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DESIGN AND ANALYSIS OF CABLE STAYED BRIDGE CONSIDERATION WITH SEISMIC AND WIND LOAD BY CHANGING THE CABLE POSITION

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Abstract: In past few decades cable stayed bridge is designed for providing free space between two piers for movement of ships and other water bodies, hence concept of cable stayed bridge is popular in this era. The conceptual design of bridge structure depends upon reliability, serviceability, visual appearance and the cost of structure. Cable Stayed Bridge is the best design example of bridge structure which fulfill all above aspects with great efficiency. In cable stayed bridge shear force taken by cable and compression by pillars, so all possible forces in pillars are stabilized by the main cable, this is main reason cable stayed bridge is designed for long span with economical cost. In this study eight number of models of bridge with the variation of cable position is analysed. The main span of bridge is taken at 250m and side span is 125m including two lanes each 3.5m wide and 1.5m wide pathway is taken for analysis. The prepared geometry of the eight models of cable stayed bridge is analyzed in STAAD.Pro v8i series VI software for various structural properties. The wind zone-IV and seismic zone-V is selected for the detailed analysis. The bridge with the variation in cable position is design in STAAD.Pro software and analyzed for maximum horizontal shear force (Fx), maximum vertical shear force (Fy), maximum horizontal moment (Mx) and maximum vertical moment (My) for side span & main span along without bracing in pylon. The obtained results for different cable profile are analyzed and compared to obtain optimum position. Further results revealed that the cable arrangement as per model M4 gives best result, also bracing is not playing too much role to reduce shear force and bending moment.

Keywords: Bridge, Cable, Compression, Pylon, Stiffness

I.INTRODUCTION

Thousand years ago, people cross water bodies with the help of cable attached with wooden block. It was born of cable stayed and suspension bridge but mainly cable stayed bridge developed in 1595 and commonly used in 19th century. In early days, Cable Bridge was constructed with combination of suspension bridge and cable stayed bridge. In 1808 an American inventor named James give the born of modern cable bridge. Two cables are used over the top of many towers and anchoring this chain on the either side of bridge structure. He hung lesser chain in another side and used them to fixed with a rigid deck and this was the form of modern cable stayed bridge and suspension bridge.

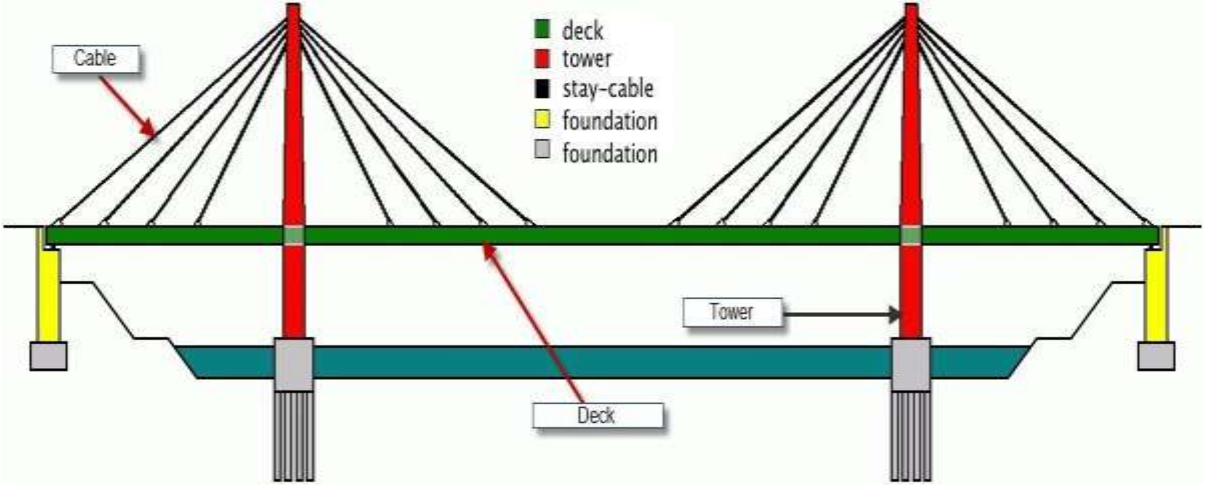

Fig.1 Component of Cable Stayed Bridge

Suspension bridges and cable stayed bridge are much similar but basic difference between both is in suspension bridge deck force transfer to the cable with help of suspender attached with cable and deck but in cable stayed bridge cable is directly connected with deck. Cable stayed bridges become popular due to light weight, better aesthetic view and long span design. The main function of cable stayed bridge to safely supported self-weight, upcoming traffic loads and also looks aesthetically pleasing, demonstrated satisfactory serviceability performance under the all possible combination of load. A Cable stayed bridge deck is suspended with the help of steel wire cable. These cables are fixed with the top vertical towers, cables transfer shear force to the vertical member and these vertical members convert this shear force into compression force.

