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Analysis Of Hps And Mild Steel In Cable Stayed Bridges

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Abstract— ***The Bridge is among one of the finest and the greatest invention of mankind which allows us to travel over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. Over the centuries many types of bridges are being designed and the cable stayed bridge has received much attention due to its formation over large span and its extremely elegant appearance makes it an architectural landmark. Bridge design should be effective enough to bear any possible load in future. The material plays a vital role in providing adequate strength to the bridge structure and the construction cost is also a primary factor which should be considered after the strength and the stability of the bridge structure. The cost of the bridge can be reduced by replacing conventional material and adopting high performing alternatives. Due to its low tensile strength the replacement of mild steel is needed for long span bridges. The material such as high performance steel (HPS) which has high tensile strength, weld-ability, cold formability and corrosion resistance can be a very good alternative. The main focus of the paper is to examine the performance of the material mild steel (MS) and high performance steel (HPS) in cable stayed bridge. The analysis and design is carried out using STAAD PRO V8i software. The analysis is based on the values of shear force on bridge element along x, y and z-axis and the moment along x, y and z-axis using mild steel and HPS steel in cable stayed bridge.***

Keywords: Cable stayed bridge**,** Mild steel, high performance steel **(**HPS).

I. INTRODUCTION

The bridge is a structure which should be carefully designed considering all the loads and stresses acting on the structure to avoid any future failure. The design of the bridge can be tested on various software (here STAAD PRO) which will examine stress and the moments produced on various elements of the structure. The material can be selected on the basis of all the loads acting on the bridge structure. The adequate material is selected which will have required strength and durability to bear these loads. Steel is a primary material which is used in most of the bridges so the quality of bridge is totally depended on the type of steel used. There are various types of steel which can be used in bridges among which the mild steel is been conventionally used. Due to its low tensile strength the replacement of mild steel is needed for long span bridges. High performance steel (HPS) is the name given to the steel which offer higher performances in tensile strength, weld-ability, toughness, cold formability and corrosion resistance than used in bridge constructions. High performance steel can cut the cost of construction due to its extremely high properties. As the spans of bridges are getting longer and longer, there is strong demand for steel with regard to the increased strength. However, careful attention must be paid for the fabrication of structural members using high strength steel due to their inherent poor weld ability.

(i) CABLE STAYED BRIDGE

A cable stayed bridge is a structure which provides passage over an obstacle without closing the way beneath. The obstacles which are to be crossed may be a river, road, railway or valley. The structural system of cable stayed bridge is divided into four main components-

1. The deck
2. The cables which supports the deck (stays)
3. The pylons or towers supporting the cable system
4. The anchor blocks or anchor piers

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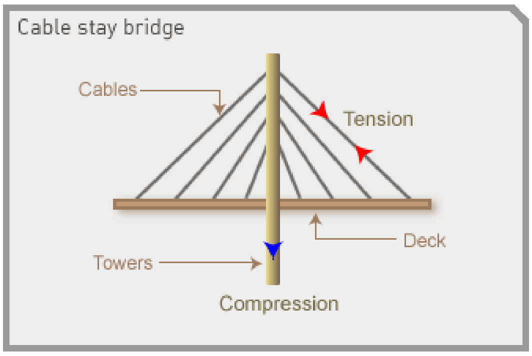


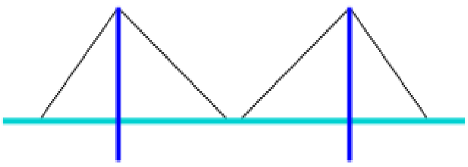
(ii) GENERAL DESIGN OF CABLE STAYED-BRIDGES

The main structural elements of a cable stayed bridges are the bridge deck, piers, towers and the stays. The deck supports the live load and transfers them to the stays through bending and compression. The stays then transfer the forces to the towers, which transmit them by compression to the foundations. In the cable-stayed bridge, the towers are the primary load-bearing structures which transmit the load of bridge to the ground through the cables which supports the deck.

The material chosen for the tower depends on the characteristics of the foundation soil, the construction speed and the construction process. The cross section of the deck influences the whole structure due to its self-weight and aerodynamics. Most cable-stayed bridges usually adopts one way reinforced concrete slab.

