CALCULATION BOOK

REPORT OF MYSTAGE STRESS ANALYSIS

Sept. 23, 2022

1) Takeaways

In this report loads on MyStage, a portable stage with 5 legs, 465 mm height and 1219mm x 1219mm top surface have been modeled and studied. Result show that:

- Required load by code is 50 psf.
- Maximum stress that is caused by this load is 55.4 MPa (8.04 ksi) which is considerably less than the material yield stress of 241 MPa (34.95 ksi). Thus, the stage can bear this load with a great safety margin.
- Applying higher loads to the model shows that deformation and fracture does not occur until the overall distributed vertical force reaches 3,479 lbs (15,475 N).
- Based on this study, the stage is properly designed and can handle the intended loads.

2) Material and Mechanical Properties:

AL6005-T5: Fy=35 Ksi ; Fy=241 Mpa
poisson coefficient: 0.333
Modulus of Elasticity: 69.0 GP

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TABLE 2 *Continued*

Temper	Specified Section or Wall Thickness, in.	Area, $in.^2$	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in. or 4 × Diameter, min, %[C,D]
			min	max	min	max	
O	all	all	14.0	19.0	5.0	. . .	25
H112	all	all	14.0	. . .	5.0	. . .	25
			Alloy Alclad 3003[F]				
O	all	all	13.0	18.0	4.5	. . .	25
H112	all	all	13.0	. . .	4.5[K]	. . .	25
			Alloy 3004[F]				
O	all	all	23.0	29.0	8.5	. . .	. . .
			Alloy 3102				
H112[L]	0.028–0.050	all	11.0	18.0	4.0	. . .	25
			Alloy 5052				
O	all	all	25.0	35.0	10.0	. . .	. . .
			Alloy 5083[F]				
O	up through 5.000[M]	up through 32	39.0	51.0	16.0	. . .	14
H111	up through 5.000[M]	up through 32	40.0	. . .	24.0	. . .	12
H112	up through 5.000[M]	up through 32	39.0	. . .	16.0	. . .	12
			Alloy 5086[F]				
O	up through 5.000[M]	up through 32	35.0	46.0	14.0	. . .	14
H111	up through 5.000[M]	up through 32	36.0	. . .	21.0	. . .	12
H112	up through 5.000[M]	up through 32	35.0	. . .	14.0	. . .	12
			Alloy 5154				
O	all	all	30.0	41.0	11.0	. . .	. . .
H112	all	all	30.0	. . .	11.0	. . .	. . .
			Alloy 5454[F]				
O	up through 5.000[M]	up through 32	31.0	41.0	12.0	. . .	14
H111	up through 5.000[M]	up through 32	33.0	. . .	19.0	. . .	12
H112	up through 5.000[M]	up through 32	31.0	. . .	12.0	. . .	12
			Alloy 5456[F]				
O	up through 5.000[M]	up through 32	41.0	53.0	19.0	. . .	14
H111	up through 5.000[M]	up through 32	42.0	. . .	26.0	. . .	12
H112	up through 5.000[M]	up through 32	41.0	. . .	19.0	. . .	12
			Alloy 6005				
T1	up through 0.500	all	25.0	. . .	15.0	. . .	16
T5	up through 0.124	all	38.0	. . .	35.0	. . .	8
	0.125–1.000	all	38.0	. . .	35.0	. . .	10

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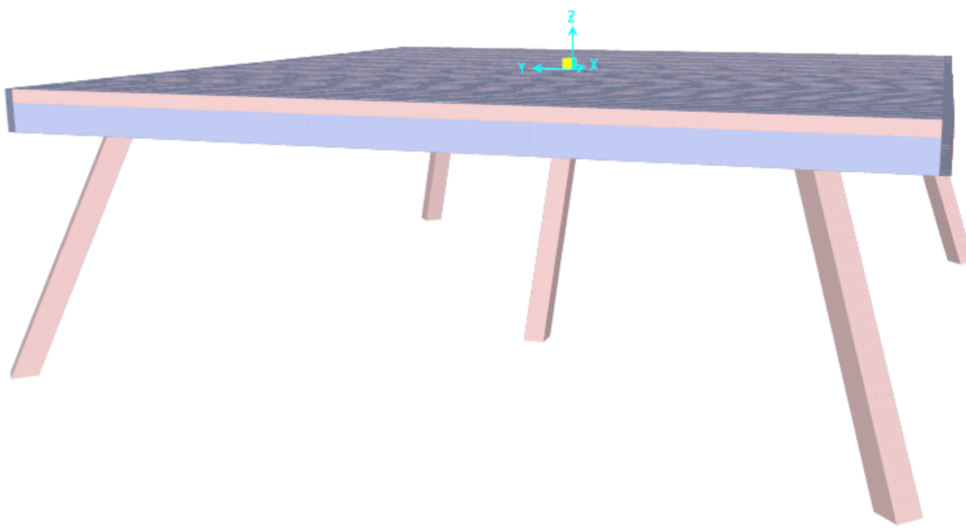
3) Loading:

Gravity Load =50 psf
Lateral load on floor=10*3*/(4*4)=1.875 psf (Sec. 4.14 ASCE 7-22)

Note1: Wind, temperature, fatigue, etc. loads are not considered.
Note2: Assumed all joints on the ground are fixed.



