**FORWARD THINKING ENGINEERING**
**Mechanical Engineering Consultants**
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Date: March 15, 2012

To: Merritt Equipment

From: Steven Forrester, P.E.

Subject: 40" Frame Extension with a Certified FMVS 223
Rear Impact Guard

To whom it may concern,

We have completed our analysis of the Under Ride Bumper and supporting structure for a 40" frame extension to be attached to a Merritt Equipment Grain Trailer. We have made modifications to the original design of the mounting structure and these changes are reflected in Merritt Equipment's drawing #82-9532-007.

The bumper and mounting structure will perform satisfactorily when built and installed per the diagrams and written specifications located on drawing #82-9532-007. The bumper and mounting structure are designed to with stand a rear impact FMVS223 and support itself while in use. NO OTHER EQUIPMENT OR STRUTURAL MEMBERS ARE TO BE ADDED TO THE BUMPER STRUCTURE.

Regards,

Steven Forrester, P.E.


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# FEA Results of the Under Ride Bumper for the Final Manufacture Attached to a Removable 40” Frame Extender to be Used in Conjunction with a Merritt Equipment Co. Commodity Trailer

Author: Steven Forrester MSME P.E.

March 15, 2012

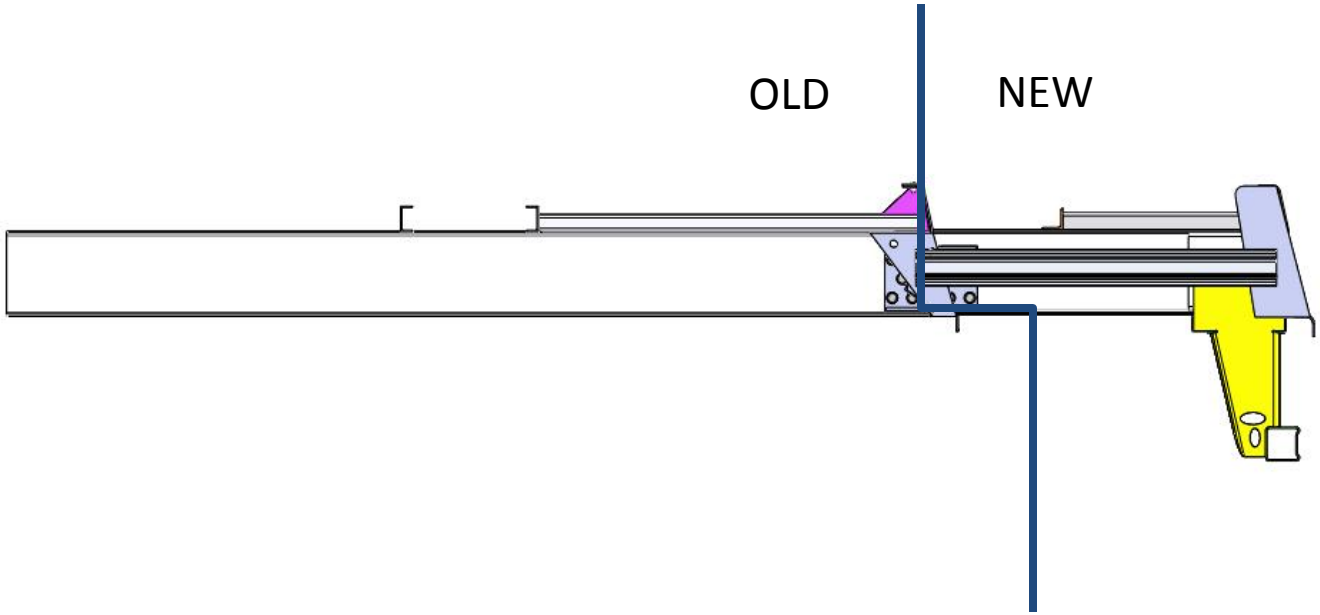
# Synopsis

The Final Manufacture takes a Merritt Equipment's Standard grain trailer and adds a conveyor to deliver fertilizer from the hoppers to the spreader in the field.  The Department of Transportation (DOT) has requested that an under ride bumper be attached the rear of the trailers.  The bumpers need to project out from the back of the trailer 40"  inches to meet the requirements set by the Department of Transportation.

A field fix is required to take Merritt Equipment's standard under ride bumper attached to a frame extension structure, and create a bumper and structure assembly to attach to the grain trailers already in service.

# Existing Condition

# Field Fix



# FEA MODELING APPROACH

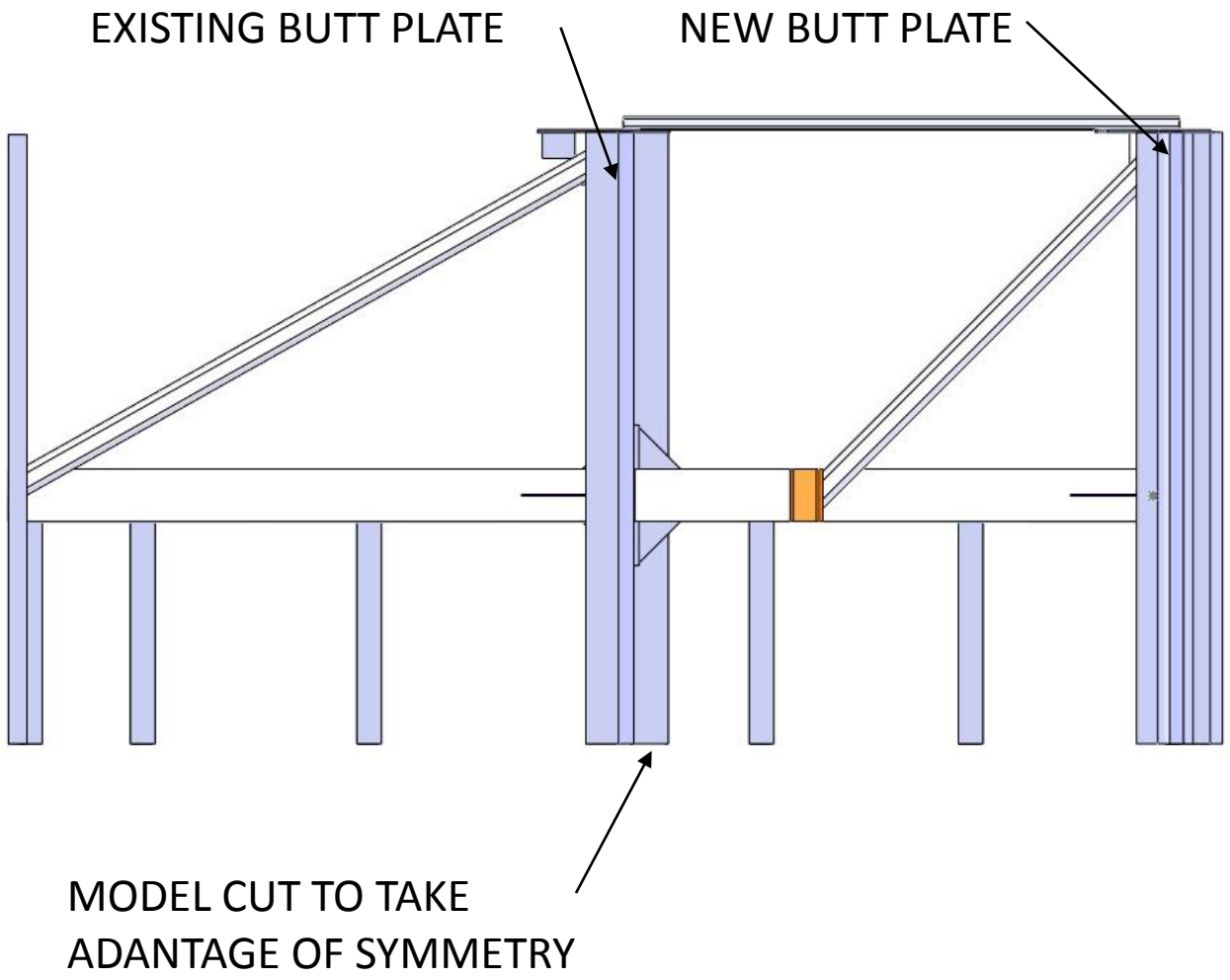
THE MODEL WAS SIMPLIFIED TO REMOVE ANY GEOMETRY THAT WAS NOT SIGNIFICANT TO THE MOUNTING OF THE BUMPER. THE BUMPER WAS MODELED AND TESTED TO MEET THE CANADIAN TRANSPORTATION REQUIREMENTS IN A PREVOUIS STUDY.

THE FEA MODEL IS ONLY USED TO ENSURE THAT THE MOUNTING ASSEMBLY IS STRONG ENEOUGH TO RESIST THE LOADS IN A REAR IMPACT AND STRONG ENOUGH TO RESIST THE LOADS WHILE THE STRUCTURE IS INSTALLED IN SERVICE. THE STRUCUTRE IS ONLY TO BE USED TO SUPPORT THE BUMPER AND NOT OTHER COMPONENT OF THE TRAILER OR CONVEYOR SYSTEM.

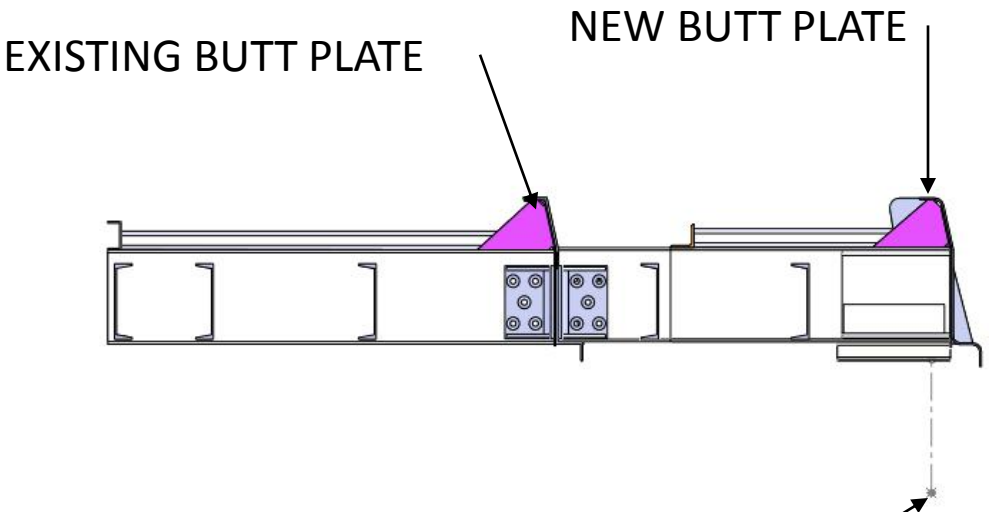
WE DEVELEOPED A SIMPLIFIED MODEL TO OBTAIN THE OVER ALL STRESS AND DISPLACEMENTS OF THE STRUCTURE. THIS MODEL HAD TWO STUDIES. ONE WAS LOADED WITH AN HORIZONTIAL LOAD OF 22,481 LBS REPLICATING A REAR IMPACT AND THE SECOND WITH A 2,000 LBS LOAD REPLICATING A 3G LOAD OF THE WEIGHT OF THE STRUCTURE. CHANGES WERE MADE TO THE MODEL AS NECESSARY TO PROVIDE AN ACCEPTABLE FACTOR OF SAFETY.

