HydraSafe

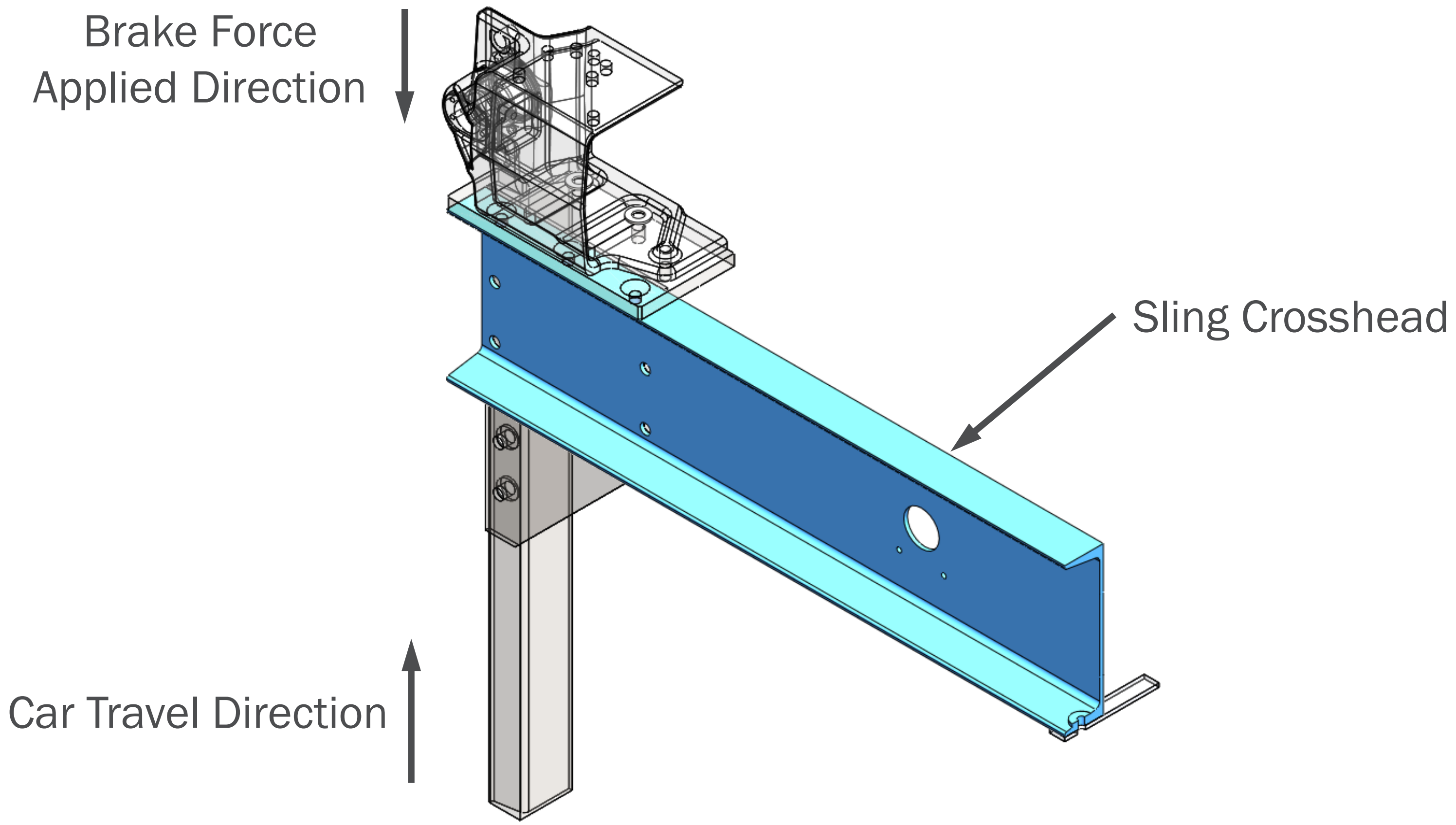
Sling Hot Rolled Structural Steel Crosshead FEA

2024/02/20

This report represents data as a result of Finite Element Analysis studies run by DiMonte Group Inc. for its client.
This data is accurate to the best of our knowledge, based on parameters calculated and supplied by our client.
None of the data in this report can be interpreted as a guarantee or warranty of the product design analyzed.

