Glass Handrails – Multi-Panel Modeling

Created By: Ryan Kubr

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Problem:

Modeling of multi-panel glass handrails systems can become overly conservative or unconservative in various cases due to multi-panel system geometry and modeling constraints in software such as SJ Mepla which only allow single panels.

Modeling of straight railing systems consisting of rectangular panels can be modeled as a single system as shown in the Solution section below.

Modeling of other railing systems on stairs or in other non-rectangular single floor applications cannot be modeled as a single system due to interactions between panels and must be modeled as a system to obtain the correct stresses and deflections.

Solution:

Straight railings (rectangular)

1. Model in SJ Mepla directly using typical edge fixing or spring modeled base shoe w/ top cap stiffness included as an edge beam

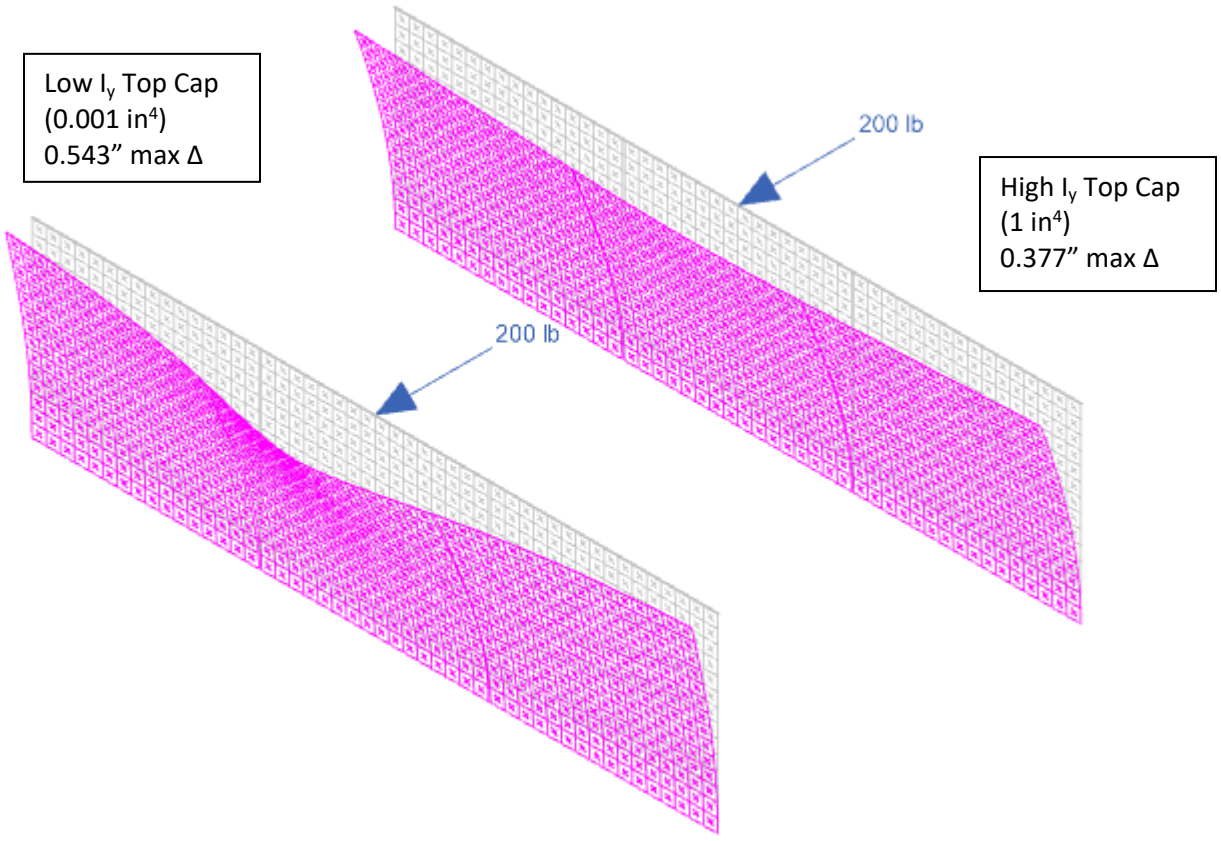
Other multi-panel railings

1. Model railing system in RISA 3D using AutoCAD DXF import and equivalent thickness method
2. For base show type railings
    a. Use RISA 3D output stress directly if plate meshing is adequately refined to show locations or controlling stresses.
    b. Model panels from top of base shoe to top of glass or provide fixity for height of shoe base
3. For point fitting type railings
    a. Transfer controlling panel reactions from RISA 3D modeling to SJ Mepla for hole and fitting analysis.
    b. Panel must be modeled in SJ Mepla in “reverse” with the top of the panel held and fitting reactions from RISA applied as fitting forces in SJ Mepla (fixing type 2).
        i. Deflections should be similar but will not match exactly due to support differences
    c. Check glass stress at holes per normal procedures