4) Geometry:

As per provided drawings by client. The 3D model of portable stage in SAP2000 software is shown in Figure-1.

Figure-1: SAP2000 3D model of Portable Stage.

5) Allowable axial & shear stresses:

Safety factor:
for axial stress: 2.20 (ASD)
for shear stress 2.64 (ASD)
Note: Please see table1.

Axial Allowable Stress: Ft=Fy/F.S.=241/2.2=109.50 Mpa

Shear Allowable Stress: Fv=Fy/F.S.=241/2.64=91.30 Mpa

TABLE 8.3 Factors of Safety for Allowable Stress Design

Component	Failure mode	Buildings and similar type structures	Bridges and similar type structures
Tension	Yielding	1.95	2.20
	Ultimate strength	1.65	1.85
Columns	Yielding (short col.)	1.65	1.85
	Buckling	1.95	2.20
Beams	Tensile yielding	1.65	1.85
	Tensile ultimate	1.95	2.20
	Compressive yielding	1.65	1.85
	Lateral buckling	1.65	1.85
Thin plates in compression	Ultimate in columns	1.95	2.20
	Ultimate in beams	1.65	1.85
Stiffened flat webs in shear	Shear yield	1.65	1.85
	Shear buckling	1.20	1.35
Mechanically fastened joints	Bearing yield	1.65	1.85
	Bearing ultimate	2.34	2.64
	Shear str./rivets, bolts	2.34	2.64
Welded joints	Shear str./fillet welds	2.34	2.64
	Tensile str./butt welds	1.95	2.20
	Tensile yield/ butt welds	1.65	1.85

Data from The Aluminum Association, *Structural Design Manual*, 1994.

Table-1: Data from the Aluminum Association, Structural Design Manual.

6) Load pattern

Load pattern of the spatial distribution of forces, which act on the portable stage in table-2.

TABLE: Load Pattern Definitions		
Load Pat	**Design Type**	**SelfWtMult**
Text	Text	Unitless
DEAD	DEAD	1
LIVE	LIVE	0
LAT-X	OTHER	0
LAT-Y	OTHER	0

Table-2: Load Pattern Definitions

7) Load case definition

Please see the load case definition that is a combination of different types of loads. During the analysis, loads or forces are applied to the structure, and the resulting deflections are measured. These loads and forces can be combined to create one or several load cases.

TABLE: Load Case Definitions						
Case	**Type**	**InitialCond**	**ModalCase**	**BaseCase**	**DesTypeOpt**	**DesignType**

Text	Text	Text	Text	Text	Text	Text
DEAD	LinStatic	Zero			Prog Det	DEAD
LIVE	LinStatic	Zero			Prog Det	LIVE
LAT-X	LinStatic	Zero			Prog Det	OTHER
LAT-Y	LinStatic	Zero			Prog Det	OTHER
BUCKLING	LinBuckling	Zero			Prog Det	DEAD

Table-3: Load Case Definitions

8) Load Combination

Please see load combination that results when more than one load type acts on the structure in table-4. Codes usually specify a variety of load combinations together with load factors (weightings) for each load type in order to ensure the safety of the structure under different maximum expected loading scenarios.

TABLE: Combination Definitions					
ComboName	**ComboType**	**AutoDesign**	**CaseType**	**CaseName**	**ScaleFactor**
Text	Text	Yes/No	Text	Text	Unitless
COMB1	Linear Add	No	Linear Static	DEAD	1
COMB1			Linear Static	LIVE	1
COMB1			Linear Static	LAT-X	1
COMB2	Linear Add	No	Linear Static	DEAD	1
COMB2			Linear Static	LIVE	1
COMB2			Linear Static	LAT-X	-1
COMB3	Linear Add	No	Linear Static	DEAD	1
COMB3			Linear Static	LIVE	1
COMB3			Linear Static	LAT-Y	1
COMB4	Linear Add	No	Linear Static	DEAD	1

COMB4			Linear Static	LIVE	1
COMB4			Linear Static	LAT-Y	-1
ENVELOPE	Envelope	No	Response Combo	COMB1	1
ENVELOPE			Response Combo	COMB2	1
ENVELOPE			Response Combo	COMB3	1
ENVELOPE			Response Combo	COMB4	1

Table-4: Load combination

9) Stress Analysis Result

Please see the result of stress analysis in SAP200 software in pictures below:

Figure-2: Axial stress analysis on axis S11- abs Max (Envelope-Max)

Figure-3: Axial stress analysis on axis S11- abs Max (Envelope-Min)

Figure-4: Axial stress analysis on axis S22- abs Max (Envelope-Max)

