Comparative Analysis of Cable Stay Bridge Designs Using Ansys

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Abstract— The Aim of the research study is to design a Cable Stay bridge structure with fan type, harp type and suspension type cable connections using ANSYS tool and to execute a modal analysis of bridge problem. The objective of the research study is to model a cable stay bridge with three different design i.e. harp, fan type and suspension type, using ANSYS software and to perform a modal analysis of bridge problem. For all four materials eight node solid element is designated and meshing is completed separately for each modal. The material property of each material is selected as per literature database in ANSYS software. The modal examination and design of bridge in ANSYS is completed to find the natural frequency, deformations, stresses and mode shapes of bridge to avoid the resonance of the bridge. Optimize cable and bridge deformations with comparison of harp, suspension and fan type bridge designs.
Keywords: Cable-Stayed Bridge, Dynamic Load, Suspension Bridge, Cable Layout, Ansys

I. INTRODUCTION

A cabled bridge, one of the most popular bridges today, consists of a solid shaft (sock) consisting of at least one column or tower in the center. The link between these columns or towers and the shaft extends corner to corner. These connections support the beam. Instead of at the top, they are close to the peak. The latest scaffold construction trends are aimed at a wider range of small and lightweight auxiliary structures. The support progress depends on the increased use of elite material. The cable has remained a modern structural structure commonly feasible in the mixture of material developments, engineering advancement and technological limits over the last few decades. Due to stylish suspense, simple usefulness, improved firmness contrasted and suspension attachment, simplicity of production, more notable opposition to simplified operation and functional substructure, the cable stayed attached proved to be one of the most common extension frames used across the globe. The connection between the mill cable and at least one tower is built up in the center of the range. Sloping ties stretch from these towers to support the roof.

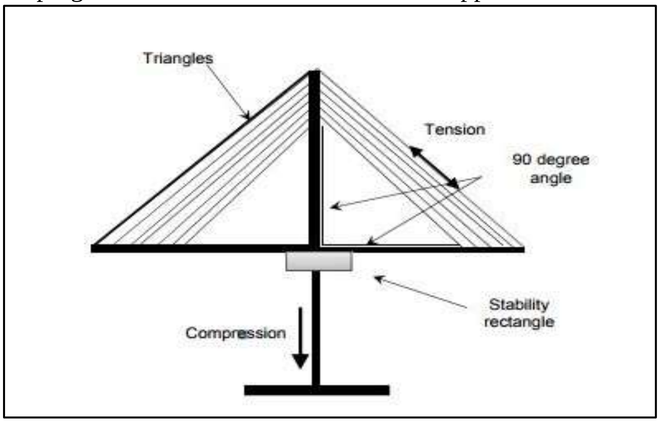

Fig. 1: Simple illustration of typical cable- stayed bridge

II. TYPES OF CABLE STAYED BRIDGE AND ITS COMPONENT

The number of links, number of poles, type of brace, number of links and so on will decide cable-stayed Bridges. The number and type of towers, the number and the scheme of links are numerous. The development material used in major fundamental segments and the concepts of stay cables and tower can therefore also sort connected scaffolds. The various basic components of a stayed cable connector are:

- Towers
- Types of cables
- Cable arrangement

In the construction of cable stayed bridges, the cables are picking based on high and steady estimation of modulus of elasticity, in this manner, the parallel wire strands are the most generally utilized link type. we plan three kinds of link stayed connect in this investigation harp type, suspension type and fan type.

Applying boundary conditions on bridge, shows the fixed support In Harp type, Fan type and suspension type cable stay bridge structure. Applying live load of 338 KN on bridge.

Figure 2, Figure 3 and Figure 4 shows the applying boundary conditions on the bridge structure Harp type bridge, Fan type bridge and suspension type bridge.

A. Fan type

In this framework, the cables are associated at a similar separation from the highest point of the pinnacle it is the most efficient setup of cables. The fan composed link framework expands the buckling issues.

