PARAMETRIC STUDY OF CABLE STAYED BRIDGE FOR DIFFERENT PYLON CONFIGURATION

Krunali Mavani[1], **Abhishek Raturi**[2], **Maulik Kakadiya**[3]
[1]Student, Dept. of Civil Engineering, Chhotubhai Gopalbhai Patel Institute of Technology, Bardoli, Gujarat, India
[2]Assistant Professor, Dept. of Civil Engineering, Chhotubhai Gopalbhai Patel Institute of Technology, Bardoli, Gujarat, India
[3]Assistant Professor, Dept. of Civil Engineering, Chhotubhai Gopalbhai Patel Institute of Technology, Bardoli, Gujarat, India

Abstract: ***In recent years, several cable-stayed bridges have been constructed with different shapes of pylons such as H-shaped, 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 different parameters. This paper deals with the modelling of Cable Stayed Bridges with different pylon configuration. The cable stayed bridge is one of the modern bridges which were built for the longer spans. There is a need of study on the effect of shape of pylon for different height of cable stayed bridge, for this, the bridge span dimension and other parameters are kept constant, and only the pylon shape is varied i.e. A type, H type. The height of the pylon is also change for all the shapes for comparison purpose. The modelling of bridge is prepared on SAP 2000 software.***

Keywords- Cable Stayed Bridge, Pylon Shape, Pylon Height, Parametric Study

I. INTRODUCTION

Many cable stayed bridges have been successfully built around over the world in only last two decades of the 20th century. Due to their highly appreciable appearance & significantly utilized structural materials, cable stayed bridges have been taken as one of the most popular type of bridges in last decades. With increasing span length, the modern cable stayed bridges are more acceptable & flexible strong enough to the effect wind as compare to ever. A typical cable stayed bridge consists of deck with one or two pylons erected above the piers in the middle of the span. The cables are attached diagonally to the girder to provide additional supports.

The German engineer F.Dischinger (1949) rediscovered the stayed bridge, while designing a suspension bridge across the Elbe River near Hamburg in 1938.He recognized that the inclined cables of the early cable-stayed bridges were never subject to any initial tension, thus cables started to perform properly only after considerable deformations of the whole structure. In earlier development, this behavior led to the misconception that this type of bridge was unacceptably flexible and consequently unsafe. The requirements of efficient use of materials and speedy construction made cable stayed bridges the most economical design for the replacements. The first modern cable-stayed bridge, the Stromsund Bridge designed by F. Dischinger, was completed in Sweden in 1955. The design and construction of this bridge represent the beginning of a new era of modern cable-stayed bridges. The rapid growths of modern cable stayed bridges throughout the world afterwards is due to the many advances in bridge engineering leading towards better understanding of the behavior and performance and recognizing the advantages of this type of bridges in terms of economy, ease of fabrication and construction, aesthetics and the different possibilities in structural arrangements, etc... Nowadays, the cable stayed bridge has been recognized as a very efficient and competitive design for bridges of span ranging from 200m to 1000m. For a span length between 200m and 400m, the reinforced concrete girder design for the longitudinal bridge member is generally considered more economical. For a span length between 400m to 600m, the composite deck cross-section can be considered, whereas for 600m to 1000m, the steel box girder or composite deck design is preferable.


Figure 1. H-Type Pylon


Figure 2. Inverted Y Pylon


Figure 3. Y-Types Pylon


Figure 4. Delta Pylon


Figure 5. Diamond Pylon

II. LITERATURE REVIEW

A. Dr Niraj D Shah ,Dr Jatin A Desai , Dr H S Patil , “Effect of pylon shape on analysis of cable-stayed bridges”, Journal of Engineering Research and Studies.

Dr Niraj D Shah, Dr Jatin A Desai, Dr H S Patil “Effect of pylon shape on analysis of cable-stayed bridges”. The present paper made an attempt to presents finite element approach for the geometric nonlinear aerostatic analysis of self anchored cable-stayed bridges with different pylon configurations along with vehicular interaction. The example bridges

are supported by three different pylon configurations such as H shape, A shape and Inverted Y shape. For above mentioned bridges, linear and non-linear analysis was carried out for a wind speed of 55 m/s for both self-anchored and partially earth anchored (bi-stayed) bridges.