SJ Mepla models are found under JEI Templates\Lessons Learned

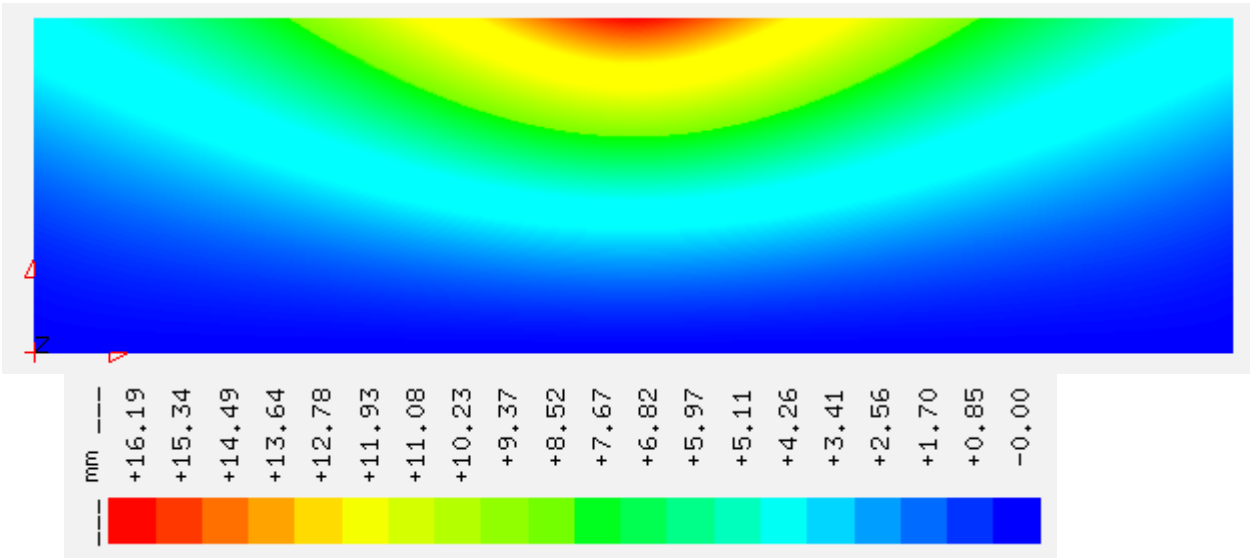
Straight Railing Equivalents – RISA 3D 200 lb point load, center span

Behavior of rectangular railings joined by a top cap behave similarly in RISA 3D and SJ Mepla. Base show railings can be modeled in either application to obtain similar results. SJ Mepla is recommended to best account for the glass-interlayer interactions.

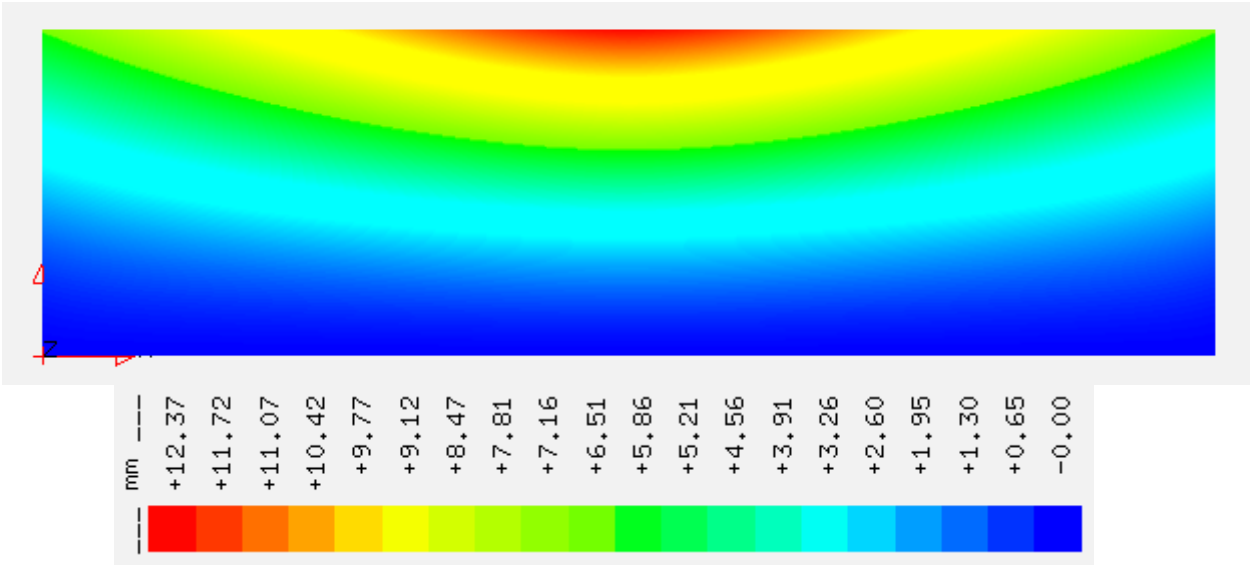


Straight Railing Equivalents – SJ Mepla 200 lb point load, center span

Geometric Non-Linear (Weak top cap) (16.19 mm = 0.637”)



Geometric Non-Linear (Strong top cap) (12.37 mm = 0.487”)