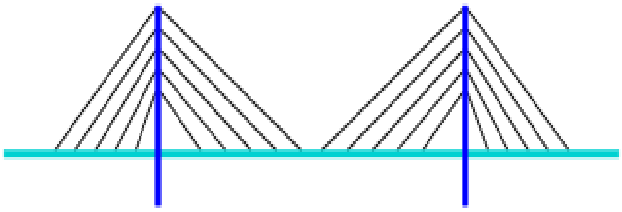
The connection between the deck and the tower is also of great importance to know how effectively the structure carries live load. There are mainly four ways for connecting deck and the tower through cables –

1. **MONO DESIGN**: This design uses a single cable for connecting deck and tower. Bridges of this design are rarely in existence.



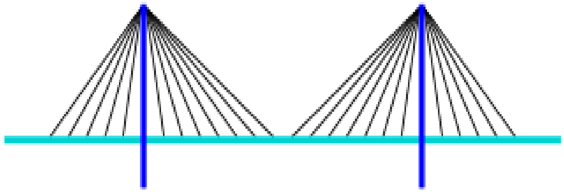
MONO DESIGN

2. **HARP DESIGN**: In harp or parallel design, the cables are nearly parallel to each other so that the height of their attachment to the tower is proportional to the distance from the tower to their mounting on the deck.



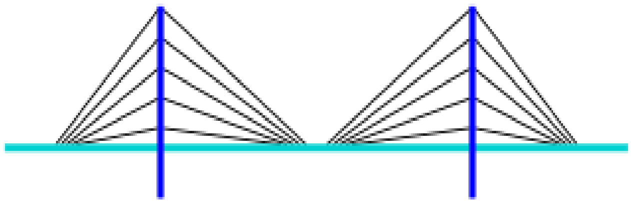
HARP DESIGN

3. **FAN DESIGN**: In fan design, all the cables are attached at the top of the tower which provides minimum moment at the tower but usually semi fan design is used. In semi fan design, all the cables are attached at the top of tower but with sufficient space in between every attachment so that that can be individually accessible for maintenance purposes.



FAN DESIGN

4. **STAR DESIGN**: In star design, cables attached to towers are same as in harp design but they are mounted at a point or sufficiently spaced points on the deck.



STAR DESIGN

The suspension system is usually one of two main types, with the stays anchored to the top of the tower (Fan) or the anchors are distributed along the length of the tower (harp).

(iii) ADVANTAGES OF THE CABLE-STAYED BRIDGE

- Cable stayed bridges have much more stiffness than the other types of bridge so that the chances of deformation of the deck under live loads are very minimal.
- This bridge is constructed by step by step cantilevering out the deck and then attaching cables to the tower and again the deck is cantilevered out

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and the same process goes on from both sides of towers. The cables act as temporary (as in star and mono design bridge construction) as well as permanent (as in harp and fan design bridge construction) supports to deck.

- If the bridge is in symmetrical design that is spans on either side of the tower are the same that means the horizontal forces are in balanced condition and large ground anchorages are not required.
- High strength steel is the reason of designing simple and light weight structures.

II. OBJECTIVE

The aim of paper is to analyze the HPS and MILD steel in cable stayed bridge using STAAD PRO software and the comparison of these materials is done on the basis of shear force along x, y, z-axis and moment along x, y, z-axis.

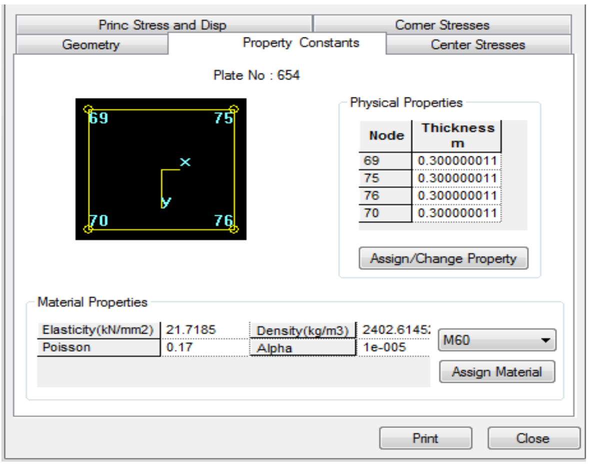
III. CASE STUDY

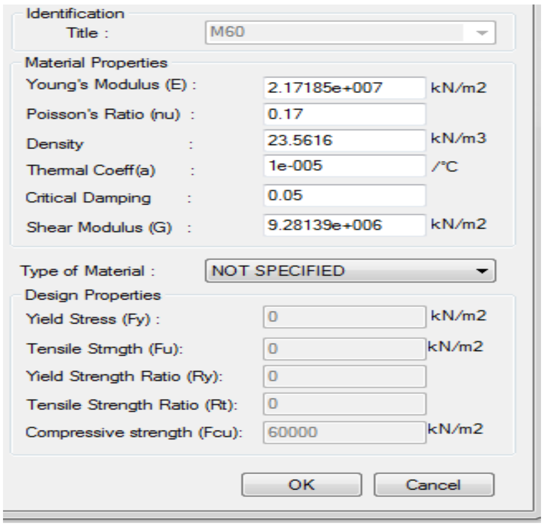
(i) DATA USED

The data used in case study of a cable-stayed bridge with a deck using MS, HPS are as below –

