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Review-Seismic Analysis of Cable Stayed Bridge Under Moving Loads Using IRC & AASTHO Methods with Different Shapes of Pylons

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Abstract: Cable-stayed bridges represent a pinnacle of modern structural engineering, combining aesthetics with functionality across long spans. However, their seismic performance, especially under the simultaneous action of dynamic loads such as vehicular movement and earthquakes, remains a critical area of study. This review explores the seismic analysis of cable-stayed bridges subjected to moving loads using two major design standards: the Indian Road Congress (IRC) and the American Association of State Highway and Transportation Officials (AASHTO) methods. Emphasis is placed on evaluating the influence of varying pylon shapes—A-shaped, H-shaped, inverted-Y, and others—on the dynamic response of the bridge system. The paper presents a comparative understanding of both design codes, analysis techniques, seismic provisions, and their implications on structural behavior, safety, and performance. Through detailed evaluation of recent research and simulation-based findings, this study aims to inform future design practices and highlights key areas for further investigation, including nonlinear dynamic analysis, soil-structure interaction (SSI), and pylon geometry optimization.
Keywords*: Cable-stayed bridge, Seismic analysis, Moving loads, IRC, AASHTO, Pylon shapes*

I.INTRODUCTION:

Since the last two decades of the 20th century, plentiful cable stay bridge projects have been effectively erected all over the world. Cable stayed bridges have been regarded as one of the most communal types of bridges in recent decades due to their extremely substantial look and uniquely adopted structural elements. The design of cable stayed bridge has merged as the strongest output in nearly two decades from both conceptual and construction point of view. Cable stayed bridges are considered as the indeterminate structure. Determinacy and indeterminacy depends upon the end support condition of the beam. The advancements were made in the structure system of bridges to increase the stress in the cables to prevent sagging. Modern cable stayed bridges are more adequate & extendable vigorous enough to withstand lateral forces than ever before due to the lengthening of bridge spans. A conventional cable stay bridge has a deck with one or two pylons in the middle of the span that are raised by piers or walls. To offer further support, the wires are angularly attached to the girder. Cable stayed bridges are also constructed in high seismic areas and further attempts are adopted for the challenging structure with the natural evolution of economic growth of the continents. For such reasons the cable stayed bridges are recognized as the most economical with easier construction techniques for the span up to 1000m.the first bridge structure was a combination of suspension and cable system. They were first constructed at the end of 18th century. In addition to the previously mentioned concept, another important component that will affect how the pylons perform is their geometric shape, which is influenced by the applied loads, the cable-stay system, and aesthetic concerns. In recent years, several cable-stayed bridges have been constructed with different shapes of pylons such as Hshaped, A-shaped, Diamond shaped, Inverted Y-shaped etc. which results in a great demand to evaluate the effects of different shapes of pylon on cable stayed bridges under the consideration of lateral effect and vehicular loading.

II.LITERATURE REVIEW

2.1 Review of Literatures

Atul K Desai (2013) "Siesmic Time History Analysis for Cable Stayed Bridges considering different geometrical configuration for near field earthquakes", ISSN: 0975-6744 Volume 7, Issue 1 PP 65-82 - studied the seismic time history analysis for cable stayed bridge considering different geometrical configuration for near the field of earthquakes. He studied the comparison between different geometrical configuration of pylon for straight cable stayed bridge i.e. Y shaped pylons & conventional A shaped pylons. In this he also considered different inclination of wings of Y shaped pylons & different anchoring systems of backstays

i.e. self anchored & bi stayed systems. He also considered the model with and without intermediate side span supports and dampers at pylon supports of deck. The different vertical inclination of pylons was also considered for the curved cable stayed bridge. He also deals with the dynamic analysis of cable stayed bridges. He concluded that bi stayed bridge with intermediate side span support gives the min value of bending moment at pylon base. Spread pylon with 30 degree spread angle gives the min value of deflection at mid span. By providing back stay in curved cable stayed bridge reduces the bending moment at pylon base and deflection at mid span. He also concluded the relation between peak ground acceleration & earthquake displacement ratio for vertical and lateral directions.

