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سایت آموزش مهندسی مکانیک ایران

Stress Analysis Using ANSYS

The Composite Recurve Bow

ME 450 Project, Fall 2000

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Project Goals

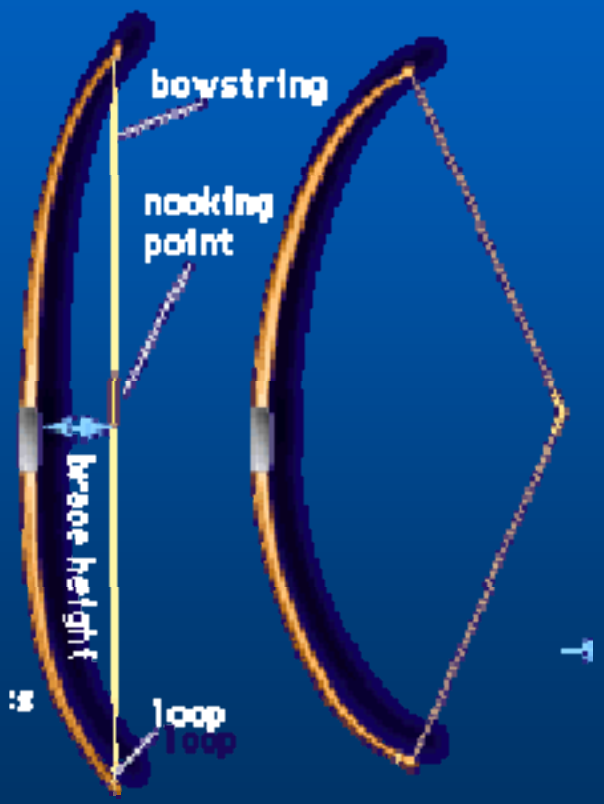
- **Create Model Using Pro E**
- **Mesh, Constrain, and Apply String Displacement to Model**
- **Obtain Displacement and Stress Solution For Each Composite Bow Using ANSYS Finite Element Analysis Software**
- **Compare Results**

The Early Bow

- Known to Neolithic hunters, clearly depicted in cave paintings of 30,000 B.C.
- In its simplest form, the bow consisted of a single piece of wood slightly bent by the tension of a bowstring connecting its two ends.
- The bow stores the force of the archer's draw as potential energy, then transfer's it to the bowstring as kinetic energy, imparting velocity and power to the arrow.
- The total amount of potential energy that an archer could store in the bow was a function of the bow's length.
- The more energy stored per unit of work is contained within the draw length.

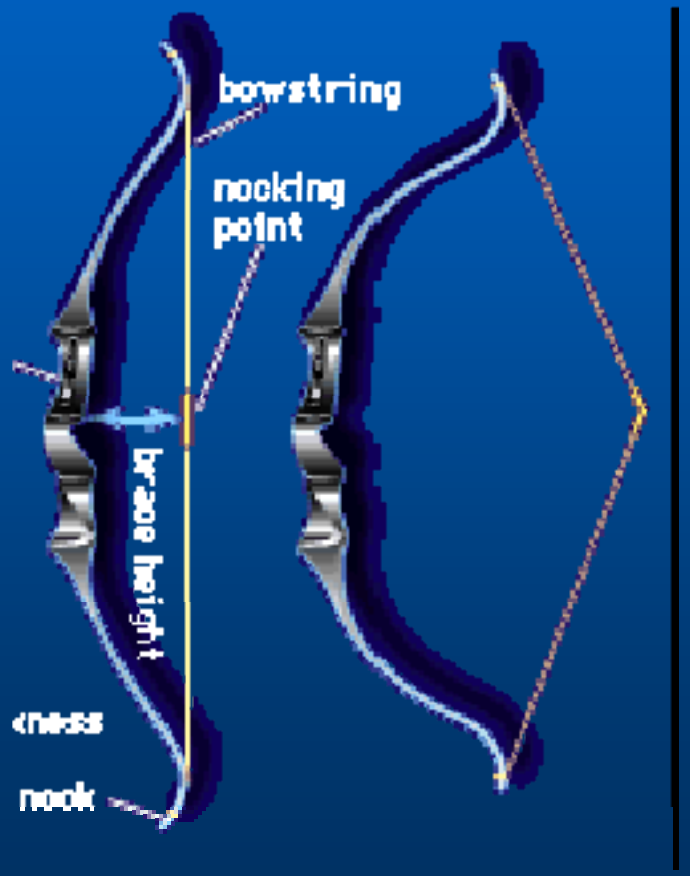
The Early Bow

- The longer bow's more massive arms accelerated slowly, a longer bow transmitted kinetic energy to the string and arrow at a lower velocity.
- The shorter bow's stored less energy for the same amount of work expended in the draw, but transmitted the energy to the arrow, at a higher velocity.
- In sum, the shorter bow transmitted less total energy to the arrow, but it did so at a higher velocity.
- Maximum range was attained by stiff short bows shooting a very light arrow.
- Maximum power, at medium ranges, was attained by a long bow driving a relatively heavy arrow.