Purpose of Sling Crosshead FEA

The purpose of the FEA is to show the Stress, Displacement and FOS for the structural steel crosshead.



Required FOS for crosshead

Per ASME A17.1-2016/CSA B44-16 2.24.3 the FOS for the crosshead should be 8 or greater.

2.24.2.3.3 For Noncircular Elastomeric-Coated Steel Suspension Members. Where surfaces are used to provide traction, sufficient traction shall be provided between the noncircular elastomeric-coated steel suspension member and the surface, and in the event of failure of the elastomeric coating, between the load-carrying cords and the sheave contact surface, to safely stop and hold the

2.24.3 Factor of Safety for Driving Machines, Sheaves, and Drums

The factor of safety to be used in the design of driving machines, sheaves, and drums used with suspension means and compensating means shall be not less than

(a) 8 for metals having an elongation of at least 14% in a gauge length of 50 mm (2 in.) when tested in accordance with ASTM E8.

(b) 10 for cast iron or for metals having an elongation of less than 14% in a gauge length of 50 mm (2 in.) when tested in accordance with ASTM E8.

(c) 10 for sheaves of plastic, fiber-reinforced plastic, or combinations thereof. The material used shall ensure that the factor of safety is not less than 8 during the service life of the sheave.

The load to be used in determining the factor of safety shall be the resultant of the maximum tensions in the suspension means leading from the sheave or drum with the elevator at rest and with the rated load in the car.

2.24.3.1 Factors of Safety Based on Alternating/Reversing Stresses

2.24.3.1.1 Driving-machine components subjected to alternating or reversing stresses shall have a factor of safety not less than 1.5.

2.24.3.1.2 This factor of safety shall be the ratio of the endurance limit of the components (see Section 1.3) to the actual alternating or reversing stress to which the components can be subjected under any normal operating condition. The endurance limit shall be based on 10^7 cycles of stress reversals. The actual stress shall include all designed or anticipated load conditions and stress risers, such as sharp corners, shock loading, surface finish, keyways, material variations, and alignment tolerances.

2.24.3.2 Factors of Safety at Emergency Braking. Driving-machine components including bedplate, where used, subject to forces due to the application of the emergency brake (see 2.19.4) shall be designed to withstand the maximum forces developed during the retardation phase of emergency braking so that the factor of safety resulting from the emergency braking and all other loading acting simultaneously, if applicable, shall be not less than specified in 2.24.3(a) and 2.24.3(b).

2.24.4.1.3 When the connection is designed t transmit the torque by the friction of the clamped surface resulting from the applied fastener torques, 2.24.4.1. shall not apply.

2.24.4.1.4 The factors of safety to be used in th design of fasteners transmitting load or clamped surface transmitting torque in driving machines and sheaves sha be not less than those specified in 2.24.3.

2.24.4.2 Flexible Connections. Where flexibl couplings are used to transmit load, means shall b provided to prevent disengagement of the couplin components in the event of the failure of or excessiv motion in the flexible connection.

2.24.5 Shaft Fillets and Keys

A fillet shall be provided at any point of change in th diameter of driving-machine shafts and sheave shafts t prevent excessive stress concentrations in the shafts (se 2.24.3.1).

Shafts that support drums, sheaves, gears, coupling and other members, and that transmit torque, shall b provided with tight-fitting keys.

2.24.6 Cast Iron Worms and Worm Gears

Worms and worm gears made of cast iron shall not b used in elevator driving machines.

2.24.7 Friction Gearing and Clutches

Friction gearing or a clutch mechanism shall not be use to connect a driving-machine drum or sheave to the mai driving mechanism.

2.24.8 Braking System and Driving-Machine Brakes (See Nonmandatory Appendix F, Table F-1)

2.24.8.1 General Requirements. The elevator shall b provided with a braking system conforming to 2.24.8.

Sling Crosshead FEA Forces

The 10,000lb mass used in the FEA was calculated using a 20,000lb moving mass and a 0.5 stopping reaction force.

