



TECHNOLOGIES, INC.

LICK

2.4m Telescope

Multi-part Truss Design

Finite Element Analysis

FEA-12625-1



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Issue: 1

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LICK

Multi-part Truss Design Analysis

1 INTRODUCTION

1.1 SCOPE

This document describes the finite element analysis of the Multi-part Truss design, ASY-12411.

1.2 CONFIGURATION

This manual has been configured as FEA-12625-1 and is a designated controlled document under the EOS Quality System.

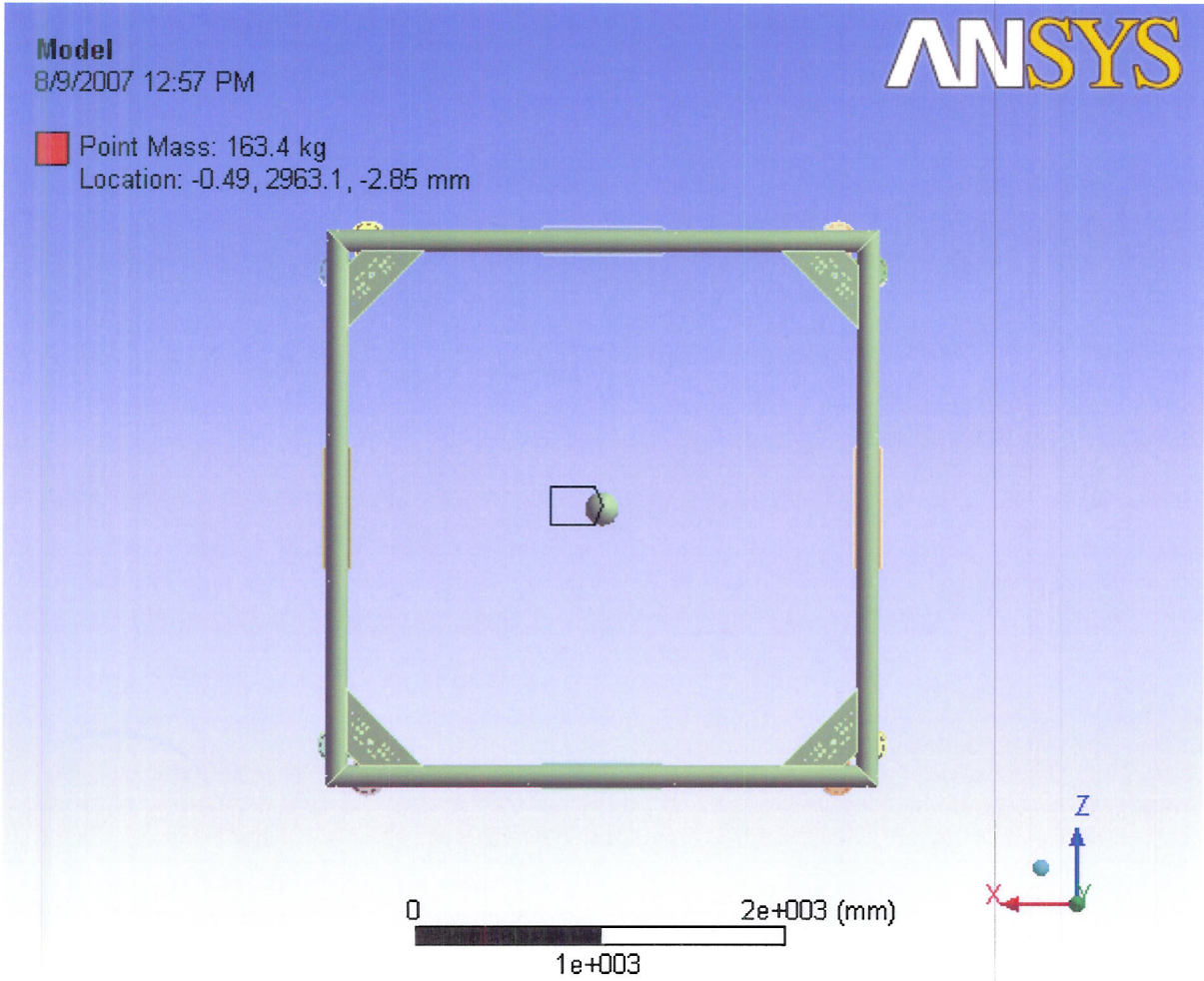
1.3 ANALYSIS DOCUMENT

The following document, consisting of 33 pages, outlines the analysis and results for the Multi-part Truss design. This document constitutes the body of this report.



Project

First Saved	Thursday, August 09, 2007
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Units

TABLE 1

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

Model

Geometry

TABLE 2
Model > Geometry

Object Name	Geometry	
State	Fully Defined	
Definition		
Source	P:\Lick Telescope\mechanical\drawings\ASY-12411.SLDASM	
Type	SolidWorks	
Length Unit	Meters	
Element Control	Program Controlled	
Display Style	Part Color	
Bounding Box		
Length X	3135.1 mm	
Length Y	2665.5 mm	
Length Z	3135.1 mm	
Properties		
Volume	1.5446e+008 mm ³	
Mass	1375.9 kg	
Statistics		
Bodies	21	
Active Bodies	21	
Nodes	263151	
Elements	127311	
Preferences		
Import Solid Bodies	Yes	
Import Surface Bodies	Yes	
Import Line Bodies	Yes	
Parameter Processing	Yes	
Personal Parameter Key	DS	
CAD Attribute Transfer	No	
Named Selection Processing	No	
Material Properties Transfer	No	
CAD Associativity	Yes	
Import Coordinate Systems	No	
Reader Save Part File	No	
Import Using Instances	Yes	
Do Smart Update	No	
Attach File Via Temp File	No	
Analysis Type	3-D	
Mixed Import Resolution	None	
Enclosure and Symmetry Processing	Yes	

TABLE 3
Model > Geometry > Parts

Object Name	COM-12409-1	COM-5280-leg-1	COM-5280-top-1	COM-12410-2	COM-12409-2
State	Meshed				
Graphics Properties					

Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Material	Structural Steel				
Stiffness Behavior	Flexible				
Nonlinear Material Effects	Yes				
Bounding Box					
Length X	265.34 mm	2603.9 mm	2984.3 mm	248.43 mm	265.34 mm
Length Y	173.71 mm	2259.5 mm	422.29 mm	167.73 mm	173.71 mm
Length Z	265.07 mm	150. mm	2984.3 mm	244.76 mm	265.07 mm
Properties					
Volume	4.1155e+005 mm ³	1.5694e+007 mm ³	8.4562e+007 mm ³	4.789e+005 mm ³	4.1155e+005 mm ³
Mass	3.2307 kg	123.2 kg	663.81 kg	3.7594 kg	3.2307 kg
Centroid X	1257.8 mm	0.24028 mm	-0.12226 mm	-1273.3 mm	-1257.8 mm
Centroid Y	2609.7 mm	1368.5 mm	2954.2 mm	2641.3 mm	2609.7 mm
Centroid Z	1435. mm		-3.2535e-003 mm	1435. mm	
Moment of Inertia Ip1	10372 kg·mm ²	1.247e+008 kg·mm ²	9.7498e+008 kg·mm ²	11168 kg·mm ²	10372 kg·mm ²
Moment of Inertia Ip2	18467 kg·mm ²	6.5814e+007 kg·mm ²	1.9447e+009 kg·mm ²	20685 kg·mm ²	18467 kg·mm ²
Moment of Inertia Ip3	10382 kg·mm ²	5.9245e+007 kg·mm ²	9.7549e+008 kg·mm ²	11167 kg·mm ²	10382 kg·mm ²
Statistics					
Nodes	4624	23870	84231	5806	4624
Elements	1992	11945	43251	2543	1992

TABLE 4
Model > Geometry > Parts

Object Name	COM-12410-1	COM-12409-3	COM-12410-5	COM-12410-4	COM-12410-3
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Material	Structural Steel				
Stiffness Behavior	Flexible				
Nonlinear Material Effects	Yes				
Bounding Box					
Length X	266.85 mm	265.07 mm	244.76 mm	248.43 mm	244.76 mm
Length Y	176.79 mm	173.71 mm	167.73 mm		
Length Z	265.07 mm	265.34 mm	248.43 mm	244.76 mm	248.43 mm
Properties					