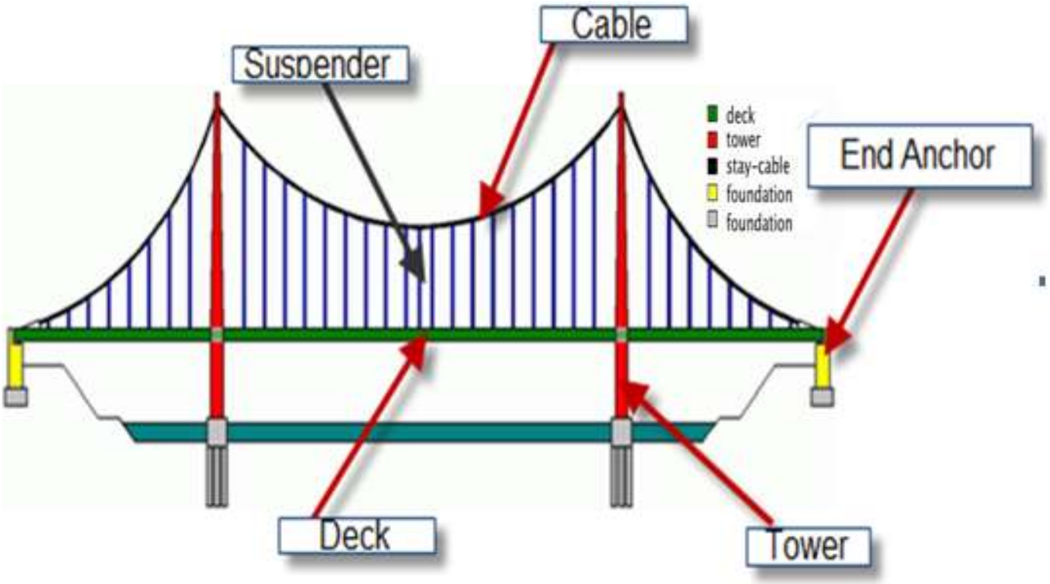

Fig.2 Component of Suspension bridge

This compression force is transfer to the bottom strata of soil. This is load flow mechanism of a Cable stayed bridge. Cable stayed bridge is so simple and straight forward that give the advantage of design of long span with safety. In preliminary design stage of a Cable stayed bridge, it is necessary to see that structure should be safe, economical and serviceable during the whole life span. In design of a Cable stayed bridge live load and deflection should be acceptable in limit and have sufficient stiffness.

II. LITERATURE REVIEW

Following are some important literatures which are reviewed for the investigation:

1. **Mathews et al (2021) [1]** Due to their structural efficiency, cost, and aesthetics, cable-stayed bridges are one of the most fascinating icons in the field of engineering and are commonly used bridge typologies for spans ranging from 200m to 1100mm. A cable-stayed bridge's basic structural form is a series of overlapping triangles made up of the pylon, cables, and girder. The H-shaped twin tower pylon was chosen for a two plane cable system with semi-fan pattern because it combines the benefits of harp (aesthetics) and fan (efficiency) patterns while eliminating their drawbacks. The cable angle was discovered to be between 25° and 61°, with a cable spacing of 10m, which is ideal for concrete deck and cast-in-place balanced cantilever construction.
2. **Mohammed et al (2017)** Because of their vast spans and complexity of structures, there is an increasing interest in monitoring the dynamic behaviour of cable stayed bridges. These bridges were designed as a long-term structural health monitoring tool since their performance is constantly challenged by a variety of traffic loads. The goal of this study is to propose sensor location under a dead load situation. Finite element analysis is an effective and accurate method for determining highly stressed grid spots caused by bridge member vibration to a certain extent. The bridge in question is a Penang cable-stayed Harp type bridge. Proposed that the pervious comparative study between the methods of hanger installation by using nonlinear finite element method with the 3d model of cable is complex and time consuming. This paper proposed efficient method that gives the optimal parameter of the installation of hanger in suspension bridge and also give the idea about ideal construction of hanger installation in bridge by using coordinate iteration. This method effectiveness is tested by comparative studies, field test verification and application on real bridge. This method is based on coordinate iteration-based method in specific rob model. This method gives the process to control peak tension in hanger based on linear

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coordinate iteration.

3. **Arora et al (2017)** proposed numerical analysis method for pre-stressing force computation for cable stayed bridge. Algorithm based method is proposed in this analysis that is relevant to time dependent effect. This analysis proposed the possible formulas for computing the pre-stressing force on concrete cable stayed bridge. It is required numerical iteration for eliminated metrical nonlinearities and in proposed method geometrical nonlinearities is conclude for calculation of cable installation force. This analysis also includes construction stage time dependent effect and geometrical nonlinearities for the calculation of cable force and also include the limit state of service like creep, shrinkage etc. for design purpose. This paper also proposed future scope of work that is depended upon optimum design of cable cross-section and pre-stressing force.

III. THEORETICAL ASPECT OF PROPOSED WORK

Details of models

In the present investigation total eight model is prepared, the detail of each model is summarized in the below mentioned Table

UB = Un-bracing, B=Bracing

Table: 1 Summary of models

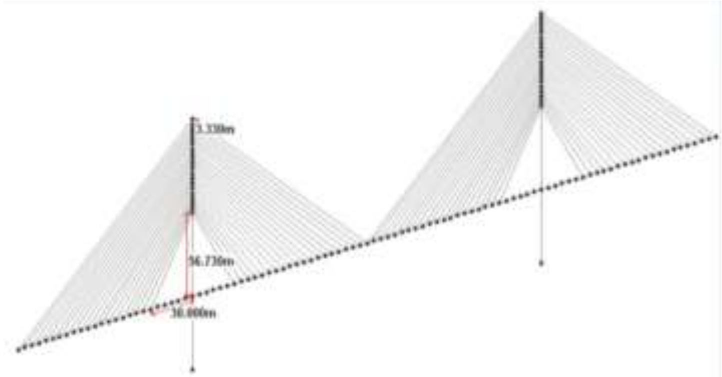
S. No.	Model Name	Bracing	Main span of bridge (meter)	Side span of bridge (meter)	Vertical Node distance (meter)	Vertical distance between each bracing (meter)
1	M1	UB	250	125	3.33	-
2	M2	UB	250	125	3.68	-
3	M3	UB	250	125	4.21	-
4	M4	UB	250	125	4.74	-
5	M5	B	250	125	3.33	6.67
6	M6	B	250	125	3.68	7.37
7	M7	B	250	125	4.21	8.42
8	M8	B	250	125	4.74	9.47

