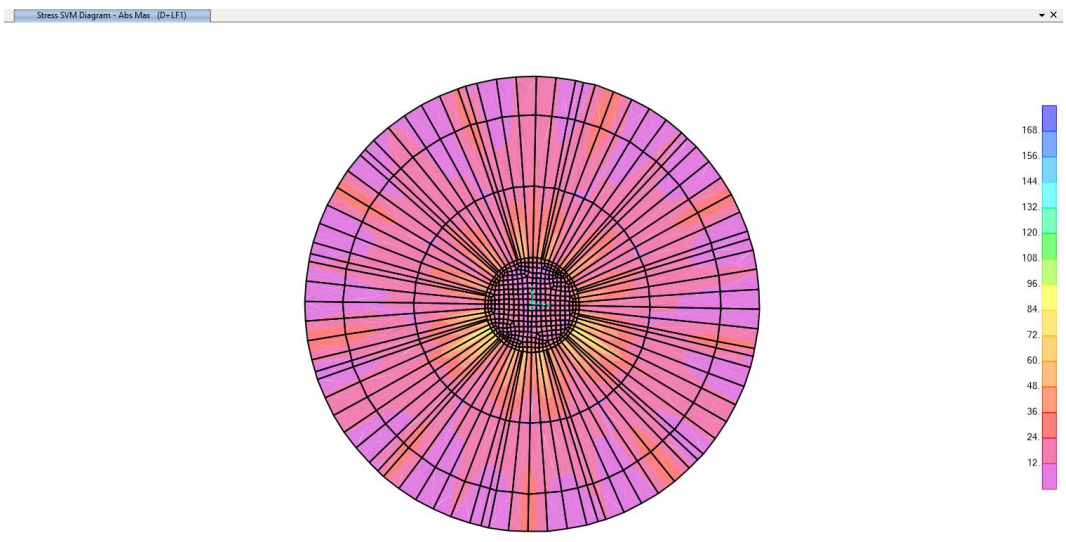
Frame : 332 X Mid: -2105.732 Combo: def(D+PE) Design Type: Beam
Length: 870.57 Y Mid: 4514.089 Shape: UPN140-COR Frame Type: OMF
Loc : 0. Z Mid: 2100. Class: Slender Princpl Rot: 0. degrees

DEFLECTION CHECK (Combodef(D+PE)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	1.83	4.353	0.42	OK
Super DL+LL	Yes	0.	4.353	0.	OK
Live Load	Yes	0.	4.353	0.	OK
Total Load	Yes	4.21	4.353	0.967	OK
Total-Camber	Yes	4.21	4.353	0.967	OK

7.1.3. Deck Plates

New



Corroded

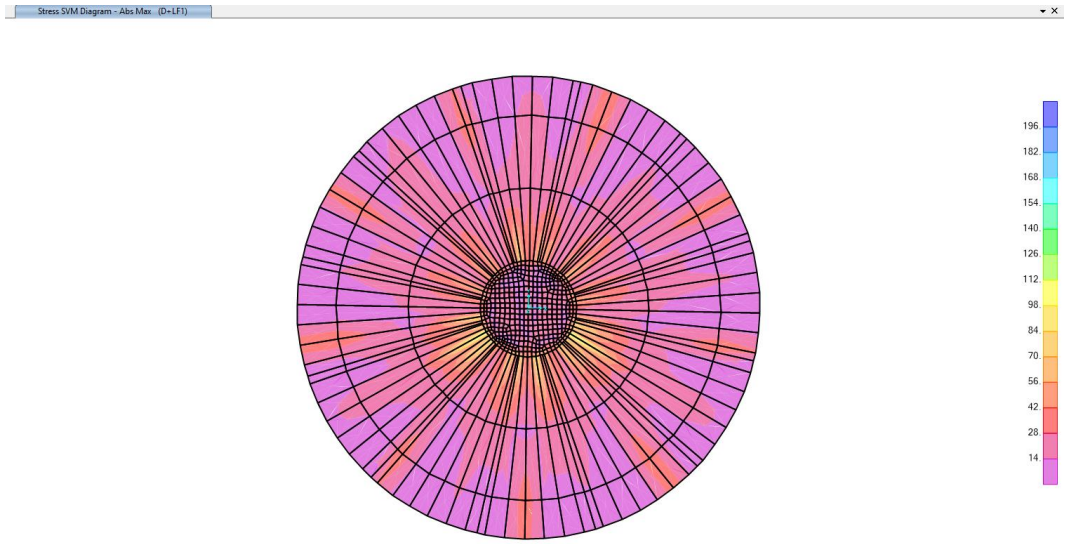
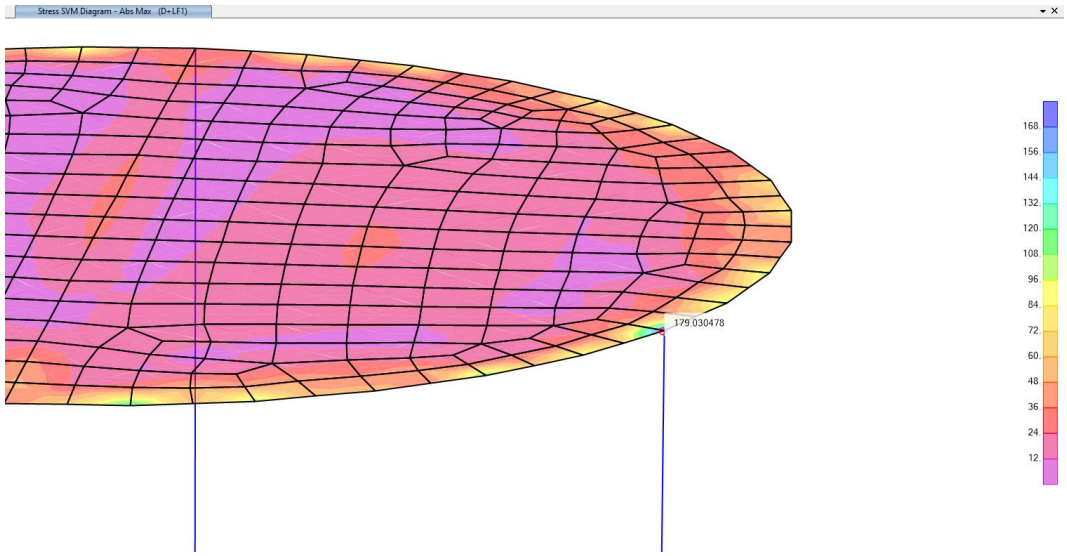


Figure 21: Deck Plate Stress (MPa) – Maintenance case

Based on above results SVM of most of plates are in the allowable range (under 120 MPa). The highest stresses in the results (179 MPa for new and 202 MPa for corroded) are due to stress concentration at the location of supports. These points will be reinforced by an additional pad. For more information, see bellow figures:

New



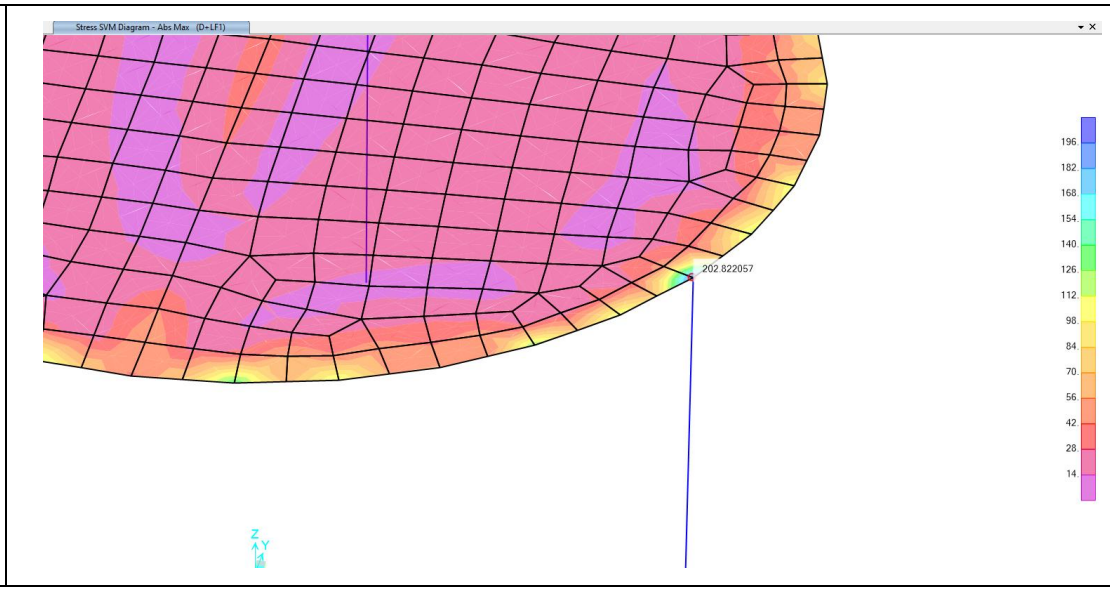
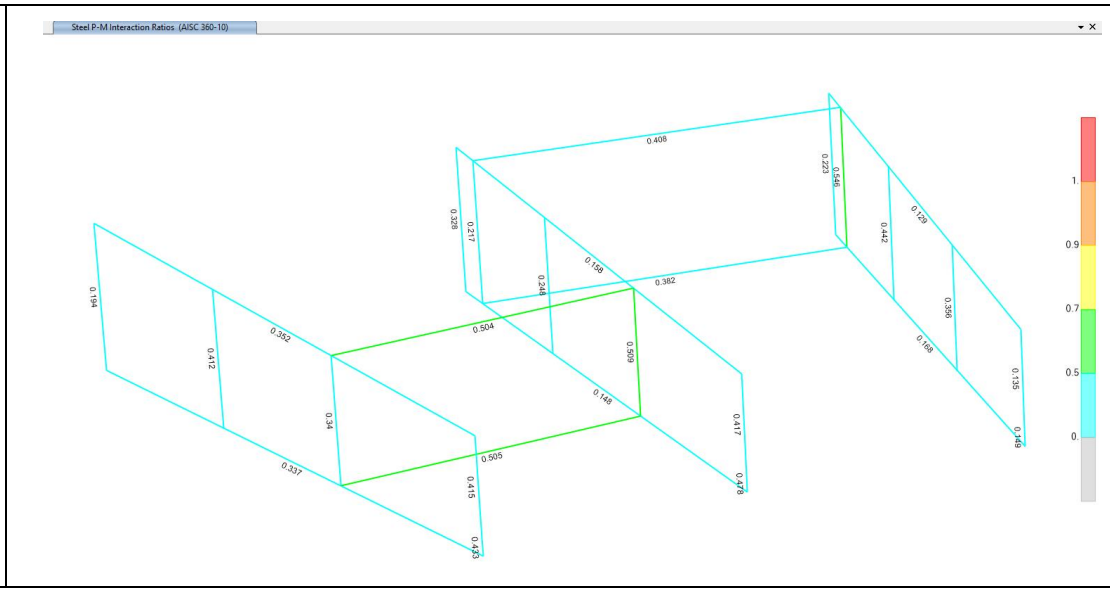
Corroded	

Figure 22:Stress Concentration at the Deck Plate (MPa) -Maintenance Case

7.1.4. Pontoon Structure

New	

Corroded

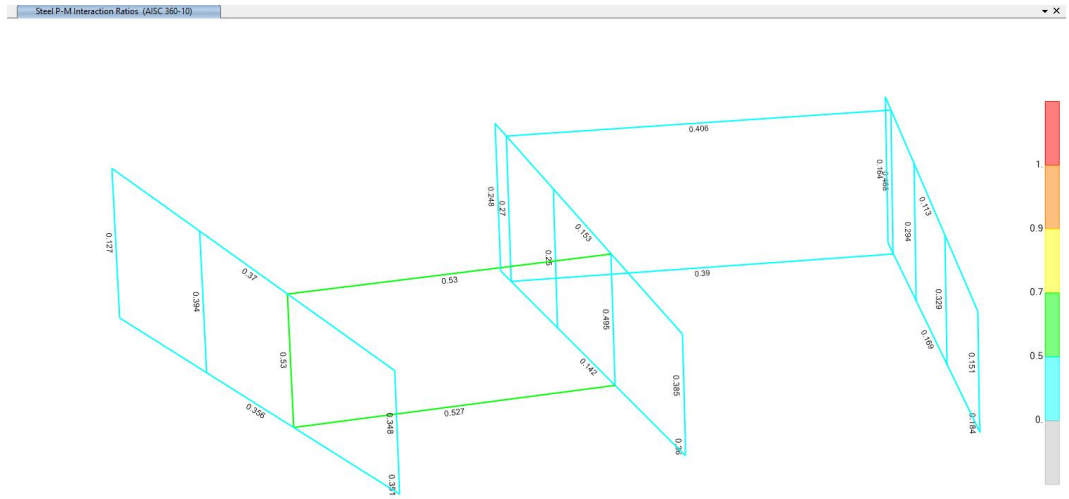
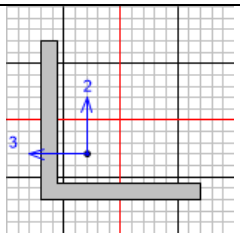


Figure 23:P-M Ratio for Frames in a Pontoon Compartment– Maintenance case

P-M Ratio for the worst case - NEW



AISC 360-10 STEEL SECTION CHECK (Summary for Combo and Station)
Units : N, mm, C

Frame : 598 X Mid: 3746.815 Combo: ENV Design Type: Column
Length: 768.108 Y Mid: -10289.981Shape: L70X7 Frame Type: OMF
Loc : 768.108 Z Mid: 2384.054 Class: Compact Princpl Rot: 45. degrees

Provision: ASD Analysis: Direct Analysis
D/C Limit=0.95 2nd Order: General 2nd Order Reduction: Tau-b Fixed
AlphaPr/Py=0.009 AlphaPr/Pe=0.003 Tau_b=1. EA factor=0.8 EI factor=0.8

OmegaB=1.67 OmegaC=1.67 OmegaTY=1.67 OmegaTF=2.
OmegaV=1.67 OmegaV-RI=1.5 OmegaVT=1.67

A=931. I33=432190.531 r33=21.546 S33=8657.48 Av3=490.
J=14618.088 I22=432190.531 r22=21.546 S22=8657.48 Av2=490.
Ixy=-255896.053 Imax=688086.583 rmax=27.186 Smax=14633.103
Rot= 45. deg Imin=176294.478 rmin=13.761 Smin=6208.444
E=199947.979 Fy=248.211 Ry=1.5 z33=15597.925
RLLF=1. Fu=399.896 z22=15597.925

STRESS CHECK FORCES & MOMENTS (Combo ENV)

Location	Pr	Mr33	Mr22	Vr2	Vr3	Tr
768.108	-1279.55	899042.651	78242.076	-1677.976	-226.392	-250.814

PMM DEMAND/CAPACITY RATIO (H2-1)
D/C Ratio: 0.642 = 0.011 + 0.212 + 0.419
= fa/Fa + fbw/Fbw + fbz/Fbz

AXIAL FORCE & BIAXIAL MOMENT DESIGN (H2-1)

Factor	L	K1	K2	B1	B2	Cm
Major Bending	1.	1.	1.	1.	1.	0.454
Minor Bending	1.	1.	1.	1.	1.	0.615

	Lltb	Kltb	Cb
LTB	1.	1.	1.

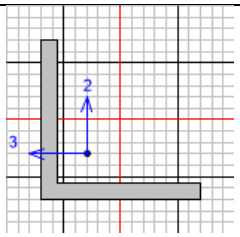
	Pr Force	Pnc/Omega Capacity	Pnt/Omega Capacity
Axial	-1279.55	117441.028	138374.075

	Mr Moment	Mn/Omega Capacity	Mn/Omega No LTB	Mn/Omega Cb=1
Major Moment	691044.657	3262366.52	3262366.52	3262366.52
Minor Moment	-580393.653	1384137.004		

SHEAR CHECK

	Vr Force	Vn/Omega Capacity	Stress Ratio	Status Check
Major Shear	1677.976	43697.076	0.038	OK
Minor Shear	1037.558	43697.076	0.024	OK

P-M Ratio for the worst case - CORRODED



AISC 360-10 STEEL SECTION CHECK (Summary for Combo and Station)
Units : N, mm, C

Frame : 598 X Mid: 3746.815 Combo: ENV Design Type: Column
Length: 768.108 Y Mid: -10289.981Shape: L70X7 Frame Type: OMF
Loc : 768.108 Z Mid: 2384.054 Class: Compact Princpl Rot: 45. degrees

Provision: ASD Analysis: Direct Analysis
D/C Limit=0.95 2nd Order: General 2nd Order Reduction: Tau-b Fixed
AlphaPr/Py=0.009 AlphaPr/Pe=0.004 Tau_b=1. EA factor=0.8 EI factor=0.8

OmegaB=1.67 OmegaC=1.67 OmegaTY=1.67 OmegaTF=2.
OmegaV=1.67 OmegaV-RI=1.5 OmegaVT=1.67

A=931. I33=432190.531 r33=21.546 S33=8657.48 Av3=490.
J=14618.088 I22=432190.531 r22=21.546 S22=8657.48 Av2=490.
Ixy=-255896.053 Imax=688086.583 rmax=27.186 Smax=14633.103
Rot= 45. deg Imin=176294.478 rmin=13.761 Smin=6208.444
E=199947.979 Fy=248.211 Ry=1.5 z33=15597.925
RLLF=1. Fu=399.896 z22=15597.925

STRESS CHECK FORCES & MOMENTS (Combo ENV)

Location	Pr	Mr33	Mr22	Vr2	Vr3	Tr
768.108	-1362.221	894009.971	77804.378	-1638.573	-218.754	-252.468

PMM DEMAND/CAPACITY RATIO (H2-1)
D/C Ratio: 0.639 = 0.012 + 0.211 + 0.417
= fa/Fa + fbw/Fbw + fbz/Fbz

AXIAL FORCE & BIAXIAL MOMENT DESIGN (H2-1)

Factor	L	K1	K2	B1	B2	Cm
Major Bending	1.	1.	1.	1.	1.	0.464
Minor Bending	1.	1.	1.	1.	1.	0.611

	Lltb	Kltb	Cb
LTB	1.	1.	1.

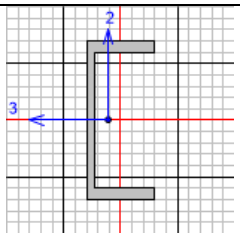
	Pr Force	Pnc/Omega Capacity	Pnt/Omega Capacity
Axial	-1362.221	117441.028	138374.075

	Mr Moment	Mn/Omega Capacity	Mn/Omega No LTB	Mn/Omega Cb=1
Major Moment	687176.516	3262366.52	3262366.52	3262366.52
Minor Moment	-577144.51	1384137.004		

SHEAR CHECK

	Vr Force	Vn/Omega Capacity	Stress Ratio	Status Check
Major Shear	1638.573	43697.076	0.037	OK
Minor Shear	1015.879	43697.076	0.023	OK

Deflection for the worst case - NEW



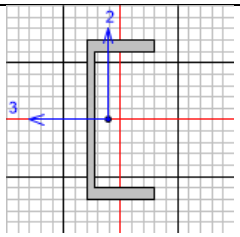
AISC 360-10 STEEL SECTION CHECK (Deflection Details)
Units : N, mm, C

Frame : 219 X Mid: -10957.662Combo: def(D+PE) Design Type: Beam
Length: 1924.688 Y Mid: -960.103 Shape: UPN140 Frame Type: OMF
Loc : 0. Z Mid: 2000. Class: Slender Princpl Rot: 0. degrees

DEFLECTION CHECK (Combodef(D+PE)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	0.767	9.623	0.08	OK
Super DL+LL	Yes	0.	9.623	0.	OK
Live Load	Yes	0.	9.623	0.	OK
Total Load	Yes	1.581	9.623	0.164	OK
Total-Camber	Yes	1.581	9.623	0.164	OK

Deflection for the worst case - CORRODED



AISC 360-10 STEEL SECTION CHECK (Deflection Details)
Units : N, mm, C

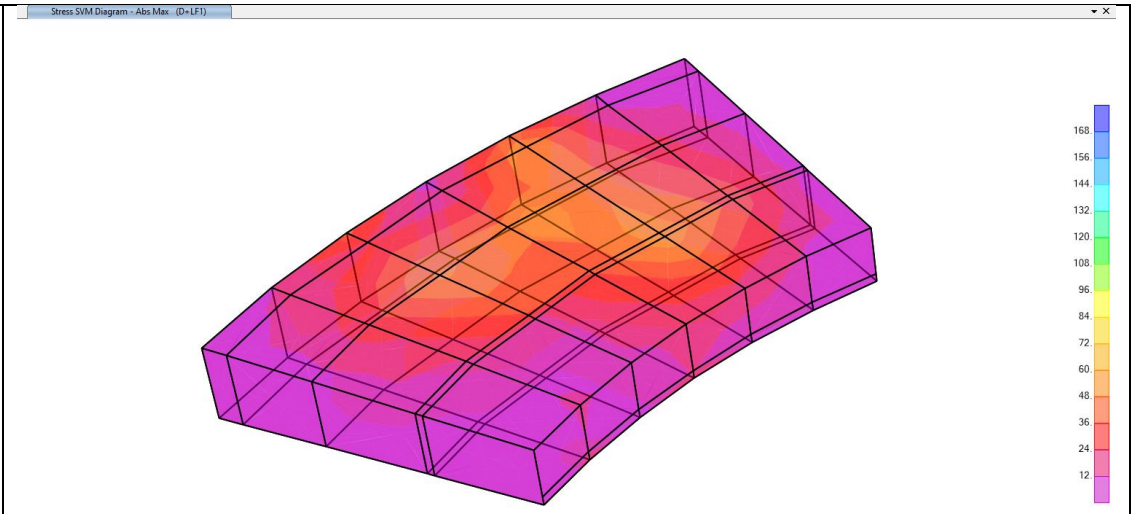
Frame : 219 X Mid: -10957.662Combo: def(D+PE) Design Type: Beam
Length: 1924.688 Y Mid: -960.103 Shape: UPN140 Frame Type: OMF
Loc : 0. Z Mid: 2000. Class: Slender Princpl Rot: 0. degrees

DEFLECTION CHECK (Combodef(D+PE)

