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Analysis of cable stayed suspension Hybrid Bridge for different geometrical configuration

Prof. Anjali R. Palheriya el[1], Prof. Bobby N. Ramteke, el[2], Prof. Chetna P. Shelke, el[3]

ABSTRACT
The development of nation is considered on the basis of development of infrastructure of the nation. Now days the demand of long span bridge has increased to get the maximum crossway. To get the maximum central span in bridges is a difficult task for the engineers. The bridge with maximum central span can be achieve by using high quality materials and upgraded technology in the innovative forms of the bridges. The cable-stayed bridge provide good structural stability and suspension bridge has ability to provide longer span and thus combination of above two structural systems can give very long span cable-stayed suspension hybrid bridge. To investigate the behaviour and check the feasibility of this innovative form of Hybrid Bridge, 280.5m central span and 130.9m side span cable-stayed suspension hybrid bridge is considered for analysis. The suspension portion length in central span of the bridge is also shows the important role in behaviour of the entire bridge with different geometrical configuration of bridge. Paper also discusses results of modal analysis carried out using SAP2000 v18.0.0. The time period of bridge is used to present the behaviour of bridge.
Key words: Cable stayed bridge, suspension bridge; cable stayed suspension hybrid bridge; different geometric configuration.

INTRODUCTION

Now a days demand of longer span bridges is increased and hence it is tough challenge for the construction of longer spans bridge structures. To provide long span bridge, the use good quality of material and high strength steel cables as tension resistance structural elements is important. The concept of Hybrid Bridge might be chosen for the solution of huge and complicated traffic problems and simultaneously it provide a faster track of development to a country. The different structural systems of bridges which used to achieve longer span are as listed below.

1. Cable-stayed bridge
2. Suspension bridge
3. Cable-stayed Suspension Hybrid Bridge

1. Cable-Stayed Bridge

The cable-stayed bridge deck is in compression, pulled towards the towers, and has to be stiff at all stages of construction and use. The cable-stayed bridge is well balanced, the terminal piers have little to do for the bridge except hold the ends in place and balance the live loads, which may be upward or downward, depending on the positions of the loads. Cable stayed bridges provide good architectural appearance due to the arrangement of small diameter cables and unique overhead structure.

2. Suspension Bridge

In the suspension bridge the deck portion is hangs below suspension cables using vertical suspenders. The vertical suspenders carry the weight of the deck. . In suspension bridges, the cables ride freely across the tower, transmitting the load to the anchorages at either end.

3. Cable-stayed suspension hybrid bridge The cable-stayed suspension hybrid bridge is an better option for the long span suspension and cable-stayed bridges. Hybrid cable-stayed suspension bridge is composite structure of cable-stayed bridge and suspension bridge.

