STUDY OF CABLE STAYED BRIDGE WITH DIFFERENT PYLON ARRANGEMENT AS PER IRC LOADING

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ABSTRACT: The cables in a cable stayed bridge are exposed to corrosion, abrasion and fatigue processes which may cause a reduction in their section and a decrease in their resistance capacity. A bridge is a structure, which connects two ends of obstacles such as river, valley, other road and railway lines for the purpose of providing small routes as possible for safe journey. There are many different designs that each serve a particular purpose and apply to different situations. A cable stay bridge consist of cable, deck, pylon and foundation. Literature survey revealed that comparative study of different type of pylon for cable Stay Bridge. The cable forces and nodal vertical displacements before and after the loss of cable is investigated and compared. The analysis results show that cable loss leads to the redistribution of load to adjacent cable. The effect is significant when the cable loss is in middle or far to pylon as compared to loss of the cable near to pylon. It is concluded through this study that A-type pylon is comparatively more stable, economical and efficient in bearing load whereas H-type is second best and Y-type is third in comparison. On the basis of various parameters considered.
Keywords:Staad, Analysis, Cable stay, Pylon, Finite element analysis, IRC loading, Deflection, Bending, Forces.

I. INTRODUCTION

Bridge is an important structure required for the transportation network. Now a day with the fast innovation in technology the conventional bridges have been replaced by the cost effective structured system. For analysis and design of these bridges the most efficient methods are available. Different methods which can be used for analysis and design are AASHTO, Finite element method, Grillage and Finite strip method. Vehicle load capacity analysis of a bridge superstructure is required as per I.R.C. and manual for standards and specifications for Indian road congress norms. Its main purpose is to assure, that bridge is safe for the user or public. By the load capacity analysis, a bridge might be found to be incapable of securely conveying some legal loads. Furthermore, when the loads are beyond the range of permit loads need to be utilizing a particular structure, load limit analysis can give answer about which loads are securely satisfactory. STAAD.Pro is efficient and accurate software used for concrete and steel bridge analysis and design. The advantage of the software is that it incorporates this provision of Indian Road Congress (IRC) bridge design specifications and railway specifications. STAAD.Pro is a general purpose structural analysis and design tool with applications chiefly in the building industry - commercial buildings, bridges and highway constructions, industrial constructions, chemical plant structures, dams, retaining walls, foundations, culverts and other embedded structures, etc. STAAD. Pro is basically based on Finite Element Analysis for carrying out the computations for Analysis and Design of a Structure.

Fig: Bridge Structure

II. LITERATURE REVIEW

The study of the bridge section superstructure has analysed using analysis software (STAAD.Pro) which is a traditional type use in bridges. In Chapter 1, we have discussed the advantages of the bridge in the construction point of view. A literature review is an evaluative report of studies found in literature related to selected area. The literature related to selected area. The literature review should describe, summarize, evaluate, and clarify the literature. A literature review goes beyond the search for information and includes the identification and articulation of relationship between the literature and field of research. While the form of literature review might be varying with various types of studies. We have different literature review from papers, journals, websites and dissertation.

Wilson and Gravelle (1991) (Linear analysis of cable stay bridge) Presented techniques for modelling cable-stay bridges for dynamic analysis by using linear finite element model. In their study findings, a linear model can work well for analysing cable-stay bridges.

Wang & Huang (1994) (Analysis of deck type bridge as per standard loadings) reported that in recent years, considerable efforts have been made for better understanding the dynamic behaviour of bridges with moving loads across the rough bridge decks5. Most of these previous studies were concentrated on the dynamic analysis of beam/girder type bridges. Only a few have studied the impact of vehicles on cable-stay bridges. The study on dynamic response analysis of vehicle-bridge system for cable-stay bridge in strong windy environment has shown that the vertical displacement response of the bridge under strong wind is affected significantly by the wind load, and lateral displacement response is also controlled by the wind load. Carrying out dynamic response study of vehicles-bridge system under wind circumstance has been found to be very necessary.