Volume	4.789e+005 mm ³	4.1155e+005 mm ³	4.789e+005 mm ³		
Mass	3.7594 kg	3.2307 kg	3.7594 kg		
Centroid X	1273.3 mm	1435. mm	-1435. mm	1273.3 mm	1435. mm
Centroid Y	2641.3 mm	2609.7 mm	2641.3 mm		
Centroid Z	1435. mm	1257.8 mm	-1273.3 mm	-1435. mm	1273.3 mm
Moment of Inertia Ip1	11168 kg·mm ²	10372 kg·mm ²	11168 kg·mm ²		
Moment of Inertia Ip2	20685 kg·mm ²	18467 kg·mm ²	20685 kg·mm ²		
Moment of Inertia Ip3	11167 kg·mm ²	10382 kg·mm ²	11167 kg·mm ²		
Statistics					
Nodes	5806	4624	5806		
Elements	2543	1992	2543		

TABLE 5
Model > Geometry > Parts

Object Name	COM-12410-8	COM-12410-7	COM-12410-6	COM-12409-5	COM-12409-4
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Material	Structural Steel				
Stiffness Behavior	Flexible				
Nonlinear Material Effects	Yes				
Bounding Box					
Length X	265.07 mm	266.85 mm	265.07 mm		265.34 mm
Length Y	176.79 mm			173.71 mm	
Length Z	266.85 mm	265.07 mm	266.85 mm	265.34 mm	265.07 mm
Properties					
Volume	4.789e+005 mm ³			4.1155e+005 mm ³	
Mass	3.7594 kg			3.2307 kg	
Centroid X	-1435. mm	-1273.3 mm	1435. mm	-1435. mm	1257.8 mm
Centroid Y	2641.3 mm			2609.7 mm	
Centroid Z	1273.3 mm	-1435. mm	-1273.3 mm	-1257.8 mm	-1435. mm
Moment of Inertia Ip1	11168 kg·mm ²			10372 kg·mm ²	
Moment of Inertia Ip2	20685 kg·mm ²			18467 kg·mm ²	
Moment of Inertia Ip3	11167 kg·mm ²			10382 kg·mm ²	
Statistics					
Nodes	5806			4624	
Elements	2543			1992	

TABLE 6
Model > Geometry > Parts

Object Name	COM-5280-leg-5	COM-12409-8	COM-12409-7	COM-12409-6	COM-5280-leg-7
State	Meshed				

Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Material	Structural Steel				
Stiffness Behavior	Flexible				
Nonlinear Material Effects	Yes				
Bounding Box					
Length X	150. mm	265.07 mm	265.34 mm	265.07 mm	150. mm
Length Y	2259.5 mm	173.71 mm			2259.5 mm
Length Z	2603.9 mm	265.34 mm	265.07 mm	265.34 mm	2603.9 mm
Properties					
Volume	1.5694e+007 mm ³	4.1155e+005 mm ³			1.5694e+007 mm ³
Mass	123.2 kg	3.2307 kg			123.2 kg
Centroid X	1435. mm	-1435. mm	-1257.8 mm	1435. mm	-1435. mm
Centroid Y	1368.5 mm	2609.7 mm			1368.5 mm
Centroid Z	-0.24028 mm	1257.8 mm	-1435. mm	-1257.8 mm	0.24028 mm
Moment of Inertia Ip1	1.247e+008 kg·mm ²	10372 kg·mm ²			1.247e+008 kg·mm ²
Moment of Inertia Ip2	6.5814e+007 kg·mm ²	18467 kg·mm ²			6.5814e+007 kg·mm ²
Moment of Inertia Ip3	5.9245e+007 kg·mm ²	10382 kg·mm ²			5.9245e+007 kg·mm ²
Statistics					
Nodes	23870	4624			23870
Elements	11945	1992			11945

TABLE 7
Model > Geometry > Parts

Object Name	COM-5280-leg-6
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Material	Structural Steel
Stiffness Behavior	Flexible
Nonlinear Material Effects	Yes
Bounding Box	
Length X	2603.9 mm
Length Y	2259.5 mm
Length Z	150. mm
Properties	

Volume	1.5694e+007 mm ³
Mass	123.2 kg
Centroid X	-0.24028 mm
Centroid Y	1368.5 mm
Centroid Z	-1435. mm
Moment of Inertia Ip1	1.247e+008 kg·mm ²
Moment of Inertia Ip2	6.5814e+007 kg·mm ²
Moment of Inertia Ip3	5.9245e+007 kg·mm ²
Statistics	
Nodes	23870
Elements	11945

TABLE 8
Model > Geometry > Point Masses

Object Name	<i>Point Mass</i>
State	Fully Defined
Scope	
Geometry	4 Faces
X Coordinate	-0.49 mm
Y Coordinate	2963.1 mm
Z Coordinate	-2.85 mm
Location	Defined
Definition	
Mass	163.4 kg
Mass Moment of Inertia X	0. kg·mm ²
Mass Moment of Inertia Y	0. kg·mm ²
Mass Moment of Inertia Z	0. kg·mm ²
Suppressed	No
Behavior	Deformable

Connections

TABLE 9
Model > Connections

Object Name	<i>Connections</i>
State	Fully Defined
Auto Detection	
Generate Contact On Update	Yes
Tolerance Type	Slider
Tolerance Slider	0.
Tolerance Value	12.933 mm
Face/Face	Yes
Face/Edge	No
Edge/Edge	No
Priority	Include All
Same Body Grouping	Yes
Revolute Joints	Yes
Fixed Joints	Yes

Transparency	
Enabled	Yes

TABLE 10
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-12409-1 To COM-5280-leg-1</i>	<i>Bonded - COM-5280-leg-1 To COM-12409-1</i>	<i>Bonded - COM-12409-3 To COM-5280-leg-5</i>	<i>Bonded - COM-5280-leg-5 To COM-12409-3</i>	<i>Bonded - COM-12409-6 To COM-5280-leg-5</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	1 Edge				
Target	1 Face				
Contact Bodies	COM-12409-1	COM-5280-leg-1	COM-12409-3	COM-5280-leg-5	COM-12409-6
Target Bodies	COM-5280-leg-1	COM-12409-1	COM-5280-leg-5	COM-12409-3	COM-5280-leg-5
Definition					
Type	Bonded				
Scope Mode	Manual				
Suppressed	No				
Advanced					
Formulation	Pure Penalty				
Normal Stiffness	Program Controlled				
Update Stiffness	Never				
Thermal Conductance	Program Controlled				
Pinball Region	Program Controlled				

TABLE 11
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-5280-leg-5 To COM-12409-6</i>	<i>Bonded - COM-12409-4 To COM-5280-leg-6</i>	<i>Bonded - COM-5280-leg-6 To COM-12409-4</i>	<i>Bonded - COM-12409-7 To COM-5280-leg-6</i>	<i>Bonded - COM-5280-leg-6 To COM-12409-7</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	1 Edge				
Target	1 Face				
Contact Bodies	COM-5280-leg-5	COM-12409-4	COM-5280-leg-6	COM-12409-7	COM-5280-leg-6
Target Bodies	COM-12409-6	COM-5280-leg-6	COM-12409-4	COM-5280-leg-6	COM-12409-7
Definition					
Type	Bonded				

Scope Mode	Manual
Suppressed	No
Advanced	
Formulation	Pure Penalty
Normal Stiffness	Program Controlled
Update Stiffness	Never
Thermal Conductance	Program Controlled
Pinball Region	Program Controlled

TABLE 12
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-12409-5 To COM-5280-leg-7</i>	<i>Bonded - COM-5280-leg-7 To COM-12409-5</i>	<i>Bonded - COM-12409-8 To COM-5280-leg-7</i>	<i>Bonded - COM-5280-leg-7 To COM-12409-8</i>	<i>Bonded - COM-12409-2 To COM-5280-leg-1</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	1 Edge				
Target	1 Face				
Contact Bodies	COM-12409-5	COM-5280-leg-7	COM-12409-8	COM-5280-leg-7	COM-12409-2
Target Bodies	COM-5280-leg-7	COM-12409-5	COM-5280-leg-7	COM-12409-8	COM-5280-leg-1
Definition					
Type	Bonded				
Scope Mode	Manual				
Suppressed	No				
Advanced					
Formulation	Pure Penalty				
Normal Stiffness	Program Controlled				
Update Stiffness	Never				
Thermal Conductance	Program Controlled				
Pinball Region	Program Controlled				

TABLE 13
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-5280-leg-1 To COM-12409-2</i>	<i>Bonded - COM-12410-1 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-1</i>	<i>Bonded - COM-12410-3 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-3</i>
State	Fully Defined				
Scope					
Scoping	Geometry Selection				

