Stress Concentration analysis and optimization of rectangular beam subjected to maximum load

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Abstract: ***A simple cantilever beam has multiple uses whether it be vehicle's foot rest or as big as modern day bridges. Cantilever beam; beam supported at one end and carrying a load at the other end or distributed along the unsupported portion. Stresses are an integral part of any mechanical structure and its optimization is one of the main aspects for any engineer. This paper will try to optimize the configuration of a rectangular cantilever beam so as to distribute the stress concentration and to apply to the same loading conditions. Analysis of the beam is done with the help of software application "Dassault's Solid works" and the results are compared with the use of same software.***

Keywords: about four key words separated by commas.

1. Introduction

Cantilever beam; beam supported at one end and carrying a load at the other end or distributed along the unsupported portion. The upper half of the thickness of such a beam is subjected to tensile stress, tending to elongate the fibers, the lower half to compressive stress, tending to crush them. Cantilevers are employed extensively in building construction and in machines. In building, any beam built into a wall and with the free end projecting forms a cantilever. Longer cantilevers are incorporated in a building when clear space is required below, with the cantilevers carrying a gallery, roof, canopy, runway for an overhead travelling crane, or part of a building above.

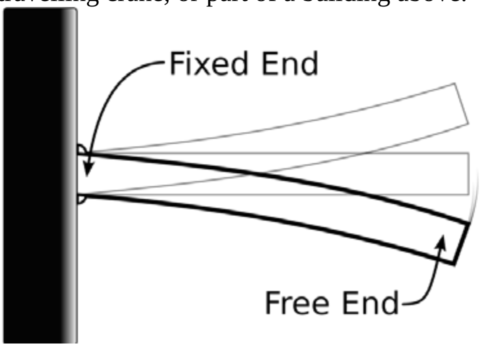


Figure 1: Basic operation of cantilever

One of the biggest problems with cantilever beam is that most of the stresses are concentrated to the fixed end. These stresses should be needed to distribute. For this we need to do an analysis of stress concentration on beam and through removal of material either by through hole or by notches should be distributed throughout the beam. here.

1. Theory:

1.1Stress Concentration

In design of any mechanical element the following three fundamental formulas are applied:

$$\sigma_t = \frac{P}{A}$$

$$\sigma_b = \frac{M_b y}{I}$$

$$\tau = \frac{M_t r}{J}$$

Figure 2: Elementary equations applied to cantilever

The main assumption we consider while applying these equations is that the cross section is same throughout the area. But in real life problems the cross section always changes. According to Design of Machine elements by V.B.Bhandari, stress concentration is defined as localization of stress due to irregularities present in the component and abrupt changes in cross section.

Geometric discontinuities cause an object to experience a local increase in the intensity of a stress field. Examples of shapes that cause these concentrations are cracks, sharp corners, holes, and changes in the cross-sectional area of the object. High local stresses can cause objects to fail more quickly, so engineers must design the geometry to minimize stress concentrations.

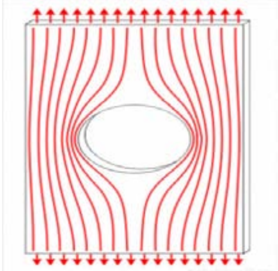


Figure 3: Stress Concentration about hole.

1.2 Cantilever Beam

A cantilever is a beam anchored at only one end. The beam carries the load to the support where it is forced against by a moment and shear stress. Cantilever construction allows for overhanging structures without external bracing. Cantilevers can also be constructed with trusses or slabs.

Main advantages are:-

Building out from each end enables construction to be done with little disruption to navigation below

The span can be greater than that of a simple beam, because a beam can be added to the cantilever arms

Because the beam is resting simply on the arms, thermal expansion and ground movement are fairly simple to sustain

Cantilever arms are very rigid, because of their depth

Main disadvantages are-

Like beams, they maintain their shape by the opposition of large tensile and compressive forces, as well as shear, and are therefore relatively massive

Truss construction is used in the larger examples to reduce the weight

2. Problem Statement:

Suppose we have to design a cantilever beam with cross section 10in x 0.5in x 0.38in. The beam is required to support a load of 50lbs. We need to check if the beam with given cross section is suitable for carrying this much load. If not then what are the stress generating in the beam and what ways does we evolve to reduce these stresses.

