Analysis of Cable Stayed Bridge under Dynamic Loading Considering different Pylon Types

Avinash Singh[1] Pratiksha Malviya[2]
[1]P.G. Scholar [2]Assistant Professor & Head of Department
[1,2]Department of Civil Engineering
[1,2]M.I.T.S, Bhopal, India

Abstract— A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. In engineering, a bridge is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object". In this Project work, live project of cable stayed bridge i.e. (Raja Bhoj Setu), Bhopal is considered. It is located at V.I.P. road. It has been designed, constructed considering details and hydraulic data as per site. In this study analysis of different types of pylon in cable stayed bridge i.e. H-type, A-type and Y-type is presented to determine the most suitable type and compare it with the executed H-type pylon. It is concluded in this research work that A-type pylon is comparatively more stable, economical and efficient in bearing load whereas H-type is second best and Y-type is worst in comparison.

Key words: Staad, Analysis, Cable Stayed, 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 Now a day with the fast innovation in technology the conventional bridges have been replaced by the cost effective structured system.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.

In this Project work, live project of cable stayed bridge i.e. (Raja Bhoj Setu), Bhopal is considered. It is located at V.I.P. road. It has been designed, constructed considering details and hydraulic data as per site. In this study analysis of different types of pylon in cable stayed bridge i.e. H-type, A-type and Y-type is presented to determine the most suitable type and compare it with the executed H-type pylon.

II. BRIDGE STRUCTURE

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. In engineering, a bridge is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object". A "two-force member" is a structural component where force is applied to only two points. Although this rigorous definition allows the members to have any shape connected in any stable configuration, structure typically comprise five or more triangular units constructed with straight members whose ends are connected at joints referred to as nodes. In this typical context, external forces and reactions to those forces are considered to act only at the nodes and result in forces in the members that are either tensile or compressive. For straight members, moments (torques) are explicitly excluded because, and only because, all the joints in a truss are treated as revolutes, as is necessary for the links to be two-force members.

Fig. 1: Bridge structure

III. LITERATURE REVIEW

Davison and Birkemoe (1982) determined that there are two residual stress gradients in the longitudinal direction, one across the tube face and around the cross section, denoted as membrane, and the other perpendicular to the tube face through the material thickness, denoted as bending. "The perimeter (membrane) residual stress gradient represents the variation in the mean value of the longitudinal residual stress [and] the through thickness (bending) residual stress gradient is the deviation from this mean value normal to the perimeter through the material thickness".

Blesson and Thakkar (November 2011) Studied that the dynamic and aerostatic effect on different shapes of pylons of a cable stayed bridge. The different shapes of pylons considered here are H type, A type, Inverted Y type, Diamond type and Delta type. The central span of the cable stayed bridge is also varied as 100m, 200m, 300m, 400m to study the combined effects due to shape and span. The study is carried out by taking live load according to IRC 6:2000, IRC Class A and Class 70R vehicle load along with Aerostatic wind loads was undertaken. A Dynamic analysis in the form of Linear Time-history is also carried out using El-Centro ground motion and various response quantities such as Bending-moment, Shearforce, Torsion and Axial force are represented.

T.Pramod Kumar, G.Phani Ram (July 2015) This research's objective was to estimate the economic importance of the railway cum road bridge. This paper was carried out to find out the reduction in cost of construction by providing single bridge for both road as well as railways. The analysis and design phase of the project was done utilizing STAAD PRO V8i. It was observed that the construction of a single

bridge reduced the cost of two separate bridges for road and railways, also land acquisition problem is reduced to some extent.

Hussain Hararwala and Savita Maru (August 2017) Stated that the linear static analysis of Cable Stayed Bridges with different shapes of pylons under its own weight. The cable stayed bridge is one of the modern bridges which were built for the longer spans. Therefore, there is a need of study on the behaviour of the pylons before implementing it in actual practice. For this study, the different shapes of Pylons have been compared with the bridge span dimension and other parameters are kept unvarying. The modelling of bridge has been prepared using SAP 2000 software. For this study, the arrangement of cable stay has been taken as semi fan type as well as fan type. The study reveals the following points regarding to the behaviour of Pylons such as the Axial Force in Pylon, Bending Moment in Pylon, and Shear Force in Pylon & Deflection at the top of Pylon. This study will be helpful for make an appropriate choice for the shape of Pylon used for Cable Stayed Bridge in particular conditions.

IV. OBJECTIVES

The main objectives of the present study are as follows:-

- Study of Cable Stayed Bridge with different pylon types under Dynamic Loading Condition.
- To determine the most suitable type of pylon for cable stayed bridge located at V.I.P Bhopal.
- To determine the effect of pylon on deck of bridge.
- To calculate vehicular load as per I.R.C. chapter-3.

