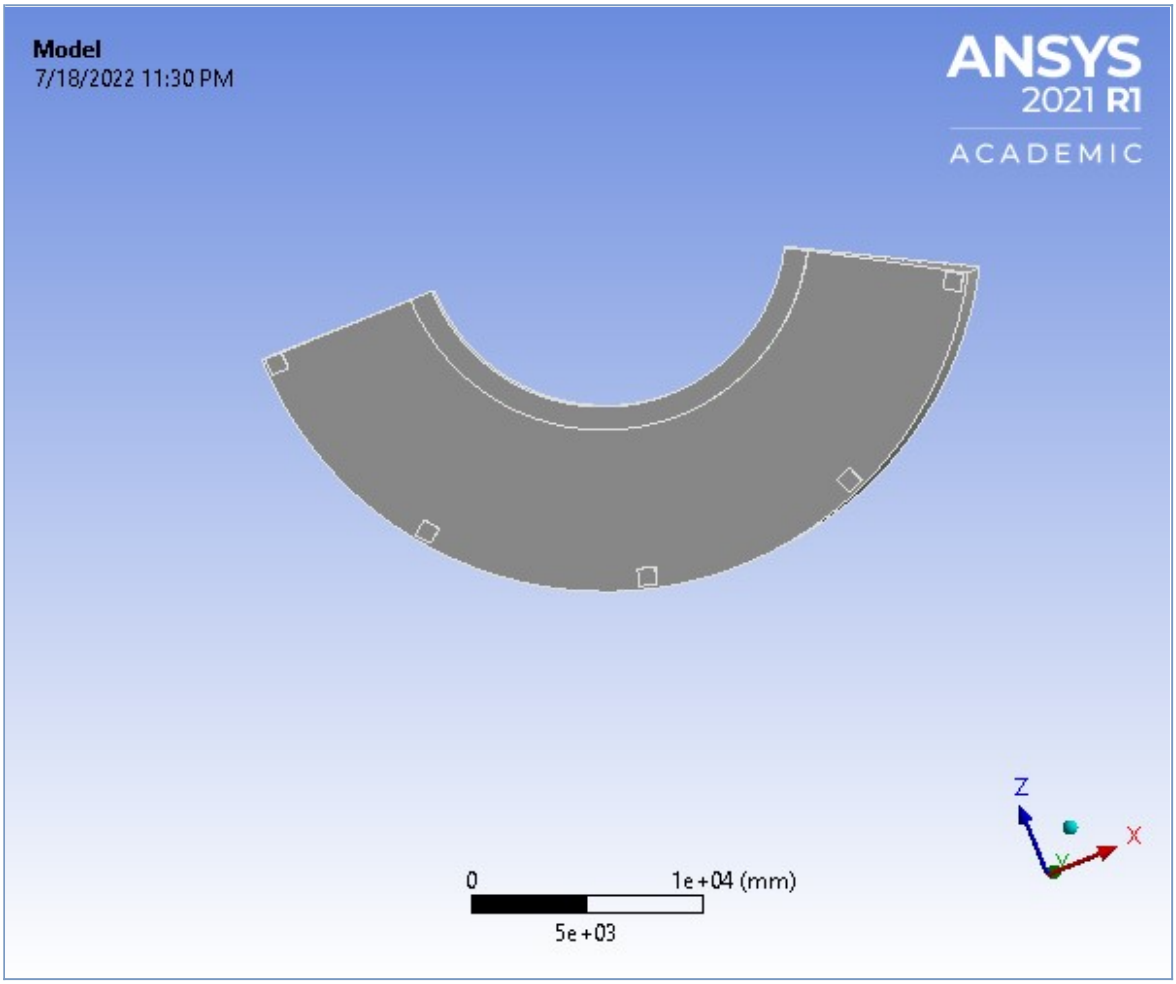
Project*

First Saved	Sunday, July 17, 2022
Last Saved	Monday, July 18, 2022
Product Version	2021 R1
Save Project Before Solution	No
Save Project After Solution	No



Contents

Units

TABLE 1

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4, B4)

Geometry

TABLE 2
Model (A4, B4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	D:\Users\janga\OneDrive - IIT Kanpur\Extra activities\SnT solidworks& ansys\Final_Project_OAT\oat_files\dp0\SYS\DM\SYS.scdoc
Type	SpaceClaim

Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	29856 mm
Length Y	5041.5 mm
Length Z	16000 mm
Properties	
Volume	7.2439e+011 mm³
Mass	5.6865e+006 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	97724
Elements	57757
Mesh Metric	None
Update Options	
Assign Default Material	No
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	Yes
Parameters	Independent
Parameter Key	
Attributes	Yes
Attribute Key	
Named Selections	Yes
Named Selection Key	
Material Properties	Yes
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	Yes
Coordinate System Key	
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 3
Model (A4, B4) > Geometry > Parts

Object Name	*SYS\Boss-Extrude2*
State	Meshed

Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Treatment	None
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	29856 mm
Length Y	5041.5 mm
Length Z	16000 mm
Properties	
Volume	7.2439e+011 mm³
Mass	5.6865e+006 kg
Centroid X	-9950.6 mm
Centroid Y	-1791.3 mm
Centroid Z	-9560.2 mm
Moment of Inertia Ip1	7.2981e+013 kg·mm²
Moment of Inertia Ip2	4.881e+014 kg·mm²
Moment of Inertia Ip3	4.3022e+014 kg·mm²
Statistics	
Nodes	97724
Elements	57757
Mesh Metric	None
CAD Attributes	
PartTolerance:	0.00000001
Color:143.149.175	

FIGURE 1
Model (A4, B4) > Geometry > Figure

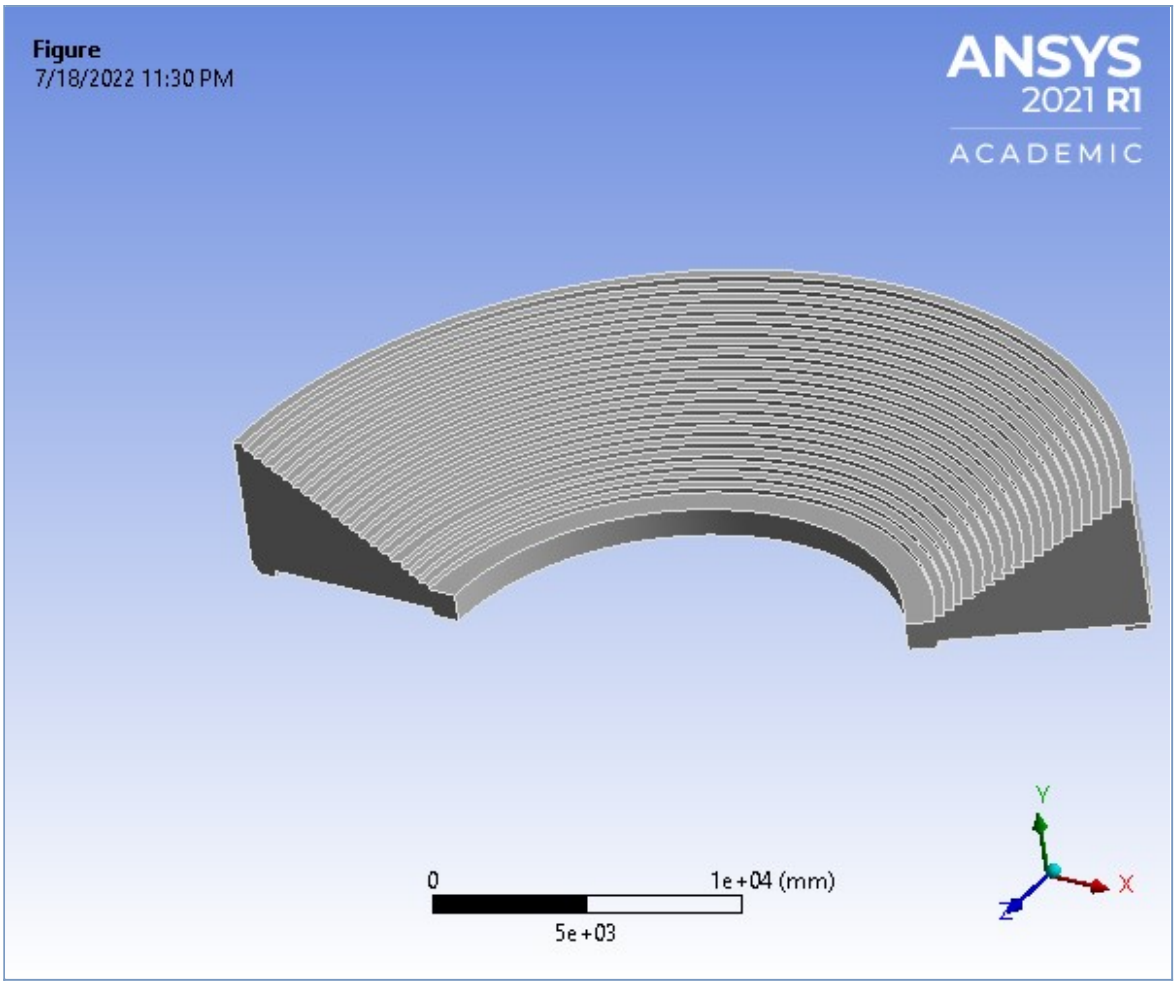


TABLE 4
Model (A4, B4) > Materials

Object Name	*Materials*
State	Fully Defined
Statistics	
Materials	1
Material Assignments	0

Coordinate Systems

TABLE 5
Model (A4, B4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]

Z Axis Data	[0. 0. 1.]