THE POINT OF CONNECTION OF THE BUMPER STRUCTURE WAS MODELED SPERATELY TO ACCURATELY OBTAIN THE STRESSES INVOLVED. THE DISPLACEMENTS FROM THE SIMPLIFIED MODEL WAS USED IN THE CONNECTION MODEL AS THE LOADS.

# FEA MODELING

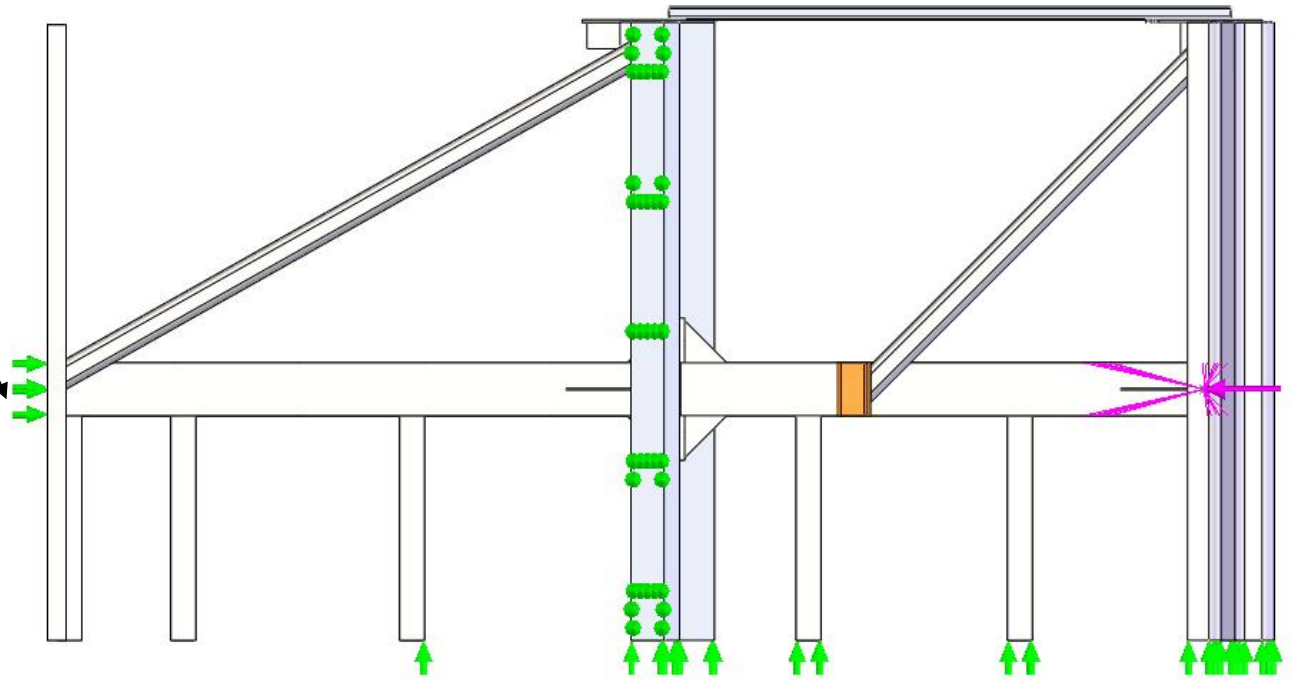


# FEA MODELING



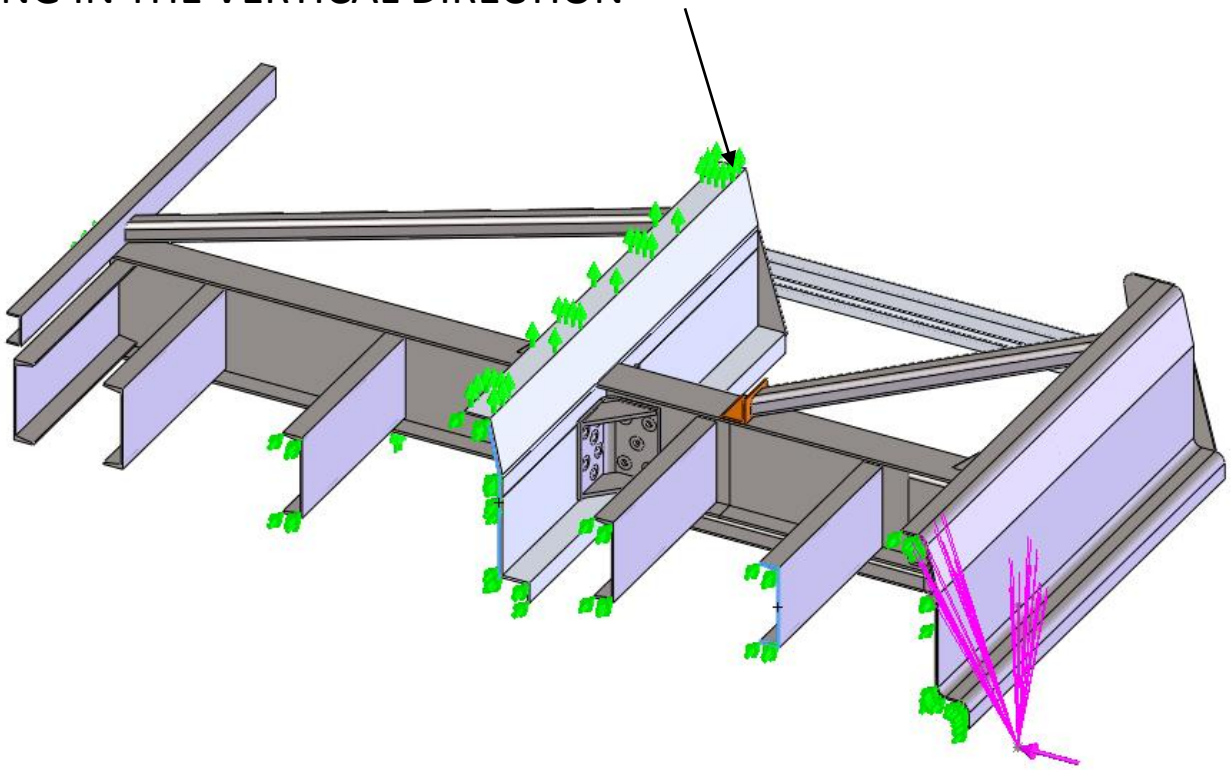
# FEA MODELING CONSTRAINTS

BOGIE RAIL CONSTRAINED FROM MOVING FORWARD

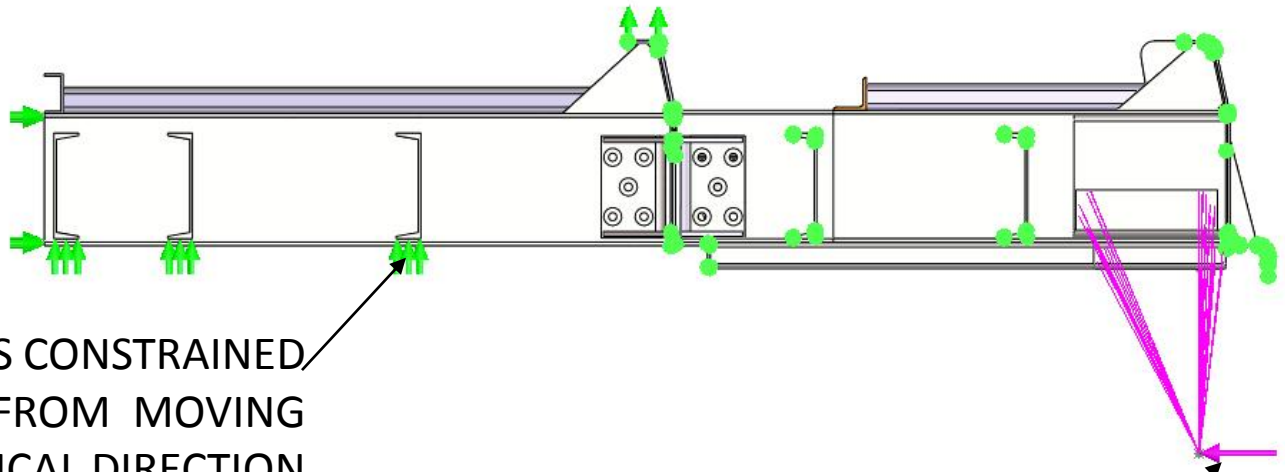


# FEA MODELING CONSTRAINTS

REAR BUTT PLATE CONSTRAINED FROM MOVING IN THE VERTICAL DIRECTION



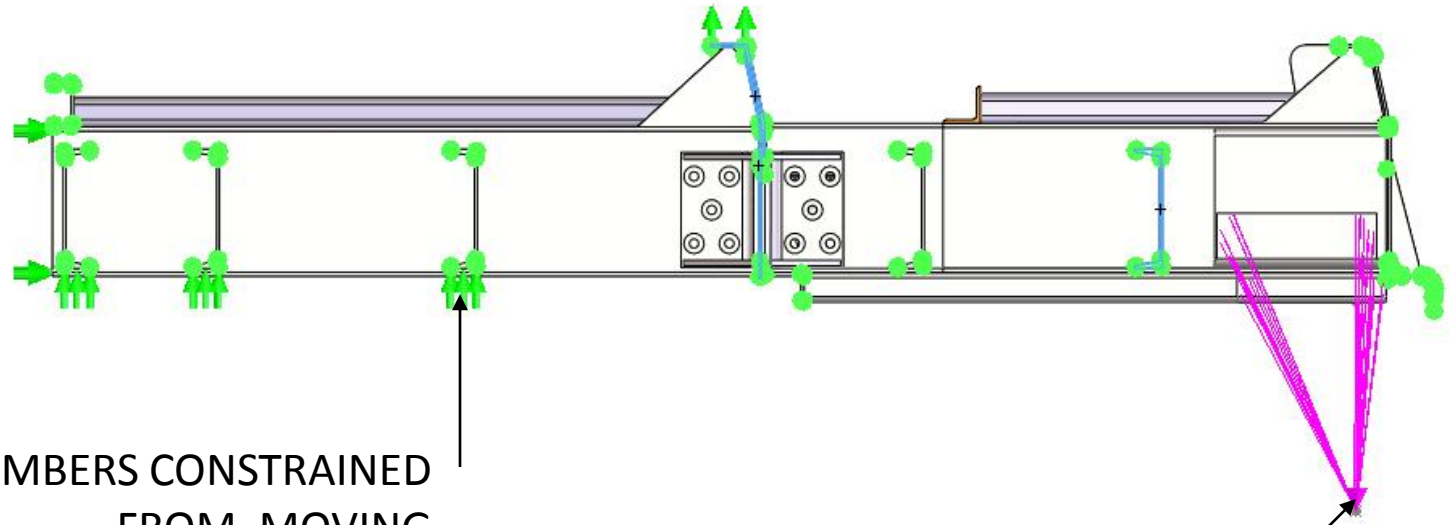
# FEA MODELING CONSTRAINTS



CROSSMEMBERS CONSTRAINED
FROM MOVING
IN THE VERTICAL DIRECTION

100,000 N (22,480 LB) FORCE APPLIED FOR IMPACT.
LOAD IS APPLIED IN A HORIZONTIAL DIRECTION