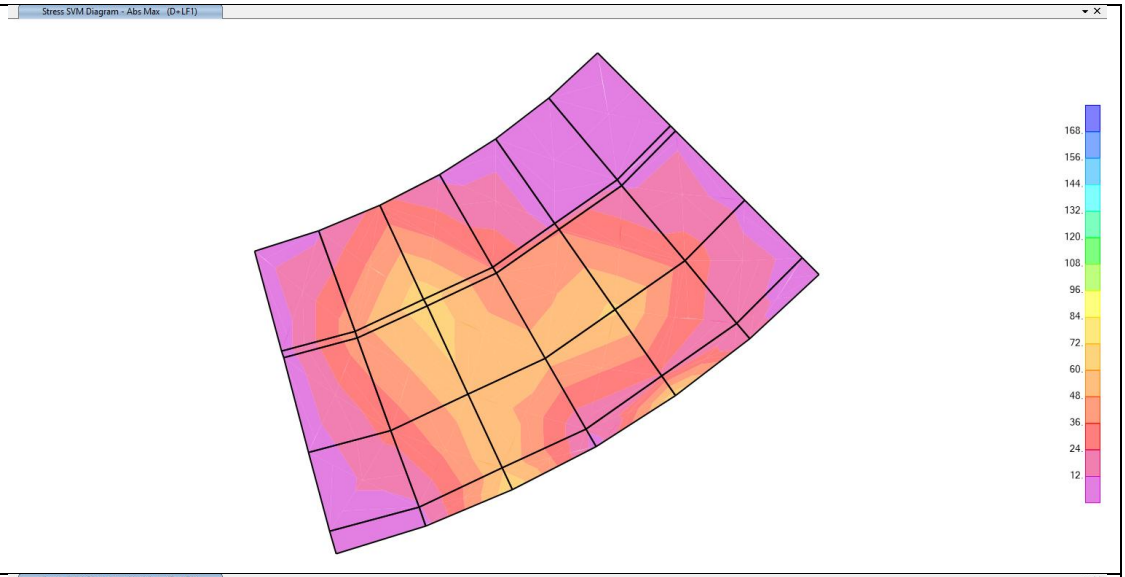
Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	0.737	9.623	0.077	OK
Super DL+LL	Yes	0.	9.623	0.	OK
Live Load	Yes	0.	9.623	0.	OK
Total Load	Yes	1.523	9.623	0.158	OK
Total-Camber	Yes	1.523	9.623	0.158	OK

7.1.5. Pontoon and Compartment Plates

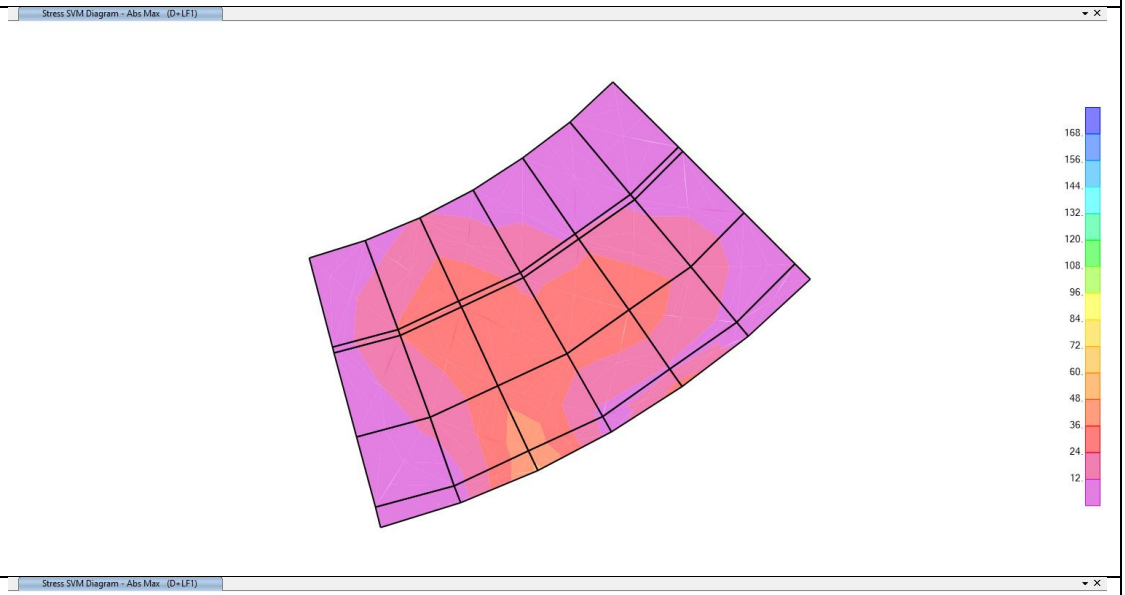
SVM-Overall (MPa) -New



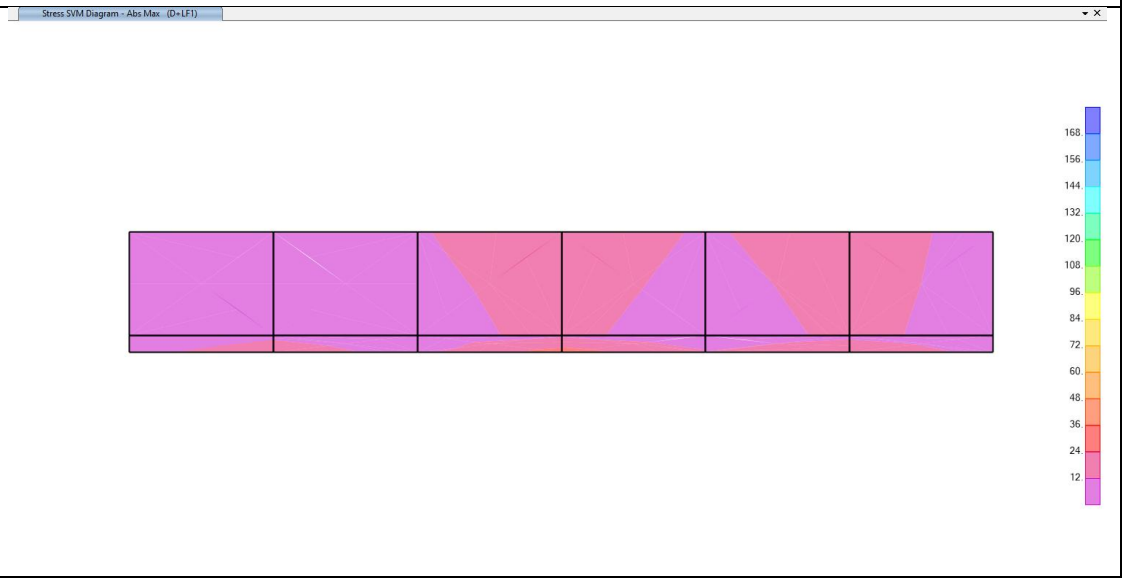
SVM-Top Plate (MPa) -New



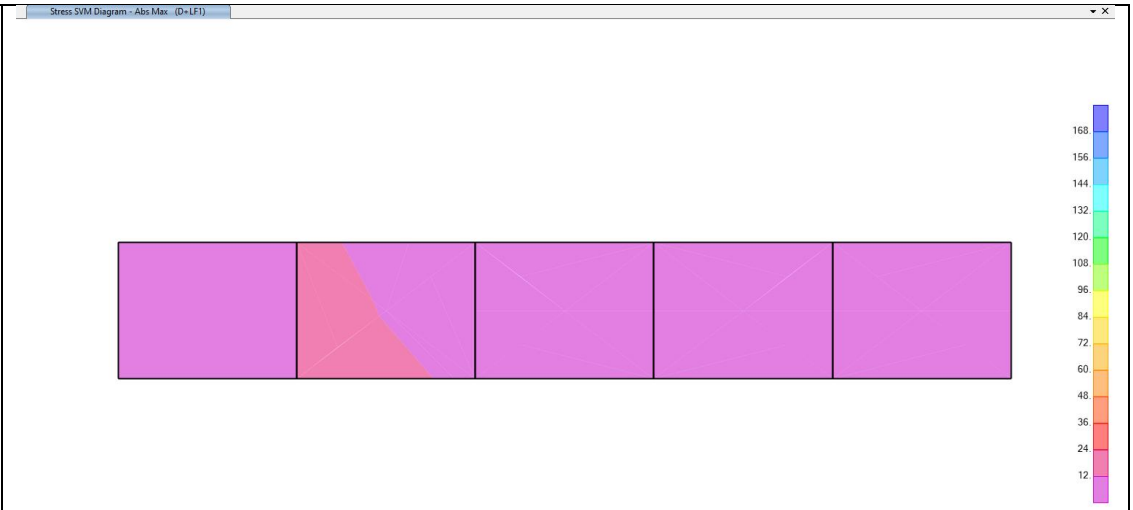
SVM-Bottom Plate (MPa) -New



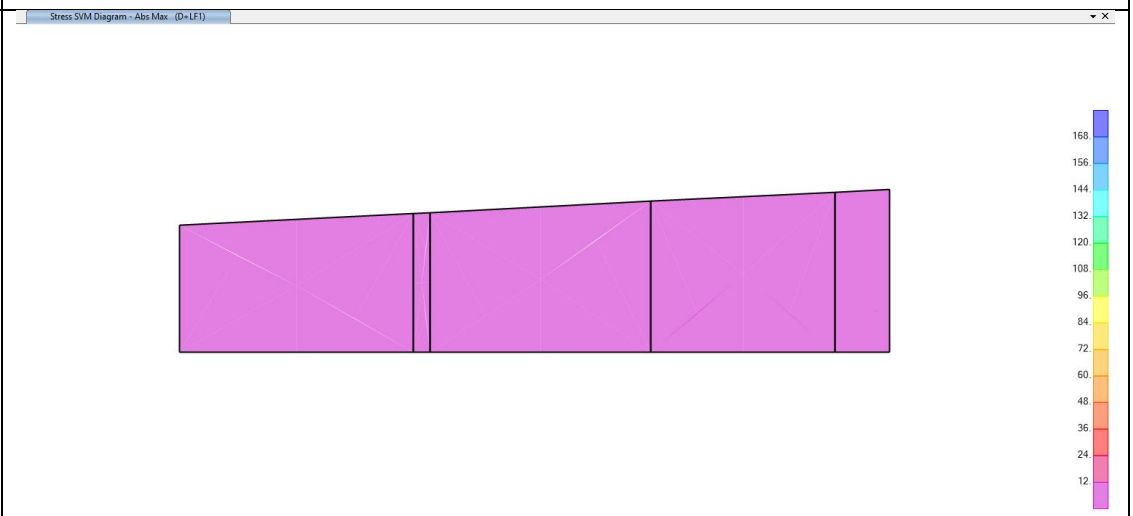
SVM-Inner Rim (MPa) -New



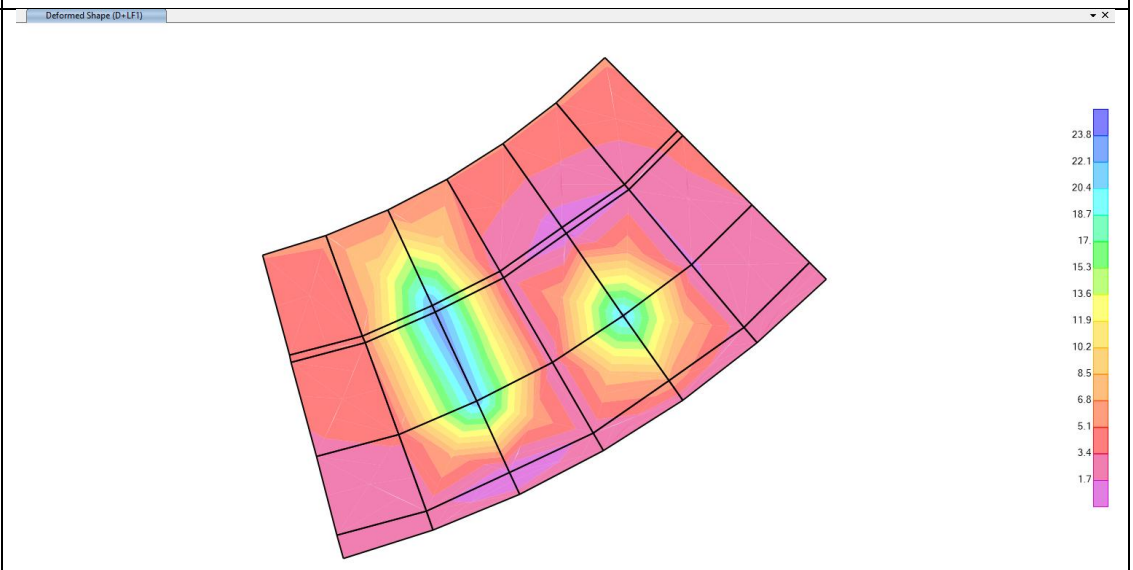
SVM-Outer Rim (MPa) -New



SVM-Compartment Plate (MPa) -New



Deflection-Top Plate (mm) -New



Deflection-Bottom Plate (mm) -New

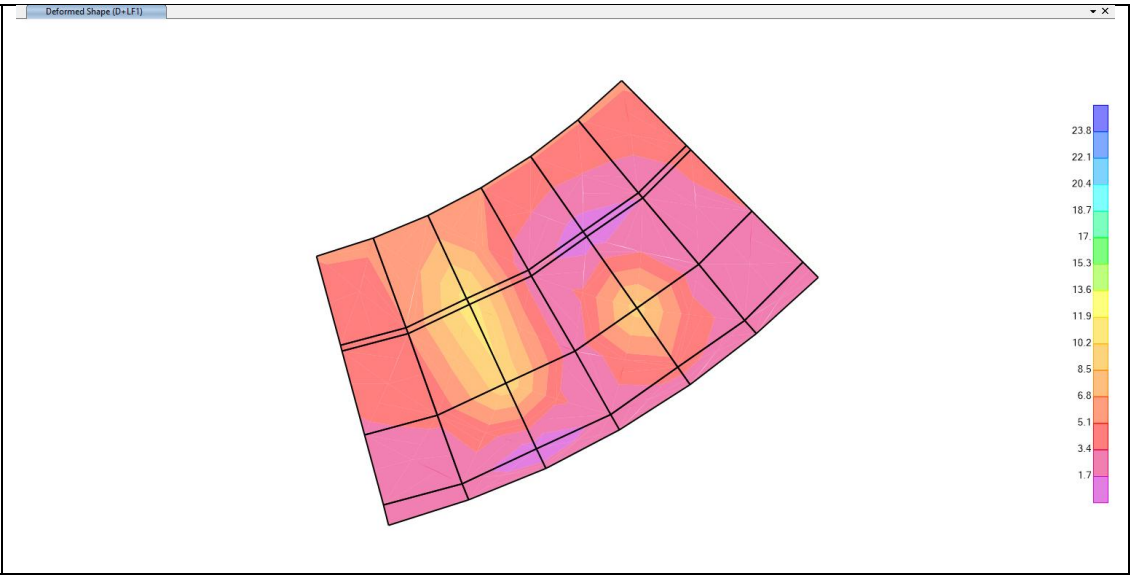
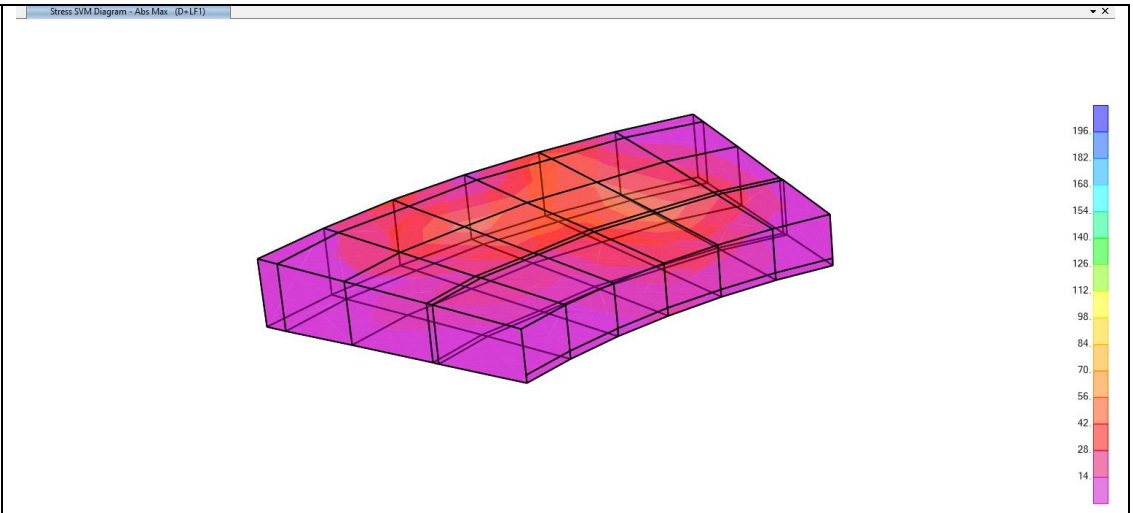
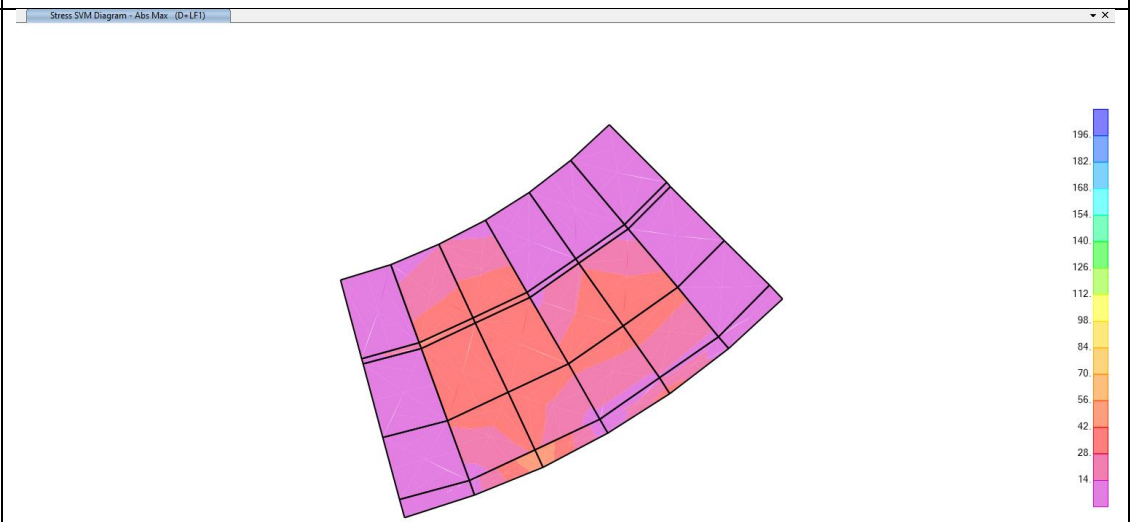