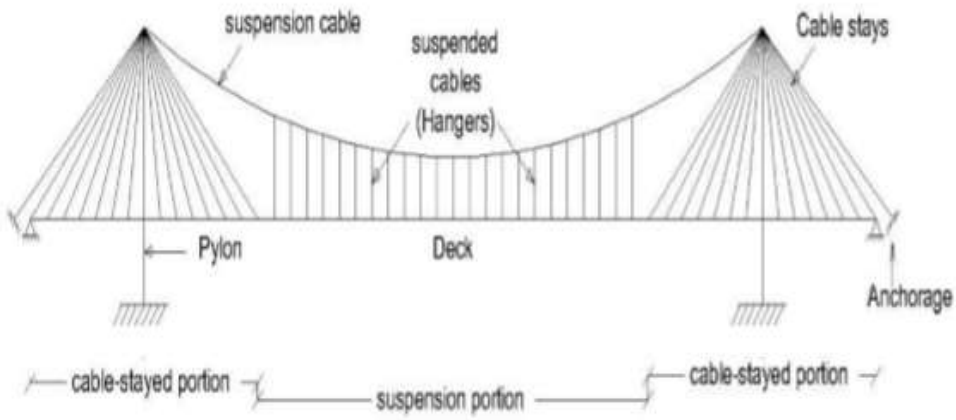

Fig.1 Hybrid cablestayed suspension Bridge

During the few years, many researchs are carried out with the main purpose to propose proper procedure to calculate the optimum configuration of bridge for the great stability of bridge. The zero displacement methods is based on the use of explicit constraint equations, which results the bridge structure under dead loading to remain practically unreformed. Konstantakopoulos et. al. gives a mathematical model for investigation of the dynamic behaviour of a composite cable system of bridges under moving loads. The deformation of bridge under the action of moving loads is also studied [1]. There are so many existing cable supported bridges are designed by using traditional techniques, in which the iterative methods based on simple design rules considered by designer's experienced [2]. Lonetti et. al. gave description of methods to forecast post-tensioning forces and dimensioning of the cable system for hybrid cable stayed suspension bridges [3]. Lewis proposed a mathematical model to calculate the comparative material costs of the supporting elements for cable stayed and cable suspension bridges. In this paper requirement of material for different type of bridges is base on the range of span/dip ratios [4]. Zhang et. al. had done work on the limit span of self-anchored cable-stayed suspension bridge. The relations between the geometrical parameters, loads and material characteristics are also investigated [5]. Zhang has proposed the static and dynamic characteristics of 1400 m main span cable-stayed suspension Hybrid Bridge. The aerodynamic stability is investigated by 3D nonlinear analysis [6]. Zhang et. al. presented analysis of a self-anchored cable-stayed-suspension bridge with best possible cable tensions under stationary loads.[7]. Authors suggest from the analysis carried out that the short suspension portion in main span is aerodynamically favorable [8].

ADVANTAGES OF CABLE-STAYED SUSPENSION HYBRID BRIDGE

Advantages of combination of both the bridges are discussed below.

1. In the hybrid bridge the suspension portion can be reduced by replacing the suspenders by cable stays, due to this the axial force in the main cables reduced.
2. In the hybrid bridge, the suspension portion is reduced the cost of main cable construction and massive anchorage is also reduced effectively.
3. As compared to cable-stayed bridges with the same span length of hybrid bridge, the number of cable stays are reduced. Due to this it results in the reduced height of tower, length of stays and the axial forces in thed deck.
4. The wind stability of the bridge under construction may therefore improve.

Hence the hybrid cable-stayed suspension bridge becomes an easy and attractive option for the design of long span bridge systems.

BRIDGE CONFIGURATION

In this paper the bridge model resembles to the Quincy Bayview Bridge located in Illinois, crossing the Mississippi river at Quincy, USA is chosen. The cable stayed bridge is composed of 56 stay cables. The bridge consist of two H- shaped concrete pylon, and the cables are arrange in double-plane fan type cables and composite concrete- steel girder bridge deck[9].

Fig. 2 Quincy Bayview Bridge

a) Modelling details of cable stayed bridge

The dimensions of the bridge are modified for the convenience of modeling of all the bridges having same superstructure, only cable arrangements are changed. The total length of the bridge L = 542.3 m with a main span length M = 280.5 m and two side spans l1 = l2 = 130.9 m as depicted in Fig.3. In this figure the deck superstructure is supported by stay cables with a semi-fan arrangement. The precast concrete deck has a thickness of 0.23 m and a width of 14.2 m.

