Space Habitat Floor Reconfiguration Structural Analysis

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Utilizing MDF flooring will apply a 300 kg (661 lbf) distributed load. On a two caster supported floor frame this loading would produce a 13 MPA max stress and .5 mm max deflection. Additionally I ran two yield studies, one finding a point load yield condition and distributed mass load yield condition. Given a >3 FOS an allowable yield stress of <80.4 MPA was chosen as the stress limit. For the point load analysis a max stress of 79.6 MPA and max deflection of 5.7 mm. For the distributed mass yield condition a max stress of 79.95 MPA and max deflection of 3.096 mm was calculated. The lower deflection on the distributed mass yield could be from additional shear stresses at the critical cross section.

I. MDF Flooring Load and Deflection Analysis

This analysis covers the projected load and deflection caused by the MDF flooring proposed for the Analogue. This analysis was made with the same assumptions as the previous analysis and made with the same FEA model.

Assumptions

- Beam Analysis approximation used for simplification
- All junctions assumed to be welded together
- FOS >3 keeping us under 80.4 MPA for Yield Stress

From there the analysis was done with Solidworks standard mesh density evenly distributed evenly around the habitat. Seed and meshing density were not varied to perform a convergence study and Solidworks did not give me the ability to choose the finite elements used in the mesh.

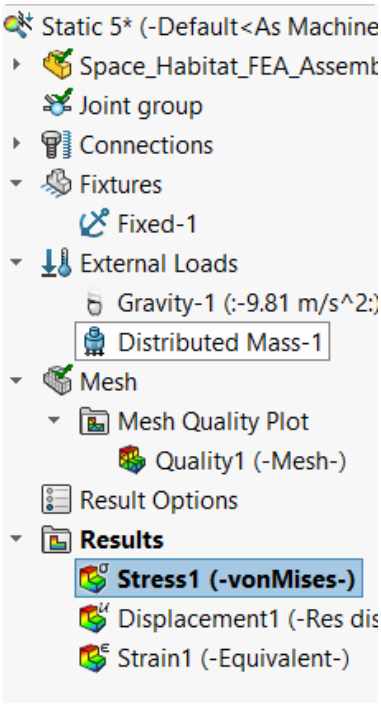

Fig. 1 MDF Floor Analysis Settings 300kg Mass

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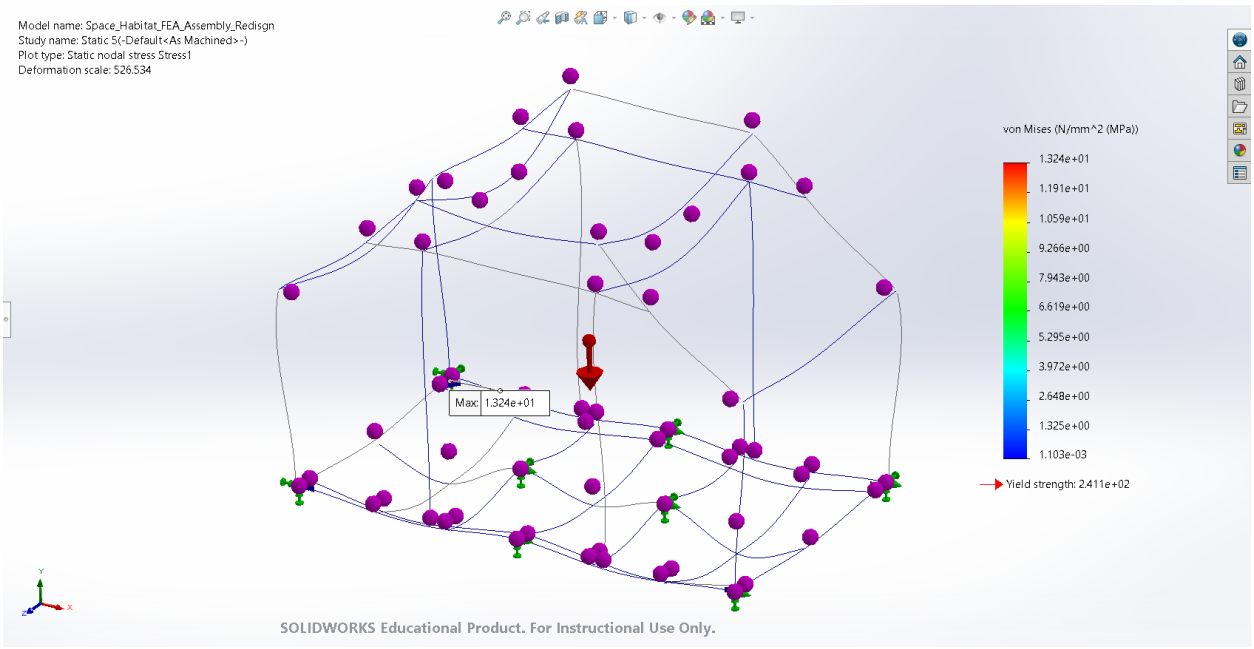