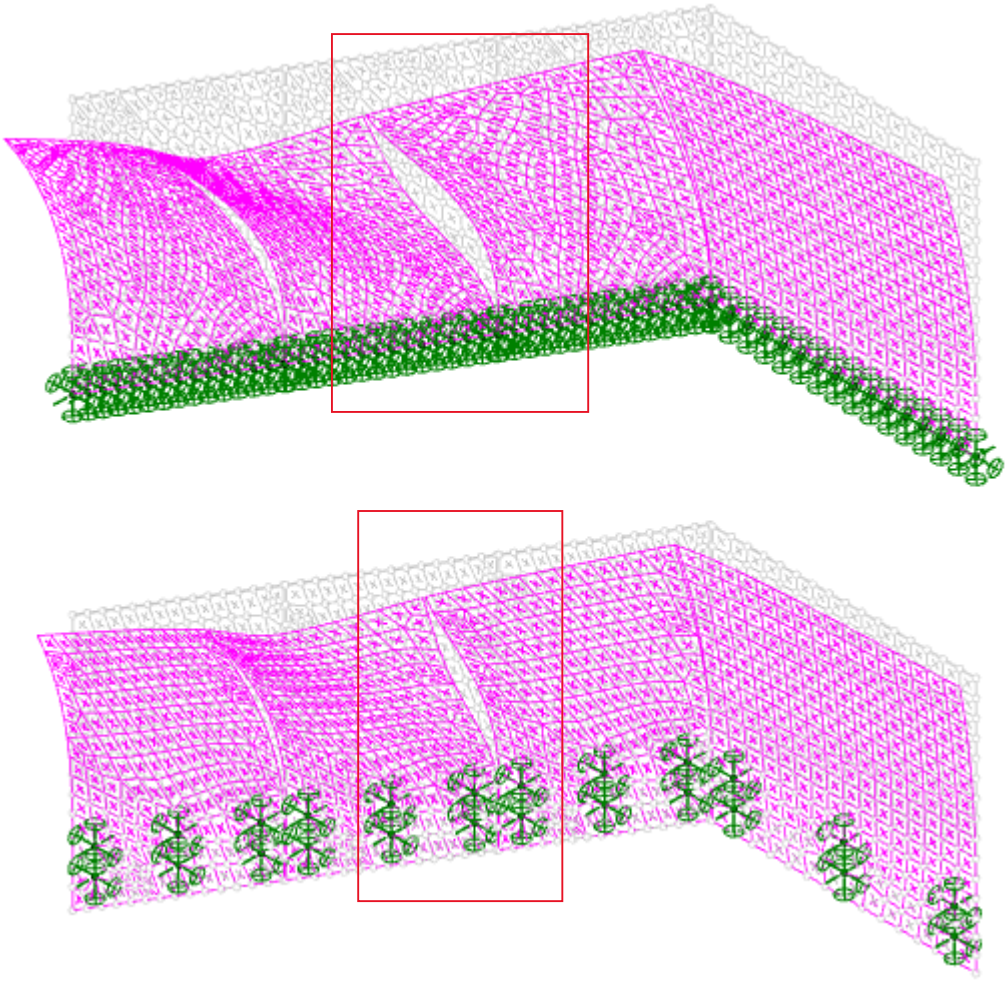


Multi Panel Railings – RISA 3D Behavior (weak top cap)

Gaps between panels separate leading to varying (and unpredictable) deflection behavior versus using one continuous panel model in SJ Mepla. Stresses also may occur in variable locations and will not align with peak stress locations in a single panel model.

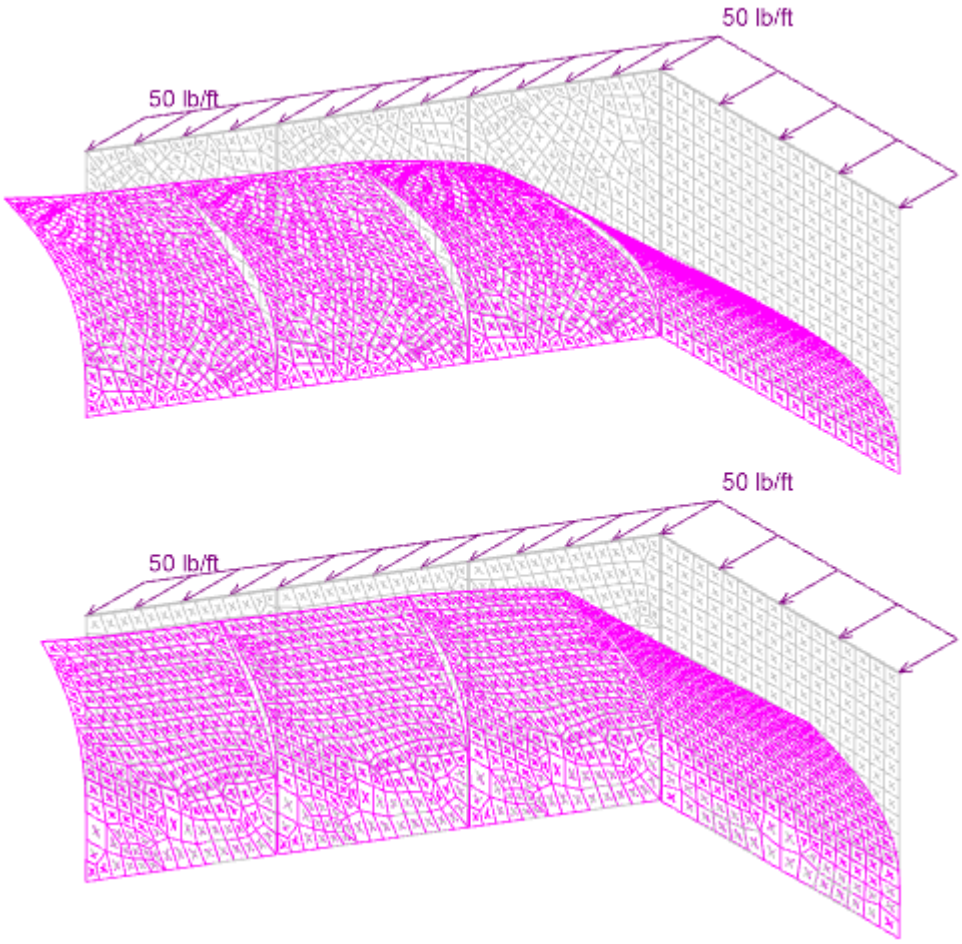
LC 1 = 200 lb point mid span of stair
LC 2 = 50 lb/ft