Mesh

TABLE 6
Model (A4, B4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Use Geometry Setting
Defaults	
Physics Preference	Mechanical
Element Order	Program Controlled
Element Size	300.0 mm
Sizing	
Use Adaptive Sizing	Yes
Resolution	Default (2)
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Span Angle Center	Coarse
Initial Size Seed	Assembly
Bounding Box Diagonal	34246 mm
Average Surface Area	1.2587e+007 mm²
Minimum Edge Length	173.85 mm
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Aggressive Mechanical
Target Quality	Default (0.050000)
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	97724
Elements	57757

TABLE 7
Model (A4, B4) > Mesh > Mesh Controls

Object Name	*Refinement*

State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	6 Faces
Definition	
Suppressed	No
Refinement	1

FIGURE 2
Model (A4, B4) > Mesh > Figure

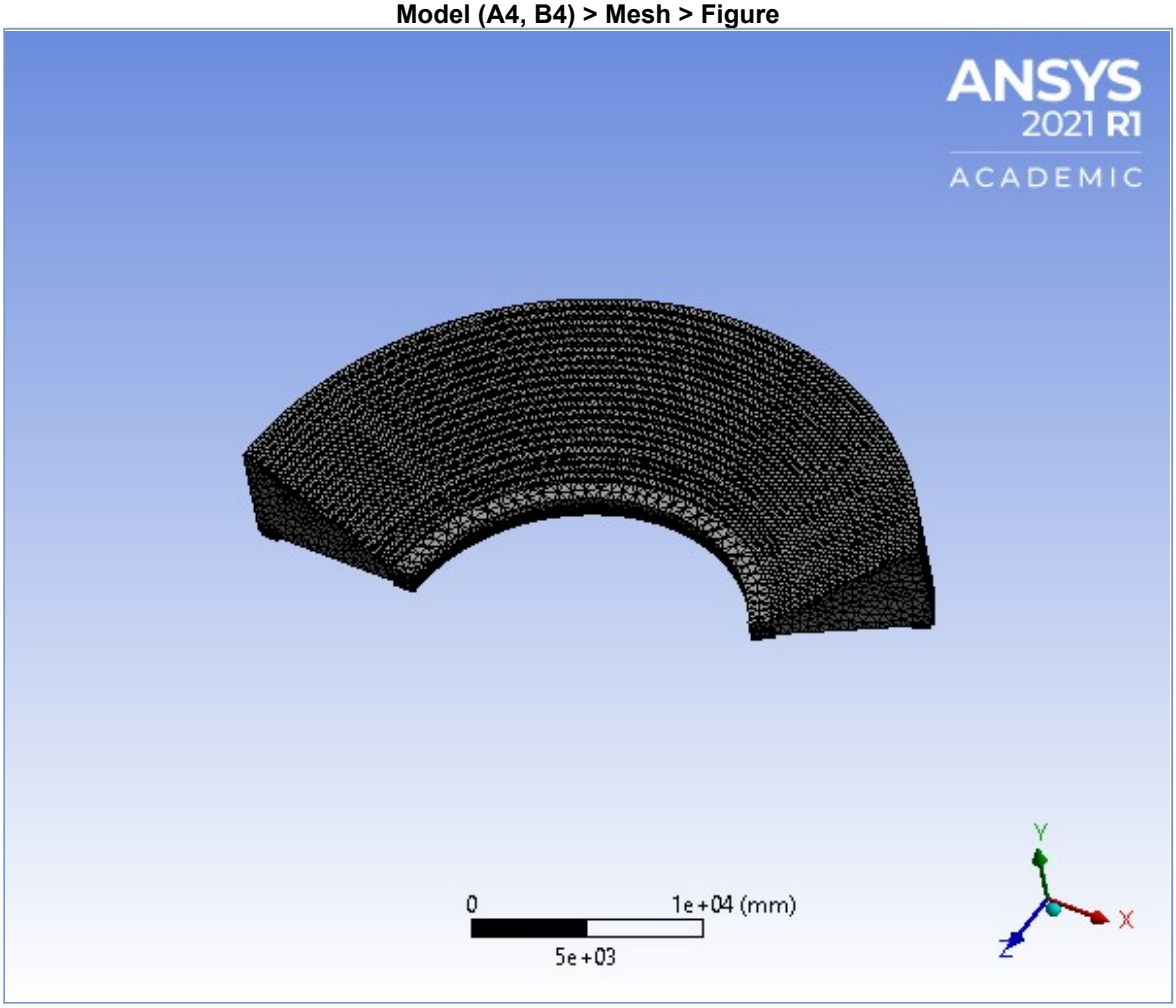
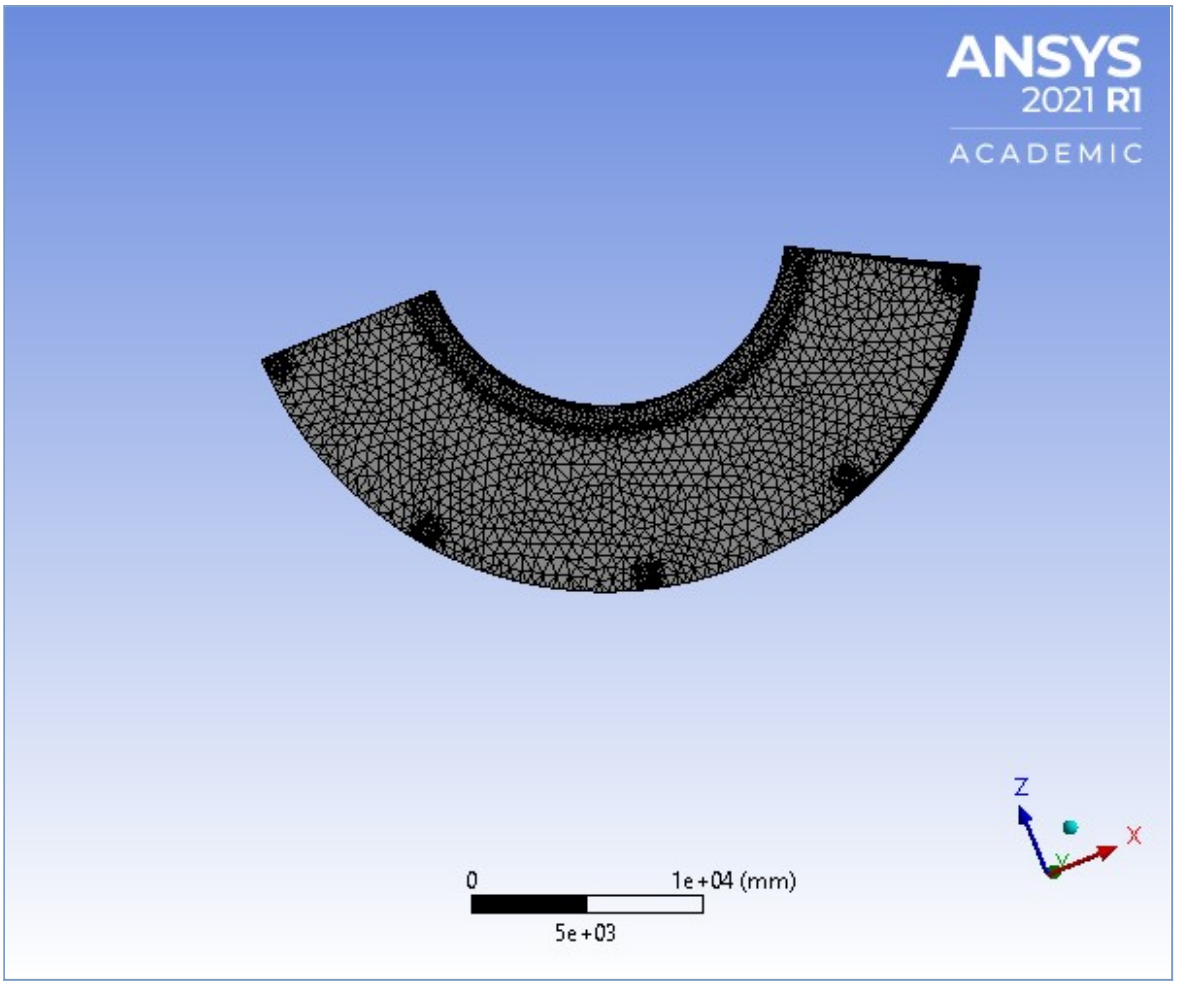