Smiguelc. Simoes and joaohenrique (january 1998) optiniization of cable-stay bridges subjected to earthquakes with non-linear behaviour) Outlined that Earthquake-safe provisions are fundamental highlights of the structure of cable-stay bridges based on seismic inclined regions. Improvement can be utilized to lessen cost and upgrade geometrical or potentially mechanical properties of the structure. The basic investigation program created here takes into account a three-dimensional portrayal of cable-stay bridges. Affectability investigation is done by diagnostic means both for the joined modular examination/reaction spectra and the time-history techniques. This empowers the forecast of the variety of the basic reaction to earthquakes as for changes in the structure factors. The improvement comprises of an issue of different objectives trying to enhance goals, for example, cost, stresses, code of training and erection necessities. This improvement issue ends up being proportional to the minimization of an unconstrained

III. METHODOLOGY

This chapter deals with methodology for calculation of the critical load placing over the considered bridge using finite element method. In this methodology, we have used STAAD-Pro software which is based on the application of Finite Element Method. This software is a widely used in the field of structural design and analysis. Now a day this software is very much friendly for the analysis of different type of structures and to calculate the result at every node & element wise. Analysis for the bridge members, prepared the conceptual dimension geometry of the superstructure which are shown in figure 4.1 –

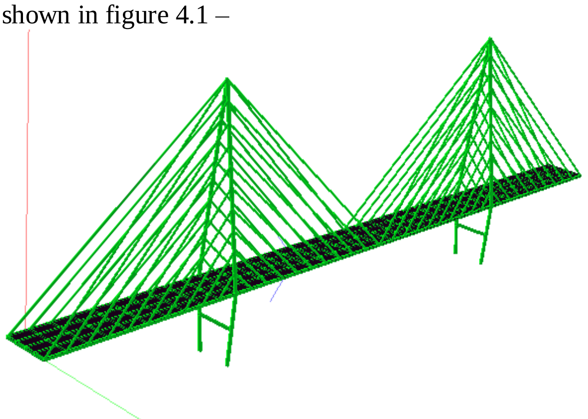

Fig: 4.1 Bridge model

Here R.C.C. bridge frame is modeled in analysis tool staad pro in which deck bridge is analyzed and optimized, and I.R.C. loading is considered as class 70R+A loading, dead load as per 875 part-1 and superimposed live load as per 875 part-2 is calculated and applied.

Three cases has been considered for comparative analysis:

- First Cable stay bridge with H-type pylon.
- Second Cable stay bridge with A-type pylon.
- Third Cable stay bridge with Y-type pylon.

All these are prepared as per data for Raja BhojSetu bridge at V.I.P. road Bhopal with length 262 m.

The following three activities must be performed to achieve that goal -

- Modeling of the frame using STAAD.Pro.
- The calculations to decide the explanatory results.
- Result check is all empowered by devices contained in the framework's graphical environment.

Analysis of R.C.C. bridge 262 m span expansion to expansion has been considered for the parametric analysis of vehicle critical load position as per Indian Road Congress 70R+A loading standard which are analysedwith the help of staad pro software. proposed steps are as followings:

Step 1: Selection the geometry of superstructure by using coordinate system in STAAD Pro or plot over the AUTO CAD, which can be import in Staad-Pro as per dimension of girder, c/c distance of bearing, expansion to expansion distance and number of diaphragm etc. Schematicsketch of the superstructure are shown in below figures.

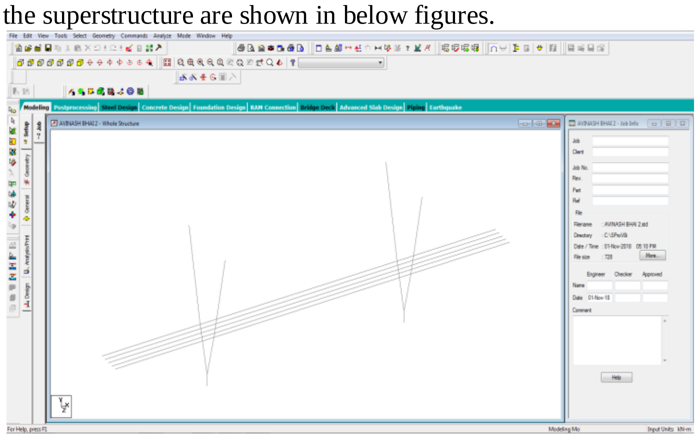

Fig: 4.2 R.C.C Bridge Type

Step 2: With different type of pylon in cable stay bridge models are prepared of same dimension and same loadings as per Indian standards. finite element modelling of the model considering the above parameters. It is considered thatR.C.C. bridge with three different type of pylon such as H-type, A-type and Y-type geometry of superstructure define the dimensions like 262 length, 15.9 meter wide, which include in the girder property and steel material property of the structure as per Indian sections.