LC 1 deflected shape shown below
0.639” max deflection @ shoe mount rail

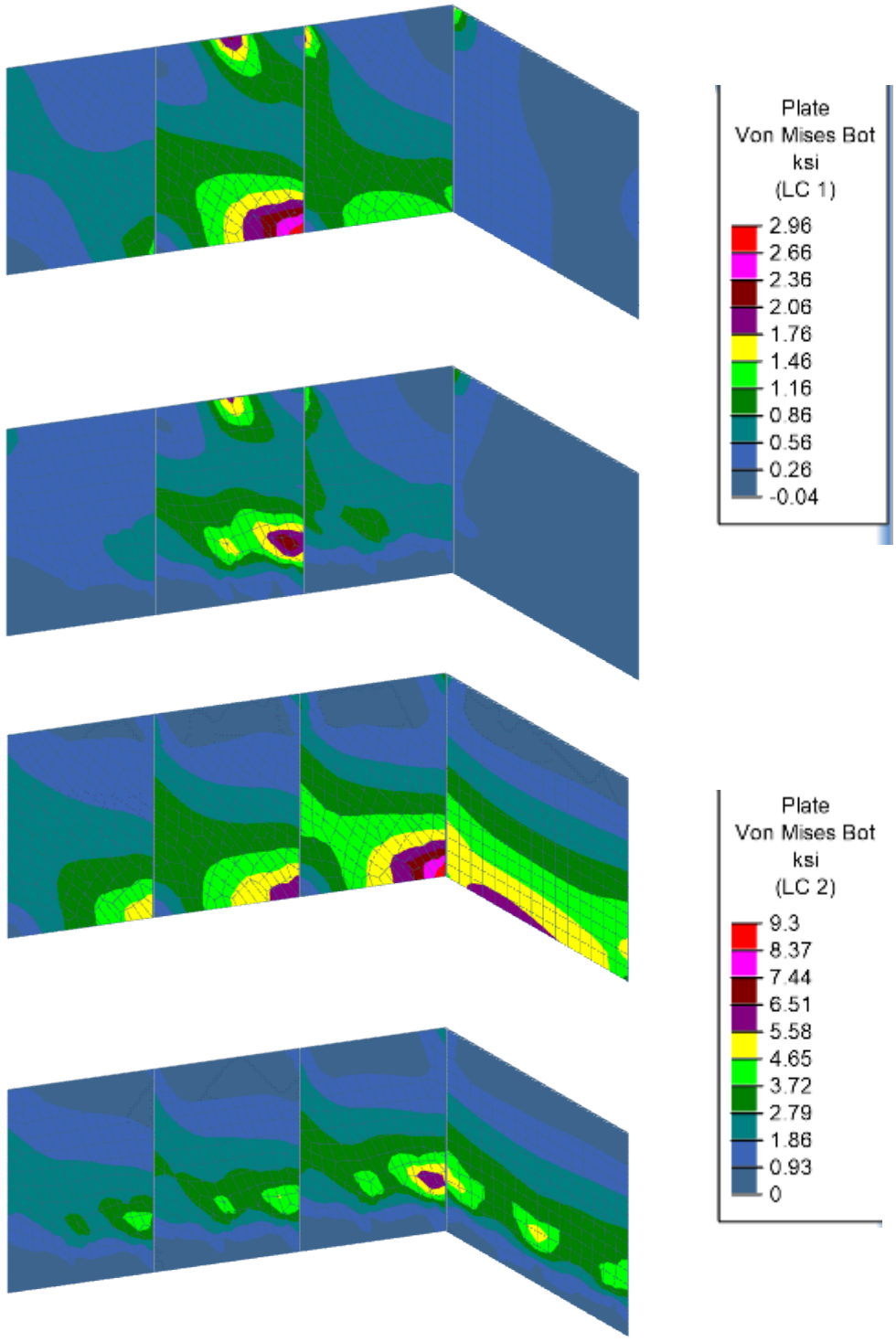


Multi Panel Railings – RISA 3D Behavior (weak top cap)