Table: 2 Description of work

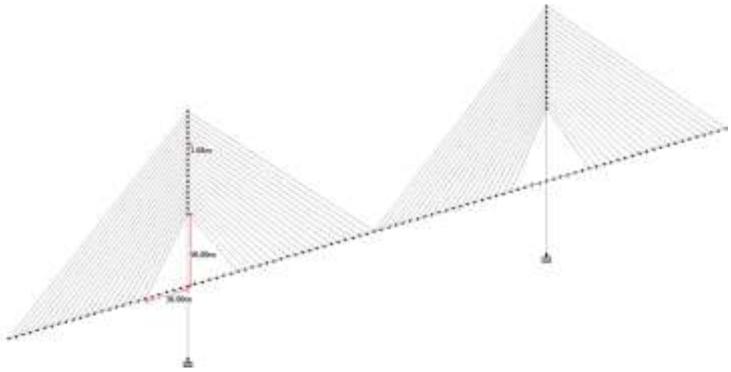
S.No.	Property	Pylon UB	Pylon B
1	HSF (Fx, N)	✓	✓
2	VSF (Fy, N)	✓	✓
3.	HM (Mx, kN-m)	✓	✓
4.	VM (My, kN-m)	✓	✓

IV. STAAD PRO MODELS

M1



M2



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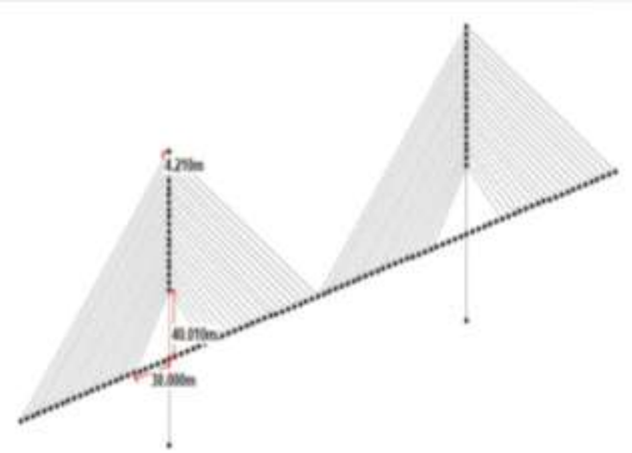
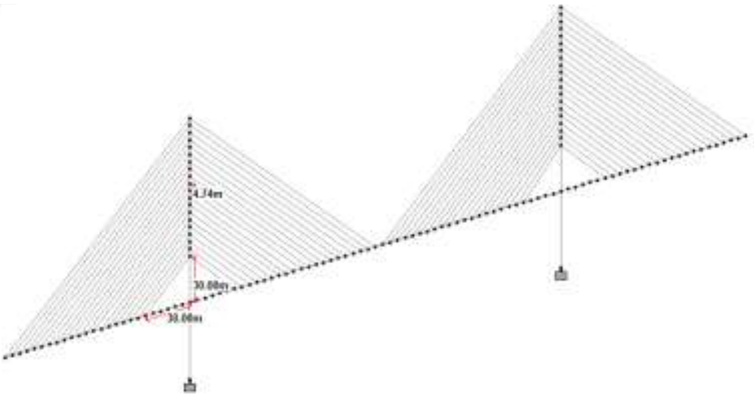
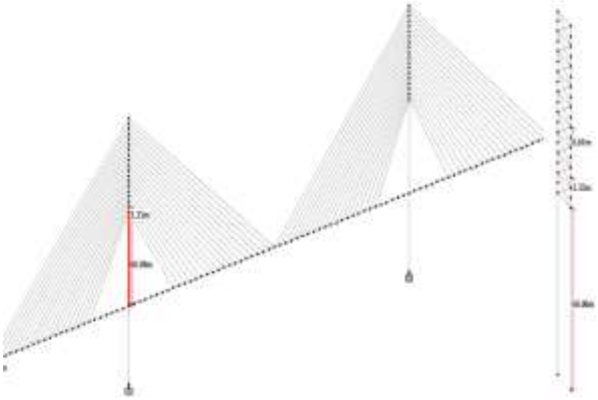
M3