3. Methodology

1. We design the prototype of the beam using solidworks and using the material as plain carbon steel.

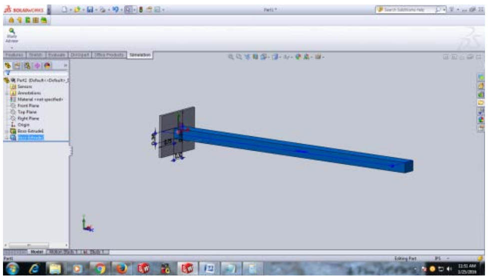


Fig 4: Software application in analysis

2. Now we are using finite element analysis module of solidworks. Initially we are applying a load of 50lbs

3.1 Model Information

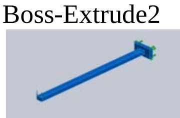
<L_MdInf_SldBd_Nm/>	Treated As	Volumetric Properties
Boss-Extrude2 	Solid Body	Mass:0.292739 kg Volume:3.8018e-005 m^3 Density:7700 kg/m^3 Weight:2.86884 N

Table 1: Showing material properties

3.2 Material Properties

Model Reference	Properties		Components
	**Name:**	Alloy Steel	**SolidBody 1(Boss-Extrude2)(Part2)**
	Model type:	Linear Elastic	
	Default failure criterion:	Max von Mises Stress	
	Yield strength	6.20422e+008 N/m^2	
	Tensile strength:	7.23826e+008 N/m^2	
	Elastic modulus:	2.1e+011 N/m^2	
	Poisson's ratio:	0.28	
	Mass density:	7700 kg/m^3	
	Shear modulus:	7.9e+010 N/m^2	
	Thermal expansion coefficient:	1.3e-005 /Kelvin	

3.3 Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	0.132427 in
Tolerance	0.00662135 in
Mesh Quality	High

3.4 Mesh Information - Details

Total Nodes	14759
Total Elements	8931
Maximum Aspect Ratio	3.9327
% of elements with Aspect Ratio < 3	99.9
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:01
Computer name:	MECH-52

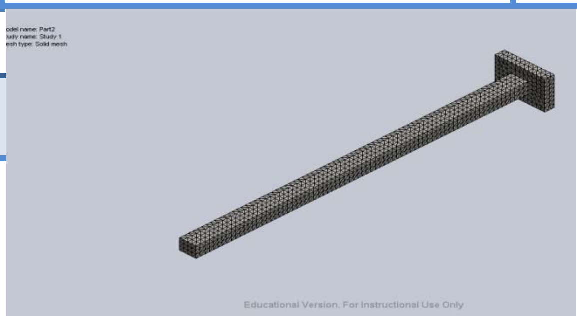


Fig 5: Software model of relevant queation.

Results:

Case 1: Solid Cross section

Name	Type	Min	Max

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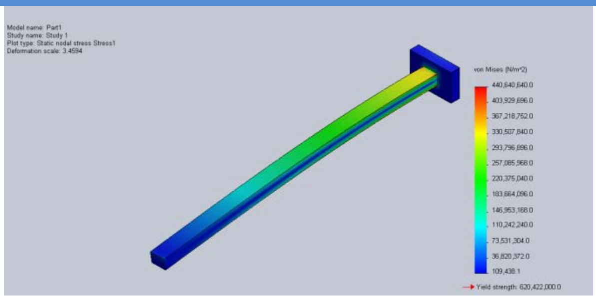
Stress1	VON: von Mises Stress	109438 N/m^2 Node: 9	4.40641e+008 N/m^2 Node: 11851