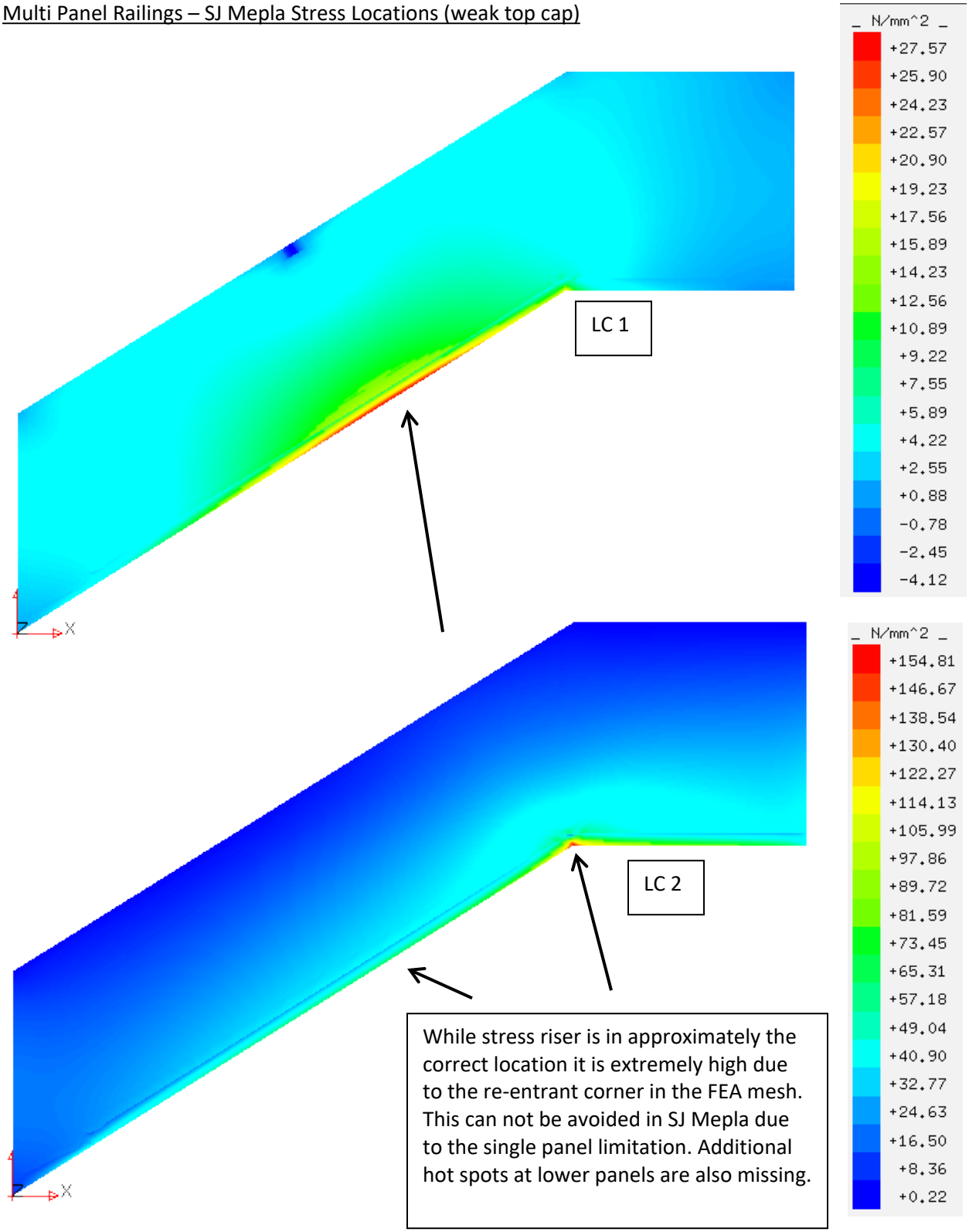
LC 2 deflected shape shown below
2.657” max deflection @ shoe mount rail



Multi Panel Railings – RISA 3D Stress Locations (weak top cap)