FIGURE 3
Model (A4, B4) > Mesh > Figure 2



Named Selections

TABLE 8
Model (A4, B4) > Named Selections > Named Selections

Object Name	*NONE*	*NONE_(Faces)_*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	198 Edges	72 Faces
Definition		
Send to Solver	Yes	
Protected	Program Controlled	
Visible	Yes	
Program Controlled Inflation	Exclude	
Statistics		
Type	Imported	
Total Selection	198 Edges	72 Faces
Length	1.5462e+006 mm	
Suppressed	0	
Used by Mesh Worksheet	No	
Surface Area		9.0624e+008 mm²

Static Structural (A5)

TABLE 9
Model (A4, B4) > Analysis

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 10
Model (A4, B4) > Static Structural (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Off
Solver Pivot Checking	Program Controlled
Large Deflection	Off
Inertia Relief	Off
Quasi-Static Solution	Off
Rotordynamics Controls	
Coriolis Effect	Off
Restart Controls	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
Combine Restart Files	Program Controlled
Nonlinear Controls	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Program Controlled
Advanced	
Inverse Option	No
Contact Split (DMP)	Off
Output Controls	
Stress	Yes
Surface Stress	No
Back Stress	No
Strain	Yes
Contact Data	Yes

Nonlinear Data	No
Nodal Forces	Yes
Volume and Energy	Yes
Euler Angles	Yes
General Miscellaneous	No
Contact Miscellaneous	No
Store Results At	All Time Points
Result File Compression	Program Controlled
Analysis Data Management	
Solver Files Directory	D:\Users\janga\OneDrive - IIT Kanpur\Extra activities\SnT solidworks& ansys\Final_Project_OAT\oat_files\dp0\SYS\MECH\
Future Analysis	Topology Optimization
Scratch Solver Files Directory	
Save MAPDL db	No
Contact Summary	Program Controlled
Delete Unneeded Files	Yes
Nonlinear Solution	No
Solver Units	Active System
Solver Unit System	nmm

TABLE 11
Model (A4, B4) > Static Structural (A5) > Loads

Object Name	*Fixed Support*	*Force*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	6 Faces	20 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Applied By		Surface Effect
Magnitude		10000 N (ramped)
Direction		Defined