# FEA MODELING CONSTRAINTS

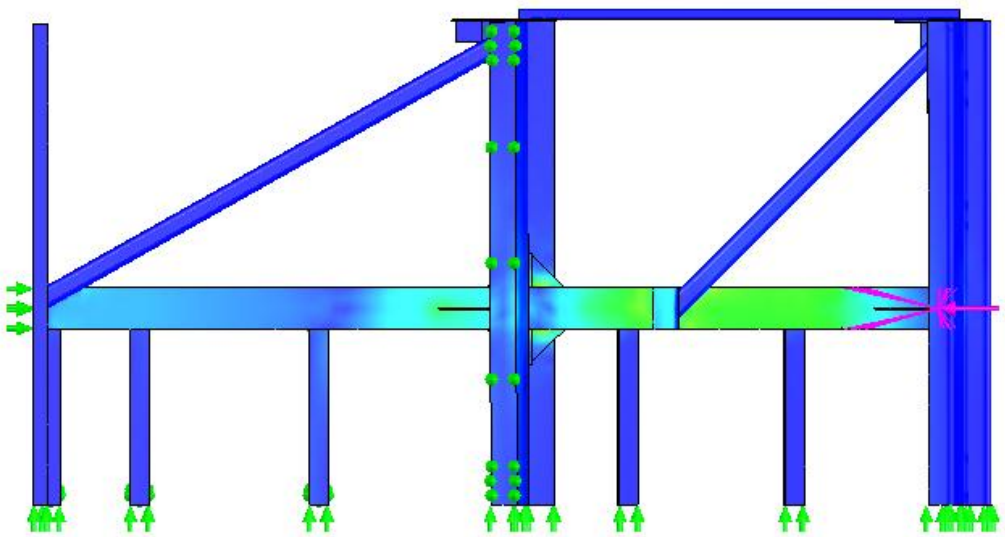


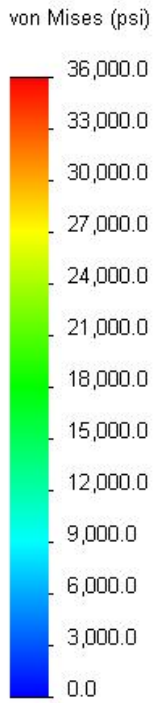
CROSSMEMBERS CONSTRAINED
FROM MOVING
IN THE VERTICAL DIRECTION

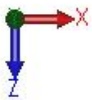
2,000 LB FORCE APPLIED
FOR 3G LOADING OF THE STRUCTURE.
LOAD IS APPLIED IN A VERTICAL DIRECTION.

# FEA MODELING STRESS RESULTS IMPACT LOAD

Model name: davis equipment
Study name: Study 2
Plot type: Static nodal stress Stress1
Deformation scale: 5

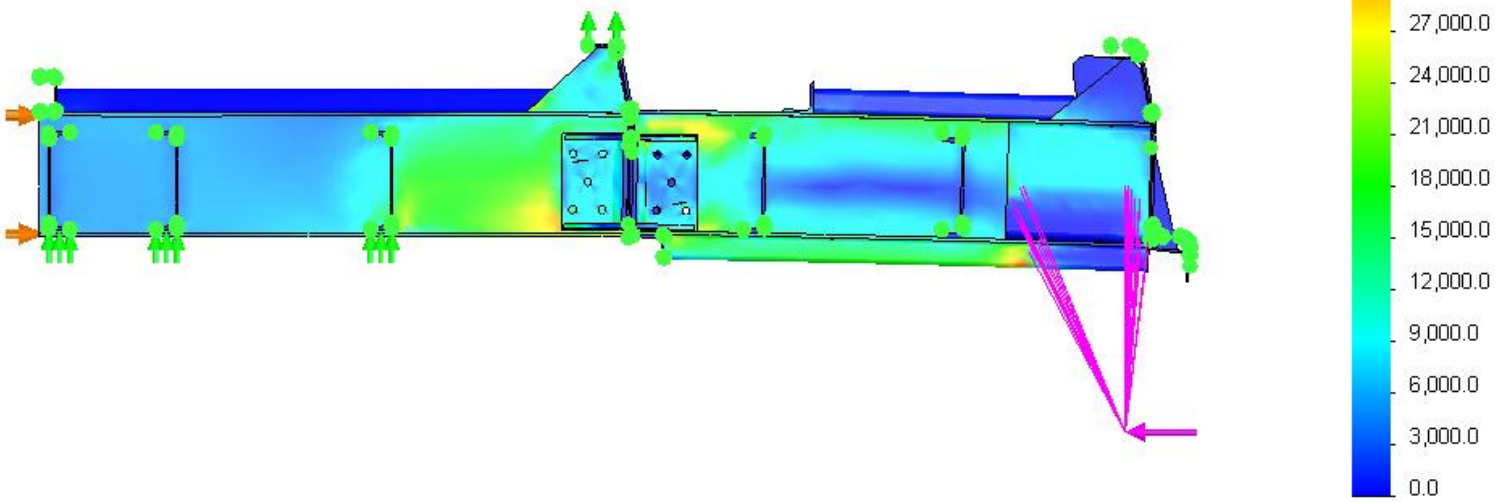




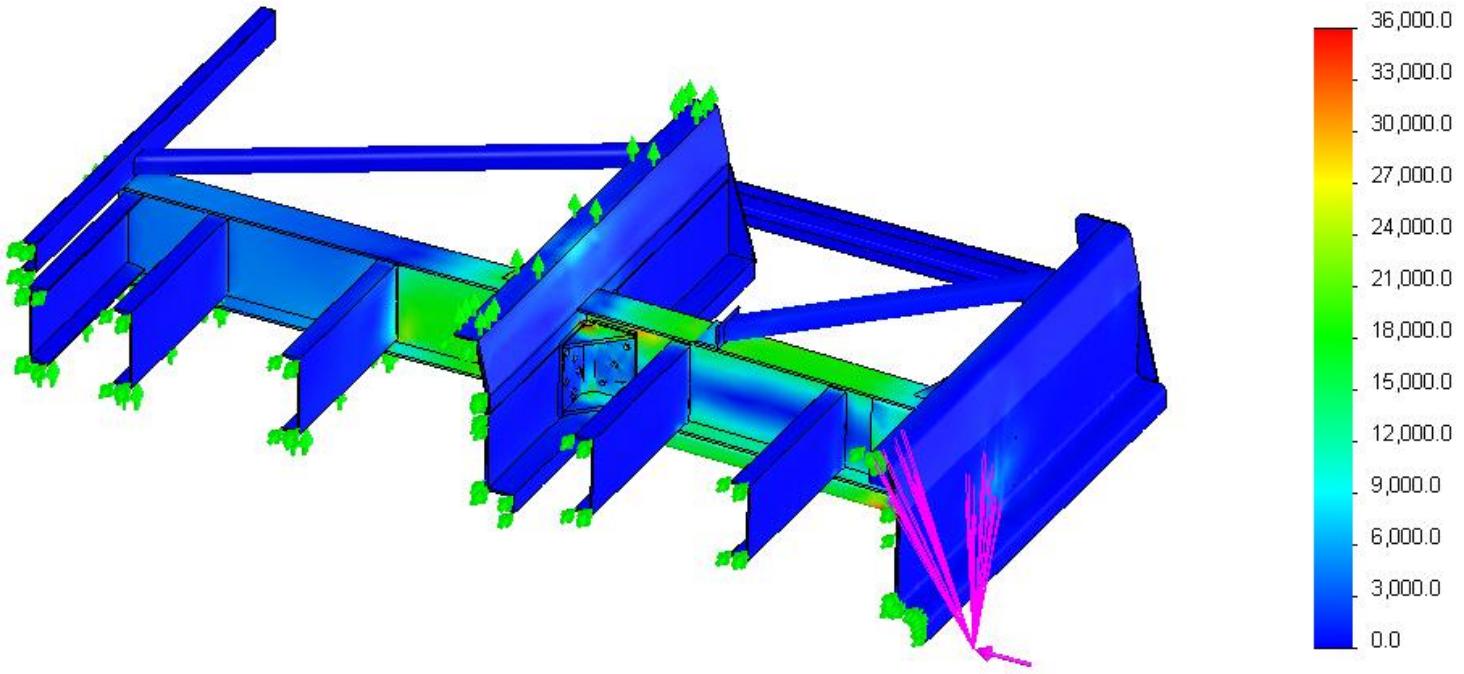
# FEA MODELING STRESS RESULTS IMPACT LOAD

Model name: davis equipment
Study name: Study 2
Plot type: Static nodal stress Stress1
Deformation scale: 5



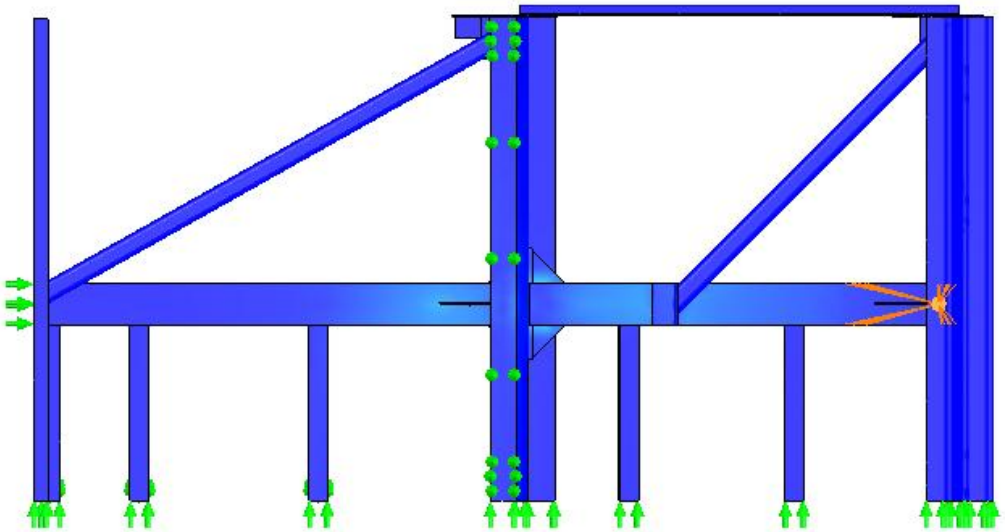
# FEA MODELING STRESS RESULTS IMPACT LOAD

