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DESIGN AND OPTIMIZATION OF SPREADER BEAM

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ABSTRACT:

A spreader beam is the simplest configuration of the beam, which is used for two or more than two point lift and also a leveled lift. A spreader beam absorbs the compressive force to protect the load being lifted. A spreader beam consists of lifting eyes which is attached to the spreader beam by means of welding. Its purpose is to connect the load to the beam and beam to the crane hook with the help of lifting accessories. In this project, our emphasis was to design a two point lift spreader beam of 10 tonne capacity by selecting 3 standard cross sections, Universal I Beam, Square hollow section and circular hollow section and subsequently suggesting the appropriate cross section for the spreader beam.

KEYWORDS

Spreader Beam, Pad Eye, Bending Stress.

INTRODUCTION

Spreader beams are also known as lifting beam, is a fabricated structure, which is used for two or more than two point lift and also a leveled lift (horizontal or at a required angle). A spreader beam absorbs compressive and bending force to protect the load being lifted. A spreader beam consists of lifting eyes on the top and bottom which is attached to the spreader beam by means of welding. Its purpose is to connect the load to the beam and beam to the crane hook with the help of lifting accessories. Generally the lifting beam consists of two lifting eyes on the top which is connected to the crane hook and two or more lifting eyes at the bottom which is connected to the load.

In this paper, an attempt has been made to compare the weight of the 3 types of cross section, I-Section, Square Hollow Section and Circular hollow section having approximately same strength by means of analytical calculation in MathCAD and FEM analysis in ANSYS.

Modeling

The spreader beam is principle lifting element for two or more than two point lift. The layout is shown in Fig. 1. The material for the calculation is selected as structural steel and the cross section has been done selecting I- Section, Square Hollow Section and Circular hollow Section as shown in Fig.2, The dimension properties are given in Table. 1. The cross section of the beam has been modeled using Plane42 element and the beam is meshed in to 2 node beam elements, for the accurate analysis, using ANSYS Version 14. These elements offer more accuracy and less time for the computer for meshing and computing, while modeling axis symmetric object.

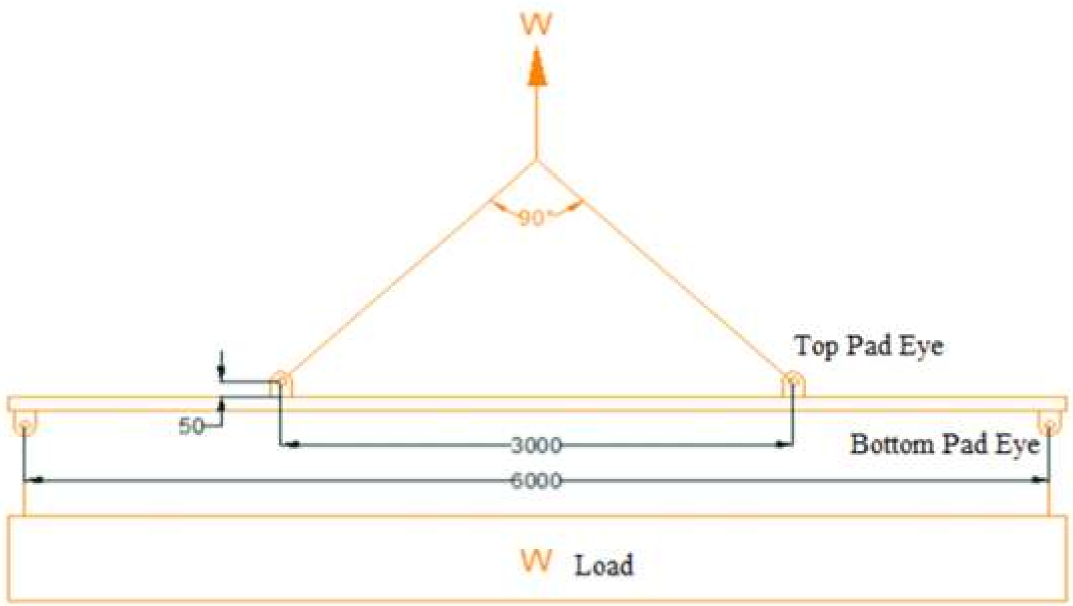


Figure 1- Spreader Beam

Problem Specification

A 10 tonne uniform load to be lifted by using spreader beam of sling angle 45 degree, the distance between the bottom pad eyes is 6 m and the top pad eye is 3 meter as in the Fig. 1, the free body diagram is shown in Fig.3. The lifting point from the top surface of the beam can be considered as 50 mm.

