ADVANCED STRUCTURAL MATERIALS FOR POWER SUBSTATIONS

Team Members: Arnold Ignacio, Angelica Ibarra, Sako Garoian, Jonathan Gaytan, Tony (Dongwei) Chen
Faculty Advisor: Dr. Stephen Felszeghy
Southern California Edison (SCE) Liaison: Andrew Kao, PE & Jin Yoon, SE
Department of Mechanical Engineering
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

Fig. 1 SCE MESA Substation

Background

The electricity that charges your phone and powers your home appliances comes from your local power stations. Electrical power substations are facilities with very high voltage lines (Fig 1.) Such power substations convert voltage systems from power transmission levels to distribution levels. SoCal Edison (SCE) is in the process of constructing a 500kV power station in their MESA facility. SCE wants to eliminate the use of steel in their A-Frames. A-frames are the structures that uphold the high voltage lines. These high voltage lines, when in contact with the steel, poses a large safety concern to SCE employees. The safety concern is the driving force for SCE desire to eliminate the use of steel.

Objective

To find a non-conductive composite material that can sustain, with sufficient strength and stiffness, the design loads of the steel A-frame. It should also withstand the wears of the environment such as the heat from the sun, rain, and UV exposure. The material shall serve as a non-conductive substitute for steel in power substation A-frames, dead-ends, and equipment racks.

Requirements

The composite material shall meet the following requirements:

1. It shall withstand environmental factors but not be limited to UV radiation, rain, wind .
2. It shall mimic material values for ASTM 992 Steel
   - Ultimate Tensile Strength of 65ksi
   - Yield Strength of 50ksi
   - Youngs Modulus 190-210-GPa
3. The material shall serve as a non-conductive substitute for steel, with an electrical conductivity close to or equal to 0.

Design Approach

SCE's interest in the FRP influenced the material choice. Fiber Reinforced Polymers (FRP) is one of the few composite material being used heavily in today's structural industry. The team had to redesign the current beams being manufactured to create members suitable for replacement of steel in dead-end (A-frame) structures. The approach in developing a new dimension for the beam was by matching the product of E (Elastic Modulus) with I (Second Moment of Inertia) of the steel members (W18x65, W10x49).

Fig 2. A FRAME structure CAD, Steel (left) FRP (Right)

Fig. 3 Longitudinal loading, buckling is observed

Material Testing

Electrical :
In order to calculate the materials electrical conductivity, a multimeter was used to measure the electrical resistivity of the FRP beams.

Mechanical:
A four-point load test was conducted resembling the manufacturers test, to compare the deflection and the Young Modulus property of the material.

Fig. 4 Vertical loading, shear failure is observed

FEA Analysis Results

Two Finite Element Analyses were conducted to compare the performance of the A-frame structure made from the FRP material (Fig. 2), using the proposed beam dimensions, to the original steel A-frame structure (Fig. 3.) According to the FEA results, the FRP model performed well when compared to the steel model. The FRP model observed very minimal stresses for a model of its size. Furthermore, the FRP model experienced a deflection of 11% greater than the steel model, which is acceptable.