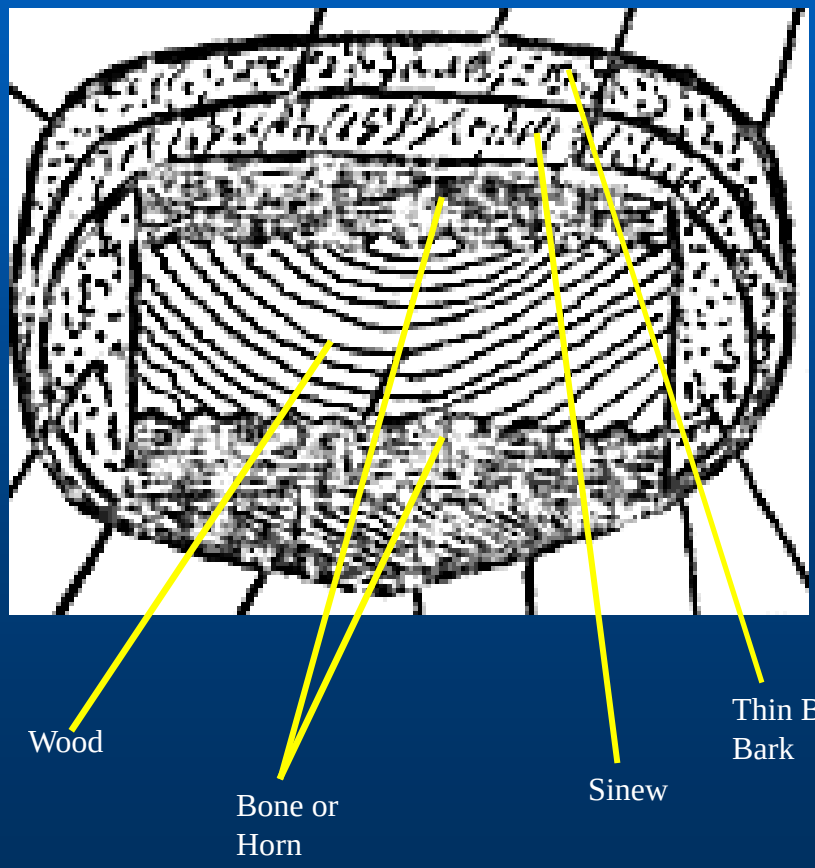
The Recurve Bow Is Born.

- The recurve bow has limbs that curve forward prier to loading.
- When loaded with a string these limbs offer a mechanical advantages over the traditional long bows because the sting is closer to the handle allowing for a greater draw length which accounts for an increase in stored energy.



The Early Composite Bow

- It is common belief that composite bows are of recent origin.
- However, there have been composite bows identified to have originated earlier than 1200 B.C.
- These ancient composite bows are believed to be of Assyrian Origin.
- Made of wood, bone/horn, sinew, thin strips of birch bark, and glue.

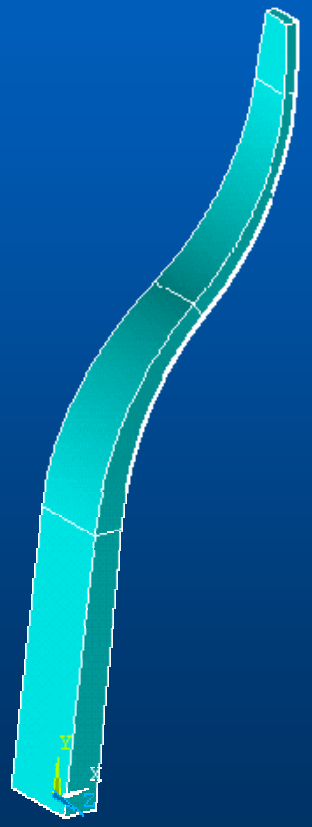


Composite Materials

- **Composite- A solid material that results when two or more different substances, each with its own characteristics, are combined to create a new substance whose properties are superior to those of the original components in a specific application.**
- **This is achieved by embedding fibers of one substance in a host matrix of another.**
- **Binding the fibers together using an adhesive, the rigid fibers impart structural strength to the composite, while the matrix protects the fibers from the environmental stress and physical damage and offers thermal stability.**

Procedure

- Created the solid model in Pro Engineer using the advanced modeling technique: Swept Blend.
- Because the bow is symmetric, only half the bow is modeled.
- Exported this file to ANSYS as an IGIS file.
- Import failed partially by not recognizing the solid, hence the model was completed using ANSYS modeling techniques.



Meshing

- Once all of the area's are segmented, the entire volume is meshed.
- A Beam was added from the central node at the top of the bow straight down to the midpoint of the bow to represent the string.

Model with Constraints Applied

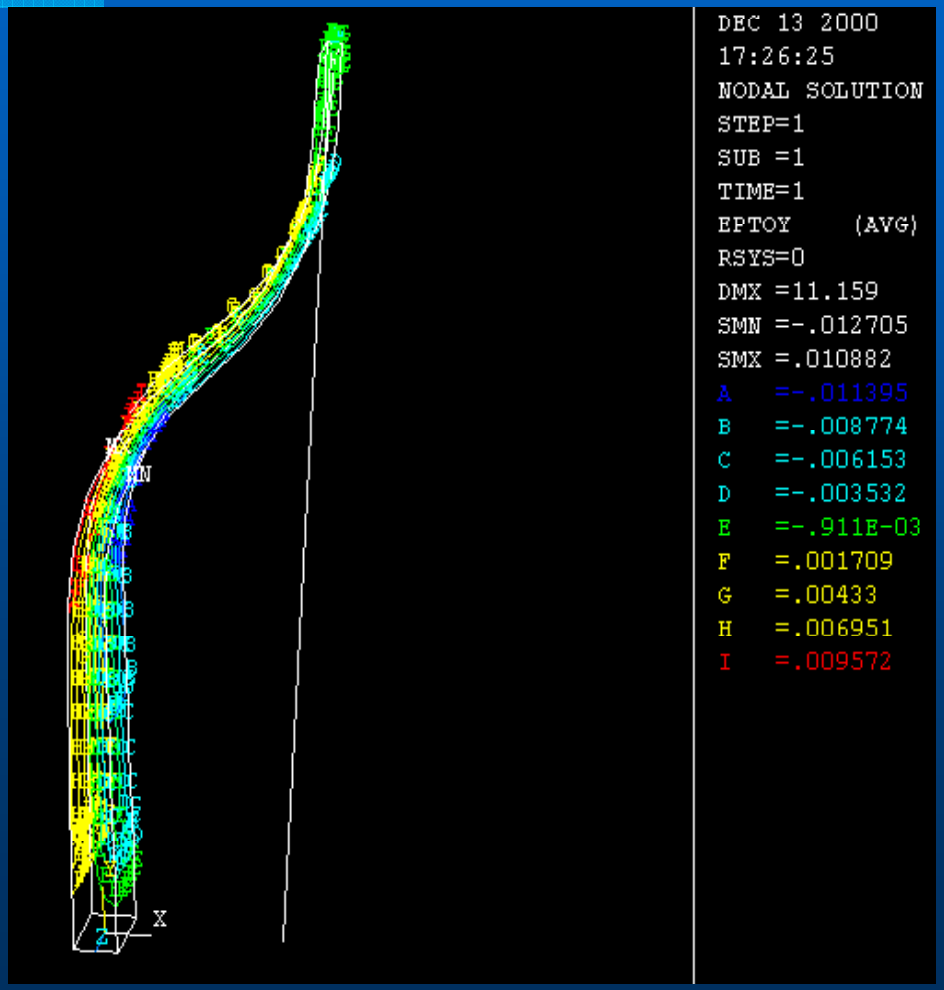
- After meshing is complete the constraints are applied
- The model was constrained in All DOF for the bottom three layers to simulate a persons hand gripping the bow.
- The bow itself was constrained in the z direction and also the rotational x and y directions.
- The base point of the string was allowed to move in the x direction only with rotational freedom in Z.