Method					
Contact	1 Edge				
Target	1 Face				
Contact Bodies	COM-5280-leg-1	COM-12410-1	COM-5280-top-1	COM-12410-3	COM-5280-top-1
Target Bodies	COM-12409-2	COM-5280-top-1	COM-12410-1	COM-5280-top-1	COM-12410-3
Definition					
Type	Bonded				
Scope Mode	Manual				
Suppressed	No				
Advanced					
Formulation	Pure Penalty				
Normal Stiffness	Program Controlled				
Update Stiffness	Never				
Thermal Conductance	Program Controlled				
Pinball Region	Program Controlled				

TABLE 14
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-12410-6 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-6</i>	<i>Bonded - COM-12410-4 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-4</i>	<i>Bonded - COM-12410-7 To COM-5280-top-1</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	1 Edge				
Target	1 Face				
Contact Bodies	COM-12410-6	COM-5280-top-1	COM-12410-4	COM-5280-top-1	COM-12410-7
Target Bodies	COM-5280-top-1	COM-12410-6	COM-5280-top-1	COM-12410-4	COM-5280-top-1
Definition					
Type	Bonded				
Scope Mode	Manual				
Suppressed	No				
Advanced					
Formulation	Pure Penalty				
Normal Stiffness	Program Controlled				
Update Stiffness	Never				
Thermal Conductance	Program Controlled				
Pinball Region	Program Controlled				

TABLE 15
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-5280-top-1 To COM-12410-7</i>	<i>Bonded - COM-12410-5 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-5</i>	<i>Bonded - COM-12410-8 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-8</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	1 Edge				
Target	1 Face				
Contact Bodies	COM-5280-top-1	COM-12410-5	COM-5280-top-1	COM-12410-8	COM-5280-top-1
Target Bodies	COM-12410-7	COM-5280-top-1	COM-12410-5	COM-5280-top-1	COM-12410-8
Definition					
Type	Bonded				
Scope Mode	Manual				
Suppressed	No				
Advanced					
Formulation	Pure Penalty				
Normal Stiffness	Program Controlled				
Update Stiffness	Never				
Thermal Conductance	Program Controlled				
Pinball Region	Program Controlled				

TABLE 16
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-12410-2 To COM-5280-top-1</i>	<i>Bonded - COM-5280-top-1 To COM-12410-2</i>	<i>Bonded - COM-12410-1 To COM-12409-1</i>	<i>Bonded - COM-12410-3 To COM-12409-3</i>	<i>Bonded - COM-12410-6 To COM-12409-6</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	1 Edge		2 Faces		
Target	1 Face		2 Faces		
Contact Bodies	COM-12410-2	COM-5280-top-1	COM-12410-1	COM-12410-3	COM-12410-6
Target Bodies	COM-5280-top-1	COM-12410-2	COM-12409-1	COM-12409-3	COM-12409-6
Definition					
Type	Bonded				
Scope Mode	Manual				
Suppressed	No				
Behavior	Symmetric				

Advanced	
Formulation	Pure Penalty
Normal Stiffness	Program Controlled
Update Stiffness	Never
Thermal Conductance	Program Controlled
Pinball Region	Program Controlled

TABLE 17
Model > Connections > Contact Regions

Object Name	<i>Bonded - COM-12409-4 To COM-12410-4</i>	<i>Bonded - COM-12409-7 To COM-12410-7</i>	<i>Bonded - COM-12409-5 To COM-12410-5</i>	<i>Bonded - COM-12409-8 To COM-12410-8</i>	<i>Bonded - COM-12409-2 To COM-12410-2</i>
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	2 Faces				
Target	2 Faces				
Contact Bodies	COM-12409-4	COM-12409-7	COM-12409-5	COM-12409-8	COM-12409-2
Target Bodies	COM-12410-4	COM-12410-7	COM-12410-5	COM-12410-8	COM-12410-2
Definition					
Type	Bonded				
Scope Mode	Manual				
Behavior	Symmetric				
Suppressed	No				
Advanced					
Formulation	Pure Penalty				
Normal Stiffness	Program Controlled				
Update Stiffness	Never				
Thermal Conductance	Program Controlled				
Pinball Region	Program Controlled				

Mesh

TABLE 18
Model > Mesh

Object Name	<i>Mesh</i>
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Advanced	

Relevance Center	Coarse
Element Size	Default
Shape Checking	Standard Mechanical
Solid Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Initial Size Seed	Active Assembly
Smoothing	Low
Transition	Fast
Statistics	
Nodes	263151
Elements	127311

Zenith

TABLE 19
Model > Analysis

Object Name	<i>Zenith</i>
State	Fully Defined
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Options	
Reference Temp	22. °C

TABLE 20
Model > Zenith > Analysis Settings

Object Name	<i>Analysis Settings</i>
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	Program Controlled
Inertia Relief	Off
Nonlinear Controls	
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Output Controls	
Calculate Stress	Yes
Calculate Strain	Yes
Calculate Results At	All Time Points
Analysis Data Management	

Solver Files Directory	H:\LICK\Lick Stuff\ansys\new truss Simulation Files\Zenith\
Future Analysis	None
Save ANSYS db	No
Delete Unneeded Files	Yes
Nonlinear Solution	No

TABLE 21
Model > Zenith > Accelerations

Object Name	<i>Standard Earth Gravity</i>
State	Fully Defined
Scope	
Geometry	All Bodies
Definition	
X Component	0. mm/s ² (ramped)
Y Component	-9806.6 mm/s ² (ramped)
Z Component	0. mm/s ² (ramped)
Suppressed	No
Direction	-Y Direction