Figure 24:Pontoon Plates Results– Maintenance case -New

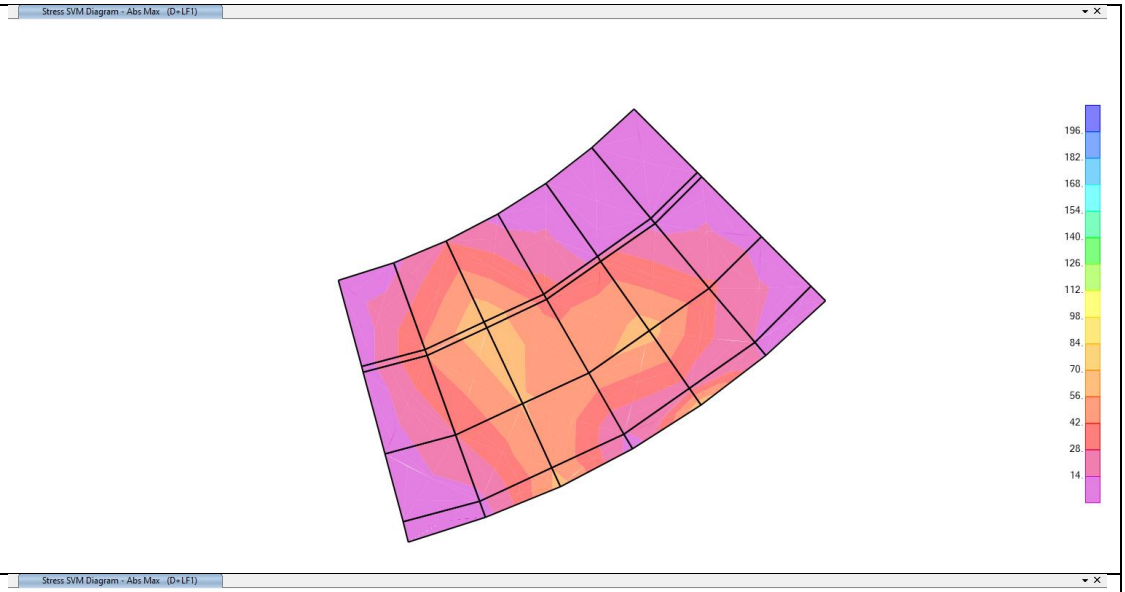
SVM-Overall (MPa) - Cor



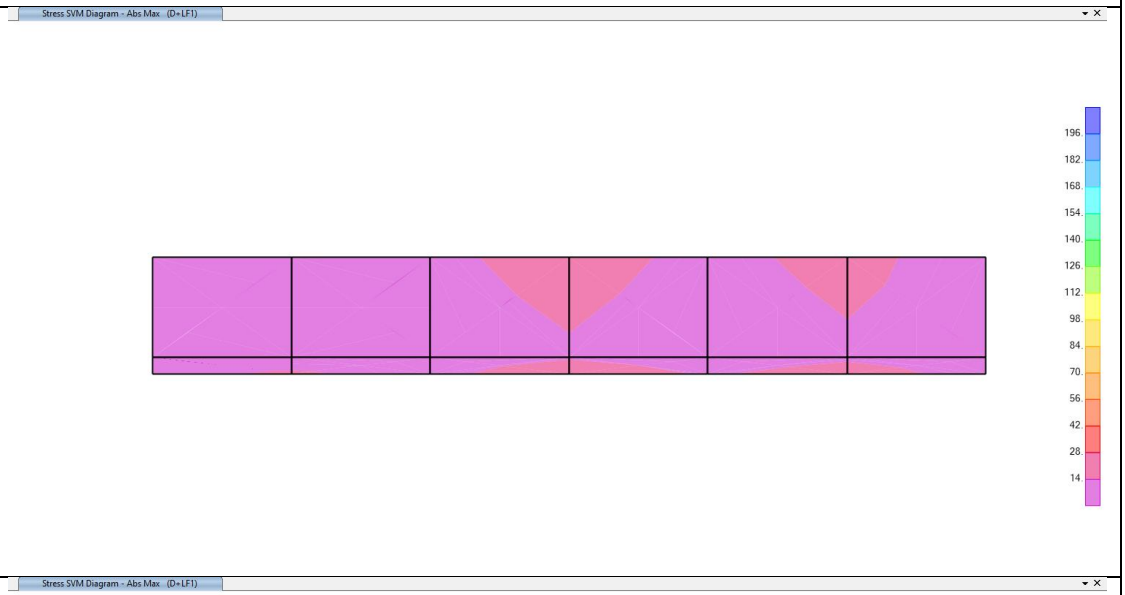
SVM-Top Plate (MPa) - Cor



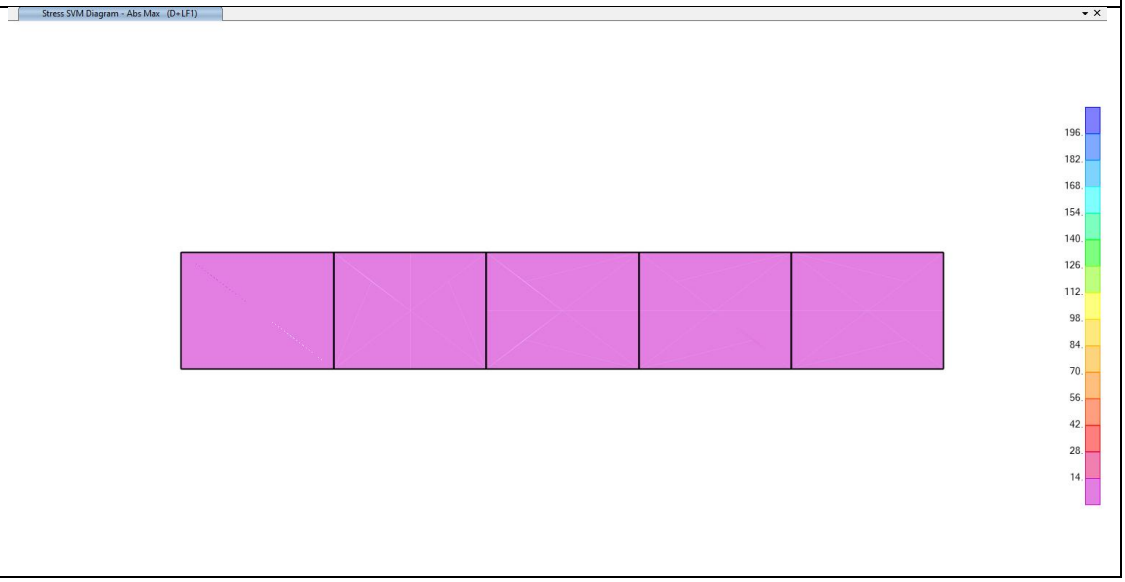
SVM-Bottom Plate (MPa) - Cor



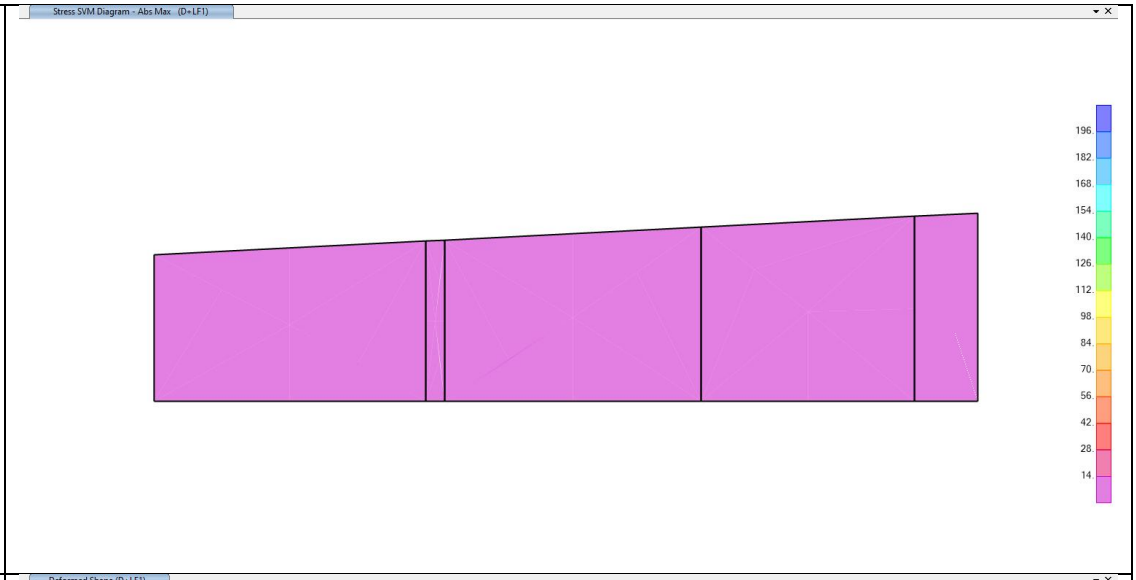
SVM-Inner Rim (MPa) - Cor



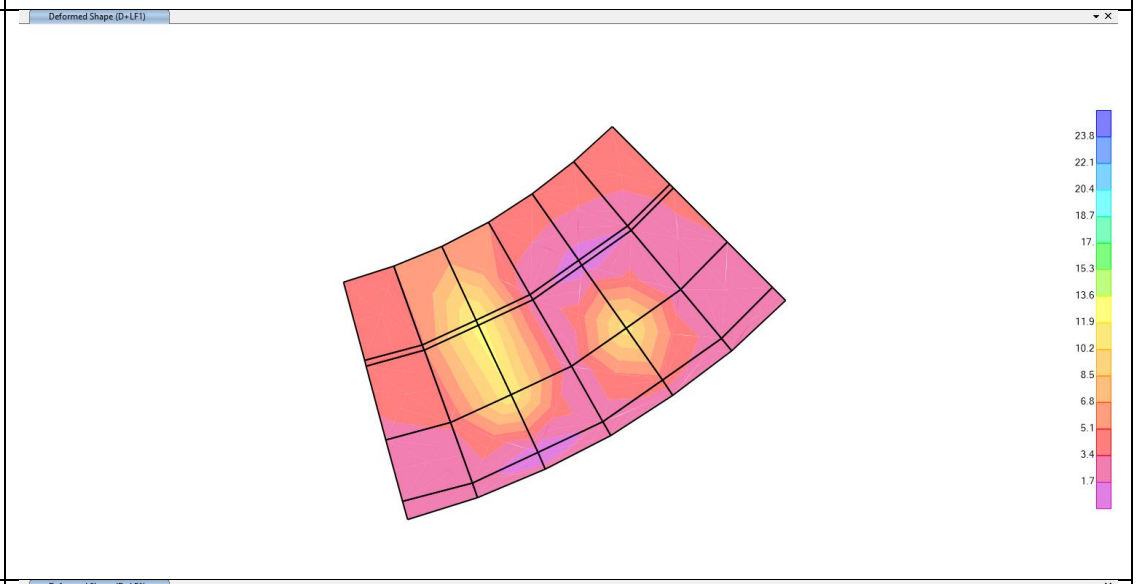
SVM-Outer Rim (MPa) - Cor



SVM-Compartment Plate (MPa) - Cor



Deflection-Top Plate (mm) - Cor



Deflection-Bottom Plate (mm) - Cor

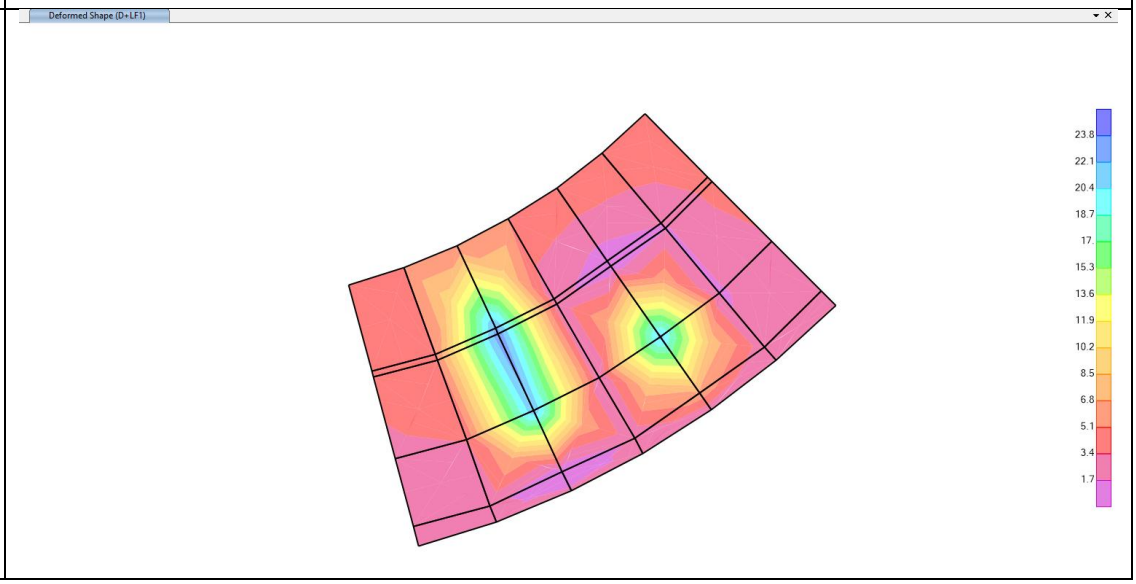


Figure 25:Pontoon Plates Results – Corroded – Maintenance case

7.2. Floating Case

7.2.1. Intact Roof

(I) Overall View

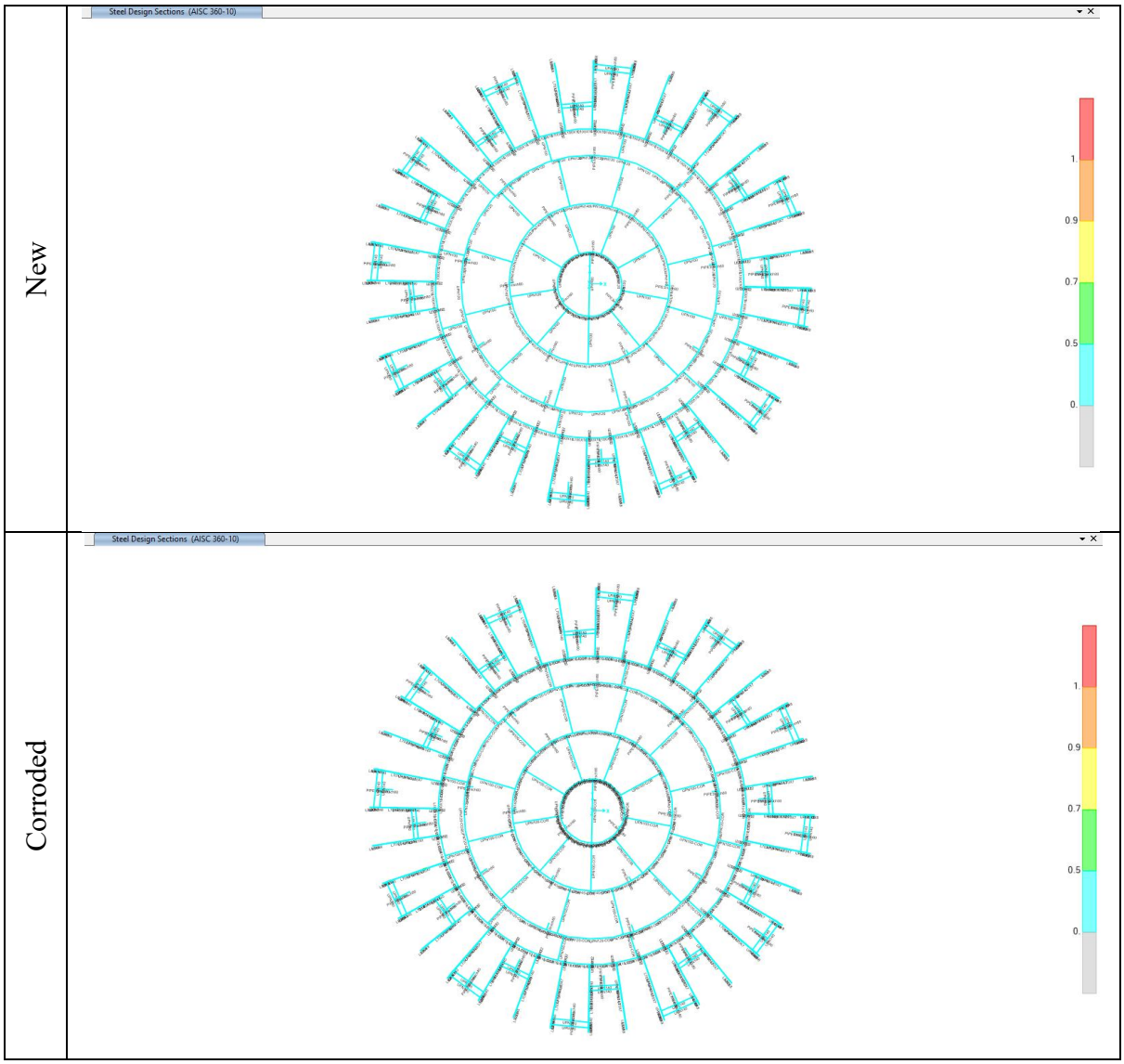


Figure 26:P-M Ratio of the Roof Structure – Floating case - Intact Roof

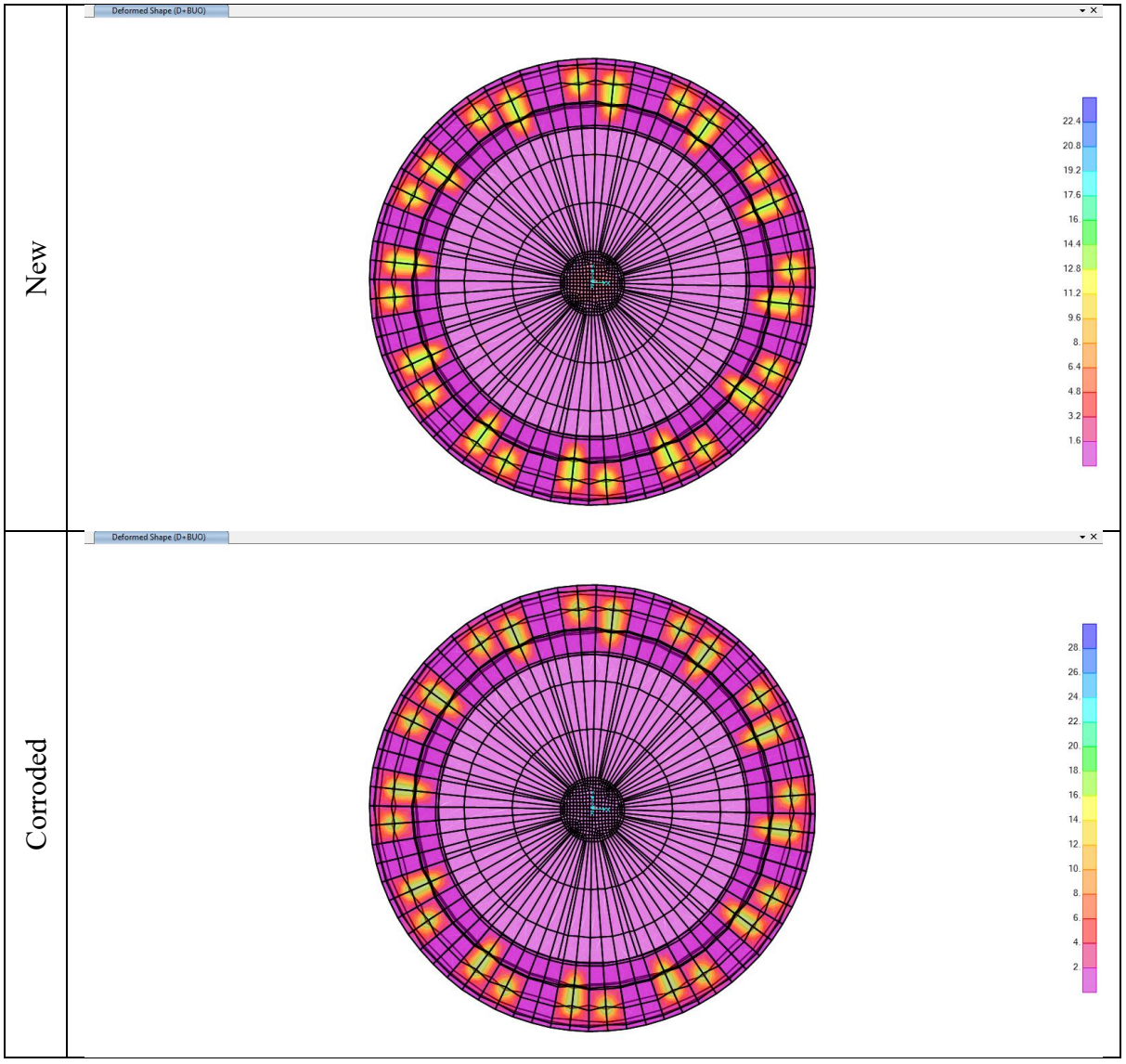
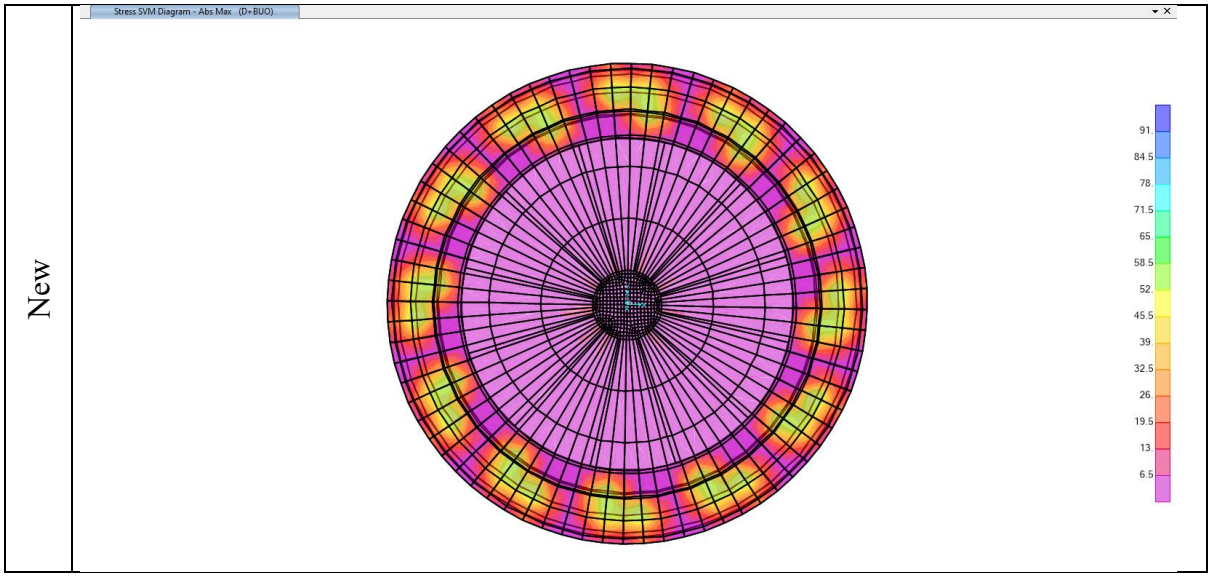


Figure 27:Deflection of Plates (mm) – Floating case - Intact Roof



Corroded

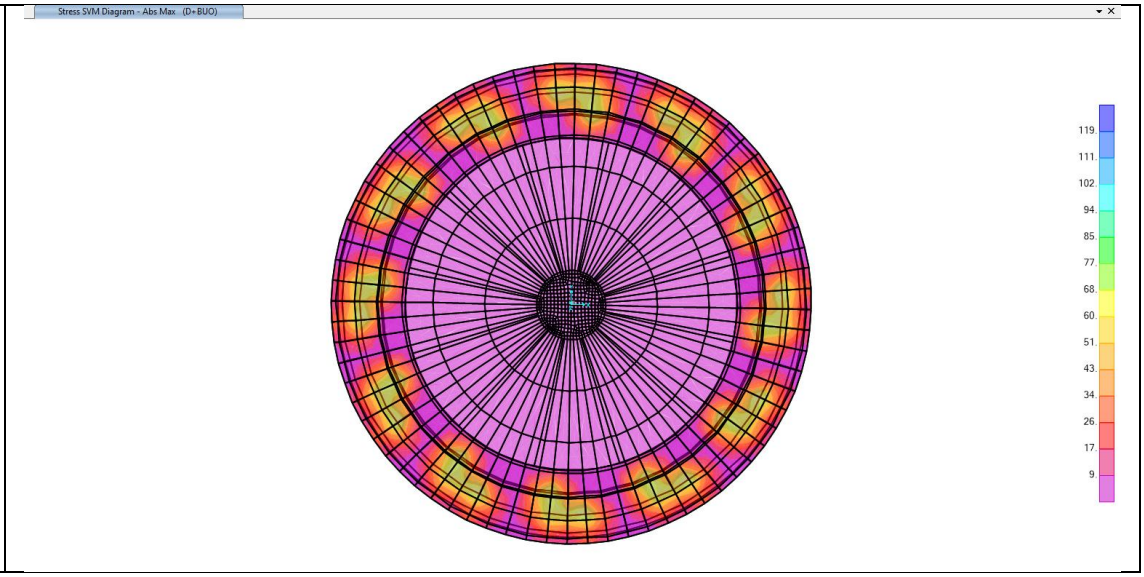
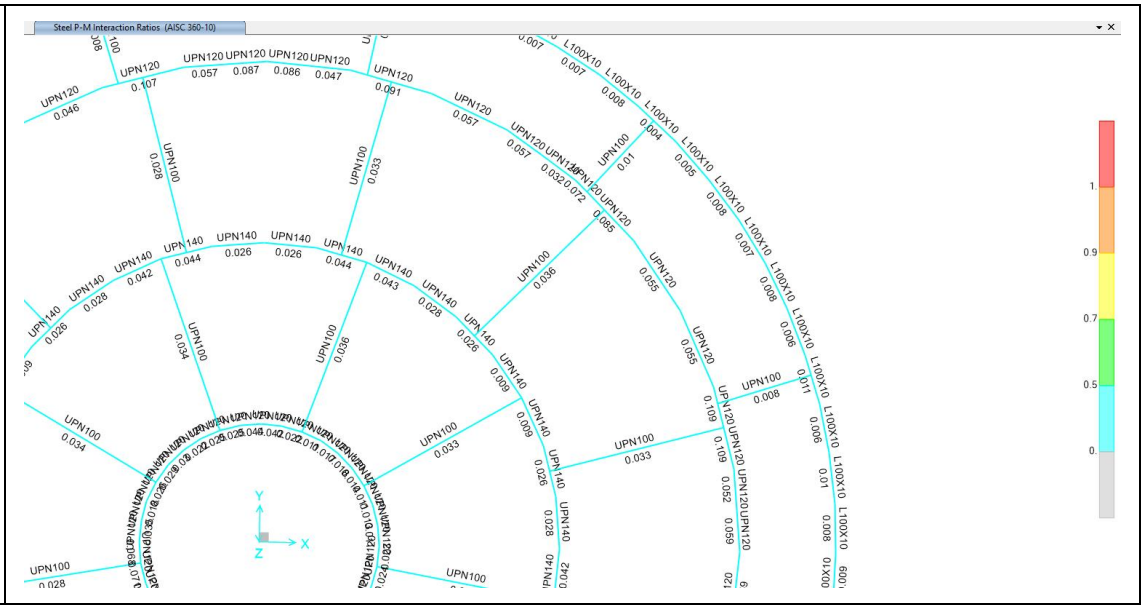