Analysis

- This projects analyzes an A and B comparison between two composite materials.
- Materials used: Graphite Epoxy and Glass Epoxy
- This comparison will determine which epoxy yields less stress for a standardized displacement on the bow string.

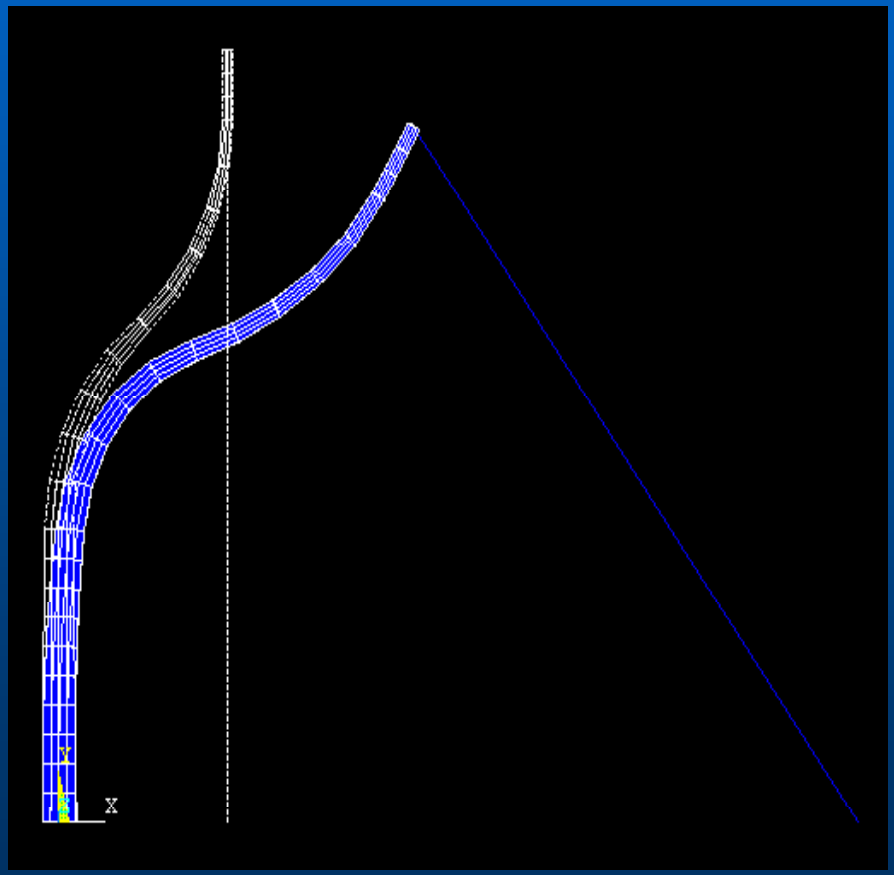
Initial Stress Generated From String

- When the string is attached to the bow it generates an initial strain and stress.
- This initial strain was selected to be 5% of initial length.
- This plot shows the initial stress on the bow when the string is applied.



