International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Effect of Pylon Shape on the Seismic Response of Curved and Straight Cable Stayed Bridges

Almas M A[1], Rajesh A K[2]
[1]M.Tech Student, Dept of Civil Engineering, Ilahia College of Engineering, Muvatupuzha, India
[2]Assistant Professor, Dept of Civil Engineering, Ilahia College of Engineering, Muvatupuzha, India

***Abstract*— *Cable stayed bridge is the demand of every nation and it could be achieved with use of enhanced materials. Generally, cable supported bridges comprise both suspension and cable-stayed bridge. Cable supported bridges are flexible in behaviour. These flexible systems are susceptible to the dynamic effects of wind and earthquake loads. Here focus is given on the effect of shape of pylon on the seismic response of cable stayed bridge, for this, the bridge span dimension and other parameters are kept constant, and only the pylon shape is varied viz. A type, H shape and inverted Y shape. The height of the pylon is kept constant for all the shapes for comparison purpose. The 3D bridge model is preparing on ANSYS software and bridge is analyzing seismically. Straight and curved cable stayed bridges are analysed to study the seismic behaviour and effect of pylon shape of both.*

***Keywords*— *Curved cable stayed bridge, straight cable stayed bridge, pylon shape, A shape, H shape, inverted Y shape, seismic performance.*

I. INTRODUCTION

Bridges are one of the most important critical lifeline facilities which should remain functional without much damage after an earthquake to facilitate the rescue and relief operations in that area affected by the earthquake. Over the years cable stayed bridges have become more interesting due to the advancements in computer technology and the use of high strength of materials. A cable-stayed bridge has one or more towers (or pylons), from which cables support the bridge deck. A distinctive feature is the cables which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines. This is in contrast to the modern suspension bridge, where the cables supporting the deck are suspended vertically from the main cable, anchored at both ends of the bridge and running between the towers. The cable-stayed bridge is optimal for spans longer than the cantilever bridges, and shorter than suspension bridges. This is the range where cantilever bridges would rapidly grow heavier if the span were lengthened, while suspension bridge cabling would not be more economical if the span were shortened.

The tower shape is mainly selected for aesthetic reasons, and is refined based on proportions, materials, and restrictions associated with the tower design. A considerable variety of tower shapes exist. In general, the shape of the tower is governed by the required height and the environmental loading conditions, such as seismic zones and wind criteria. The towers are classified according to the basic forms. The towers are subjected to axial forces. Thus they must provide resistance to buckling. They can be fabricated out of steel or reinforced or prestressed concrete. Concrete towers are more common than steel towers because they allow more freedom of shaping, and are more economical

A. Different Shaped Pylons

The H-shaped design is similar in concept to the portal. The A shaped pylon achieves the same goal by angling the two columns towards each other to meet at the top, eliminating the need for the third member. The inverted Y design combines the A-shaped on the bottom with the single on top.

II. IGEOMETRICAL DETAILS OF STRUCTURE

In this work, the problem proposed for investigation is the preparation of three-dimensional models using A shape, H shape and inverted Y shape pylons for straight and curved cable-stayed bridges. The most suitable configuration is further studied with its inclination angle.

Modelling is carried out by using ANSY software of version 16.1

A. Salient Features of the Structure

Type of structure: Cable Stayed Bridge
Deck type: Rectangular
Deck thickness: 1.35m
Deck width: 11.75m
Cable diameter: 0.8m
End beams: 3x3m
Intermediate beams: 3.5x1.35m
Height of deck from ground: 10m
Height of pylon: 37.86m
Material of pylon: RCC
Grade of concrete: M50
Poisson‘s ratio for concrete: 0.15
Poisson‘s ratio for steel: 0.3
Density of concrete: 2500 N/mm^3
Method of Analysis: Modal Analysis & Time History Analysis

III. MODELLING

The geometrical models of the bridges are modelled by using ANSYS 16.1 software. These are shown below

Almas M A and Rajesh A K, "Effect of pylon shape on the seismic response of curved and straight cable stayed bridges," *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 267-271, 2017.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