1. Xu Xie, Xiaozhang and Yonggang Shen (2014) Active control of long span cable – stayed bridges under seismic loads. International symposium on traffic induced vibrations and controls. Beijing, Japan; 2014 investigated the static and dynamic characteristics of a long span cable stayed bridge which is made up of CFRP (Carbon Fibre Reinforced Plastic) cables. In this study, the mechanical properties, the static and the dynamic characteristics of

CFRP cables were also determined. The parametric vibration characteristics of CFRP cable were also taken into consideration. From the results, it has been concluded that the natural frequency of CFRP cable are more than the steel cables and the vibration amplitudes are less than of steel cables. It was also concluded that the deflection of girder is more of CFRP cable stayed bridge than that of steel cable stayed bridge. Therefore by using CFRP cables is facilitate in terms of mechanical properties as the manufacturing process matures and the cost decreases.

2. Shiva Shankar .M, T.sowmya and Amit Nagar[2015] Conceptual Seismic Design of Cable-Stayed Bridges, Journal of Earthquake Engineering, ISSN 2668:3589, Vol. 2, PP. 1139-1171 (2015) worked on 'dynamic analysis of cable stayed of bridge under moving loads with the effect of corrosion of cables'. This study gives that the loads are applied on the cable stayed bridge and also corrosion which gives the differential displacement of pylon and deck.
3. Nitesh .K, Kirank.Shetty and Premanand Shenoy[2015] "Cable Stayed Bridge Concpet of Longer Spans", Journal of Bridge Engineering, Aug 2015, Volume 1, 99-103 - worked on 'the performance of cable stayed bridge:. This study explained to find the initial shape of the cable stayed bridge under the application of dead loads.
4. Yogesh B. kumar, Suresh MR[2017] Analysis and Control of Cable-Stayed Bridges Subject to Seismic Action, Structural Engineering International Journal ISSN 1889:2451,
5. PP. 27-36 (2017) worked on; time –history analysis of a cable stayed bridge for various spans and pylon height.' The main objective of this study is to understand the behavior of cable stayed bridge under dynamic loads in terms of time –history.
6. Madhuri Yadav and kaushik Mujundar [2018] behavior analysis of stayed bridge with different cable arrangement using STAADPRO. International Journal of engineering and research technology, ISSN-2277-9655(June-2018) PP 36-41 worked on behavior analysis of stayed bridge with different cable arrangement using STAADPRO. This study deals with the design and analysis for different arrangements of cables with the difference of pylons shapes in STAAD PRO. In this study, the pylon shapes considered are A –shape, y-shape and H- shape pylons.
7. Ishitaarora,er.Rajenderesingh ,Aishwarya Parauram Pandit [2019] A Review on the study of cable stayed bridges, International Research Journal of Engineering and Technology ISSN 2998: 3451 Vol 3, PP. 1–4 (2019) worked on "a review on the study of cable stayed bridges ".In this study, the efficiency of the cable stayed bridges are studied. This study shows that the stiffness of the cable stayed bridge is high since the cables can tolerate even high pressure.
8. Thippeswamy AO and Dr.Sunil Kumar Tengali [2019] Analysis of load optimization in cable stayed bridge using CSI bridge software'. International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Page Number 7 (2019). worked on 'analysis of load optimization in cable stayed bridge using CSI bridge software'. The study deals with the analysing of load with different types of cable stayed bridges based on different cable arrangements.
9. Abhishek Pandey and Nitesh Kushwah, [Seismic Analysis and Design of Cable Stayed Bridge with Different Cable Arrangements], International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 12 | Dec 2020 This research paper dealt with the design and analysis for different cables arrangement with the different shapes of pylons using STAAD Pro. And for conscious minds arrangements with both the H, Both a Y shape tower, those who regarded multiple cases together with dead load & live load for analysis using Stand Pro software. Results stated that the circular or the H shape pylon can have a small amount of sag and moment in the cables or the deck among all of the pylons (i.e. one axial layer of stay and two lateral of stays) also because greater number with joints was n't homogeneous such that the composition with pressure and anxiety carrying capacity of both the cables wasn't really efficient towards the other parts of both the cable which might lead with sec, In comparison with a circular with a homogeneous member.
10. Neel Shah, Prashant Kanzariya, and Dr. Bimal Shah, [parametric study of cable state Bridge using different pylon configuration], International Journal of Engineering Applied Sciences and Technology, 2021, Vol. 5, Issue 10, ISSN No. 2455-2143, Pages 342-348 This study was carried out to find the dynamic effect on different configurations of pylons of a cable-stayed bridge. A pylon was inclined at 5o , 10o, 15o, 20o, 25o and 30o with vertical and horizontal axis both and compared with vertical pylon to study the dynamic response of the bridge. The 3D bridge models were prepared on CSI BRIDGE software and the bridge was analyzed seismically by Imperial Valley 1947, Earthquake. The bridge response in terms of Pylon, Girder and Cable axial force, moment and torsion was obtained. Results stated that minimum axial force was obtained at 10o in Cable at main span near pylon in X - Direction and Y - Direction both. Minimum axial force we got in girder at 10o at main span and side span both in X – Direction. Minimum axial force we got in pylon at 10o in X – Direction and at 15o for Y – Direction. Minimum moment in pylon we got at 10o and minimum torsion in pylon at 5o.
11. Priyanka Singh, Mirza Jahangir Baig, Bhumika Pandey and Kartik Papreja, [Analysis of the behaviour of Cable stayed bridge with different types of Pylon], E3S Web of