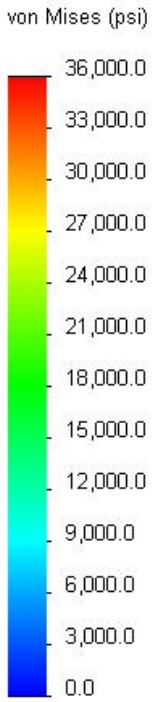
Model name: davis equipment
Study name: Study 2
Plot type: Static nodal stress Stress1
Deformation scale: 5

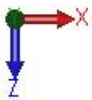


# FEA MODELING STRESS RESULTS
# ROAD LOAD

Model name: davis equipment
Study name: Study 3
Plot type: Static nodal stress Stress1
Deformation scale: 5

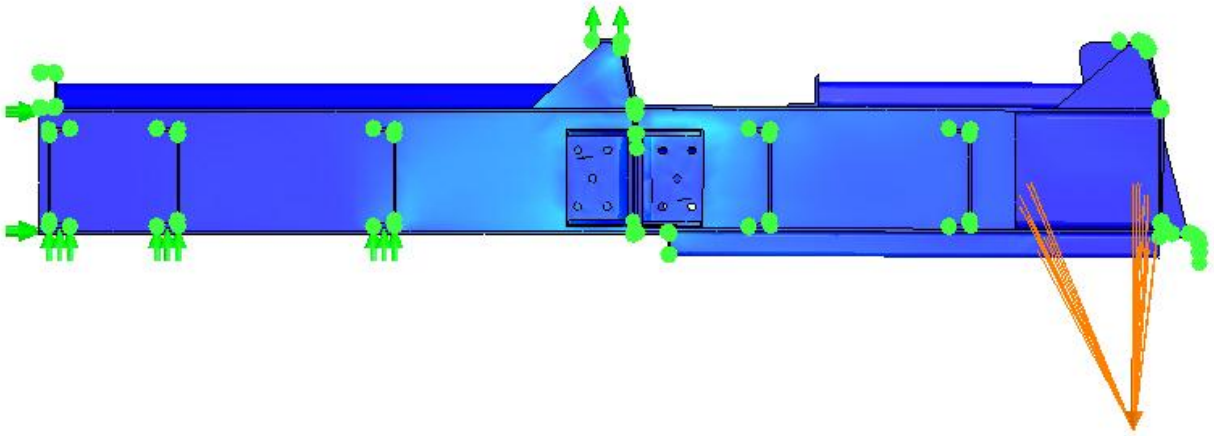


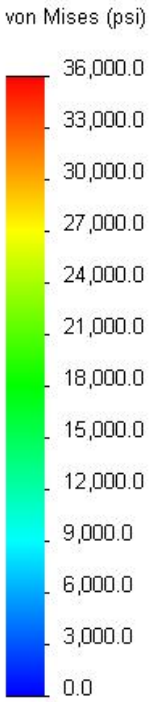


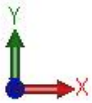



# FEA MODELING STRESS RESULTS
# ROAD LOAD

Model name: davis equipment
Study name: Study 3
Plot type: Static nodal stress Stress1
Deformation scale: 5

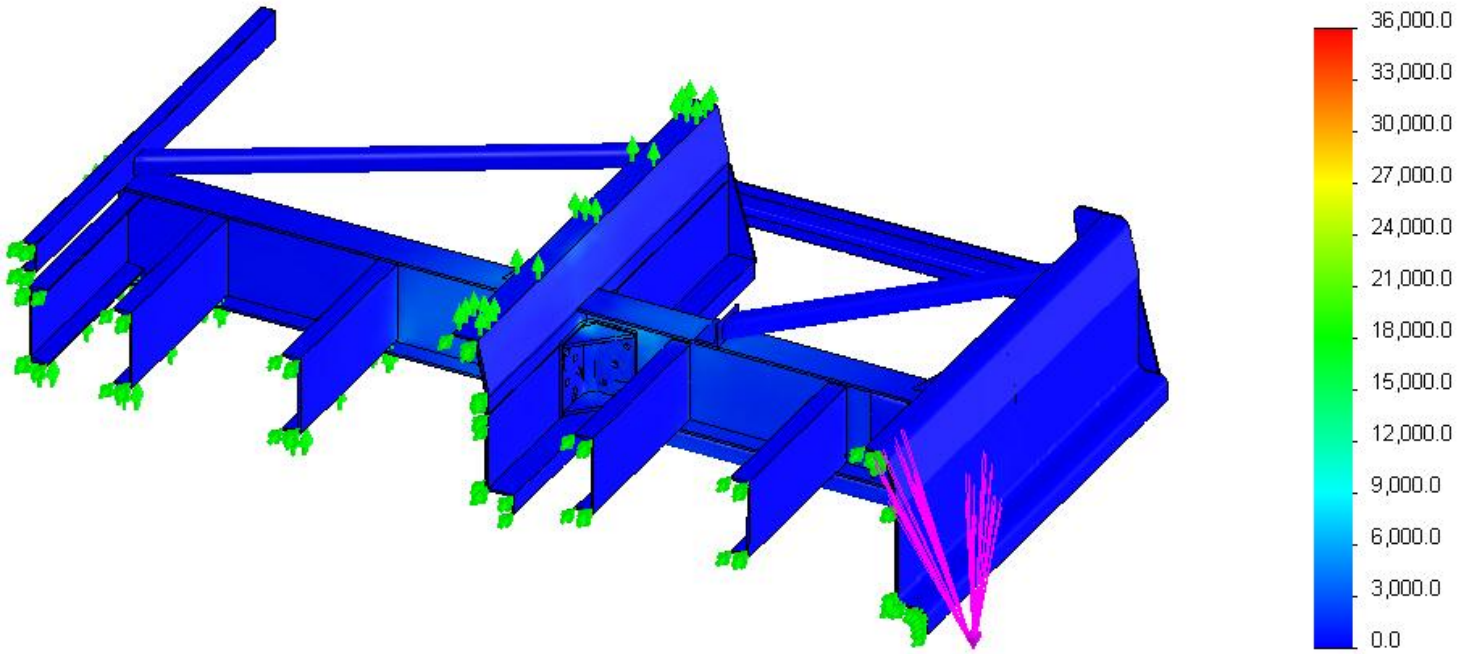


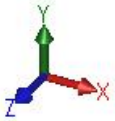


# FEA MODELING STRESS RESULTS
# ROAD LOAD

Model name: davis equipment
Study name: Study 3
Plot type: Static nodal stress Stress1
Deformation scale: 5



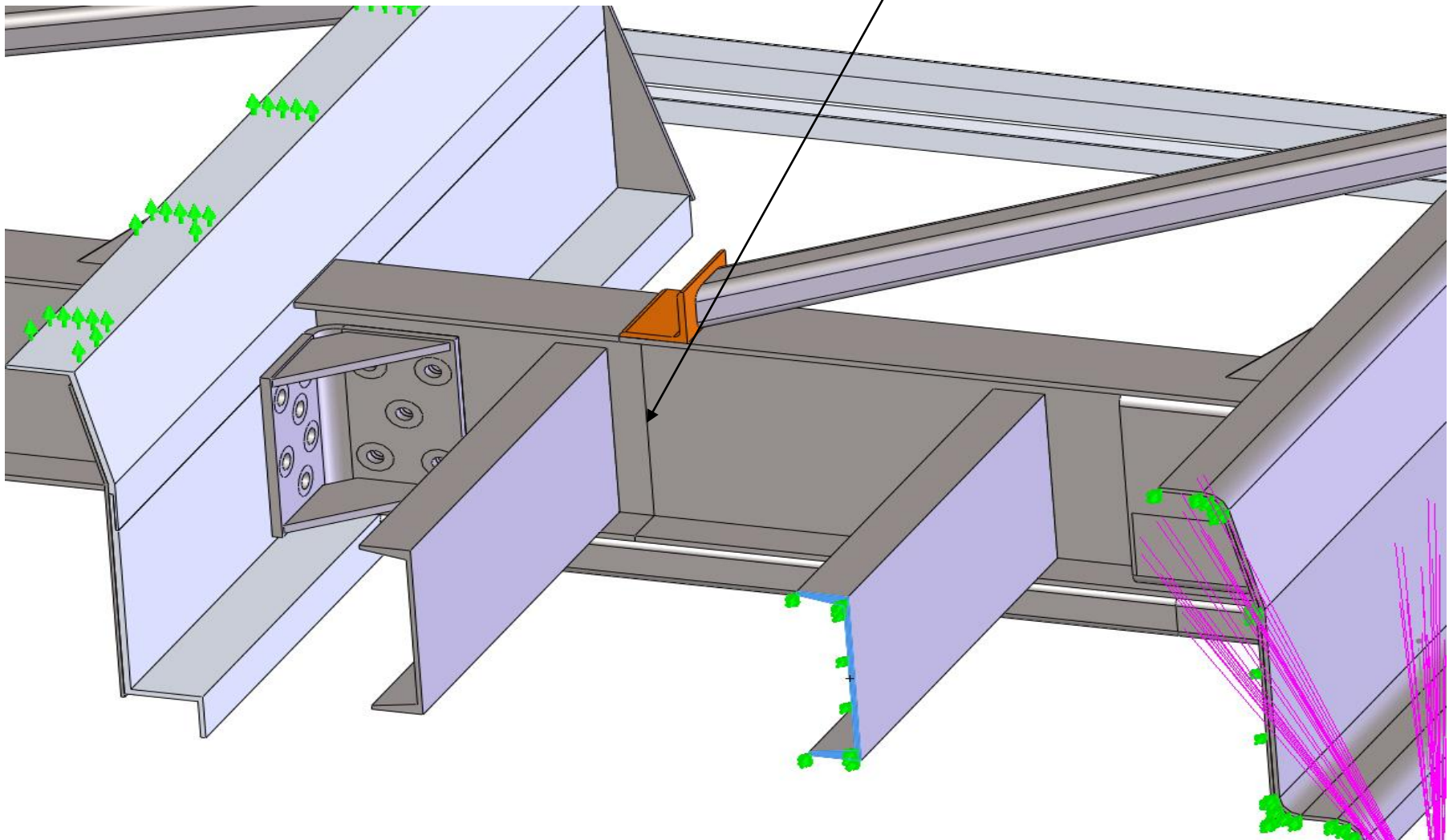



# FEA MODELING RESULTS OF SIMPLIFIED MODEL

THE STRESS RESULTS FGIVEN ABOVE INDICATE THAT THERE IS NO STRESS HIGHER THAN THE MATERIALS YIELD STRENGTH.  TO MODEL THE CONNECTIONS OF THE STRUCTURE WE CREATED A MODEL OF WITH THE RAILS CUT AWAY FROM THE CONNECTIONS UP TO THE FIRST CROSSMEMBER.

