

Analysis of Different Types of Cable Arrangement in Cable Stayed Bridge with Different Material Properties using STAAD Pro

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Abstract:- Cable stayed bridges have good stability, optimum use of structural materials, aesthetic, relatively low design and maintenance costs and efficient structural characteristics. There are 4 types of cable arrangements that are Fan, Harp, Radial and Star type arrangements. Then we consider 3 different Material properties for this cable arrangements. The bridge is analyzed and designed for these cables arrangement by STAAD Pro software. The most efficient cable arrangement is proposed after analysis among the twelve. The comparison is made for Shear force, bending moment and displacements for the cases. The results are summarized and discussed. This can be useful in the modifying the drawbacks of others.

1. INTRODUCTION

Cable stayed bridges are becoming more and more popular and are usually preferred for long span crossings compared to suspension bridges. A cable-stayed bridge consists of one or more towers with cables supporting the bridge deck. In terms of cable arrangements, the most common types of cable stayed bridges are Harp, Radial, Fan and Star bridges. Because of their large size and nonlinear structural behaviour, the analysis of these types of bridges is more complicated than conventional bridges. In these bridges, the cables are the main source of non-linearity. An optimum design of a cable-stayed bridge with minimum cost while achieving strength and serviceability requirements is a challenging task. In this thesis, cable stayed bridge is analyzed by changing the cables arrangement each time, to obtain the results for bending moment, forces and deflection. The four cable's arrangement considered Harp, Radial, Fan and Star arrangement. Comparison between the four types, in terms of forces, bending moment and deflection, is carried out in this thesis. The bridge is analyzed by the commercial finite element based software STAAD Pro.

2. LITERATURE REVIEW

A typical cable stayed bridge is a deck with one or two pylons erected above the piers in the middle of the span. The cables are attached diagonally to the girder to provide additional supports. The pylons form the primary load-bearing structure in these types of bridges. Large amounts of compression forces are transferred from the deck to the cables to the pylons and into the foundation. The design of the bridge is conducted such that the static horizontal forces resulting from dead load are almost balanced to minimize

the height of the pylon. Cable stayed-bridges have a low center of gravity, which makes them efficient in resisting earthquakes. Cable stayed bridges provide outstanding architectural appearance due to their small diameter cables and unique overhead structure.

3. ANALYSIS

In this analysis, The Cable Stayed Bridge is studied for the four types of arrangement of cables i.e., fan type arrangement, radial type arrangement, harp type arrangement and star arrangement and assigning 3 different material properties for this 4 types of cable arrangements. The comparison is made for the twelve models of shear force, bending moment and displacement. The analysis is done by using STAAD Pro software. The most efficient arrangement is proposed after comparison of the twelve cases.

3.1 METHODOLOGY

In this paper analysis of two span double plane cable stayed bridge is performed. A complex Structural linear analysis is carried out with the help of STAAD PRO software. For linear analysis IRC class AA is considered as moving load on bridge and wind load is taken as per the IS 873 part 6 the wind speed is taken for Bangalore region which is 33mph.

3.2 DESCRIPTION OF CONSIDERED MODEL.

Analysis is made for cable stayed bridge. The total span of the bridge is 200 m. The total width of the deck of the bridge is 10 m. The diagram of bridge is as shown in Figure.2. In construction; firstly edge beams are erected and then followed by deck slab with crossbeams. The total height of bridge is 65 m. The pylon used here is H shaped. Bridges with Fan arrangement, and star arrangement are as shown in Figure 3 and Figure 4. The earthquake load is not considered. The thesis is limited to the two cables arrangement only, other are not considered. The 3 different material properties are considered. The properties limited only to the shear force, bending moment and deflections. Other evaluations are not considered. The Size of the member and their materials are given table 1. Six Models have been created based on the material combination showed in table no 2 and analysed.