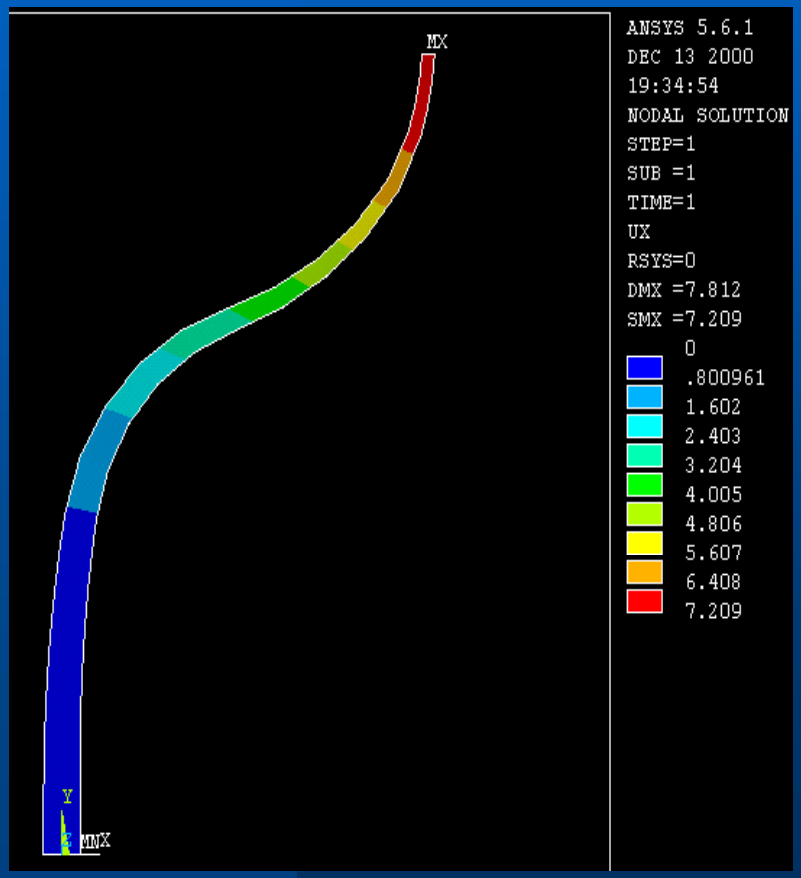
Analysis

- For the analysis section, a displacement was given to the base string node.
- This displacement was based on an average persons draw length of 28 inches.
- This plot demonstrates the displacement that occurs and the resulting deformation of the bow.

