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Parametric Study of Structural Behavior of Self Anchored Suspension Bridge

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***Abstract*— A self anchored suspension bridge is a type of bridge in which the deck hangs on vertical suspenders called hangers. This hanger is connected to main suspension cable. This cable passes through top of pylon and anchored at the ends of the deck. The largest existing main span for a self anchored suspension bridge is 300 meters. It is well suited in areas where ground anchorage is not possible. The study is done to determine the influence of various components like main cable, hangers, pylons, girders and sag on the structural behavior of self anchored suspension bridge. In order to achieve this goal, a self anchored suspension bridge of 275m span is modeled in SAP 2000. The effect of main cable and hangers is determined by modeling various types of cables and hanger patterns. The pylon and girder influence is determined by changing the dimensions. Effect of sag is determined by modeling suspension bridges with various sag values. The effect of variation is then measured by deflection and bending moment acting on box girder of self anchored suspension bridge. From the above results an optimized self anchored suspension bridge is modeled.**

Keywords*— *Self anchored suspension bridge, girder, pylon, hangers, main cable

I. INTRODUCTION

The concept of self anchored suspension bridge was originated in second half of 19th century. The number of self anchored suspension bridge is very limited as compared with the normal suspension bridge. Konohana bridge in Japan is the longest self anchored suspension bridge. It has a span of 300 meter. The normal suspension bridge can have much longer span as compared with self anchored suspension bridge. The Akashi Kaiko bridge in Japan is the largest suspension bridge. It has a span of 1991 meters.

The erection method of self anchored suspension bridge is complex, while erection is easy in case of normal suspension bridge. This is the main disadvantage of self anchored suspension bridge and the complexity in erection is due to the fact that cables can be erected only after bridge deck is erected. Hence self anchored suspension bridge makes it technically and economically less feasible than other cable bridge types. Most of self anchored suspension bridge are chosen based on aesthetical reason.

Gaining insight about the structural behaviour of self anchored suspension bridge will help to achieve optimum design, which will make the self anchored suspension bridge more competitive, compared with other cable bridges.

II. SELF ANCHORED SUSPENSION BRIDGE

The major components of self anchored suspension bridge are stiffening girder, main cables, hangers, pylon and anchorage. Under the action of loads main cable and hangers will be subjected to tension while pylon and stiffening girder will be subjected to compression.

In case of normal suspension bridge the tensile force from main cable is transferred to the external anchorage. In self anchored suspension bridge the tensile force from main cable is transferred to the bridge deck. As a result deck will be subjected to large compressive force resulting in buckling.

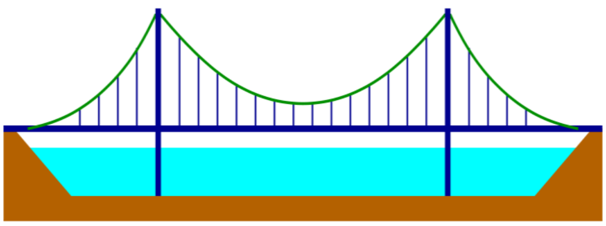

Fig 1: Self anchored suspension bridge

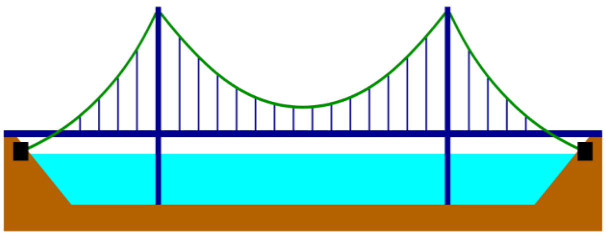

Fig 2**:** Normal suspension bridge

III. OBJECTIVE OF PARAMETER STUDY

By varying the important design parameters within a certain range gives insight in to the structural behaviour of self anchored suspension bridge. This will help to optimize the design of self anchored suspension bridge. The bridge parameters are varied one at a time while others are kept fixed makes comparison possible. In this study comparison is done on the basis of deflection and bending moment in girder and deflection of pylon.