Fig. 2 MDF Floor Max Stress (13 MPA)

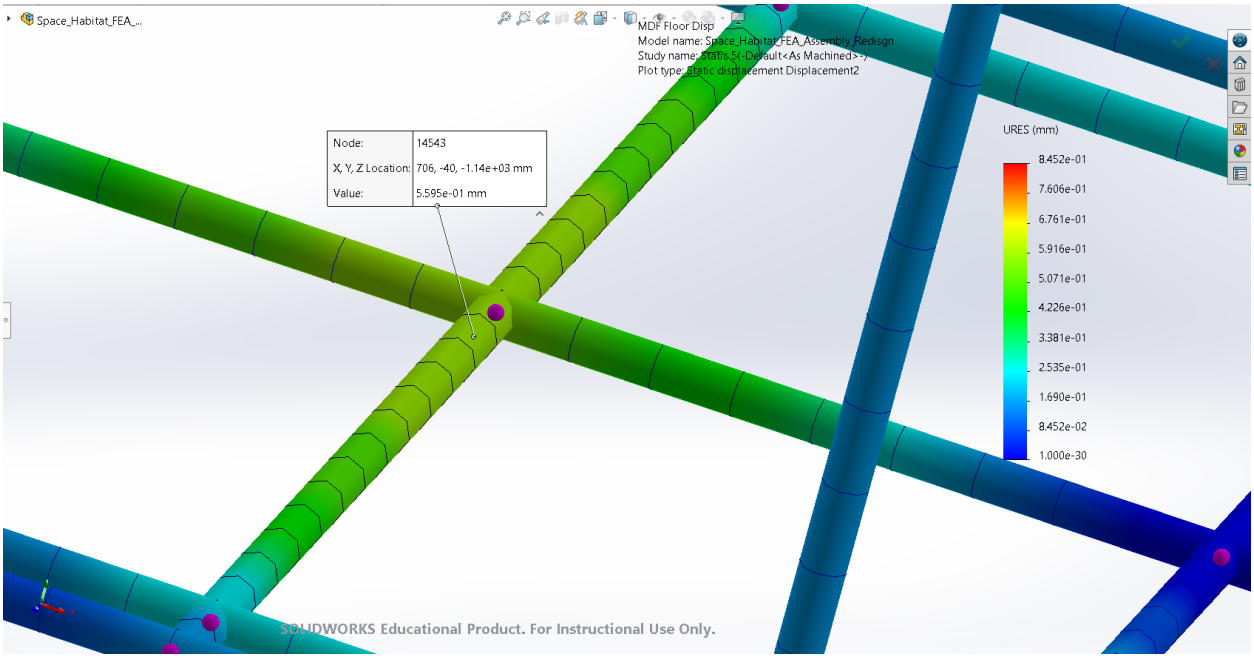

Fig. 3 Max Displacement .5 mm

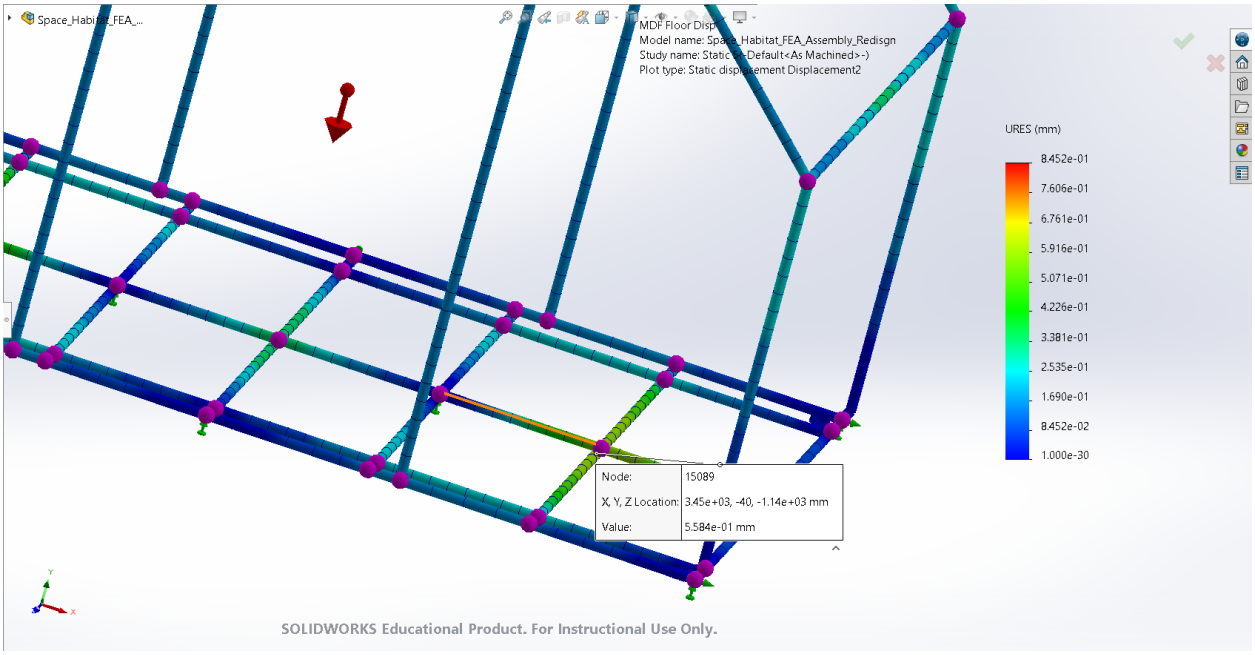

Fig. 4 Max Displacement .5 mm

When properly supported with two casters in the middle which were model as fixing the floor in translation and rotation we can see the MDF should produce a max stress of 13 MPA which is well under our 80.4 Max load and a max deflection of approximately .5 mm. The load applied was an evenly distributed 300 kg mass. This value was calculated from taking the density of MDF 800 kg/m^3 multiplying by the floor volume of 0.3739 m^3 giving us a mass of approximately 300 kg, Hand Calcs attached for reference.

