ISSN:- 2230-7850 VOLUME-5 | ISSUE-2 | MARCH -2015

INDIAN STREAMS RESEARCH JOURNAL

# DYNAMIC ANALYSIS OF A MONORAIL BEAM FOR AN OVERHEAD CRANE

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**Abstract :**

A monorail beam is subjected to dynamic load. The design engineer is more concerned with its vibration behavior under undamped, no load condition to avoid resonance, which may lead to a catastrophic failure. One of the major failure reasons is formation of crack and its propagation, over a time. Emphasis is to be given to the investigation of the natural frequency and corresponding natural modes of the beam material which will furnish useful data, for prevention of crack. This paper addresses estimation of vibration displacement and natural frequencies of a standard I- Section, selecting 3 commercial grade steels and subsequently suggesting the appropriate material for a monorail beam.

Keywords: Monorail Beam,Natural frequency, Resonance, Crack

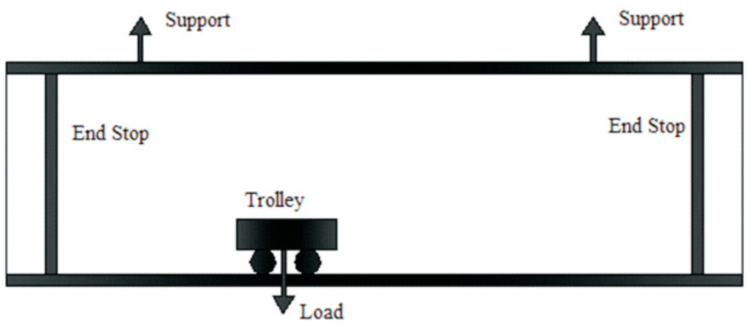
## INTRODUCTION :

Earlier works on monorail beam have focused mainly on lateral distortion, buckling and crack analysis [1, 2, 3]. Trahir [4] developed a method for designing a wide range of single span, double span, cantilever and overhanging monorails for their flexural torsional buckling analysis. Jassiam Z.A et al. [5] have reviewed different types of vibrational analysis for damage occurrence of a cantilever beam. Lee C.H. et al. [6] have compared the analytical results with the field test data and observed the possibility of resonance when a car moving on a steel bridge. Ping Lin H. [7] has analyzed the crack depth and crack position with respect to moving load on a steel structure. Yang T. H. [8] have done analysis on functionally graded beams, where the material property changes layer by layer and found that dynamic deflection is changing due to presence of an edge crack. Jena P.K. et al. [9] have analyzed the effect of crack location and crack intensity on the natural frequency and natural modes of a cantilever beam for different loading conditions. Sadettin [10] has analysed a cracked beam for its dynamic behavior.

The literature clearly reflects that the earlier works have confined to either distortional analysis or dynamic analysis of cantilever beams with an edge crack. In this paper an attempt has been made to extract first few eigenvalues and corresponding eigenvectors of a monorail beam of symmetrical I- section for an overhead crane to eliminate basically a crack formation. The work is further extended to optimize the material for the same geometry of the beam section

## Modeling

Monorail crane is the principle transporter for all plant and equipment. Layout of a structure is shown in Fig.1. The dimensions and properties as per the BS4-1:1993 aregiven in Table 1. Material optimization has been done selecting Mild Steel, Stainless Steel and low Alloy Steel. Material properties are furnished in Table. 2. The section has been modeled using Plane 42 and extruded with Solid 45, for the accurate analysis, using ANSYS Version 14. These elements offer more accuracy when modeling structure with straight boundaries. Fig.3 shows the elements. The meshing of the structure is shown in Fig.4.



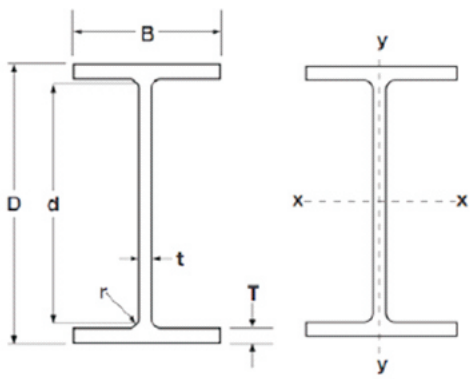
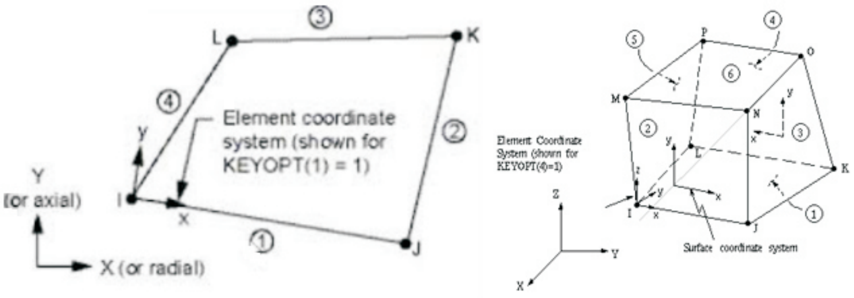