WE TOOK DISPLACMENT MEASUREMENTS ALONG THE SPLIT IN THE BOGIE RAIL FOR THE BUMPER STRUCTURE AND USED THOSE VALUES TO LOAD THE CONNECTION MODEL.

# SPLIT LINE IN BOGIE RAIL



# DISPLACEMENTS USED IN CONNECTION MODELS

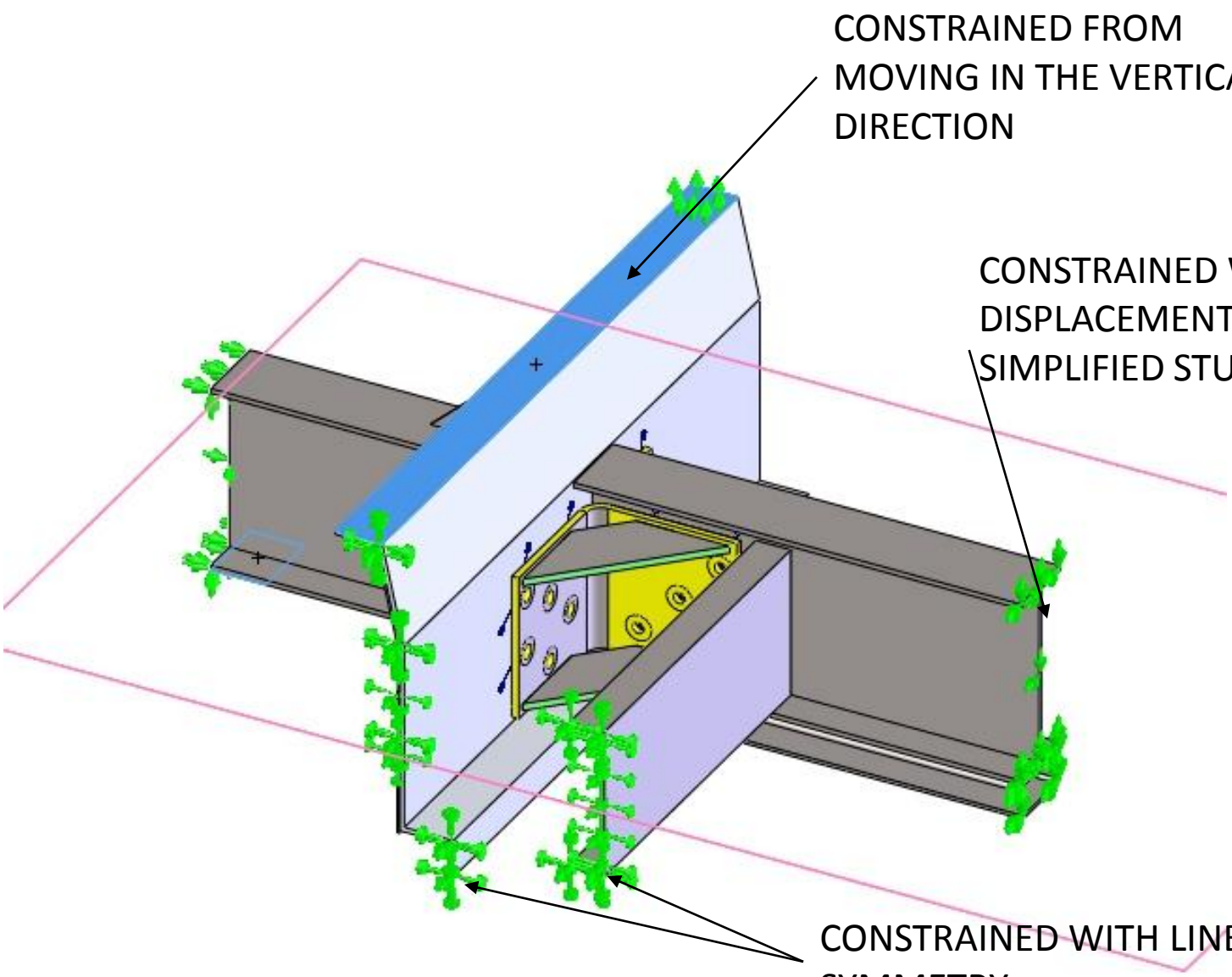
| | | |
|---|---|---|
| **Bumper Load** | | |
| X-Direction Displacement | (in) | |
| Max | 0.04566 | |
| Min | -0.0434 | |
| Average | 0.00088917 | |
| | | |
| | | |
| Y-Direction Displacement | (in) | |
| Max | -0.0899 | |
| Min | -0.09679 | |
| Average | -0.093741 | |
| | | |
| | | |
| Z-Direction Displacement | (in) | |
| Max | -4.31E-04 | |
| Min | -0.0009261 | |
| Average | -0.00025319 | |
| | | |
| | | |
| **Road Load** | | |
| X-Direction Displacement | (in) | |
| Max | 0.006653 | |
| Min | -0.005673 | |
| Average | 0.00052758 | |
| | | |
| | | |
| Y-Direction Displacement | (in) | |
| Max | -0.013431 | |
| Min | -0.01393 | |
| Average | -0.013695 | |
| | | |
| | | |
| Z-Direction Displacement | (in) | |
| Max | 6.54E-05 | |
| Min | -1.01E-04 | |
| Average | 1.99E-05 | |

# BOLTED CONECTIONS TO EXISTING BOGIE RAIL

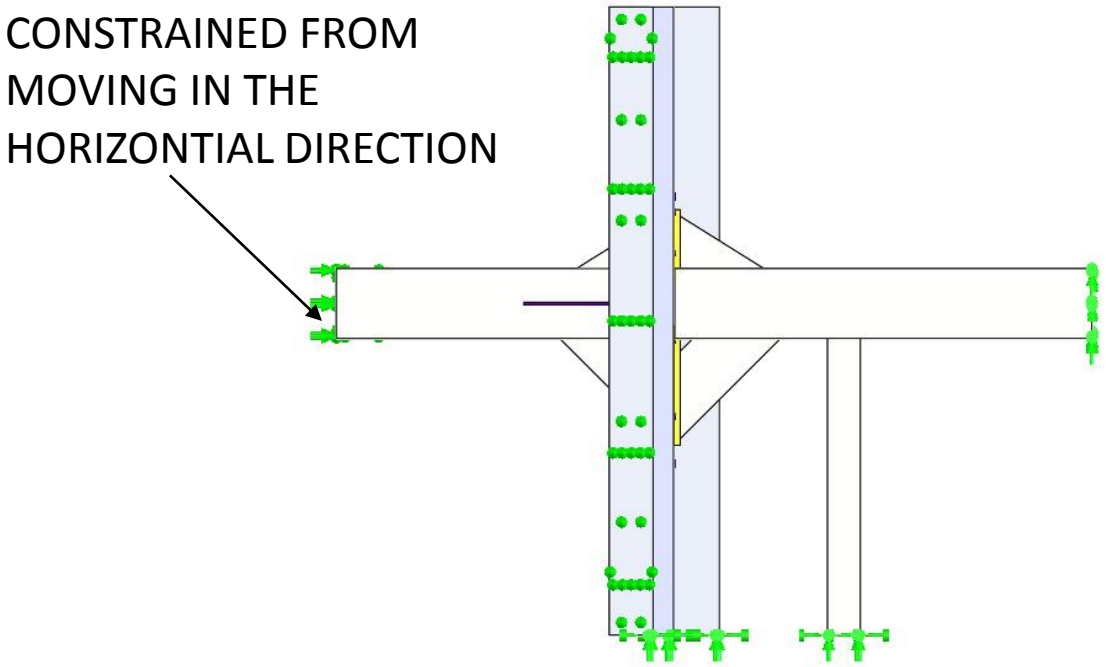
AFTER ANALYZING THE BOLTED CONNECTIONS TO THE EXISTING BOGIE RAIL AND BUTT PLATE IT WAS DETERMINED THAT WELDING THE BRACKETS IN PLACE CREATED A STRONGER CONNECTION.

THE REUSLTS FOR THE WELDED CONNECTIONS ARE GIVEN IN THE FOLLOWING SLIDES.