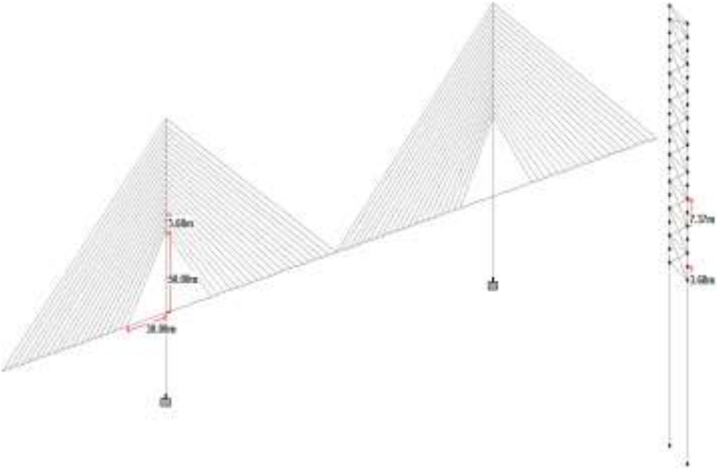
M4



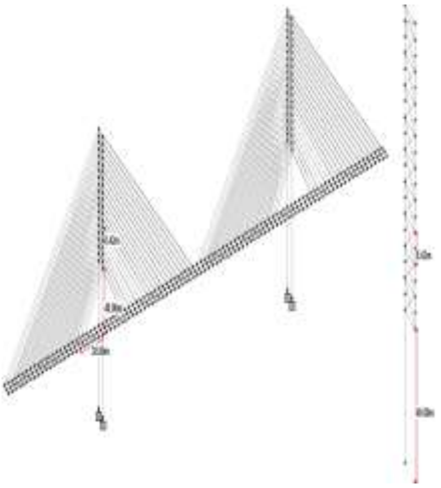
M5



M6



M8



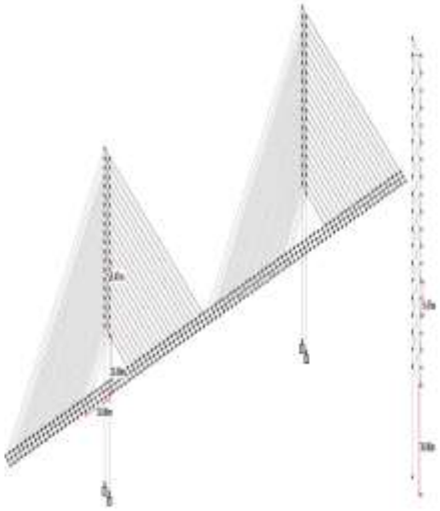


Fig.3 STAAD Pro models [M1 to M8]