V. METHODOLOGY

Following steps are followed to complete this study:

1) Step 1: To investigate the past literature work done related to bridge and their different types also analysis methods are included in findings.
2) Step 2: To Prepare aim, need, motive and objectives of our study.
3) Step 3: To prepare modelling. Assigning sectional data, properties and supports to the structure using analysis tool Staad.pro.
4) Step 4: To assign different types of pylon for provided data of live project.

S.NO	Description	Value
1	Length of Bridge	262 m.
2	Number of bays in X direction	52
3	Number of bays in Z direction	32 m
4	Height of Bridge structure	4 m
5	Width of the bridge section	15.90 m
6	Bay width in Z direction	3 m
7	Support type	Fixed support

Table 1: Live Project Data

5) Step 5: To compare all these cases in terms of forces, bending, deflection and F.E.M. based study.

S. No.	Loading Type	Standard
1	Dead Load	I.S. 875-I
2	Live Load	I.S. 875-II
3	Vehicle Load	I.R.C. A-A Class Loading

Table 2: Loads Assigned

6) Step-6: To prepare comparative results using M.S. Excel.
7) Step-7: To conclude the study.

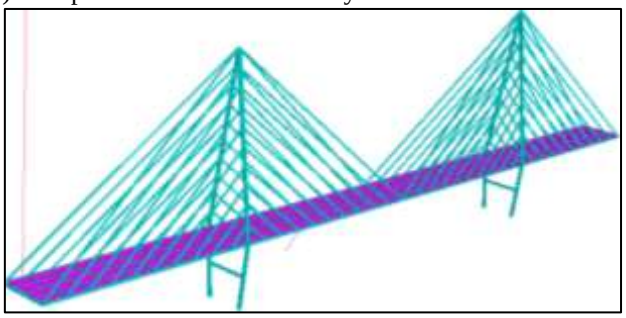

Fig. (A): A-Type Pylon

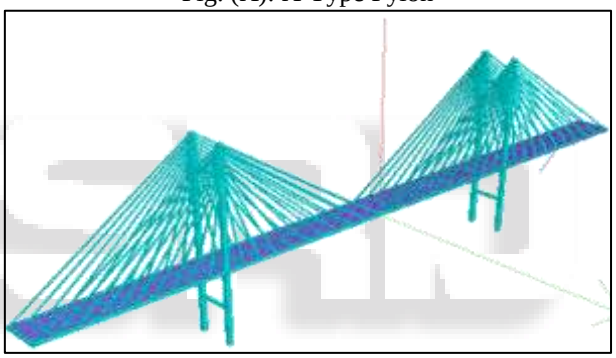

Fig. (B): H-Type Pylon

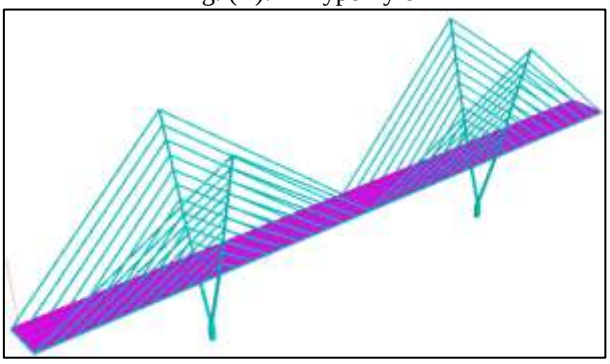

Fig. (C): Y-Type Pylon

Fig. 2: Types of Pylon Considered

A. Analysis Results

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.