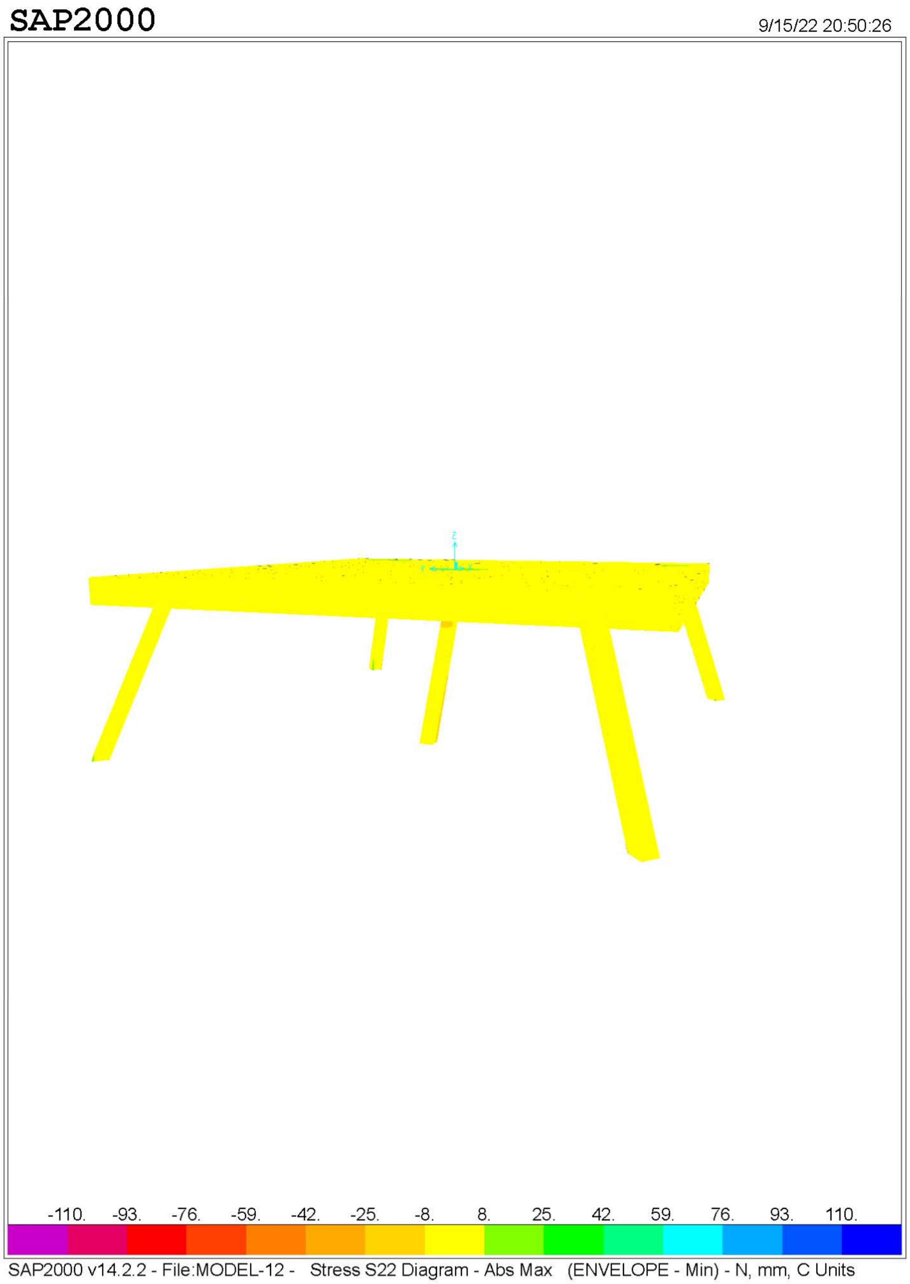


Figure-5: Axial stress analysis on axis S22- abs Max (Envelope-Min)

