Analysis of a Cable Stayed Bridge with Different Arrangement of Cable and Pylon Types

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Abstract— Cable stayed bridges are similar to the suspended bridge i.e. it has towers and a deck that is held by using cables, but its cables keep the deck through connecting it immediately to the towers as a substitute via suspender cables. It normally carries pedestrians, bicycles, cars, vans, and mild rail. It has more than one tower also called pylons, through which cables guide the bridge deck. A one-of-a-kind feature is the cables which run immediately from the tower to the deck, generally forming a fan-like pattern or a chain of parallel strains. That is in evaluation to the modern-day suspension bridge, wherein the cables assisting the deck are suspended vertically from the principle cable, anchored at both ends of the bridge and running between the towers. The cable-stayed bridge is most useful for spans longer than cantilever bridges and shorter than suspension bridges. However it is the range where cantilever bridges would develop heavier if the span has been lengthened; at the same time as suspension bridge cabling might not be more in economical aspect if the span had been shortened. In this study we are analysing a 500 m long cable stayed bridge with different cable or pylon type arrangement using analysis tool staad. In this research work we are analysing the loading conditions as per conventional (manual) method. Here it is concluded that with respect to the shape of tower we noticed that H shape pylon shows low amount of sag and moment in the cables and in the deck because it has more number of joints which are not uniform so that the concentration of stress and tension carrying capacity of the cables was not effectively distributed to the other parts of the cable which may lead to maximum concentration in some cables, when compared to circular which has homogeneous member.

Key words: Structural Analysis, Conventional Design, Hydraulic Design, Cable, Span, Pylons, Arrangements

I. Introduction

Cable-stayed bridges have good stability, as they make the best use of structural materials, asthey are aesthetic and tremendously low designed. They require very less protection costs and are efficient structural traits. The cable-stayed therefore, are kind of bridges which are becoming more and more famous and are generally preferred for lengthy span crossings as compared to the suspension bridges. A cable-stayed bridge includes more than one tower with cables helping the bridge deck. The best examples of cable stayed bridges are fan, harp, and semi fan bridges. Because of their big length and nonlinear structural behaviour, the analysis of these kinds of bridges is more complex than conventional bridges. However in these bridges, the cables are the principle supply of nonlinearity. An optimal design of a cable-stayed bridge with minimum cost with accurate strength and serviceability necessities is a challenging project.

Cable stayed bridge works on the concept: that deck of the bridge can be supported by way of the inclined chambers which might be stretched from the tower and acts as the tension members to carry the load coming over the bridge and transfer the load into the sub structure through the towers. The concept of cable stayed bridge was first posted by the French engineer Navier in 1823. He has done lots of investigation regarding bridge deck supported by the wrought iron chains.

However wrought iron chains provide the further stiffness to the bridge deck. In 1938 FranzDischinger studied on cable stayed bridge wherein the outer part of the bridge deck in longitudinal direction is attached by using the cable on the top of the tower similar to Navier’s work. But he did a few adjustments inside the centre span of the bridge in which cables are connected between the towers and deck as the arrangement of suspension and cable stayed bridge.

However it is noted that this system is not used for construction as this system had many structural faults. So Dischinger proposed a new system which can be known as the pure cable stayed bridge system. This system is adopted within the construction of the Stromsund Bridge as a result Dischinger is known as “the father of modern cable stayed bridge”. Stromsund Bridge was completed in the year 1955 becoming the primary ever contemporary cable stayed bridge built. Another bridge similar to The Stromsund bridge was built over the Rhine river at dusseldorf which is designed by Leonhardt in 1957 and the name of the bridge is Theodor Heuss bridge .These two bridges had been very stiff, appealing, reasonably-priced and comparatively easy to erect. In this manner they became an extensive and successful utility.

II. Cables

We can say that cables are wire-like arrangements and it has no bending stiffness, hence they can carry only axial tension force. But even if it is fully flexible against bending, then the shape of a cable can be found by the external forces that are acting on the cable.

Cables are commonly made from a couple of strands of cold-drawn high-strength steel wires twisted together. Normally, they have got strength 4 to five instances that of structural steel and practically inextensible underneath working loading situations. Given that cables bring only axial tension, complete capacity of the cable go-section can be applied in transferring forces. Therefore, cables are capable of convey the equal quantity of force with a much smaller cross-section compared to different structural systems.