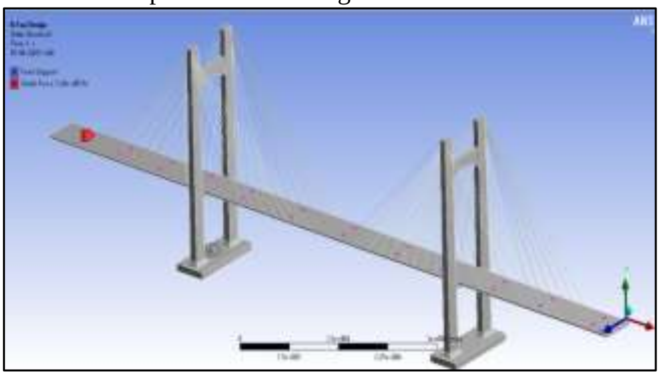

Fig. 2: Fan type Cable stay Bridge

B. Harp type

In this type of cable framework, the links are associated with the pinnacle at various statures and are parallel to one another. The compression is higher in this type of example. The harp typed cable framework expands the bending issues.

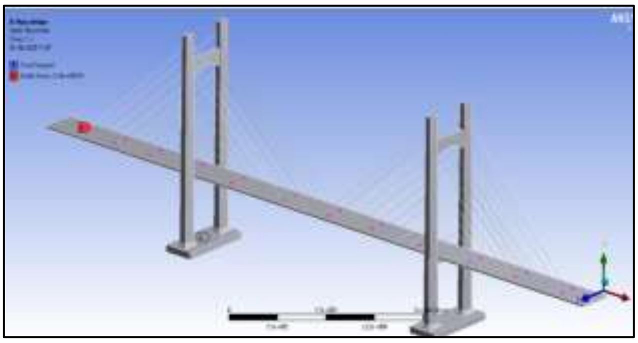

Fig. 3: Harp type Cable stay Bridge

C. Suspension type

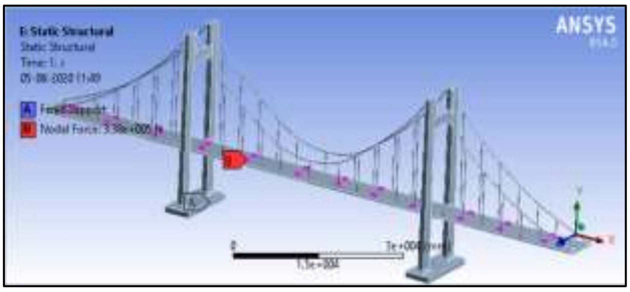

Fig. 4: Suspension type Cable stay Bridge

III. PROPERTIES OF CABLE STAYED BRIDGE

A. Dimensions of Cable Stayed Bridge

Height of Bridge = 31 Meter (101.7 Ft)
Length of Bridge Deck = 110 Meter (360.89 Ft)
Width of Bridge Deck = 5.5 Meter (18.04 Ft)
Length of Pillar to Pillar = 48.8 Meter (160.10 Ft)
Cable Cross Section is Circular = 101.6 mm (Radius)

B. Material Properties of Concrete for Bridge Structure

Density = 2300 Kg/m3
Poisson Ratio = 0.18
Young's Modulus = 30000 Mpa
Tensile Ultimate Strength = 5 Mpa
Compressive Ultimate strength = 41 Mpa

C. Material Properties of steel for Bridge Structure

Density = 7850 Kg/m3
Poisson Ratio = 0.3
Young's Modulus = 2E+5 Mpa
Tensile Ultimate Strength = 460 Mpa
Compressive Yield strength = 250 Mpa
Tensile Yield Strength = 250 Mpa

IV. RESULTS AND ANALYSIS OF CABLE STAY BRIDGE

The structural investigation of bridges for dynamic loading conditions will give us deformations and stresses values. In the present study Cable stayed Bridge designed as fan type and harp type are modeled and comparative analysis is made to find out magnitude of deformations due to self-weight and live load.

Bridge Types	Total Deformations (mm)	Directional Deformations (mm)	Stress in cables (Mpa)
Harp Design	13.44	6.05	0.86
Fan Design	26.78	8.203	1.83
Suspension design	14.69	5.08	6.86