- Total span = 200 m
- Central span = 100 m
- Side span = 50 m
- Height of tower = 75 m
- Spacing in stays = 10m
- No. of stays = 20 (in one set)
- Width of deck slab = 10 m
- Width of footpath = 1.750 m
- Carriage width = 7.5 m
- Size of kerb = 500 x 400 mm
- Railings = 250 mm
- Yield strength of steel (fy) = 250 Mpa
- Young's modulus of steel = 2 x 10^5 Mpa
- Grade of concrete = M60
- Impact factor = as per IRC 6
- Thickness of deck slab = 300 mm
- MS Reinforcement grade = Fe410
- HPS Reinforcement grade = Fe590
- σ_{st} (as per IRC 2) = 200 Mpa
- Cover provided = 40 mm

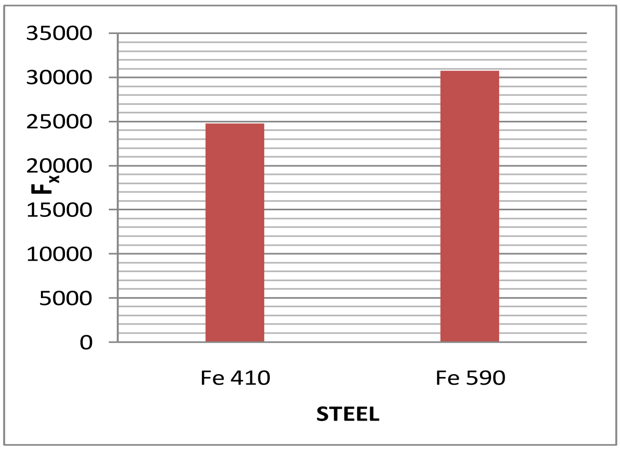
(ii) MATERIAL CONSIDERED





IV. RESULTS

The cable-stayed bridge is analyzed using mild steel and HPS on staad pro software. The variation between the shear forces and moments on a bridge structure is carried out and presented in graphs.



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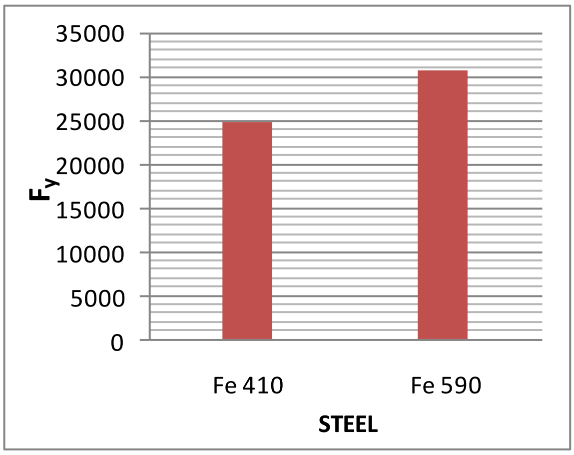
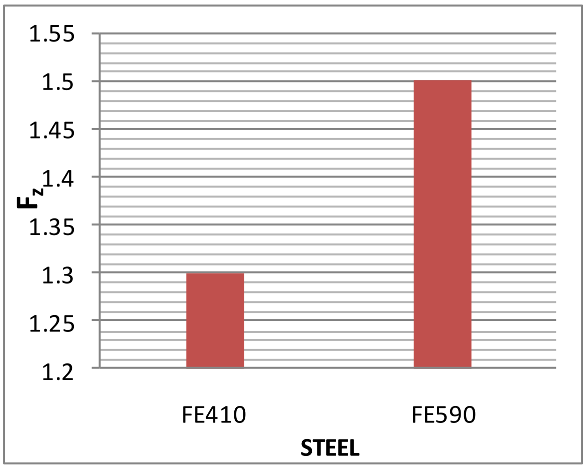
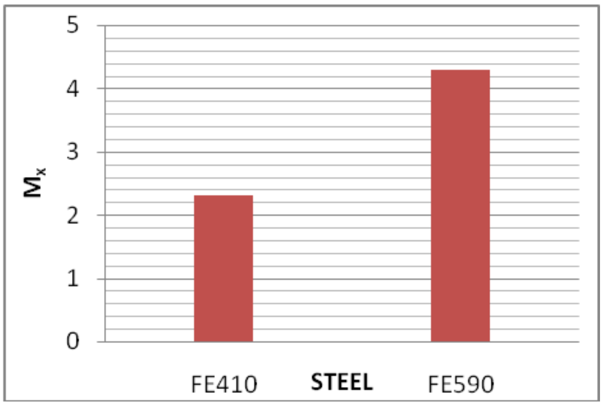
Variation of F_X (shear along x-axis) in mild and HPS steel