FIGURE 4
Model (A4, B4) > Static Structural (A5) > Fixed Support > Figure

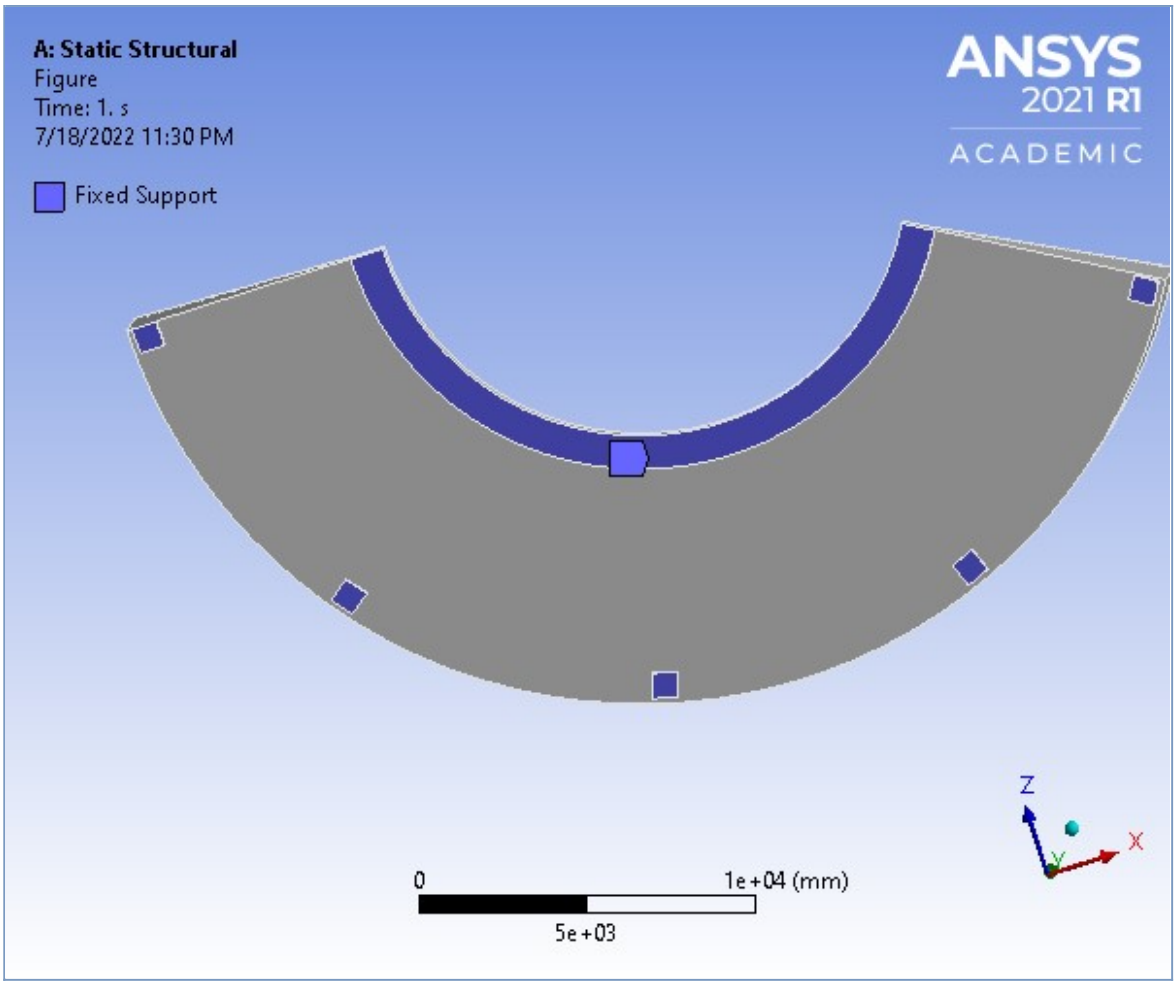


FIGURE 5
Model (A4, B4) > Static Structural (A5) > Force

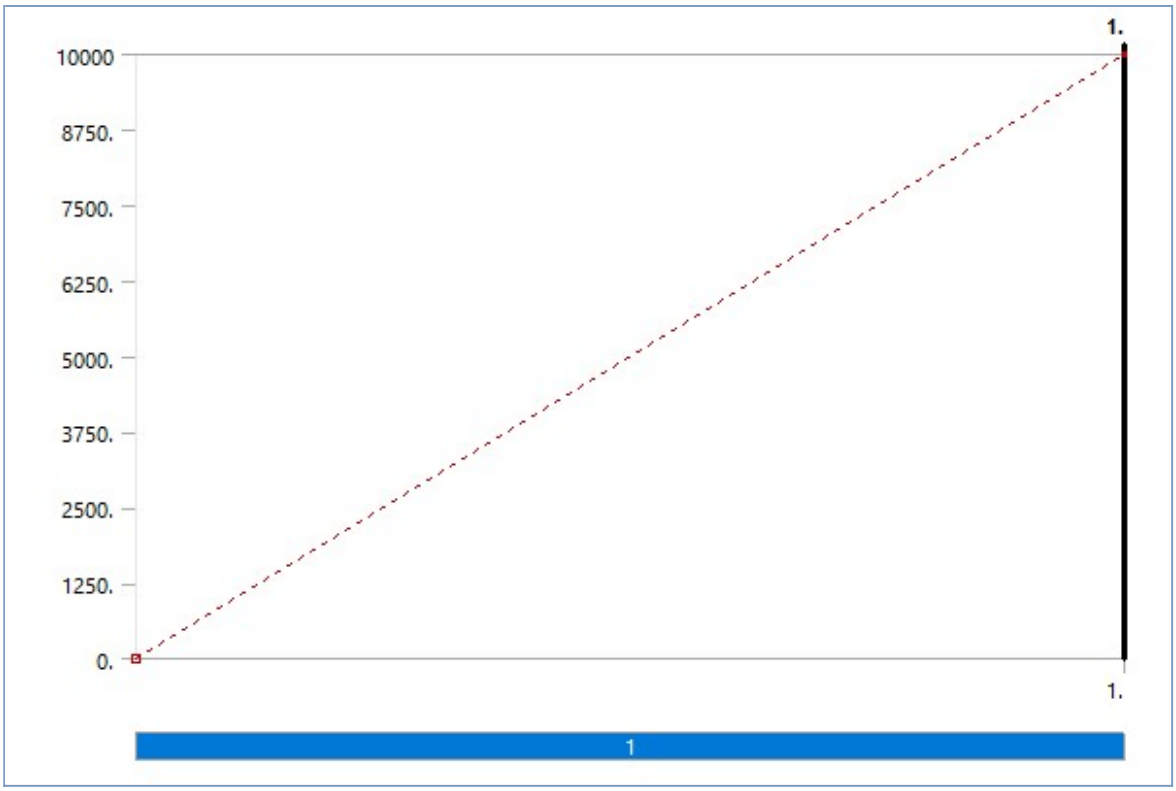
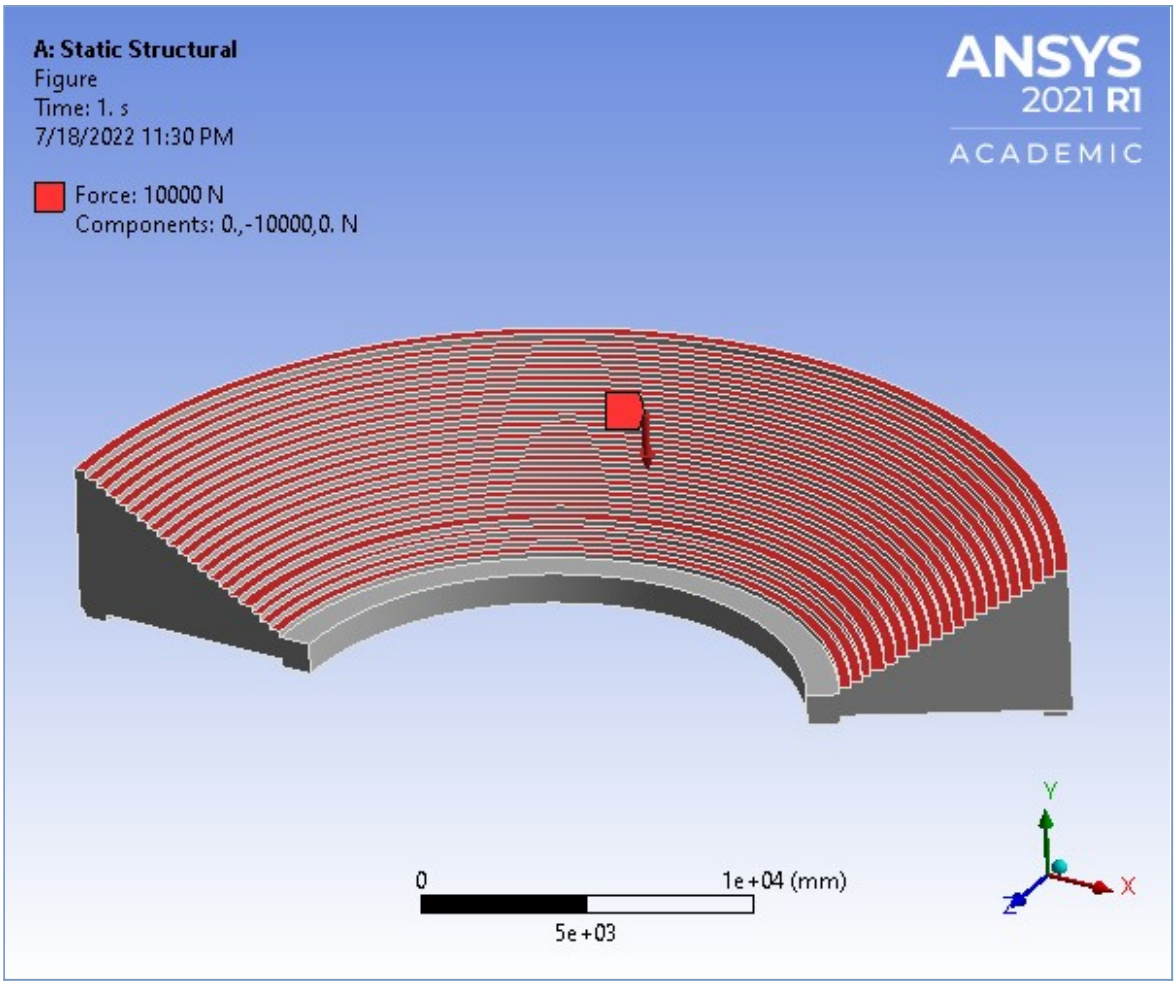


FIGURE 6
Model (A4, B4) > Static Structural (A5) > Force > Figure



Solution (A6)

TABLE 12
Model (A4, B4) > Static Structural (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	12. s
MAPDL Memory Used	553. MB
MAPDL Result File Size	66.688 MB
Post Processing	
Beam Section Results	No
On Demand Stress/Strain	No

TABLE 13
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output

Newton-Raphson Residuals	0
Identify Element Violations	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

TABLE 14
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Total Deformation	Equivalent (von-Mises) Stress
By	Time	
Display Time	Last	
Calculate Time History	Yes	
Identifier		
Suppressed	No	
Results		
Minimum	0. mm	4.9342e-006 MPa
Maximum	1.3929e-005 mm	4.7674e-003 MPa
Average	8.0122e-006 mm	2.4711e-004 MPa
Minimum Occurs On	SYS\Boss-Extrude2	
Maximum Occurs On	SYS\Boss-Extrude2	
Information		
Time	1. s	
Load Step	1	
Substep	1	
Iteration Number	1	
Integration Point Results		
Display Option		Averaged
Average Across Bodies		No

FIGURE 7
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Total Deformation

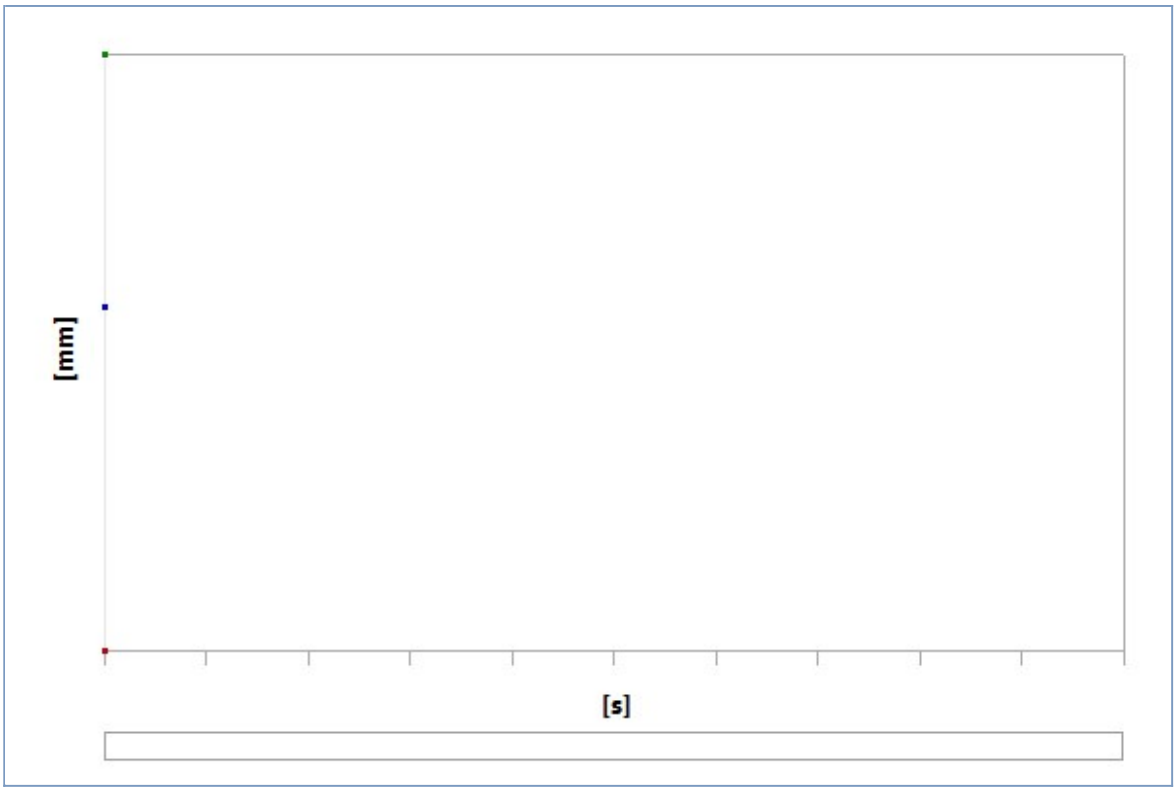


TABLE 15
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.	0.	1.3929e-005	8.0122e-006