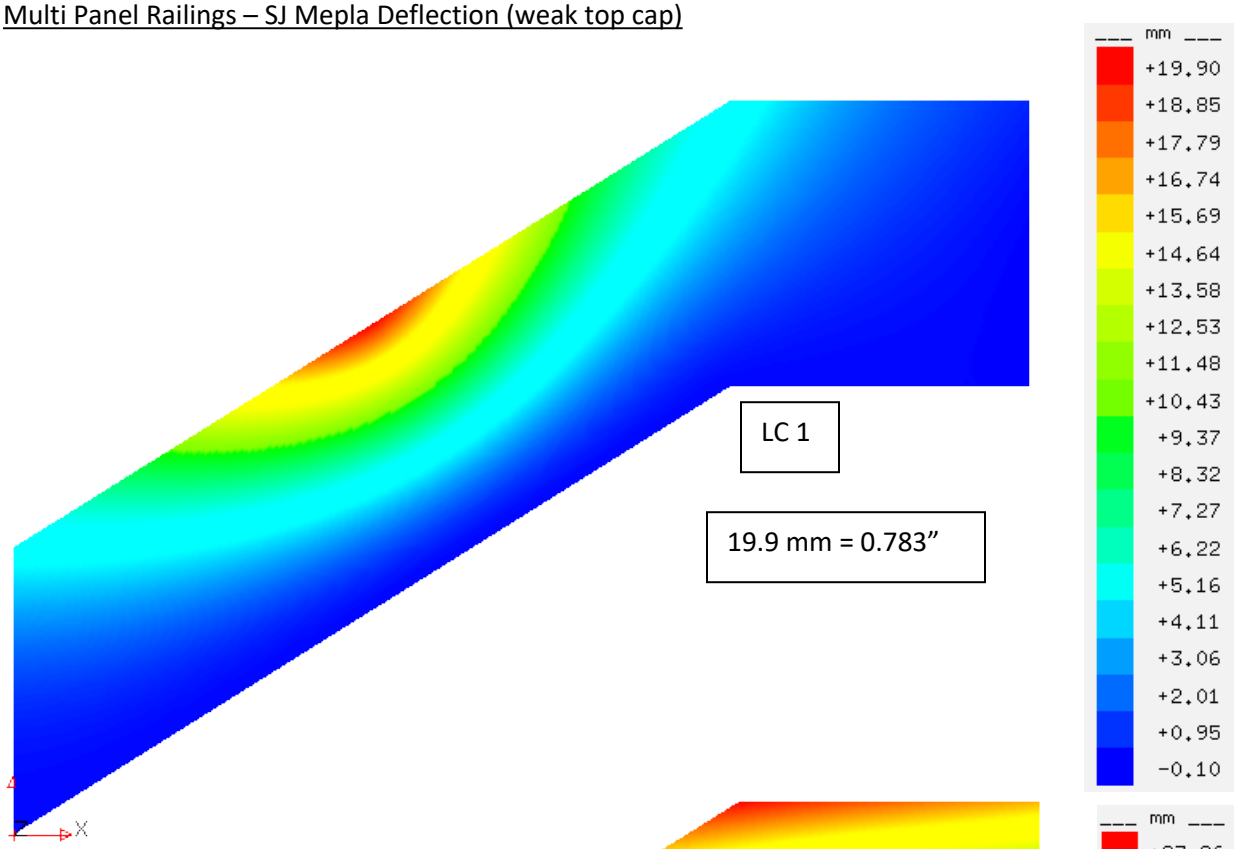


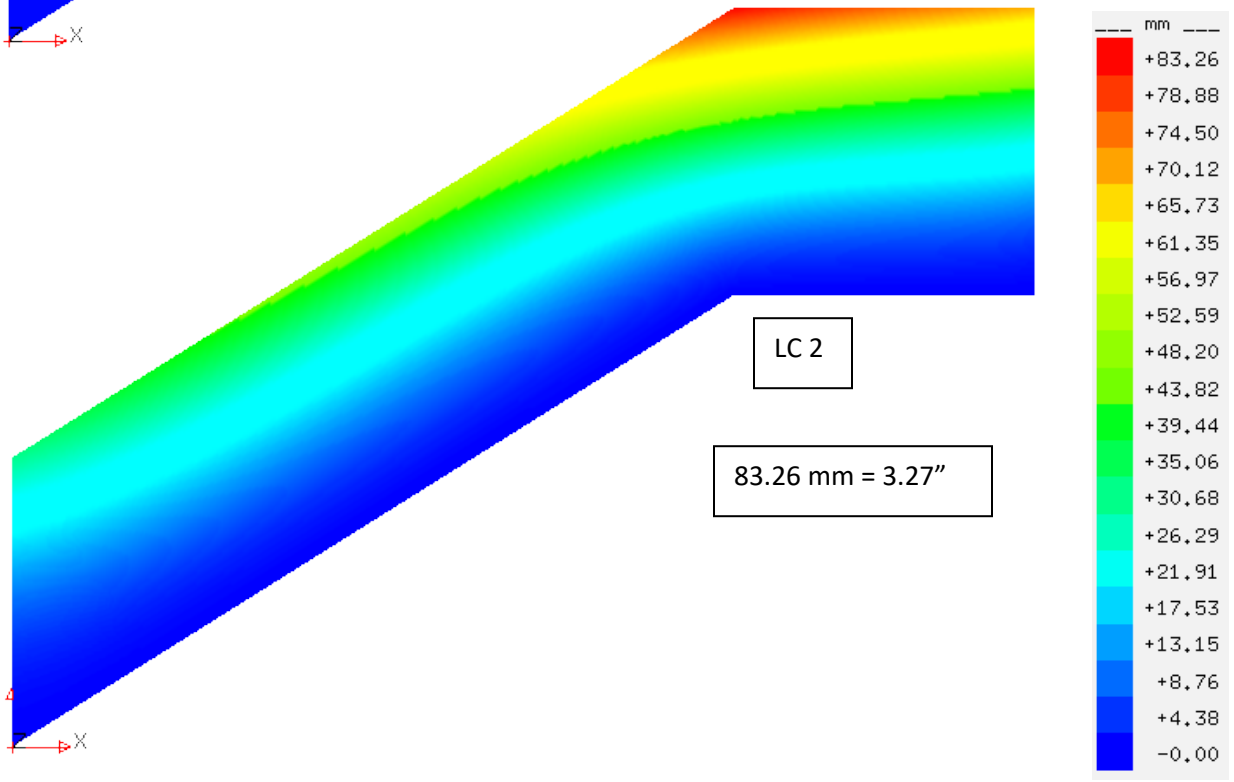
Multi Panel Railings – SJ Mepla Stress Locations (weak top cap)