Figure 28:Shell SVM Stress (MPa) – Floating case - Intact Roof

(II) Deck Structure

New



Corroded

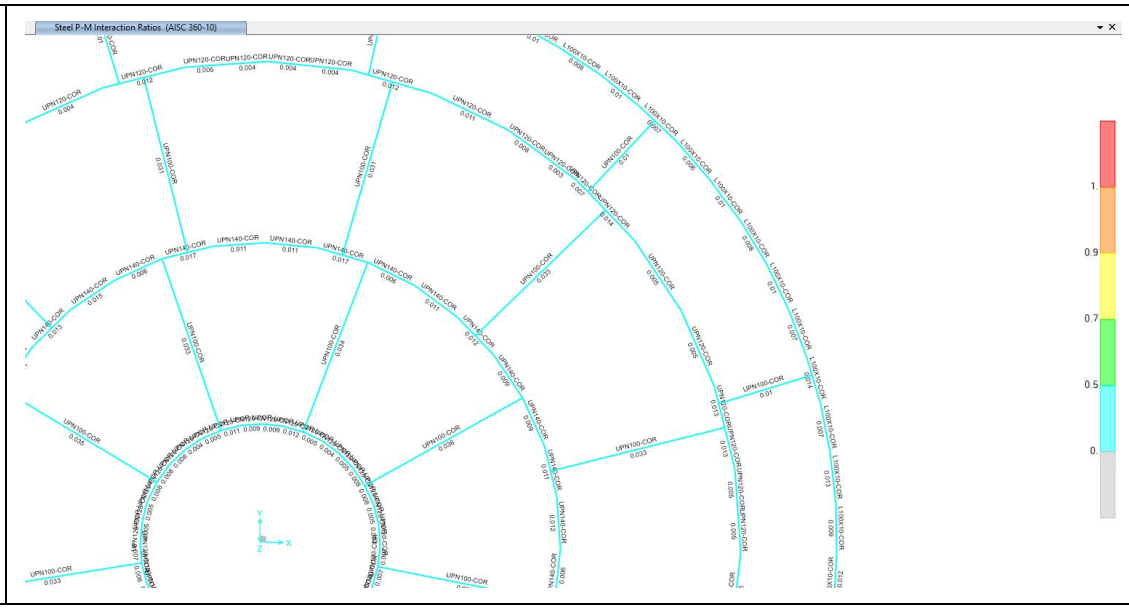
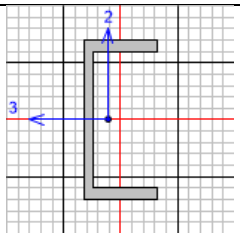


Figure 29:P-M Ratio of the Roof Structure– Floating case - Intact Roof

P-M Ratio for the worst case - NEW



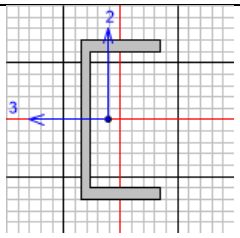

```
AISC 360-10 STEEL SECTION CHECK     (Summary for Combo and Station)
Units  :  N, mm, C

Frame :  607      X Mid:  -1724.982 Combo:  D+BUO           Design Type:  Beam
Length:  699.163  Y Mid:  -7788.399 Shape:  UPN120          Frame Type:  OMF
Loc   :  0.       Z Mid:  2100.     Class:  Compact         Princpl Rot: 0. degrees

Provision: ASD    Analysis: Direct Analysis
D/C Limit=0.95    2nd Order: General 2nd Order       Reduction: Tau-b Fixed
AlphaPr/Py=0.001  AlphaPr/Pe=8E-05  Tau_b=1.         EA factor=0.8     EI factor=0.8

OmegaB=1.67       OmegaC=1.67       OmegaTY=1.67      OmegaTF=2.
OmegaV=1.67       OmegaV-RI=1.5     OmegaVT=1.67

A=1704.           I33=3675168.      r33=46.441        S33=61252.8       Av3=990.
J=35132.17        I22=491416.592    r22=16.982        S22=13084.785     Av2=840.
E=199947.979      Fy=248.211        Ry=1.5            z33=73152.        Cw=1053471116.3
RLLF=1.           Fu=399.896                          z22=23668.


STRESS CHECK FORCES & MOMENTS (Combo D+BUO)
    Location              Pr         Mr33         Mr22         Vr2         Vr3          Tr
    0.               289.914 -1176284.59      -527.26   -1145.366       0.695    1404.426

PMM DEMAND/CAPACITY RATIO   (H1.2,H1-1b)
    D/C Ratio:    0.109 = 0. + 0.108 + 0.
                        = (1/2)(Pr/Pc) + (Mr33/Mc33) + (Mr22/Mc22)

AXIAL FORCE & BIAXIAL MOMENT DESIGN   (H1.2,H1-1b)
    Factor                 L          K1          K2          B1          B2          Cm
    Major Bending          1.          1.          1.          1.          1.          1.
    Minor Bending      0.597           1.          1.          1.          1.          1.

                        Lltb        Kltb          Cb
    LTB                0.597          1.       1.241

                          Pr   Pnc/Omega   Pnt/Omega
                       Force    Capacity    Capacity
    Axial            289.914  241363.931  253264.687

                          Mr    Mn/Omega    Mn/Omega    Mn/Omega
                      Moment    Capacity      No LTB        Cb=1
    Major Moment -1176284.59 10872546.02 10872546.02
    Minor Moment     -527.26 3111656.215

SHEAR CHECK
```

	Vr Force	Vn/Omega Capacity	Stress Ratio	Status Check
Major Shear	1145.366	74909.274	0.015	OK
Minor Shear	0.695	88285.93	7.870E-06	OK

CONNECTION SHEAR FORCES FOR BEAMS

	VMajor Left	VMajor Right
Major (V2)	1145.366	826.358

P-M Ratio for the worst case - CORRODED



AISC 360-10 STEEL SECTION CHECK (Summary for Combo and Station)
Units : N, mm, C

Frame : 429 X Mid: -3031.51 Combo: D+BUO Design Type: Beam
Length: 3000. Y Mid: 1749.271 Shape: UPN100-COR Frame Type: OMF
Loc : 1500. Z Mid: 2100. Class: Compact Princpl Rot: 0. degrees

Provision: ASD Analysis: Direct Analysis
D/C Limit=0.95 2nd Order: General 2nd Order Reduction: Tau-b Fixed
AlphaPr/Py=0.002 AlphaPr/Pe=0.01 Tau_b=1. EA factor=0.8 EI factor=0.8

OmegaB=1.67 OmegaC=1.67 OmegaTY=1.67 OmegaTF=2.
OmegaV=1.67 OmegaV-RI=1.5 OmegaVT=1.67

A=1187.5 I33=1801690.505 r33=38.951 S33=36582.548 Av3=751.75
J=17379.428 I22=277359.446 r22=15.283 S22=8617.598 Av2=517.125
E=199947.979 Fy=248.211 Ry=1.5 z33=43152.469 Cw=401141632.7
RLLF=1. Fu=399.896 z22=15475.513

STRESS CHECK FORCES & MOMENTS (Combo D+BUO)

Location	Pr	Mr33	Mr22	Vr2	Vr3	Tr
1500.	373.528	192456.318	1.405	-8.991	-0.008	-0.572

PMM DEMAND/CAPACITY RATIO (H1.2,H1-1b)
D/C Ratio: 0.035 = 0.001 + 0.034 + 0.
= (1/2)(Pr/Pc) + (Mr33/Mc33) + (Mr22/Mc22)

AXIAL FORCE & BIAXIAL MOMENT DESIGN (H1.2,H1-1b)

Factor	L	K1	K2	B1	B2	Cm
Major Bending	1.	1.	1.	1.	1.	1.
Minor Bending	1.	1.	1.	1.	1.	1.

	Lltb	Kltb	Cb
LTB	1.	1.	1.176

	Pr Force	Pnc/Omega Capacity	Pnt/Omega Capacity
Axial	373.528	31937.457	176497.545

	Mr Moment	Mn/Omega Capacity	Mn/Omega No LTB	Mn/Omega Cb=1
Major Moment	192456.318	5616923.528	6413730.346	4776596.841
Minor Moment	1.405	2049327.11		

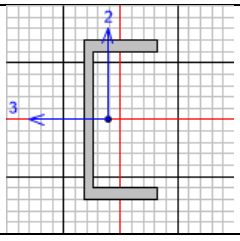
SHEAR CHECK

	Vr Force	Vn/Omega Capacity	Stress Ratio	Status Check
Major Shear	8.991	46116.022	0.	OK
Minor Shear	0.008	67039.341	0.	OK

CONNECTION SHEAR FORCES FOR BEAMS

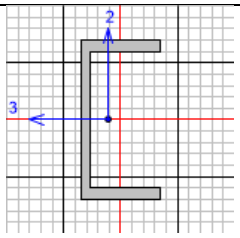
	VMajor Left	VMajor Right
Major (V2)	296.917	278.936

Deflection for the worst case - NEW



```
AISC 360-10 STEEL SECTION CHECK    (Deflection Details)
Units  :  N, mm, C

Frame :  607      X Mid:  -1724.982 Combo:  def(D+BUO)      Design Type:  Beam
Length:  699.163  Y Mid:  -7788.399 Shape:  UPN120          Frame Type:  OMF
Loc   :  0.       Z Mid:  2100.     Class:  Slender         Princpl Rot: 0. degrees


DEFLECTION CHECK (Combodef(D+BU)
           Type     Consider  Deflection       Limit       Ratio      Status
      Dead Load          Yes       0.068       3.496       0.019          OK
    Super DL+LL          Yes          0.       3.496          0.          OK
      Live Load          Yes          0.       3.496          0.          OK
     Total Load          Yes       0.068       3.496       0.019          OK
   Total-Camber          Yes       0.068       3.496       0.019          OK
```

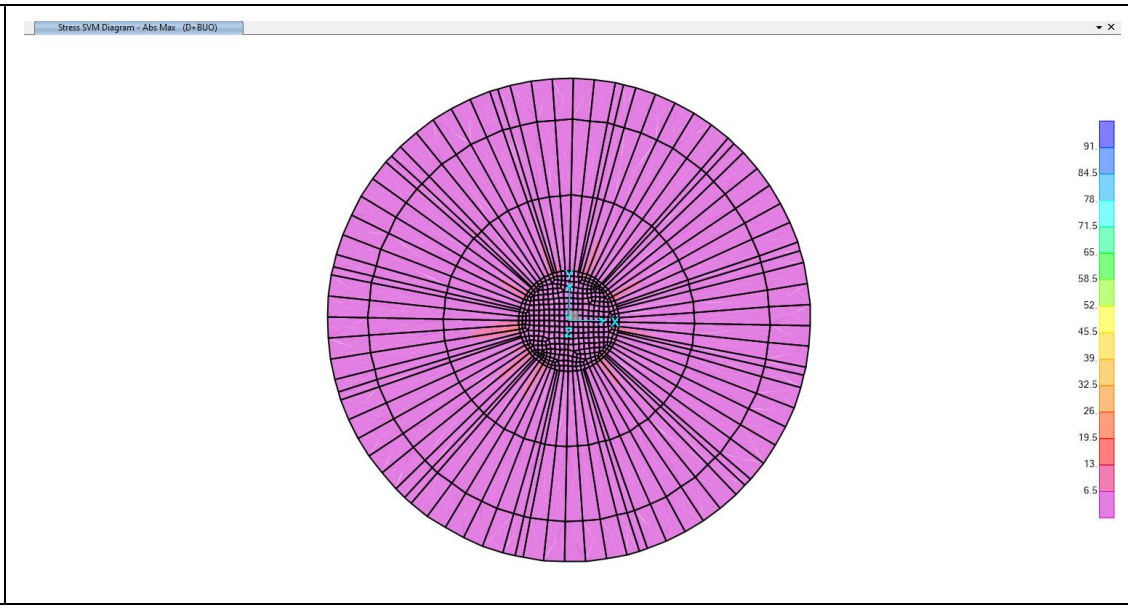
Deflection for the worst case - CORRODED




```
AISC 360-10 STEEL SECTION CHECK    (Deflection Details)
Units  :  N, mm, C

Frame :  429      X Mid:  -3031.51  Combo:  def(D+BUO)      Design Type:  Beam
Length:  3000.    Y Mid:  1749.271  Shape:  UPN100-COR      Frame Type:  OMF
Loc   :  0.       Z Mid:  2100.     Class:  Slender         Princpl Rot: 0. degrees


DEFLECTION CHECK (Combodef(D+BU)
           Type     Consider  Deflection       Limit       Ratio      Status
      Dead Load          Yes       0.476         15.       0.032          OK
    Super DL+LL          Yes          0.         15.          0.          OK
      Live Load          Yes          0.         15.          0.          OK
     Total Load          Yes       0.476         15.       0.032          OK
   Total-Camber          Yes       0.476         15.       0.032          OK
```

(III)Deck Plates

New



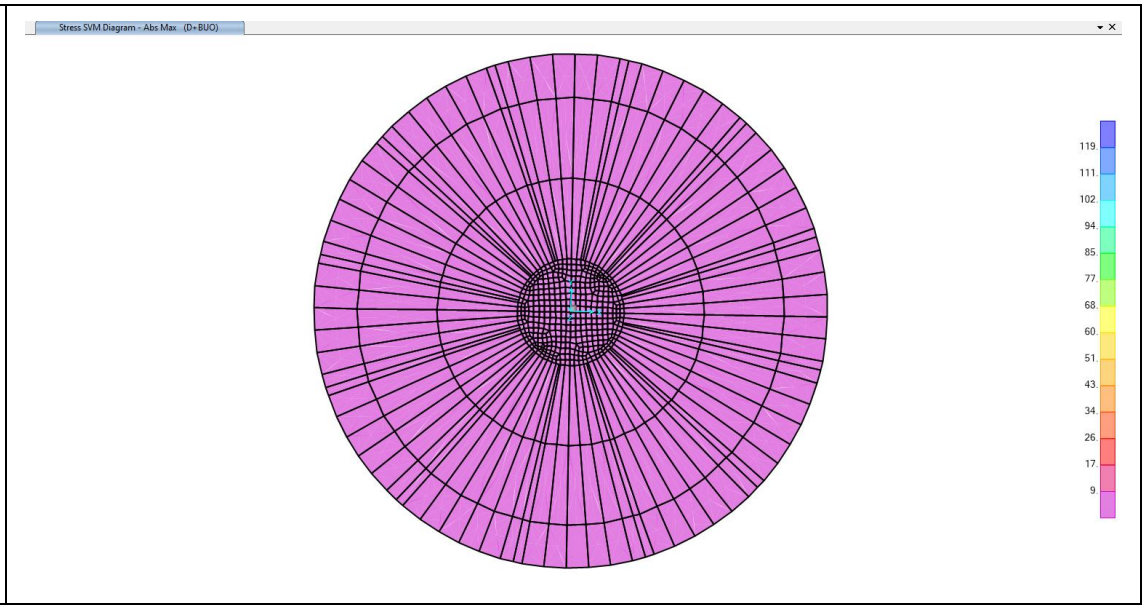
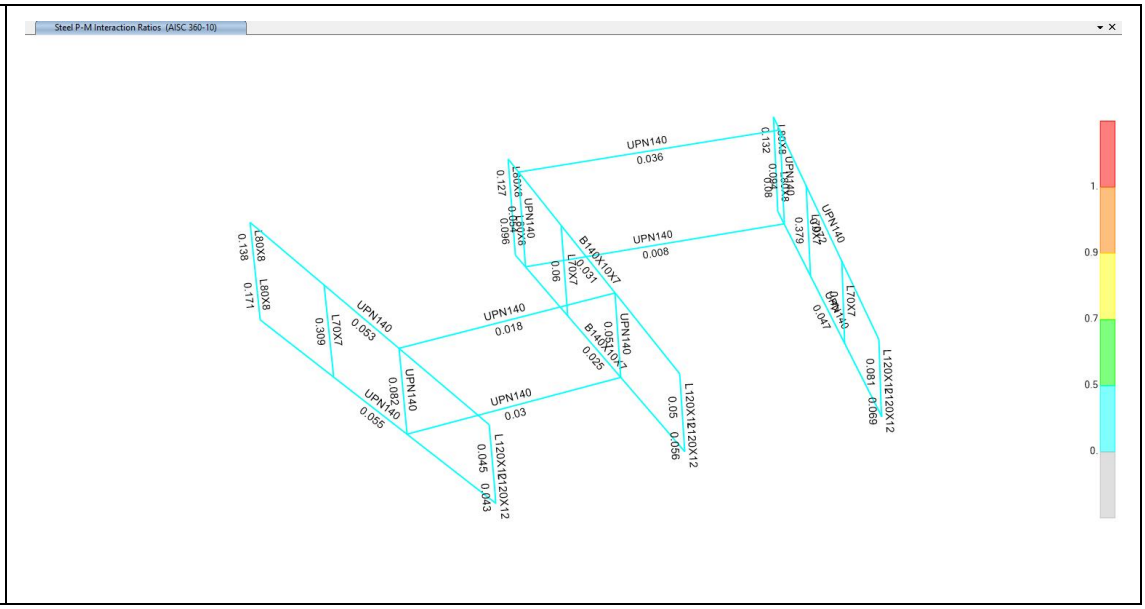
Corroded	

Figure 30: Deck Plate Stress (MPa) – Floating case - Intact Roof

(IV)Pontoon Structure

New	

Corroded

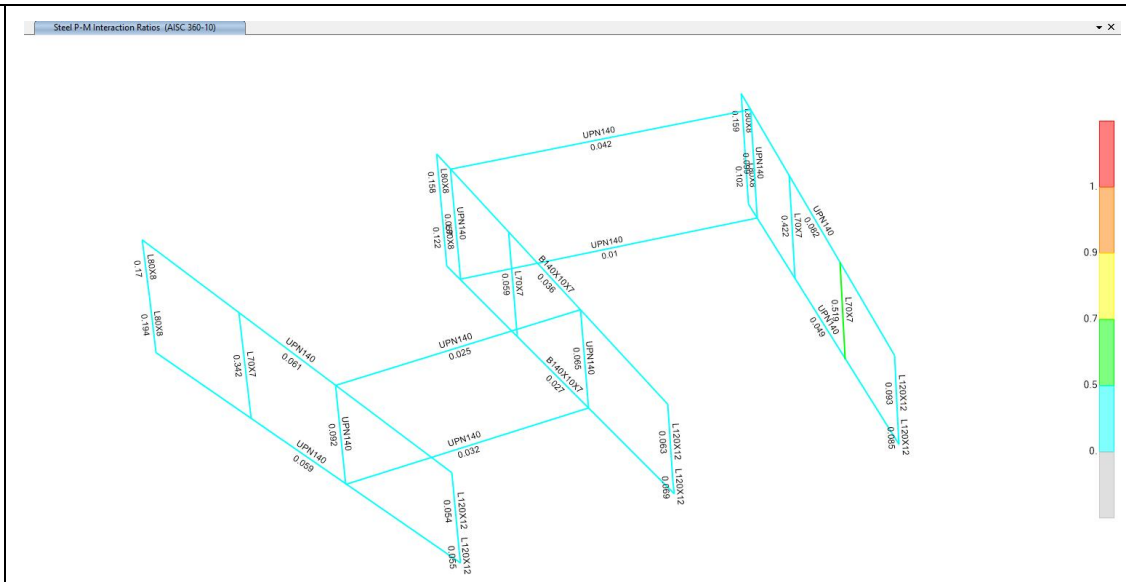
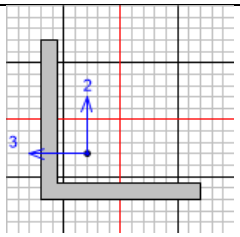


Figure 31:P-M Ratio for Frames in a Pontoon Compartment– Floating case - Intact Roof

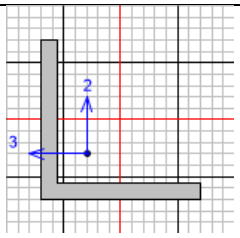
P-M Ratio for the worst case - NEW




```
AISC 360-10 STEEL SECTION CHECK     (Summary for Combo and Station)
Units  :  N, mm, C

Frame :  601      X Mid:  10289.981 Combo:  D+BUO          Design Type:  Column
Length:  768.108  Y Mid:  3746.815  Shape:  L70X7          Frame Type:  OMF
Loc   :  0.       Z Mid:  2384.054  Class:  Compact        Princpl Rot: 45. degrees

Provision: ASD    Analysis: Direct Analysis
D/C Limit=0.95    2nd Order: General 2nd Order       Reduction: Tau-b Fixed
AlphaPr/Py=0.027  AlphaPr/Pe=0.01   Tau_b=1.         EA factor=0.8     EI factor=0.8

OmegaB=1.67       OmegaC=1.67       OmegaTY=1.67     OmegaTF=2.
OmegaV=1.67       OmegaV-RI=1.5     OmegaVT=1.67

A=931.            I33=432190.531    r33=21.546       S33=8657.48       Av3=490.
J=14618.088       I22=432190.531    r22=21.546       S22=8657.48       Av2=490.
Ixy=-255896.053   Imax=688086.583   rmax=27.186      Smax=14633.103
Rot= 45. deg      Imin=176294.478   rmin=13.761      Smin=6208.444
E=199947.979      Fy=248.211        Ry=1.5           z33=15597.925
RLLF=1.           Fu=399.896                         z22=15597.925


STRESS CHECK FORCES & MOMENTS (Combo D+BUO)
    Location          Pr         Mr33        Mr22         Vr2         Vr3          Tr
    0.            -3837.806  308244.185  725272.984     535.211     862.036    -187.341

PMM DEMAND/CAPACITY RATIO   (H2-1)
    D/C Ratio:     0.47 = 0.033 + 0.224 + 0.213
                       = fa/Fa + fbw/Fbw + fbz/Fbz

AXIAL FORCE & BIAXIAL MOMENT DESIGN   (H2-1)
    Factor                L          K1          K2          B1          B2          Cm
    Major Bending         1.          1.          1.          1.          1.       0.585
    Minor Bending         1.          1.          1.          1.          1.       0.759

                        Lltb        Kltb          Cb
    LTB                   1.          1.          1.

                          Pr    Pnc/Omega   Pnt/Omega
                       Force     Capacity    Capacity
    Axial          -3837.806  117441.028  138374.075

                          Mr    Mn/Omega    Mn/Omega    Mn/Omega
                      Moment     Capacity      No LTB        Cb=1
    Major Moment  730806.998  3262366.52  3262366.52  3262366.52
    Minor Moment  294883.892 1384137.004
```