FIGURE 8
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure

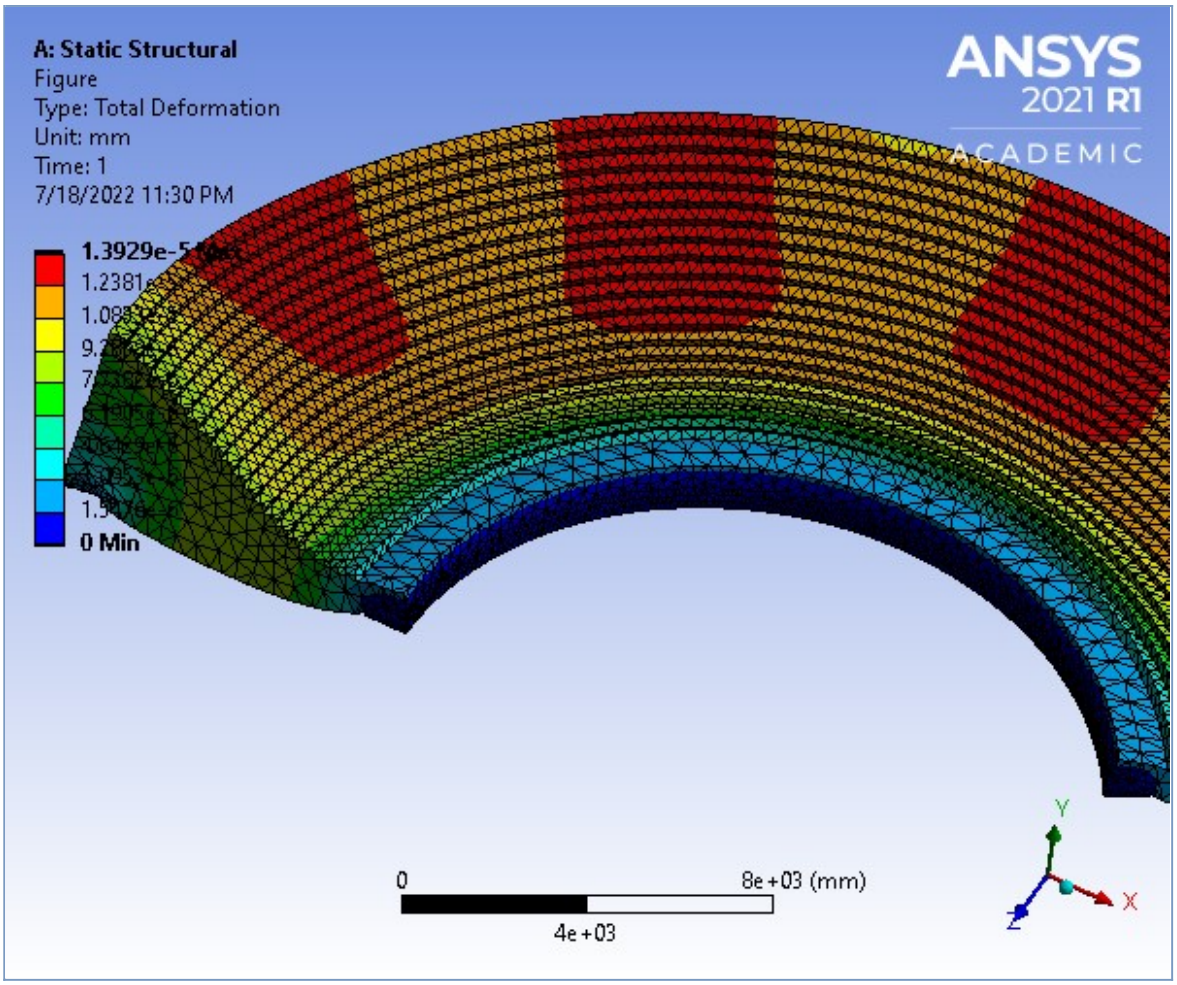


FIGURE 9
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

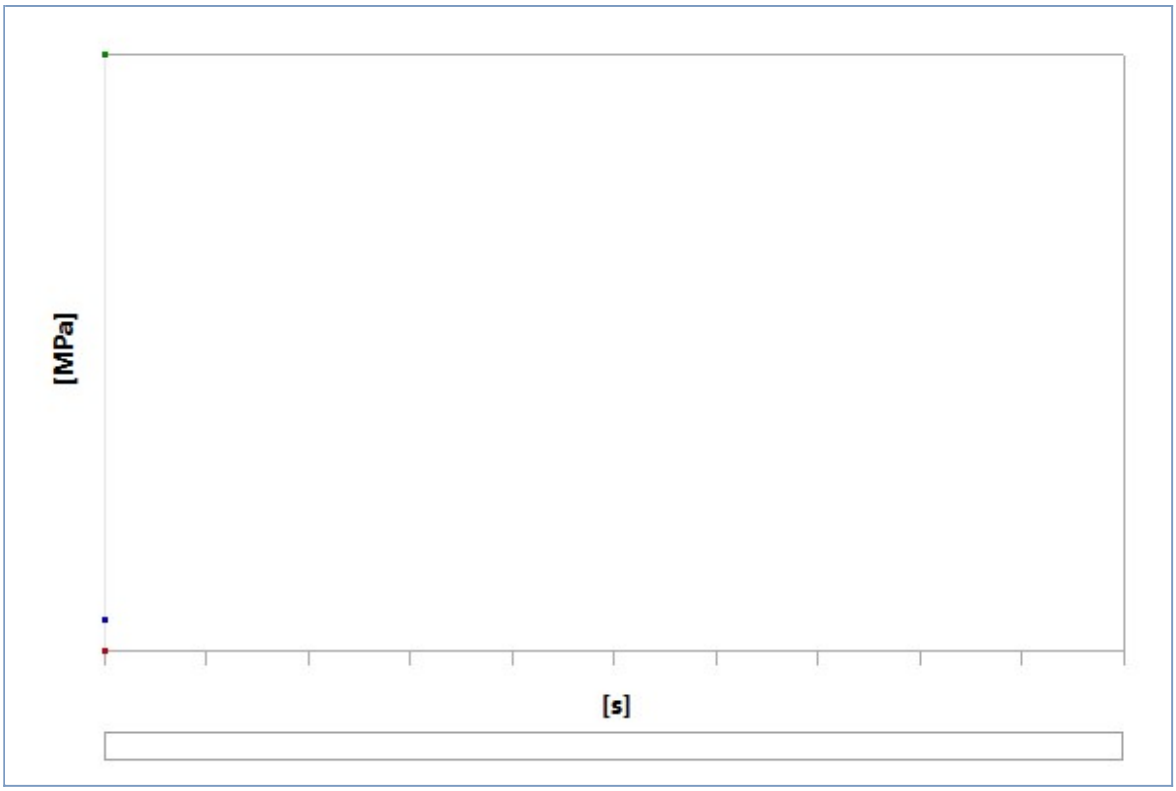
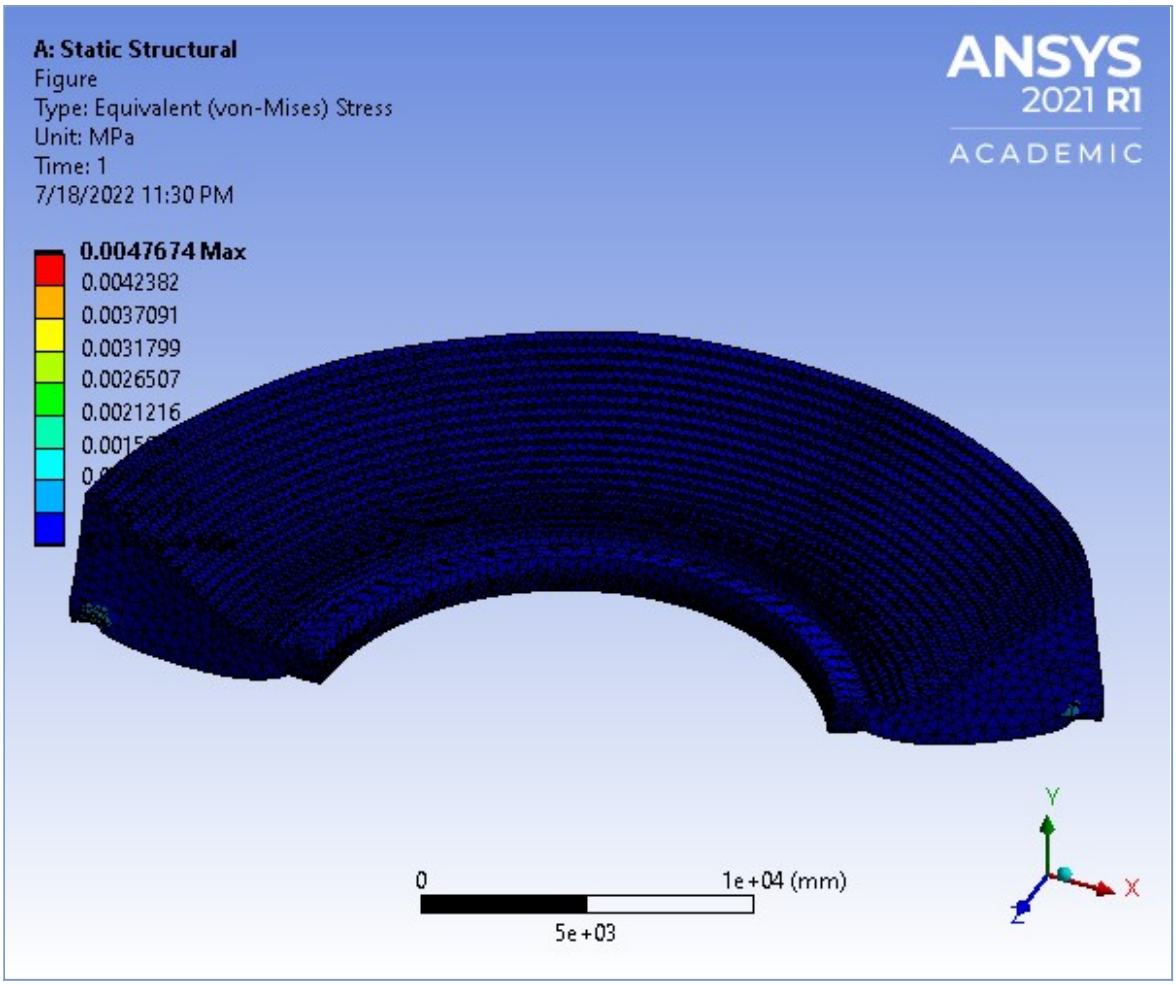