Different types of bridge sections considered are as follows:

A. A-type pylon bridge:

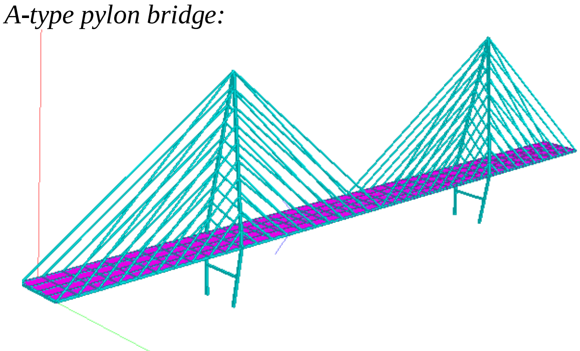

Fig: 4.3 A-type pylon cable stay Bridge

B. H-type Cable Stay Bridge:

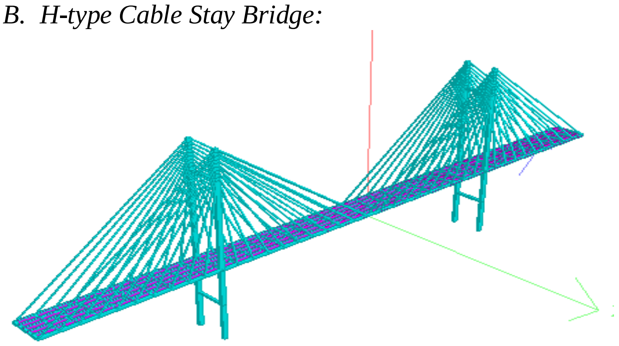

Fig: 4.4 H-type Cable Stay Bridge

C. Y-type Cable Stay bridge

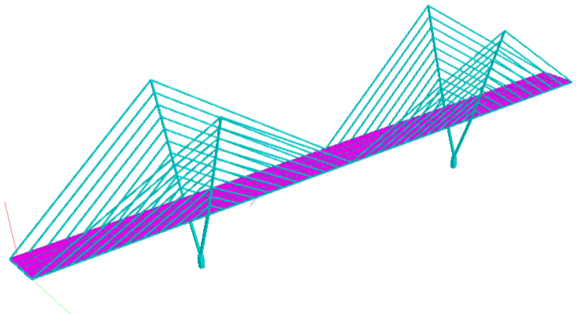

Fig: 4.5 Y-type Cable Stay Bridge

Step 3: Apply the material property as shown in above figures, after that support condition has been considered at the bearing locations of the superstructure which is fixed support as shown in below figure.

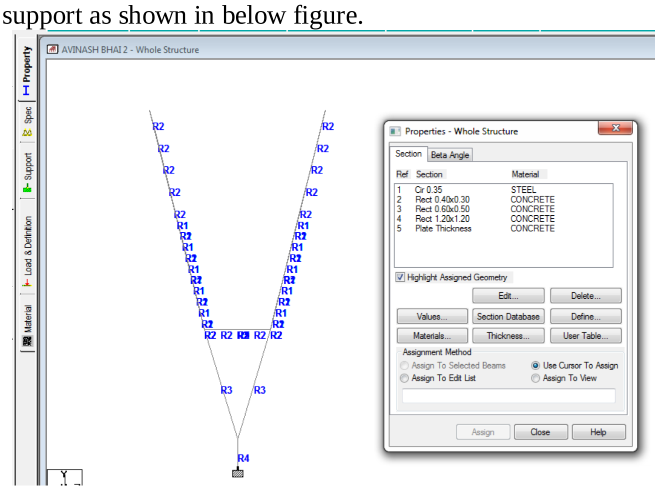

Fig: 4.6 Support condition

Step 4: After apply the support condition, now the next step to be considered for the Deal Load of the superstructure i.e. "self-weight".

Step 5: After apply the Dead Load, now the next step to be considered for the Equivalent Uniformly Distributed Loads (EUDL) load.

For Bending Moment, L is equal to the effective span in metres. For Shear Force, L is the loaded length in metres to give the maximum Shear Force in the member under consideration. The Equivalent Uniformly Distributed Load (EUDL) for Bending Moment (BM), for spans up to 10 m, is that uniformly distributed load which produces the BM at the centre of the span equal to the absolute maximum BM developed under the standard loads. For spans above 10 m, the EUDL for BM is that uniformly distributed load which produces the BM at one-sixth of the span equal to the BM developed at that section under the standard loads. EUDL for Shear Force (SF) is that uniformly distributed load which produces SF at the end of the span equal to the maximum SF developed under the standard loads at that section.