Conferences 304, 02006 (2021) In the research paper, the bridge design, model, and analyses for different types of pylons namely, H-type pylon, A-type pylon and inverted Y-type pylon was done using STAAD Pro. The comparison for three cases was done on the basis of shear force and bending moment in terms of self-weight to obtain the most efficient type of pylon design. Maximum shear force is observed in A-type pylon i.e., 605.876kN, 468.210kN for inverted Y-type and H-type pylon design i.e., 508.93kN. In terms of bending moment, it is observed that maximum bending is in inverted Y-type pylon i.e., 444.329kN-m, 271.430kN- m for H- type pylon whereas minimum is observed in A-type pylon i.e., 213.8kN-m which shows that this pylon design is more economical in comparison to other types as bending moment is directly proportional to the amount of reinforcement requirement. In case of deflection, it was observed that pylon type H has maximum deflection i.e., 172.5mm, followed by inverted Y- type pylon design i.e., 149.8mm, whereas it minimum in A-type pylon design, i.e., 76.9mm, which concludes that A-type pylon is most suitable and stable section in comparison.

12. N. Sonjoh Chebelem and Hakan Erdogan, [Effect of Pylon Shapes on Seismic Response of a Long Long-Span Steel Box Box-Girder CableCable Stayed Bridge], Kocaeli Journal of Science and Engineering, 4(2): (2021) 120-127 This research paper focused on the effect of A and H shape reinforced concrete pylons on the seismic behavior of a long span steel triple box-girder cable stayed bridge that was presumed to be located in an earthquake- prone region in Turkey. The 3D models of the bridge were constructed using SAP2000 software and the time history analysis was carried out considering cable sag, large displacement effects. The seismic responses of the bridges were compared in terms of axial force on cables, deflections on the pylons and the deck. Results stated that the pylon vibration became dominant in the earlier modes for H shape pylon with respect to A shape pylon. This behaviour possibly led to almost two-fold difference among the maximum pylon top transverse displacements of the two different pylons, namely H shape pylon experienced greater displacement. On the contrary, the maximum deck mid span transverse displacement was observed in cable stayed bridge model with A shape pylon.

