EMSEAL Corporation

Seismic Joint System Analysis

Project Number – W0097

Reference Quote – N/A

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Project Description

The EMSEAL Seismic Joint System configuration will be used in a fork lift application applying loads up to 2100 lb_f per wheel. Using Finite Element Analysis, it has been requested to analyze the cover plate and spine together when the load is applied. The loading case will include both front wheels of the fork lift on one plate. The plate will be considered in three different thicknesses and two different materials. The spine will remain unchanged in all case studies.

Objective

To determine the minimum thickness of cover plate to achieve a safety factor no less than five (5).

Given

Two different materials are used for the cover plate

1. Aluminum 3003
2. Stainless Steel 303

Item Description	Material	Yield Strength	Ultimate Strength
Cover Plate	Aluminum 3003 Alloy	18,000 psi	18,800 psi
Cover Plate	Stainless Steel 303	39,800 psi	84,000 psi
Spine	Aluminum 6061-T6 Alloy	40,000 psi	45,000 psi

Material mechanical properties are shown in detail in the appendix at the end of this report. Three cover plate thicknesses will be used; 3/8", 1/2" and 5/8"

Load applied per Wheel = 2190 lbs

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Assumptions

1) The elastomeric supports on each side of the cover plate can be replaced by rigid supports.
2) Foundation (stiff) springs are used to simulate the effects of the connection between spines. These stiff springs were given a spring rate equal to 50,000 lb_f/inch. Spring rates of 10,000 lb_f/inch and 100,000 lb_f/inch were also applied and results reviewed but not included in this report.

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Results

Parameters	Units	Set1	Set2	Set3
Nominal Joint Size	in	9	9	9
Max Unsupported Span	in	13.5	13.5	13.5
Cover Plate Width	in	16.5	16.5	16.5
Thickness	in	0.625	0.5	0.375
Material - Aluminum 3003				
Maximum Stress	psi	12709	14716	16979
Nominal Stress	psi	6362	7367	8500
Maximum Displacement	in	0.018	0.031	0.064
Factor of Safety (YTS)		2.8	2.4	2.1
Material - Stainless 303				
Maximum Stress	psi	10720	14008	21416
Nominal Stress	psi	5506	7195	11000
Maximum Displacement	in	0.007	0.013	0.026
Factor of Safety (YTS)		7.2	5.5	3.6

Set 1, set 2 and set 3 represent the three different studies carried out for each of the cover plate materials. The variable for the studies is the thickness of cover plate. The first group of results reflects the aluminum 3003 cover plate and the second group reflects the stainless 303 cover plate. The same spine was used in both cases.

The safety factor was calculated using nominal stresses. Nominal stresses are defined as “stresses developed by load and geometrical discontinuities” and do not include contact stresses. In these studies, it is believed that the maximum stresses are developed by the contact of the plate to the spine specifically in the region of the screw connector.

The reaction force created by the supporting spring on each end of the spine is approximately 295 lb_f. This implies that 590 lbs of the applied load or 27% is transferred to the adjacent plates.