FIGURE 1
Model > Zenith > Standard Earth Gravity

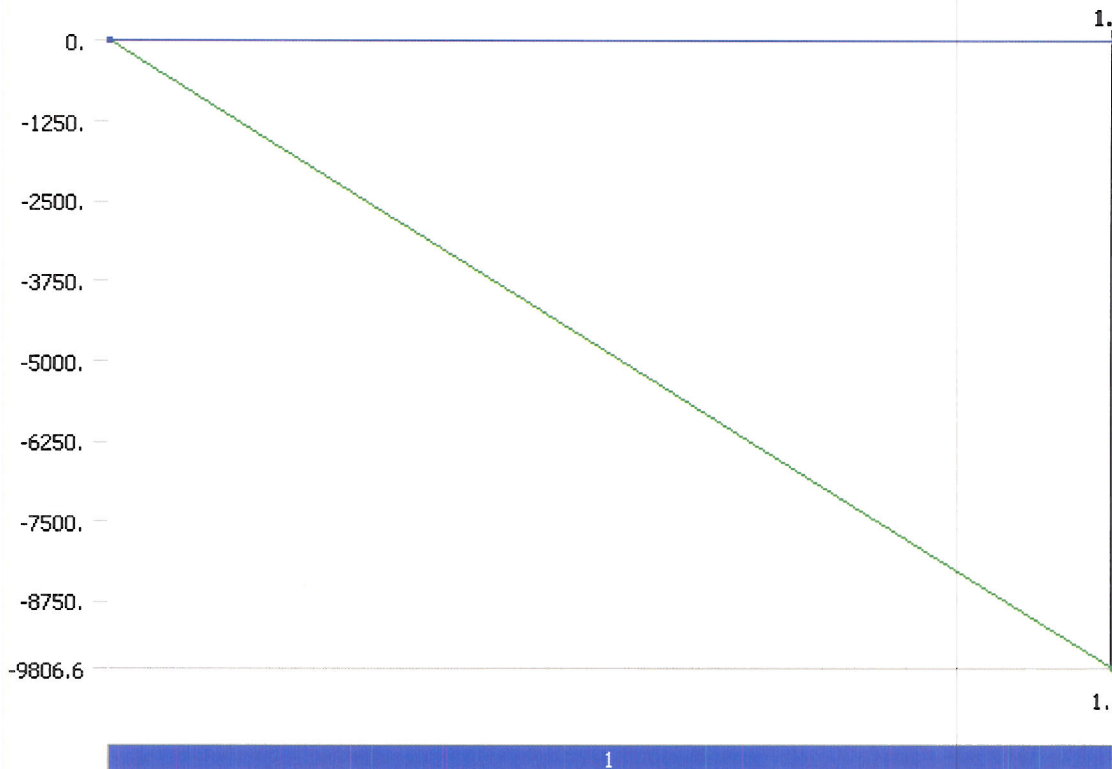
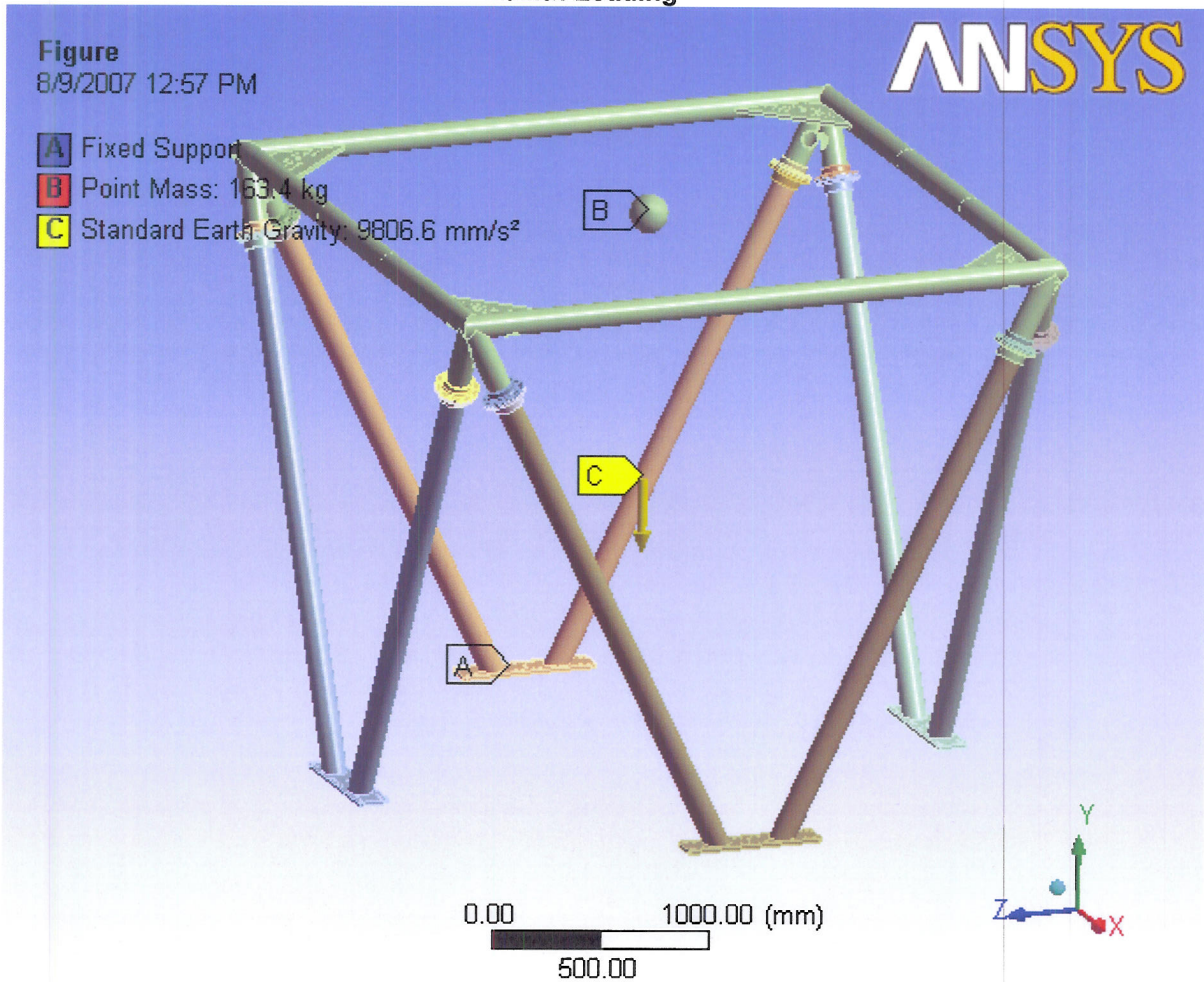


TABLE 22
Model > Zenith > Loads

Object Name	<i>Fixed Support</i>
State	Fully Defined

Scope	
Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Type	Fixed Support
Suppressed	No

FIGURE 2
Model > Zenith > Figure
Zenith Loading



Solution

TABLE 23
Model > Zenith > Solution

Object Name	<i>Solution</i>
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.

TABLE 24**Model > Zenith > Solution > Solution Information**

Object Name	<i>Solution Information</i>	
State	Solved	
Solution Information		
Solution Output	Solver Output	
Newton-Raphson Residuals	0	
Update Interval	2.5 s	
Display Points	All	

TABLE 25**Model > Zenith > Solution > Results**

Object Name	<i>Total Deformation</i>	<i>Equivalent Stress</i>
State	Solved	
Scope		
Geometry	All Bodies	
Definition		
Type	Total Deformation	Equivalent (von-Mises) Stress
Display Time	End Time	
Results		
Minimum	0. mm	7.7631e-005 MPa
Maximum	0.22139 mm	16.348 MPa
Minimum Occurs On	COM-5280-leg-1	COM-5280-leg-5
Maximum Occurs On	COM-5280-top-1	
Information		
Time	1. s	
Load Step	1	
Substep	1	
Iteration Number	1	

FIGURE 3**Model > Zenith > Solution > Total Deformation > Figure
Zenith Total Deformation**

Figure

Type: Total Deformation

Unit: mm

Time: 1

8/9/2007 12:57 PM

0.22139 Max

0.19679

0.1722

0.1476

0.123

0.098397

0.073798

0.049199

0.024599

0 Min



0.00 1000.00 (mm)
500.00

FIGURE 4
Model > Zenith > Solution > Equivalent Stress > Figure
Zenith Von Mises Stress

Figure

Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 1

8/9/2007 12:57 PM

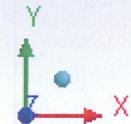
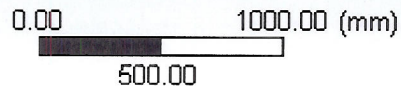
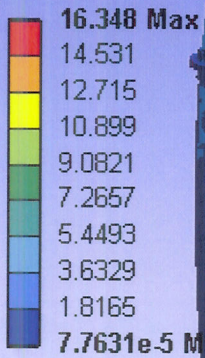


TABLE 26
Model > Zenith > Solution > Stress Safety Tools

Object Name	<i>Stress Tool</i>
State	Solved
Definition	
Theory	Max Equivalent Stress
Stress Limit Type	Tensile Yield Per Material

TABLE 27
Model > Zenith > Solution > Stress Tool > Results

Object Name	<i>Safety Factor</i>
State	Solved
Scope	
Geometry	All Bodies
Definition	
Type	Safety Factor
Display Time	End Time
Results	
Minimum	> 10

Minimum Occurs On	COM-12409-1
Information	
Time	1. s
Load Step	1
Substep	1
Iteration Number	1

TABLE 28
Model > Zenith > Solution > Stress Safety Tools

Object Name	<i>Stress Tool 2</i>
State	Solved
Definition	
Theory	Max Equivalent Stress
Stress Limit Type	Tensile Ultimate Per Material

TABLE 29
Model > Zenith > Solution > Stress Tool 2 > Results

Object Name	<i>Safety Factor</i>
State	Solved
Scope	
Geometry	All Bodies
Definition	
Type	Safety Factor
Display Time	End Time
Results	
Minimum	> 10
Minimum Occurs On	COM-12409-1
Information	
Time	1. s
Load Step	1
Substep	1
Iteration Number	1

Horizon

TABLE 30
Model > Analysis

Object Name	<i>Horizon</i>
State	Fully Defined
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Options	
Reference Temp	22. °C

TABLE 31
Model > Horizon > Analysis Settings

Object Name	<i>Analysis Settings</i>
-------------	--------------------------

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	Program Controlled
Inertia Relief	Off
Nonlinear Controls	
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Output Controls	
Calculate Stress	Yes
Calculate Strain	Yes
Calculate Results At	All Time Points
Analysis Data Management	
Solver Files Directory	H:\LICK\Lick Stuff\ansys\new truss Simulation Files\Horizon\
Future Analysis	None
Save ANSYS db	No
Delete Unneeded Files	Yes
Nonlinear Solution	No

TABLE 32
Model > Horizon > Accelerations

Object Name	<i>Standard Earth Gravity</i>
State	Fully Defined
Scope	
Geometry	All Bodies
Definition	
X Component	0. mm/s ² (ramped)
Y Component	0. mm/s ² (ramped)
Z Component	9806.6 mm/s ² (ramped)
Suppressed	No
Direction	+Z Direction