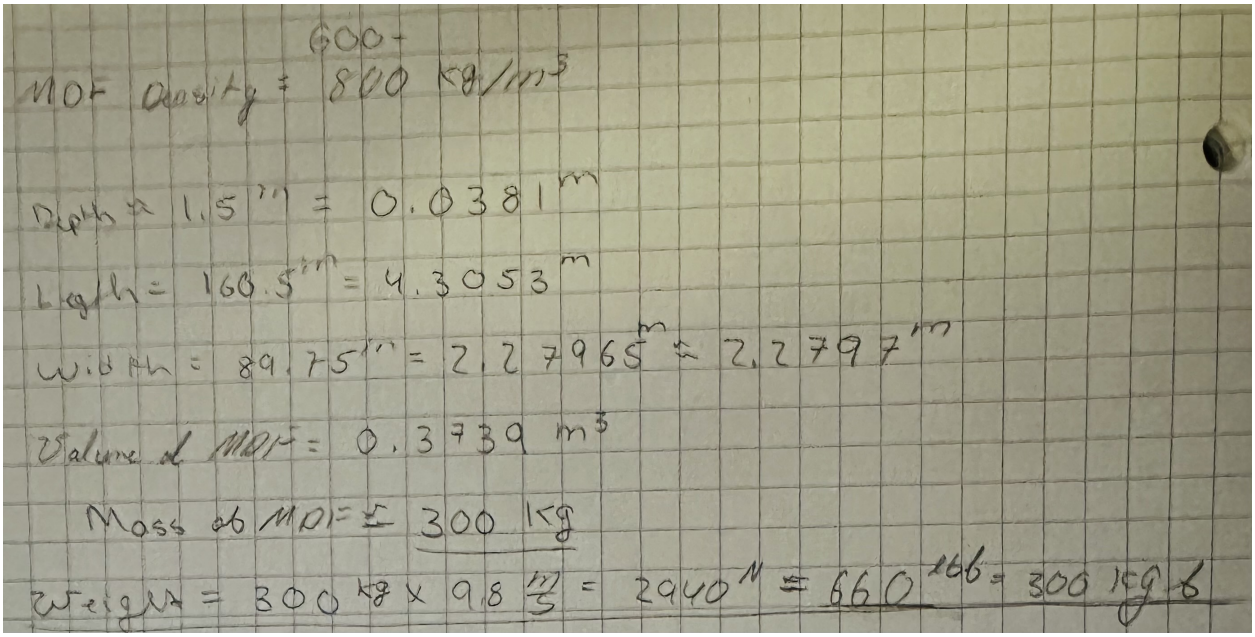

Fig. 5 Hand Calculations for MDF Volume and Weight

Given the flooring weight is contained within a rigid wood piece it might not be perfectly accurate to use a distributed mass load given the mass will be distributed in a gradient centered on the fixtures in the middle of the floor. However I

think for our purposes it should suffice. However, partly to due to curiosity and partly to test yield conditions I ran two yield studies looking at point loads and another distributed mass load.

II. Point Load Yield Condition

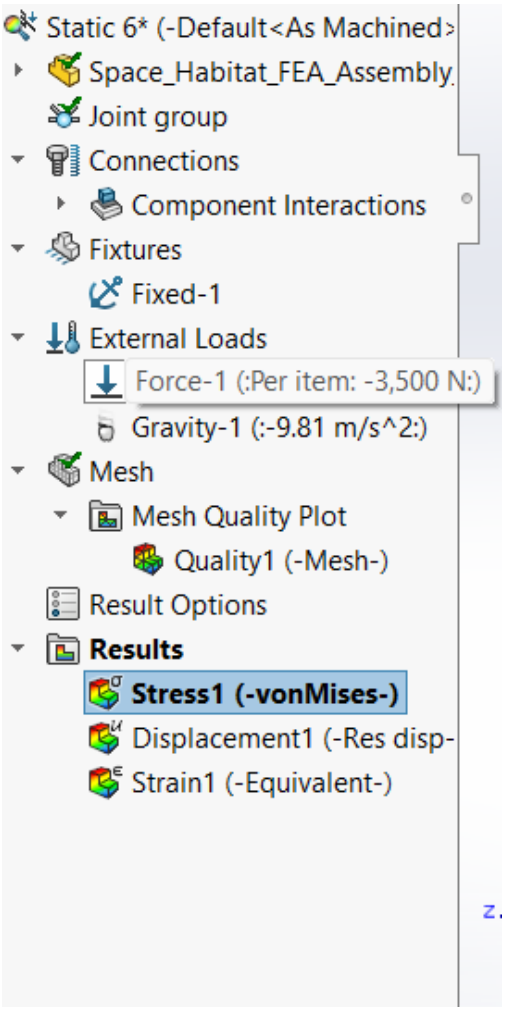

Fig. 6 Point Load Yield Condition Analysis Settings (357 kg)