B. Shear Force

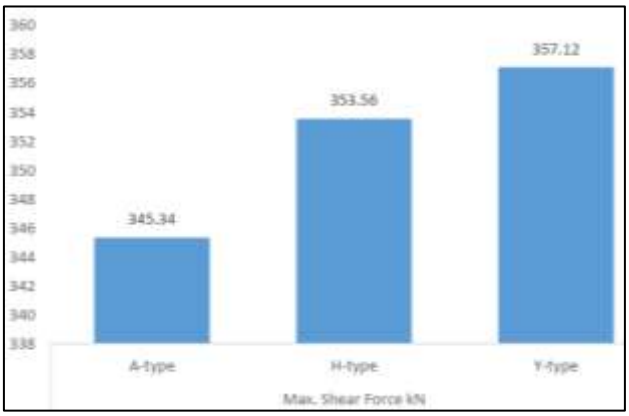

Fig. 3: Shear Force

C. Axial Force

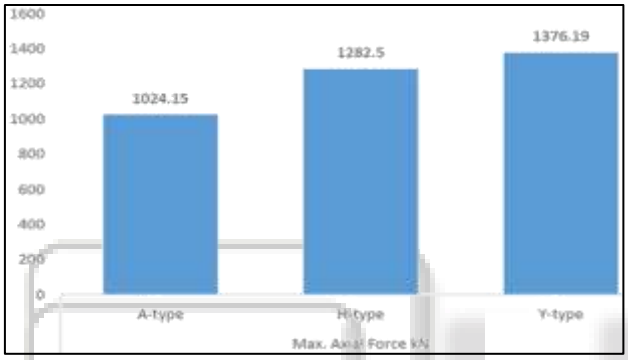

Fig. 4: Axial Force

D. Bending Moment

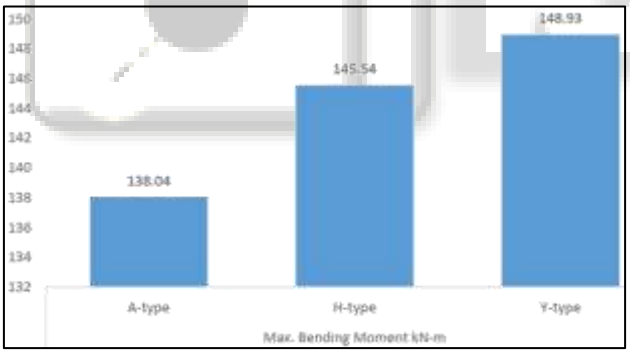

Fig. 5: Bending Moment

E. Deflection

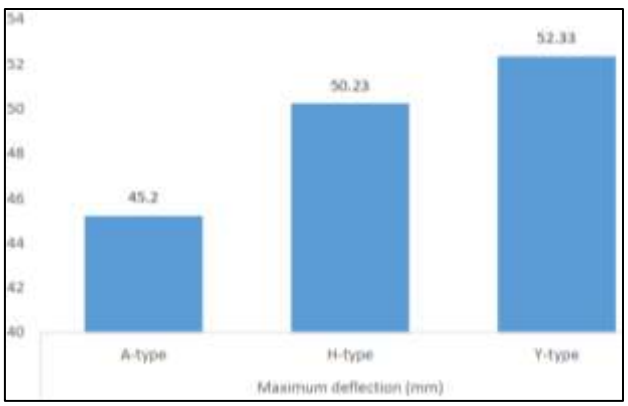

Fig. 6: Deflection

F. Deck Analysis

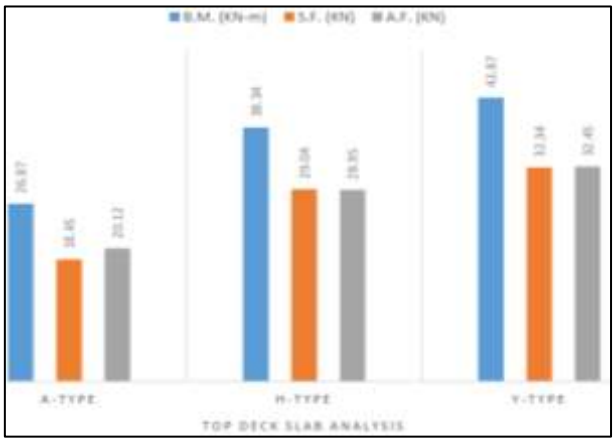

Fig. 7: Deck Analysis

VI. CONCLUSION

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 worst.

1) In case of deflection we observed in above chapter that maximum deflection is obtained in Y-type pylon 23.54 mm whereas least is observed in A-type pylon 17.65 mm, which concludes that A-type pylon is most suitable and stable section in comparison.
2) In terms of bending moment it is observed that maximum bending is in Y-type pylon i.e. 73.43 kN-m, whereas minimum is observed in A-type pylon i.e. 45.87 kN-m which shows that A-type pylon is comparatively most economical in comparison as bending moment is directly proportional to reinforcement requirement.
3) 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. 245.43 kN, whereas minimum in A-type pylon i.e. 201.34 kN.
4) 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. 1476.09 kN, whereas minimum in A-type pylon i.e. 1004.65 kN, thus A-type pylon require minimum cross sectional piers for load distribution.
5) 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.

REFERENCES

[1] Bridge rules (Railway Board). Rules specifying the loads for design of super structure and substructure of bridges and for assessment of the strength of existing bridges.
[2] Coenraad Esveld, MODERN RAILWAY TRACK, MRT - Productions, 1989.
[3] Coenraad ESVELD and Valéri MARKINE, SLAB TRACK DESIGN FOR HIGHSPEED.

[4] David N. Bilow, P.E., S.E. and Gene M. Randich, P.E., SLAB TRACK FOR THE NEXT 100 YEARS, Portland Cement Association, Skokie, IL.
[5] EN 1991-2 Euro code for traffic loads on bridges
[6] Indian railway standards-Steel Bridge Code indian railway standard code of practice for the design of steel or wrought iron bridges carrying rail,road or pedestrian traffic.
[7] IRC: 6-2014 Section –II (Loads & Stesses) standard specifications and code of practice for road bridges.
[8] IRC: 21 Section –III Cement Concrete (plain and reinforced) standard specifications and code of practice for road bridges.