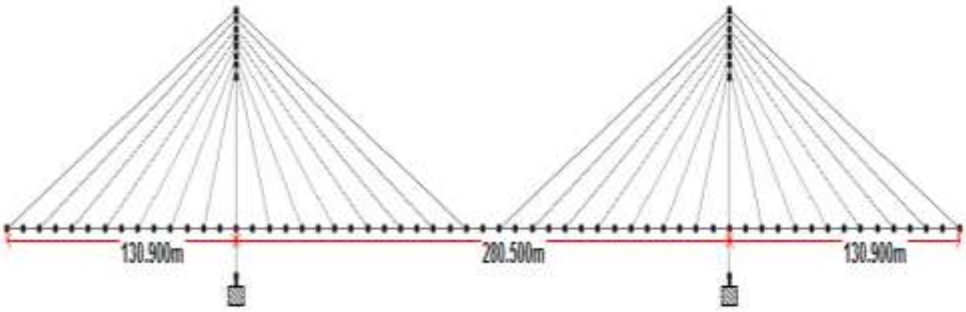

Fig. 3 Front view of cable stayed bridge model

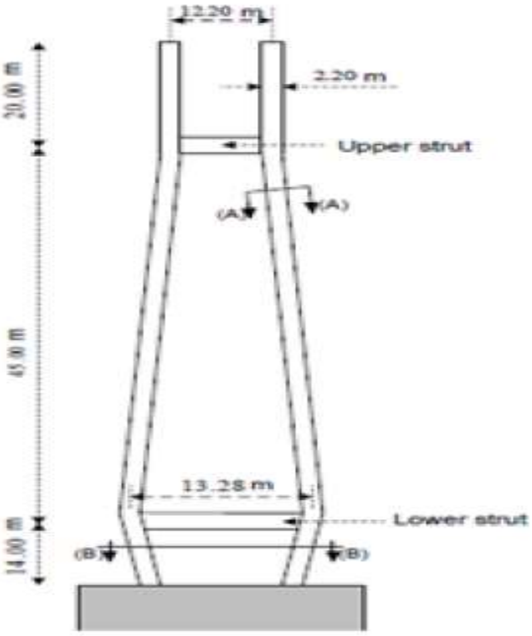

Fig. 4(a) Cross section of bridge pylon

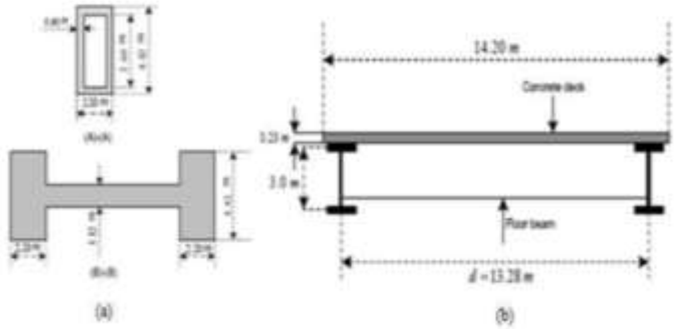

Fig. 4(b) Cross section at mid span of bridge

It has two steel main girders, located at the outer edge of the deck. The main girders are internally connected by a set of equally spaced floor beams. The pylons have two concrete legs as they are connected internally with a pair of struts. The lower legs of the tower are connected by a 1.12 m thick wall. The elevation view of tower is shown in Fig. 4. The pylon has a H-shape with two concrete legs. The upper strut cross beam height is 45 m, and the lower strut cross beam supports the deck [10]. Here the sections for the stay cables are assumed due to the lack of data of the reference bridge. The stay cable of diameter 0.2m has taken. The connection between deck and pylon is assumed to be fixed against translation in the vertical and transverse directions and fixed against rotation about the longitudinal axis. The pylon footings are considered to be fixed against both translation and rotation.

b) Modelling details of suspension bridge

In the model of suspension bridge all the super structural components besides of stay cables are kept remain for the point of view of comparison with the cable stayed bridge and other two type of composite bridges. Here the stay cables are replaced by suspension cables and hangers. Hangers are erected at the same places where the stay cables were placed with the cable stayed bridge girders. Hangers are not joined to each other directly. They are connected through the suspension cable i.e. these are hanging from the suspension cable. Here girder, deck slab, pylon are taken same as like cable stayed bridge. Only two new structural sections had been added into this viz. suspension cable and hanger. The taken diameters of suspension cables and hangers are 0.5m and 0.2m.