FIGURE 5
Model > Horizon > Standard Earth Gravity

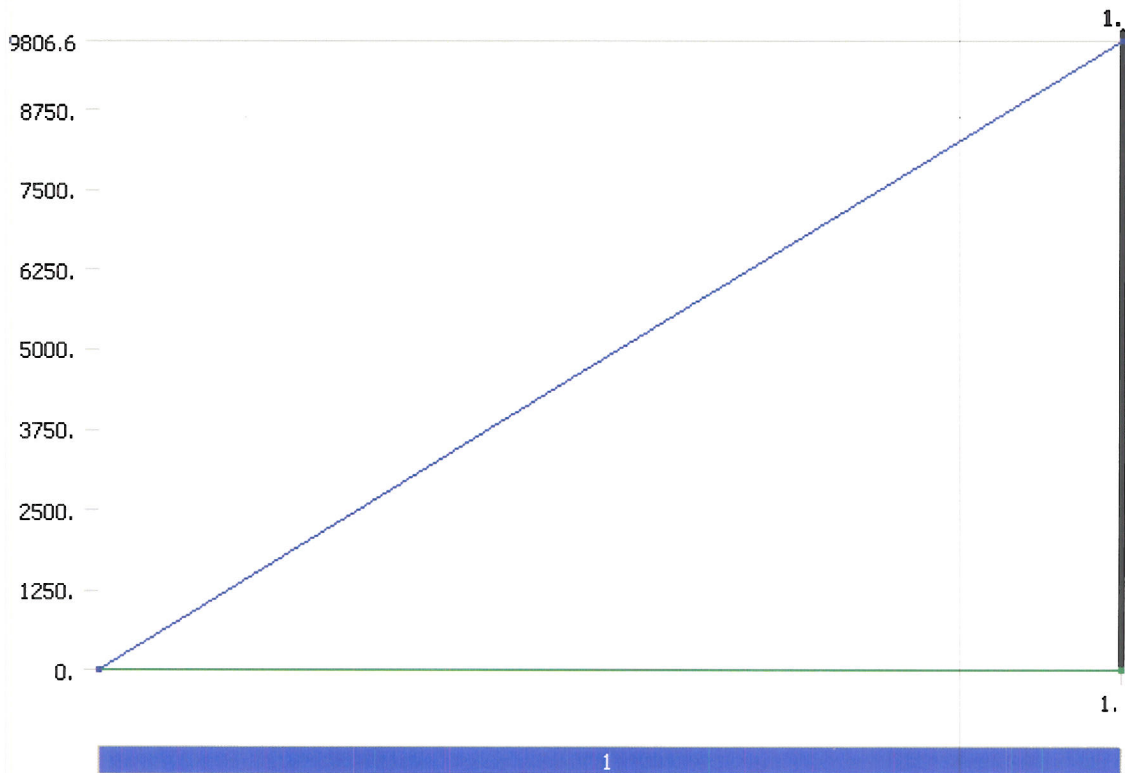


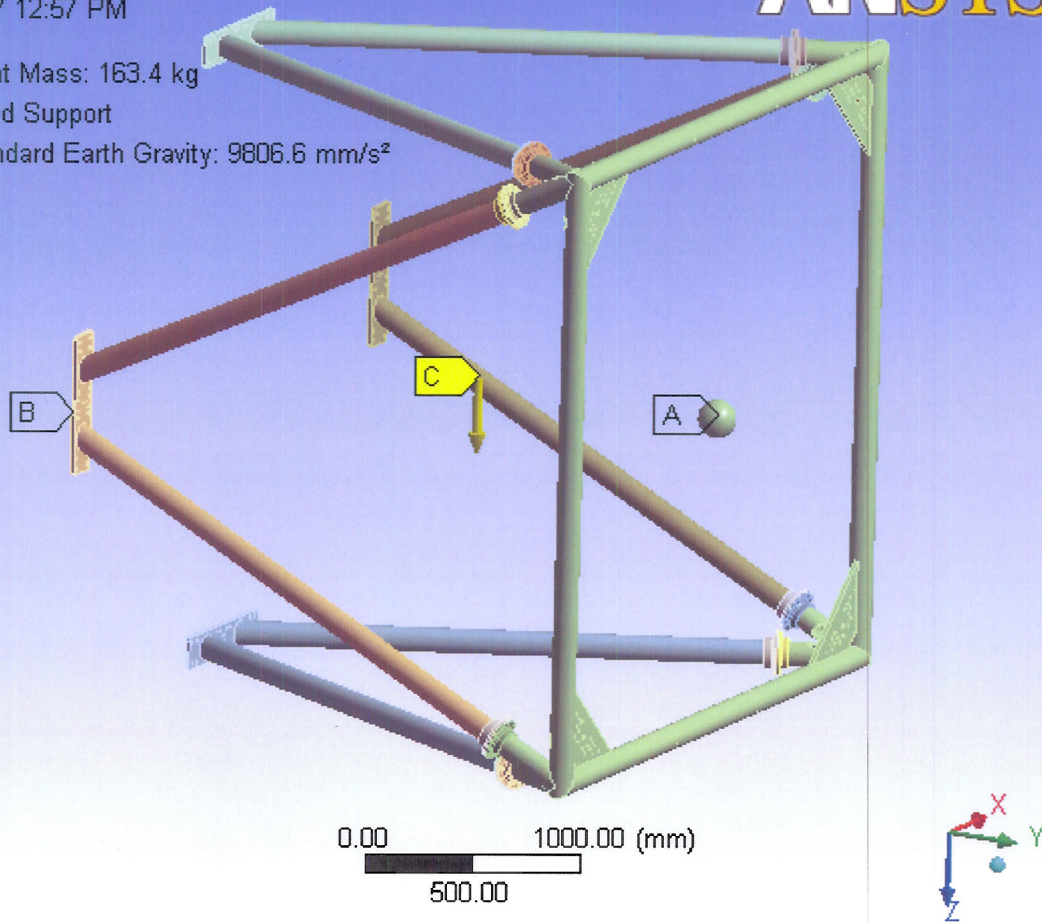
TABLE 33
Model > Horizon > Loads

Object Name	<i>Fixed Support</i>
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Type	Fixed Support
Suppressed	No

FIGURE 6
Model > Horizon > Figure
Horizon Loading

Figure
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- A** Point Mass: 163.4 kg
- B** Fixed Support
- C** Standard Earth Gravity: 9806.6 mm/s²



Solution

TABLE 34
Model > Horizon > Solution

Object Name	<i>Solution</i>
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.

TABLE 35
Model > Horizon > Solution > Solution Information

Object Name	<i>Solution Information</i>
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All

TABLE 36
Model > Horizon > Solution > Results

Object Name	<i>Total Deformation</i>	<i>Equivalent Stress</i>
State	Solved	
Scope		
Geometry	All Bodies	
Definition		
Type	Total Deformation	Equivalent (von-Mises) Stress
Display Time	End Time	
Results		
Minimum	0. mm	1.0007e-004 MPa
Maximum	0.21374 mm	13.812 MPa
Minimum Occurs On	COM-5280-leg-1	COM-5280-leg-5
Maximum Occurs On	COM-5280-top-1	
Information		
Time	1. s	
Load Step	1	
Substep	1	
Iteration Number	1	

FIGURE 7
Model > Horizon > Solution > Total Deformation > Figure
Horizon Total Deformation

Figure
Type: Total Deformation
Unit: mm
Time: 1
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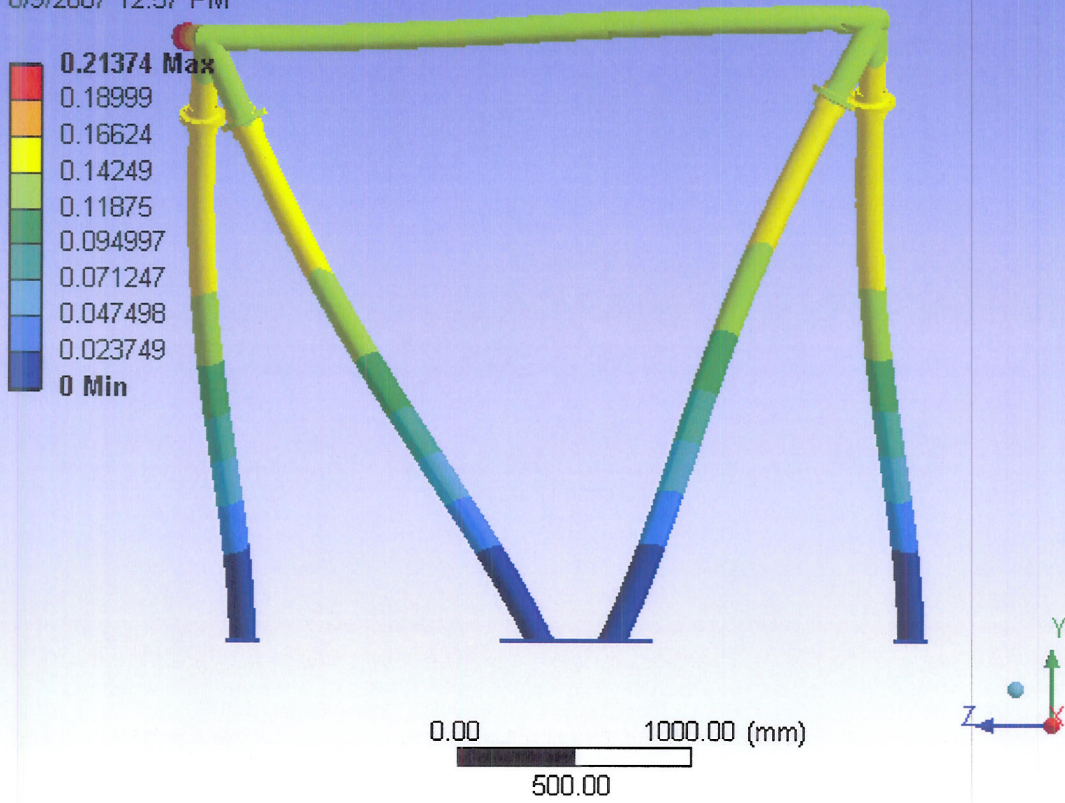