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IV. RESULTS AND DISCUSSION

- **Maximum Horizontal Shear Force (Fx) Compression of Unbraced Pylon**

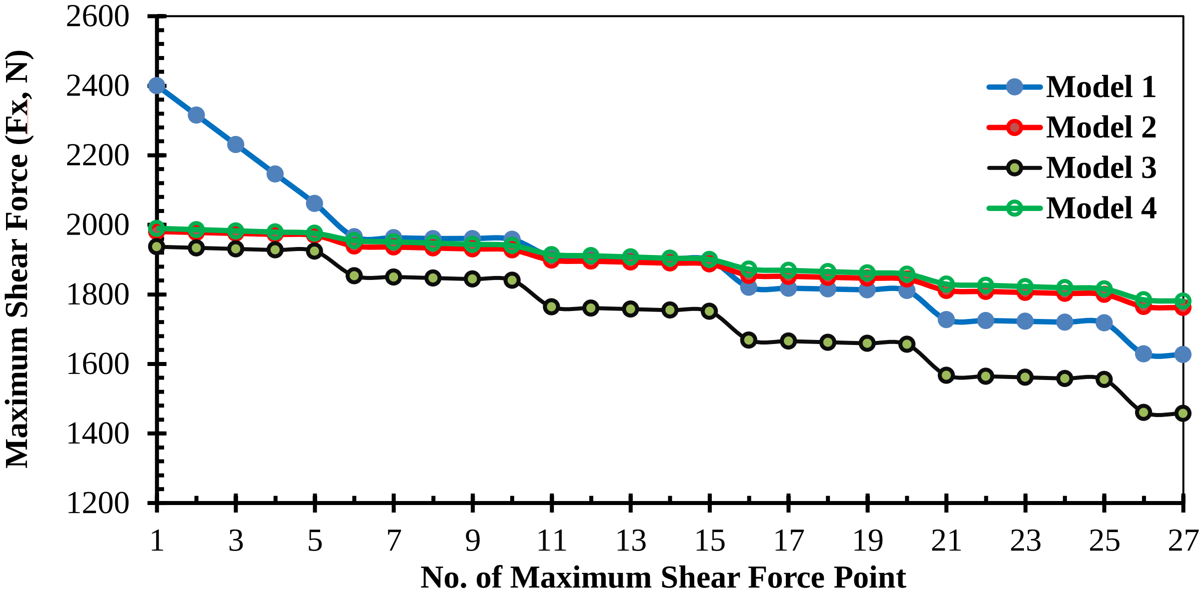

Fig.4 Maximum Horizontal Shear Force Compression of Unbraced Pylon

- **Maximum Vertical Shear Force (Fy) Compression of Unbraced Pylon**

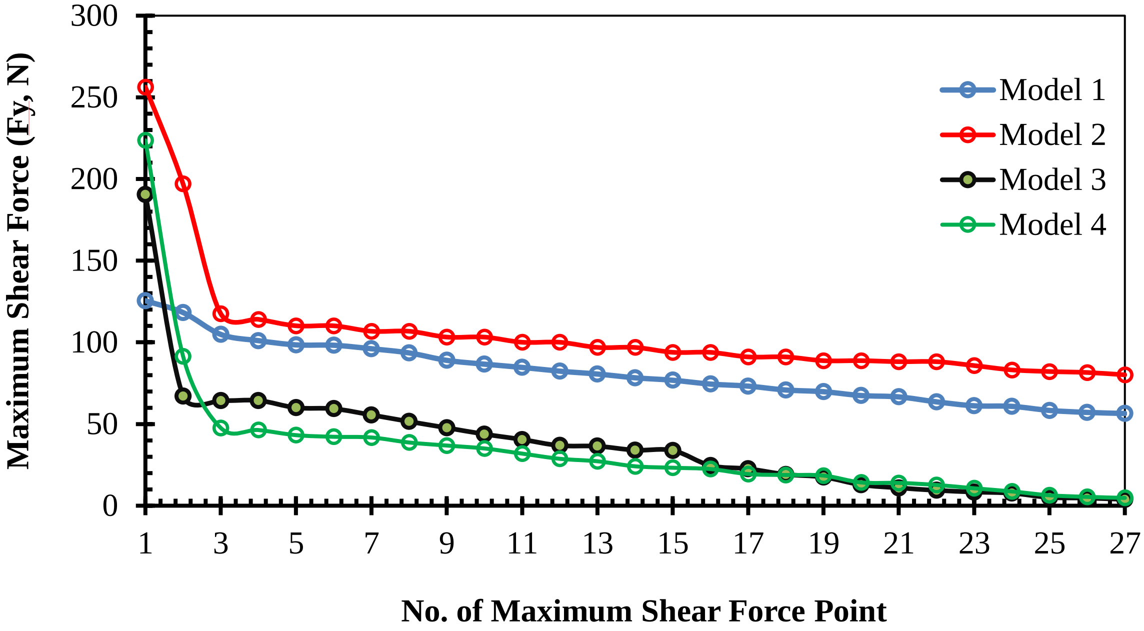

Fig.5 Maximum Vertical Shear Force Compression of Unbraced Pylon

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- **Maximum Horizontal Bending Moment (M_x) of Unbraced Pylon**