TABLE 16
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	4.9342e-006	4.7674e-003	2.4711e-004

FIGURE 10
Model (A4, B4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Figure



Topology Optimization (B5)

TABLE 17
Model (A4, B4) > Analysis

Object Name	*Topology Optimization (B5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Topology Optimization
Solver Target	Mechanical APDL
Options	
Generate Input Only	No

TABLE 18
Model (A4, B4) > Topology Optimization (B5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Reload Volume Analysis	
Reload Volume Fraction	Off
Definition	
Maximum Number Of Iterations	500.
Minimum Normalized Density	1.e-003

Convergence Accuracy	0.1 %
Initial Volume Fraction	Program Controlled
Penalty Factor (Stiffness)	3.
Region of Manufacturing Constraint	Include Exclusions
Region of Min Member Size	Exclude Exclusions
Region of AM Overhang Constraint	Exclude Exclusions
Filter	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Output Controls	
Store Results At	All Iterations
Analysis Data Management	
Solver Files Directory	D:\Users\janga\OneDrive - IIT Kanpur\Extra activities\SnT solidworks& ansys\Final_Project_OAT\oat_files\dp0\SYS-1\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Solver Units	Active System
Solver Unit System	nmm
Max Num Of Intermediate Files	All Iterations

TABLE 19
Model (A4, B4) > Topology Optimization (B5) > Optimization Region

Object Name	*Optimization Region*
State	Fully Defined
Design Region	
Scoping Method	Geometry Selection
Geometry	All Bodies
Exclusion Region	
Define By	Boundary Condition
Boundary Condition	All Boundary Conditions
Definition	
Suppressed	No
Optimization Option	
Optimization Type	Topology Optimization - Density Based

FIGURE 11
Model (A4, B4) > Topology Optimization (B5) > Optimization Region > Figure

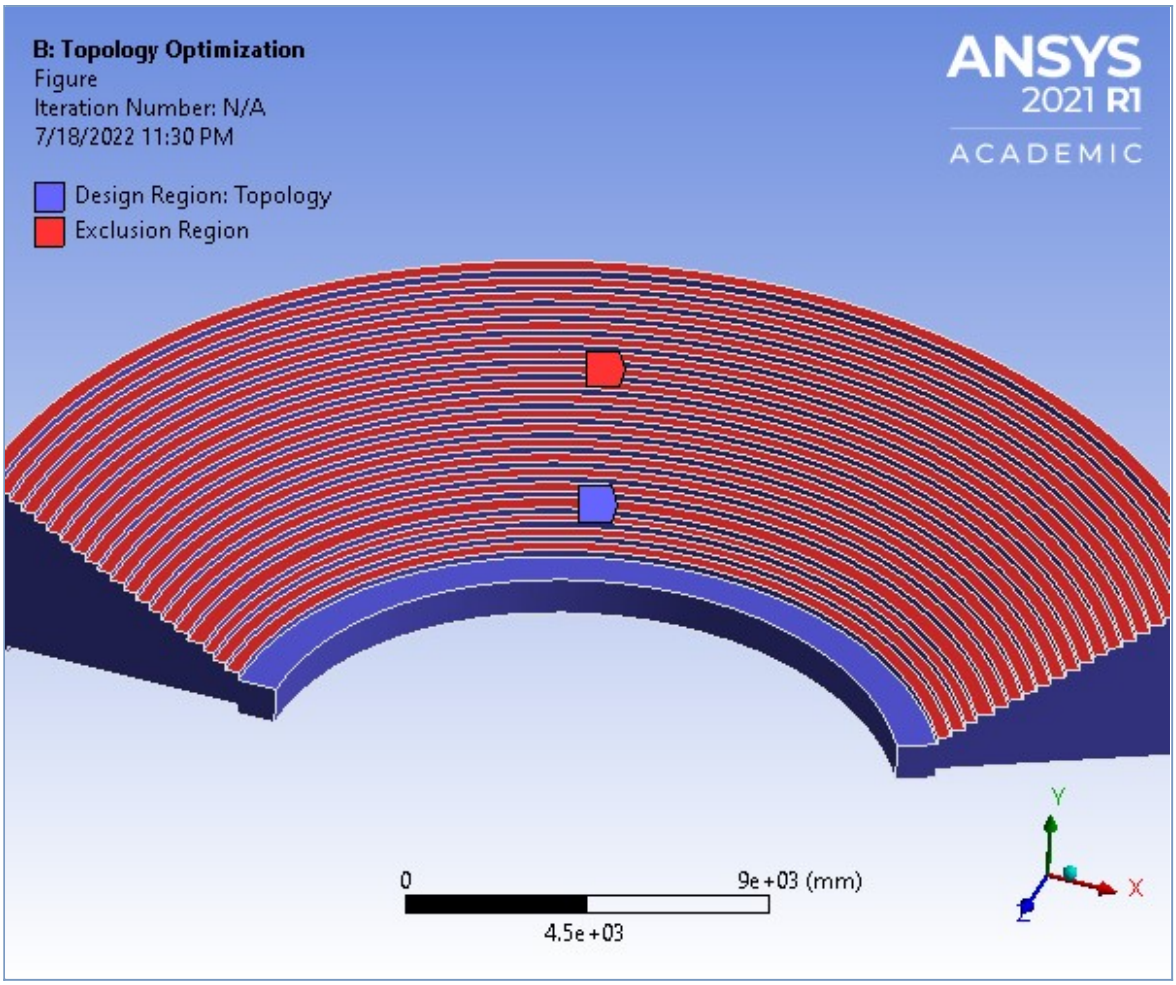


TABLE 20
Model (A4, B4) > Topology Optimization (B5) > Objective

Object Name	*Objective*
State	Fully Defined
Definition	
Suppressed	No
Normalized Sum	No

Model (A4, B4) > Topology Optimization (B5) > Objective

Response Type	Goal	Criterion	Formulation	Environment Name	Weight	Multiple Sets	Start Step	End Step	Step	Start Mode	End Mode	Mode
Compliance	Minimize	N/A	Program Controlled	Static Structural	N/A	Enabled	1	1	1	N/A	N/A	N/A