Speed (ft/min)	Stopping distance (ft) at acceleration (g)										
	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
50	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	0.9	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
200	3.5	1.7	0.9	0.6	0.4	0.3	0.3	0.2	0.2	0.2	0.2
500	21.6	10.8	5.4	3.6	2.7	2.2	1.8	1.5	1.3	1.2	1.1
1000	86.3	43.1	21.6	14.4	10.8	8.6	7.2	6.2	5.4	4.8	4.3
1500	194.1	97.0	48.5	32.3	24.3	19.4	16.2	13.9	12.1	10.8	9.7
2000	345.1	172.5	86.3	57.5	43.1	34.5	28.8	24.6	21.6	19.2	17.3

$$v^2 = u^2 + 2as$$

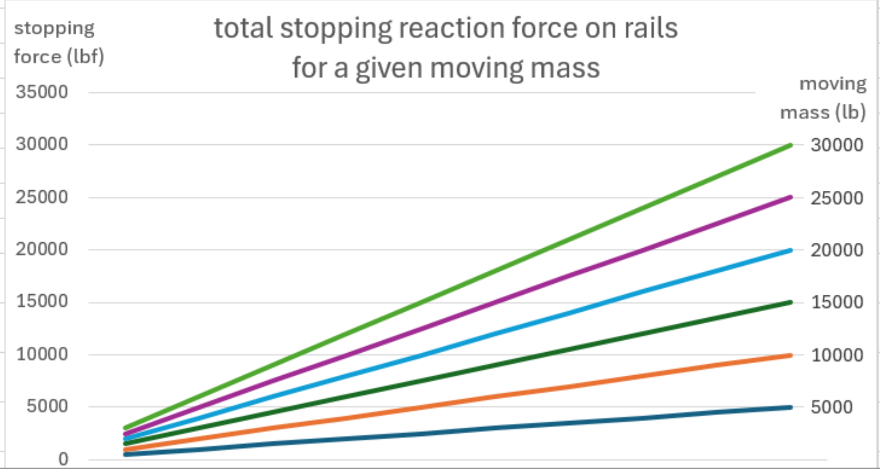
where:

- v is the final velocity,
- u is the initial velocity,
- a is the acceleration,
- s is the displacement.

"Total Gross Load"

F = ma   mass = 20860 lb

Moving Mass (lb)	Stopping reaction force (lbf) at acceleration (g)										
	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
5000	250	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
10000	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
15000	750	1500	3000	4500	6000	7500	9000	10500	12000	13500	15000
20000	1000	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000



Structural steel and caliper casting materials

Channel and Beam Materials are made from hot roll material. These materials are most commonly A572, A588 and A36 steel. For this FEA, A36 steel was chosen as it has the lowest tensile strength.
The caliper casting is made from A352 LC2-1 steel.

Different Steel Compositions

In addition to choosing the right shape for your steel beams, it's important to consider the material itself. Most commonly, steel beams come in A572, A588, and A36.

Source: www.bushwickmetals.com

Structural Steel Components

A36 Tensile Strength: 69,000psi

Caliper Casting Component

A352 LC2-1 Tensile Strength: 105,000psi

Source: www.makeitfrom.com

Bolt Material, Strength and Torque

Grade 8 Bolts

A **grade 8 bolt** is the highest grade SAE bolt. Grade 8 bolts have a minimum tensile strength of 150,000 PSI. As a comparison, the ASTM A325 bolt is roughly equivalent to the SAE grade 5. A grade 8 bolt would be one that meets ASTM A490 standards.