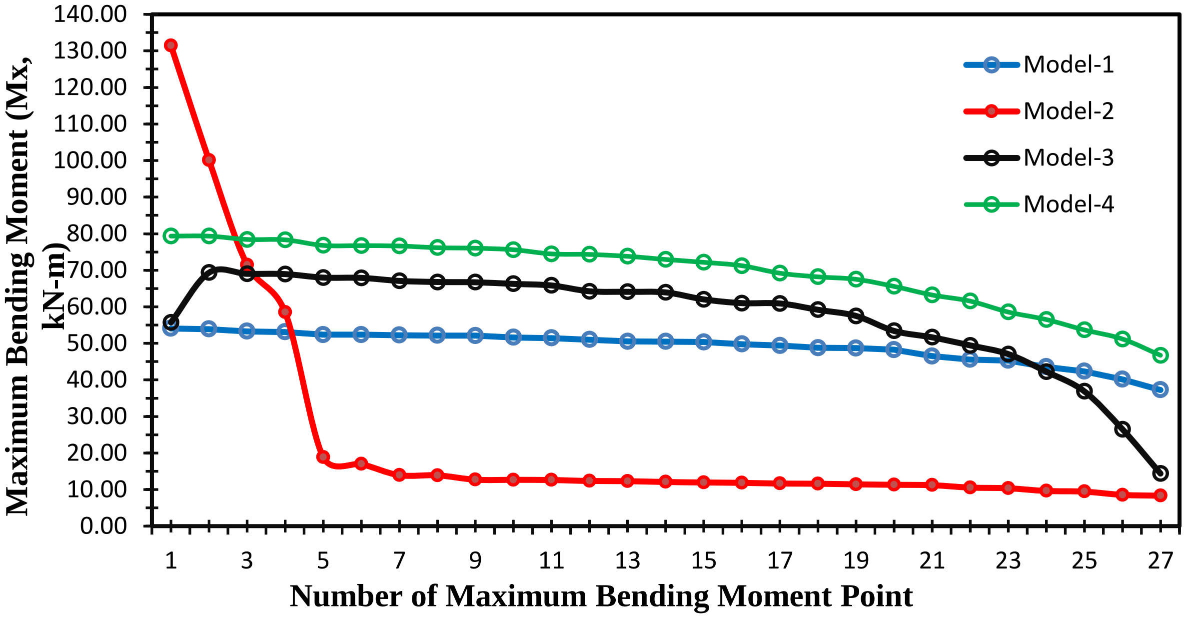

Fig.6 Maximum Horizontal Bending Moment (Mx) of Unbraced Pylon

- **Maximum Vertical Bending Moment (My) of Unbraced Pylon**

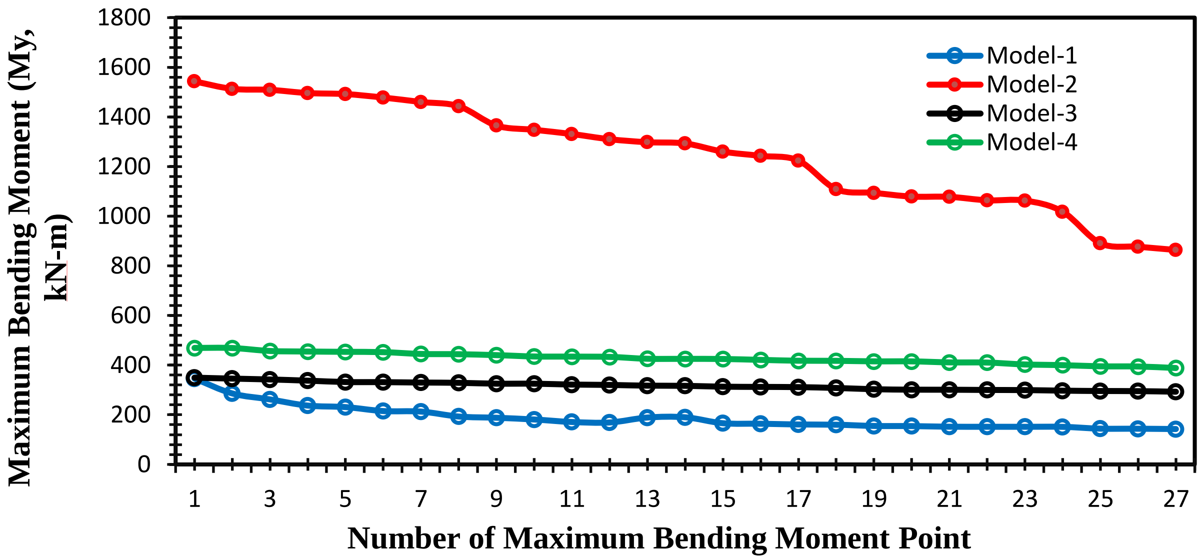

Fig.7 Maximum Vertical Bending Moment (My) of Unbraced Pylon

- **Maximum Horizontal Shear Force (F_x) Compression of Braced Pylon**

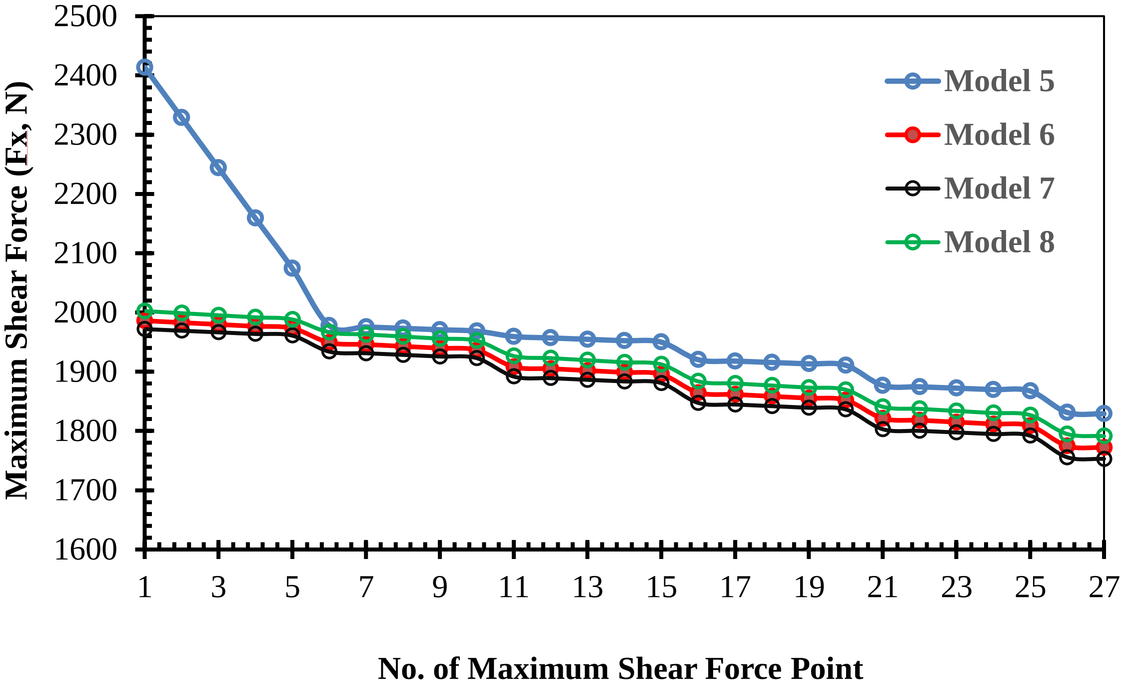

Fig.8 Maximum Horizontal Shear Force Compression of Braced Pylon

- **Maximum Vertical Shear Force (Fy) Compression of Braced Pylon**

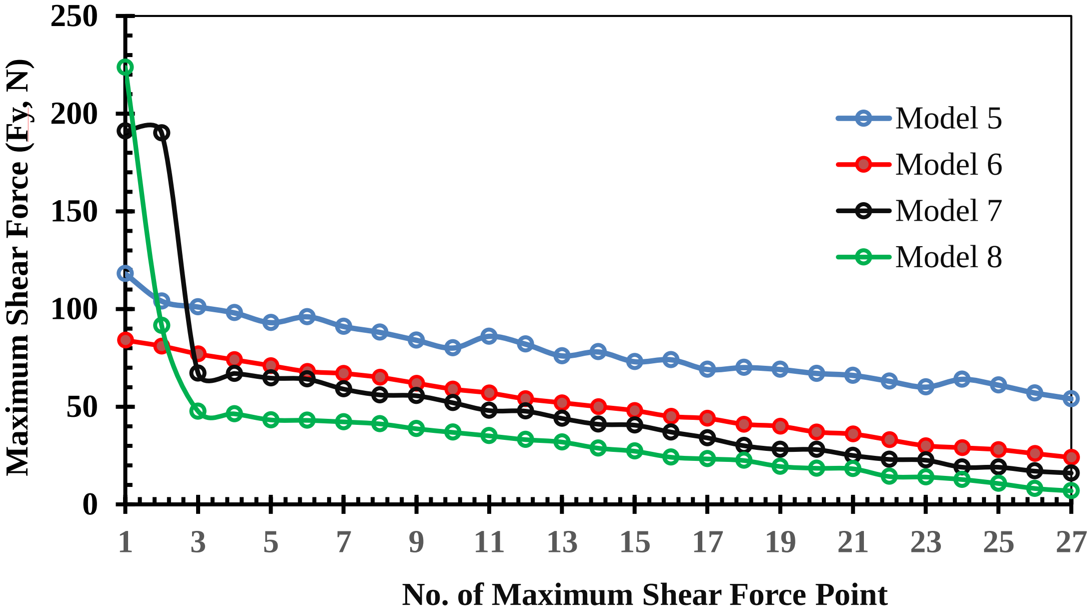

Fig.9 Maximum Vertical Shear Force Compression of Braced Pylon

- **Maximum Horizontal Bending Moment (Mx) of Braced Pylon**

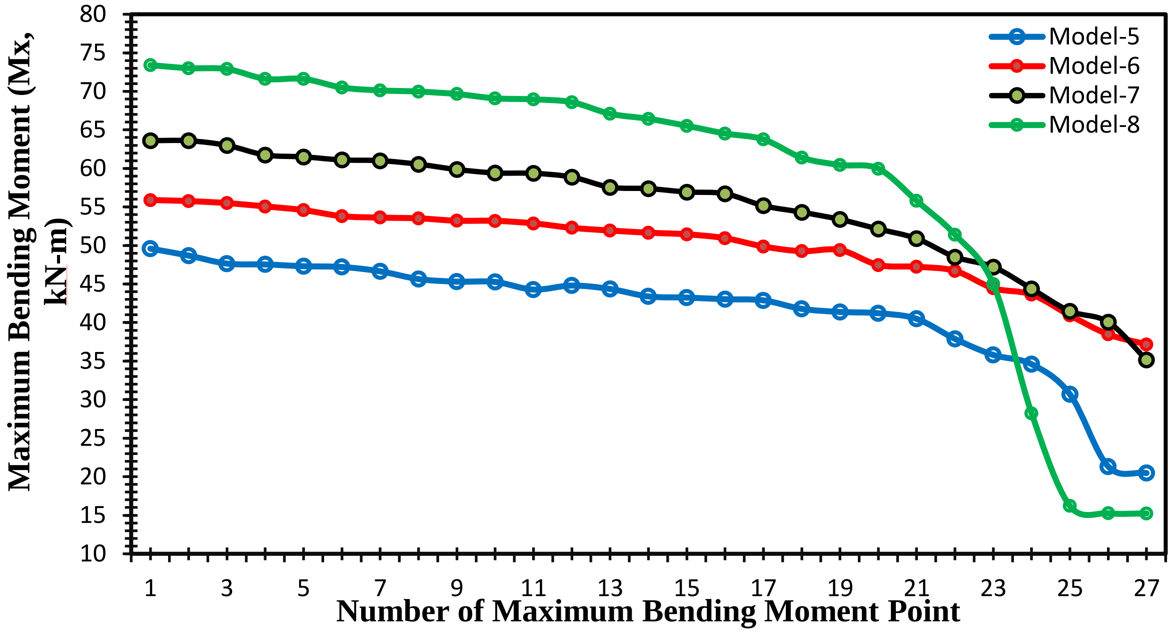

Fig.10 Maximum Horizontal Bending Moment (Mx) of Braced Pylon

- **Maximum Vertical Bending Moment (M_y) of Braced Pylon**