To better understand the effect of pylon system with conventional system, parametric studies are carried out

A long span bridge of total span of 1200m was considered to study the effect of various pylon Shapes. Three cases of typical pylon arrangement in modern cable-stayed bridge are Considered i.e. The H shape, A shape and inverted Y shape. In each case, linear and Nonlinear analysis was carried out for a wind speed of 55m/s. The deck cross section of Normandie cable-stayed bridge has considered. The displacement aerostatic load, For all model, has been calculated by taking drag coefficient CD = 1.20, coefficient of lift CL=0.38

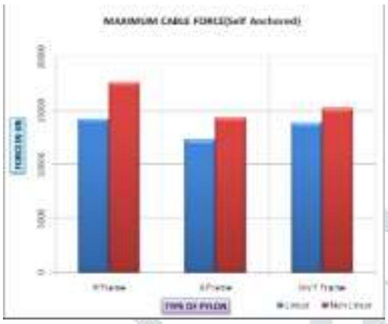


Figure 6. Nonlinearity effect on cable force

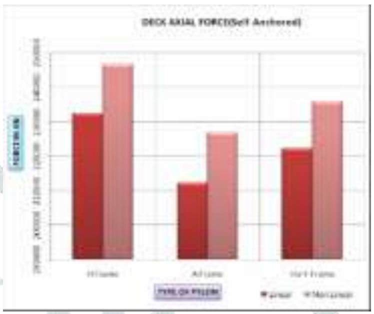


Figure 7. Nonlinearity effect on deck force

The results showed that these factors have significant influence on the aerostatic behavior and should be considered in the aerostatic analysis of long span cable stayed bridges. Analysis results will be useful for the designers to consider the shape of pylon at the initial stage of design. Again the results indicate the significant influence of pylon shapes on aerostatic behavior of such long span bridges

B. 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, jan-jun 2011

Thomas Blesson B. And S. P. Thakkar “Parametric Study of Shapes of Pylon for Cable Stayed Bridge” A study is carried out to find 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, Shear force, Torsion and Axial force are represented.

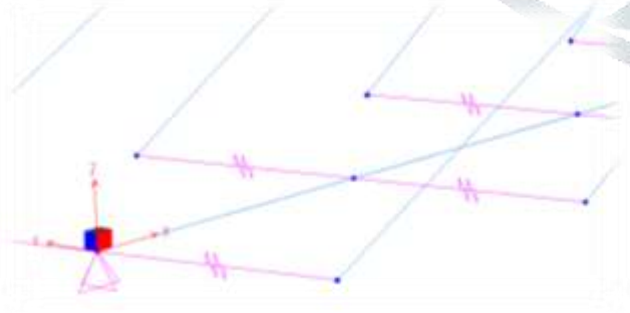


Figure 9. Model of deck

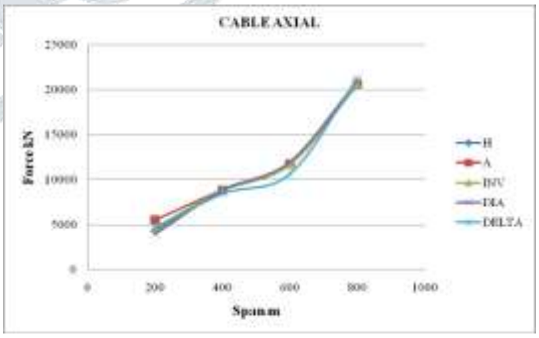


Figure 10.Dynamic case

D. Siddharth G. Shah , Desai.J.A, 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 Volume 1, No 3, 2010

Siddharth G. Shah , Desai.J.A, Solanki.C.H; “Effect of Pylon Shape on seismic response of Cable stayed bridge with soil Structure interaction” Cable stayed bridge are the most flexible bridge and getting popularity because of its economy for longer spans and aesthetics. 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 type, portal frame, spread pylon and pyramid shapes. The height of the pylon is kept constant for all the shapes for comparison purpose. Here soil structure interaction effects are considered through the soil spring at the base. The 3D bridge model is prepared on SAP 2000 software and bridge is analyzed seismically by Bhuj 2001, Earthquake India. The bridge response in terms of pylon displacement, acceleration and base moment is obtained. The study reveals that the shape of the pylon has great influence in the seismic response of cable stayed bridge. Spread pylon shape are better for resisting earthquake in longitudinal direction but weak in lateral direction, but pyramid shape pylon is better because of its geometry in resisting earthquake force from any direction and also SSI effects are minimum in this case. SSI effects are predominant for soft soil conditions for all pylon shapes. This is a numerical step by step Integration of equations of motion. It is usually required for critical/important or geometrically complex bridges. Inelastic analysis provides a more realistic measure of structural behavior when compared with an elastic analysis.