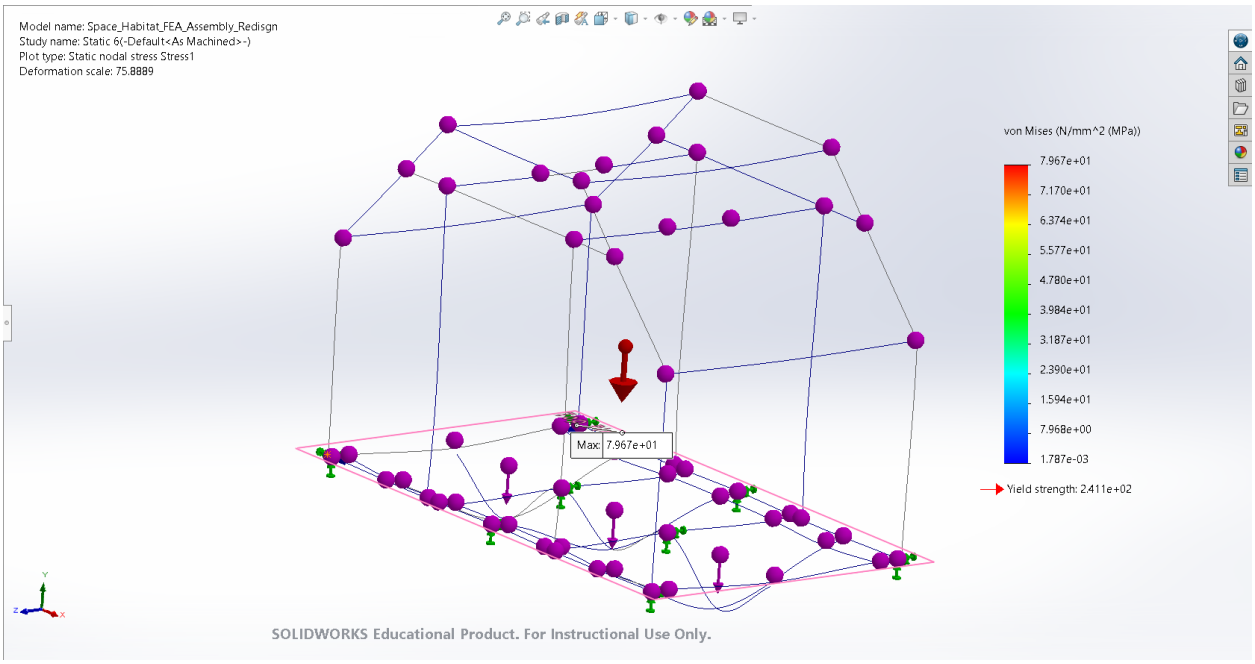

Fig. 7 Point Load Max Stress Yield Condition Analysis (79.6 MPA)

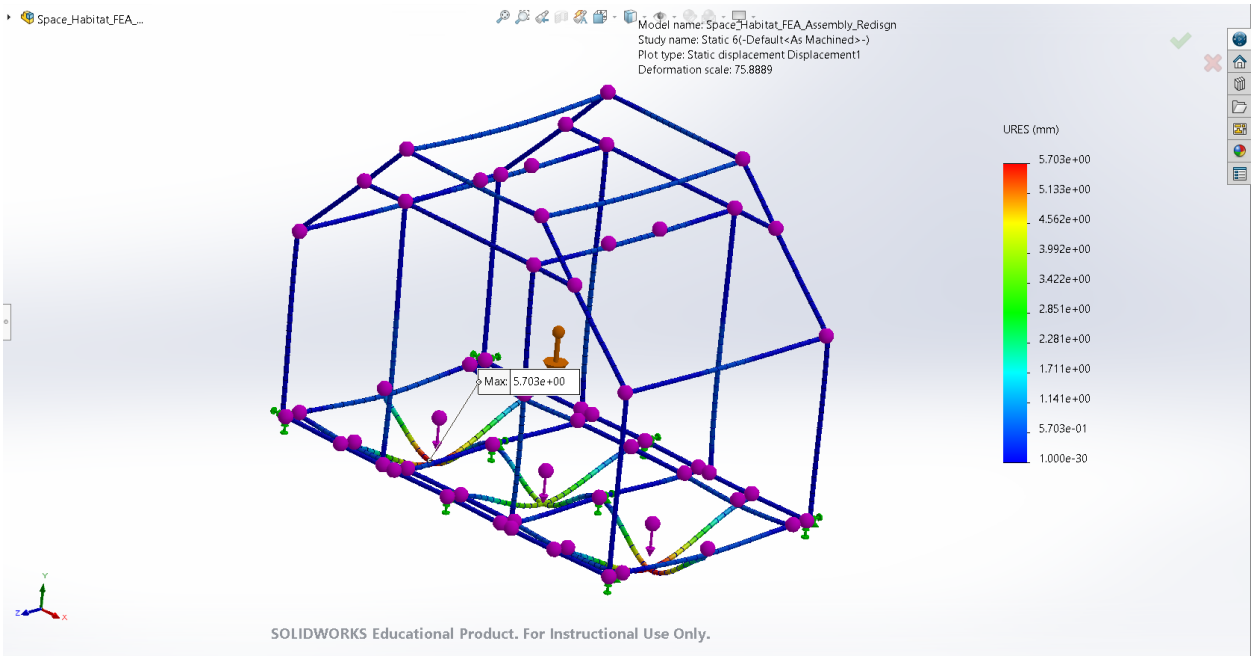

Fig. 8 Point Load Max Displacement Yield Condition Analysis (5.7 mm)

From this analysis we see the around 790 lbf at the applied points we are nearing the allowable stress for our prescribed FOS. The joints near the ends of flooring are the points that see the most deflection because the boards are not evenly spaced with the two panels most outward being around .75 inch longer than the four inward panels. Overall I do not see a point load of this magnitude being something we exceed.