# FEA CONNECTION CONSTRAINTS



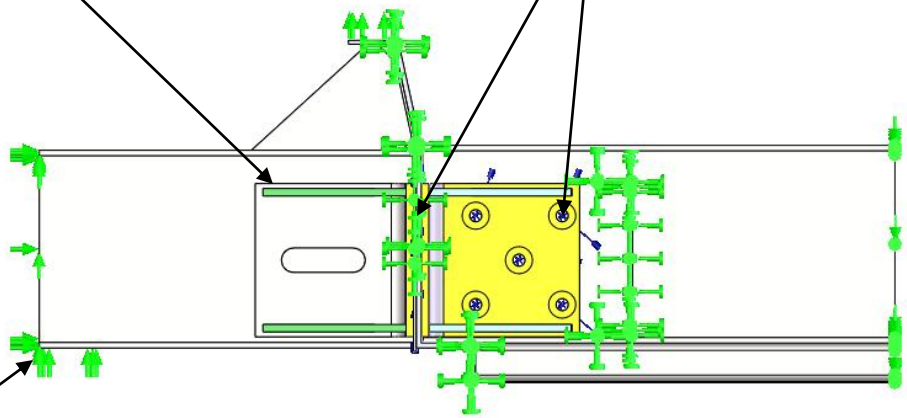
# FEA CONNECTION CONSTRAINTS



# FEA CONNECTION CONSTRAINTS

CONSTRAINED WITH WELDED CONNECTION

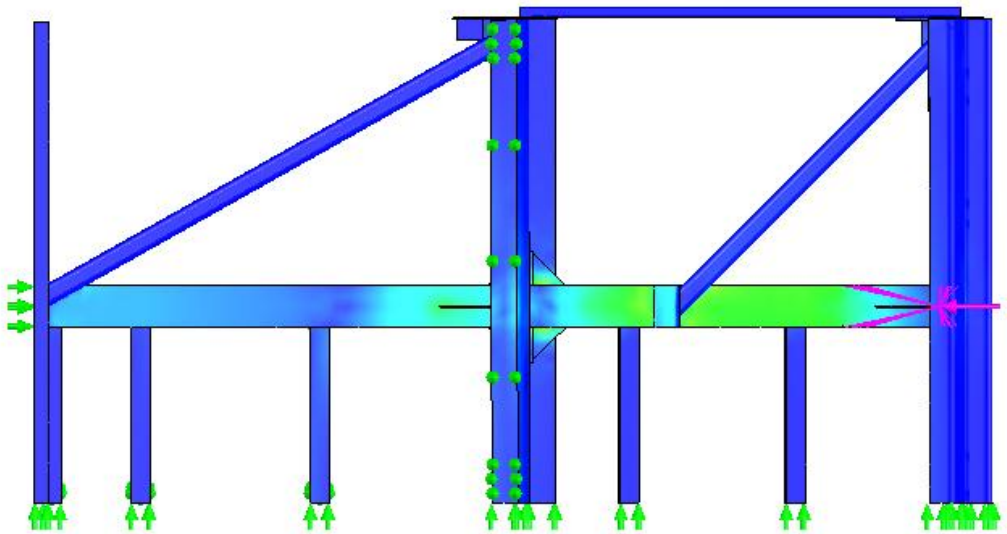
CONSTRAINED WITH BOLTED CONNECTION

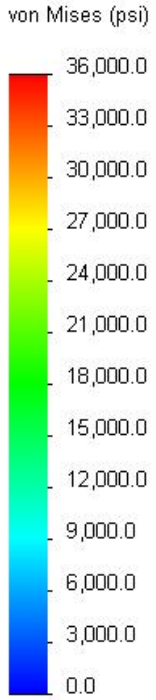


CONSTRAINED FROM MOVING IN THE VERTICAL DIRECTION

# FEA MODELING STRESS RESULTS

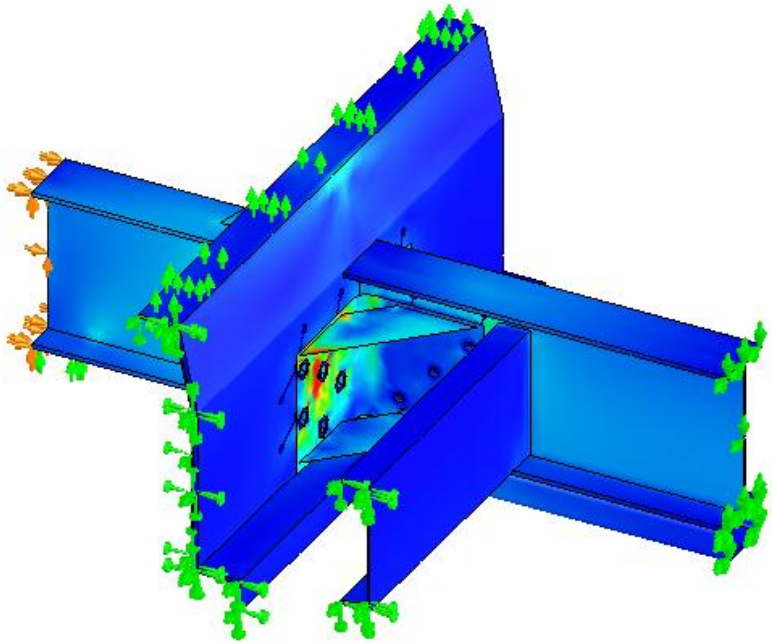
Model name: davis equipment
Study name: Study 2
Plot type: Static nodal stress Stress1
Deformation scale: 5

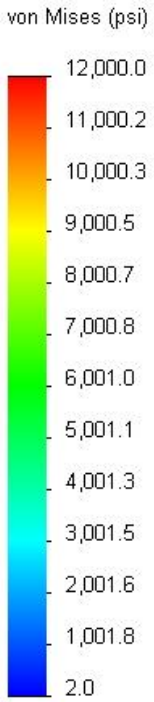


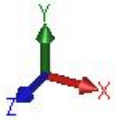



# FEA MODELING STRESS RESULTS ROAD LOAD

Model name: davis equipment bettwork
Study name: Study 8
Plot type: Static nodal stress Stress1





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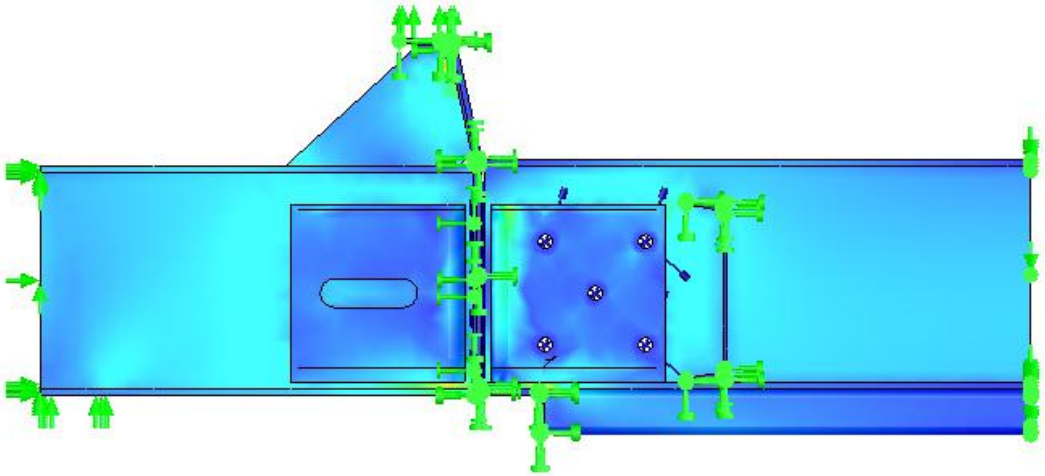
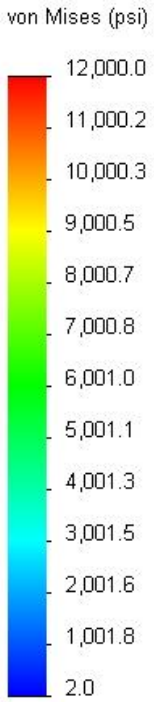
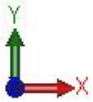
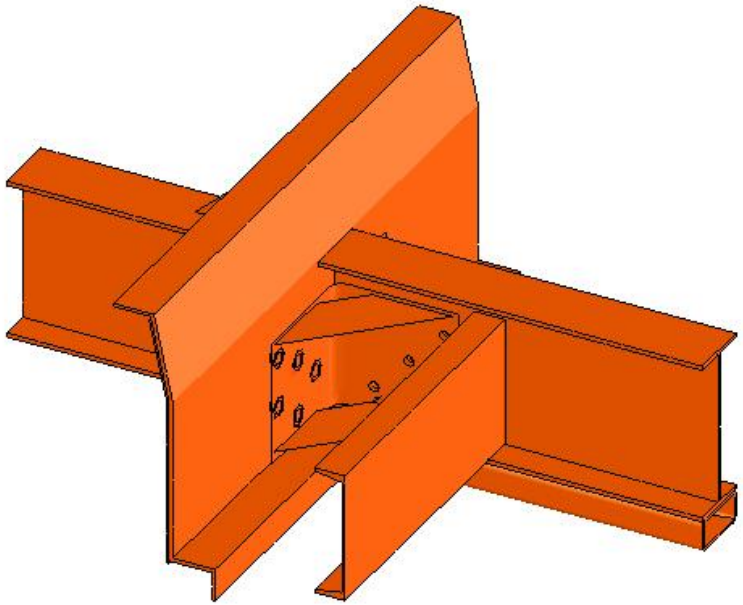


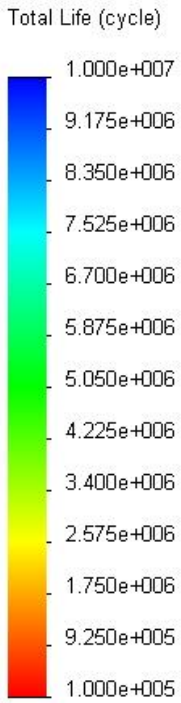


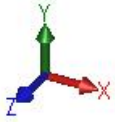



# FEA MODELING FATIGUE LIFE ROAD LOAD

Model name: davis equipment bettwork
Study name: Study 9
Plot type: Fatigue(Life) Results2





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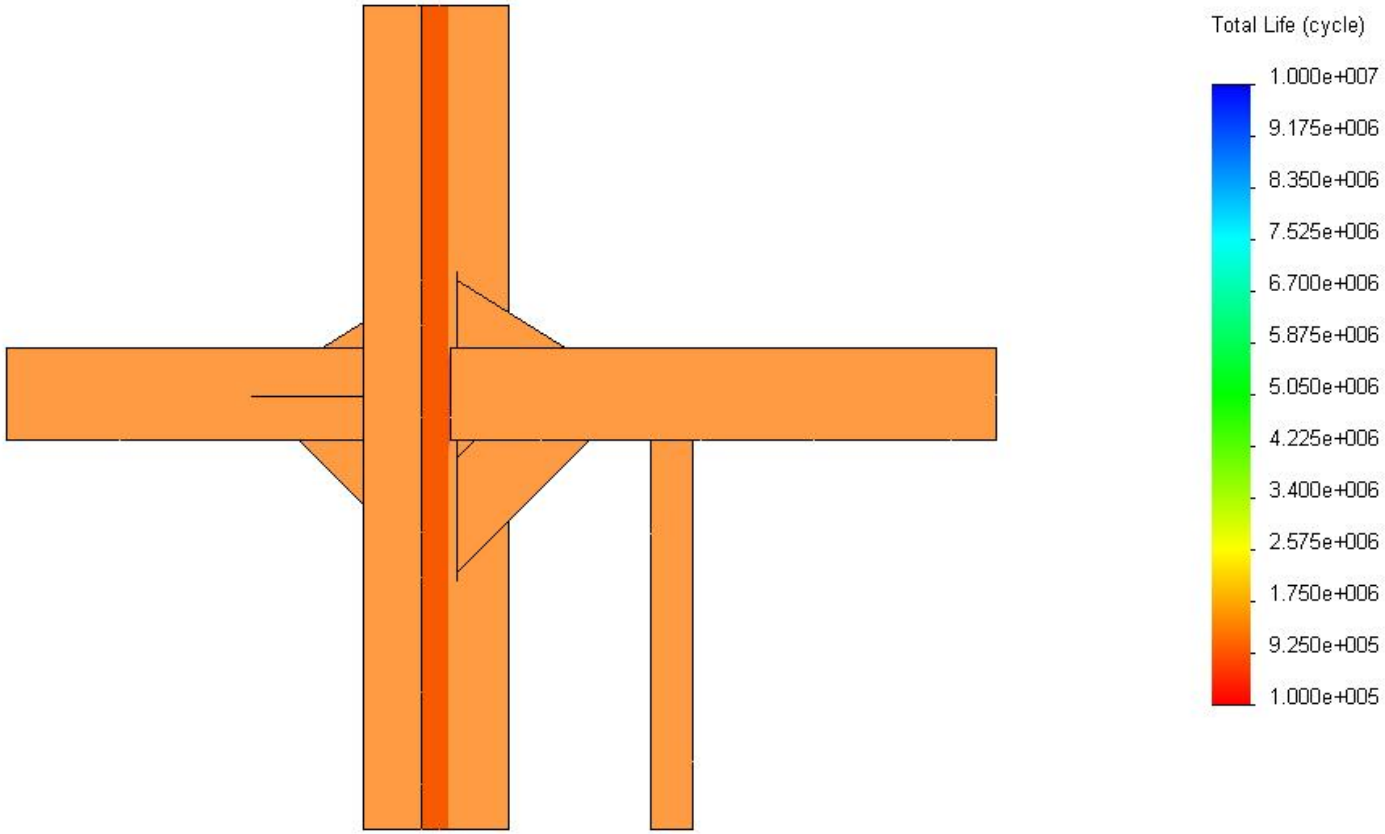
Study name: Study 9
Plot type: Fatigue(Life) Results2