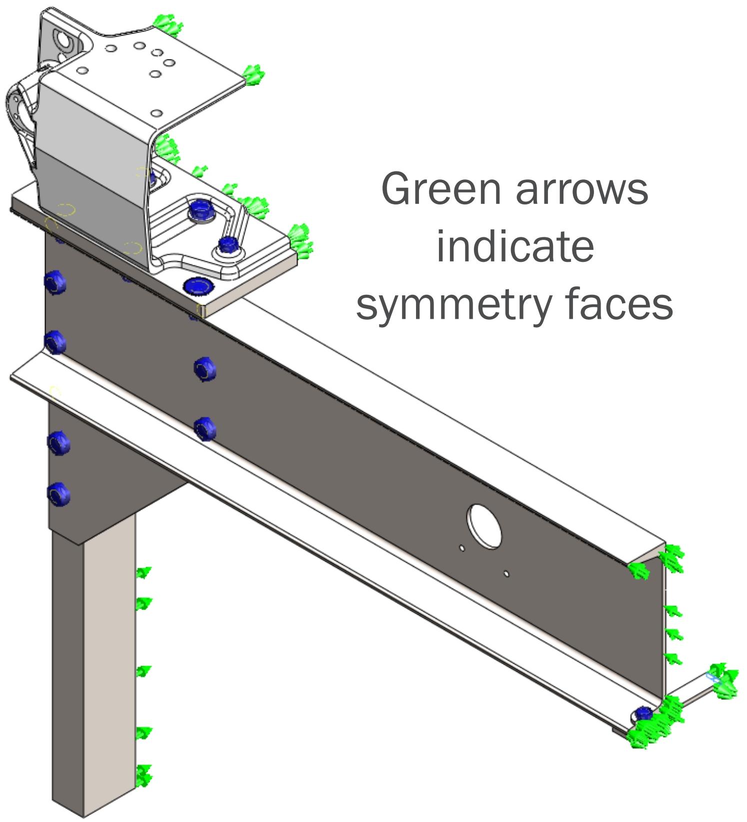
Source: www.tfgusa.com

GRADE 5 Coarse Thread				GRADE 8 Coarse Thread			
Size	Clamp Load	Plain (ft. lbs.)	Plated	Size	Clamp Load	Plain (ft. lbs.)	Plated (ft. lbs.)
1/4-20 (.250)	2025	8	76 in lbs.	1/4-20 (.250)	2850	12	9
5/16-18 (.3125)	3338	17	13 ft lbs.	5/16-18 (.3125)	4725	25	18
3/8-16 (.375)	4950	31	23 ft lbs.	3/8-16 (.375)	6975	44	33
7/16-14 (.4375)	6788	50	37 ft lbs.	7/16-14 (.4375)	9600	70	52
1/2-13 (.500)	9075	76	57 ft lbs.	1/2-13 (.500)	12750	106	80
9/16-12 (.5625)	11625	109	82 ft lbs.	9/16-12 (.5625)	16350	153	115
5/8-11 (.625)	14400	150	112 ft lbs.	5/8-11 (.625)	20325	212	159
3/4-10 (.750)	21300	266	200 ft lbs.	3/4-10 (.750)	30075	376	282
7/8-9 (.875)	29475	430	322 ft lbs.	7/8-9 (.875)	41550	606	454
1-8 (1.000)	38625	644	483 ft lbs.	1-8 (1.000)	54525	909	682
1 1/8-7 (1.125)	42375	794	596 ft lbs.	1 1/8-7 (1.125)	68700	1288	966
1 1/4-7 (1.250)	53775	1120	840 ft lbs.	1 1/4-7 (1.250)	87225	1817	1363
1 3/8-6 (1.375)	64125	1470	1102 ft lbs.	1 3/8-6 (1.375)	103950	2382	1787
1 1/2-6 (1.500)	78000	1950	1462 ft lbs.	1 1/2-6 (1.500)	126450	3161	2371