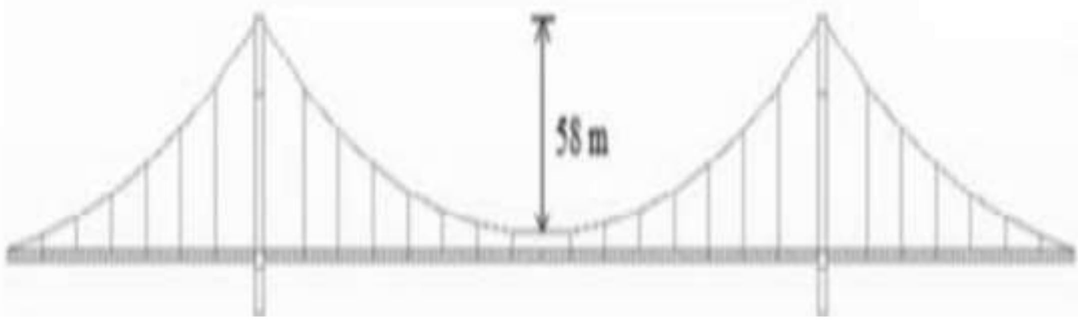

Fig.5 Front view of suspension bridge

c) Modelling details of hybrid bridge

Here stay cables are used over the two cantilever spans and suspension cables with the hangers are used over middle span of the bridge. The middle span is hanging from suspension cables through the Hangers and cantilever span is directly anchored to the pylon through the stay cables. So the transmission process of tension forces in left side and right side of every pylon are different. Here stay cables are playing two deferent roles i.e. it is acting as stiffener for the cantilever span and simultaneously anchoring the middle span.

Fig.6 Hybrid Bridge

LOADING FOR ANALYSIS

Different elements of bridge are subjected to different types of loads like dead load, SIDL, live load etc. In this configuration the static load for the bridge is only the self weight of every structural member of the bridge. The moving load analysis for this bridge is done for the two lanes both way traffic flows . The moving load is taken as per IRC-6 2016 for the two lane traffic.

ANALYZED RESULTS OF BRIDGE MODELS

Analyzed results of cable stayed, suspension, and composite type of bridges are given on the basis of displacements in longitudinal girder due to dead load, displacement in pylon due to dead load and moving load. The stability of structure depends on the proper load transformation of load and hence the comparison is done on basis of forces in cable stayed, suspender cable and hanger.