III. MODELING OF CABLE-STAYED BRIDGE

I. Geometry of Bridge

Central Span of the Bridge	253 m
Width of Bridge	12.5 m
Side Span	126.5 m
Height of Pylon	L/4 to L/5 (50m-63m)
No. of Cables	32 nos
Cable Arrangement	Fan type
Girder section	Plate type
Shape of pylon	H , Y type

II. Cable Initial Tension

a. Calculate the effective span (S) for each cable at the deck.

b. Compute the total dead load (W) of each effective span. ($Wi = wx\sin\theta$), w is the weight per unit length).

c. Compute the inclined angle between the cable and the bridge deck at the cable connection ($\theta i = \tan^{-1}\frac{hi}{li}$).

d. Compute the cable axial force at the cable lower end by using the results of Steps-2 and 3 ($Pi = \frac{Wi}{\sin\theta}$) Check the cable restrains.

The following consists of the steps carried out to model the cable-stayed bridge using SAP2000.

1. Draw the geometry of the frame either by inserting coordinates or by linking the nodes through member length.
2. Define the sections and materials for the members.
3. Define the loading values and load combinations to be applied on the structures.
4. Now assign the defined section to the members.
5. Assign the loads to the joints or members as per the case.
6. After assigning everything, set the analysis to be carried out and press run analysis.

The following model is H-shape 63 m height fan type cable stayed bridge.

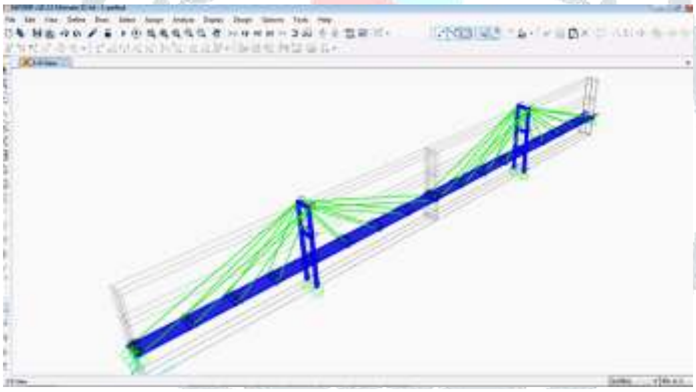


Figure 6. Model of Cable Stayed Bridge

IV. RESULTS

i. Time period of 63 m H-shape

Table 1. Time period

Mode	1	2	3	4	5	6
63 m	9.309382	4.752584	4.751607	4.751601	4.751491	4.751409

Mode	7	8	9	10	11	12
63 m	4.75140	4.751144	4.7511	4.751144	4.751144	4.751142

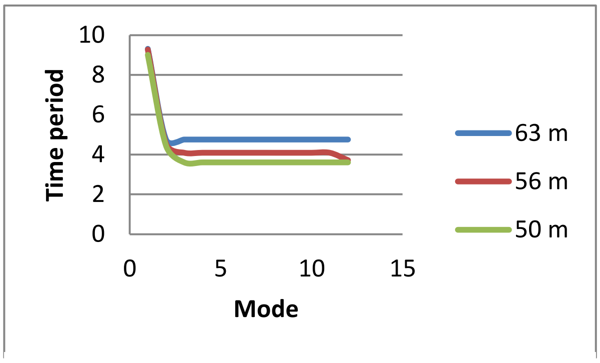


Figure 7. Comparison of H-shape

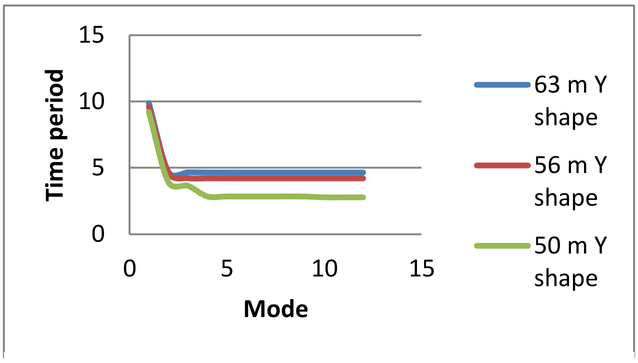


Figure 8. Comparison of Y-shape

Here fig 7 and 8 shows decreasing in time period by comparing for different height of H-shape and Y-shape.