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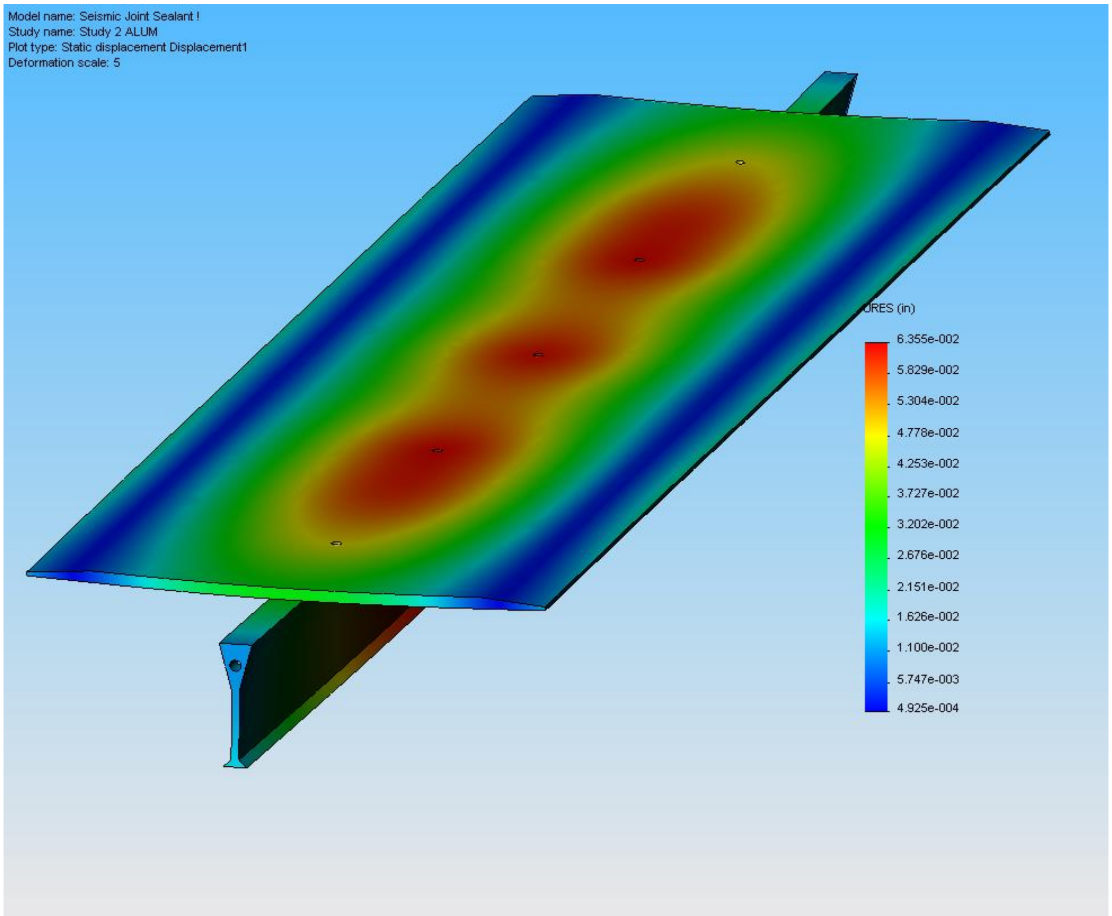
Deformation Graphic



Note: Deformations are exaggerated by a factor of 5.

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Conclusions

Care should be taken to ensure that the high stresses around the screw connections are not detrimental. These stresses are localized around the screw hole. The stresses as computed by the linear method exceed the yield of aluminum 3003 and approach the yield of the 303 stainless in this area. Non-linear analysis may produce different results as the elemental stiffness changes with deformation. However, non-linear analysis would assume permanent deformation of the materials.

The stiffness of the supporting springs influences the results significantly. The value of 50,000lb/inch was taken arbitrarily and should be determined through experimental methods.

Physically measuring the stress developed in the cover plate and spine is recommended by the means of strain gages.

The results of the above studies indicate that an aluminum cover plate will not provide adequate factor of safety for the loads given. In the case of the stainless steel cover plate, the factor of safety was more than adequate for the 1/2” thickness. Although the 3/8” stainless steel cover plate did not achieve the desired safety factor of 5, in many applications a safety factor of 3.5 to yield is considered sufficient. The stainless steel cover plate is also the better selection because of its much higher ductility and resistance to fatigue failures.

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Appendix – Material Properties

Aluminum 3003

Density (×1000 kg/m^3)	2.73	25	
Poisson's Ratio	0.33	25	
Elastic Modulus (GPa)	70-80	25	
Tensile Strength (Mpa)	130	25	H12 more
Yield Strength (Mpa)	125		
Elongation (%)	10		
Reduction in Area (%)			
Hardness (HB500)	35	25	H12 more
Shear Strength (MPa)	83	25	H12 more
Fatigue Strength (MPa)	55	25	H12 more

Aluminum 6061

Density (×1000 kg/m^3)	2.7	25	
Poisson's Ratio	0.33	25	
Elastic Modulus (GPa)	70-80	25	
Tensile Strength (Mpa)	115	25	O (Alclad) more
Yield Strength (Mpa)	48		
Elongation (%)	25		
Reduction in Area (%)			
Hardness (HB500)	30	25	O more
Shear Strength (MPa)	83	25	O more
Fatigue Strength (MPa)	62	25	O more

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Stainless Steel 303

Density (×1000 kg/m^3)	2.7	25	
Poisson's Ratio	0.33	25	
Elastic Modulus (GPa)	70-80	25	
Tensile Strength (Mpa)	115	25	O (Alclad) more
Yield Strength (Mpa)	48		
Elongation (%)	25		
Reduction in Area (%)			
Hardness (HB500)	30	25	O more
Shear Strength (MPa)	83	25	O more
Fatigue Strength (MPa)	62	25	O more

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