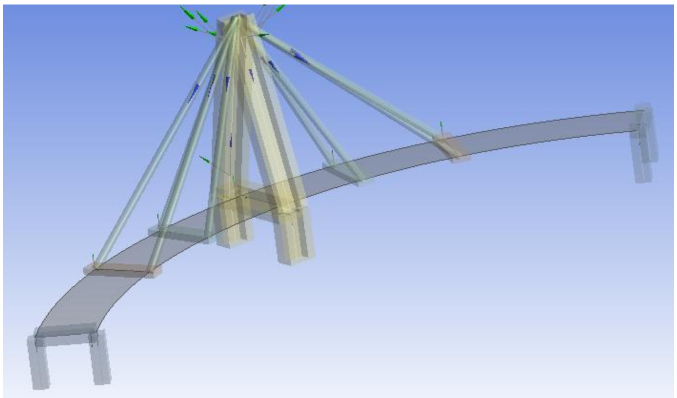

Fig. 1. Curved cable stayed bridge with A shape pylon.

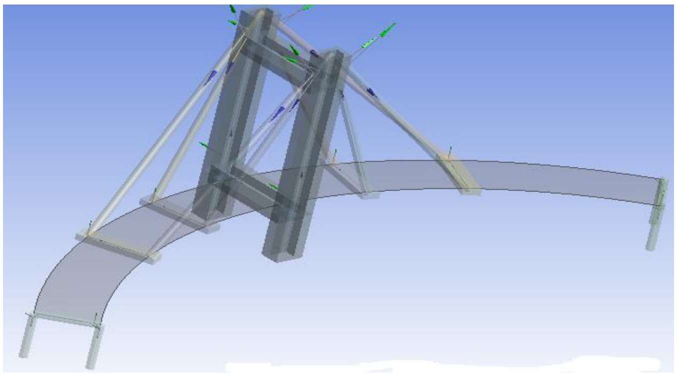

Fig. 2. Curved cable stayed bridge with H shape pylon.

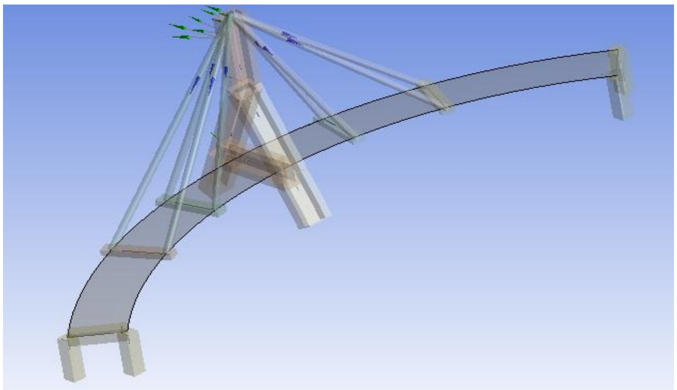

Fig. 3. Curved cable stayed bridge with inverted Y shape pylon.

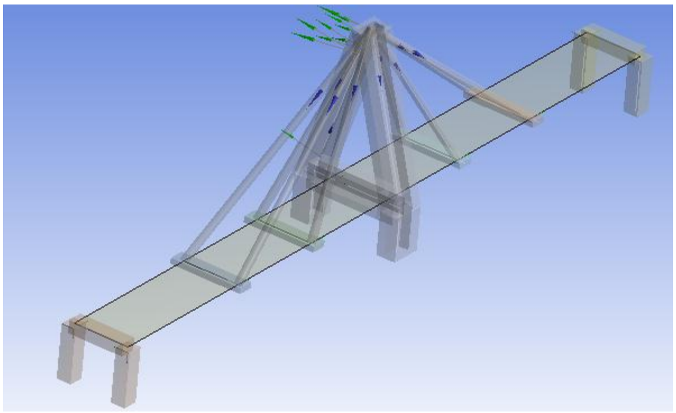

Fig. 4. Straight cable stayed bridge with A shape pylon.