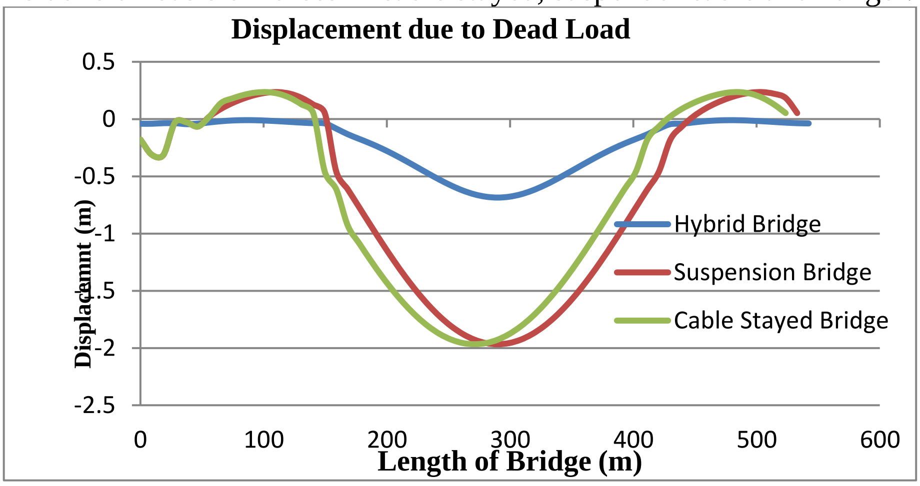

Fig. 7 Displacement due to dead load in main girder

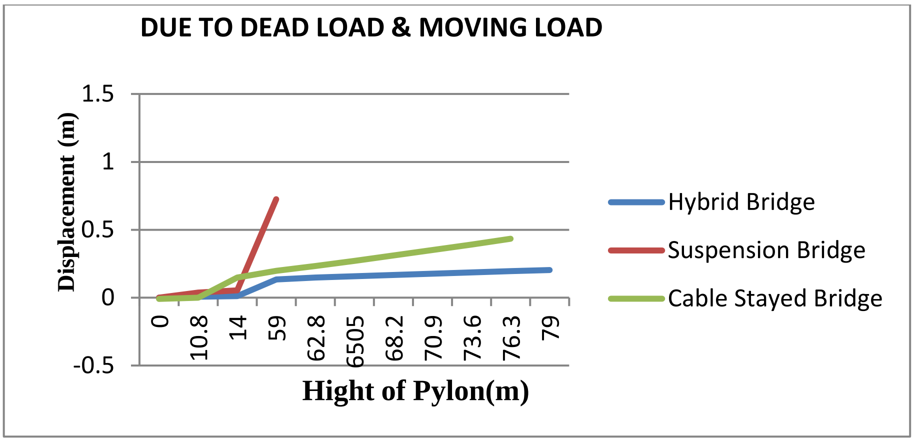

Fig. 8 Displacement due to dead load and moving load in pylon

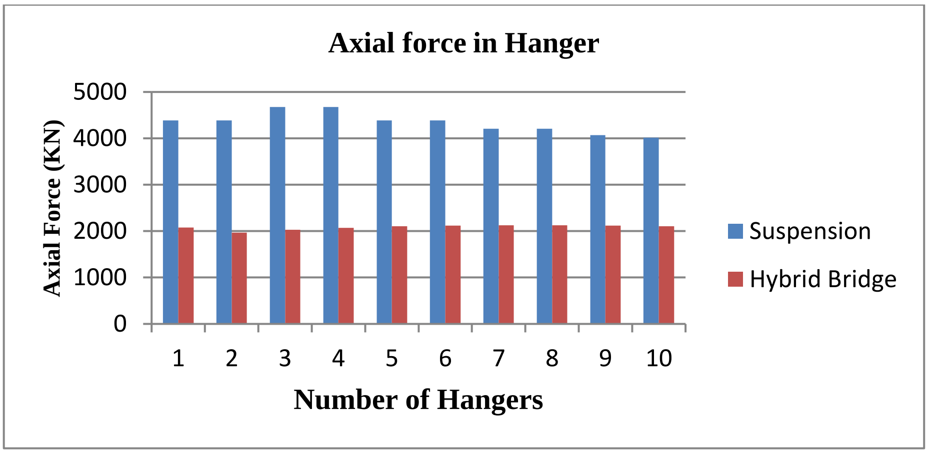

Fig. 9 Axial forces in Hangers

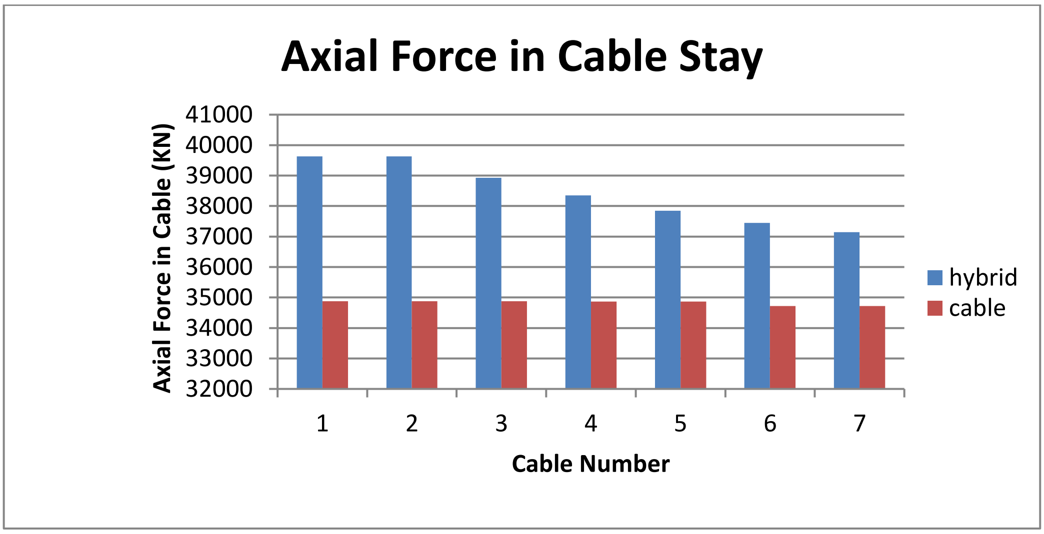

Fig. 10 Axial force in Cable stayed

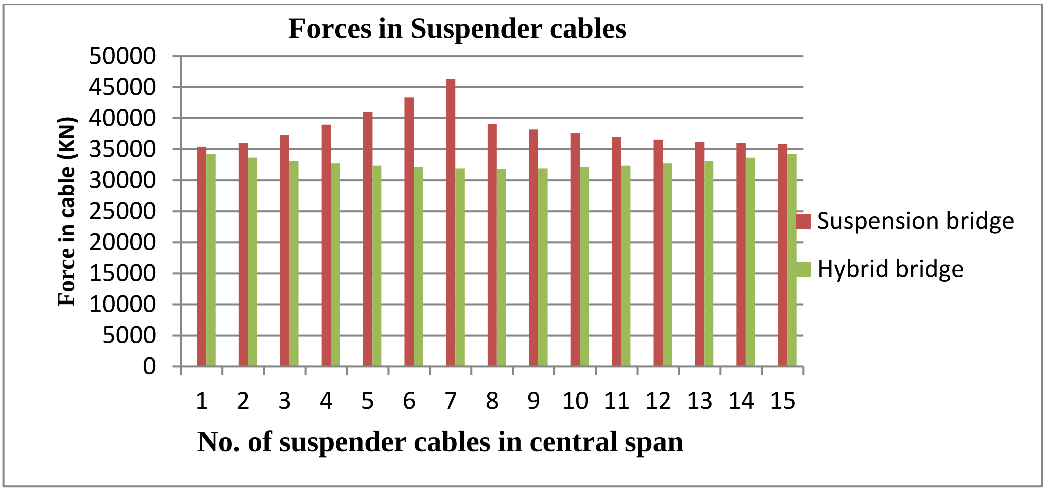

Fig. 11 Forces in Suspender cables

CONCLUSIONS

The overall conclusion shown through the comparison of all the three bridges, displacement in hybrid bridge is in the permissible limit and comparatively lesser than suspension bridge. The displacement in pylon occurred due to the combination of dead load and live load is minimum in the hybrid bridge as compared to the cable stayed and suspension bridge. The load transformation through the cables is done more conveniently in hybrid bridge which gives more structural stability. Therefore, we concluded that hybrid bridge has great structural stability than cable stayed and suspension bridge. And hence it is the innovative form of alternative for the long span bridge.

REFERENCES

[1]. Clemente P., Marulo S., Lecce L. & Bifulco A. "Experimental modal analysis of the Garigliano cable stayed bridge", Int. J. Soil Dynamics and Earthquake Engineering, Elsevier Science, 1998; 17(7-8):485-493.