TABLE 21
Model (A4, B4) > Topology Optimization (B5) > Response Constraint

Object Name	*Response Constraint*
State	Fully Defined
Scope	
Scoping Method	Optimization Region
Optimization Region Selection	Optimization Region
Definition	
Type	Response Constraint
Response	Mass

Define By	Constant
Percent to Retain	18 %
Suppressed	No

Solution (B6)

TABLE 22
Model (A4, B4) > Topology Optimization (B5) > Solution

Object Name	*Solution (B6)*
State	Solved
Information	
Status	Done
MAPDL Elapsed Time	5 m 21 s
MAPDL Memory Used	557. MB
MAPDL Result File Size	2.1313 MB
Post Processing	
Export Optimal Shape	Only Geometry
-- Topology Result	Topology Density
Definition	
Environment Selection List	A5

TABLE 23
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Objective & Mass Response Convergence
Response Constraint	Response Constraint
Update Interval	2.5 s
Display Points	All

FIGURE 12
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Solution Information

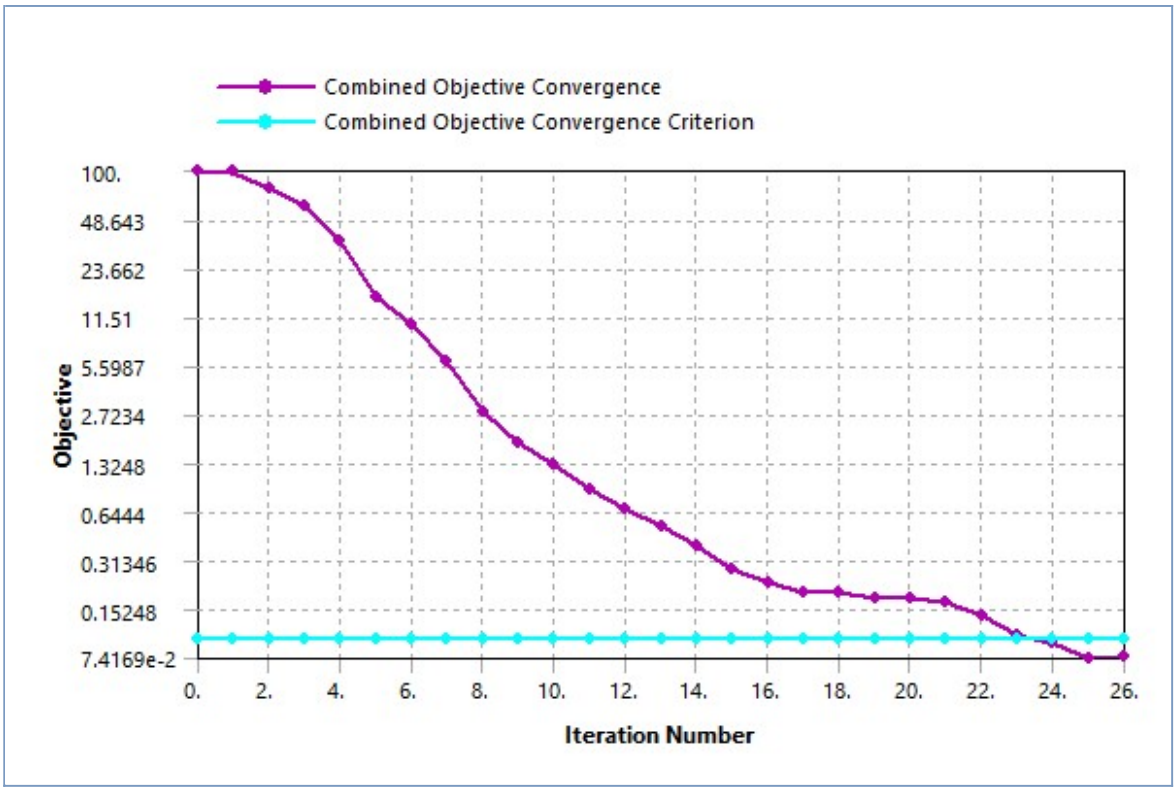


FIGURE 13
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Solution Information

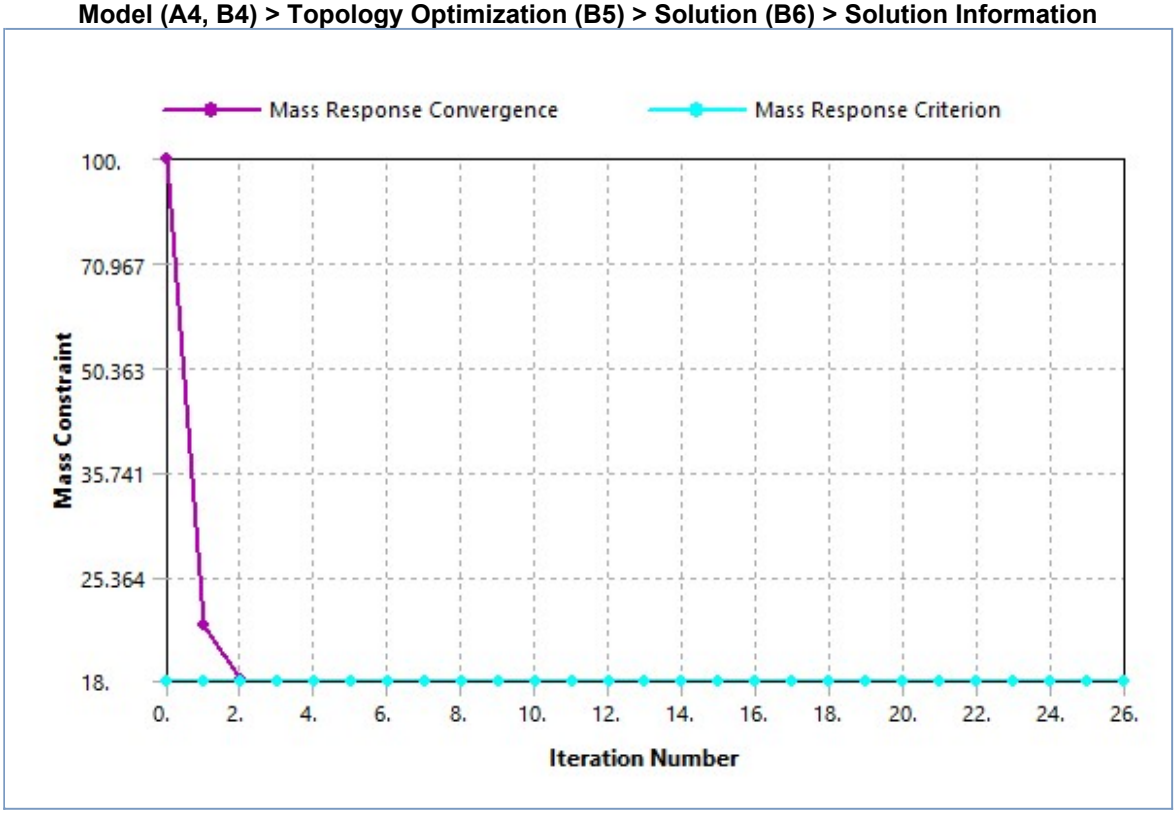


TABLE 24
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Solution Information > Results

Object Name	*Topology Density Tracker*
State	Solved

Scope	
Scoping Method	Optimization Region
Optimization Region	Optimization Region
Definition	
Type	Topology Density Tracker
By	Iteration
Iteration	Last
Retained Threshold	0.5
Suppressed	No
Results	
Minimum	1.e-003
Maximum	1.
Average	0.50287
Visibility	
Show Optimized Region	Retained Region
Information	
Iteration Number	26

TABLE 25
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Results

Object Name	*Topology Density*
State	Solved
Scope	
Scoping Method	Optimization Region
Optimization Region	Optimization Region
Definition	
Type	Topology Density
By	Iteration
Iteration	Last
Retained Threshold	0.5
Exclusions Participation	Yes
Calculate Time History	Yes
Suppressed	No
Results	
Minimum	1.e-003
Maximum	1.
Average	0.50287
Original Volume	7.244e+011 mm³
Final Volume	1.8591e+011 mm³
Percent Volume of Original	25.664
Original Mass	5.6866e+006 kg
Final Mass	1.4594e+006 kg
Percent Mass of Original	25.664
Visibility	
Show Optimized Region	Retained Region
Information	
Iteration Number	26