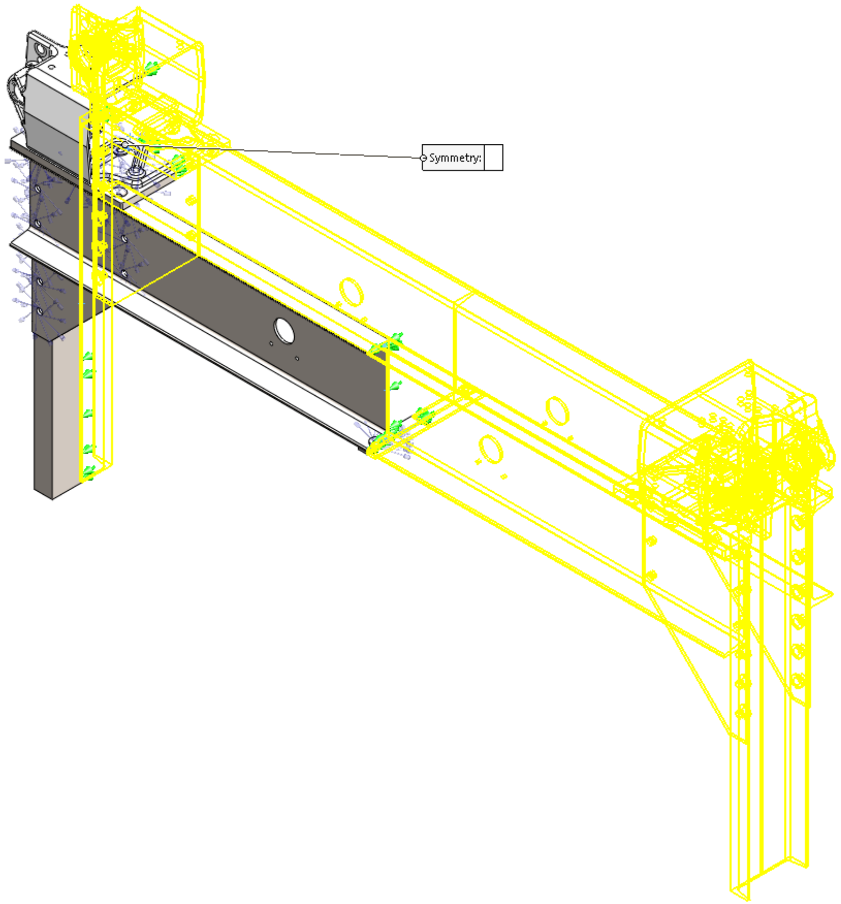
Source: www.almabolt.com

FEA Setup - Model

The FEA model was set up using ¼ of the actual assembly, and then applying symmetry fixtures in the front and right planes.



Green arrows indicate symmetry faces



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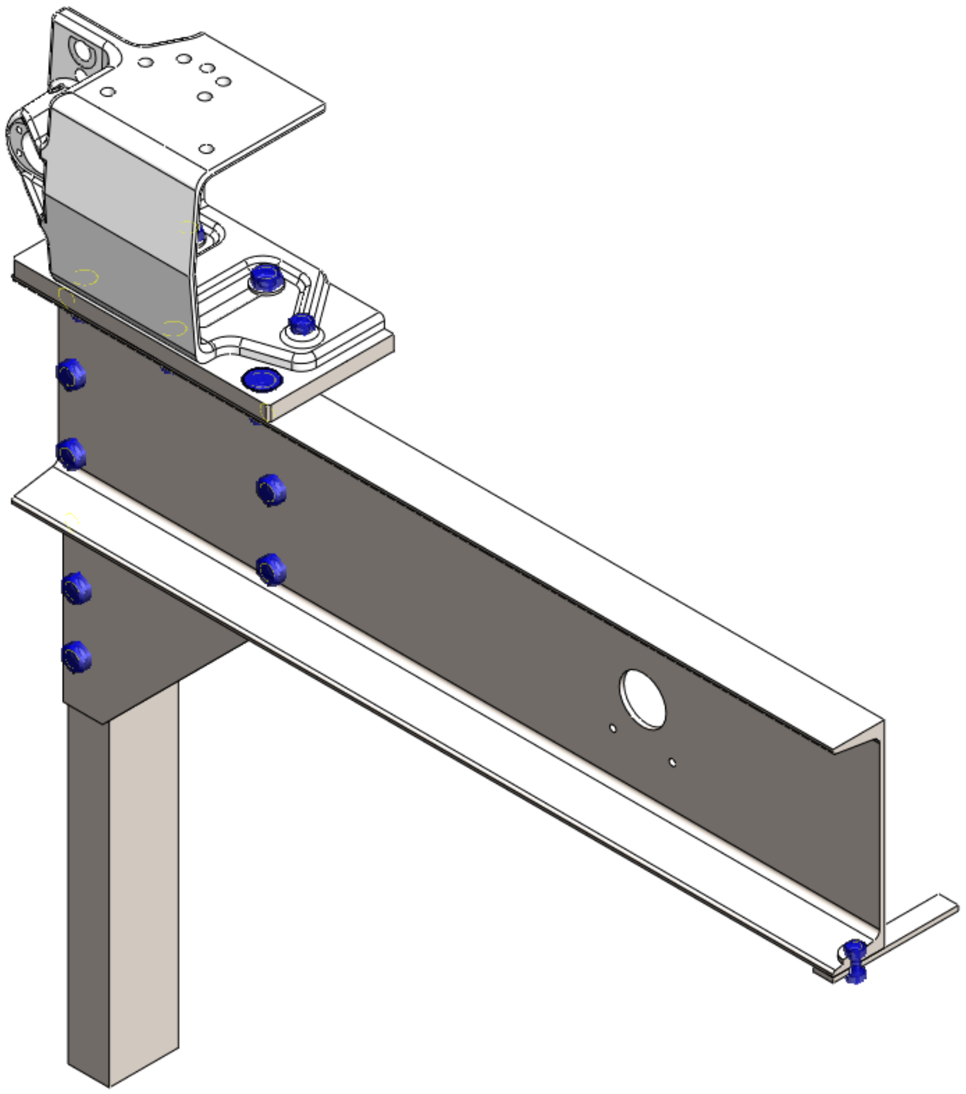
FEA Setup - Connectors