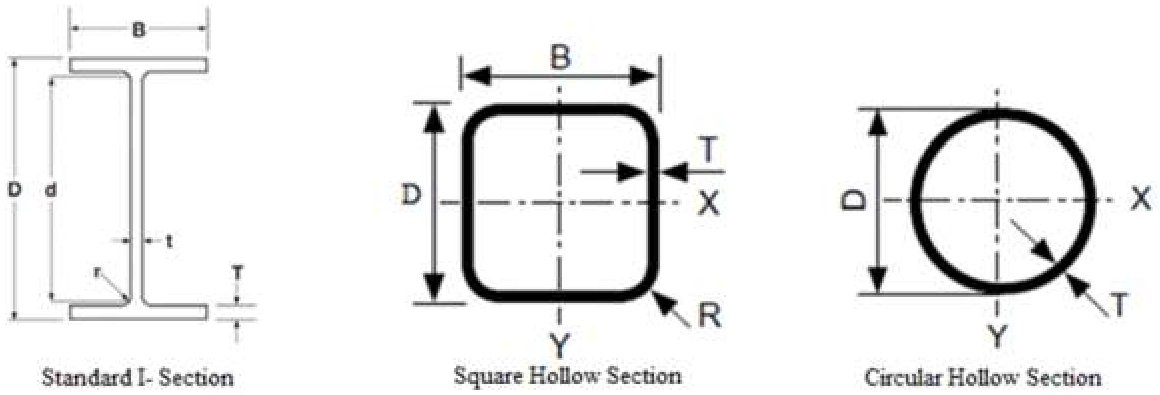


Figure 2- Standard Sections

Table 1-Geometrical Properties of The Cross Sections

Geometrical Properties	I-Sections	Square Hollow Section	Circular Hollow Section
Cross Sectional Area(cm^2)	62.1	70.09	79.39
$I_{xx}(cm^4)$	9575	7372	9910
$I_{yy}(cm^4)$	461	7372	9910
$Z_{xx}(cm^3)$	616	567.13	611.92
M (kg/m)	48.1	56	62

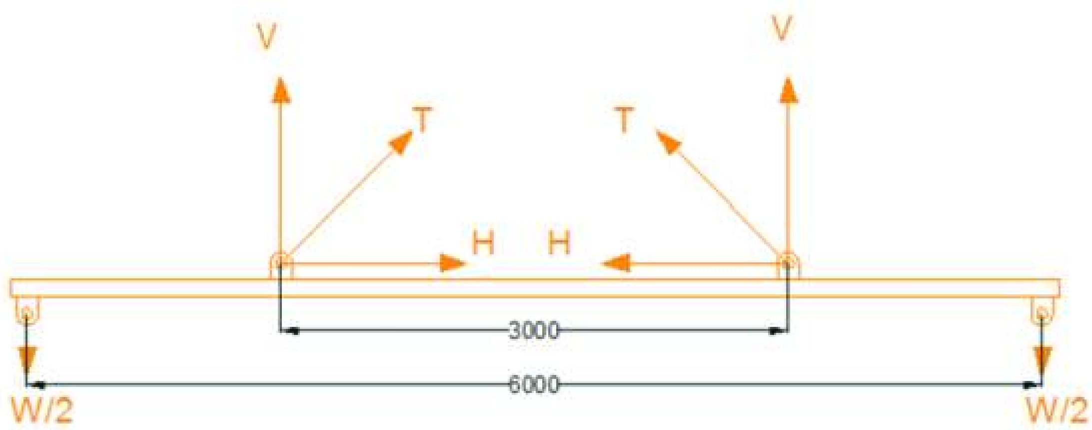


Figure 3-Free Body Diagram

Criteria for Lifting Beam

According to Indian Standard IS13591:1992, lifting beams should be designed for the capacity of the beam with impact factor of 1.1. The permissible stresses should be limited to the values given below.