FIGURE 8
Model > Horizon > Solution > Equivalent Stress > Figure
Horizon Von Mises Stress

Figure

Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 1

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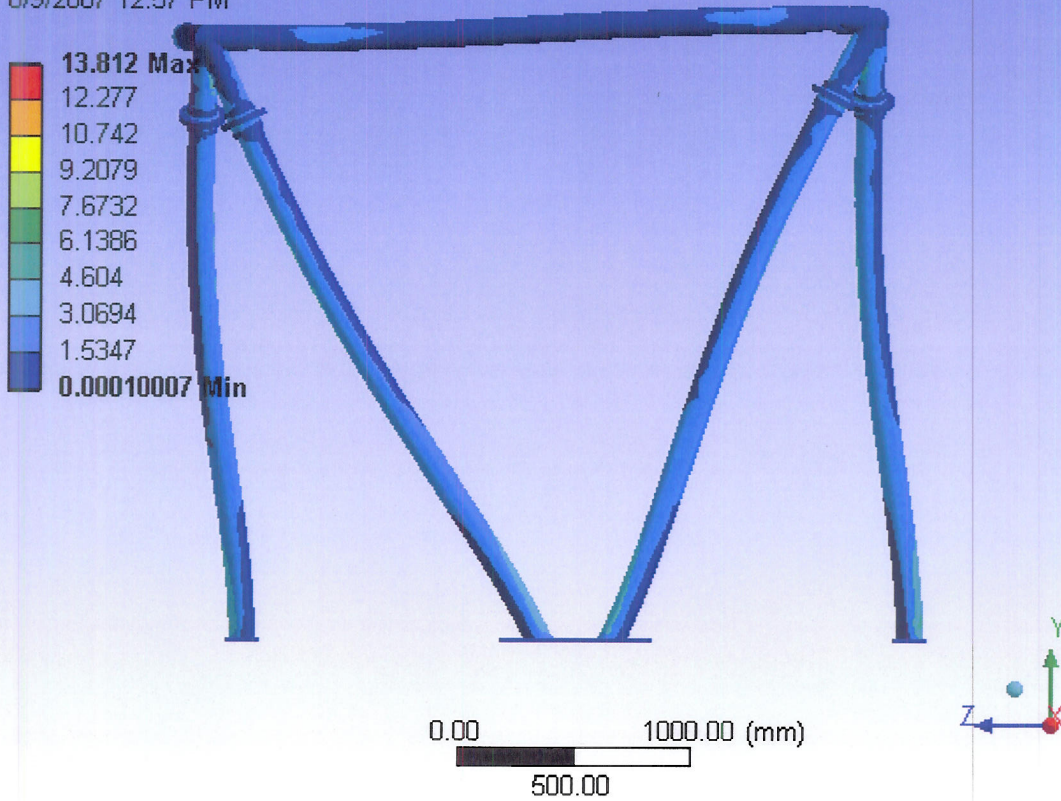


TABLE 37

Model > Horizon > Solution > Stress Safety Tools

Object Name	<i>Stress Tool</i>
State	Solved
Definition	
Theory	Max Equivalent Stress
Stress Limit Type	Tensile Yield Per Material

TABLE 38

Model > Horizon > Solution > Stress Tool > Results

Object Name	<i>Safety Factor</i>
State	Solved
Scope	
Geometry	All Bodies
Definition	
Type	Safety Factor
Display Time	End Time
Results	
Minimum	> 10

Minimum Occurs On	COM-12409-1
Information	
Time	1. s
Load Step	1
Substep	1
Iteration Number	1

TABLE 39
Model > Horizon > Solution > Stress Safety Tools

Object Name	<i>Stress Tool 2</i>
State	Solved
Definition	
Theory	Max Equivalent Stress
Stress Limit Type	Tensile Ultimate Per Material

TABLE 40
Model > Horizon > Solution > Stress Tool 2 > Results

Object Name	<i>Safety Factor</i>
State	Solved
Scope	
Geometry	All Bodies
Definition	
Type	Safety Factor
Display Time	End Time
Results	
Minimum	> 10
Minimum Occurs On	COM-12409-1
Information	
Time	1. s
Load Step	1
Substep	1
Iteration Number	1

Modal

TABLE 41
Model > Analysis

Object Name	<i>Modal</i>
State	Fully Defined
Definition	
Physics Type	Structural
Analysis Type	Modal
Options	
Reference Temp	22. °C

TABLE 42
Model > Modal > Initial Condition

Object Name	<i>Initial Condition</i>
-------------	--------------------------

State	Fully Defined
Definition	
Initial Condition Environment	None

TABLE 43
Model > Modal > Analysis Settings

Object Name	<i>Analysis Settings</i>
State	Fully Defined
Options	
Max Modes to Find	6
Limit Search to Range	No
Solver Controls	
Solver Type	Program Controlled
Output Controls	
Calculate Stress	No
Calculate Strain	No
Analysis Data Management	
Solver Files Directory	H:\LICK\Lick Stuff\ansys\new truss Simulation Files\Modal\
Future Analysis	None
Save ANSYS db	No
Delete Unneeded Files	Yes

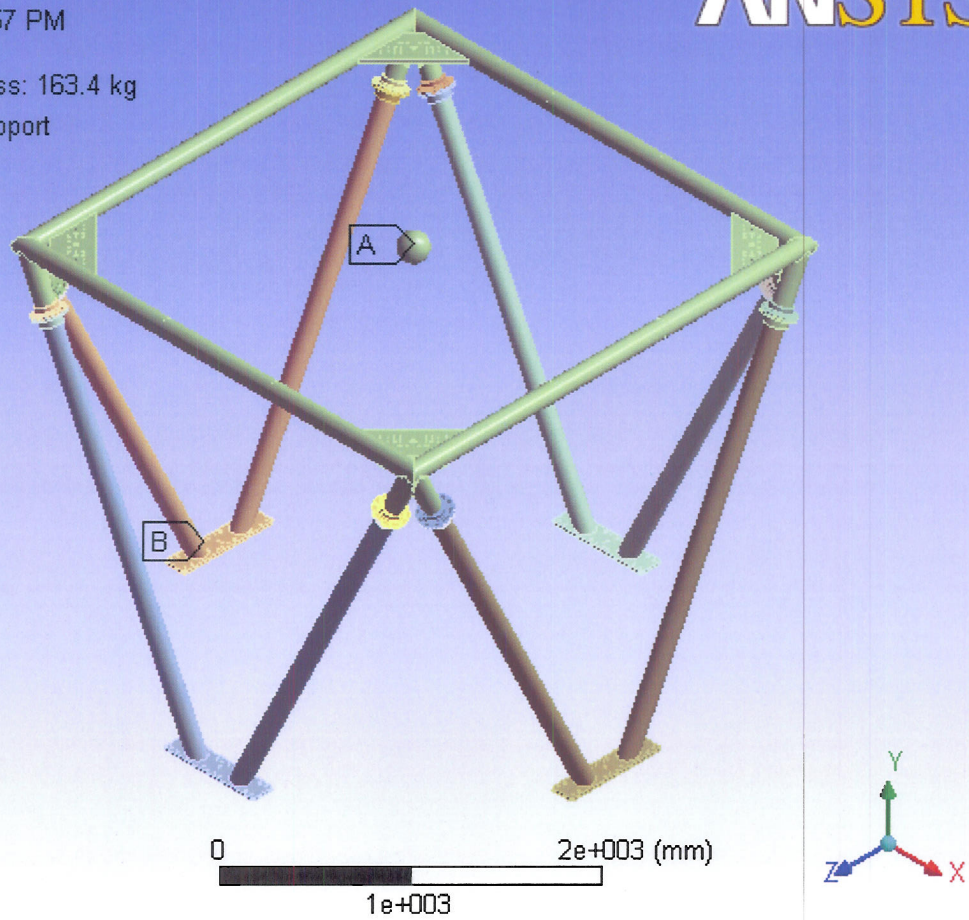
TABLE 44
Model > Modal > Loads

Object Name	<i>Fixed Support</i>
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Type	Fixed Support
Suppressed	No

FIGURE 9
Model > Modal > Figure
Modal Analysis

Figure
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- A** Point Mass: 163.4 kg
- B** Fixed Support



Solution

TABLE 45
Model > Modal > Solution

Object Name	<i>Solution</i>
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.