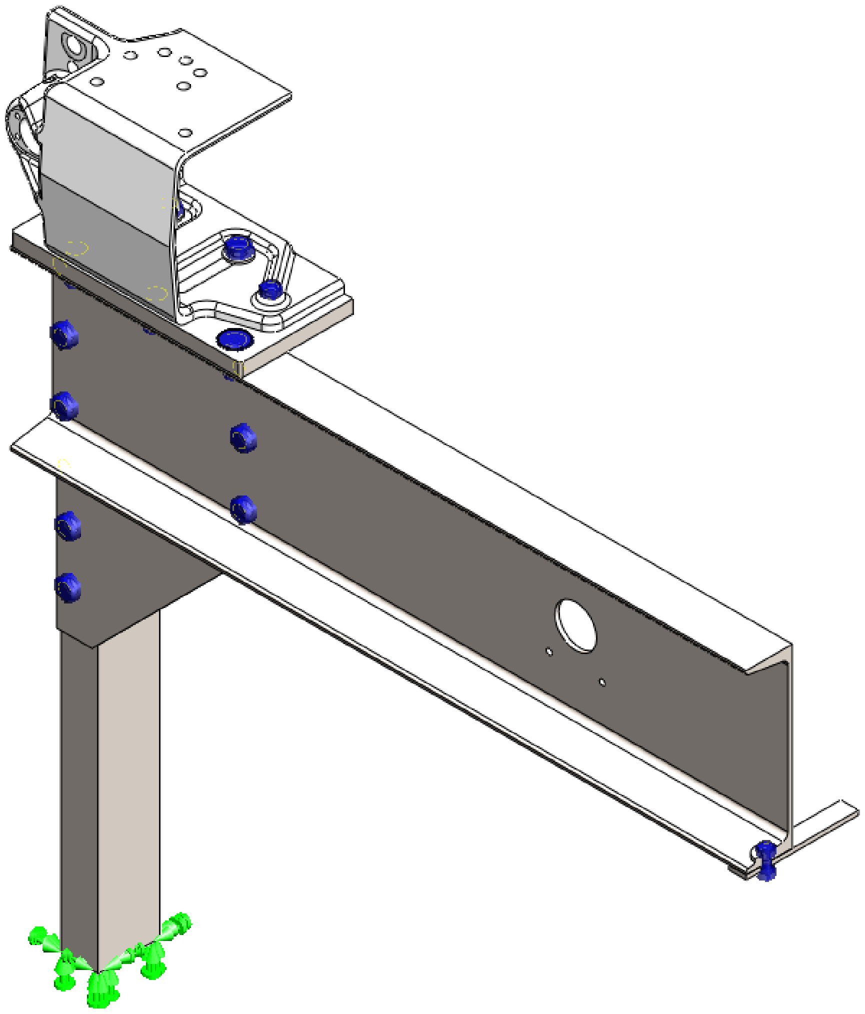
Grade 8 fasteners are used at all bolt locations.