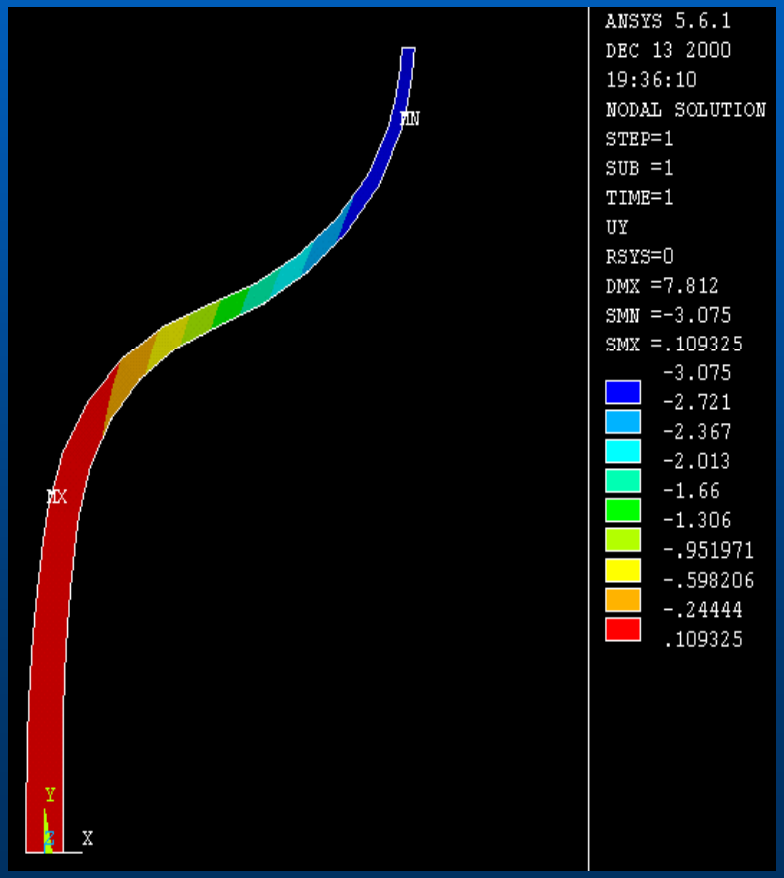


Displacement Results For Graphite Epoxy

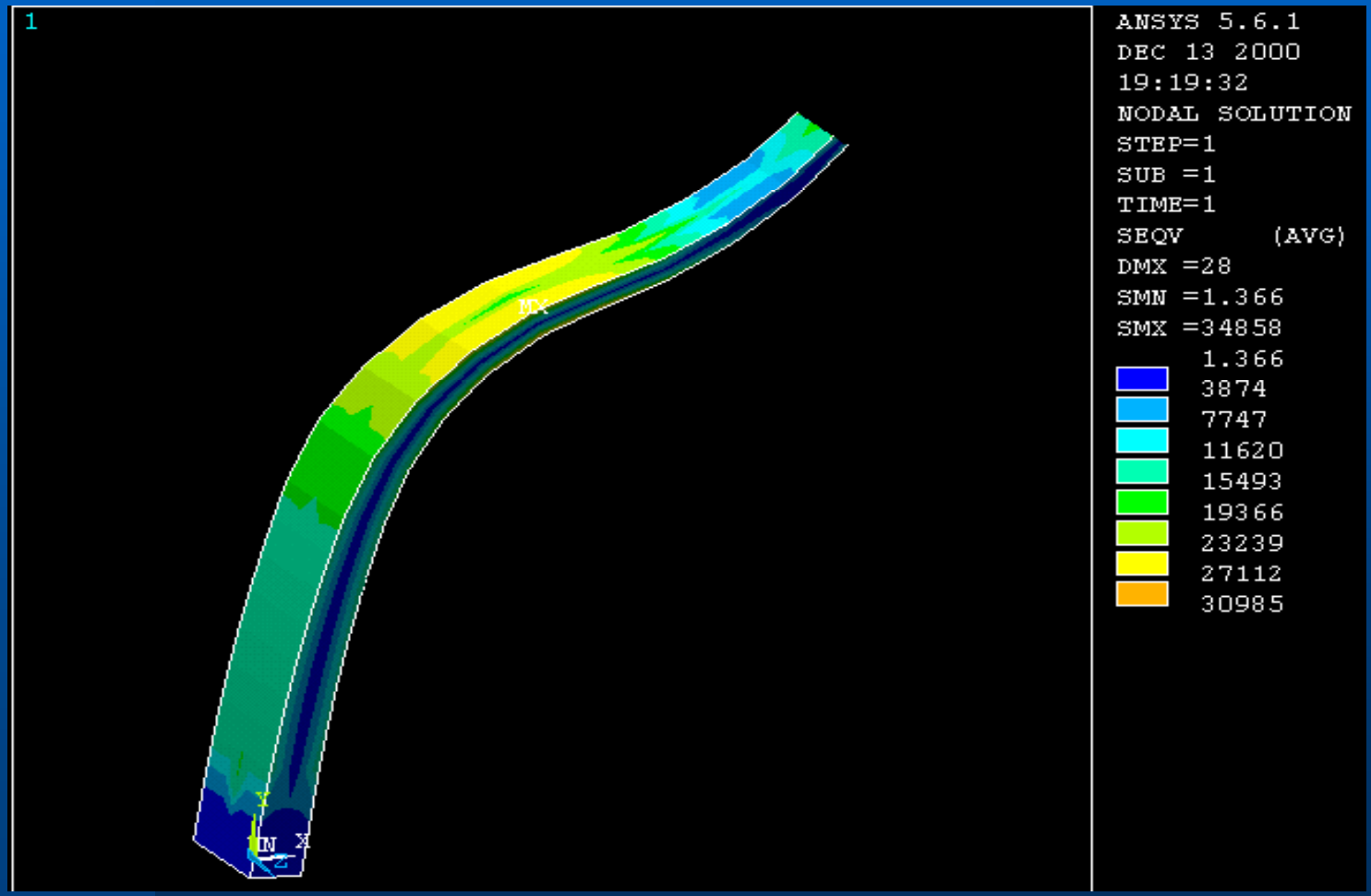
X-Displacement



Y-Displacement

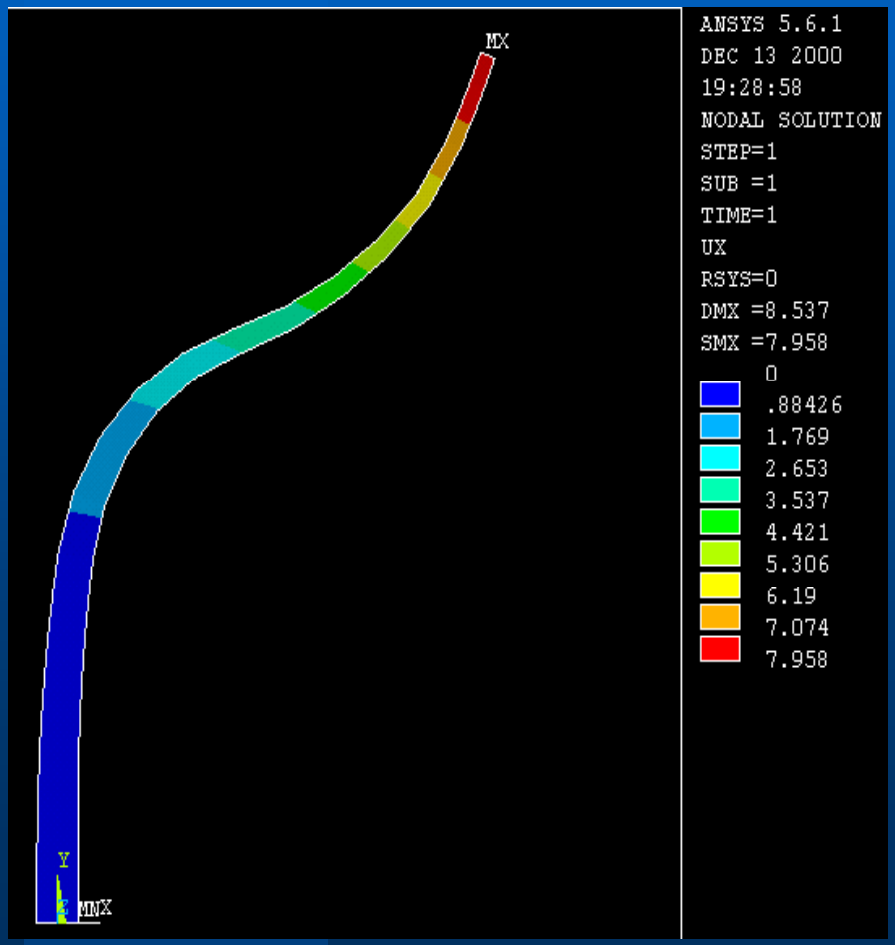