•Direct compression and compression in bending	0.55Yield Point
•Direct tension and tension in bending	0.55Yield Point
•Shear Stress	0.40Yield Point
•Combine Stress	0.75 Yield Point

Material is taken as structural steel; hence yield point value can be taken as 275MPa

Analytical Calculation

In this case the sling angle considered as 45degree therefore the horizontal and vertical component on the top lifting pad eye will be equal to half of the total load to be lifted.

Load to be lifted	W=10 tonnef
	W=98070N
Horizontal Component	H=0.5W
Vertical Component	V=0.5W

For math cad, Let X be the length of the beam

Bending Moment Equation

Abbreviation	
A_i	Area of I Section
A_r	Area of Rectangular Hollow
A_c	Area of Circular Hollow
Z_i	Sectional Modulis of I Section
Z_r	Sectional Modulis of Rectangular Hollow Section
Z_c	Sectional Modulis of Circular Hollow Section
$\sigma_{b,}$	Bending Stress
τ	Shear Stress

$$M(X) := \begin{cases} (-0.5W \cdot X) & \text{if } 0 \le X \le 1.5m \\ [-0.5W \cdot X + 0.5W \cdot (X - 1.5m) + H \cdot h] & \text{if } 1.5m \le X \le 4.5m \\ [-0.5W \cdot X + 0.5W \cdot (X - 1.5m) + 0.5W \cdot (X - 4.5m)] & \text{if } 4.5m \le X \le 6m \end{cases}$$

Shear Force Equation

$$S(X) := \begin{cases} 0.5W & \text{if } 0 \le X \le 1.5m \\ 0 & \text{if } 1.5m \le X \le 4.5m \\ -0.5W & \text{if } 4.5m \le X \le 6m \end{cases}$$

Area Properties of the cross sections

$$Z_i := 616cm^3 \qquad A_i := 62.1cm^2$$

$$Z_r := 567.13cm^3 \qquad A_r := 70.09cm^2$$

$$Z_c := 611.92cm^3 \qquad A_c := 79.39cm^2$$

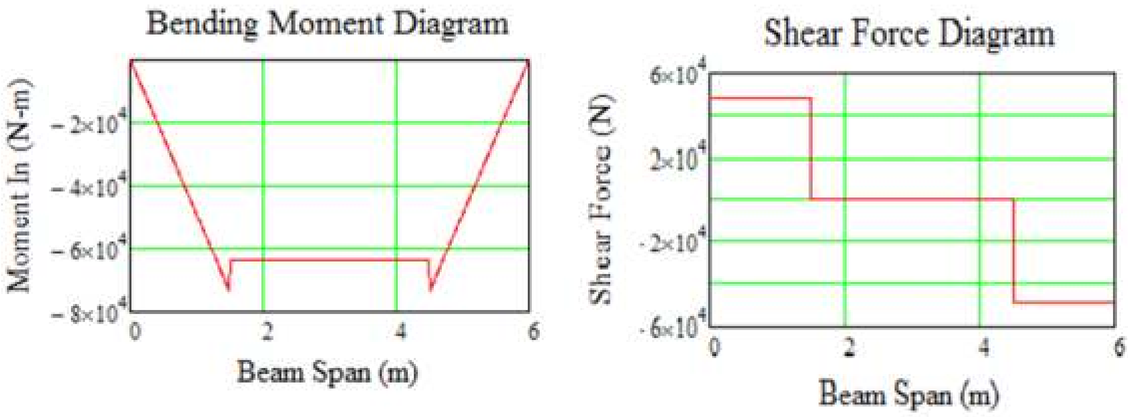


Figure 4-Bending Moment & Shear Force Diagram

Maximum Bending Moment $\qquad M_{max} := -M(1.499m) = 7.35 \times 10^4 N\cdot m$

Maximum Shear Force $\qquad S_{max} := S(0) = 4.903 \times 10^4 N$

Area Matrix and Sectional Modulus matrix

$$Z_{xx} := \begin{pmatrix} Z_i \\ Z_r \\ Z_c \end{pmatrix} \qquad Area := \begin{pmatrix} A_i \\ A_r \\ A_c \end{pmatrix}$$