Table 1: Stress and deformations in Bridge models

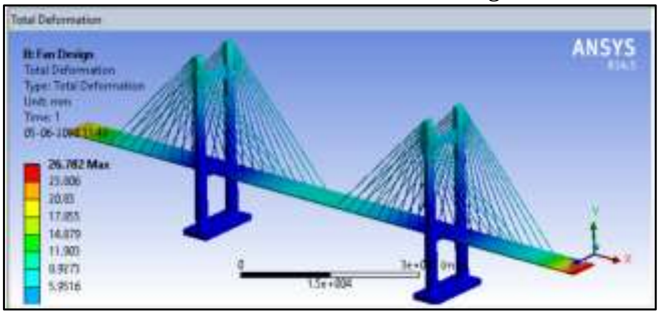

Fig. 5: Total deformations in Fan type Cable stay bridge

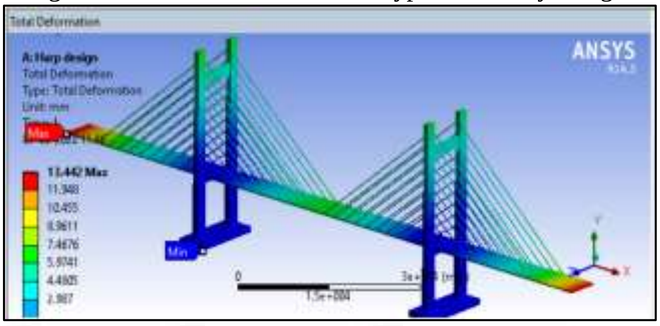

Fig. 6: Total deformations in Harp type Cable stay bridge

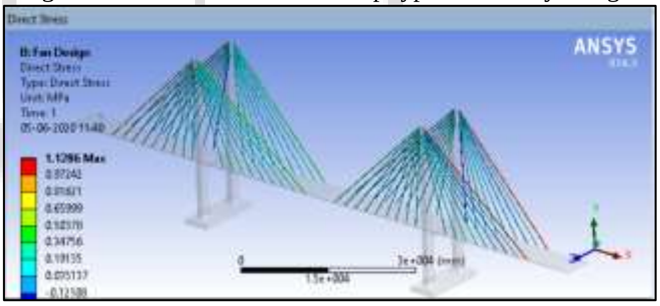

Fig. 7: Direct Stresses in Fan type Cable stay bridge

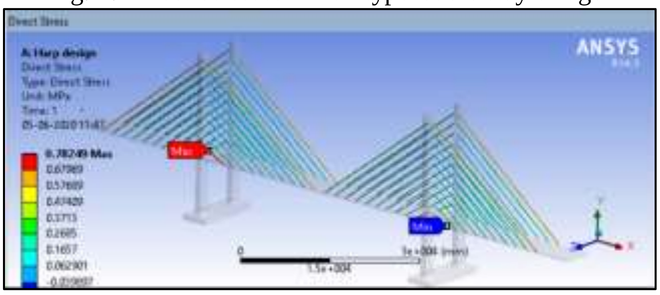

Fig. 8: Direct Stresses in Harp type Cable stay bridge

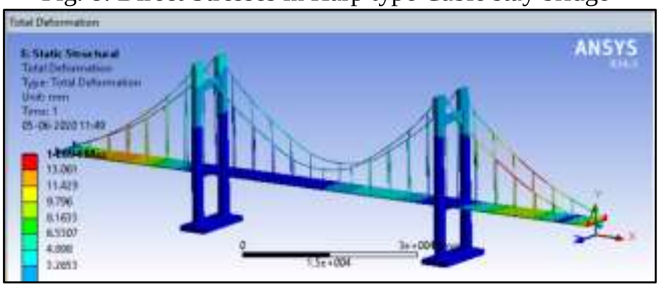

Fig. 9: Total deformations in Suspension type Cable Stay Bridge

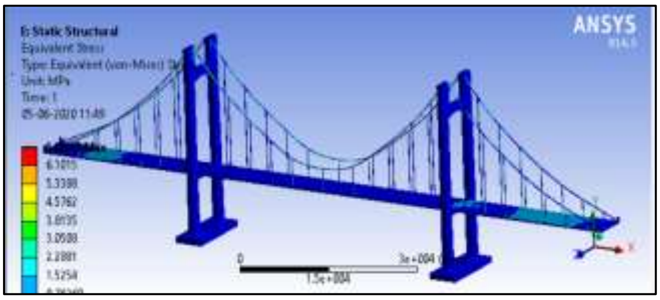

Fig. 10: Direct Stresses in Suspension type Cable Stay Bridge

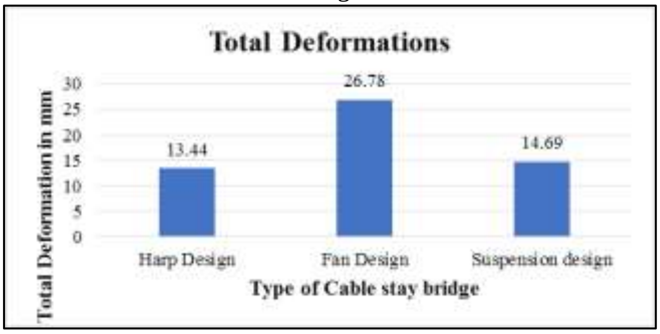

Fig. 11: Total Deformation in bridge designs

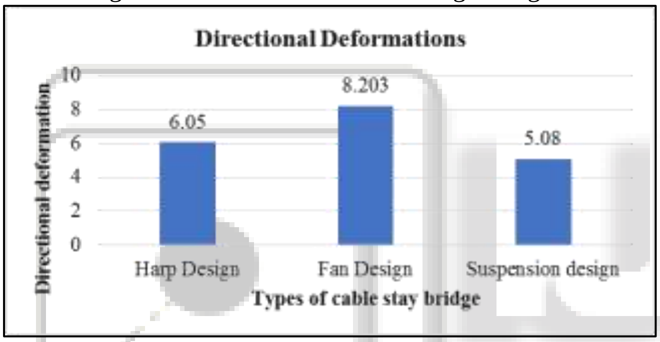

Fig. 12: Directional Deformations

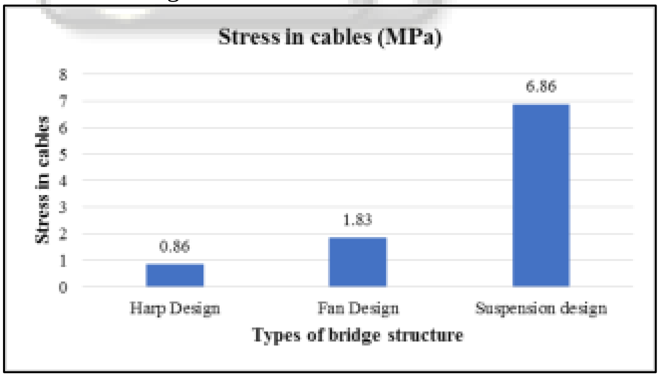

Fig. 13: Direct Stresses in cables

A. *Weight of Bridges*

In this study we optimize the mass of structure of bridge with the use of Ansys workbench. Compare the weight of all bridge structure designed in Ansys and find out weight difference in structures.

Table 2: weight comparison of bridge structures

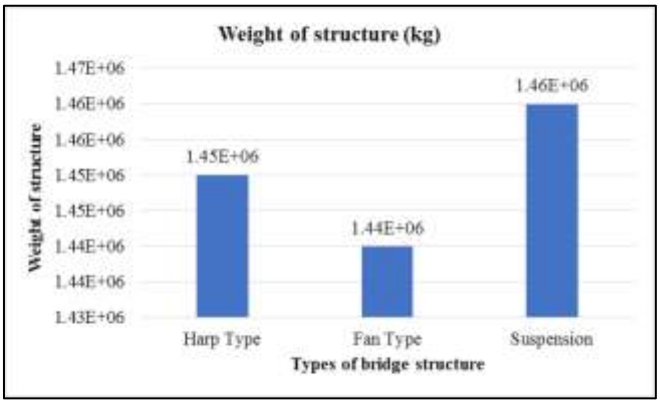

Fig. 14: Weight of structures

Vibration Analysis of Bridge Due to Natural Frequency

Cable-stay bridges usually show long basic periods, which affect their dynamic behavior. Their dynamics and flexibility depend on several parameters like the main length, the cable layout and the support conditions. The first modes of vibration, mainly related to deck modes, are very long. The cable vibration modes or the tower modes are followed, which can be connected with the deck according to support conditions.

The dynamic response features are determined by vibrational features. Therefore, it is essential to study the dynamic behavior of a cable-stayed bridge in the modal analysis. The cable-stayed bridge is complicated in structure and the cables are flexible, lightweight, damp, etc. All these above features make the cable-stayed bridge mode a worthy practical engineering issue. A system with a continuous weight and rigidity distribution is the structure of the cable-stayed bridge. It should be divided into limited DOF elements. The result of three-dimension FEM analysis is more extensive and reliable than the result of the traditional empirical formula, given the complexity of the cable-stayed bridge structure. The design of the cable-resistant bridge can be believed to have N DOF.