Stress Plot For Graphite Epoxy

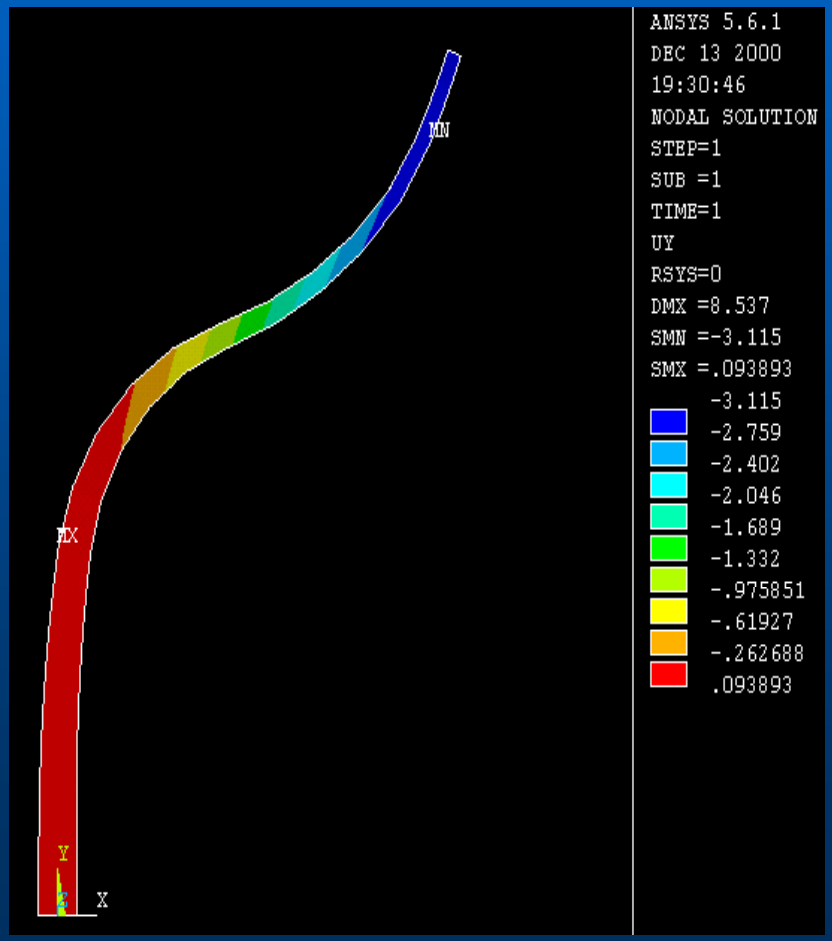


Displacement Results For Glass Epoxy

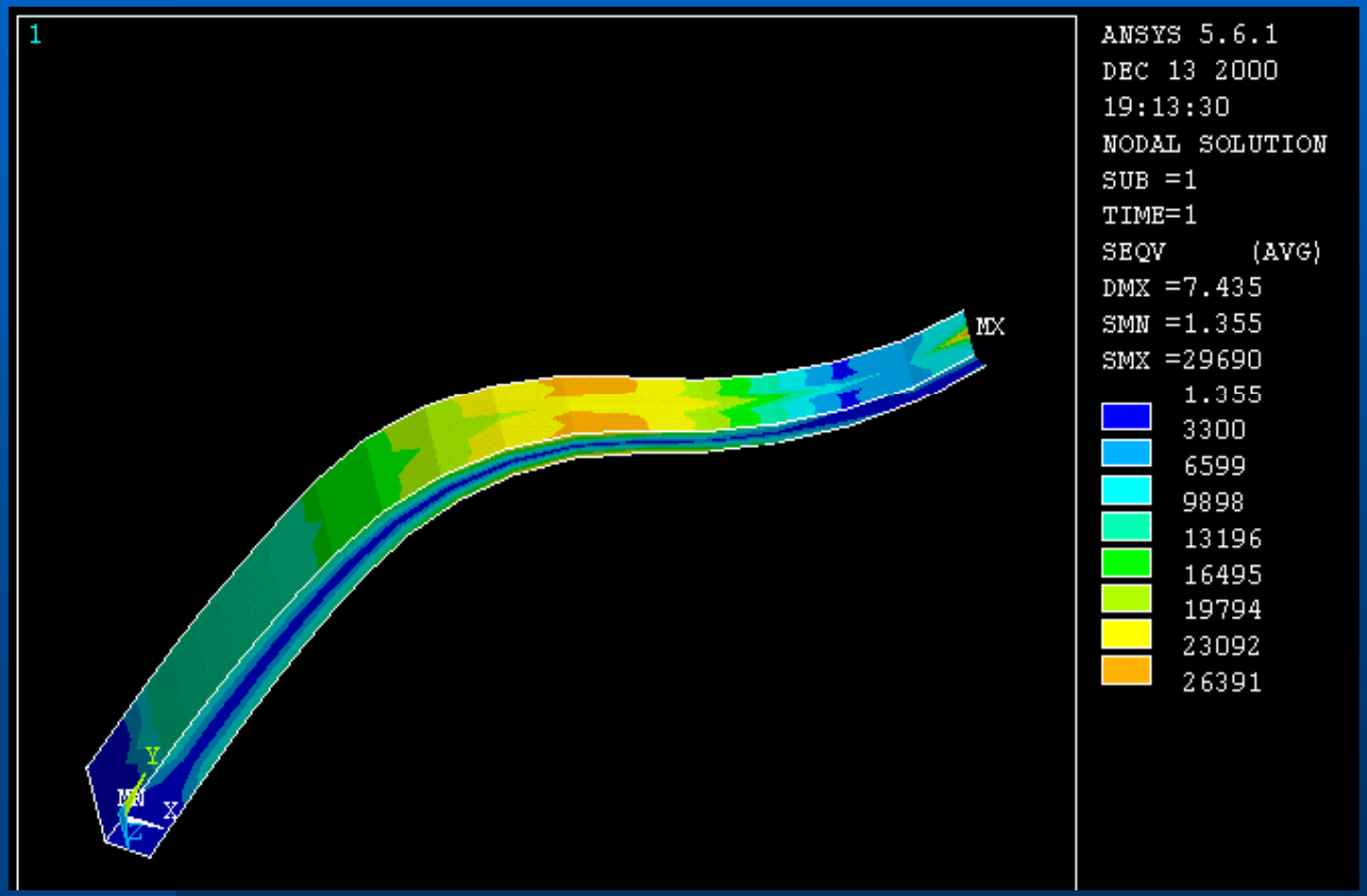
X-Displacement



