Cantilever beam characterization with axial twist

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Abstract:

Twisted beams are an important form of biological and artificial structures. Its significance were studied. Cantilever beam with single axial twist of 0, 30, 60 and 90 degree angles of twist were considered for the current study. It is observed that twisted beams behaves significantly different than the no twist beam. Normal stress distribution and load vs deflection plots were compared to reveal the impact of twist configuration.

Introduction

Twisted structures were naturally common in bio materials. Its frequently occurring in both biological and artificial structures and materials at different length scales such as nanocrystalline materials [3], chiral polymers [2] and gemini surfactants [1] these can be self-assembled into twisted ribbons. Twisting structures are theoretically modeled as pre-twisted beams bars and rods. Zhu [7], Lin and Hsiao [6], Carnegie [4, 5], used Euler's and Timoshenko's beam models to analyze the vibration of pre-twisted blades, aircraft rotary wings and satellite booms. In practical environments, twisted beams are subjected to both wind loads and self-weight. In the present paper bending of a pretwisted beams were studied using Finite Element Techniques. The beam considered for the present study is a cantilever beam which has its one and is fixed and the other end is free to deform.

Computational Model

Different beam configurations considered for current study were presented in figure 1. 0 degree twist beam is a straight cantilever beam with the axial twist of 0 degree. 30 degree twist beam is shown in figure 1 which has an axial twist of 30 degree. Other two configurations are 60 degree and 90 degree twisted beams. All the twists were given about its longitudinal axis. The beams were pre-twisted before applying any kind of loads or forces. Twisting is not the result of loading. It is assumed that the beam is manufactured in that way itself.

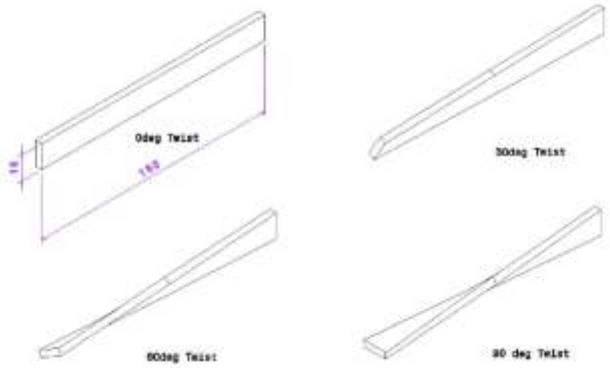


Fig 1 Beam configuration

Typical mesh distribution considered for the current study is presented in figure 2. The mesh is a structured mesh and the elements used is quad element which has 6 faces. The mesh density is quite dense and the size of the mesh cell is 1mm.

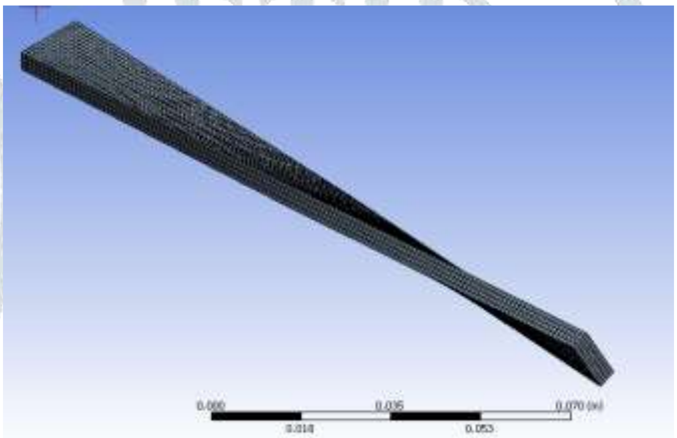
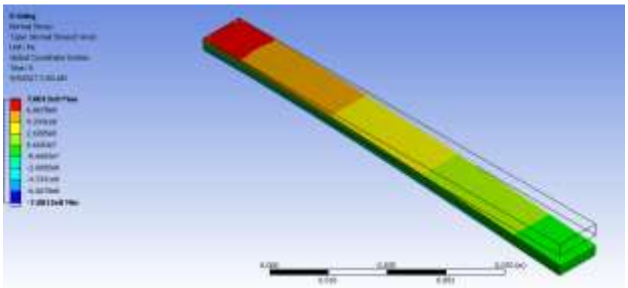


Fig 2 Mesh Disribution

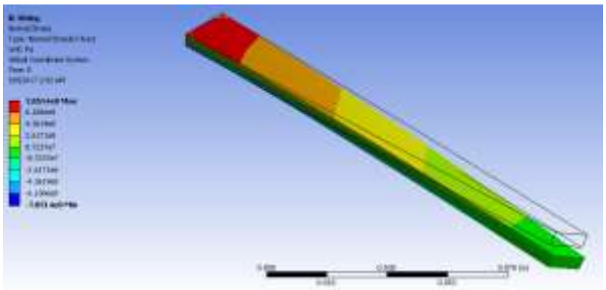
The far end at the LHS side is a fixed end and the other end is a free end. The load is distributed though the vertical surface at the end. The direction of the load is vertically downwards. The load is applied in step of 5 for 10s. At time is equal to zero the load applied is also zero and the load at 2s is equal to 100N. From then onwards its increased gradually to 180N with the interval of 20N for next 10s.