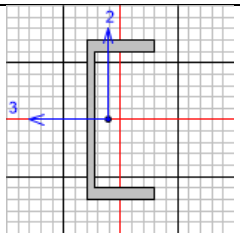
```
SHEAR CHECK
                                                Vr     Vn/Omega      Stress      Status
                                             Force     Capacity       Ratio       Check
    Major Shear      535.211    43697.076       0.012                OK
    Minor Shear      862.036    43697.076        0.02                OK
```

P-M Ratio for the worst case - CORRODED




```
AISC 360-10 STEEL SECTION CHECK     (Summary for Combo and Station)
Units  :  N, mm, C

Frame :  601       X Mid:  10289.981 Combo:  D+BUO           Design Type:  Column
Length:  768.108   Y Mid:  3746.815  Shape:  L70X7           Frame Type:  OMF
Loc   :  0.        Z Mid:  2384.054  Class:  Compact         Princpl Rot: 45. degrees

Provision: ASD     Analysis: Direct Analysis
D/C Limit=0.95     2nd Order: General 2nd Order        Reduction: Tau-b Fixed
AlphaPr/Py=0.028   AlphaPr/Pe=0.011   Tau_b=1.          EA factor=0.8     EI factor=0.8

OmegaB=1.67        OmegaC=1.67        OmegaTY=1.67      OmegaTF=2.
OmegaV=1.67        OmegaV-RI=1.5      OmegaVT=1.67

A=931.             I33=432190.531     r33=21.546        S33=8657.48       Av3=490.
J=14618.088        I22=432190.531     r22=21.546        S22=8657.48       Av2=490.
Ixy=-255896.053    Imax=688086.583    rmax=27.186       Smax=14633.103
Rot= 45. deg       Imin=176294.478    rmin=13.761       Smin=6208.444
E=199947.979       Fy=248.211         Ry=1.5            z33=15597.925
RLLF=1.            Fu=399.896                           z22=15597.925


STRESS CHECK FORCES & MOMENTS (Combo D+BUO)
    Location            Pr         Mr33        Mr22         Vr2         Vr3          Tr
    0.             -4050.431  343766.408  804368.164     607.582     981.468    -204.591

PMM DEMAND/CAPACITY RATIO    (H2-1)
    D/C Ratio:     0.519 = 0.034 + 0.249 + 0.235
                         = fa/Fa + fbw/Fbw + fbz/Fbz

AXIAL FORCE & BIAXIAL MOMENT DESIGN    (H2-1)
    Factor                  L          K1          K2          B1          B2          Cm
    Major Bending          1.          1.          1.          1.          1.       0.575
    Minor Bending          1.          1.          1.          1.          1.       0.751

                         Lltb        Kltb          Cb
    LTB                     1.          1.          1.

                           Pr    Pnc/Omega   Pnt/Omega
                        Force     Capacity    Capacity
    Axial          -4050.431   117441.028  138374.075

                           Mr    Mn/Omega    Mn/Omega    Mn/Omega
                       Moment     Capacity      No LTB        Cb=1
    Major Moment  811853.741   3262366.52  3262366.52  3262366.52
    Minor Moment  325694.626  1384137.004

SHEAR CHECK
                                                Vr     Vn/Omega      Stress      Status
                                             Force     Capacity       Ratio       Check
    Major Shear      607.582    43697.076       0.014                OK
    Minor Shear      981.468    43697.076       0.022                OK
```

Deflection for the worst case - NEW

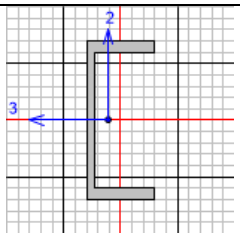



```
AISC 360-10 STEEL SECTION CHECK     (Deflection Details)
Units  :  N, mm, C

Frame :  19        X Mid:  8869.462  Combo:  def(D+BUO)      Design Type:  Beam
Length:  3939.983  Y Mid:  7443.774  Shape:  UPN140         Frame Type:  OMF
Loc   :  0.        Z Mid:  2000.     Class:  Slender        Princpl Rot: 0. degrees
```

DEFLECTION CHECK (Combodef(D+BU)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	0.441	19.7	0.022	OK
Super DL+LL	Yes	0.	19.7	0.	OK
Live Load	Yes	0.	19.7	0.	OK
Total Load	Yes	0.441	19.7	0.022	OK
Total-Camber	Yes	0.441	19.7	0.022	OK

Deflection for the worst case - CORRODED



AISC 360-10 STEEL SECTION CHECK (Deflection Details)
Units : N, mm, C

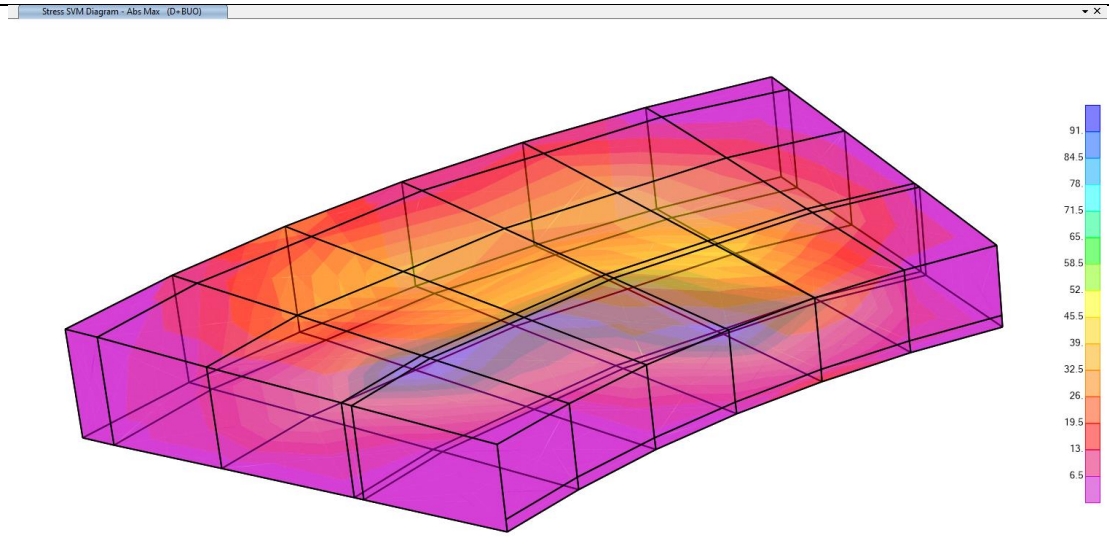
Frame : 19 X Mid: 8869.462 Combo: def(D+BUO) Design Type: Beam
Length: 3939.983 Y Mid: 7443.774 Shape: UPN140 Frame Type: OMF
Loc : 0. Z Mid: 2000. Class: Slender Princpl Rot: 0. degrees

DEFLECTION CHECK (Combodef(D+BU)

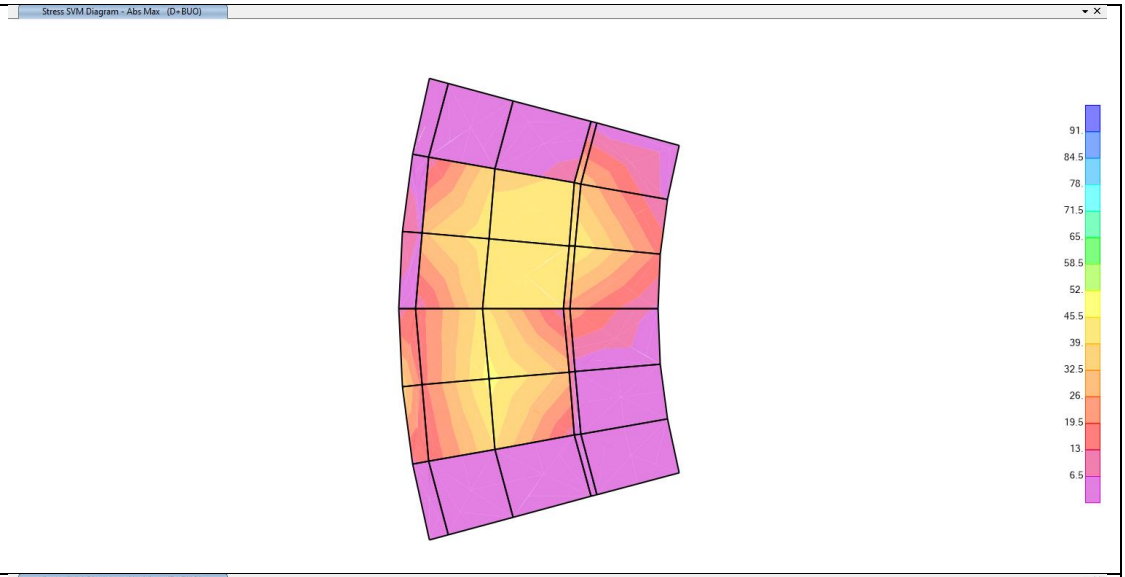
Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	0.49	19.7	0.025	OK
Super DL+LL	Yes	0.	19.7	0.	OK
Live Load	Yes	0.	19.7	0.	OK
Total Load	Yes	0.49	19.7	0.025	OK
Total-Camber	Yes	0.49	19.7	0.025	OK