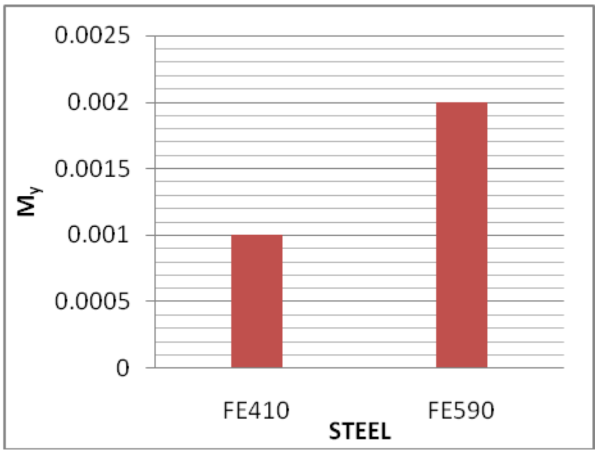
Variation of F_y (shear along y-axis) in mild and HPS steel



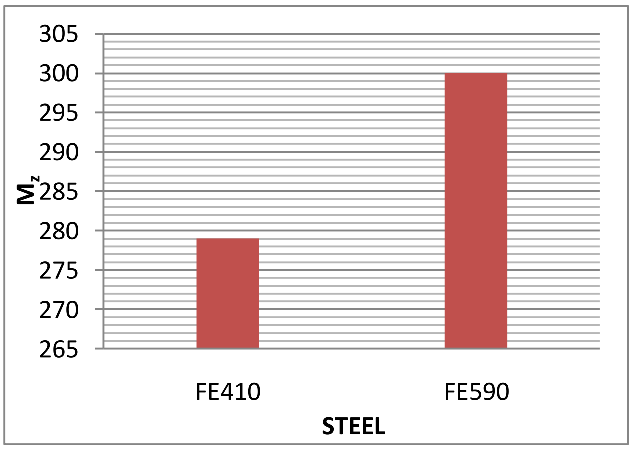
Variation of F_z (shear along z-axis) in mild and HPS steel



Variation of M_x (moment along x-axis) in mild and HPS steel



Variation of M_y (moment along y-axis) in mild and HPS steel



Variation of M_z (moment along z-axis) in mild and HPS steel

V. CONCLUSIONS

The study has described the use of HPS and MILD steel in cable-stayed bridge using STAAD PRO software and the comparison between shear force (along x, y, z-axis) and moment (along x, y, z-axis) are concluded as-

- The moment along x axis (M_x) of HPS steel is 25% more than mild steel in cable stayed bridge.
- The moment along y axis (M_y) of HPS steel is 45% more than mild steel in cable stayed bridge.
- The moment along z axis (M_z) of HPS steel is 30% more than mild steel in cable stayed bridge.
- The shear along x axis (F_x) of HPS steel is 15% more than mild steel in cable stayed bridge.

- The shear along y axis (F_y) of HPS steel is 25% more than mild steel in cable stayed bridge.
- The shear along z axis (F_z) of HPS steel is 40% more than mild steel in cable stayed bridge.

This paper concludes that HPS is much better than MILD steel in terms of tensile strength, toughness and cost effectiveness.

VI. FUTURE SCOPE

- The biggest problem in high strength steel is to achieve a balance between tensile strength and fatigue performance without losing good weld ability. The Design and analyses of cable-stayed bridge by considering weld-ability as a basic parameter can also be caries out.

- Another important problem is to overcome corrosion which is a drawback of steel bridges. Corrosion resistive material can also be used for further analysis.

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