However excessive strength -to-weight ratio makes cables very beneficial wherein light-weight systems are needed. Then again, a beam over a totally long span could require a very large (and deep) pass-section, and most of its ability may be utilized in sporting internal forces because of its personal weight. If we use cables replacing this beam or in mixture with a beam rather, a lighter shape may be required, who's self-weight will no longer add appreciably to load outcomes. The number one drawback with cables is because of their flexible geometry. Because the loading on a cable machine modifications (as in the case of shifting hundreds on a bridge) there can also be huge change in the cable geometry, and sooner or later on forces appearing in the cable. Surprising forces may additionally destabilize a cable system, causing immoderate deformations. A designer must be very careful on this regard while designing a cable system, at the side of other issues which include, large forces at the anchors, massive oscillations, and so on.

III. LITERATURE REVIEW

MycherlaChaitanya (2018) modelled Girder Bridge and Cable stayed bridge and investigate its performance under dynamic loading conditions. They consider dead load, live load and combined load for analysis purposes. At last author made comparative analysis with reference to internal forces, stresses and deformation of structure under various load effects.

KrunaliMavani (2017) performed the modelling of Cable Stayed Bridges with different pylon arrangements. Author realised that there is a need of examination of dynamic response on the effect of shape of pylon. Also in their research work the bridge specifications and other performance parameters were kept constant and the only variation is made in pylon shape with variation in height of the pylon for assessment purpose.

PravinMalwiya (2017) did linear static and nonlinear static analysis using this software SAP2000. He also investigated the cable tension, deck deflection, and base shear and made comparison for the study of behaviour of cable-stayed bridge.

PawanPatidar and Sunil Harne (2017) checked the economic status of Plate Girder Bridge (Railway) on various spans keeping one parameter constant and other parameters varying.

IV. OBJECTIVES

1) In this analysis, we will investigate the performance of the Cable Stayed Bridge with four types of common arrangement of cables i.e., fan type arrangement, star arrangement, radial arrangement and harp arrangement with different arrangement of pylon "A" shape, "Y" shape, "H" shape.
2) The comparison will be made for the these arrangement types with respect to shear force, bending moment, Axial force, plate stresses and displacement.
3) All the analysis will be done on STAAD Pro BEAVA software. After that we will propose a most efficient arrangement after comparison of the cases.

V. METHODOLOGY

1) Before starting our work, we first review the literature related to our work.
2) Next step is we will make the models as per different arrangement in STAAD Pro BEAVA and assigning member and material properties as per the design.
3) Description of the bridge considered with span of 500 m. The deck width is 10 m. The height of bridge is 70 m.
4) In our work the load considered are dead load, Imposed Loads and I.R.C. 70-R Load.
5) And finally we will make the comparison of different cases.

Description	Value
Total span of the bridge	500 m
total width of the deck of the bridge	10 m
Total height of bridge	70 m
Dia. of Pier	1.3 m
Girder size (1)	0.8 x 0.45 m
Girder size (2)	0.6 x 0.45 m
Deck thickness	.75 m
Support type	Fixed support

Table 1: Description of Structure

Dickens formula to calculate Peak Run-off from Catchment:	
Area of Catchment (A): =	11650 Ha
Dickens Constant, C_D (for Central India): =	16
Discharge = C_D x$(A)^{3/4}$ =	567.37 m^3/s
Discharge Through the Stream =	568.00 m^3/s
Regime width = 4.8 x $(Q)^{0.5}$ =	114.40 m

Table 2: Hydraulic data

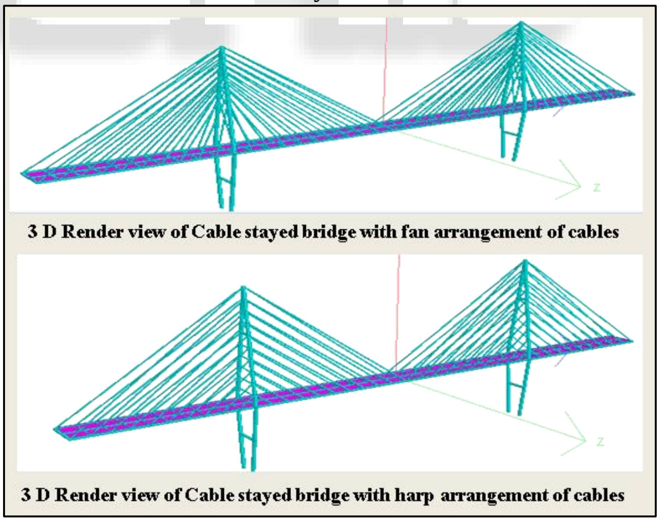

Fig. 1: Modelling and analysis of cable stayed bridge in staad.