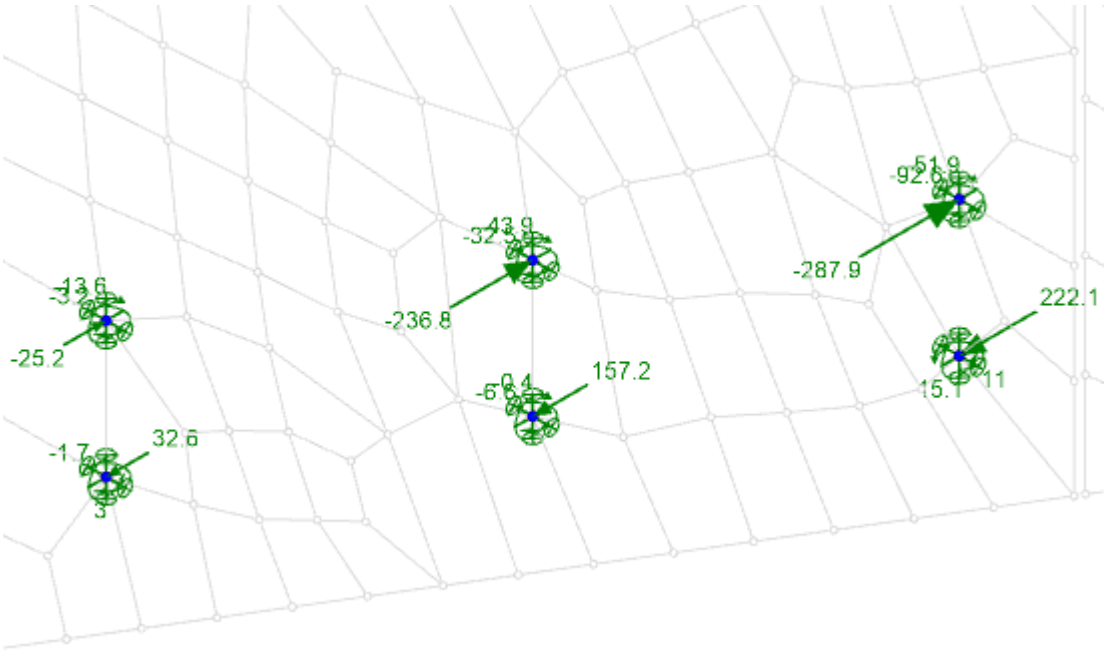
While stress riser is in approximately the correct location it is extremely high due to the re-entrant corner in the FEA mesh. This can not be avoided in SJ Mepla due to the single panel limitation. Additional hot spots at lower panels are also missing.

Multi Panel Railings – SJ Mepla Deflection (weak top cap)