Results

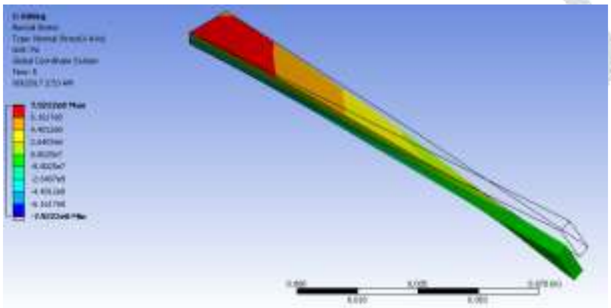
Results presented here are taken at the end of 10^{th} second (5^{th} timestep). Figure 3 shows the normal stress distribution of different configurations. Normal stress distribution for cantilever beam with no twist is shown in figure 3a. At the fixed end its observed that the stress is maximum which is equal to 7.8e08 Pa ant at the free end the stress is minimum and equal to 8.67e07 Pa its approximately 10 times lower than the maximum value. Size of the intermediate contours also constant.



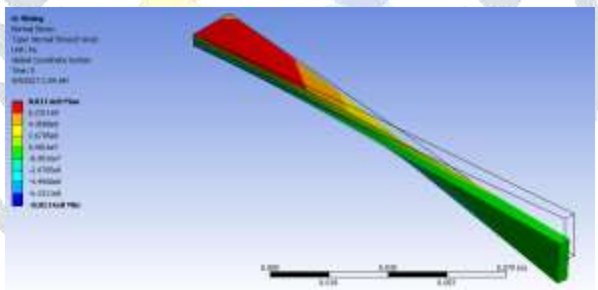
a) Cantilever beam with no twist



b) Cantilever beam with 30degree twist



c) Cantilever beam with 60degree twist



d) Cantilever beam with 90degree twist

Fig 3 Normal Stress Distribution

Figure 3b shows normal stress distribution of cantilever beam with 30degree twist. The normal stress at the fixed end and the free end slightly increases the contours also slightly increased in size. The intermediate stress contours size were small when compared with the no twist configuration.

Figure 3c shows the normal stress distribution of 60degree twisted beam. The area of maximum and minimum contours were significantly increased and its size also grows larger than the no twist model. Stress level also slightly higher than the no twist case. Figure 3d shows huge difference in normal stress distribution. The lower stress distribution contour grows inward in one edge and higher stress distribution grows outward on the other edge. The size of the intermediate stress contour were significantly smaller.

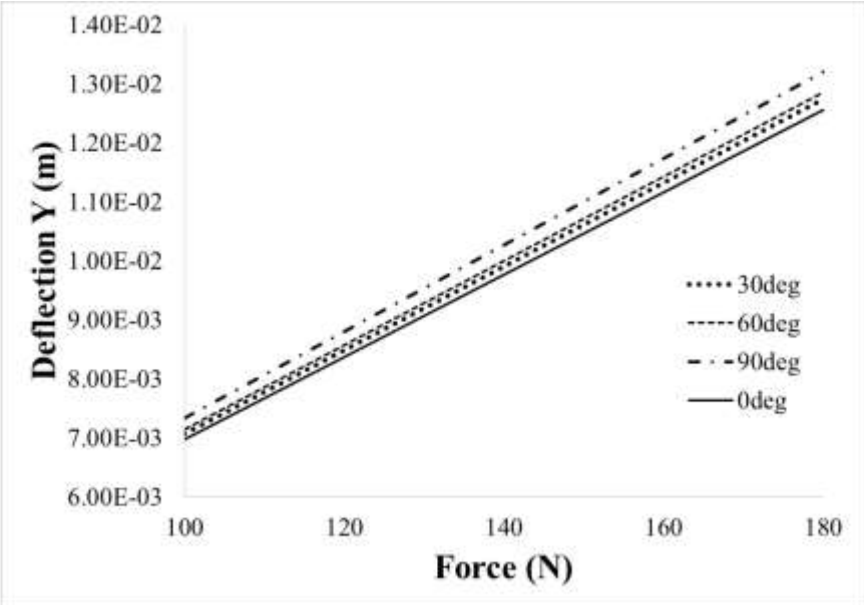


Fig 4 Force vs Deflection

Figure 4 shows the force vs deflection graph for various models. It can be observed that the deflection for given force increases with increase in twist angle. Rate of deflection remains constant throughout the load range. It can be said that the twisting of the beam slightly reduces the load bearing capacity at given loading range.

Conclusion

Resistance of a cantilever beam with axial twist were studied. All the beam configurations were single twist and the angles compared were 0, 30, 60 and 90 degrees. Its observed that the maximum minimum stress level at given loading slightly increases with the twist angle. Size of the intermediate stress contours also reduced significantly with the twist angle. Although the deflection at given loading is slightly higher than the no twist case the rate of deflection remains constant.

References:

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