FEA Setup – Fixed Component

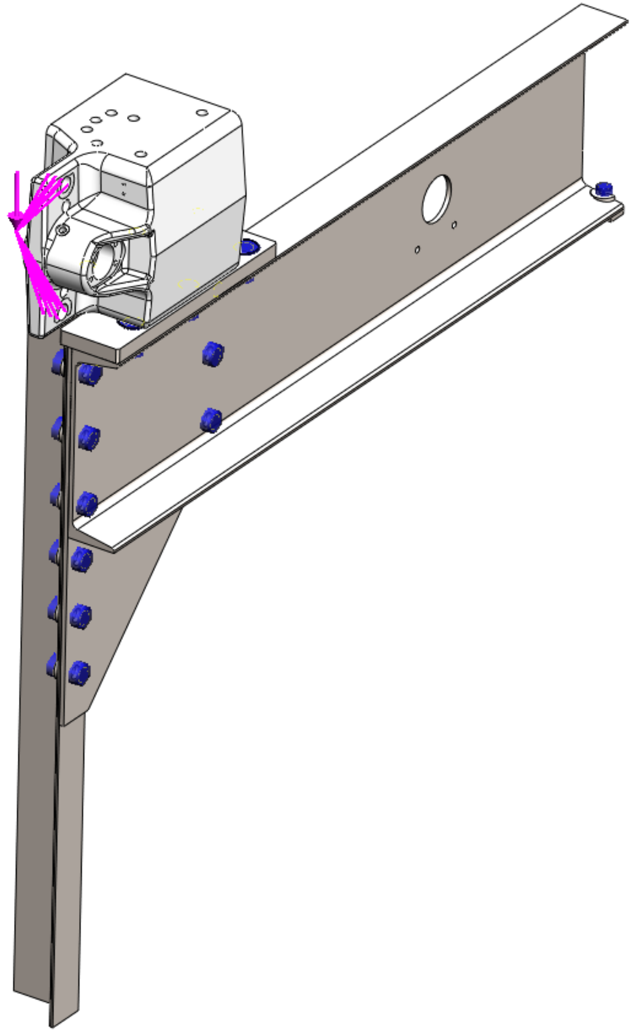
The stile was cut at 3' from the top and fixed at the base surface.