Reactions at middle stair panel – LC 1

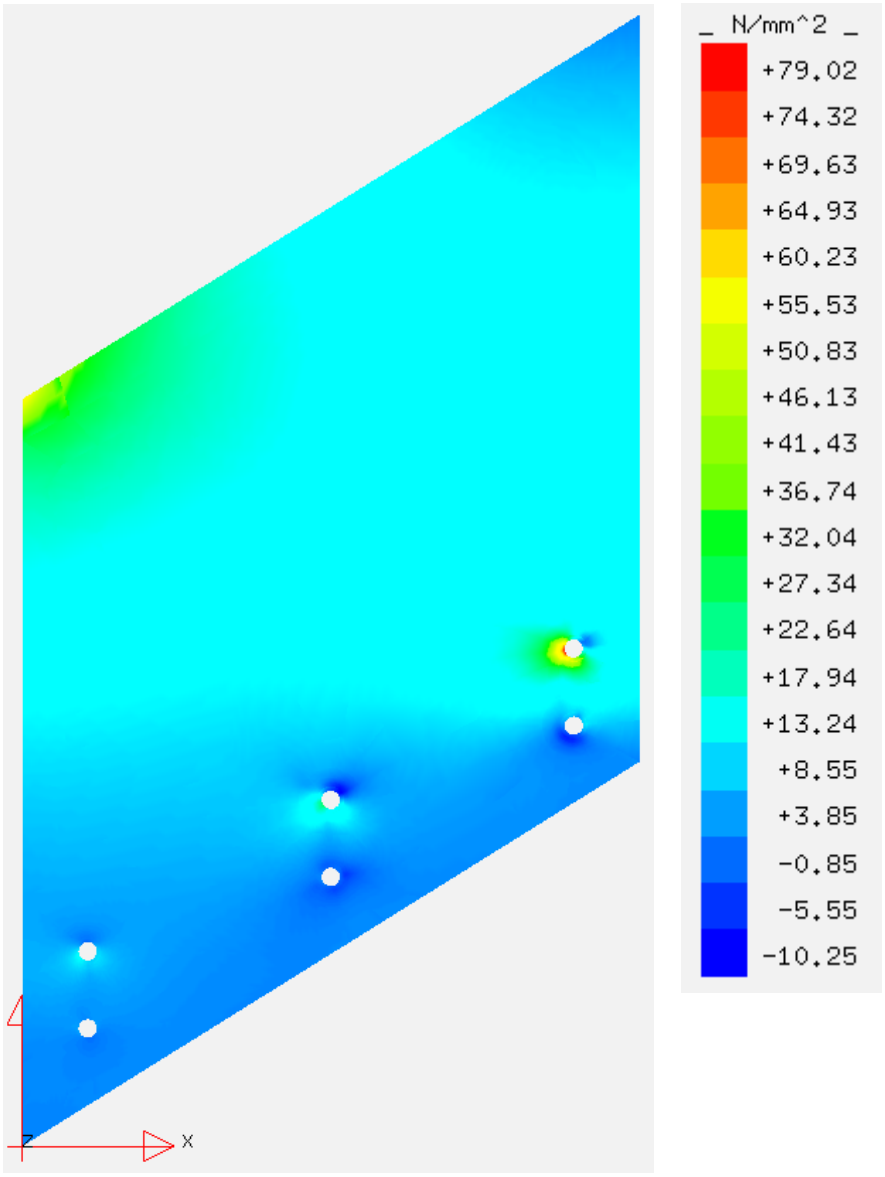


								Resultant					
		X	Y	Z	MX	MY	MZ	X	Y	Z	MX	MY	MZ
LC	Node	(lb)	(lb)	(lb)	(lb-ft)	(lb-ft)	(lb-ft)	(N)	(N)	(N)	(N-mm)	(N-mm)	(N-mm)
1	N35	0.0	0.0	-236.8	-43.9	-32.5	0.0	0.0	0.0	-1053.1	-59501.28	-44075.42	0.00
1	N31	0.0	0.0	-25.2	-13.6	-3.2	0.0	0.0	0.0	-112.1	-18376.51	-4286.32	0.00
1	N33	0.0	0.0	32.6	3.0	-1.7	0.0	0.0	0.0	145.2	4017.83	-2259.10	0.00
1	N37	0.0	0.0	157.2	-0.4	-6.6	0.0	0.0	0.0	699.1	-482.74	-8998.42	0.00
1	N41	0.0	0.0	222.1	15.1	11.0	0.0	0.0	0.0	988.1	20527.13	14868.54	0.00
1	N39	0.0	0.0	-287.9	-51.9	-92.6	0.0	0.0	0.0	-1280.4	-70360.13	-125629.33	0.00
2	N35	0.0	0.0	-590.2	-107.3	-96.5	0.0	0.0	0.0	-2625.5	-145449.98	-130887.90	0.00
2	N31	0.0	0.0	-145.8	-58.2	-16.0	0.0	0.0	0.0	-648.5	-78854.11	-21701.42	0.00
2	N33	0.0	0.0	124.2	9.7	-6.8	0.0	0.0	0.0	552.6	13191.17	-9223.51	0.00
2	N37	0.0	0.0	411.8	-4.5	-15.9	0.0	0.0	0.0	1831.7	-6102.00	-21499.38	0.00
2	N41	0.0	0.0	465.3	28.4	28.3	0.0	0.0	0.0	2069.8	38541.59	38334.12	0.00
2	N39	0.0	0.0	-500.2	-92.7	-196.4	0.0	0.0	0.0	-2225.0	-125640.18	-266325.18	0.00

SJ Mepla Panel Stresses w/ RISA 3D Reactions

Top edge of panel is fixed using edge support Type 5

*Reference	X [mm]	Y [mm]	Z_h	F_x	F_y	F_z	M_φ	M_θ	Type
DiskFixing	1089.85	983.77	0			-1280.4	-125629.33	-70360.13	2
DiskFixing	1089...	983.77	0			-128...	-125629...	-70360.13	2
DiskFixing	1089...	831.37	0			988.1	14868.5	20527.1	2
DiskFixing	609.6	684.58	0			-053.1	-44075.4	-59501.28	2
DiskFixing	609.6	532.18	0			699.1	-8998.4	-482.7	2



Peak stress is at the upper right fitting similar to the RISA 3D modeled fixed point nodes.

Peak edge stress at the hole is approximately 11.4 ksi, significantly higher than stresses show in RISA 3D.

Fitting modeling may be simplified to a single fitting centered in the glass panel using the worst case load combination reactions if spacing can be shown to now allow interaction between fitting holes (such as pipe railing mounts)