The following bar chart indicates the frequency at each calculated mode.

FIGURE 10
Model > Modal > Solution

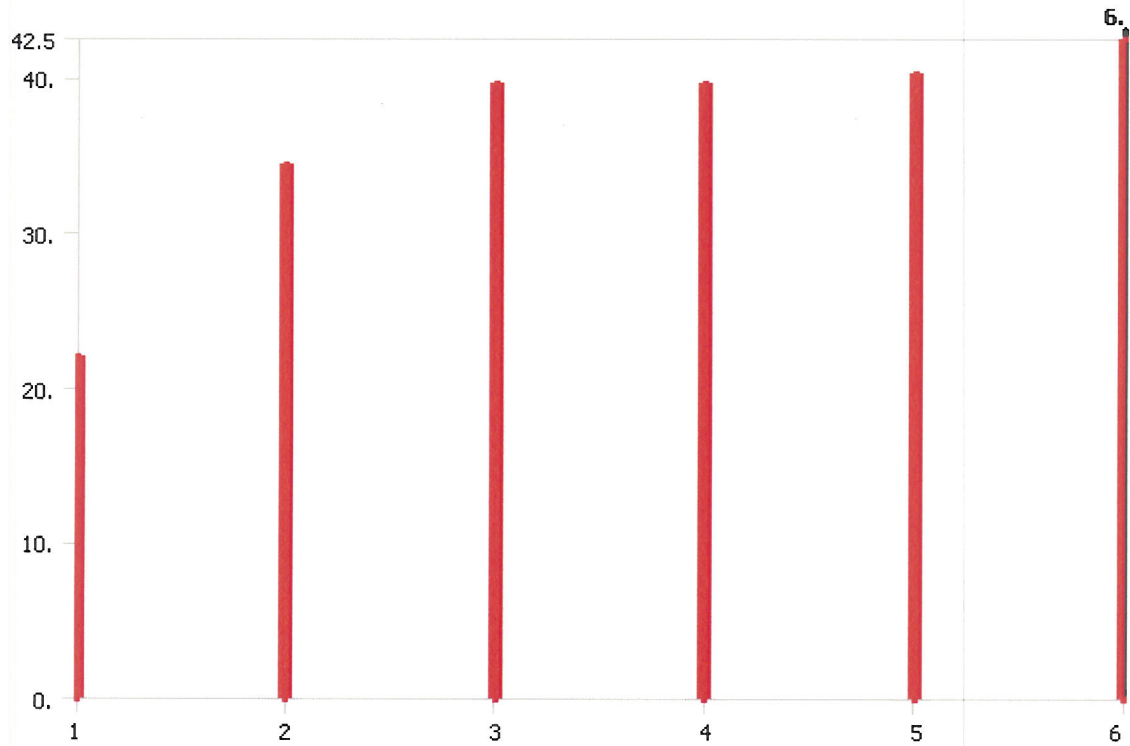


TABLE 46
Model > Modal > Solution

Mode	Frequency [Hz]
1.	22.031
2.	34.463
3.	39.677
4.	39.688
5.	40.279
6.	42.5

TABLE 47
Model > Modal > Solution > Solution Information

Object Name	<i>Solution Information</i>
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All

TABLE 48
Model > Modal > Solution > Results

Object Name	<i>Total Deformation</i>	<i>Total Deformation 2</i>
State	Solved	
Scope		

Geometry	All Bodies	
Definition		
Type	Total Deformation	
Mode	1	2
Results		
Frequency	22.031 Hz	34.463 Hz
Minimum	0. mm	
Maximum	1.2159 mm	2.1364 mm
Minimum Occurs On	COM-5280-leg-1	
Maximum Occurs On	COM-5280-top-1	

FIGURE 11
Model > Modal > Solution > Total Deformation > Figure
1st Mode - 22Hz

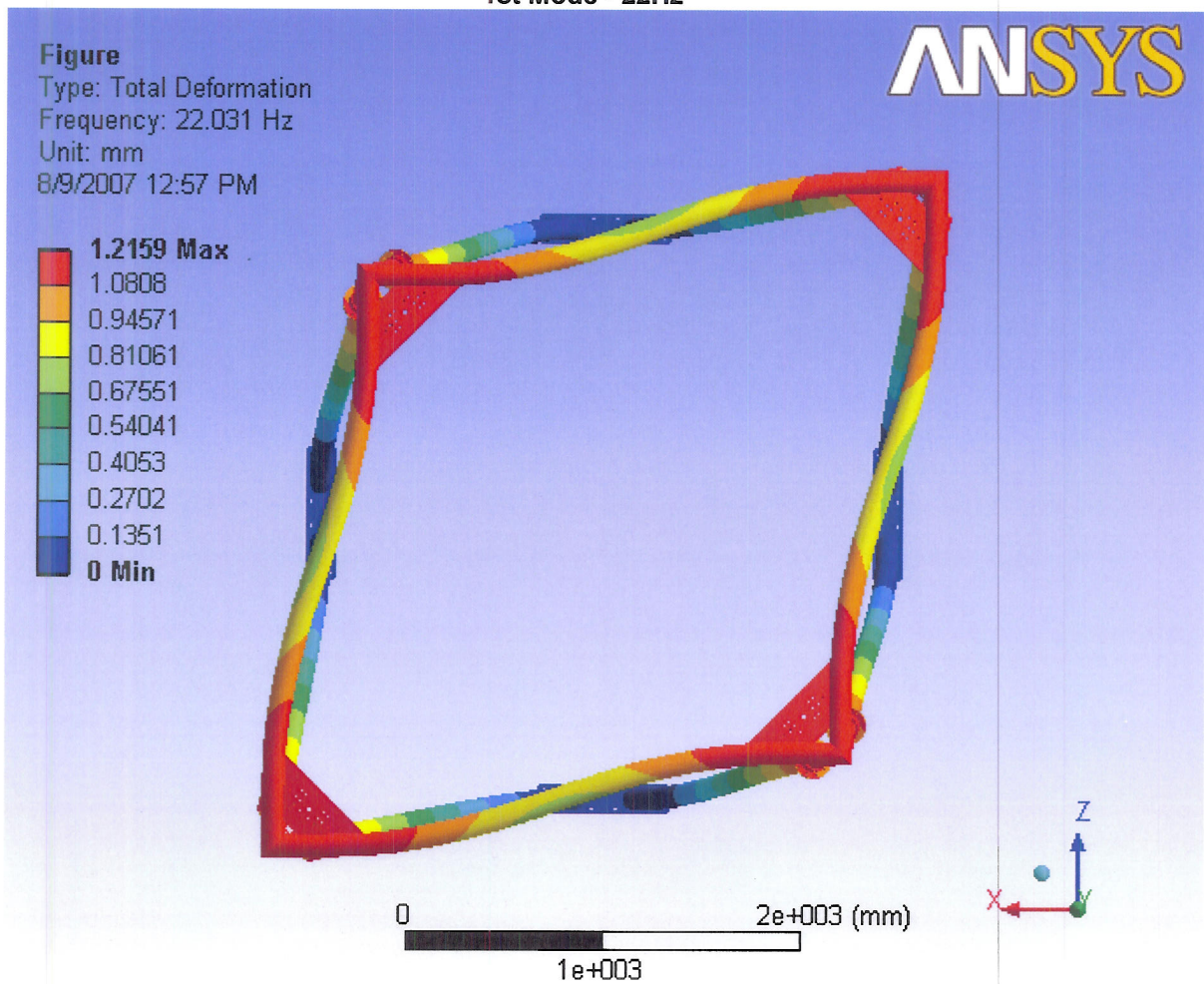
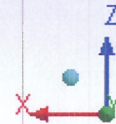
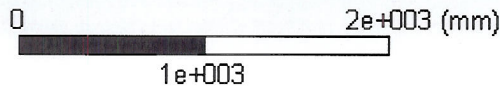
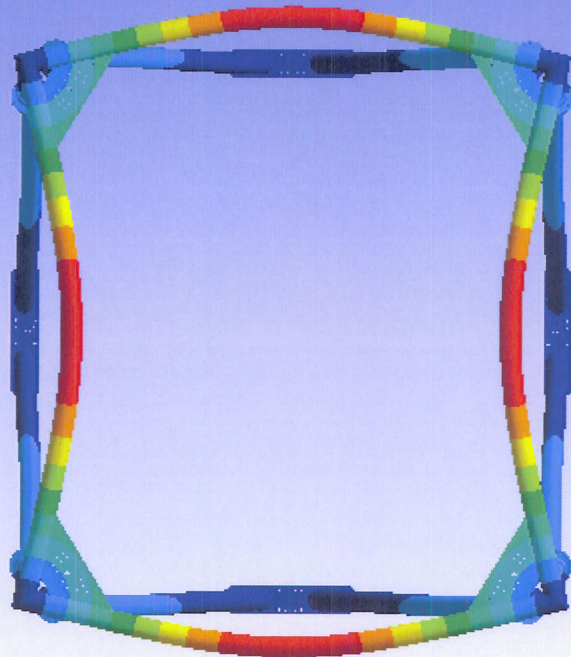
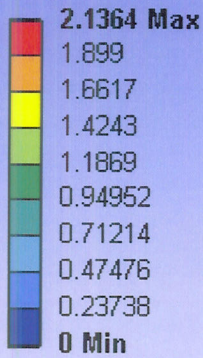