VI. RESULT ANALYSIS

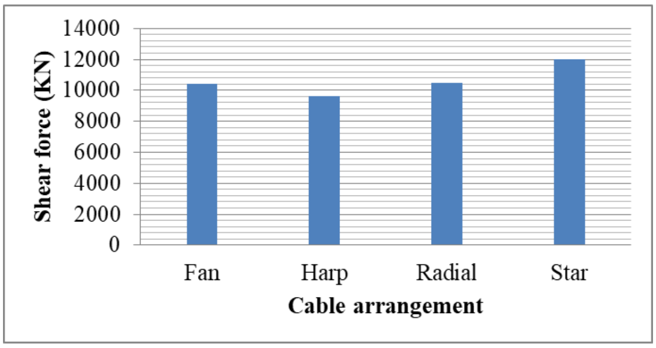

Fig. 2: Shear force for H shape tower

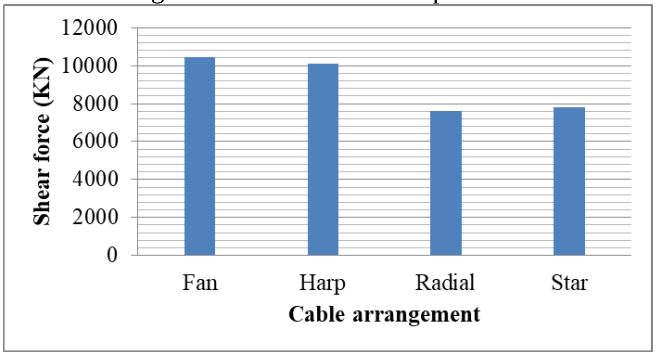

Fig. 3: Shear force for a shape tower

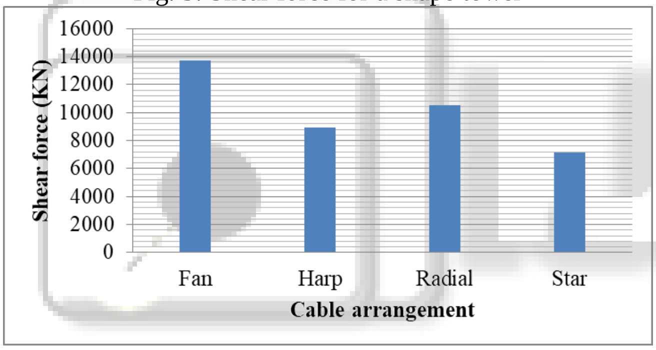

Fig. 4: Shear force for a shape tower

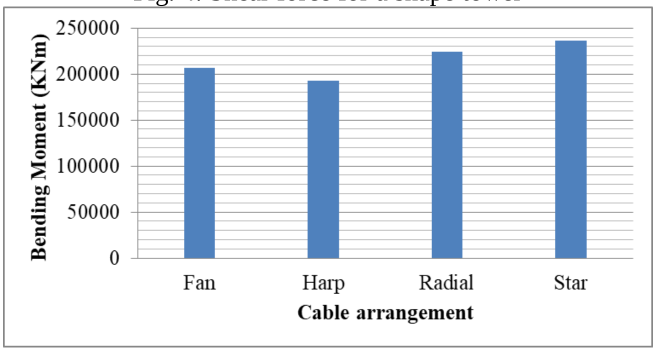

Fig. 5: Bending moment for H shape tower

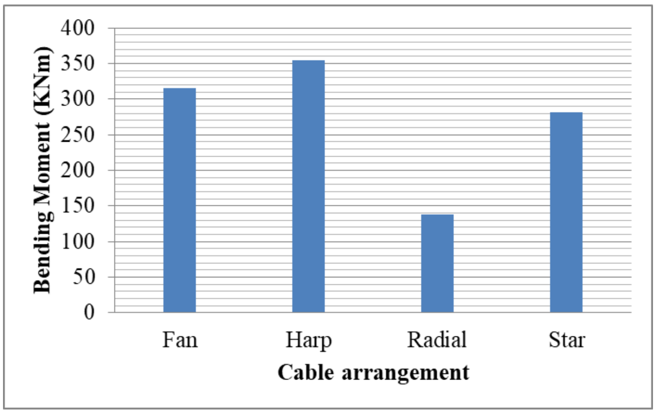

Fig. 6: Bending moment for a shape tower

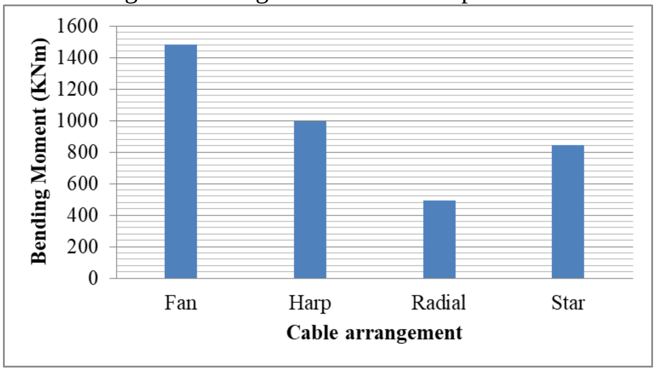

Fig. 7: Bending moment for Y shape tower

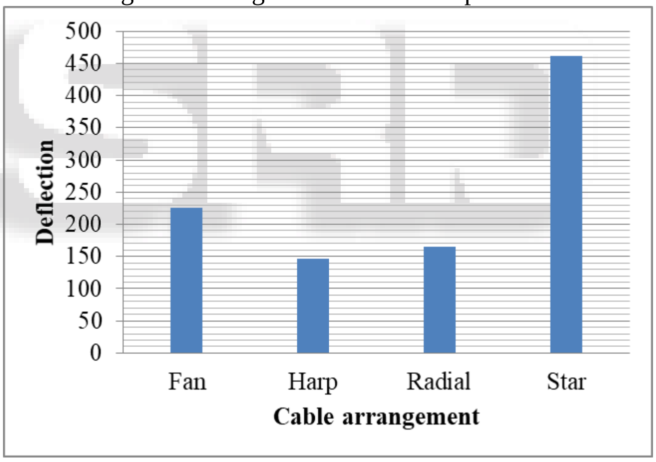

Fig. 8: Deflection with different cable arrangement for H shape tower

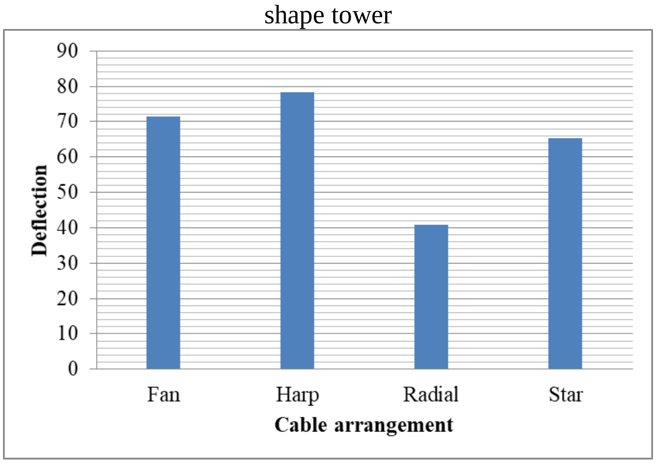

Fig. 9: Deflection with different cable arrangement for a shape tower

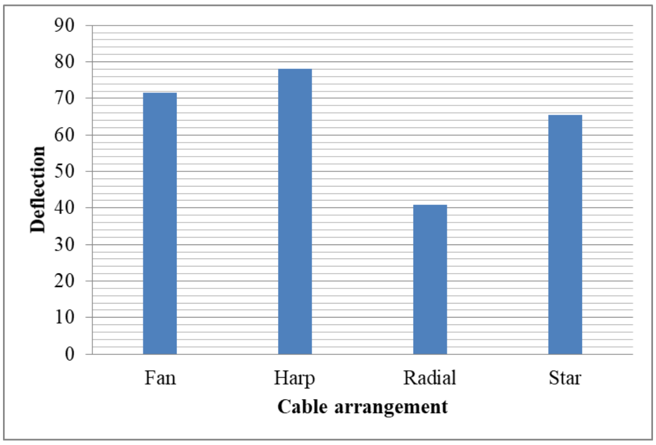

Fig. 10: Deflection with different cable arrangement for Y shape tower

VII. Conclusion

A. H shape tower

1) The shear force is more in star and least in harp arrangement
2) The bending moment is more in star and least in harp arrangement
3) Deflection is more in star and least in harp arrangement
4) The results indicated that the harp arrangement is more efficient then three other arrangement

B. A shape tower

1) The shear force is more in Fan and least in radial arrangement
2) The bending moment is more in harp and least in radial arrangement
3) Deflection is more in harp and least in radial arrangement
4) The results indicated that the radial arrangement is more efficient then three other arrangement

C. Y shape tower

1) The shear force is more in Fan and least in star arrangement
2) The bending moment is more in Fan and least in radial arrangement
3) Deflection is more in harp and least in radial arrangement
4) The results indicated that the radial arrangement is more efficient then three other arrangement

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