(V) Pontoon and Compartment Plates

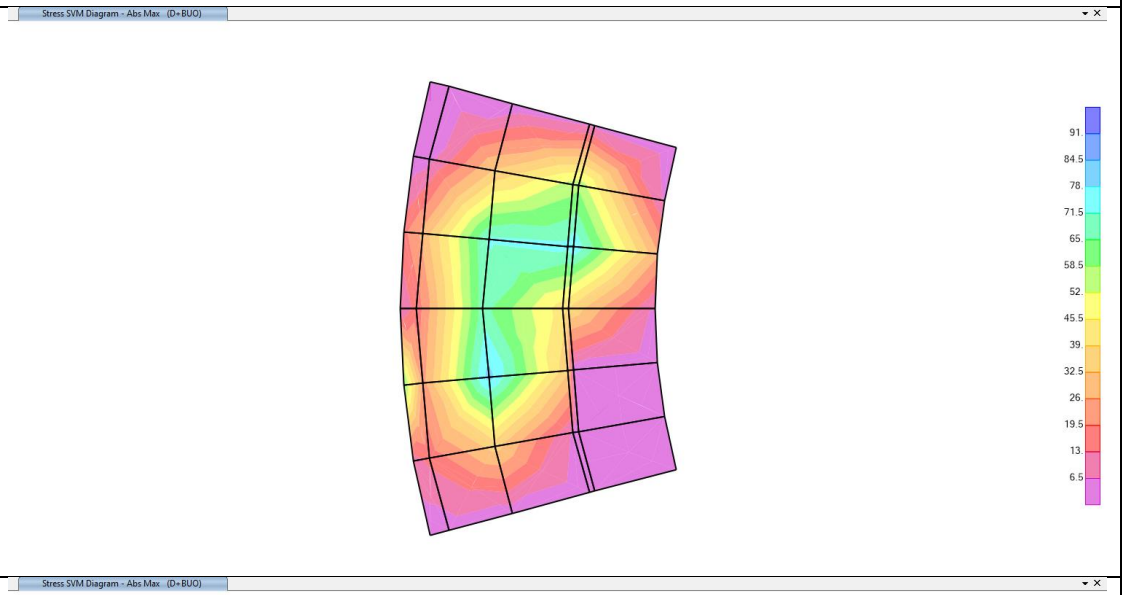
SVM-Overall (MPa) -New



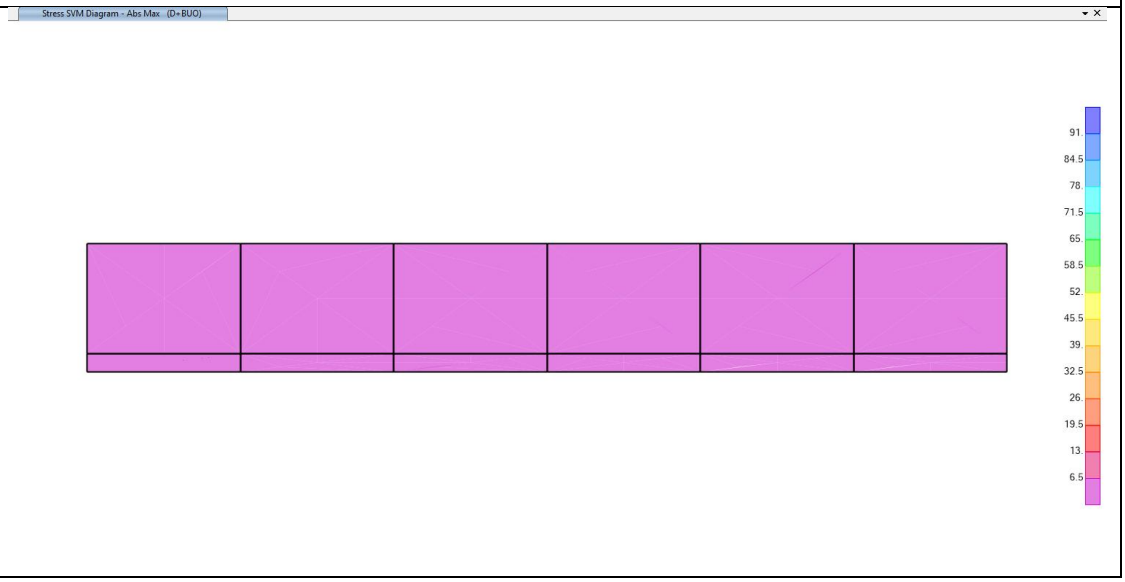
SVM-Top Plate (MPa) -New



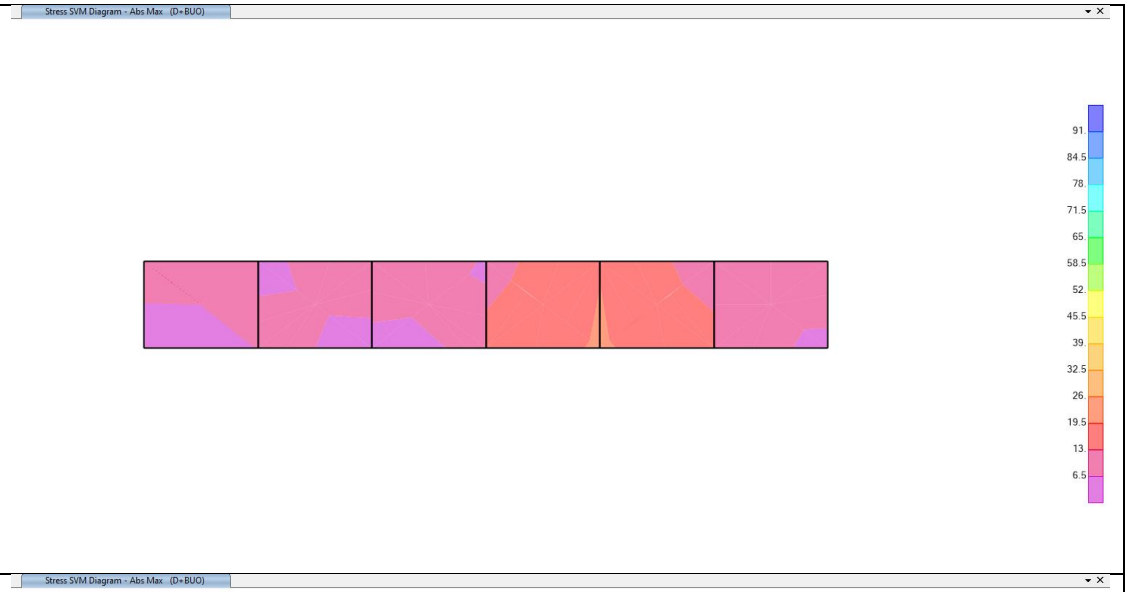
SVM-Bottom Plate (MPa) -New



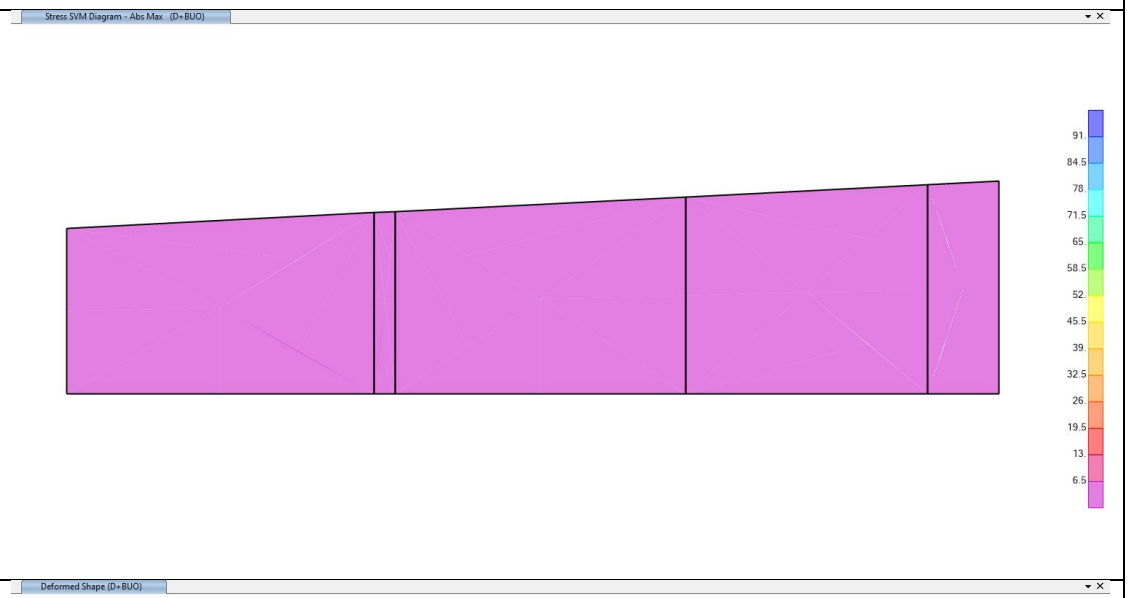
SVM-Inner Rim (MPa) -New



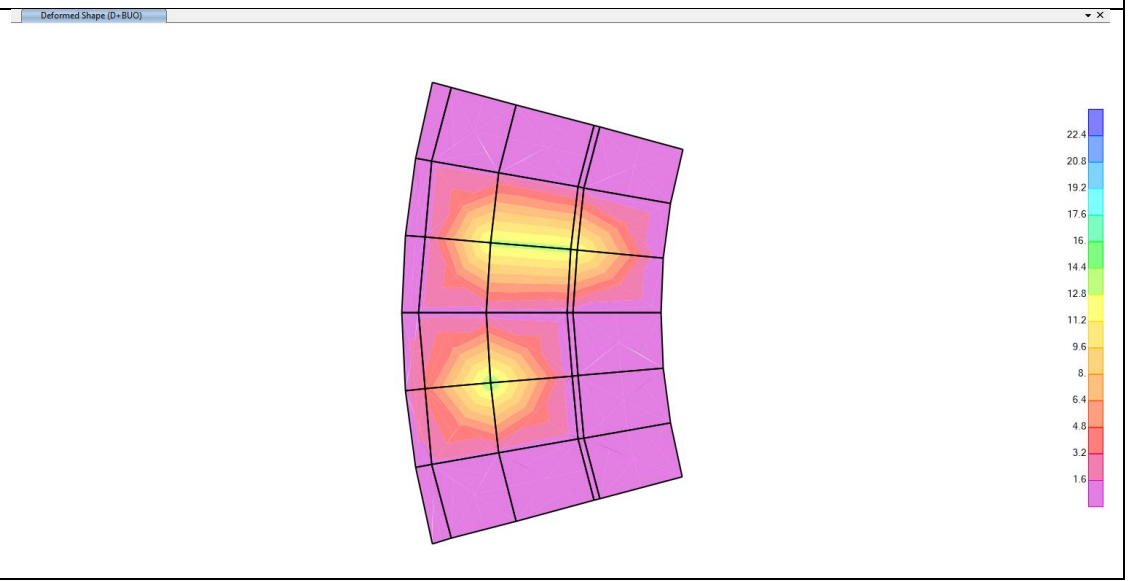
SVM-Outer Rim (MPa) -New



SVM-Compartment Plate (MPa) -New



Deflection-Top Plate (mm) -New



Deflection-Bottom Plate (mm) -New

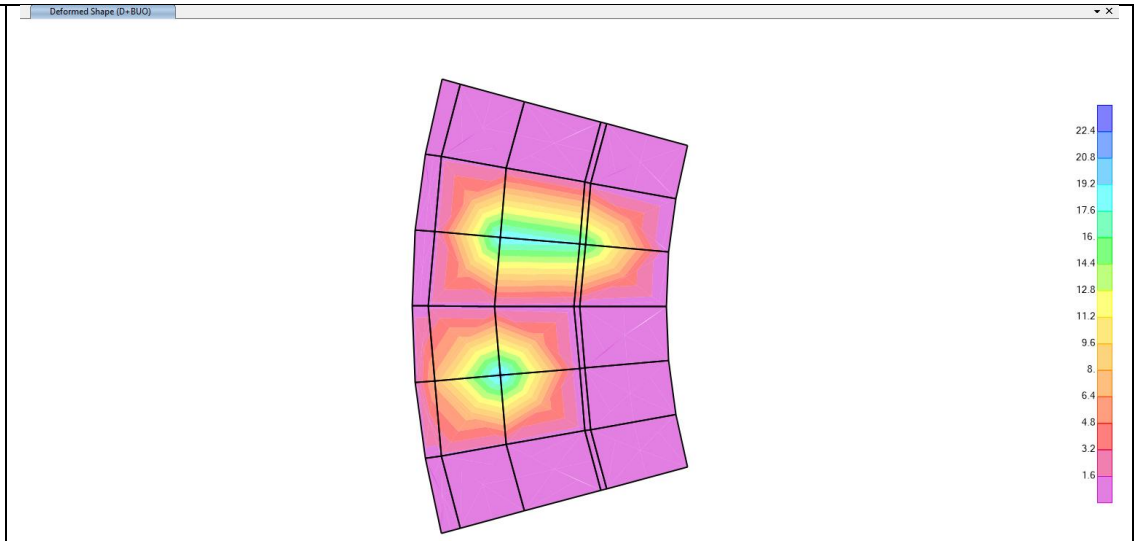
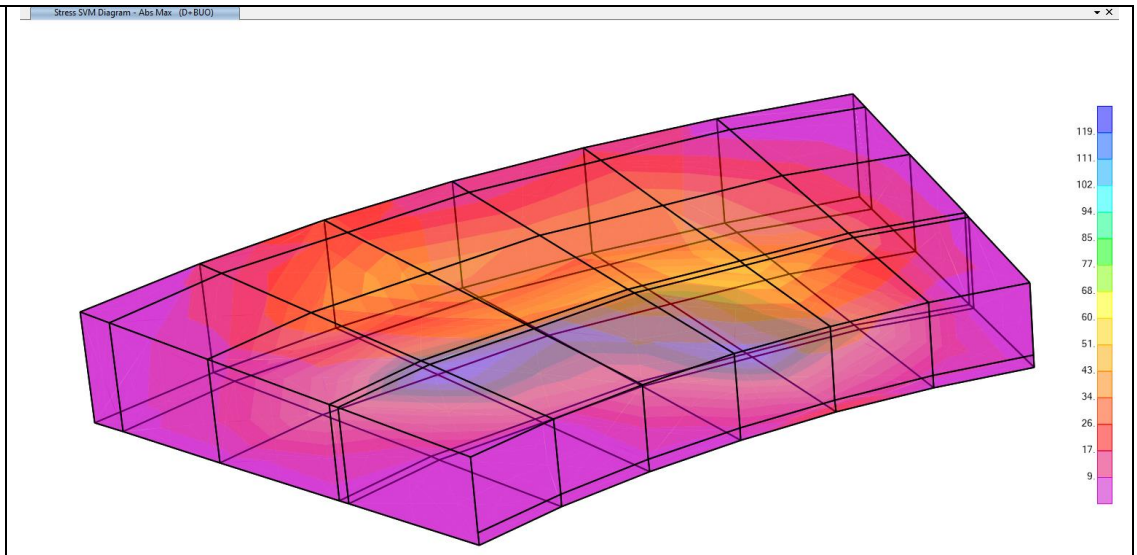
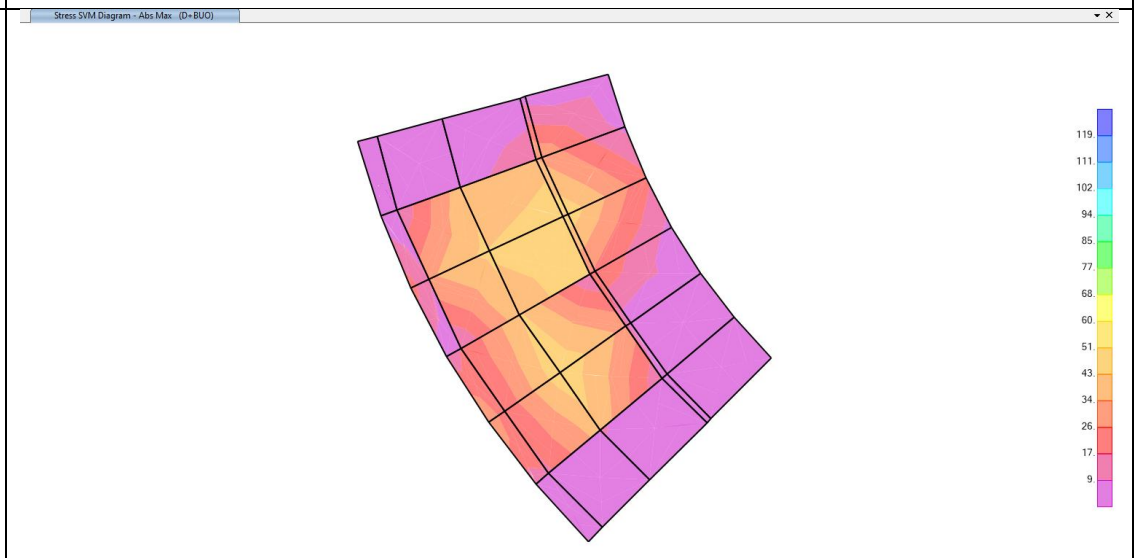


Figure 32:Pontoon Plates Results– Floating case - Intact Roof -New

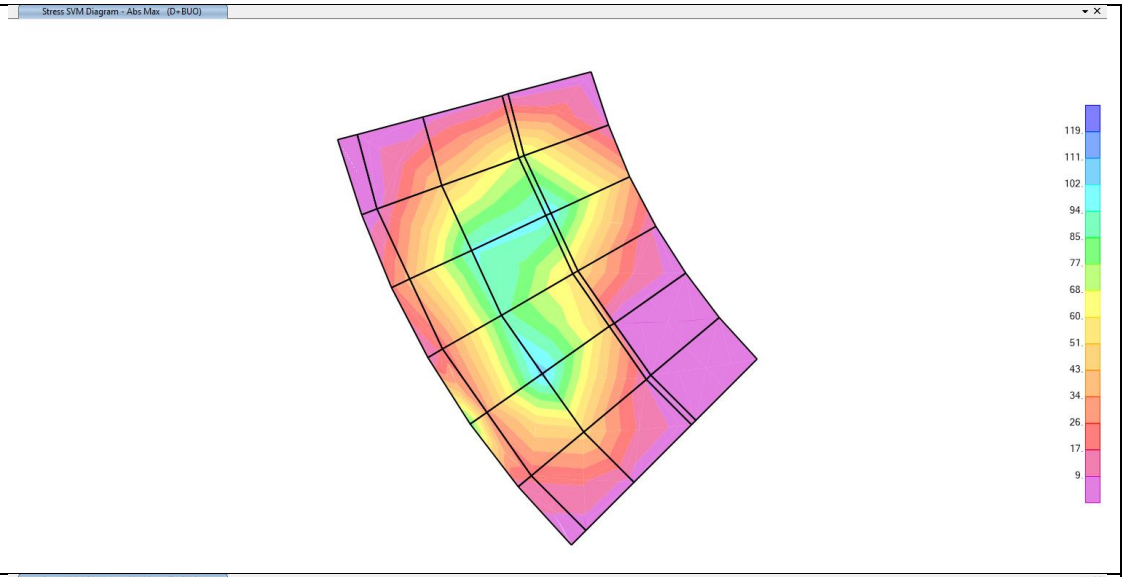
SVM-Overall (MPa) - Cor



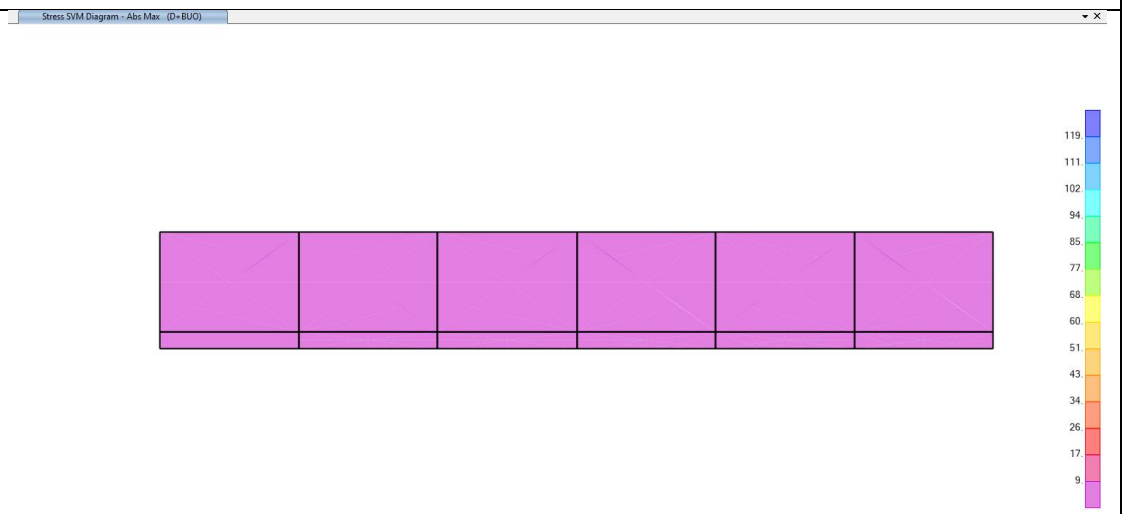
SVM-Top Plate (MPa) - Cor



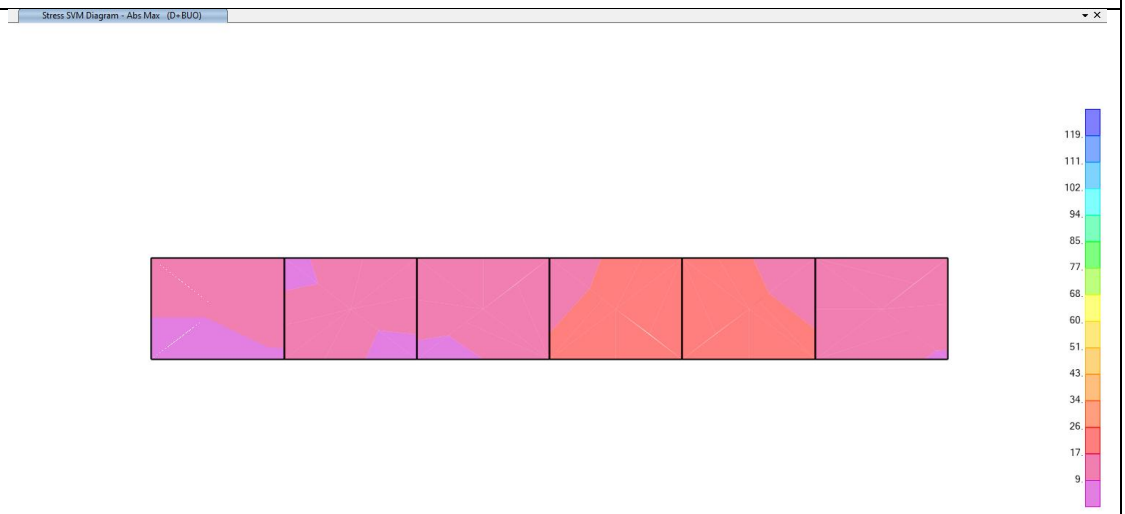
SVM-Bottom Plate (MPa) - Cor



SVM-Inner Rim (MPa) - Cor



SVM-Outer Rim (MPa) - Cor



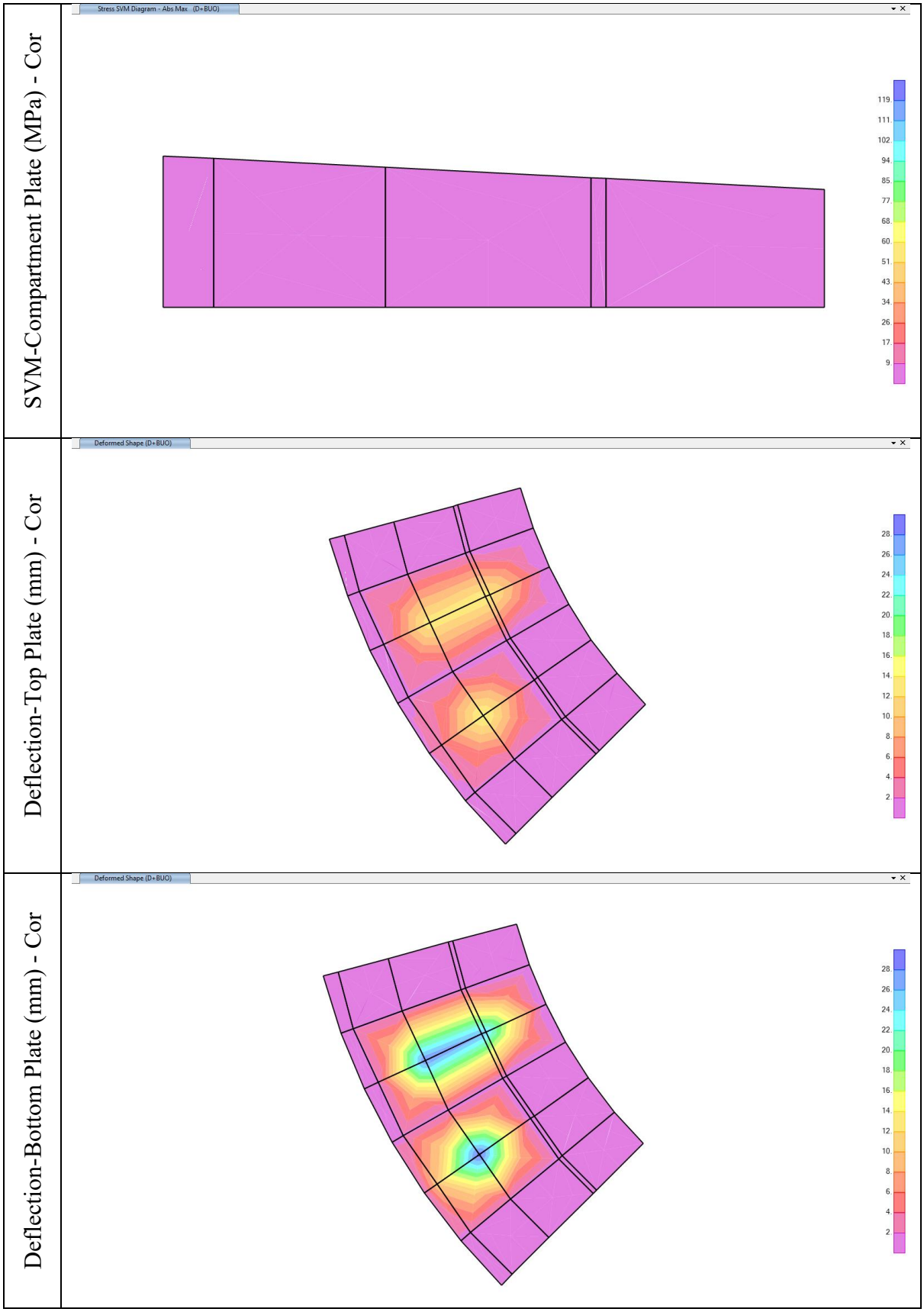


Figure 33:Pontoon Plates Results – Corroded – Floating case - Intact Roof

7.2.2. Punctured Roof

Since no hydrostatic load is applied to the deck section, only pontoon area is analyzed.