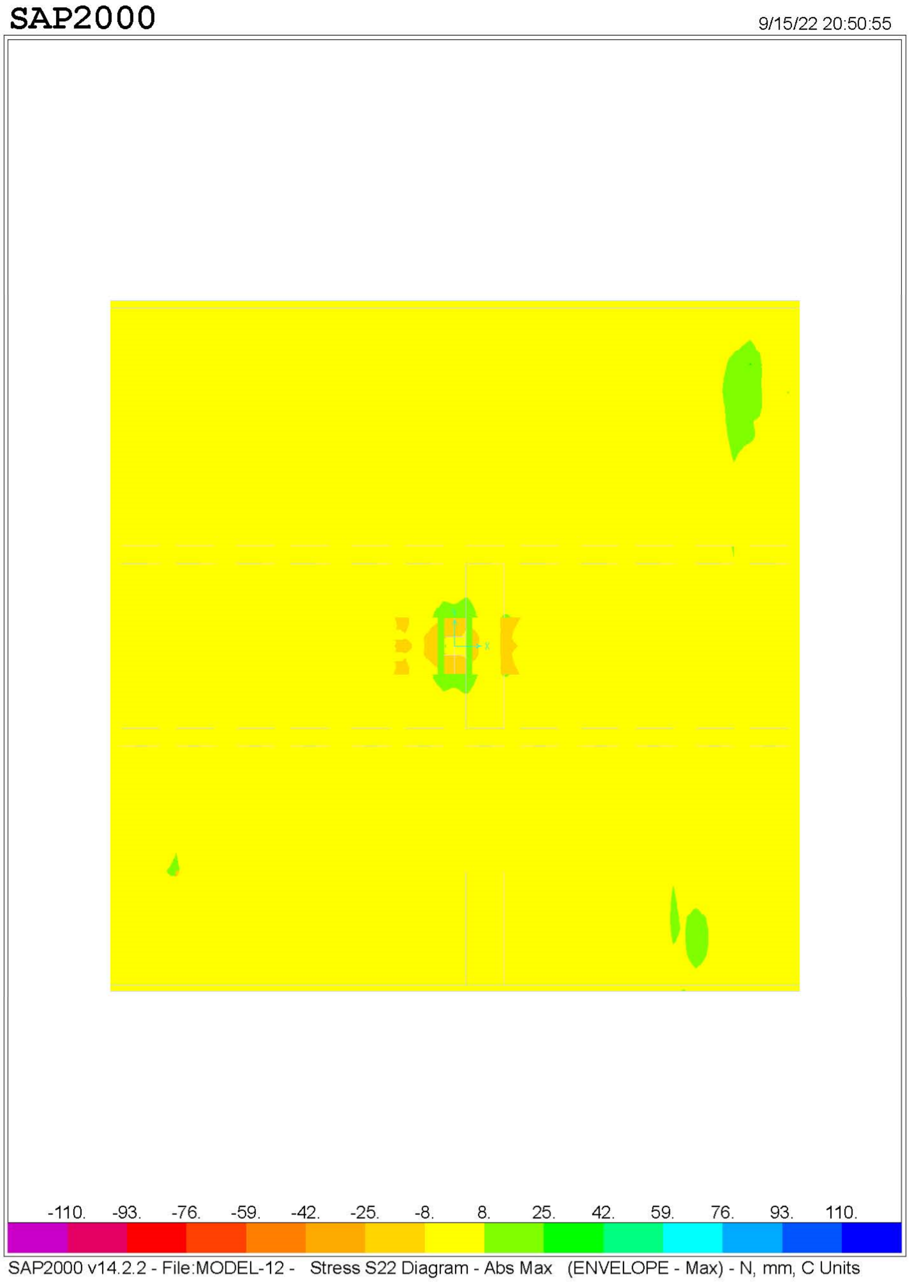


Figure-6: Axial stress analysis on axis S22- abs Max (Envelope-Max)
Top View

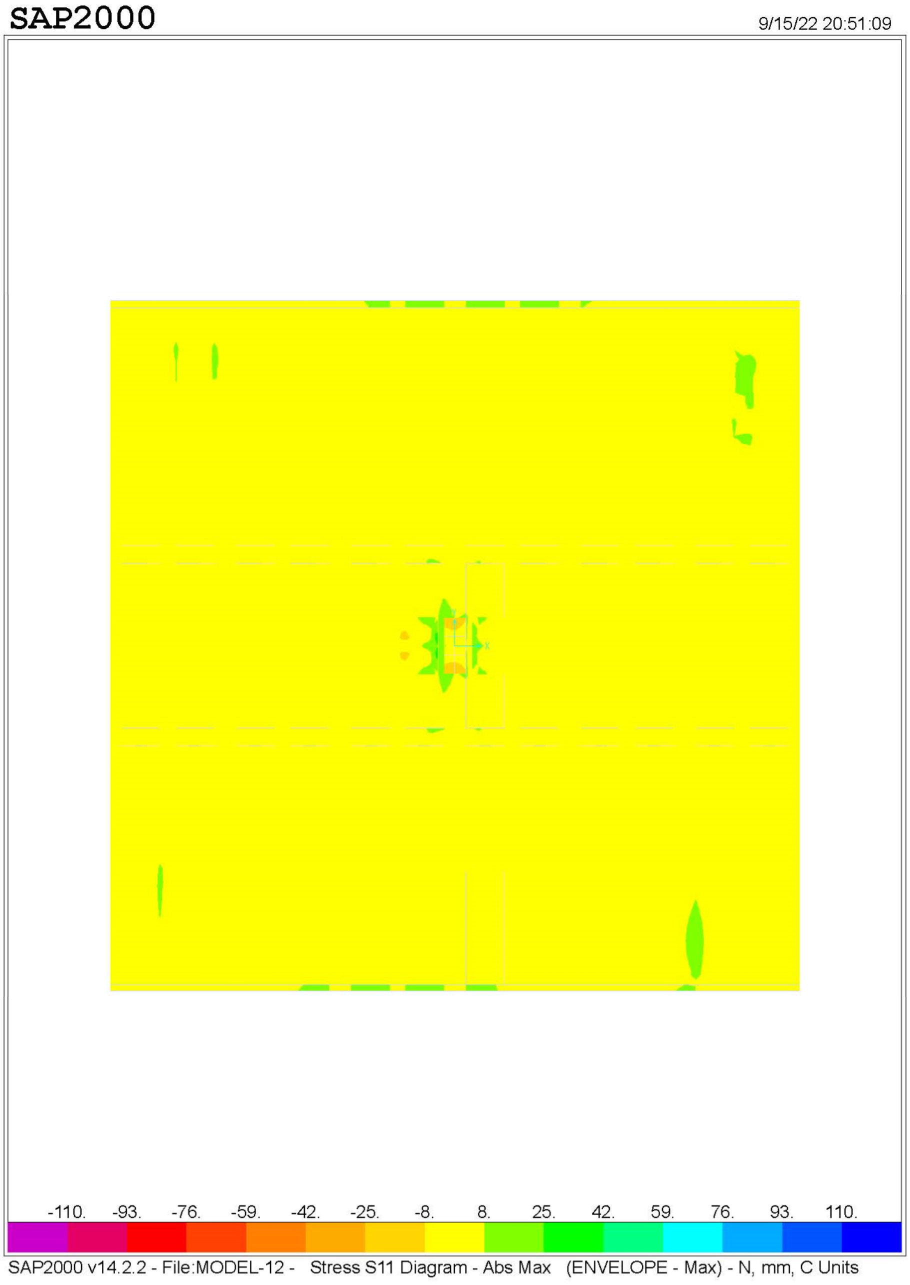