**Table 1Dimension of I section beam**

| | |
|---|---|
| D (cm) | 259.6 |
| B (cm) | 147.3 |
| T (cm) | 12.7 |
| t (cm) | 7.2 |
| $MOI_{xx}$ ($cm^4$) | 6544 |
| $MOI_{yy}$ ($cm^4$) | 677 |
| C/S area ($cm^2$) | 54.8 |




Plane 42 Solid 45

Fig. 1 Element Shapes

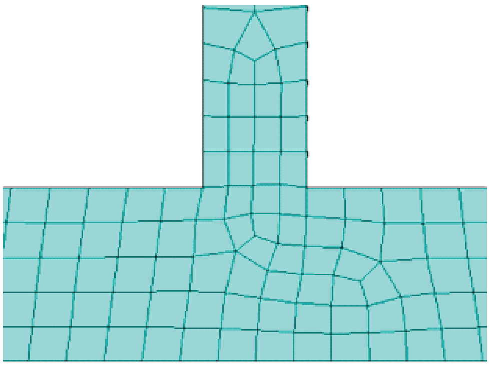


Fig. 4 Meshed Monorail

Table 1 Material properties

| Material | Young Modulus ($N/mm^2$) | Density ($Kg/mm^3$) | Poissons ratio |
|---|---|---|---|
| Mild Steel | 2.10E+05 | 7.90E-06 | 0.3 |
| Stainless Steel | 2.00E+05 | 8.00E-06 | 0.3 |
| Low Alloy Steel | 2.03E+05 | 7.80E-06 | 0.3 |

## Analysis

Modal analysis has been done for the first 10 modes to extract natural frequencies and corresponding natural modes. The investigation has been carried out selecting 1st, 5th and 10th modes.

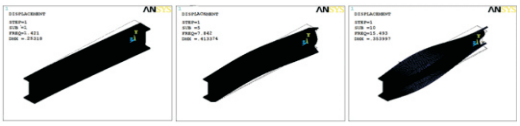
## Results and Discussion

The computed values, namely natural frequencies and max deflections are given in Table.3, for the selected modes. The deformed shapes of the beam are shown in Fig. 5. Mode shape plots are illustrated in Fig. 6. Deflection of the beams along X, Y and Z directions are plotted with respect to span are shown in Fig. 7.

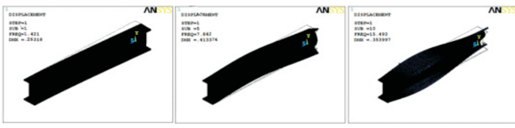
It is evident from Table.3 and Fig. 6, that stainless steel exhibiting low natural frequencies and as well as deflection at all the 3 modes compared to mild steed and Low alloy steel. The reason can be attributed to material property that is density. For all the 3 materials, deflection is observed to be maximum along X- axis that is, in the transverse direction. It is also observed from Fig.6that in 5th and 10th mode the beam is displacing along the longitudinal axis.

### Table 3 Frequency and Displacement

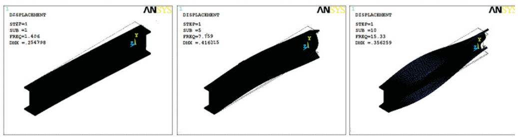
| | 1st Mode | | 5th Mode | | 10th Node | |
|---|---|---|---|---|---|---|
| Material | Freq(hz) | DMX (mm) | Freq (hz) | DMX (mm) | Freq (hz) | DMX (mm) |
| Mild Steel | 1.431 | 0.249083 | 47.401 | 0.236497 | 151.7 | 0.208909 |
| Stainless Steel | 1.387 | 0.247522 | 45.969 | 0.235014 | 147.116 | 0.207599 |
| Low Alloy Steel | 1.415 | 0.250674 | 46.902 | 0.238008 | 150.103 | 0.210243 |