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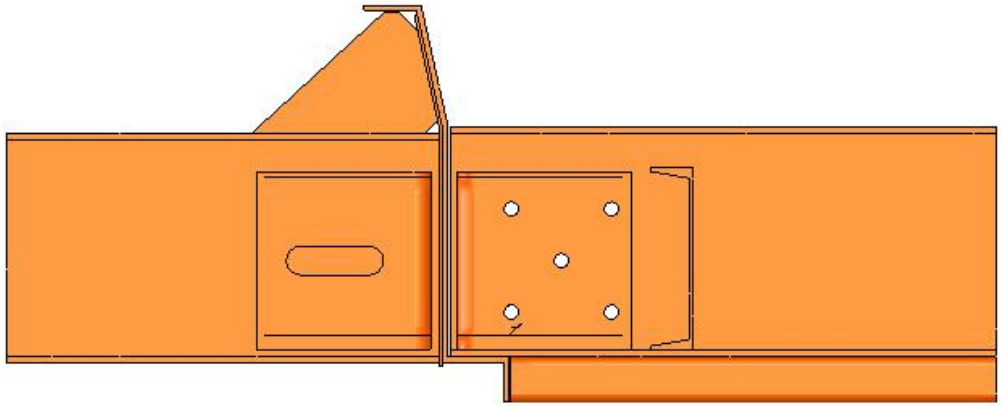
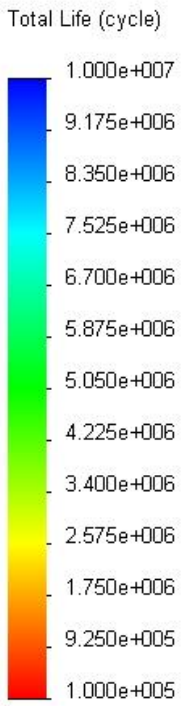
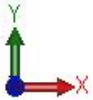
Study name: Study 9
Plot type: Fatigue(Life) Results2

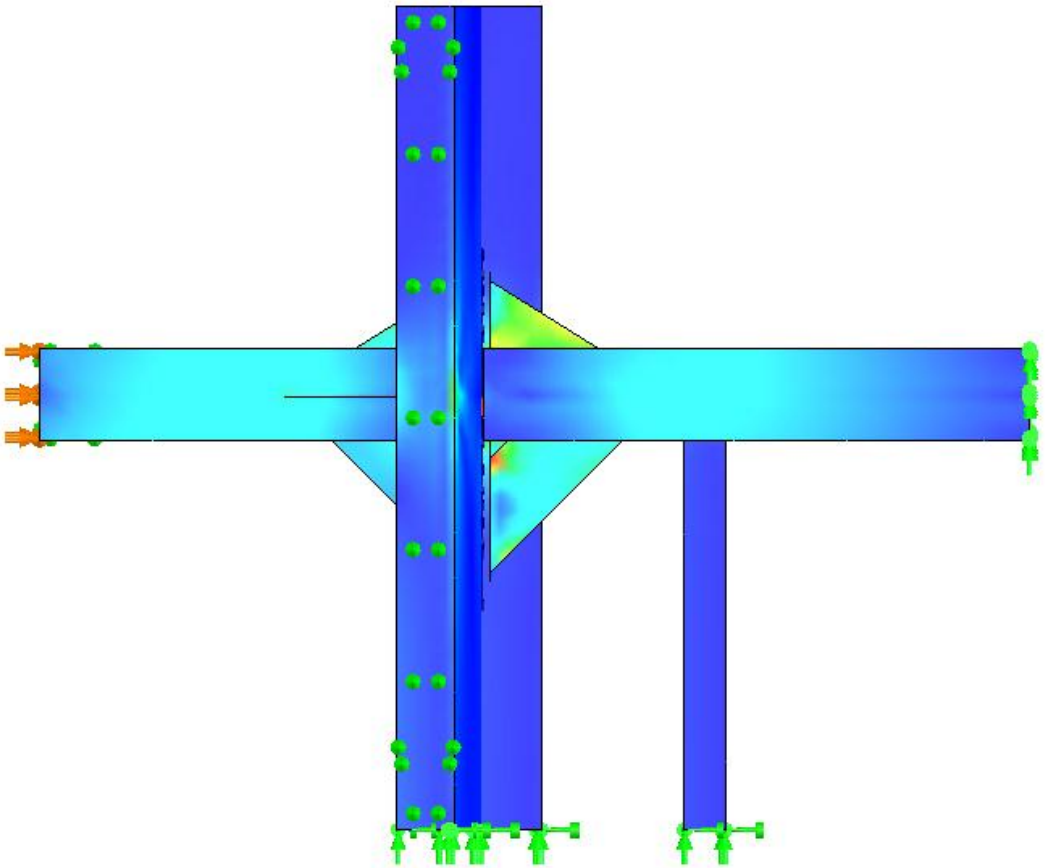


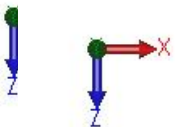


# FEA MODELING STRESS RESULTS ROAD LOAD

Model n
Study n Model name: davis equipment bettwork
Plot typ Study name: Study 11
Deforma Plot type: Static nodal stress Stress1



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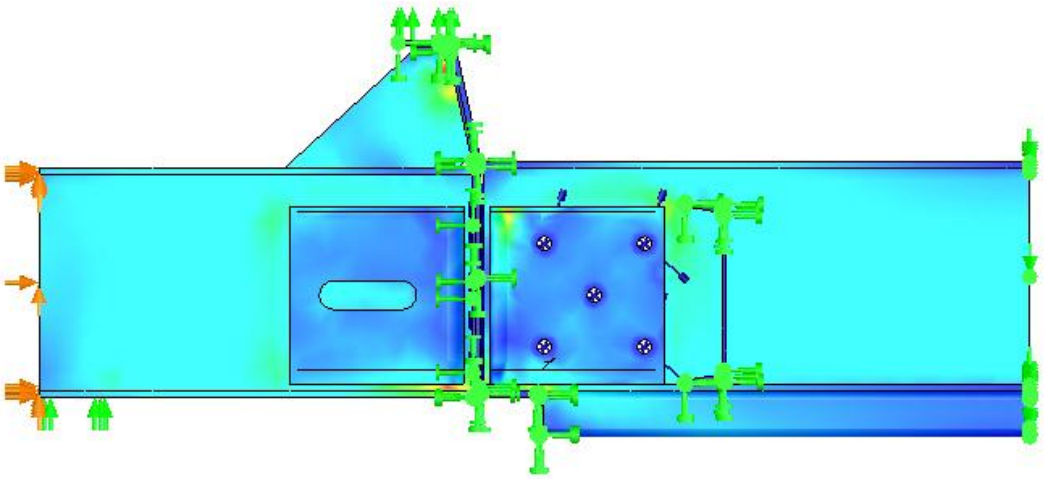
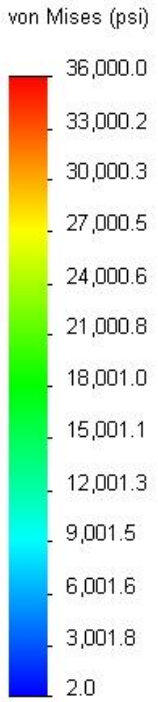
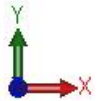
Plot type: Static nodal stress Stress1