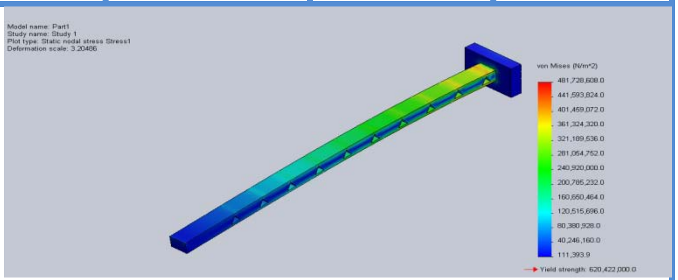


Part1-Study 1-Stress-Stress1

Fig 6: Stress analysis of solid cross section model in solidworks

Case 2: Triangular Cross Section

Name	Type	Min	Max
Stress1	VON: von Mises Stress	111394 N/m^2 Node: 14105	4.81729e+008 N/m^2 Node: 13795

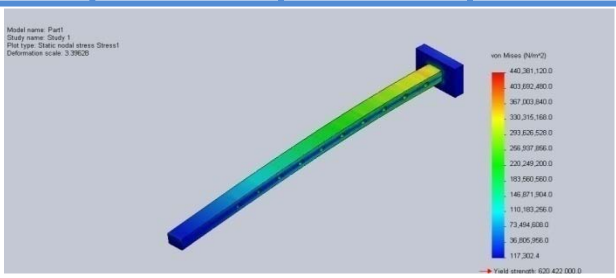


Part1-Study 2-Stress-Stress1

Fig 6: Stress analysis of model with triangular through holes

Case 3: Circular Cross Section

Name	Type	Min	Max
Stress1	VON: von Mises Stress	117302 N/m^2 Node: 13559	4.40381e+008 N/m^2 Node: 13294



Part1-Study 3-Stress-Stress1

Conclusions:

Following are the observations we get from our objective:

Table 1: Results of Analysis

Sl. No.	Cross Section (Through holes)	Load applied	Maximum Stress Induced (10^8 N/m^2)
1	Solid section	60 lbs	4.40641
2	Triangular Section	60 lbs	4.81729
3	Circular Cross section	60 lbs	4.40381

We have to design a cantilever which can handle 60 lbs of load with least stress concentration. For the fulfilment of purpose, according to results we get from static analysis of given cross section it is clear that circular cross section is most suitable among designs. This not only helps in distributing the stress concentrations but on the same end, it also minimizes the overall weight of the configuration thus optimize its structural dimensions.

References

[1] A. Bonnaccorsi, "On the Relationship between Firm Size and Export Intensity," Journal of International Business Studies, XXIII (4), pp. 605-635, 1992. (journal style)

[2] R. Caves, Multinational Enterprise and Economic Analysis, Cambridge University Press, Cambridge, 1982. (book style)

[3] M. Clerc, "The Swarm and the Queen: Towards a Deterministic and Adaptive Particle Swarm Optimization," In Proceedings of the IEEE Congress on Evolutionary Computation (CEC), pp. 1951-1957, 1999. (conference style)

[4] H.H. Crokell, "Specialization and International Competitiveness," in Managing the Multinational Subsidiary, H. Etemad and L. S, Sulude (eds.), Croom-Helm, London, 1986. (book chapter style)

[5] K. Deb, S. Agrawal, A. Pratab, T. Meyarivan, "A Fast Elitist Non-dominated Sorting Genetic Algorithms for Multiobjective Optimization: NSGA II," KanGAL report 200001, Indian Institute of Technology, Kanpur, India, 2000. (technical report style)

[6] J. Geralds, "Sega Ends Production of Dreamcast," vnunet.com, para. 2, Jan. 31, 2001. [Online]. Available: http://nl1.vnunet.com/news/1116995. [Accessed: Sept. 12, 2004]. (General Internet site)