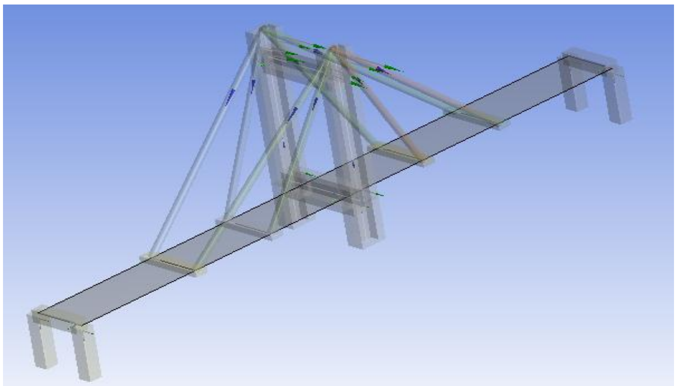

Fig. 5. Straight cable stayed bridge with H shape pylon.

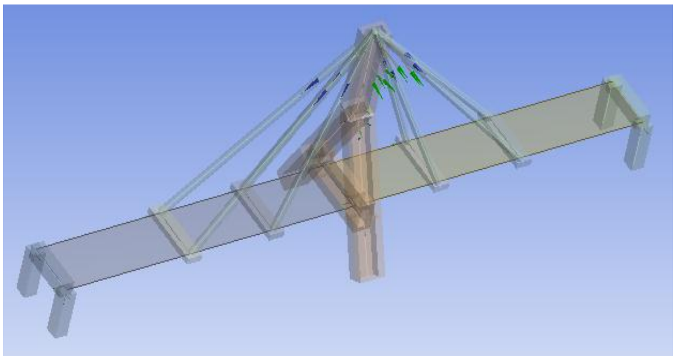

Fig. 6. Straight cable stayed bridge with inverted Y shape pylon

As per IS 1893:2002, Part 1, Kerala state comes within seismic zone III, with Ritcher scale magnitude between 6.5 and. The Acceleration time history of the 1940 El Centro earthquake commonly referred to as the Imperial Valley earthquake, which had a Ritcher magnitude of 7 was considered for the work

The earthquake produced significant damages to the buildings due to failure of underlying soil. This highlighted the fact that the seismic behavior of a structure is influenced not only by the response of superstructure, but also by the response of foundation and ground. Acceleration time history of El Centro earthquake is shown in the figure.

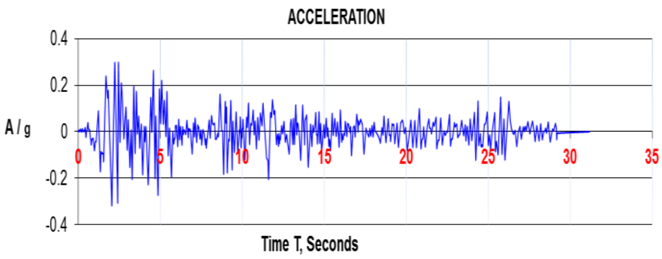

Fig. 7. Acceleration time history of El Centro earthquake.

IV. RESULTS AND DISCUSSIONS

The six modes are incorporated in the analysis. These modes are not excited in the same manner. The extent to which dynamic loading excites a specific vibration modes depends on the spatial distribution and the frequency content of the load. It is necessary to include at least six modes in the analysis in order to obtain the most fundamental movements.

Almas M A and Rajesh A K, "Effect of pylon shape on the seismic response of curved and straight cable stayed bridges," *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 267-271, 2017.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

It might be sufficient to consider only these modes in a preliminary analysis. The variation of modal frequency with mode number for three bridges is shown in Fig 8 and fig 9.