13. Atheela Mehaboob and Athira Suresh, [Dynamic Performance of Nonlinear Cable- Stayed Bridges in Effect of Height and Inclination of Pylon], International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 11 Issue 06, June- 2022 This research paper presented modelling and analysis of a curved cable-stayed bridge using SAP 2000 subjected to dynamic time history loads considering the effect of inclination of pylon on response of mode shape of pylon. Inclinations provided were 0 degree, 5 degrees, 15 degrees and 20 degrees. Results concluded that 5 degrees was the most accurate inclination over other inclinations. Since in the case of deflection analysis 5-degree inclination gives the best result, only height of 5-degree inclination varied. Actual height of the tower was 36.87m. It was reduced to 33.86m and 39.87m. Changes in longitudinal and transverse direction were found and a graph was drawn.

14. Ahmed M. Fawzy, Khaled F. El-Kashif and Hany A. Abdalla, [Seismic performance of cable stayed bridges with different geometric conditions], Journal of Engineering and Applied Science (2022) 69:82 In the research paper, the shape of pylons; the performance of many shapes was investigated after being exposed to an earthquake. The effect of changing deck width of an inverted Y-shaped pylon with variation in main span length was investigated. The numerical study was performed using MIDAS civil software. Conclusion stated that the most efficient pylon shape in terms of seismic performance was that of pyramid shape followed by a delta shape. In addition, it was found that changing deck width for the same main span gives a negligible difference to normalized shear force.

15. Abdullah Khan, Prof. Saleem Akhtar - Structural Analysis of Cable Stayed Bridge with Different Shape of Pylon Using Staad Pro - Abdullah Khan, 2023, 11:4 ISSN (Online): 2348-4098 ISSN (Print): 2395-4752 - International Journal of Science, Engineering and Technology, 2023, 11:4 International Journal of Science, Engineering and Technology The need for intricate, cost-effective engineering constructions with outstanding aesthetics has increased over the past few decades, and cable stayed bridges have also seen an increase in interest in these structures This study focuses on modelling cable-stayed bridges with various pylon shapes. One of the contemporary bridges designed for longer spans is the cable stayed bridge. STAAD Pro is used in this study to design the bridge, model it, and conduct assessments for the various types of pylons. In order to determine the most effective form of pylon design, three scenarios are compared on the basis of shear force, Torsion, bending moment in terms of self-weight and IRC Class 70R Loading. The findings are helpful in limiting the limitations of other pylon kinds. It was always key point of research for choice of strength and durability of the structure and economical structural system. The shape of pylon plays an important role in the strength and durability of cable stayed bridge. Hence it is very necessary to determine the study of behaviour of different shapes of pylons under vertical and lateral loading before implementing it in actual practice which gives an idea for the adequate strength of cable stayed bridge in a particular condition. For designers or structural engineers, these particular studies are very essential for predetermination of behaviour of cable stayed bridge under different conditions. This work will provide the comparison between the different shapes of pylons under different condition with different standards

specifications. Thus from the results obtained, one can easily identify the most suitable arrangement for better strength and durability and for economical structural system.

III.CONCLUSION

From the previous studies the following conclusion drawn

The previous study derived the conclusion about dynamic behaviour of cable stayed bridge with various patterns of pylons. when the increase in complexity of the structure increases the risk of dynamic behaviour. The cable stayed bridge is a complex structure so the dynamic behaviour also complex. From the values Inverted Y shape and Diamond shape pylon cable stayed bridge shows high values of axial force, shear force and bending moment in both pylon and girder. As well as the Inverted Y shape shows high frequency compared to others. The H shape pylon cable stayed bridge shows more stable feature in dynamic response compare to others. So, the complex structure needs more care in design, in selection of materials and need better supervision. The various type arrangements in pylon of cable stayed bridge are analysed. Inverted Y shape pylon, Diamond shape pylon, H shape pylon and needle shape pylon these are the various arrangements of pylons used in modelling. The modelling by MIDAS CIVIL software. The provided load cases are dead load, moving load and seismic load. The El Centro ground motion data are used for dynamic analysis. The dynamic response of bridge in 6 modes are calculated.

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