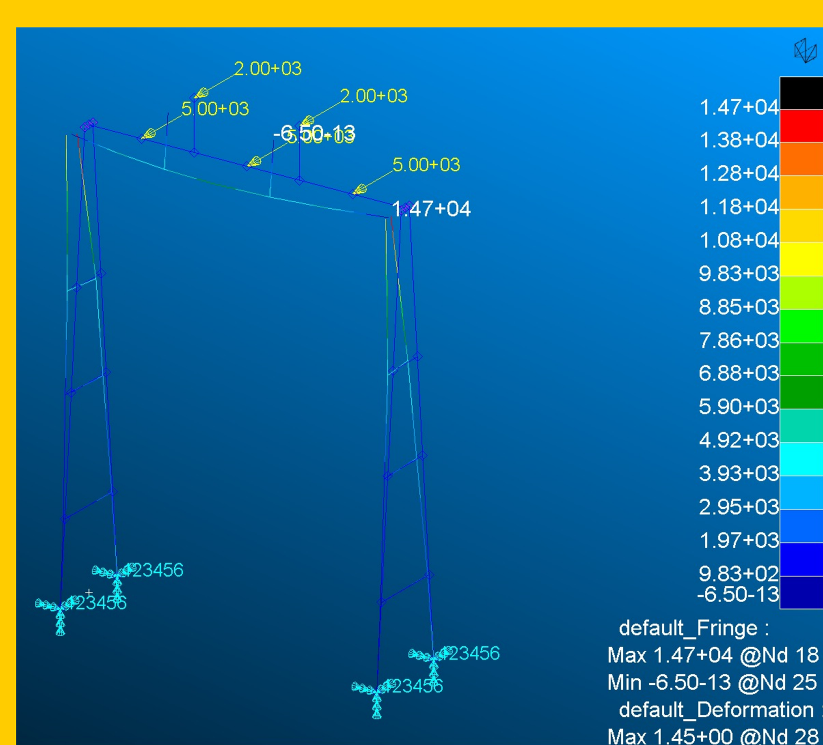

Fig. 6 FEA, Total Max Stress and Deflection of steel model.

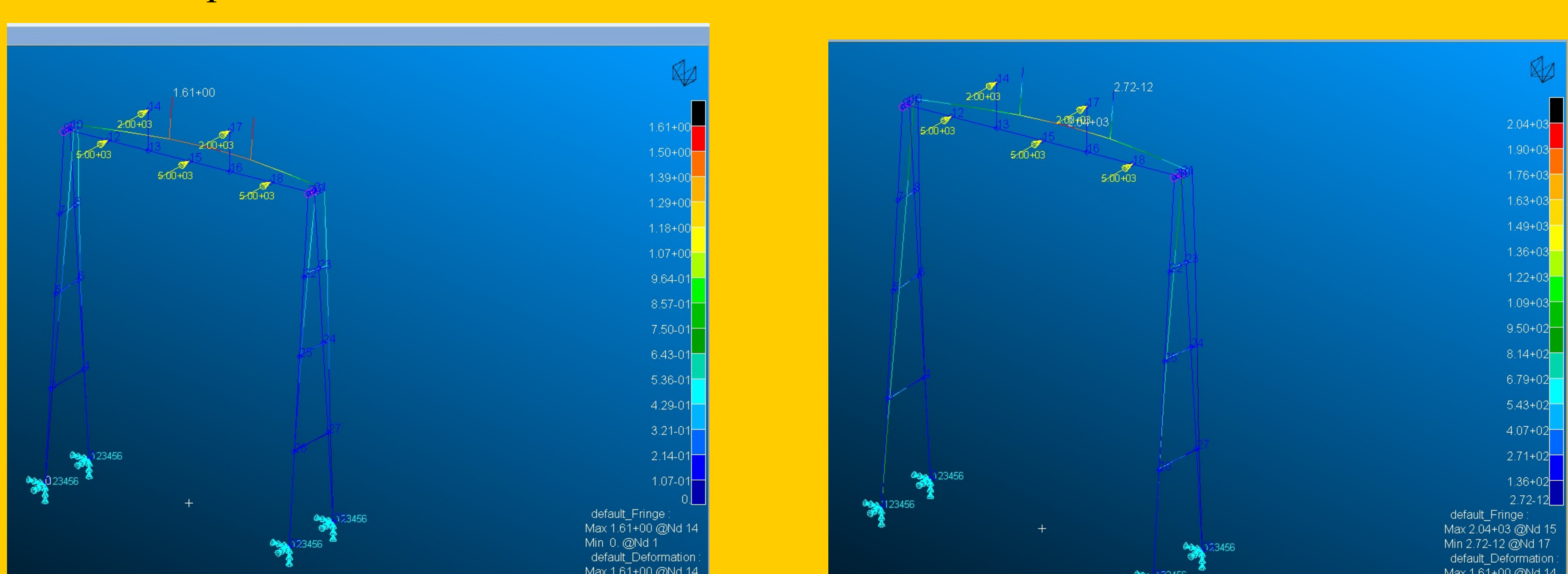

Fig. 5 FEA, Deflection (Right) and Total Stress (Left) of FRP model.

Conclusion

- Since the multimeter did not read very high resistivity, it can be concluded that the material does possesses very low, to almost 0 electrical conductivity.
- In longitudinal loading the beam experienced buckling while in vertical loading the beam experienced shear.
-The team proposes a 22"x22" 1" wall thickness rectangular beam in combination of a 20"x10" 1" wall thickness rectangular beam suitable for the A-frames.

SCE Team 26: (Left to right): Dr. Stephen Felszeghy, Angelica Ibarra, Sako Garoian, Tony (Dongwei) Chen, Jonathan Gaytan, Arnold Ignacio

THANK YOU TO DR. STEPHEN FELSZEGHY FOR HIS DEDICATION TO THE TEAM.