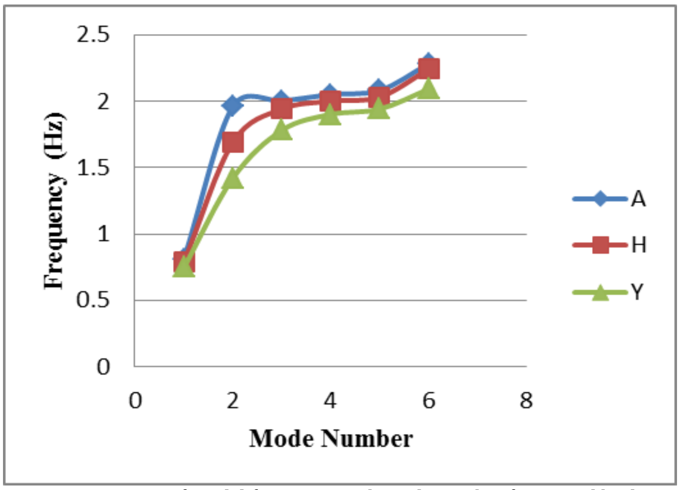

Fig. 8. Variation of modal frequency with mode number for curved bridge systems.

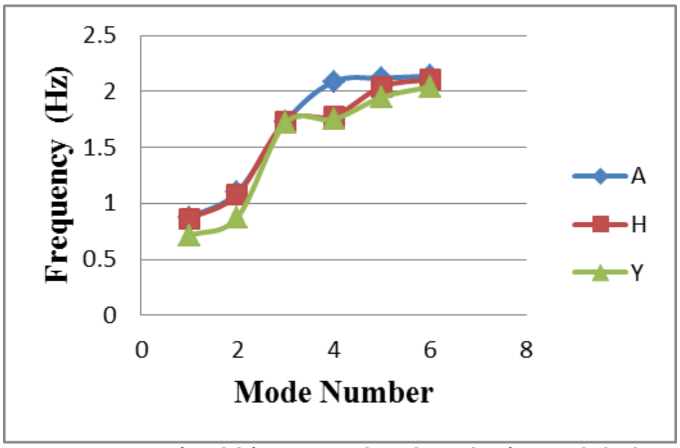

Fig. 9. Variation of modal frequency with mode number for straight bridge systems.

The curved cable stayed bridge with Y shape has less mode frequencies compared to other two shapes. For three bridge systems, the frequency is increasing proportional to the mode number. In straight cable stayed bridge also the bridge with inverted Y shape has less mode frequencies compared to other two shapes.

A. Base Shear

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Base shear values for inverted Y pylon system is much lesser than the values for A pylon and H pylon. This is due to the fact that A-pylon and H pylon system consists of larger design parameters when compared to the single pylon. The damage due to earthquake in buildings is mainly occurring at the base level. Therefore Y shape pylon system will be more resistant to the earthquake in terms of base shear. The base shear values are shown in fig 10.

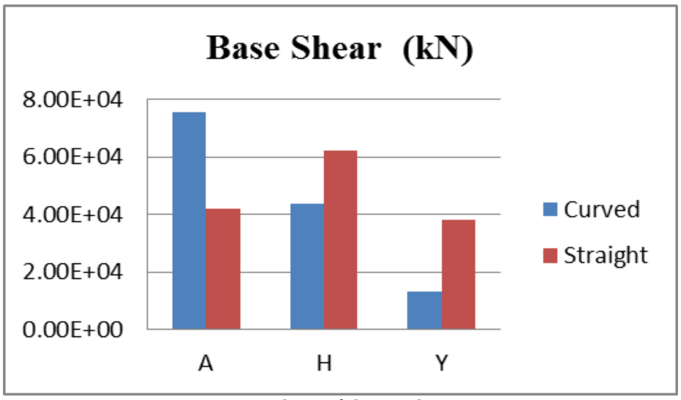

Fig. 10. Base shear of three pylon systems.

B. Cable Forces

The tensile forces which are developed at the cables of the bridges are shown in fig 11. For both curved and straight bridges the axial force in cables is less for inverted Y pylon system. For straight bridges, the axial force in cable of H and A pylon systems are 51% and 14% higher than that of Y pylon system. For curved bridges, tensile force in cables are almost same for inverted Y pylon system and H pylon system and 16% lower than that of A pylon system.