ii. Cable tension forces

Table 2. Cable initial tension force

Joint No.	Reaction(kN)	θ	$\sin\theta$	$T=\frac{Reaction}{\sin\theta}$
12	782.48	18.98	0.3252	2405.86
63	1493.28	24.63	0.4167	3583.09
62	1501.89	34.52	0.5666	2650.26
64	1493.28	53.99	0.8089	1846.029
76	1493.28	53.99	0.8089	1846.029
75	1501.89	34.52	0.5666	2650.26
77	1493.28	24.63	0.4167	3583.09
6	782.48	18.98	0.3252	2405.86
7	782.48	18.98	0.3252	2405.86
79	1493.28	24.63	0.4167	3583.09
78	1501.89	34.52	0.5666	2650.26
80	1493.28	53.99	0.8089	1846.029
82	1493.28	53.99	0.8089	1846.029
81	1501.89	34.52	0.5666	2650.26
83	1493.28	24.63	0.4167	3583.09
16	782.48	18.98	0.3252	2405.86

Here joint number which was get from model and calculation carried out for tensile force at I-end joint of cable.

iii. Cable Axial force

Table 3 Cable Axial force

Cable No.	1	2	3	4	5	6	7	8
Axial force(kN)	0.145	0.116	196.979	0.06	0.06	106.6	0.116	0.145

Cable No.	1	2	3	4	5	6	7	8
Axial force(kN)	0.145	0.116	106.6	0.06	0.06	196.979	0.116	0.145

iv. Comparison between Cable Axial forces of H and Y shape

Table 4 Axial force of H and Y-Shape

Height of pylon (m)	Cable Axial force(kN) H-shape	Cable Axial force(kN) Y-shape
50	38.02763	45.3327
56	55.04	71.444
63	62.7837	96.9853

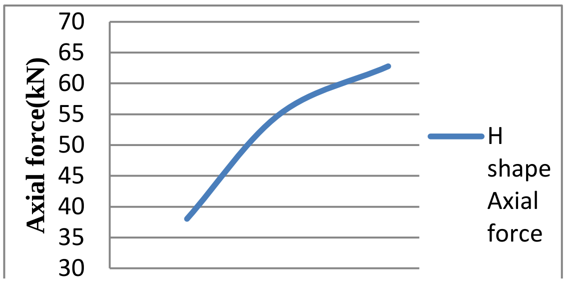


Figure 9.Cable Axial forces of H-Shape

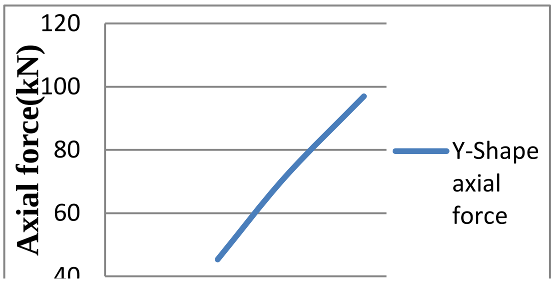
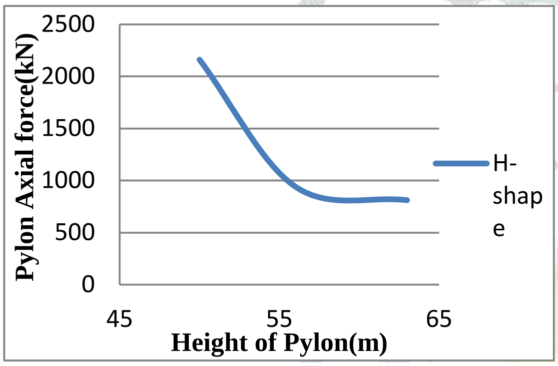


Figure 10. Cable Axial forces of Y-Shape

vi. Comparison between Pylon axial forces of H and Y shape

Table 5. Pylon Axial force

Height Of Pylon (m)	Pylon Axial force(kN) H-shape	Pylon Axial force(kN) Y-shape
50	2161.015	2512.774
56	941.2008	1031.857
63	810.921	920.829