III. Distributed Mass Yield Condition

In this FEA analysis I wanted to see the total distributed mass the habitat could handle before exceeding our prescribed yield stress.

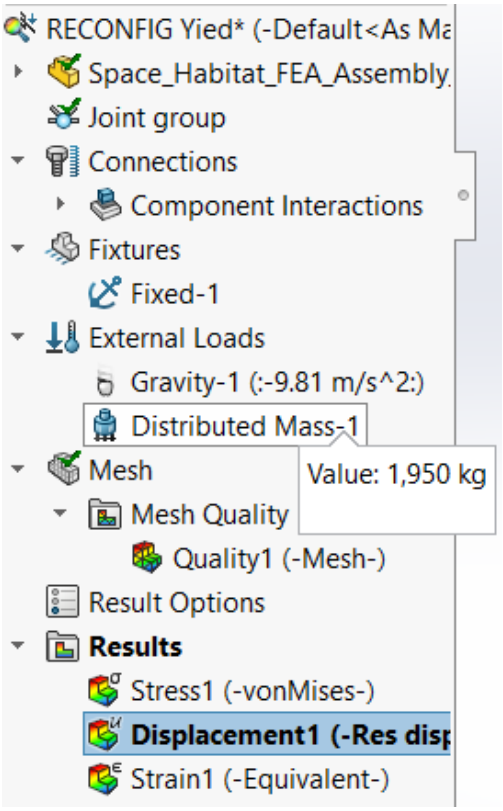

Fig. 9 Distributed Mass Yield Condition Analysis Settings (1950 kg)

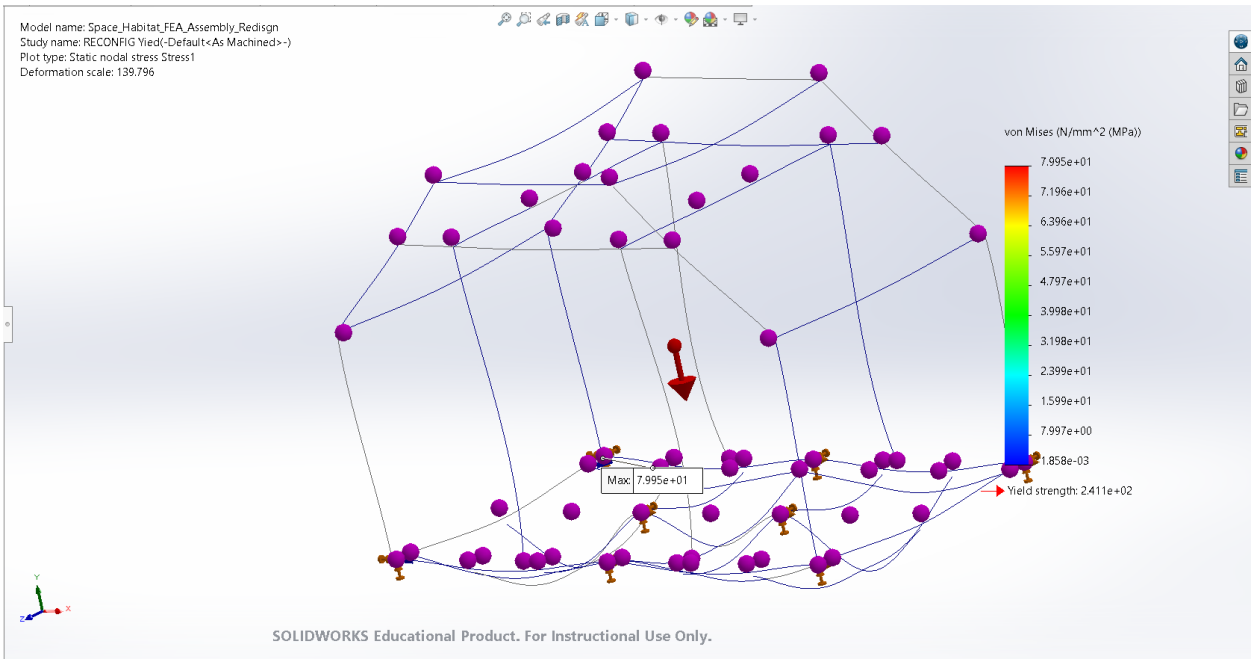

Fig. 10 Distributed Mass Stress Yield Condition Analysis (79.95 MPA)