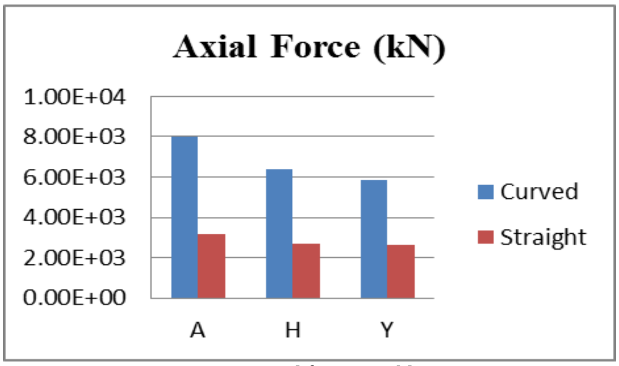

Fig. 11. Axial force in cables.

C. Girder Forces

The maximum response quantities such as Bending-moment, Shear-force, Torsion and Axial force developed in girders are compared for all three bridges to find out best suitable pylon- configuration for a given condition. These response quantities in the girders of three bridges are shown in figures.

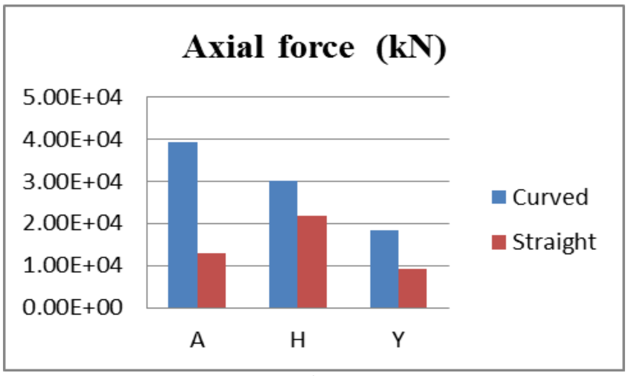

Fig. 12. Axial force in girders.

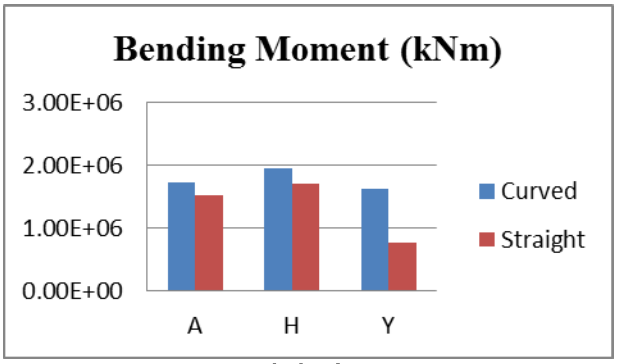

Fig. 13. Girder bending moment.

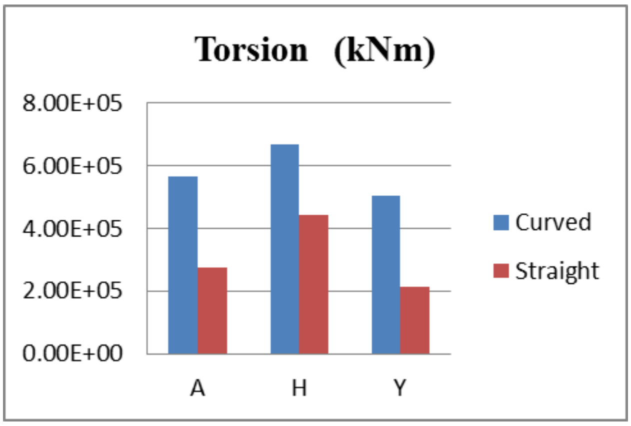

Fig. 14. Torsion in girder.