(I) Overall view

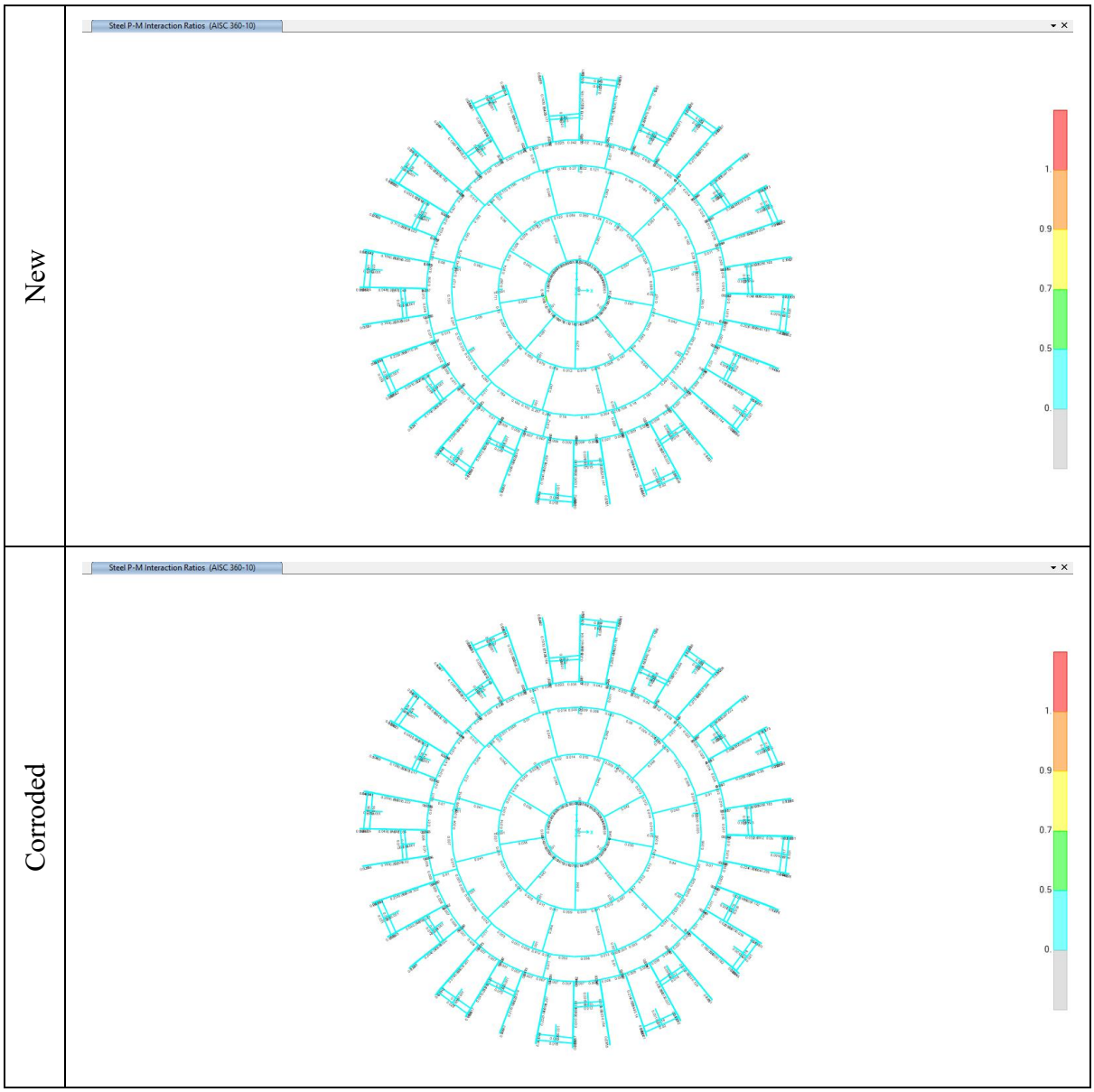


Figure 34:P-M Ratio of the Roof Structure –Floating Case - Punctured

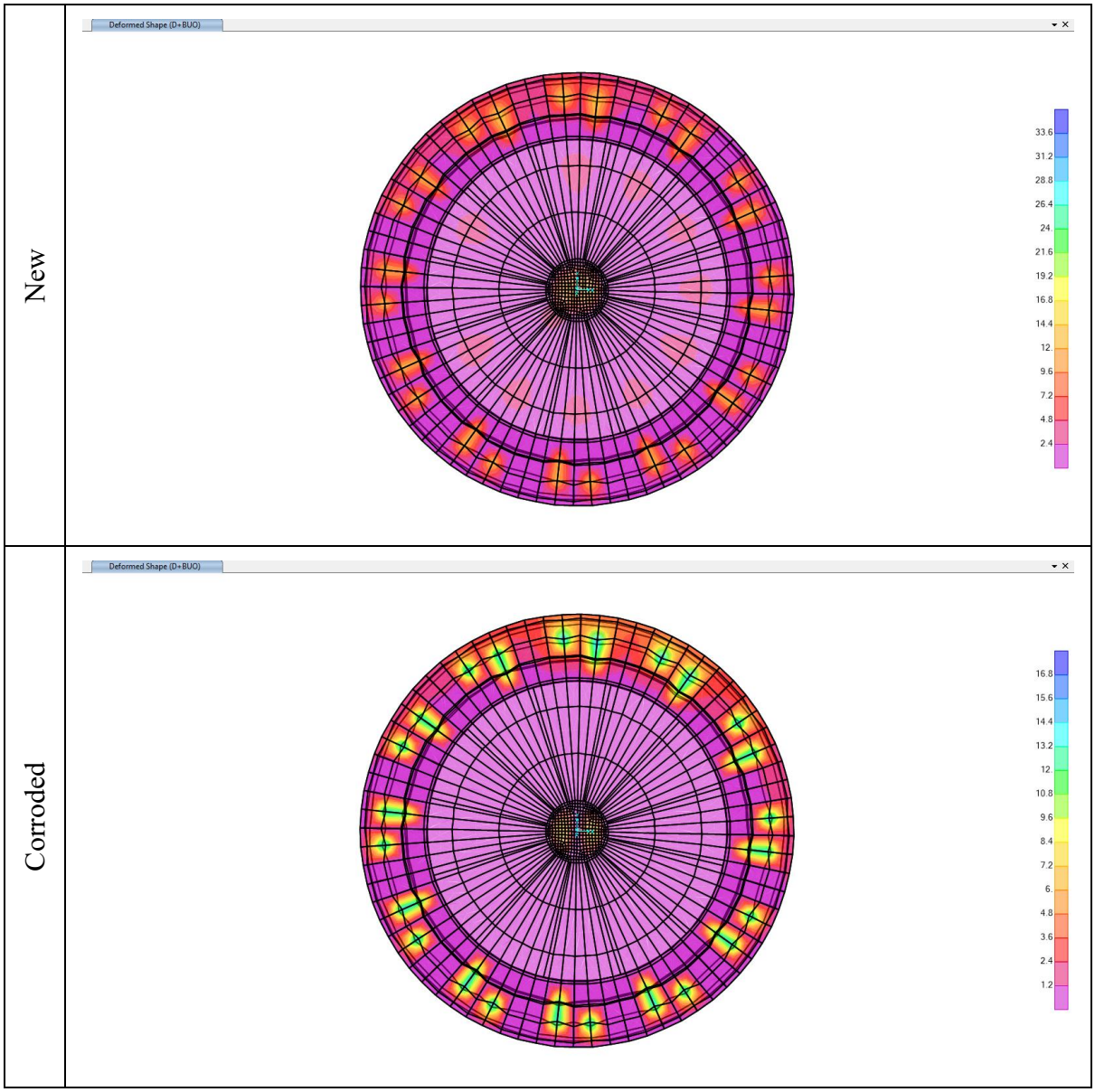


Figure 35:SVM of the Roof Structure (MPa) –Floating Case- Punctured

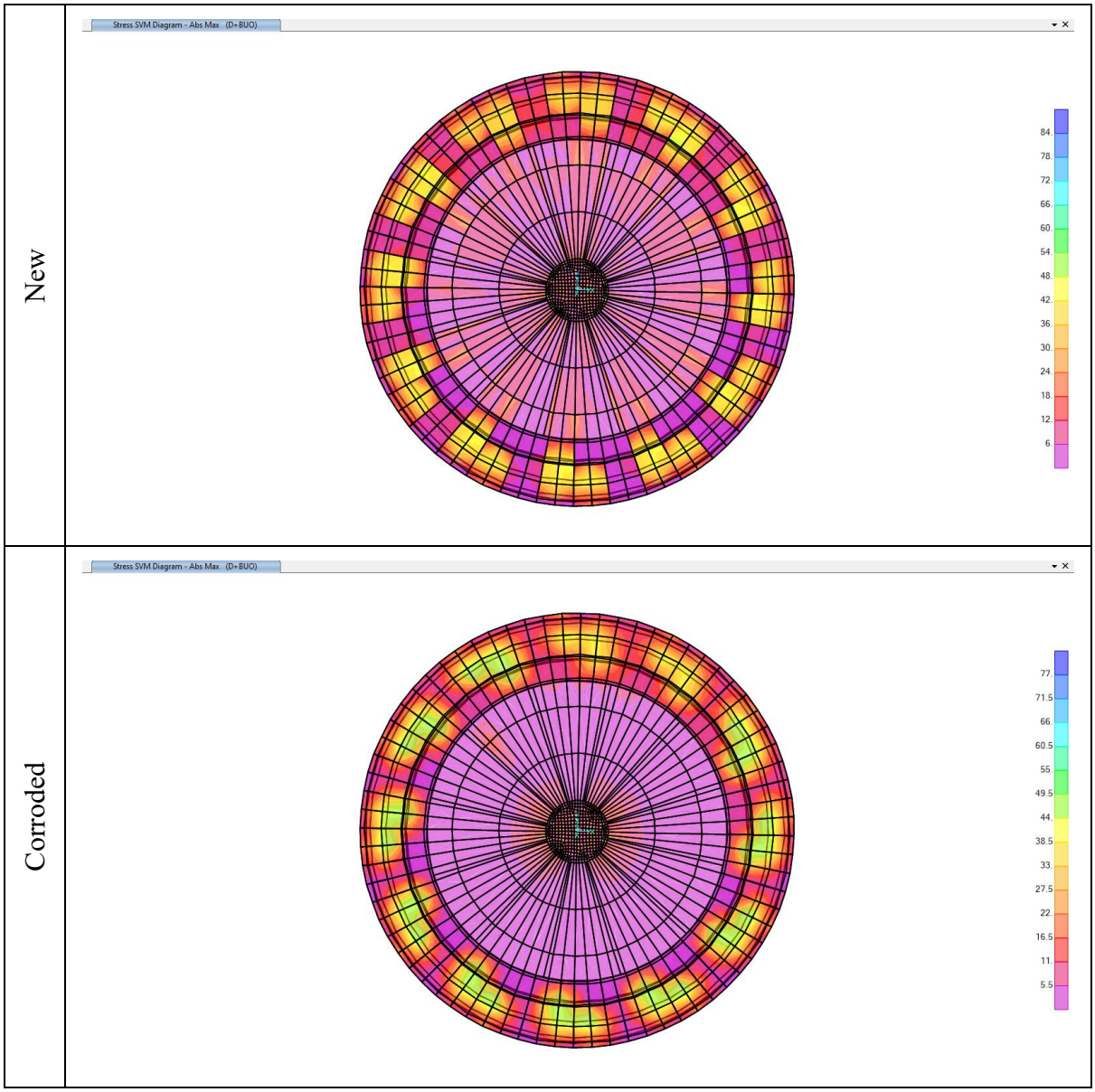


Figure 36:Deflection of Plates (mm) – Floating case- Punctured

(II) Pontoon Frame

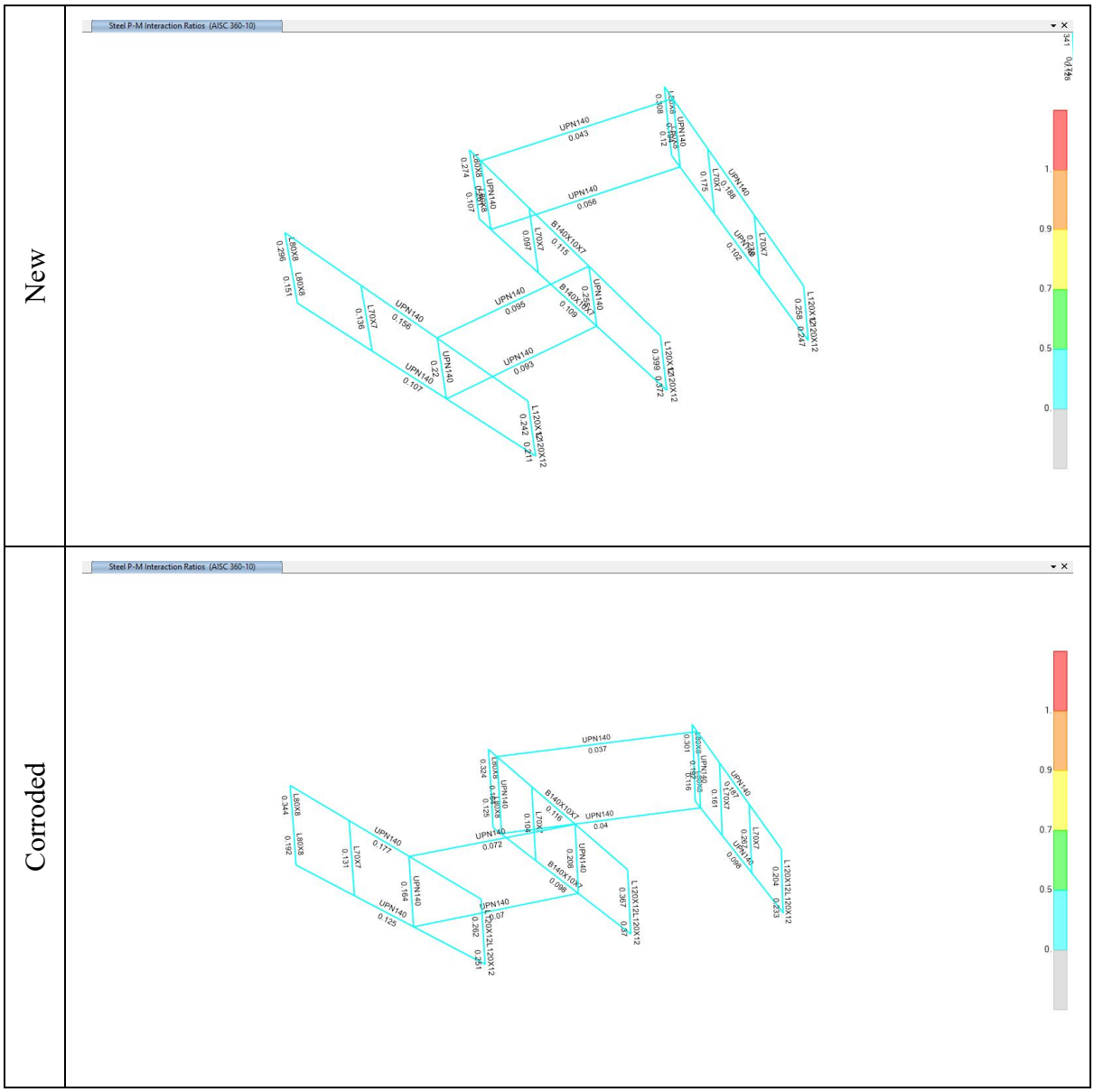
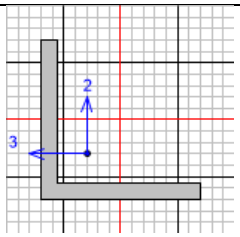


Figure 37:P-M Ratio for Frames in a Pontoon Compartment-Floating Case- Punctured

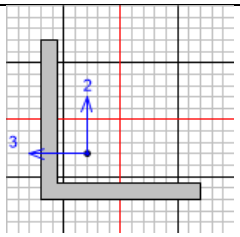
P-M Ratio for the worst case - NEW




```
AISC 360-10 STEEL SECTION CHECK     (Summary for Combo and Station)
Units  :  N, mm, C

Frame :  718      X Mid:  -4806.59  Combo:  D+BUO          Design Type:  Column
Length:  600.     Y Mid:  8320.635  Shape:  L120X12        Frame Type:  OMF
Loc   :  600.     Z Mid:  2400.     Class:  Compact        Princpl Rot: 45. degrees

Provision: ASD    Analysis: Direct Analysis
D/C Limit=0.95    2nd Order: General 2nd Order       Reduction: Tau-b Fixed
AlphaPr/Py=0.006  AlphaPr/Pe=0.     Tau_b=1.         EA factor=0.8     EI factor=0.8
```

```
OmegaB=1.67       OmegaC=1.67       OmegaTY=1.67      OmegaTF=2.
OmegaV=1.67       OmegaV-RI=1.5     OmegaVT=1.67

A=2736.           I33=3732570.947   r33=36.936        S33=43615.528     Av3=1440.
J=126247.68       I22=3732570.947   r22=36.936        S22=43615.528     Av2=1440.
Ixy=-2210021.05   Imax=5942592.     rmax=46.605       Smax=73720.125
Rot= 45. deg      Imin=1522549.89   rmin=23.59        Smin=31277.526
E=199947.979      Fy=248.211        Ry=1.5            z33=78580.8
RLLF=1.           Fu=399.896                          z22=78580.8


STRESS CHECK FORCES & MOMENTS (Combo D+BUO)
    Location              Pr        Mr33        Mr22         Vr2         Vr3          Tr
    600.          -2434.149 -305078.735 2590300.036     704.471   -7518.267     -377.42

PMM DEMAND/CAPACITY RATIO   (H2-1)
    D/C Ratio:    0.399 = 0.007 + 0.098 + 0.294
                        = fa/Fa + fbw/Fbw + fbz/Fbz

AXIAL FORCE & BIAXIAL MOMENT DESIGN   (H2-1)
    Factor                L          K1          K2          B1          B2          Cm
    Major Bending         1.          1.          1.          1.          1.       0.284
    Minor Bending         1.          1.          1.          1.          1.       0.318

                        Lltb        Kltb          Cb
    LTB                   1.          1.          1.

                           Pr   Pnc/Omega   Pnt/Omega
                       Force    Capacity    Capacity
    Axial         -2434.149  360423.678  406650.343

                          Mr    Mn/Omega    Mn/Omega    Mn/Omega
                      Moment    Capacity      No LTB        Cb=1
    Major Moment 1615895.478 16435479.14 16435479.14 16435479.14
    Minor Moment 2047341.963 6973145.024

SHEAR CHECK
                                            Vr    Vn/Omega      Stress      Status
                                        Force    Capacity       Ratio       Check
    Major Shear      704.471  128415.898       0.005          OK
    Minor Shear     7518.267  128415.898       0.059          OK
```

P-M Ratio for the worst case - CORRODED




```
AISC 360-10 STEEL SECTION CHECK    (Summary for Combo and Station)
Units  :  N, mm, C

Frame :  263      X Mid:  -2.312    Combo:  D+BUO           Design Type:  Column
Length:  100.     Y Mid:  9609.177  Shape:  L120X12         Frame Type:  OMF
Loc   :  0.       Z Mid:  2050.     Class:  Compact         Princpl Rot: 45. degrees

Provision: ASD    Analysis: Direct Analysis
D/C Limit=0.95    2nd Order: General 2nd Order        Reduction: Tau-b Fixed
AlphaPr/Py=0.006  AlphaPr/Pe=1E-05  Tau_b=1.          EA factor=0.8     EI factor=0.8

OmegaB=1.67       OmegaC=1.67       OmegaTY=1.67      OmegaTF=2.
OmegaV=1.67       OmegaV-RI=1.5     OmegaVT=1.67

A=2736.           I33=3732570.947   r33=36.936        S33=43615.528     Av3=1440.
J=126247.68       I22=3732570.947   r22=36.936        S22=43615.528     Av2=1440.
Ixy=-2210021.05   Imax=5942592.     rmax=46.605       Smax=73720.125
Rot= 45. deg      Imin=1522549.89   rmin=23.59        Smin=31277.526
E=199947.979      Fy=248.211        Ry=1.5            z33=78580.8
RLLF=1.           Fu=399.896                          z22=78580.8


STRESS CHECK FORCES & MOMENTS (Combo D+BUO)
    Location              Pr        Mr33        Mr22         Vr2         Vr3          Tr
    0.            2672.264 -565505.626 -2741574.58    1385.094    -2382.62    -617.152

PMM DEMAND/CAPACITY RATIO   (H2-1)
    D/C Ratio:     0.37 = 0.007 + 0.142 + 0.221
                        = fa/Fa + fbw/Fbw + fbz/Fbz

AXIAL FORCE & BIAXIAL MOMENT DESIGN   (H2-1)
    Factor                L          K1          K2          B1          B2          Cm
    Major Bending         1.          1.          1.          1.          1.          1.
    Minor Bending         1.          1.          1.          1.          1.          1.

                        Lltb        Kltb          Cb
    LTB                   1.          1.          1.

                           Pr   Pnc/Omega   Pnt/Omega
```

	Force	Capacity	Capacity
Axial	2672.264	393551.64	406650.343

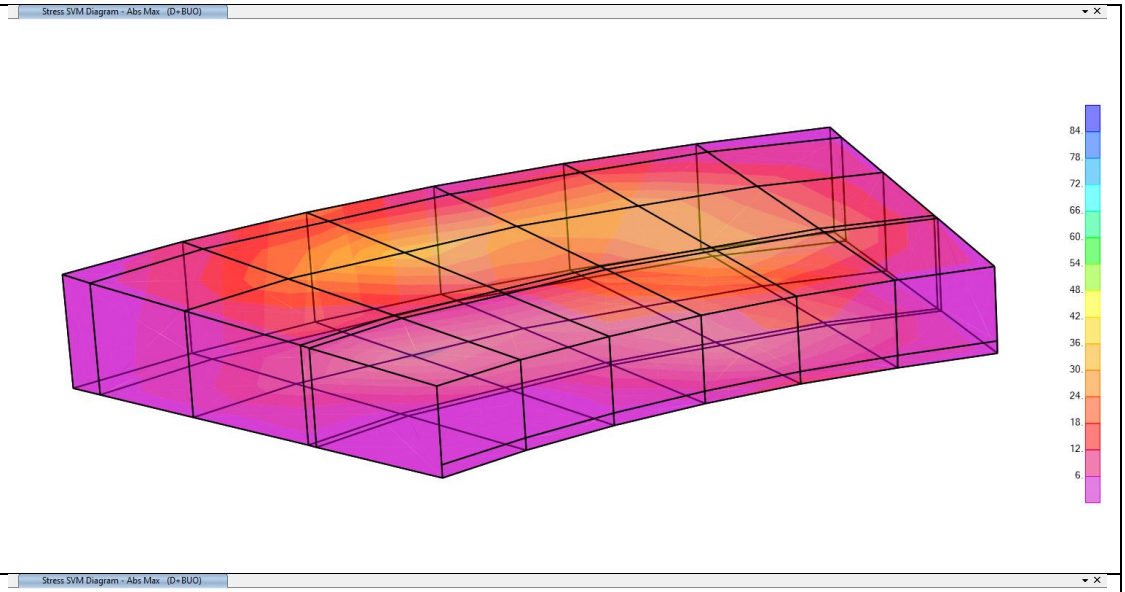
	Mr Moment	Mn/Omega Capacity	Mn/Omega No LTB	Mn/Omega Cb=1
Major Moment	-2338458.84	16435479.14	16435479.14	16435479.14
Minor Moment	-1538713.12	6973145.024		

SHEAR CHECK

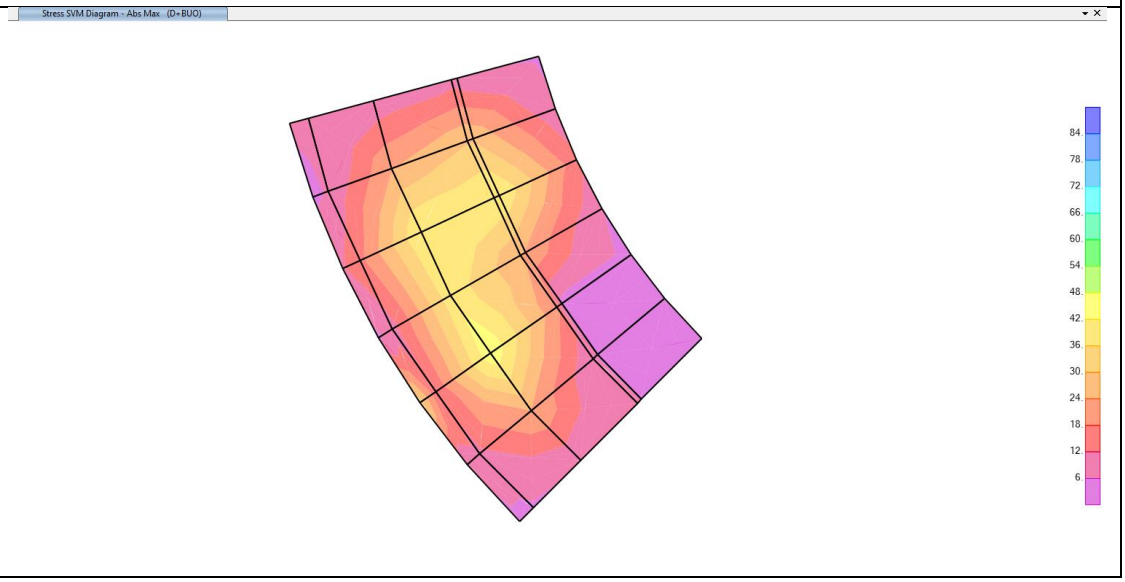
	Vr Force	Vn/Omega Capacity	Stress Ratio	Status Check
Major Shear	1385.094	128415.898	0.011	OK
Minor Shear	2382.62	128415.898	0.019	OK

(III)Pontoon Plates - Intact Compartment

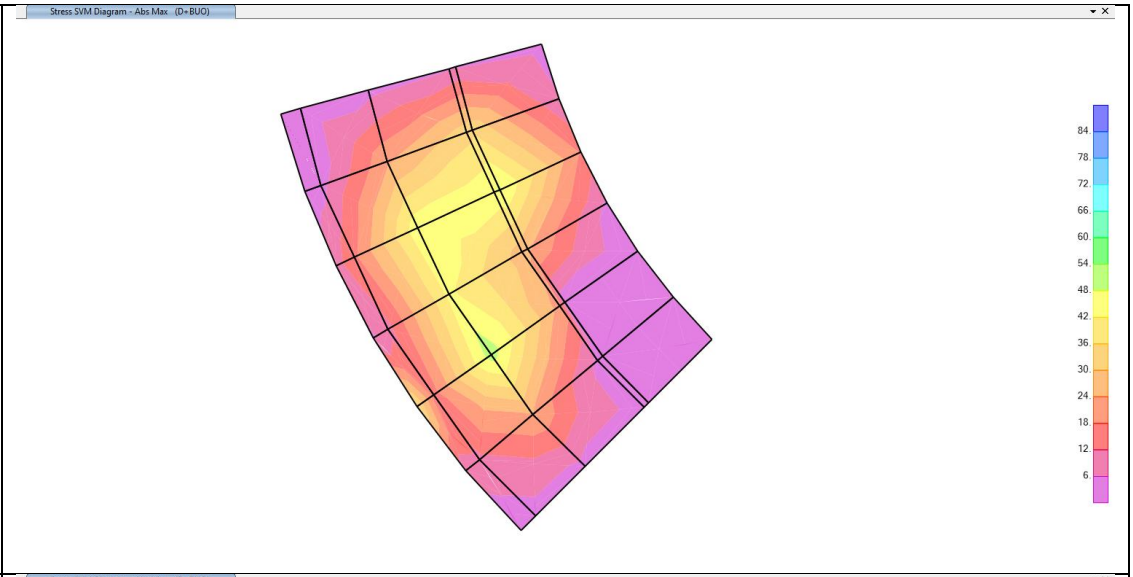
SVM-Overall (MPa)



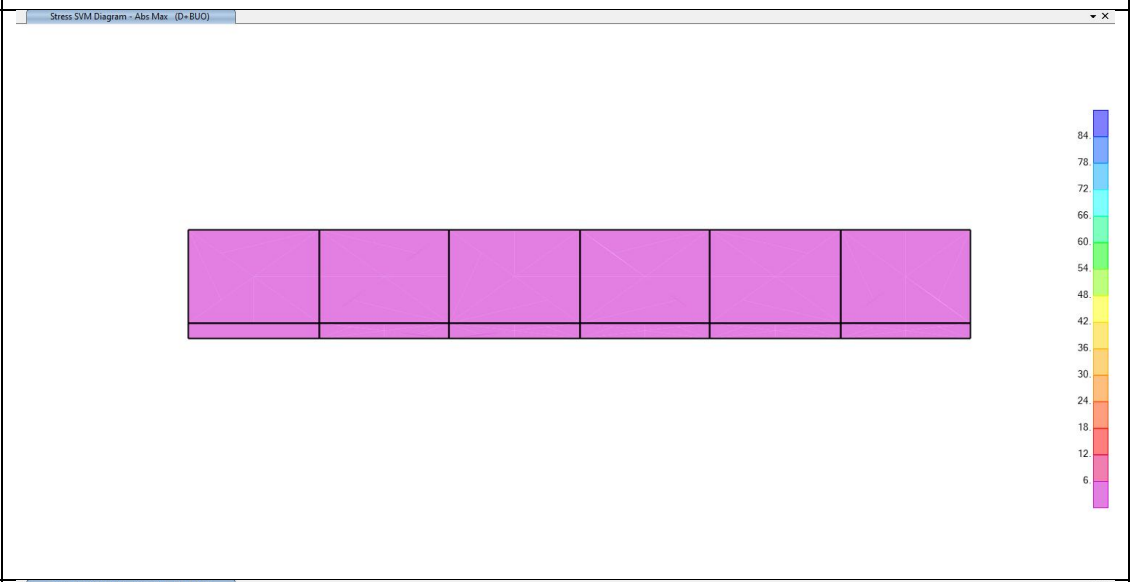
SVM-Top Plate (MPa)



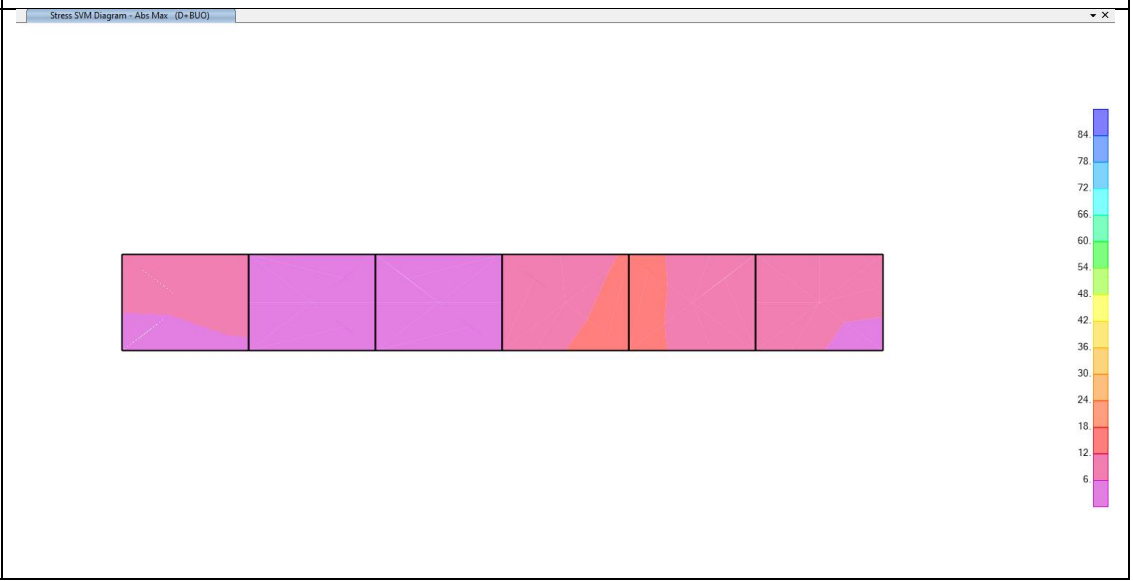
SVM-Bottom Plate (MPa)