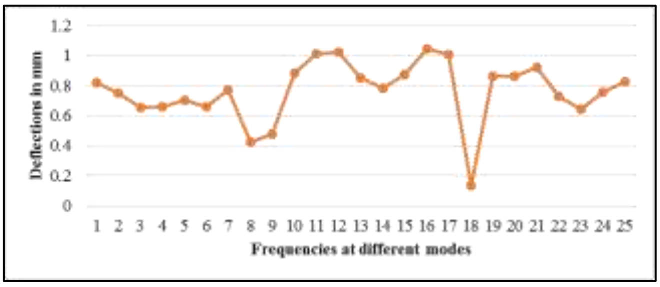

Fig. 15: Deformations in Fan type cable stay bridge due to vibration

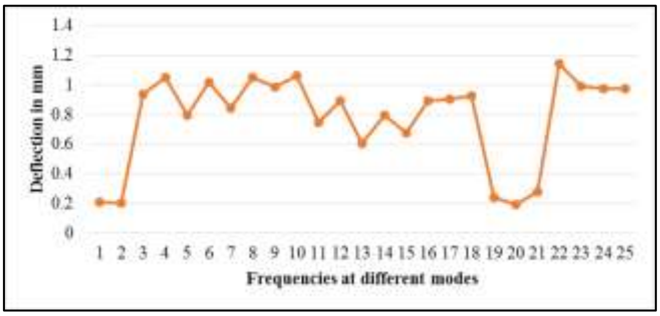

Fig. 16: Deformations in Harp type cable stay bridge due to vibration

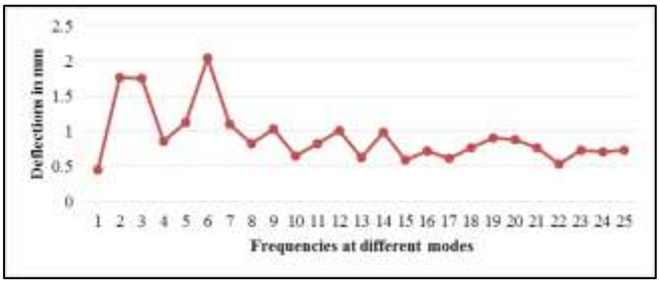

Fig. 17: Deformations in Suspension type cable stay bridge due to vibration

We may infer from this that the study of ANSYS is very informative for the cable remain bridge. The study looked at the research and configuration of steel bridges for cable restriction with stainless steel profiles locally available. Due to the research and design carried out so far, the study has shown that the building of the bridge with steel profiles locally available is worth an option. Although the cost of local production is closer to import, it is still a good option as it helps in building capacity for local construction, production and construction companies, it creates jobs for many people.

V. Conclusion

In this study, the three-type cable stay bridge design, i.e., is being compared. The type, type of fan, and type of suspension to determine the best suitable bridge in terms of structural feasibility and to determine which bridge cables require less deformation. The two bridges are first modelled with Ansys and are studied and planned. The results obtained from the analysis are compared to the following conclusions.

In harp design total deformation found 13.44 mm which is Lower than the fan type design having 26.78 mm deflection and suspension type design having 14.69 mm. harp type design shows better stability than Fan type structure and suspension bridge having minimum deformation as compare to Fan type design of bridge so, suspension bridge having better stability than Fan type bridge structure while we compare deflection of bridges structures. Harp type bridge structure having lower deflection as compared to other two designs so it shows better stability remaining two others.

In stresses found on bridge we found maximum value of stress on suspension design which is 6.86 MPa so as per study it is clear that Harp type design shows lesser stress 0.86 MPa.

While we compare weight of bridge structure, we found maximum weight of cable type suspension bridge 1460000 Kg and Harp Type Bridge having nearly similar to suspension bridge is 1450000. Fan type structure having 1440000 Kg.

As per above study it is conclusion made that Suspension and Harp type design is better as compare to Fan type design. Fan type design gives maximum deflection which is create maximum vibration in structure. But suspension structure having minimum deformation than fan type and shows that it is very efficient in condition of vibrations effect during seismic condition due to is less deformation to fan structure.

Here we found Fan type structure weak as per deformation basis.

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