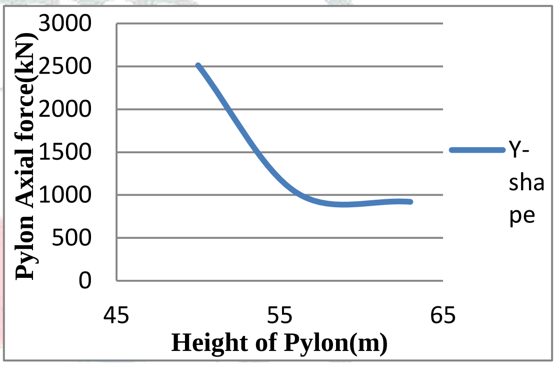


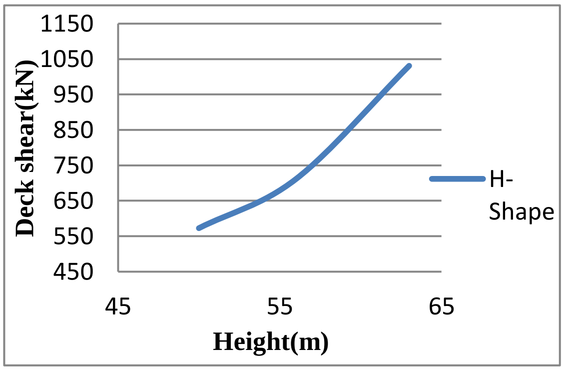
Figure 11. Pylon Axial forces of H-Shape

Figure 12. Pylon Axial forces of Y-Shape

vii. Comparison between Deck shear of H and Y shape

Table 6. Deck shear

Height of pylon (m)	Deck shear (kN) H-shape	Deck shear (kN) Y-shape
50	572.71	633.79
56	711.31	834.09
63	1030.85	1250.30



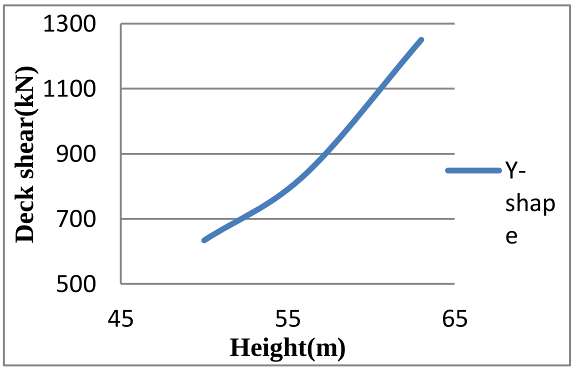


Figure 13. Deck shear of H-Shape

Figure 14. Deck shear of Y-Shape

viii. Comparison between Deck Moment of H and Y shape

Table 6.36 Deck Moment

Height of pylon (m)	Deck shear (kN.m) H-shape	Deck shear (kN.m) Y-shape
50	159.1	142.7142
56	194.7159	190.1541
63	352.0829	329.7128

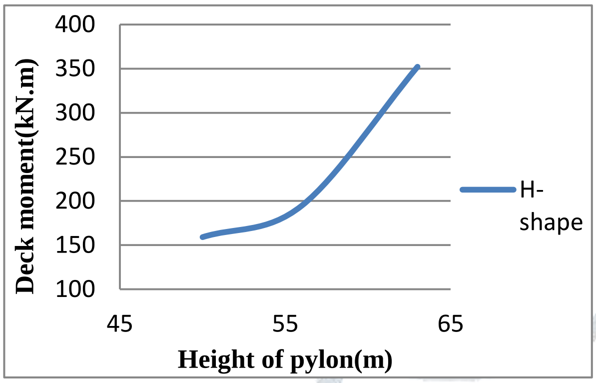


Figure 13. Deck Moment of H-Shape

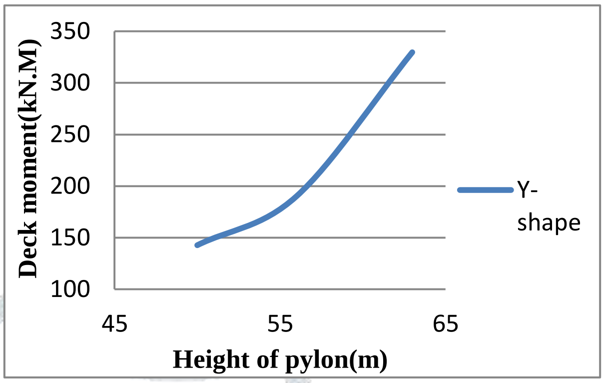


Figure 14. Deck Moment of Y-Shape

V. CONCLUSION

- As changing height of bridge from 63 m, 56 m, 50 m time period of cable stayed bridge is decreasing in both H shape and Y-shape. By changing shape of pylon form H-shape to Y-shape time period is also decreasing for different height of pylon.
- From analysis it is seen that inner cables are carrying more load compare to outer cables.
- Changing height 63m to 50 m axial force in cable is increasing for both shape H and Y.
- Changing height from 63 m to 50 m moment in deck is increasing for both shape H and Y.
- By changing height from 63 m to 50 m axial force in pylon is decreasing in both shapes.

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