- From the analysis results, it can be seen that the Y shape pylon system gives lesser value of bending moment than other systems. It is 58% lower than that of H pylon system and 53% lower than that of A pylon system for curved bridges and 57% and 53% lower in case of straight bridges
- The torsional moment is found maximum for H pylon system and minimum for inverted Y pylon system. As well as the torsional moment of Y pylon system and A pylon system are almost same and is 50% lower than that of H pylon system for curved bridges.
- Axial force in girder is also minimum for inverted Y shape pylon system and is about 82% lower than that of A pylon system and 66% lower than that of H pylon system for curved bridges. For both curved and straight bridges, the A shape pylon system gives maximum axial force

D. Pylon Forces

The primary function of the pylon is to transmit the forces arising from anchoring the stays and these forces will dominate the design of the pylon. The pylon should ideally carry these forces by axial compression where possible, such that any eccentricity of loading is minimized. These response quantities in the pylons of three bridges are shown in figures.

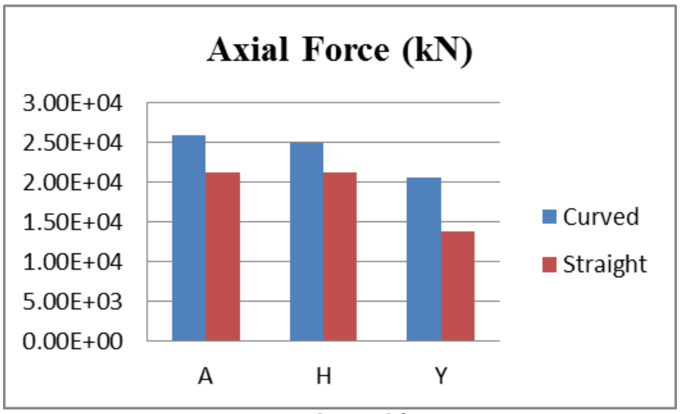

Fig. 15. Pylon axial forces.

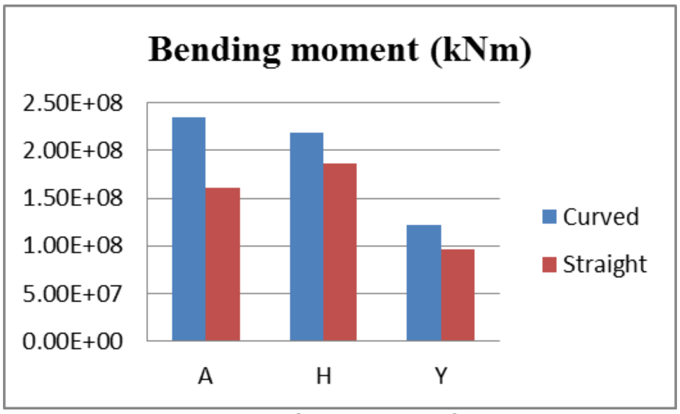

Fig. 16. Bending moment in pylons.

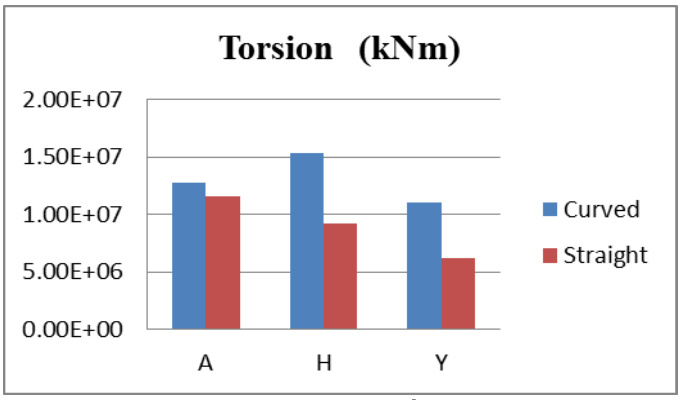

Fig. 17. Torsion in pylons.