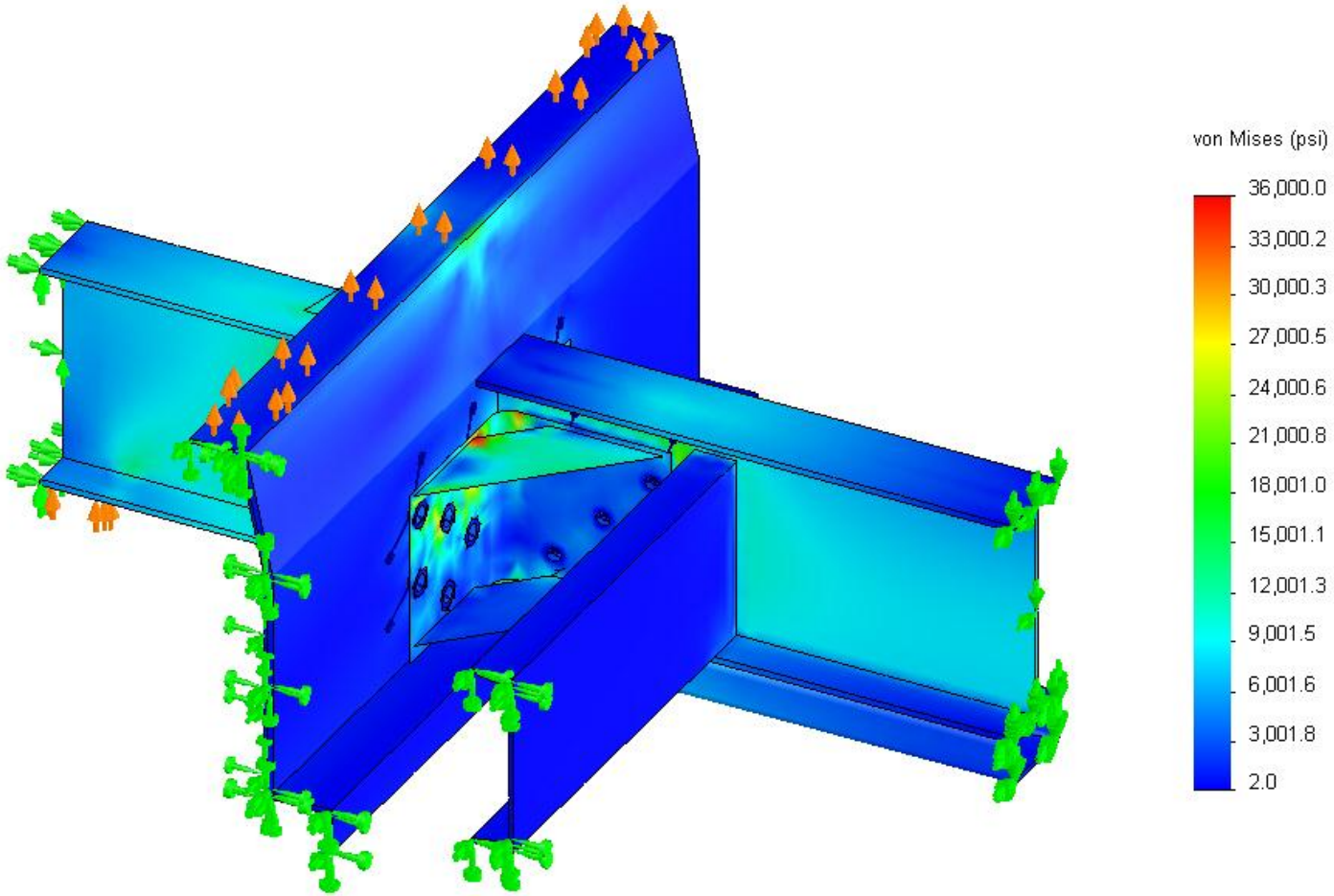


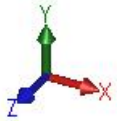


# FEA MODELING STRESS RESULTS
# ROAD LOAD

Model name: davis equipment bettwork
Study name: Study 11
Plot type: Static nodal stress Stress1



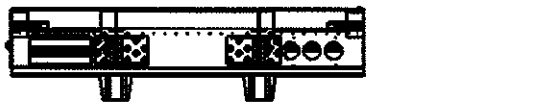



# CONCLUSION

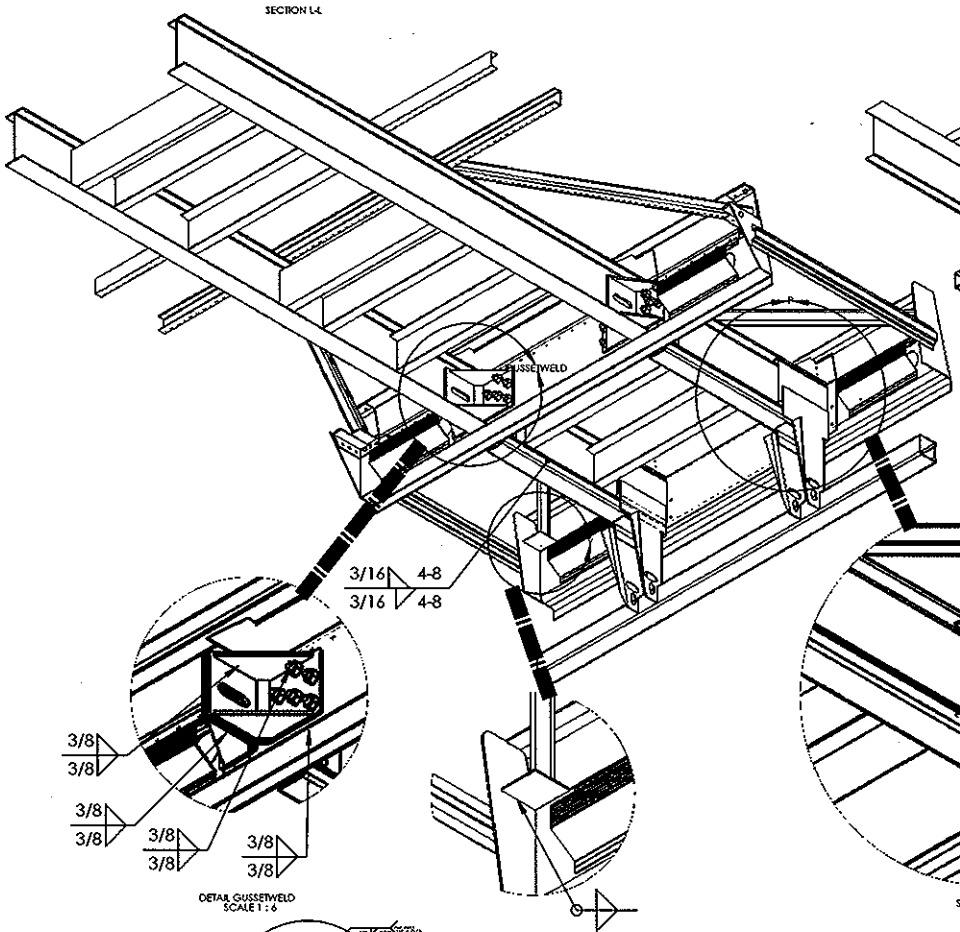
IN CONCLUSION THE BUMPER STRUCTURE AS ORGINAL DESIGNED WITH THE BOLTED GUSSETS TO THE FRAME BOGIE RAILS AND THE SPACER TUBE FOR THE BUMPER ONLY COVERING THE BUMPER WOULD NOT HAVE BEEN STRONG ENOUGH.

WELDING THE GUSSETS TO THE WELD PAD ON THE BUTT PLATE AND TO THE FRAME BOGIE RAILS STIFFENS THE GUSSETS REDUCING THE STRESSES GIVING A LONGER FATIGUE LIFE. THE TUBE EXTENSION REDUCES THE MONEMT IN THE BUMPERS RAIL REDUCING BENDING IN THE EVENT OF AN IMPACT. THESE MODIFICATION HAVE MADE THE BUMPER AND STRUCTURE PERFORM SATISFACTORY IN A REAR IMPACT PER THE FMVS 223 STANDARD AND IN A SUPPORT ITSELF WHILE IN SERVICE.

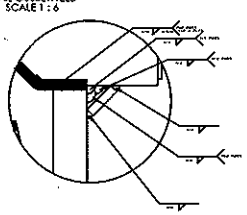
THIS FEA STUDY ASSUMES THAT THE BUMPER IS INSTALLED IN CONTROLLED ENVIORMENT BY QULAIFIED MECHANICS AND WELDERS USING AWS RECOMMONDED WELDING PROCEDURES. THE BUMPER STRUCTURE HAS ONLY BEEN DESIGNED TO RESIST THE REAR IMPACT AND SUPPORT ITSELF IN A ROAD GOING MANNER.



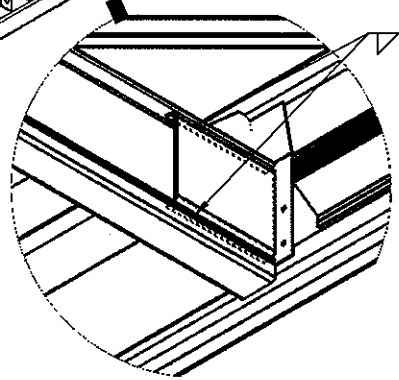
SECTION L-L



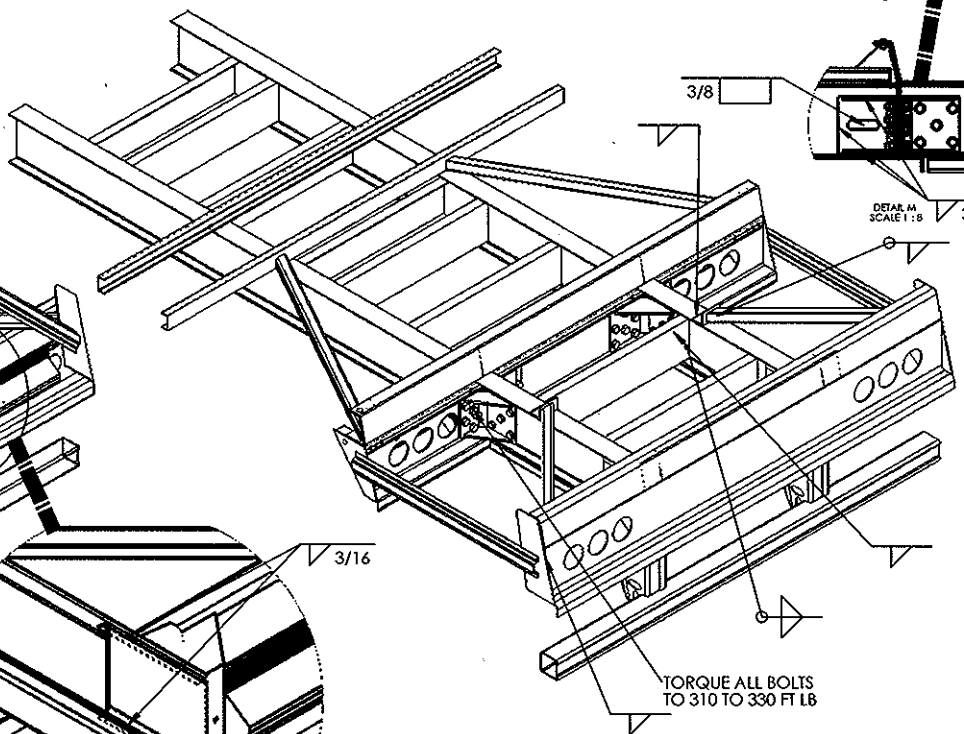

DETAIL GUSSETWELD
SCALE 1 : 6

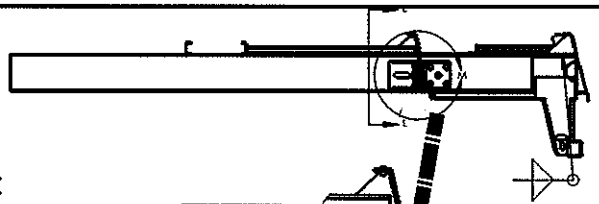


DETAIL Y
SCALE 1 : 5




DETAIL P
SCALE 1 : 5




UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
FRACTIONS: ±1/16"
DECIMAL: 0.XX = ±0.03 0.XXX = ±0.010
ANGLES: ±1°



REVISION

| LTR | DATE | DESCRIPTION | BY | ECR # |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

SCALE NONE
DWN BY MNT
REF #
WEIGHT
DATE 3/10/12

MERRITT EQUIPMENT CO.
9339 BRIGHTON RD. HENDERSON COLORADO 80640

TITLE EXTENSION, REAR FRAME
DAVIS EQUIPMENT

DWG 82-9532-007 SHT 1 OF 1 REV -