Table-1: Dimension of the bridge components

Sl no	Structure	Material	Size
1	CABLES	Fe ₅₀₀ , Fe ₅₂₀ , Fe ₅₄₀	Diameter=0.35m
2	PYLONS	M ₆₀ , M ₃₀ , M ₃₂	Diameter=2m
3	DECK	M ₆₀ , M ₃₀ , M ₃₂	4*0.75m
4	BEAM	M ₆₀ , M ₃₀ , M ₃₂	0.75*0.6m

Table-2: Materials Considered

Cable type	Material Combination:1	Material Combination:2	Material Combination:3
Fan Type	Fck=60 N/mm ² and Fy=500 N/mm ²	Fck=30 N/mm ² and Fy=520 N/mm ²	Fck=32 N/mm ² and Fy=540 N/mm ²
Harp Type	Fck=60 N/mm ² and Fy=500 N/mm ²	Fck=30 N/mm ² and Fy=520 N/mm ²	Fck=32 N/mm ² and Fy=540 N/mm ²
Radial Type	Fck=60 N/mm ² and Fy=500 N/mm ²	Fck=30 N/mm ² and Fy=520 N/mm ²	Fck=32 N/mm ² and Fy=540 N/mm ²
Star Type	Fck=60 N/mm ² and Fy=500 N/mm ²	Fck=30 N/mm ² and Fy=520 N/mm ²	Fck=32 N/mm ² and Fy=540 N/mm ²

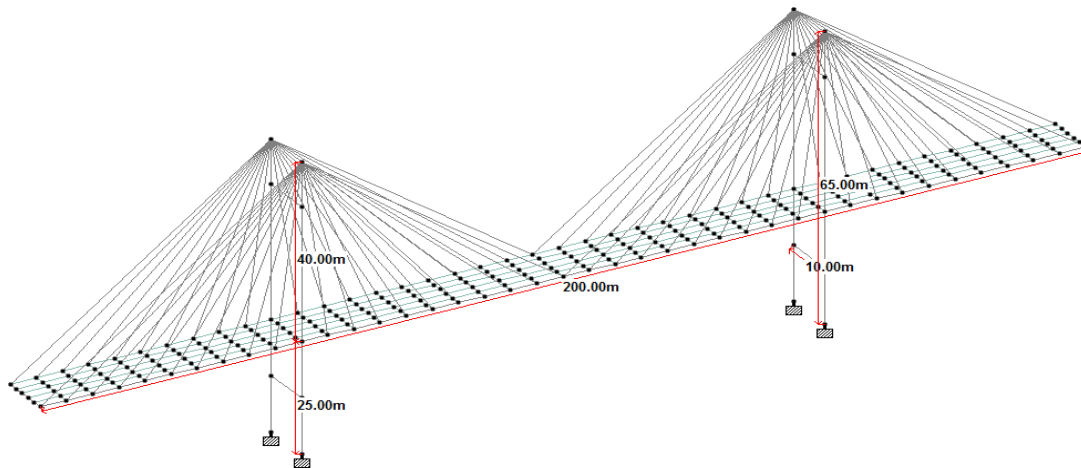


Figure 1: Cable stayed Bridge Fan arrangement with dimensions-Isometric view.

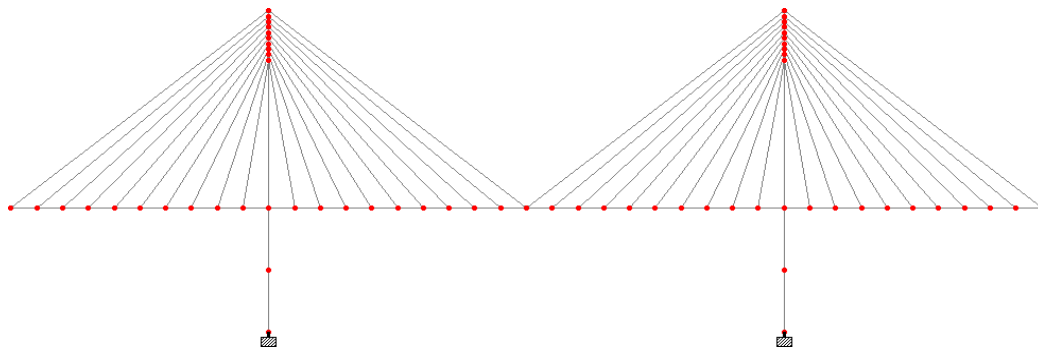


Figure 2: Cable stayed bridge with Fan arrangement of cables.