Bending Stress and Shear Stress Matrix

$$\sigma_b := \frac{M_{max}}{Z_{xx}} \qquad \sigma_b = \begin{pmatrix} 119.32 \\ 129.601 \\ 120.115 \end{pmatrix} MPa \qquad \tau := \frac{S_{max}}{Area} \qquad \tau = \begin{pmatrix} 7.896 \\ 6.996 \\ 6.176 \end{pmatrix} MPa$$

Compressive Stress $\qquad \sigma_c := \frac{H}{Area} \qquad \sigma_c = \begin{pmatrix} 7.896 \\ 6.996 \\ 6.176 \end{pmatrix} MPa$

Direct Normal Stress $\qquad \sigma_n := \sigma_c + \sigma_b \qquad \sigma_n = \begin{pmatrix} 127.215 \\ 136.597 \\ 126.291 \end{pmatrix} MPa$

Maximum Stress $\qquad \sigma_1 := \frac{\sigma_n}{2} + \sqrt{\left(\frac{\sigma_n}{2}\right)^2 + \tau^2} \qquad \sigma_1 = \begin{pmatrix} 127.704 \\ 136.955 \\ 126.593 \end{pmatrix} MPa$

The shear stress and the compressive stress found very less bending stress found the critical from the above calculation.

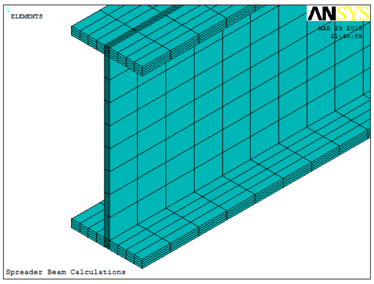
Conclusion on the Analytical Calculation

Table 2-Conclusion

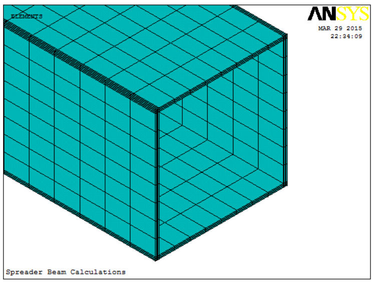
Cross Section	Bending Stress(MPa)	Maximum Stress(MPa)	Mass per length(kg/m)
I – Section	119.32	127.704	48.1
Rectangular Hollow	129.601	136.955	56
Circular Hollow	120.115	126.593	62

All the above values are within the allowable limit and nearly equal, but if we compare the mass per unit length, the I- beam is much more economic. Hence we can conclude that for one dimensional bending stress, I beam is economic.

Analysis in ANSYS



5(a)



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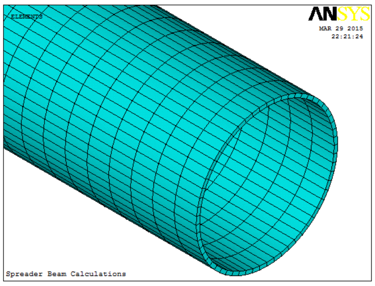
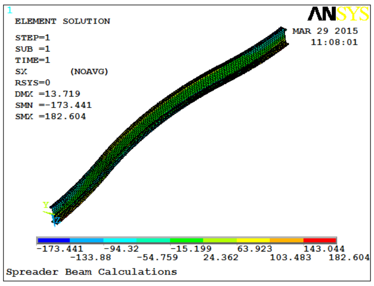
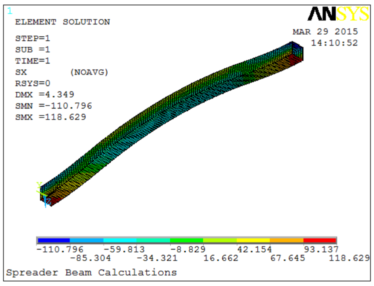


5(c)

Figure 5- Meshed Sections



6(a)