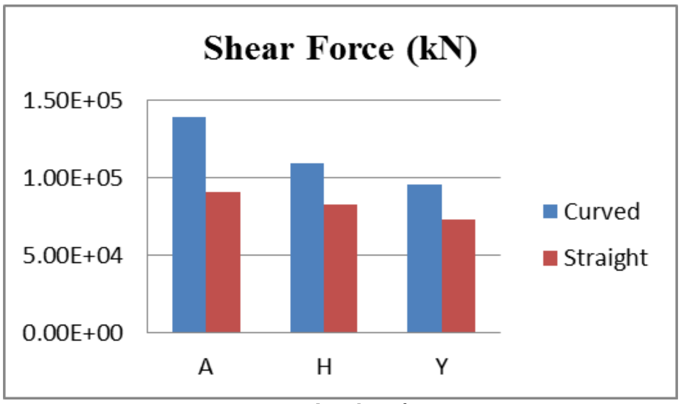

Fig. 18. Pylon shear forces.

- From the analysis results, it can be seen that the Y shape pylon system gives lesser value of bending moment in pylons than other systems. As well as the bending moment of H pylon system and A pylon system are almost same which is about 45% higher than that of Y pylon system for curved bridges.
- The torsional moment is found minimum for inverted Y pylon system. Torsional moment of Y pylon system is 66% lesser than that of H pylon system and 58% lesser than that of A pylon system for curved bridges
- Axial force in pylon is maximum for A pylon system and minimum for inverted Y pylon system for both curved and straight bridges.
- The A pylon system gives higher value of shear force which is 30 % higher than that of Y pylon system and 23% than that of H pylon system for both curved and straight cable stayed bridges.

V. CONCLUSION

- The base shear values for inverted Y pylon system is much lesser than the values for A pylon and H pylon.
- The curved cable stayed bridge with inverted Y shape pylon gives lesser value of displacement compared to other two bridges. As the pylon height increases the displacement value reduces for all the three models.
- Response quantities which are selected for the analysis are displacement, base shear and axial force, bending moment, shear force and torsional moment in cable, girders and pylons.
- After analysing these response quantities for three curved bridges, it is understood that the inverted Y shape pylon gives most suitable configuration for both curved and straight cable stayed bridges.

ACKNOWLEDGEMENT

I wish to thank the Management, Principal, and Head of Civil Engineering Department of Ilahia College of engineering and technology, affiliated by Kerala Technological University for their support. This paper is based on the work carried out by me (Almas M A), as part of my PG course, under the guidance of Rajesh A K (Assistant Professor, Ilahia College of engineering and technology Muvattupuzha, Kerala, India). I express my gratitude towards her for her valuable guidance.

REFERENCES

[1] S. G. Shah, Desai. J. A, and Solanki. C. H, “Effect of pylon shape on seismic response of cable stayed bridge with soil structure interaction,” *International Journal of Civil and Structural Engineering*, vol. 1, no. 3, pp. 667-682, 2010.

[2] Thomas Blesson B. and S. P. Thakkar, “Parametric Study of Shapes of Pylon for Cable Stayed Bridge,” *Nirma Universitty Journal of Engineering and Technology*, vol. 2, no. 1, pp. 9-16, 2011.

[3] Dr. N. D. Shah, Dr. J. A. Desai, and Dr. H. S. Patil, “Effect of pylon shape on analysis of cable-stayed bridges,” *Journal of Engineering Research and Studies*, vol. II, issue I, pp. 104-109, 2011.

[4] A. K. Desai, “Seismic time history analysis for cable-stayed bridge considering different geometrical configuration for near field earthquake,” *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*, vol. 7, no. 7, 2013.

[5] G. M. Savaliya, A. K. Desai, and S. A. Vasanwala, “The effect of lateral configuration on static and dynamic behaviour of long span cable supported bridges,” *International Journal of Civil Engineering and Technology*, vol. 6, issue 11, pp. 156-163, 2015

[6] M. Shahid Ahmed, Anil Kumar.M, Banulatha G.N, and Manu. J, “Study on behaviour of cable-stayed bridges under the action of moving loads,” I*nternational Journal of Advanced Research in Eduation Technology (IJARET)*, vol. 2, issue 2, pp. 160-163, 2015.

[7] F. S. Dhilawal and D. R. Tarachandani, “Effect of dynamic analysis on pylon configuration of cable stayed bridges,” *International Journal of Advance Research and Innovative Ideas in Education*, vol. 2, issue 3, pp. 2139-2144, 2016