[2]. Colin O"Connor and Peter. A. Shaw, Professor of Civil Engineering, University of Queensland, Australia and Senior Engineer Brisbane City Council, Australia, "Bridge Loads".
[3]. Simiu, E. and Scanlan, R.H., Wind Effects on Structures, Third Edition, John Wiley and Sons, New York, N.Y., 1996
[4]. Younes Achkire, Active Structures Laboratory, University of Libre de Bruxelles, Belgium, "Active Tendon Control of Cable-Stayed Bridges"
[5]. John Scalzi and Walter Podolny "Construction and design of cable-stayed bridges", second edition.
[6]. M.S. Troitsky "Cable-stayed bridges, Theory and Design", second edition. Baldomir, S. Hernandez, F. Nieto, J.A. Jurado. Cable optimization of a long span cable stayed bridge in La Corua (Spain). Advances in Engineering Software. 2010, 41:931-938.
[7]. L. M. C. Simes, J. H. J. O. Negro. Optimization of cable-stayed bridges with boxgirder decks. Advances in Engineering Software. 2000, 31:417-423.
[8]. Venkat Lute, Akhil Upadhyay, K.K. Singh. Computationally efficient analysis of cable staye dm bridge for GA based optimization. Engineering Applications of Artificial Intelligence 2009, 22:750-758.
[9]. Yu-Chi Sung, Dyi-Wei Chang, Eng-Huat Teo. Optimum post- tensioning cable forces of Mau-Lo Hsi cable-stayed bridge. Engineering Structures, 2006,28: 1407- 1417.