Figure-7: Axial stress analysis on axis S11- abs Max (Envelope-Max)
Top View

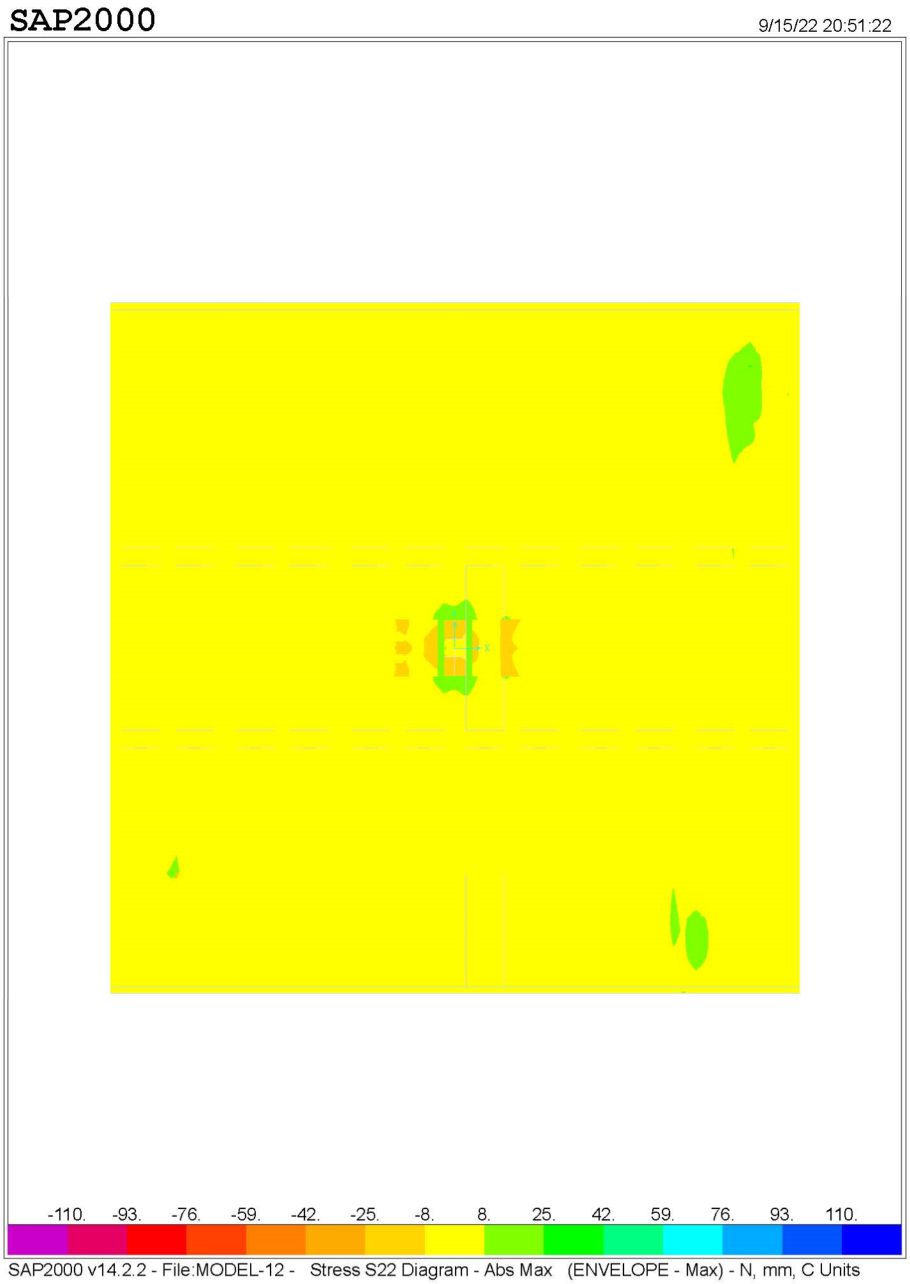


Figure-8: Axial stress analysis on axis S22- abs Max (Envelope-Max)