5(a) Mild Steel



5(b) Stainless Steel



1(a) Mild Steel

Fig. 5 Deformed Shape of the beam

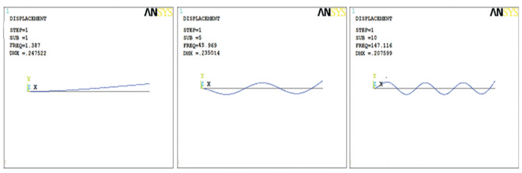


Fig.6 (a) Mild Steel

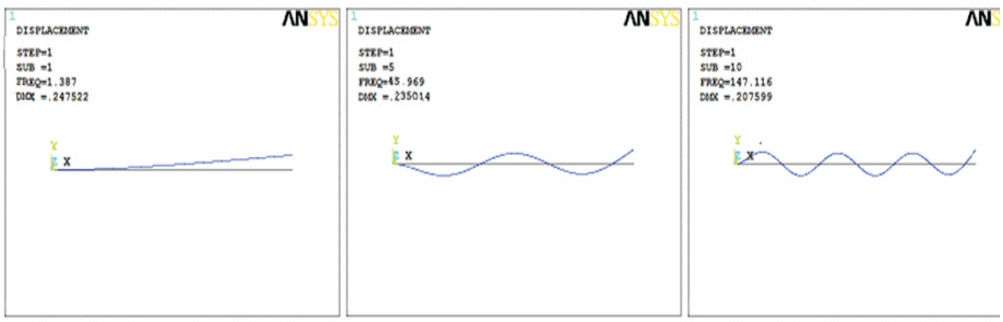



Fig. 6(b) Stainless Steel

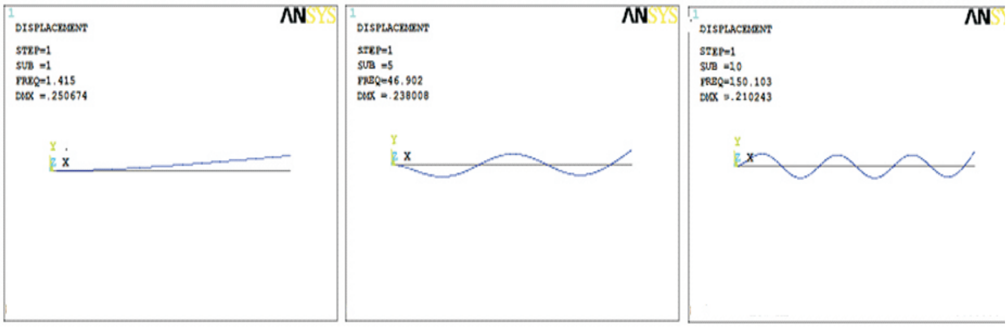



Fig. 6(c) Low Alloy Steel

Fig. 6 Mode Shape Plots

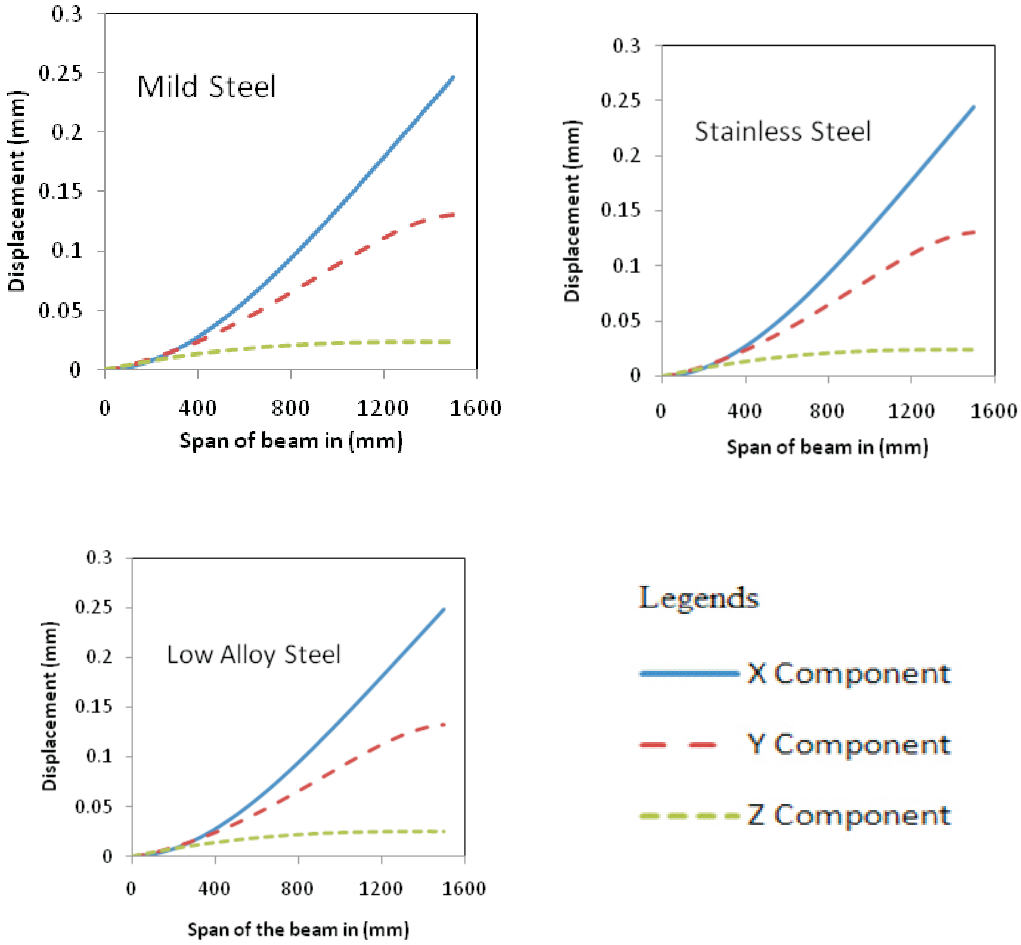



Fig.7(c)

## CONCLUSION

The dynamic analysis of industrial monorails is gaining importance. Analysis has been done on an overhead crane monorail. The theoretical investigation shows the mode shapes and natural frequencies under undamped and load free condition for 1st, 5th, and 10th modes. The analysis reflects that stainless steel is the optimum material owing to its dynamic response characteristics.

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