FIGURE 14
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Topology Density

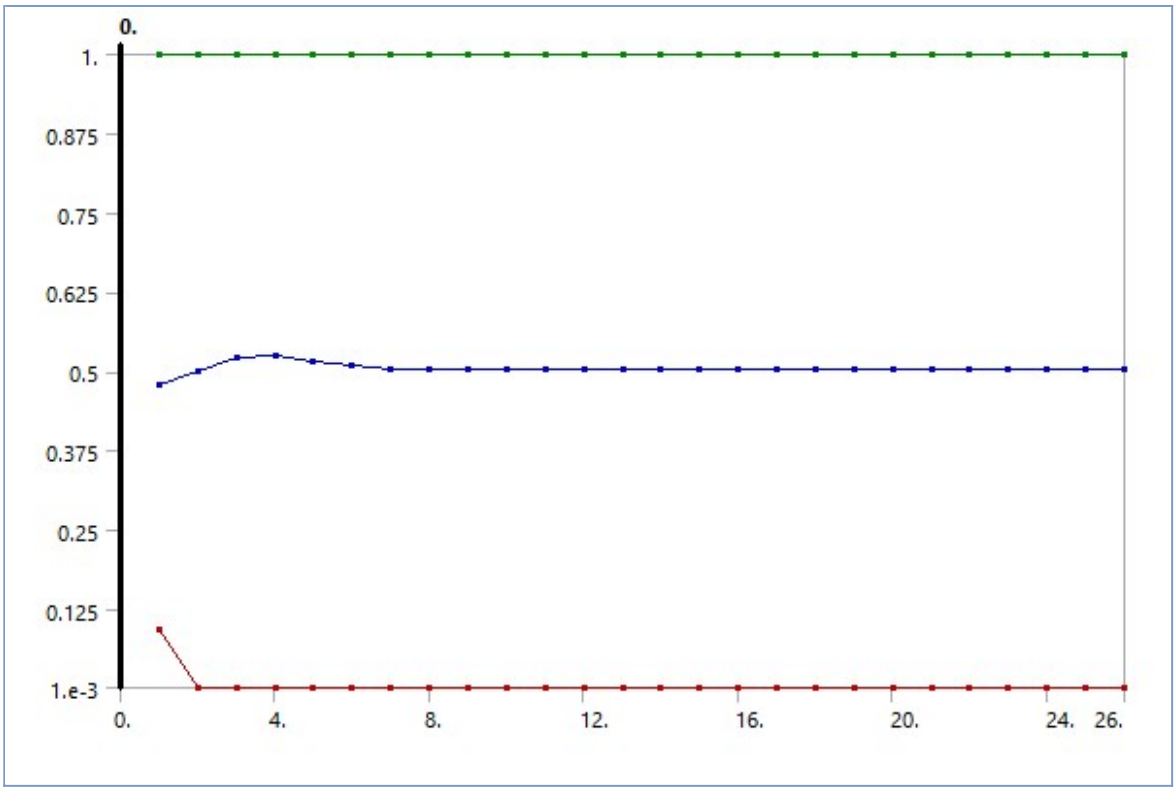
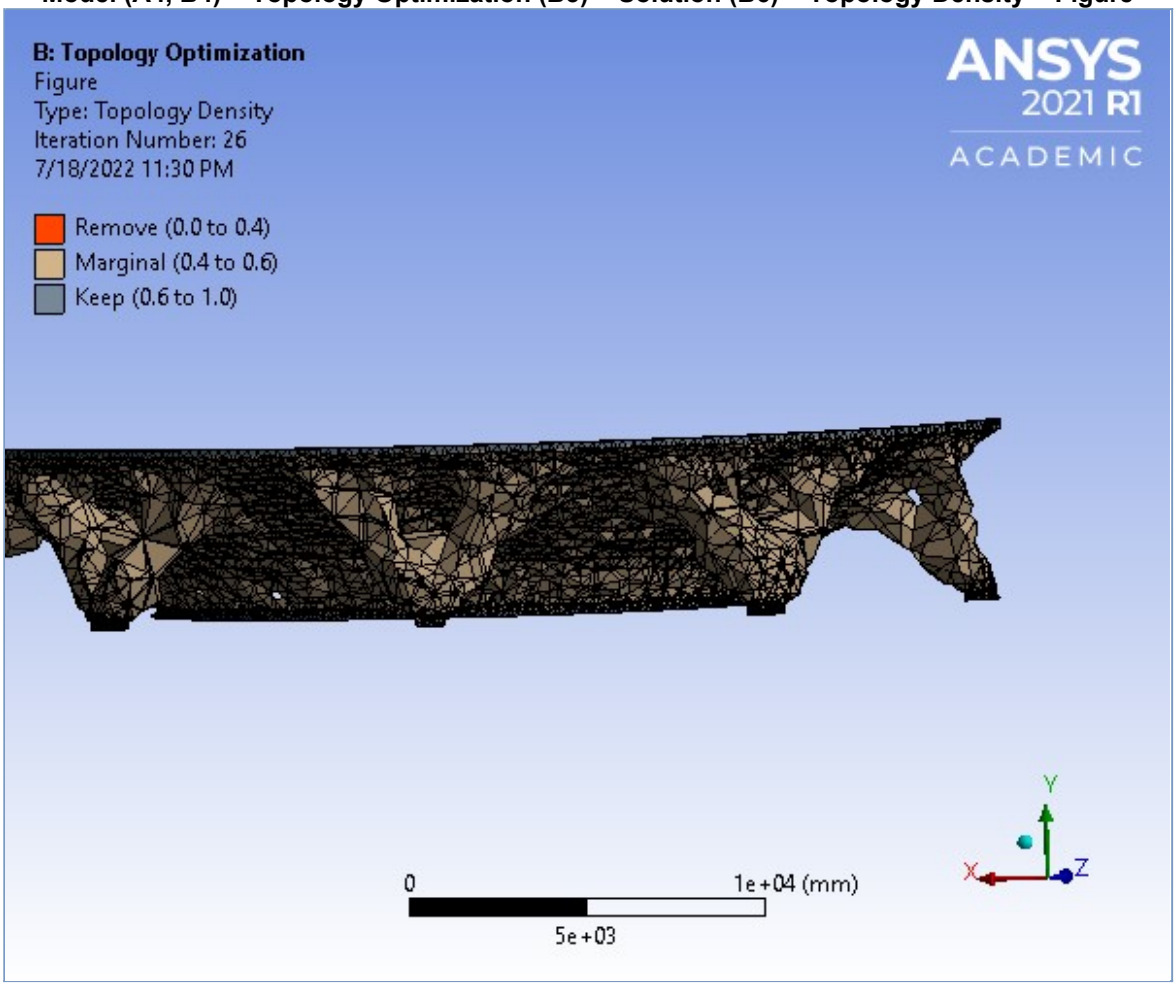


TABLE 26
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Topology Density

Iteration	Minimum	Maximum	Average
1.	9.4456e-002	1.	0.47994
2.	1.0165e-003		0.50074
3.	1.e-003		0.522
4.			0.52623
5.			0.5161
6.			0.50825
7.			0.50413
8.			0.50295
9.			0.50275
10.			0.50272
11.			0.50274
12.			0.50284
13.			0.50294
14.			0.50297
15.			0.50299
16.			0.50297
17.			0.50292
18.			0.50288
19.			0.50286
20.			0.50285
21.			0.50283
22.			
23.			0.50285
24.			0.50286
25.			0.50287
26.			

FIGURE 15
Model (A4, B4) > Topology Optimization (B5) > Solution (B6) > Topology Density > Figure



Material Data

Structural Steel

TABLE 27
Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

TABLE 28
Structural Steel > Color

Red	Green	Blue
132	139	179

TABLE 29
Structural Steel > Compressive Ultimate Strength

Compressive Ultimate Strength MPa
0

TABLE 30
Structural Steel > Compressive Yield Strength

Compressive Yield Strength MPa
250

TABLE 31
Structural Steel > Tensile Yield Strength

Tensile Yield Strength MPa
250

TABLE 32
Structural Steel > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
460

TABLE 33
Structural Steel > Isotropic Secant Coefficient of Thermal Expansion

Zero-Thermal-Strain Reference Temperature C
22

TABLE 34
Structural Steel > S-N Curve

Alternating Stress MPa	Cycles	Mean Stress MPa
3999	10	0
2827	20	0
1896	50	0
1413	100	0
1069	200	0
441	2000	0
262	10000	0
214	20000	0
138	1.e+005	0
114	2.e+005	0
86.2	1.e+006	0

TABLE 35
Structural Steel > Strain-Life Parameters

Strength Coefficient MPa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient MPa	Cyclic Strain Hardening Exponent
920	-0.106	0.213	-0.47	1000	0.2

TABLE 36
Structural Steel > Isotropic Elasticity

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa	Temperature C
2.e+005	0.3	1.6667e+005	76923	

TABLE 37
Structural Steel > Isotropic Relative Permeability

Relative Permeability
10000