Y-Displacement

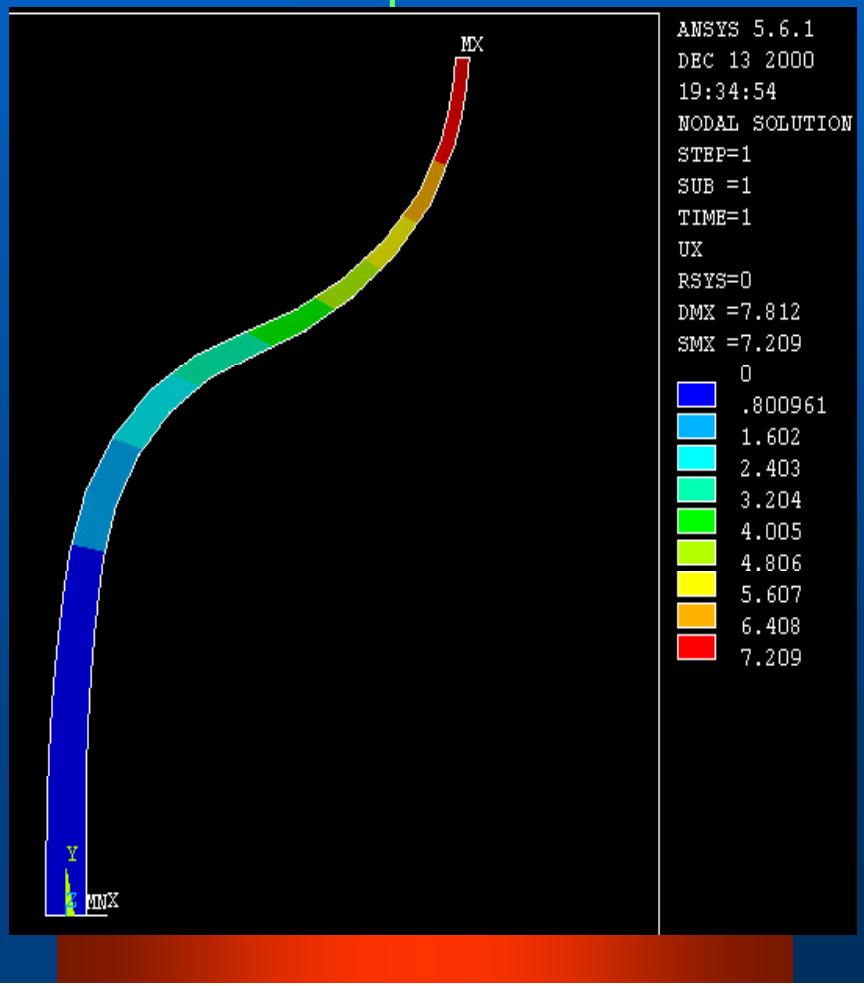


Stress Plot For Glass Epoxy

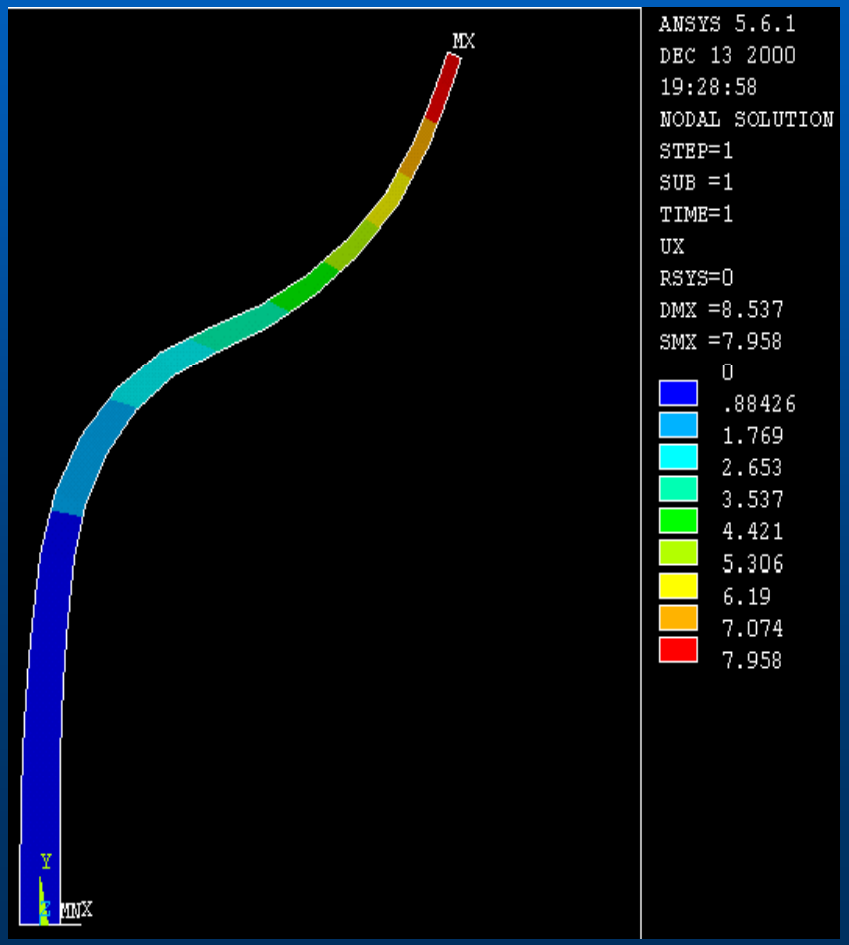


Graphite Epoxy Vs. Glass Epoxy (X-Displacement)