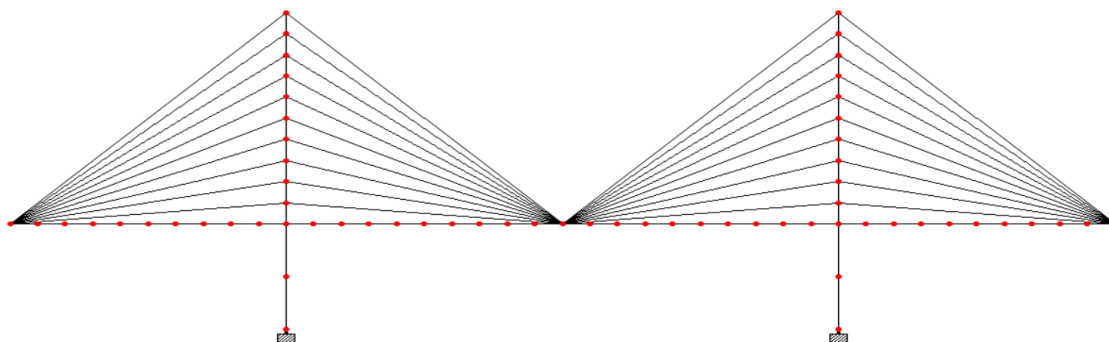


Figure 3: Cable stayed bridge with star arrangement of cables.

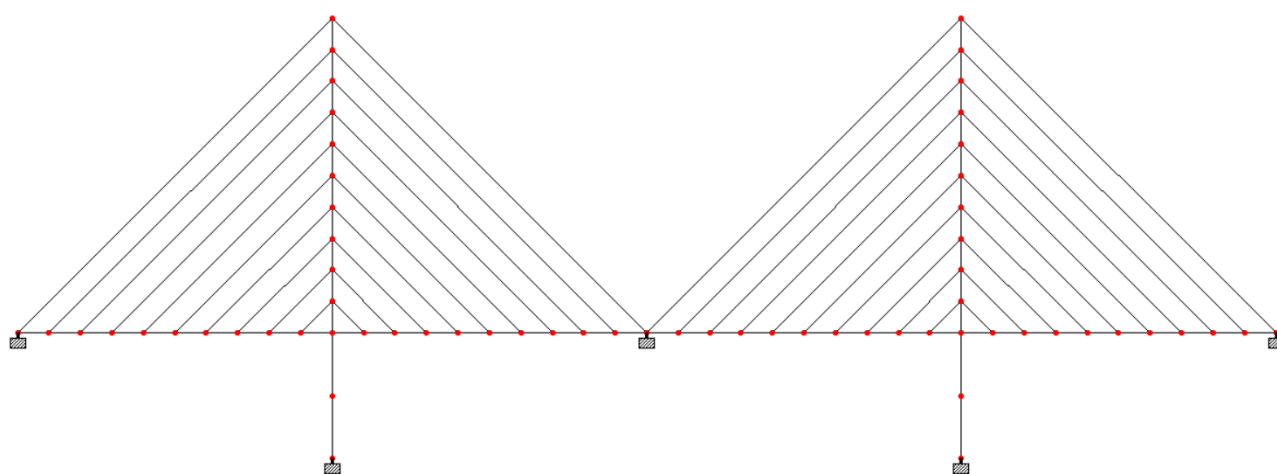


Figure 4: Cable stayed bridge with harp arrangement of cables.