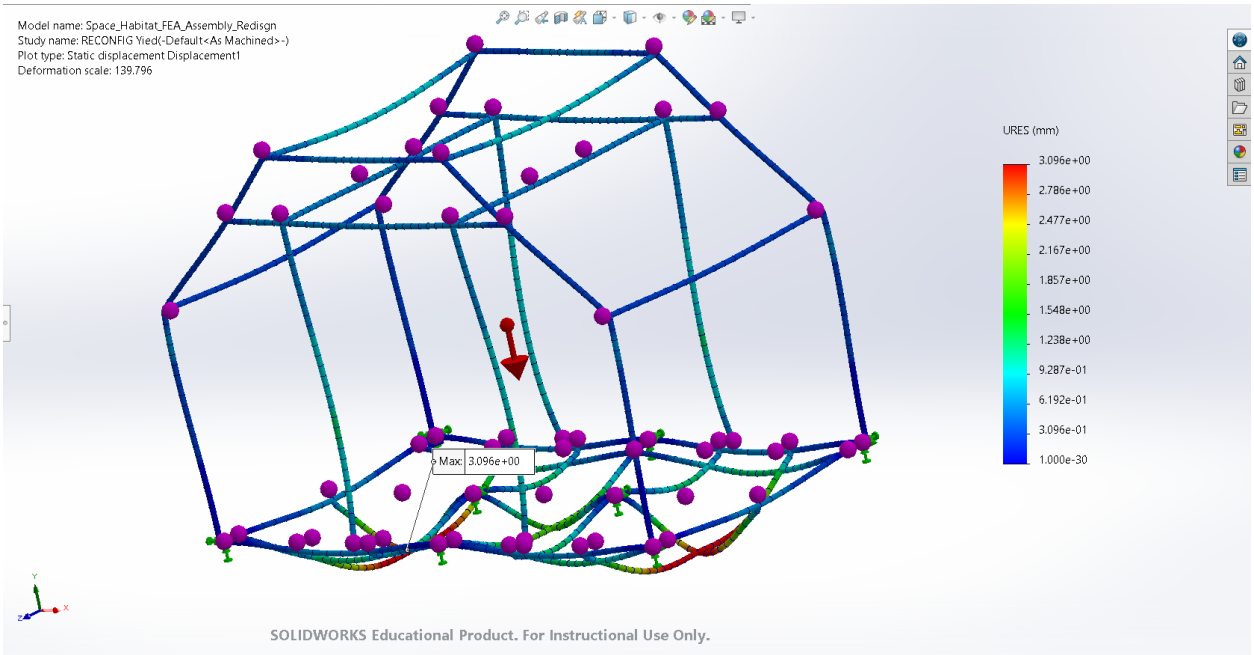

Fig. 11 Distributed Mass Max Displacement Yield Condition Analysis (3.096 mm)

Here we get that the max total distributed mass the two caster supported floor can take is approximately 4300 lbf. However it deflects less that the point load case. I think this might be since the point load failure comes purely from the bending stress in the corner from the point load. In the distributed mass loading should also introduce shear stress at the corner as well which should make the total stress higher even with less of max deflection. The casters being added from the TECO quote say they are rated to bear 600 lb which brings max caster load support to 7795 lb which minus 580 lb of the aluminum bring us to 7215 net weight we can add to the casters which still makes the floor frame the limiting load component.

IV. Conclusion/Summary

Table 1 Analysis Results Summary

Condition	Load Type	Load Magnitude	Load Magnitude	Max Stress	Max Displacement
MDF Flooring	Dist Mass	300 kg	661 lbf	13 MPA	.5 mm
Yield	Point Load	357 kg	787 lbf	79.6 MPA	5.7 mm
Yield	Dist Mass	1950 kg	4299 lbf	79.95 MPA	3.096 mm

Overall it seems like the habitat floor properly supported by two simple supports should be able to handle MDF. I do not suspect MDF to yield in compression between an applied load and the flooring frame since it has a compressive yield stress of 10 MPA. The only assumption that will come into factor in my opinion is the welded joint assumption. It is entirely possible that the internal shear forces of the beams can cause the fasteners to fail in shear. From the FEA analysis thought it seems like utilizing MDF flooring is a viable option for the flooring.