Step 6: After apply the EUDL Load, now the next step to be considered for the Moving Live Load (LL) in which include the Breaking Load and Vehicle Load are as follow: -

- DFC (*Dedicated Freight Corridor*) LOADING FOR BENDING MOMENT [Eccentric & Concentric]
- DFC LOADING FOR SHEAR FORCE [Eccentric & Concentric]
- Coefficient of Dynamic Augment (CDA) *Coefficient of Dynamic Augment* FOR PROVIDED DECK LENGTH.

Step 7: After applied all the boundary condition and forces, now the model has to be "Analyse" for getting the results i.e. Axial force, shear force, deflection and support reactions etc.

Step 8: After analysis results designing is followed as per Indian Standard 456:2000 R.C.C. design and optimization of each case is done to provide its economical section for same loading and geometry in all the cases.

Step 9: After optimization process comparative results are drawn in all cases to determine the best one with the help of graph using M.S. Excel.

IV. RESULTS AND ANALYSIS

Comparative analysis of all the three cases have been done here in terms of forces, torsion, axial force, displacement and weight of sections to determine the best suited and stable frame. In order to emphasize the differences, loading is considered same.

Parameters on which study done are-

- Shear force in KN.
- Axial Force in KN.
- Bending Moment in KN-m
- Maximum deflection due to vehicle loadings.
- Reaction at Deck.

The results of analysis of considered structure have been represented in the form of tables and figures. Inferences have been drawn based on the results so obtained.

This chapter presents the results of comparative study prepared on a R.C.C. bridge where vehicle loading for lanes is assigned as per I.R.C. specifications to compute which type of bridge will be better in all aspects. For modelling, analysis and optimized designing of all the cases analysis tool staad.pro v8i. with fixed support is considered.

These are the following forces acting due to vehicles moving load and behaviour of structures show in the values andfigures.

Shear Force

Table Shear force

Max. Shear Force kN		
A-type	H-type	Y-type
345.34	353.56	357.12

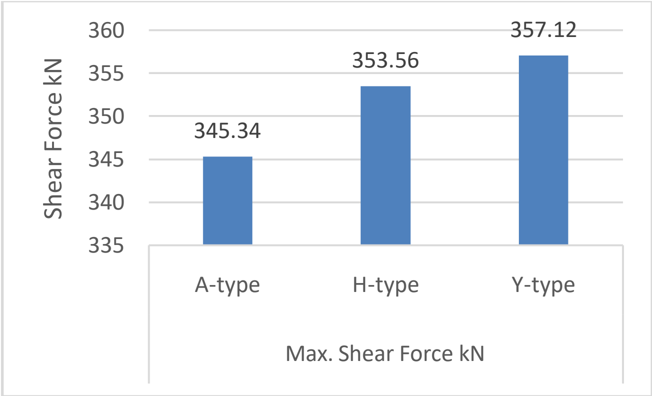

Fig: 5.1 Shear Force

Inferences: In the above fig 5.1, it is clearly observed that A-type pylon is observing less unbalance forces in comparison, whereas Y type pylon shows worst result in balancing forces.

Axial Force

Table Axial force

Max. Axial Force kN		
A-type	H-type	Y-type
1024.15	1282.5	1376.19

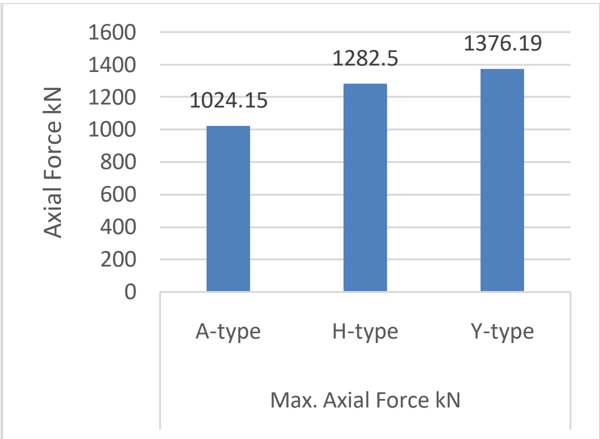

Fig: Axial Force

Inferences: An axial force is any force that directly acts on the center axis of an object. These forces are typically stretching force or compression force, depending on direction. In addition, when the force load is even across the form's geometric center, it is concentric, and when it is uneven, it is eccentric. Unlike many acting forces, an axial force is often its own counter; an object pulled or pushed evenly in opposing directions doesn't move. In above figure it is clearly observed that A-type pylon is observing less resultant in distributing axial force, hence this will be stable one.