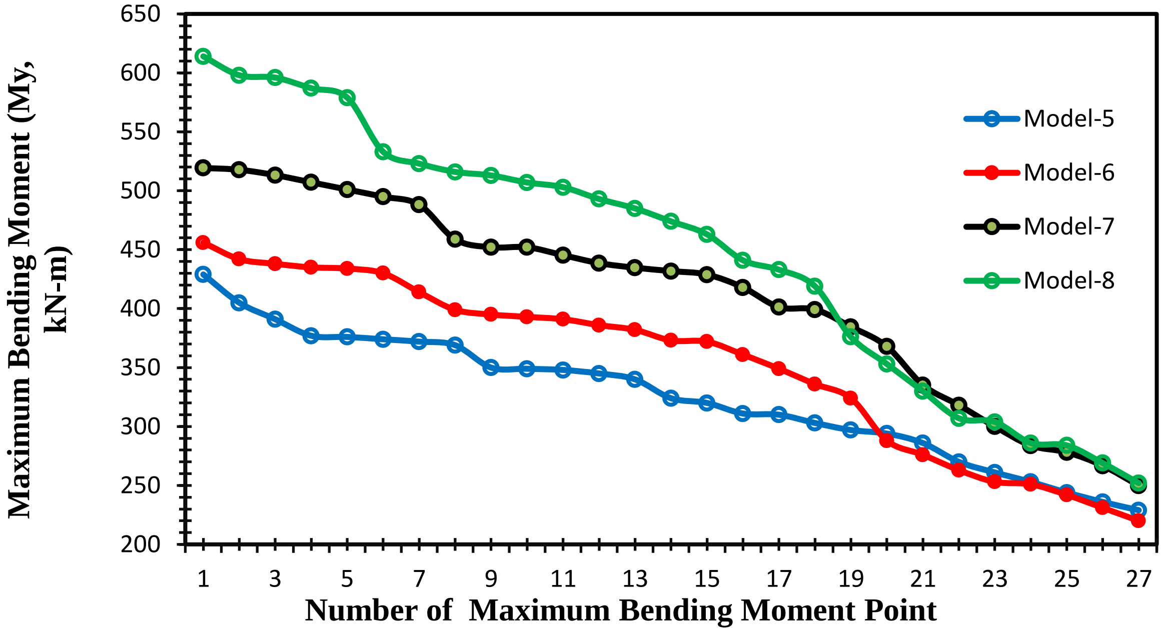

Fig.11 Maximum Vertical Bending Moment (My) of Braced Pylon

- **Comparison on shear force and bending moment of all models**

(i) Maximum Horizontal Shear Force

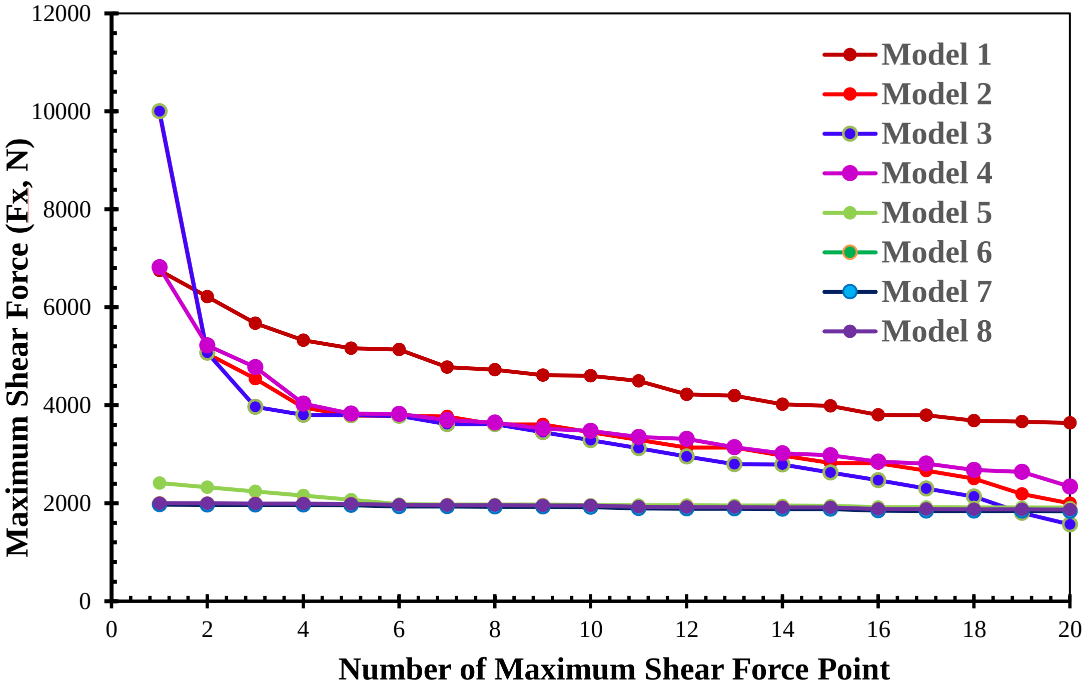

Fig. 12 Maximum Horizontal Shear Force (Fx) Compression of Pylon (M1 to M8)

(ii) Maximum Horizontal Bending Moment

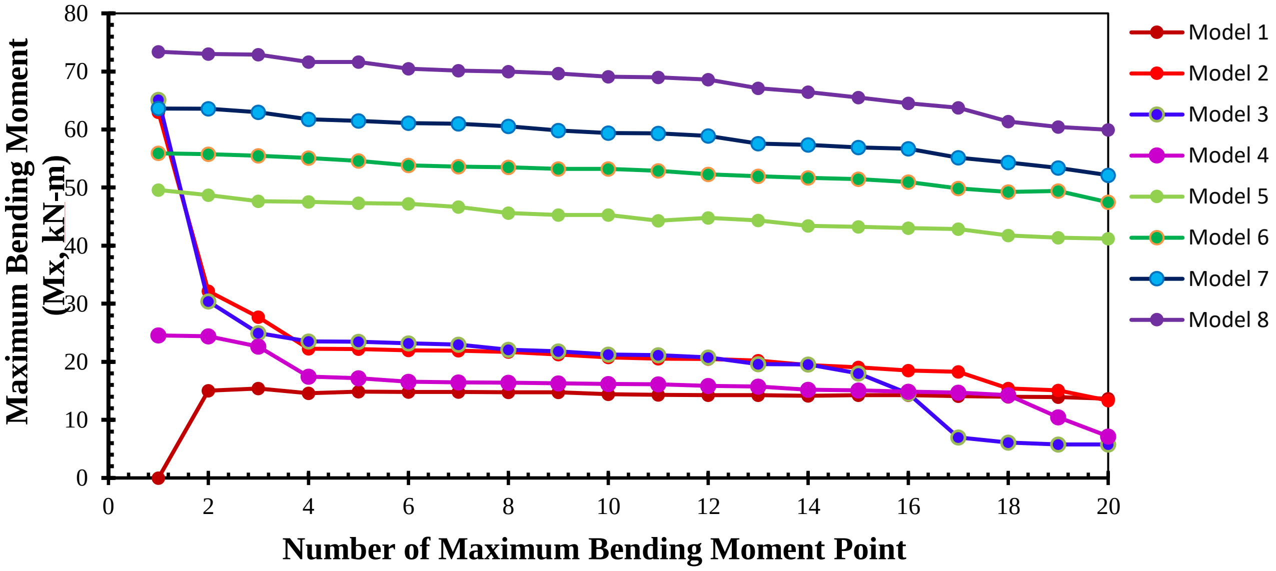

Fig.13 Maximum Horizontal Bending moment (Mx) of Pylon (M1 to M8)

V. CONCLUSION

- It is revealed from the results that model M3 gives the minimum shear force and bending moment. So, it can be considered as an optimum arrangement based on the above criteria. However, Model M4 gives the linear distribution of shear force and bending moment, can be taken as effective arrangement.
- The comparison of bracing model with unbracing model reveled that bracing are not so much efficient in the reduction of shear force and bending moment of cables.
- The number of cables affects the design of cable because if bridge is designed with a greater number of cables, the anchor failure can be managed easily. If bridge is designed for a smaller number of cables, then it is difficult to manage anchor failure.

- For the bracing arrangement, model M5 and model M8 give optimum arrangement based on the bending moment and shear force respectively.
- Model M4 gives best cable arrangement with economical criteria when comparing all eight models because it comes under unbraced condition whereas in braced condition, the net weight of the structure is increased which ultimately made them uneconomical.

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