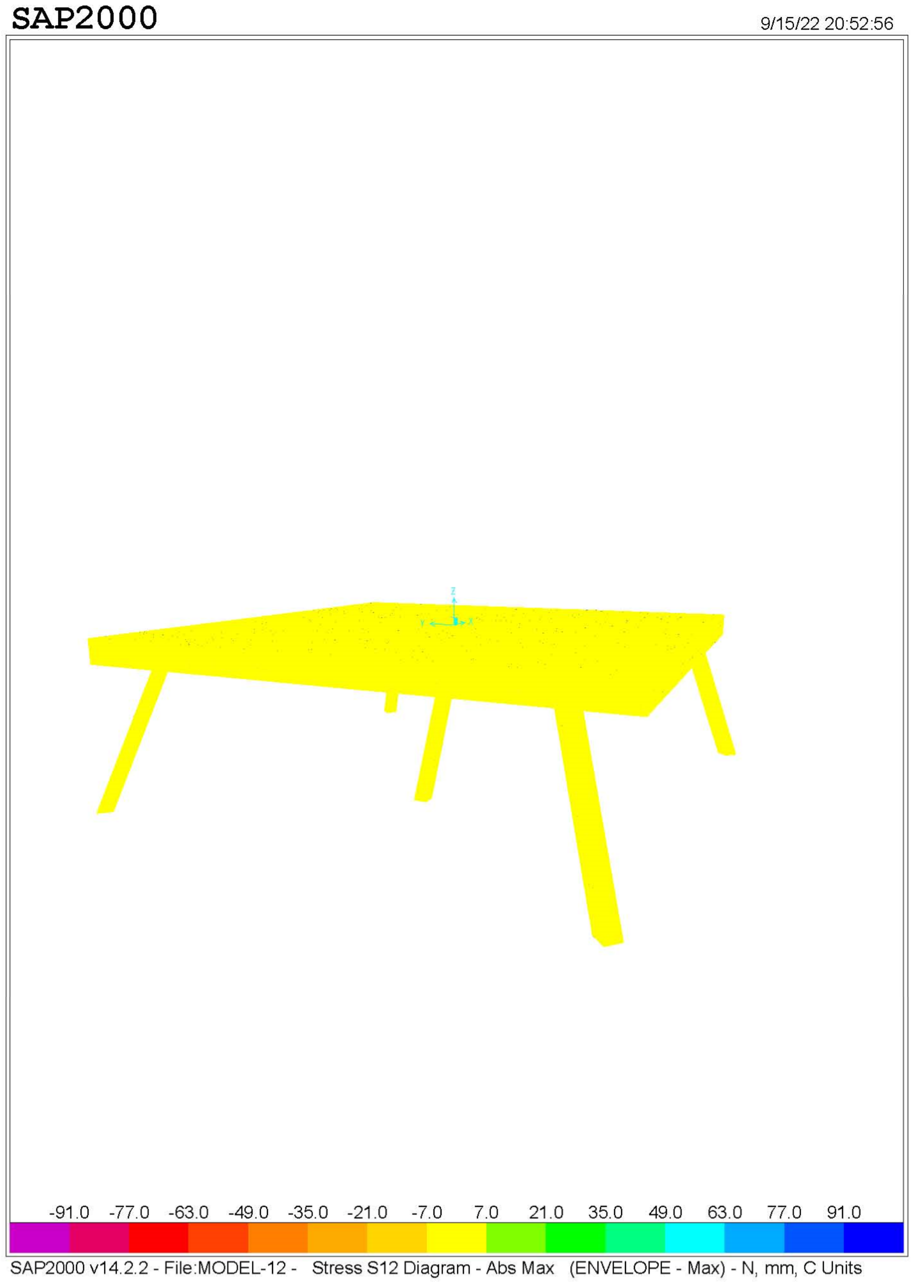


Figure-9: Shear stress analysis on axis S12- abs Max (Envelope-Max)