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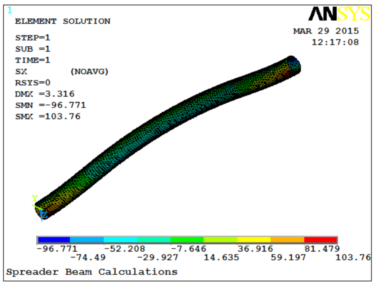
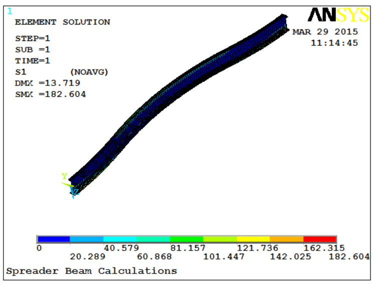
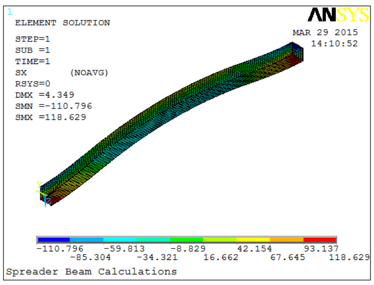


6(c)

Figure 6- XComponent Of Stress (bending)



7(a)



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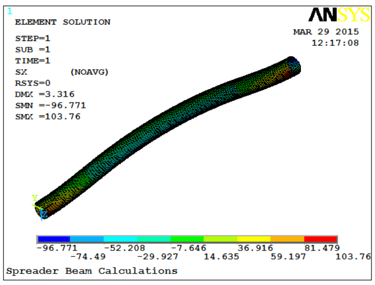
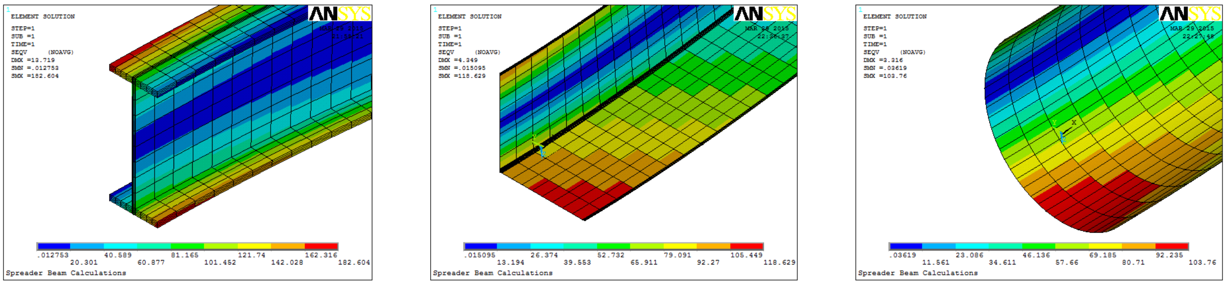


7(c)

Figure 7- Maximum Principle Stress



8(a) 8(b) 8(c)

Figure 8- Highly Stressed Elements

RESULTS AND DISCUSSION

From the analytical calculation it is clear that, the shear stress and the direct compressive stress are very less however it is accounted in the maximum principle stress. Table No. 2 shows the comparison of bending stress and the maximum principle stress and corresponding mass per unit length of the cross sections, and we can conclude that the I- Section offers good strength for the one dimensional bending.

The same cross sectional beams are modeled in ANSYS using the common section beam and meshed in to 2 Node beam element as shown in Figure 5. The bending stress(X-component of stress) with the deflection shape of the beams is shown in Figure 6. The maximum stress with deflection shape of the beam is shown in figure 7 and the highly stressed elements are highlighted in Figure.8. Table no 3. Comparison between the maximum stresses obtained from the analytical method and the FEA in ANSYS.

Table 3- Comparison between ANSYS and Analytical Solution

Cross Section	Analytical Solution	ANSYS Solution
I-Section	127.704	162
Rectangular hollow sec.	136.955	118
Circular Hollow Section	126.593	103

CONCLUSIONS

The static analysis in industrial spreader beam is gaining importance. In this paper static analysis has been made on 3 types of standard cross section I-beam, square hollow section and circular hollow section. The analysis reflects that the I- Beam is the optimum cross section for the one dimensional bending load.

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