Green arrows indicate fixed face



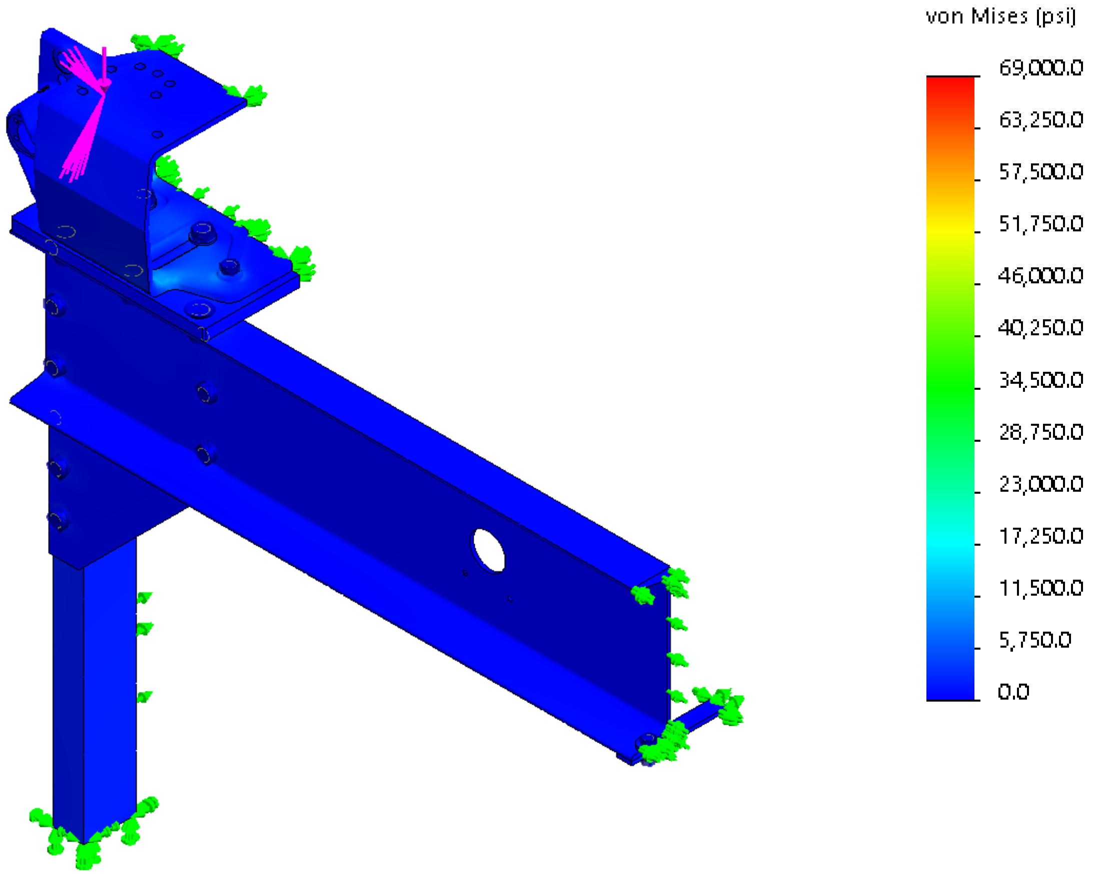
Setup - Load

A 10,000lb load for the entire car is used.
Since the model is in a ¼ section, ¼ of the 10,000lb was used.
A 2,500lb load was applied in a downward direction at the brake pad clamping location and transferred to the brake pad bolt holes in the caliper casting.
The downward force is used to simulate the car travelling in an upward direction.



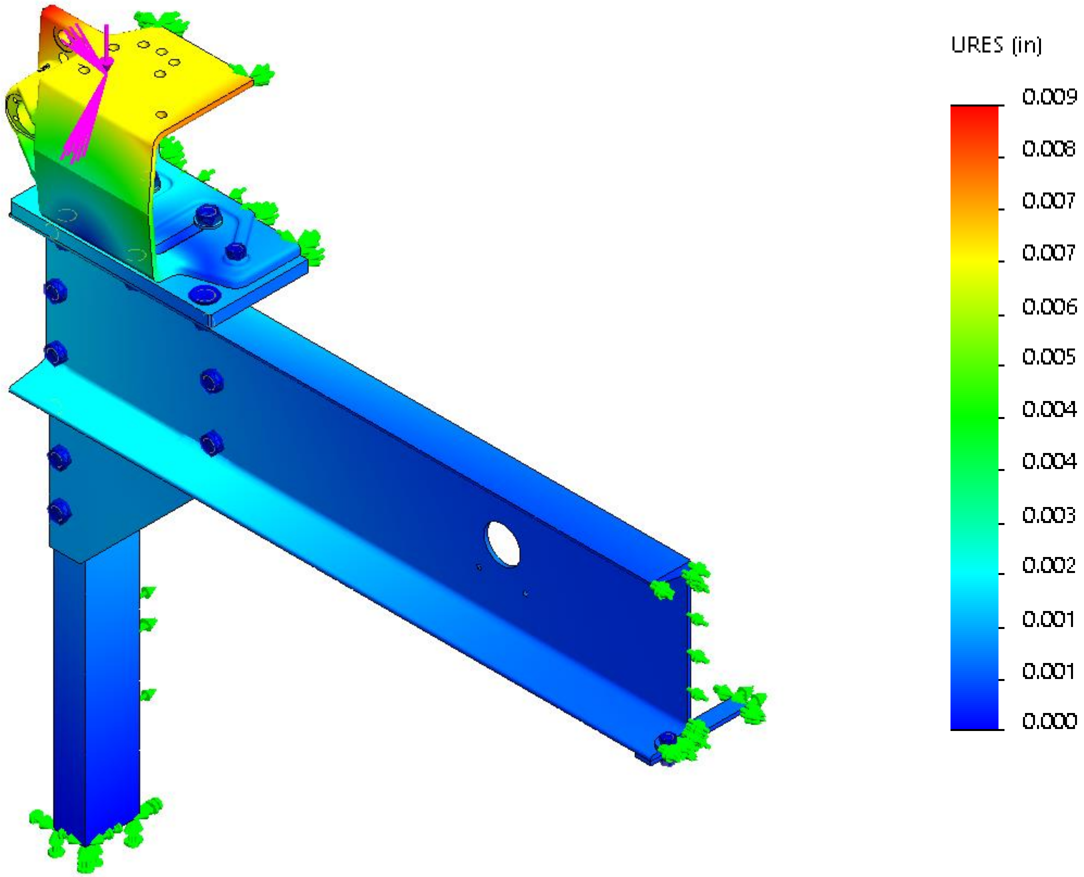
Stress Results - Crosshead

Crosshead stress is ~5,000psi.



Displacement Results - Crosshead

Crosshead displacement is ~0.002”



Factor of Safety Results - Crosshead

Crosshead FOS is over 8X.