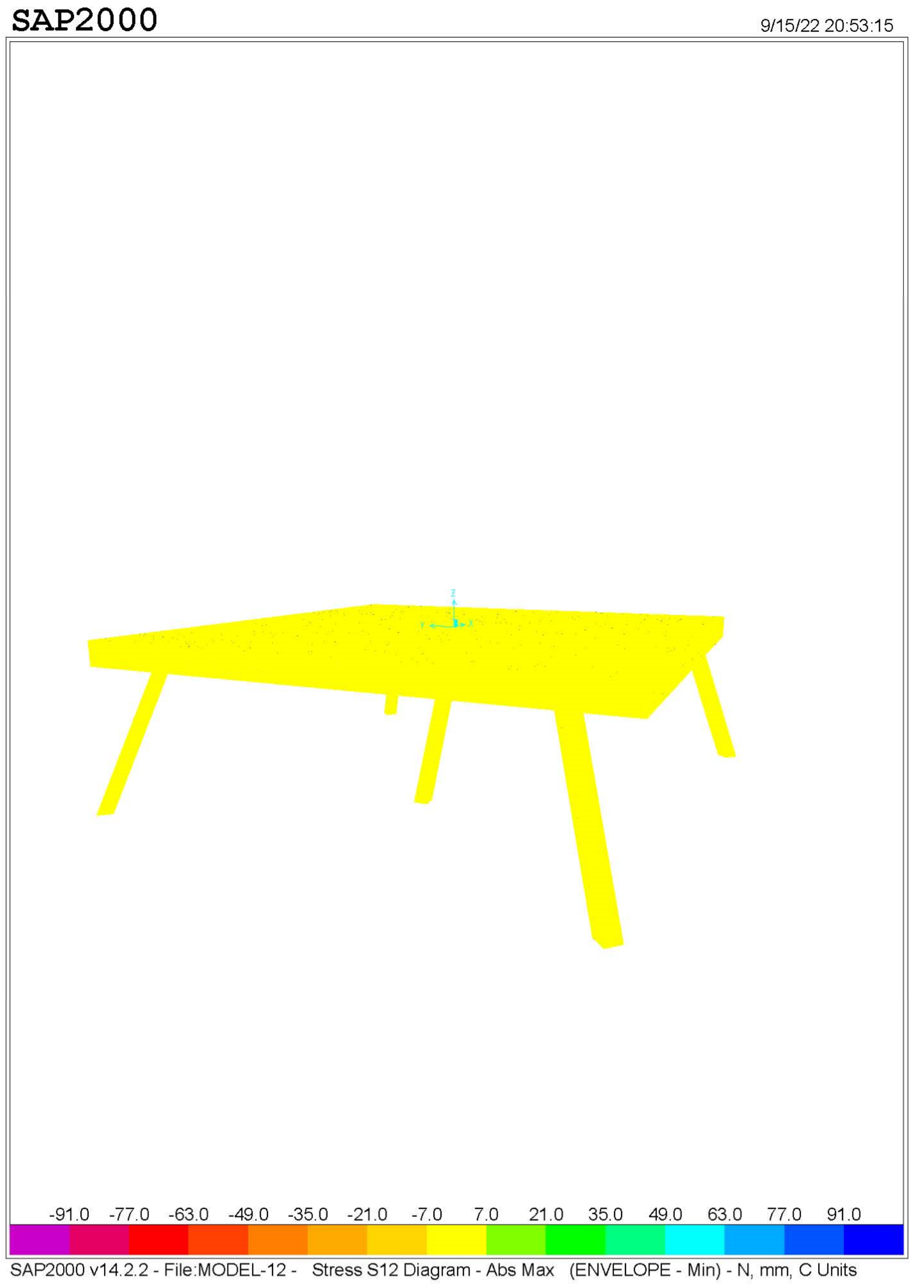


Figure-10: Shear stress analysis on axis S12- abs Max (Envelope-Min)

10) Buckling Analysis result

Please see the buckling analysis result that is generally used to estimate the critical buckling (bifurcation) load of structures in figure-11 and 12.

Figure-11: Deformed shape (Buckling) – Mode 1

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SAP2000 v14.2.2 - File:MODEL-12 - Deformed Shape (BUCKLING) - Mode 2 - Factor 19.16588 - N, mm, C Units

Figure-12: Deformed shape (Buckling) – Mode 2

11) Maximum Deformation

Please see the maximum deformation of portable stage in figure-13.