FIGURE 12
Model > Modal > Solution > Total Deformation 2 > Figure
2nd Mode - 34Hz

Figure
 Type: Total Deformation
 Frequency: 34.463 Hz
 Unit: mm
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Material Data

Structural Steel

TABLE 49
Structural Steel > Constants

Structural	
Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.3
Density	7.85e-006 kg/mm ³
Thermal Expansion	1.2e-005 1/°C
Tensile Yield Strength	250. MPa
Compressive Yield Strength	250. MPa
Tensile Ultimate Strength	460. MPa
Compressive Ultimate Strength	0. MPa
Thermal	
Thermal Conductivity	6.05e-002 W/mm·°C
Specific Heat	434. J/kg·°C

Electromagnetics	
Relative Permeability	10000
Resistivity	1.7e-004 Ohm·mm

FIGURE 13
Structural Steel > Alternating Stress

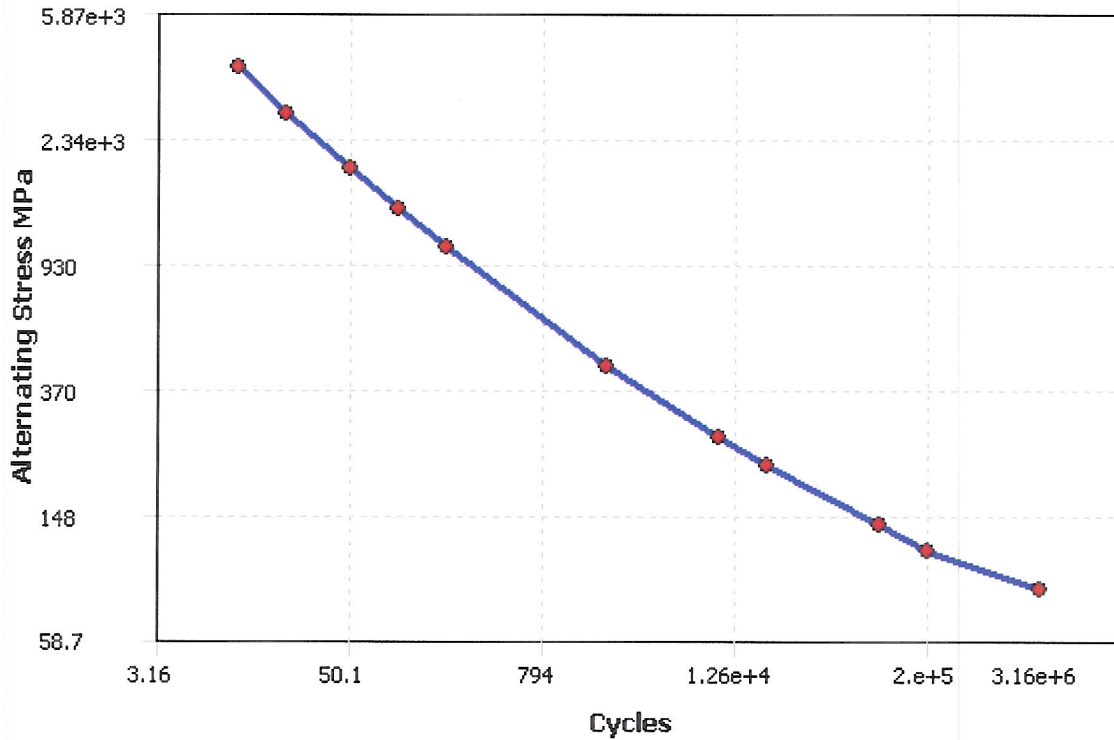


TABLE 50
Structural Steel > Alternating Stress > Property Attributes

Interpolation	Log-Log
Mean Curve Type	Mean Stress

TABLE 51
Structural Steel > Alternating Stress > Alternating Stress Curve Data

Mean Value MPa
0.

TABLE 52
Structural Steel > Alternating Stress > Alternating Stress vs. Cycles

Cycles	Alternating Stress MPa
10.	3999.
20.	2827.
50.	1896.
100.	1413.
200.	1069.
2000.	441.

10000	262.
20000	214.
1.e+005	138.
2.e+005	114.
1.e+006	86.2

FIGURE 14
Structural Steel > Strain-Life Parameters

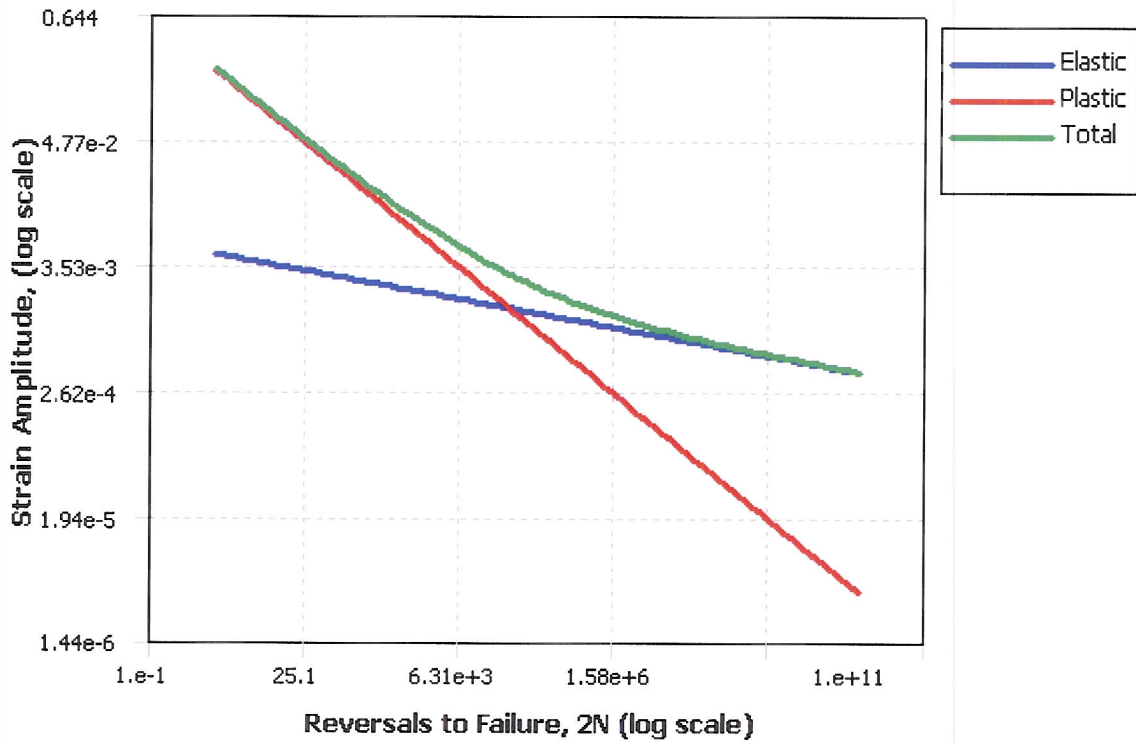


TABLE 53
Structural Steel > Strain-Life Parameters > Property Attributes

Display Curve Type Strain-Life

TABLE 54
Structural Steel > Strain-Life Parameters > Strain-Life Parameters

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