SVM-Inner Rim (MPa)



SVM-Outer Rim (MPa)



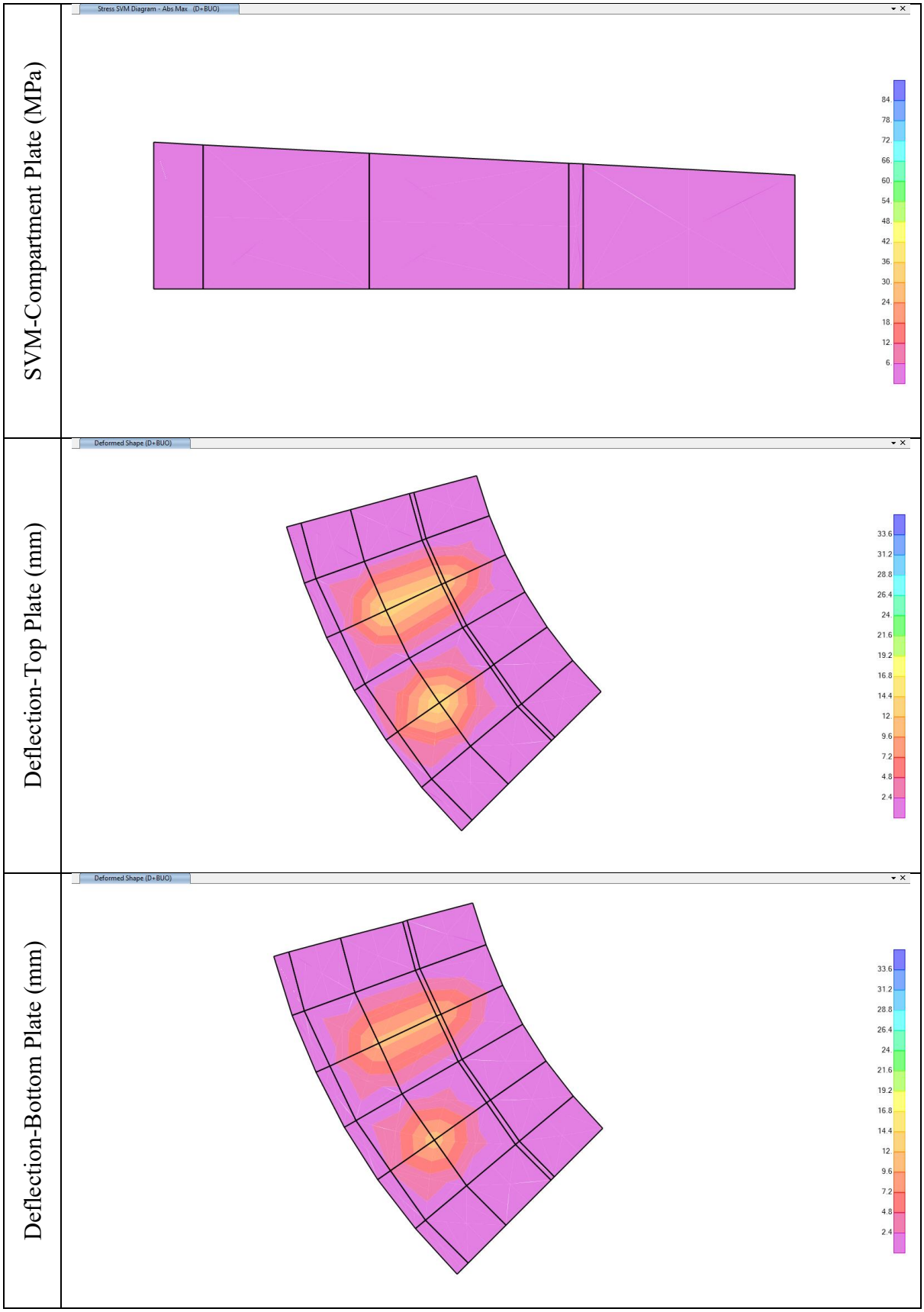
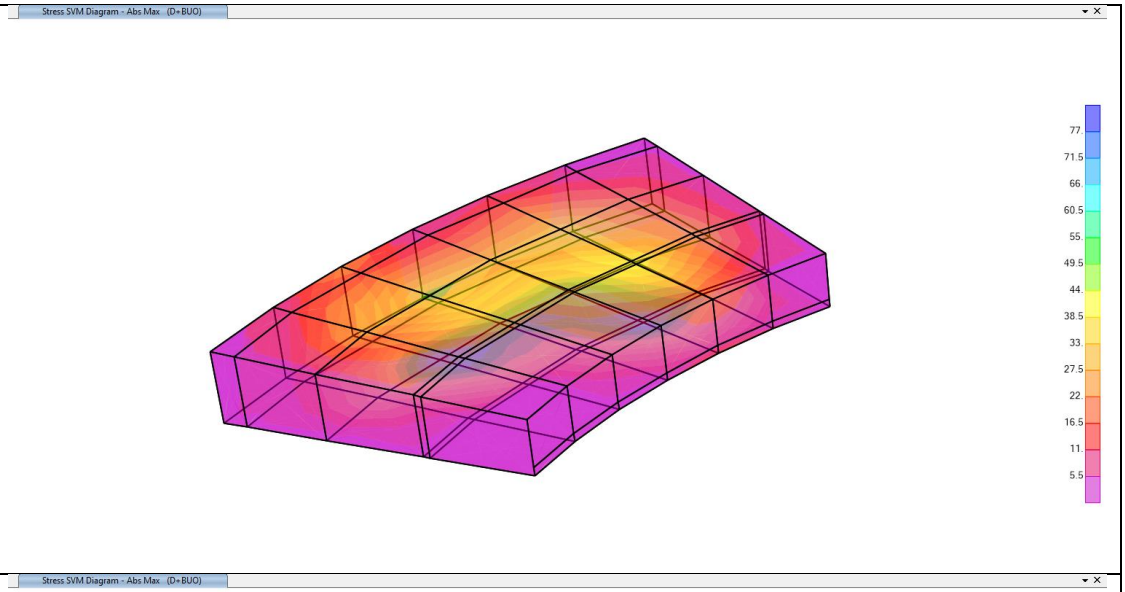
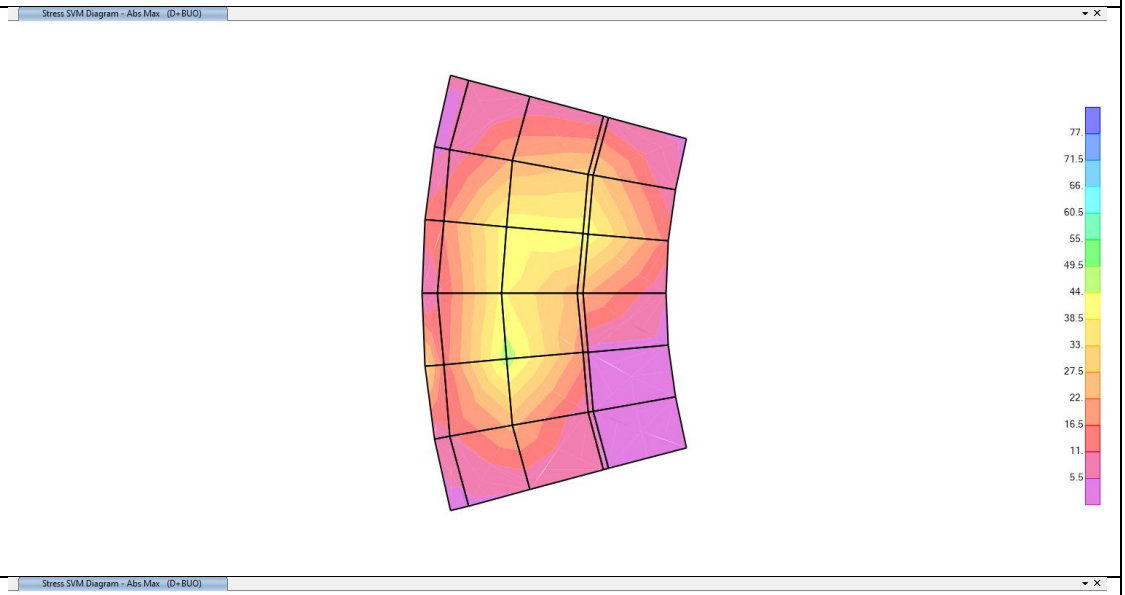


Figure 38:Pontoon Plates Results -Floating Case - Punctured - New

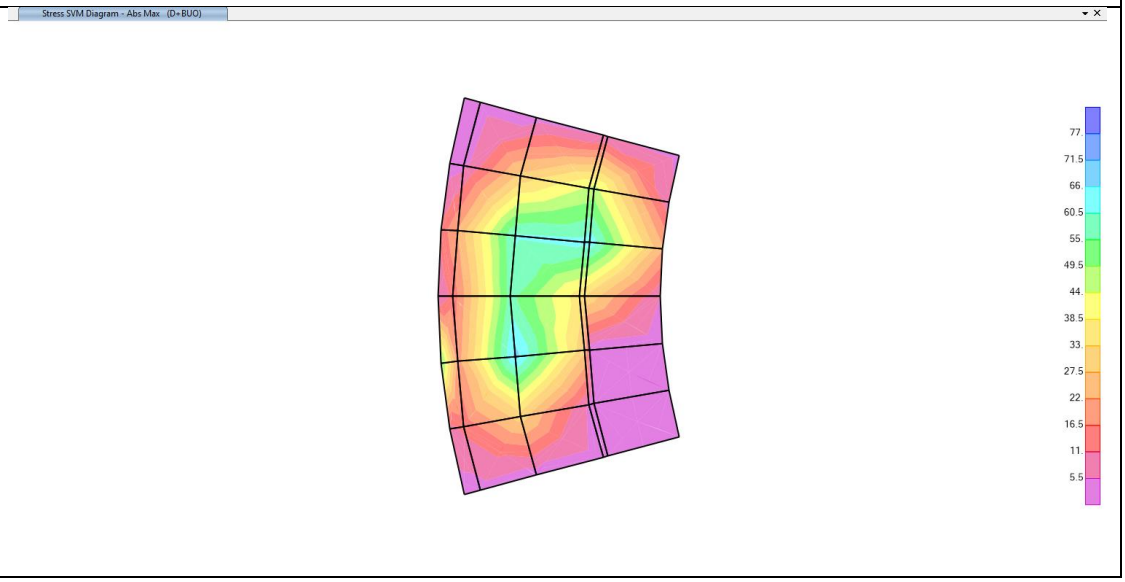
SVM-Overall (MPa) - Cor



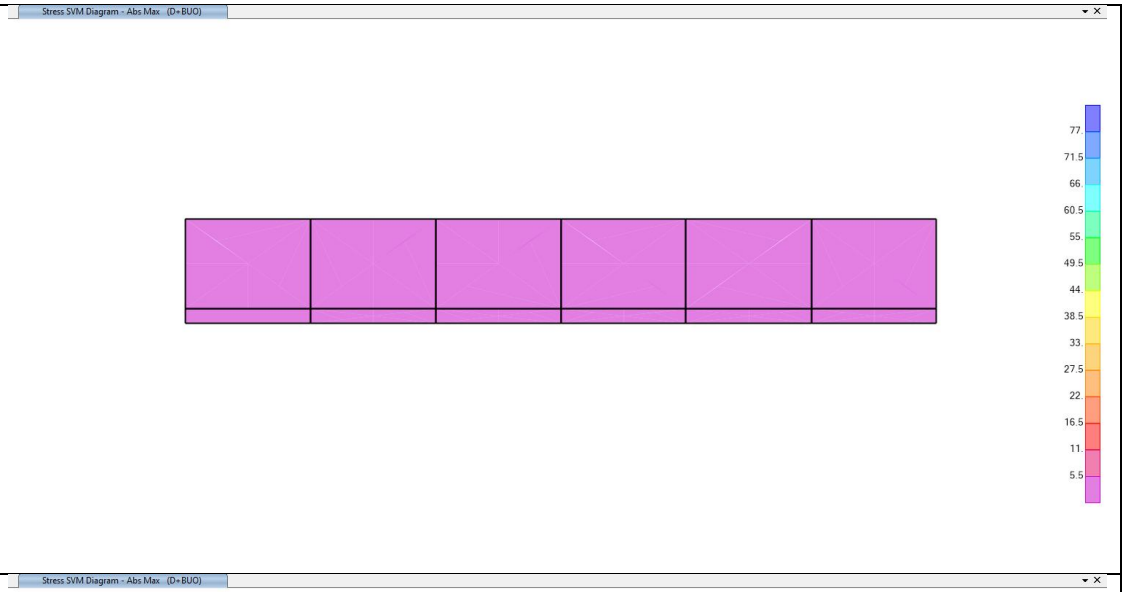
SVM-Top Plate (MPa) - Cor



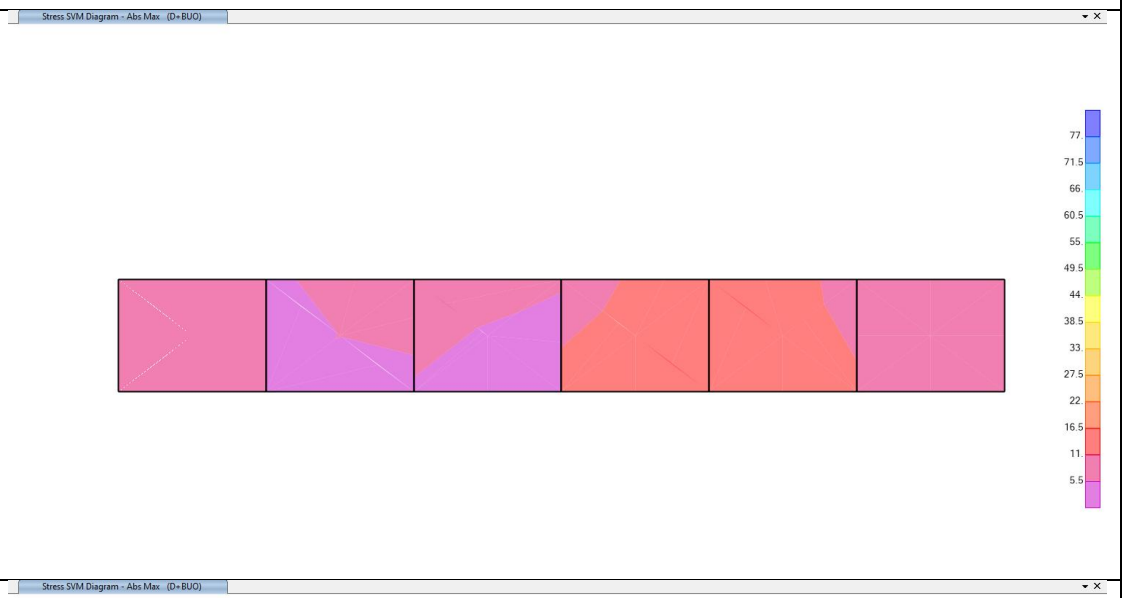
SVM-Bottom Plate (MPa) - Cor



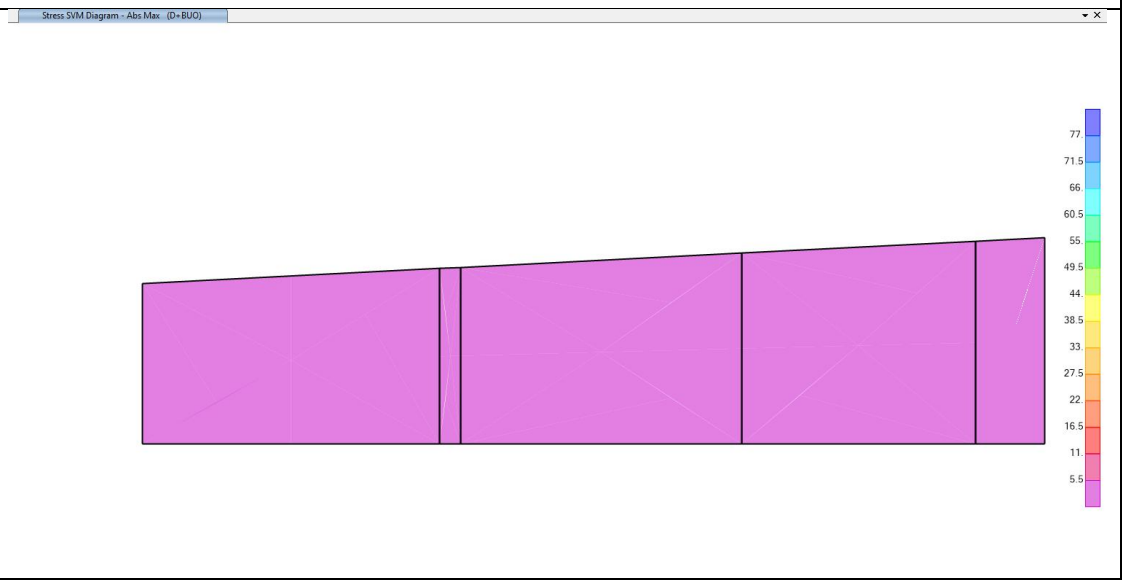
SVM-Inner Rim (MPa) - Cor



SVM-Outer Rim (MPa) - Cor



SVM-Compartment Plate (MPa) - Cor



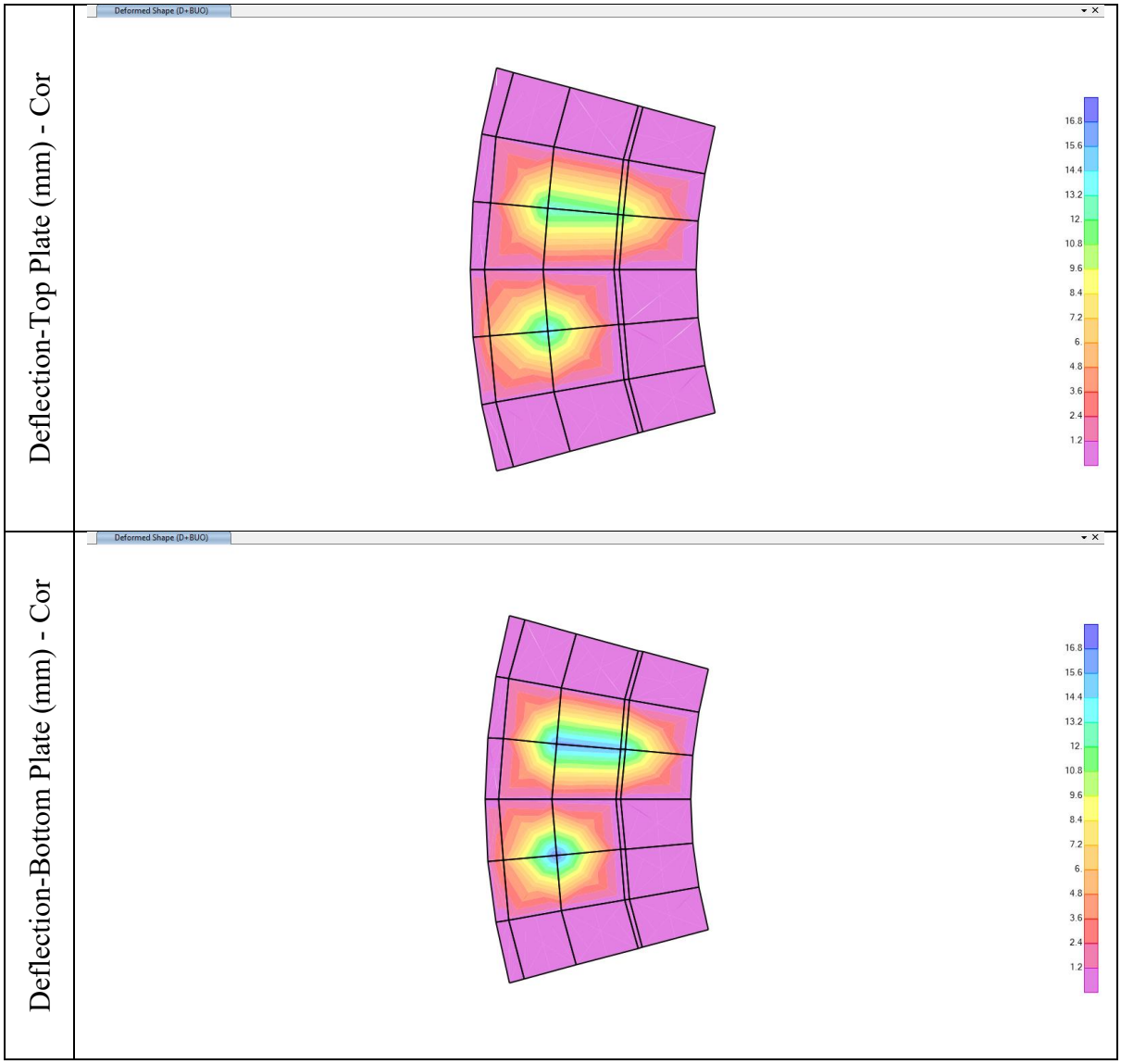


Figure 39:Pontoon Plates Results -Floating Case - Punctured - Corroded

8. Feedback Data to Mechanical Design

Table 5: Roof Structure Approximate Weight

Object Type	Material	Total Weight
Text	Text	kgf
Frame	A53GrB	1614.59
Frame	A36	12918.09
Area	A283C	54876.47
	Total	69410

9. Native File Index

Case	File Name

Maintenance Case - New	TK-2050-FloatingRoof-211022
Maintenance Case - Corroded	TK-2050-FloatingRoof-211022-COR
Floating Case - Intact	TK-2050-FloatingRoof-211022-FI
Floating Case - Intact- Corroded	TK-2050-FloatingRoof-211022-FIC
Floating Case - Punctured	TK-2050-FloatingRoof-211022-FP
Floating Case - Punctured	TK-2050-FloatingRoof-211022-FPC