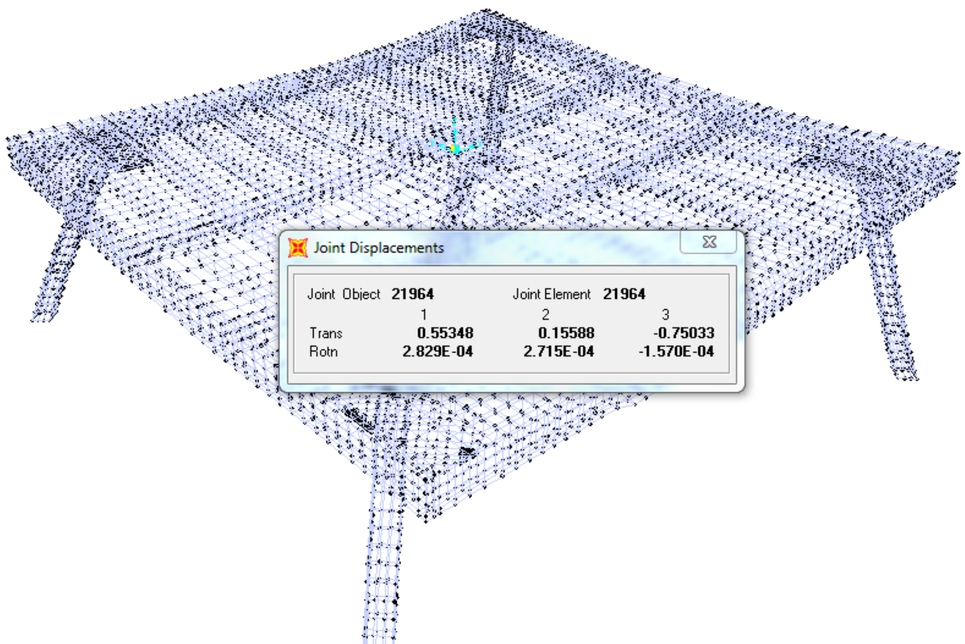

Figure-13: Maximum Deformation

12) Results:

- The structure is modeled and analyzed in SAP2000 software based on the geometry and material provided by the client.

- In the analysis of the structure, a load of 50 PSF is applied in the form of gravity and 1.875 PSF in a horizontal way on the surface.

- In the analysis of the structure, the effect of wind loads, earthquakes, temperature, and fatigue are not taken into account.

- For the applied loads, the maximum stresses and maximum displacements of the structure were compared with the amount of allowable stress and displacement (L/360). **The results show that the calculated stresses and displacement are lower than allowable amounts, and the MyStage is suitable for the intended use.**

- For more certainty, it is suggested to test the structure. For this purpose, a load of 100 psf on the surface can be gradually applied to the structure.

- Due to the fact that the effects of fatigue on the structure have not been modeled, it is necessary to explain to the users in the manual that this product is not suitable for long-term periodic loads. (This and the above case should be discussed with the manufacturer.)

- Based on the analysis, the maximum stress for the load of 50 psf on this portable stage is about 55.4 Mpa.

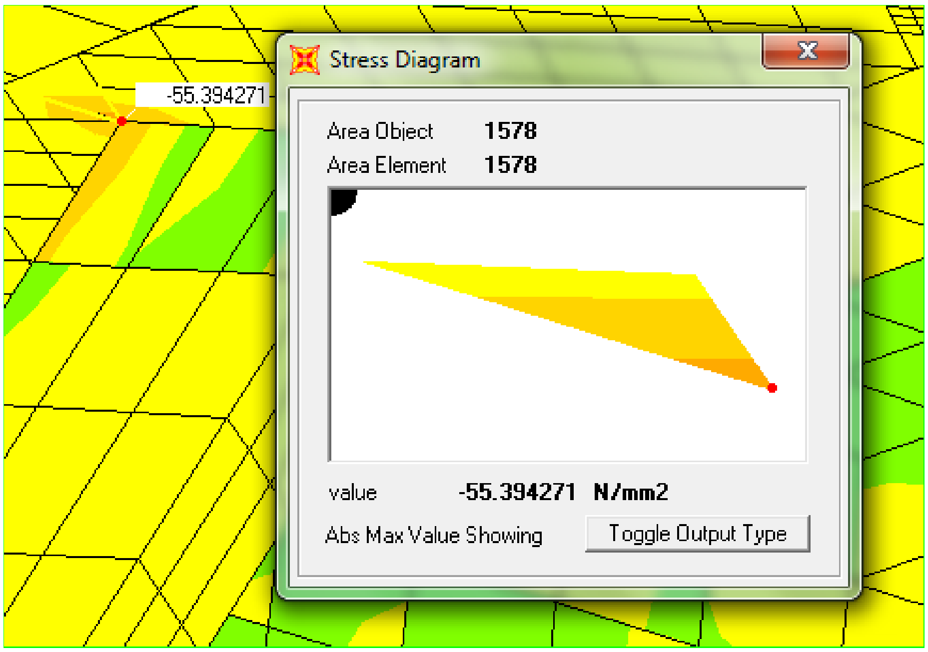

Figure-14: Maximum Stress

Considering that the analysis is linear, the final load can be determined as follows:

F_y=241 Mpa=34.95 ksi

S_{max}=55.4 Mpa=8.04 ksi

$P_{fracture}$ =Fy/Smax*50*1219*1219/(25.4*25.4*12*12)=**3479 lbs**

- Because the material used may have a higher yield and ultimate stress than the standard (In the standard, there is the minimum yield and final stress of the material), practically, we may have more load bearing capacity.

- Another point is the redistribution of loads from the beginning of the first yield point to collapse. This case is also not analyzed in the analysis. In other words, when deformation due to loads locally starts on a member, the entire structure might still be capable of tolerating higher loads. Even though higher capacities are expected, these higher loads that happen after deformation are not studied in this report.