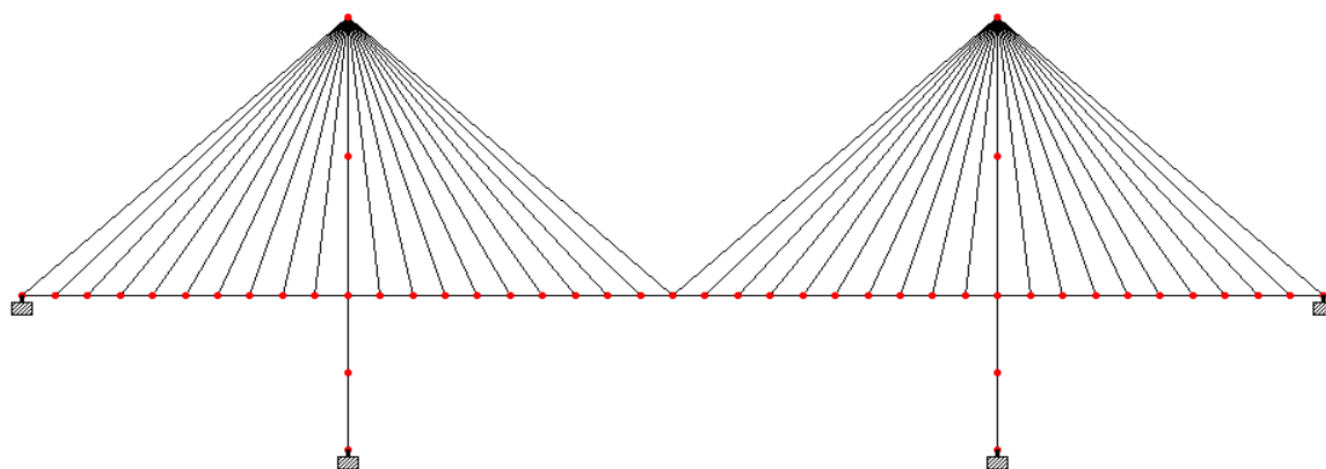


Figure 5: Cable stayed bridge with radial arrangement of cables.

3. COMPARISON

Sl.no	CABLE ARRANGEMENT	MAX SHEAR FORCE [kN]			MAX BENDING MOMENT [kN-m]			MAX DEFLECTION [mm]		
		Fck=60 and Fy=500	Fck=32 and Fy=540	Fck=30 and Fy=520	Fck=60 and Fy=500	Fck=32 and Fy=540	Fck=30 and Fy=520	Fck=60 and Fy=500	Fck=32 and Fy=540	Fck=30 and Fy=520
1.	FAN	18679	17717	17713	3003	37500	37500	40	670	658
2.	STAR	21342	21336	21335	3077	30782	30733	101	653	685
2.	HARP	18692	17713	17713	3003	37500	37500	38	670	685
2.	RADIAL	20422	20357	20351	8424	37500	37500	56	747	761

Table 3: Comparison of Fan, Star, Harp and Radial arrangement.

4. RESULT

In this section, the results for the efficient design of the four arrangements of cable-stayed bridges including fan, harp, radial and star arrangements are presented. The purpose of this is to study the effect of different cables configurations with different material properties.

1. The shear force is more in star cable arrangement for M60 and Fe500 and less in Fan cable arrangement for M30 and Fe520.
2. The bending moment is more in Radial cable arrangement for M30 and Fe520 and less in Fan cable arrangement for M60 and Fe500.
3. The deflection is more in star cable arrangement for M30 and Fe520 and less in Harp cable arrangement for M60 and Fe500.

5. CONCLUSION.

In this study, an implementation of four types of cables arrangement for the design of the cable stayed bridges have been introduced considering fan, harp, radial and star arrangements. The shear force, bending moment and deflection for four types of cable-stayed bridges are compared with each other and the result of comparisons are reported. First, bridge is developed for Fan M60 and Fe500. second, Harp M60 and Fe500 Cable arrangement. Third, Radial M60 and Fe500 Cable arrangement and Star M60 and Fe500 Cable arrangement with there material properties of cable stayed bridges. Then effect of these arrangements on the stability and efficiency of bridge components are investigated for fan, harp, radial and star arrangements are compared. At the end, the most efficient out of all these four arrangements is proposed. The results indicated that the fan arrangement of M60 and Fe500 is more efficient than the harp, radial and star arrangement of other materials.

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7. FUTURE SCOPE.

- The analysis has been carried out in this study with H type tower, it can be replaced by different type of the tower.
- Concrete pylons have been considered in this study and for extension of project steel pylons may be considered and compared.

8. REFERENCES.

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