Bending Moment

Table Bending moment

Max. Bending Moment kN-m		
A-type	H-type	Y-type
138.04	145.54	148.93

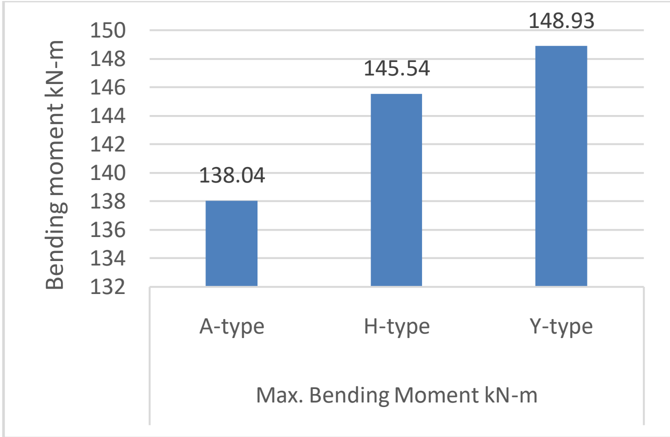

Fig: Bending moment

Inferences: As shown in fig 5.3, Max. Bending moment is observed in Y type pylon thus it will require more reinforcement, whereas A type pylon will require minimum reinforcement thus becoming economical one.

Deflection

Table Deflection

Maximum deflection (mm)		
A-type	H-type	Y-type
45.2	50.23	52.33

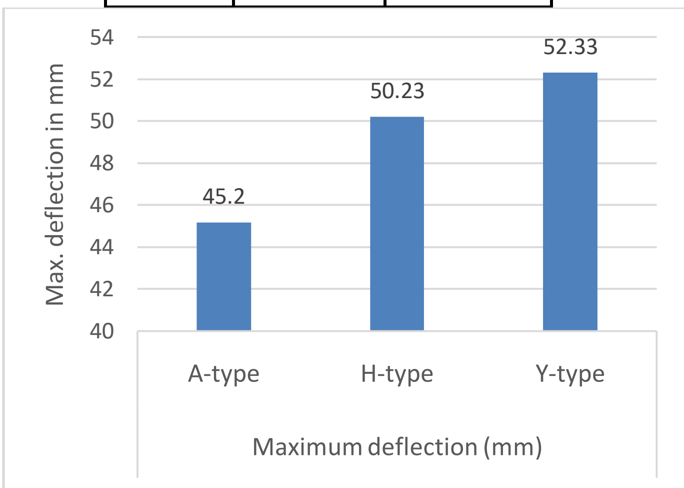

Fig Deflection

Inferences: As bridge will counteract vehicular loading which will be not continuous in nature, resulting higher intensity of deflection. Therefore the stable structure will be resisting deflection. Here it is observed that A type pylon bridge will result in less generation of deflection hence safe one.

V. CONCLUSIONS

As the aim of this study is to compare these three types of pylon for a live project. It is determined that A type pylon is most suitable, stable and resistible whereas H-type pylon is second best and Y type is observed as third best.

Following are the salient conclusions of this study-

Shear Force

The cable axial strength decreases with increase in corrosion.

Due to corrosion modulus of elasticity decreases, which resulting in reduction of structural stiffness. Shear force in known as the unbalance force observed due to transmission of load from beam to column, in our study maximum value is observed in Y-type pylon i.e. 357.12 kN, whereas minimum in A-type pylon i.e. 345.34 kN.

Axial Force

Axial force is known as the vertical force observe in piers, this force is meant to distribute load from pier to earth. In our study maximum axial force is observed in Y-type i.e. 1376.19 kN, whereas minimum in A-type pylon i.e. 1024.15 kN, thus A-type pylon requires minimum cross sectional piers for load distribution.

Bending Moment

In terms of bending moment, it is observed that maximum bending is in Y-type pylon i.e. 148.93 kN-m, whereas minimum is observed in A-type pylon i.e. 138.04 kN-m which shows that A-type pylon is comparatively most economical in comparison as bending moment is directly proportional to reinforcement requirement.

Deflection

In case of deflection we observed in above chapter that maximum deflection is obtained in Y-type pylon 52.33 mm whereas least is observed in A-type pylon 45.20 mm, which concludes that A-type pylon is most suitable and stable section in comparison.

Deck Analysis

In deck analysis using Finite element method it can be observed that analysis is resulting in small nodal distribution of slab for proper analysis, in which number of nodal are resulting forces out of which maximum value is considered. It is observed in fig. 5.5 that resultants are minimum in A type pylon case whereas maximum in Y-type pylon case.

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