Graphite

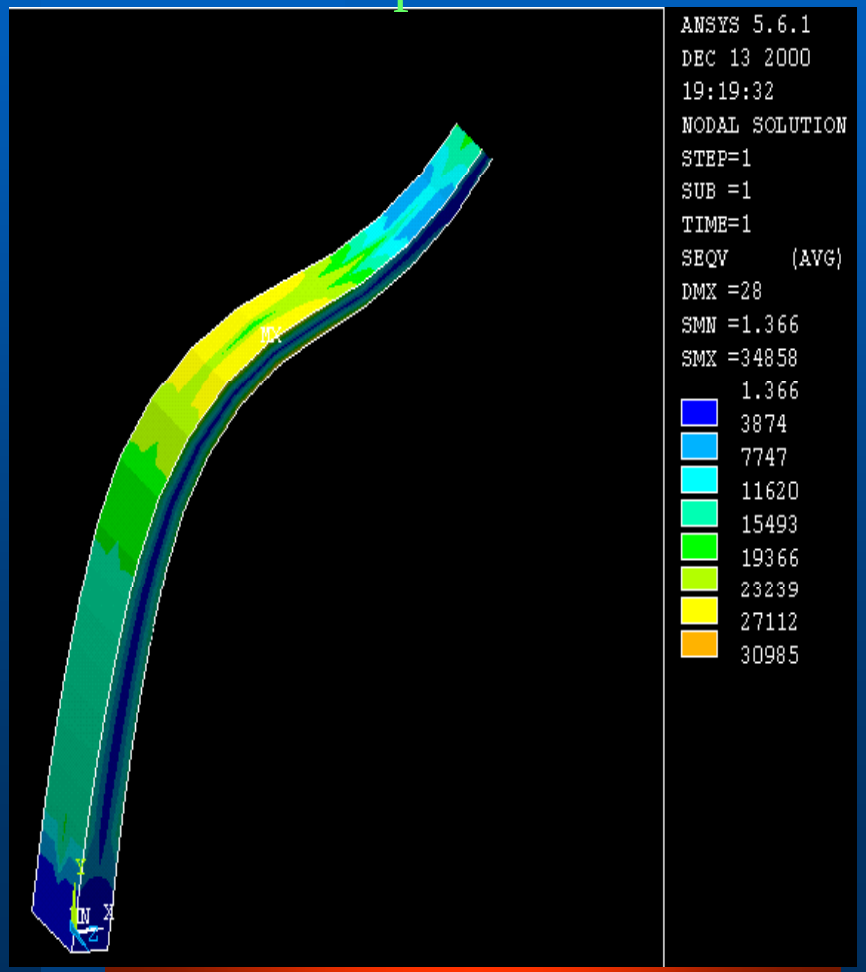


Glass

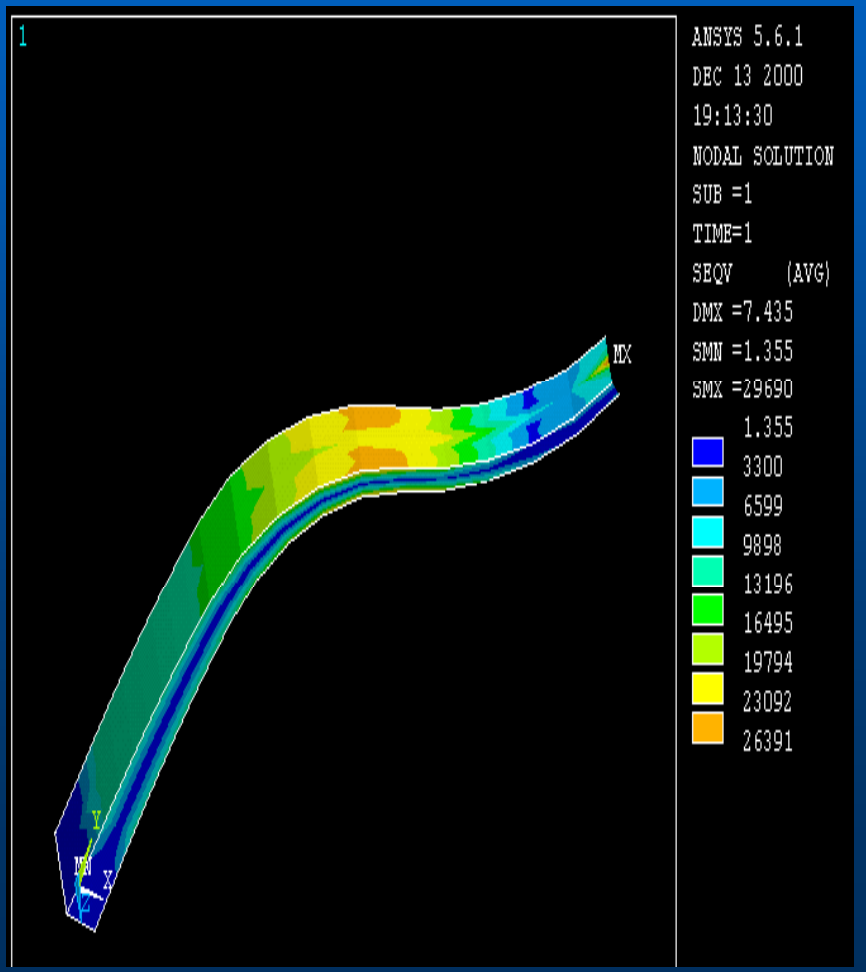


Graphite Epoxy Vs. Glass Epoxy (Stress Plots)

Graphite



Glass



Conclusion

- The X displacement for the graphite bow is less than that for the glass. Since the displacement of the bow string was kept standard during the analysis, this leads me to believe that it will be hard to pull the graphite bow to its optimal length. There will be a greater resistance with the graphite bow.
- However, based on the stress plots the graphite bow distributes the load better. The glass epoxy stress analysis reveals a more concentrated load on the outside curvature area. This leads me to believe that the glass epoxy may fatigue and fail over time in that area.
- Hence, if you can stand a little more resistance the graphite epoxy bow would be a better choice.