IV. GEOMETRY OF BRIDGE MODELLED IN SAP 2000

TABLE 1: DETAILS OF BRIDGE

1	Main span	150 m
2	Side span	62.5 m
3	Total span	275 m
4	Width	12 m
5	Height of deck above ground level	10 m
6	Deck	Box girder
7	Number of lanes	2

V. COMPONENTS OF BRIDGE MODELLED IN SAP2000

Different components of self anchored suspension bridge like main cable, hangers, girders, and pylon are discussed below.

A. Bridge deck

Bridge deck is modelled as frame section. Box girder type deck is modelled. The cross sectional properties are shown in table.

TABLE 2: DETAILS OF DECK

1	Depth	2.6 m
2	Width	12 m
3	Flange thickness	0.3 m
4	Web thickness	0.4 m

B. Main cable and Hangers

Main cable and hangers are modelled as cable elements. The cross sectional properties are shown in table. Link element is used to connect box girder and hangers.

TABLE 3: DETAILS OF MAIN CABLE

1	Diameter	350 mm
2	Area	96211 mm^2
3	Moment of inertia	7.36 x 10^8 mm^4

TABLE 4: DETAILS OF HANGER

1	Diameter	50 mm
2	Area	1963 mm^2
3	Moment of inertia	306796 mm^4

C. Pylon

Pylon is modelled as frame section.. The cross sectional properties are shown in table.

TABLE 5: DETAILS OF PYLON

1	Depth	2.5 m
2	Width	2.5 m

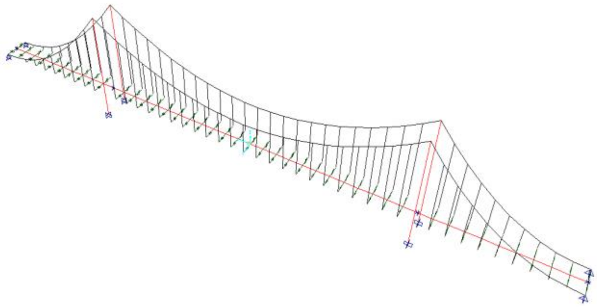

Fig 3: Suspension bridge model

VI. LOAD CASES

Load cases can be divided in to linear and non linear. Nonlinear load case is used when either geometric or material non linearity is considered. Otherwise linear load case is considered.

A. Response spectrum

Earth quake load is assigned by defining response spectrum which is a dynamic linear method.

B. Time history

Moving load is assigned as time history load case by involving direct integration method. Time history analysis is dynamic nonlinear method.

VII. PARAMETRIC STUDY

In this study influence of following bridge parameters are considered.

- Deck bending stiffness.
- Pylon bending stiffness.
- Cable stiffness.
- Hanger pattern.
- Sag of main cable.

Results of parameter study are measured with respect to

- Maximum bending moment in the girder.
- Deflection of girder at mid span.
- Deflection of pylon.

A. Deck bending stiffness

In this part the deck bending stiffness is varied by changing the structural height of box girder. The height of girder is varied from 2 m to 2.9 m. The variation of bending moment and deflection is shown in graph.

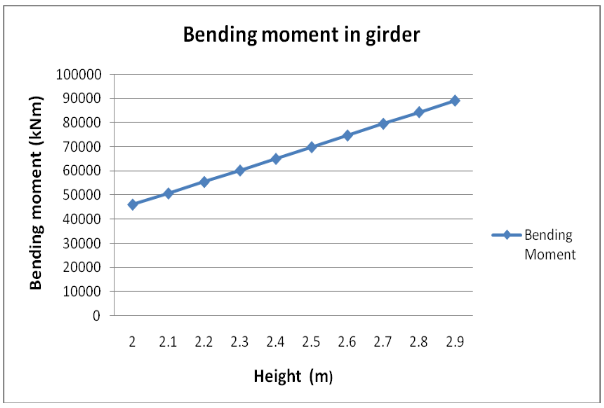

Fig 4: comparison of bending moment and height of girder.

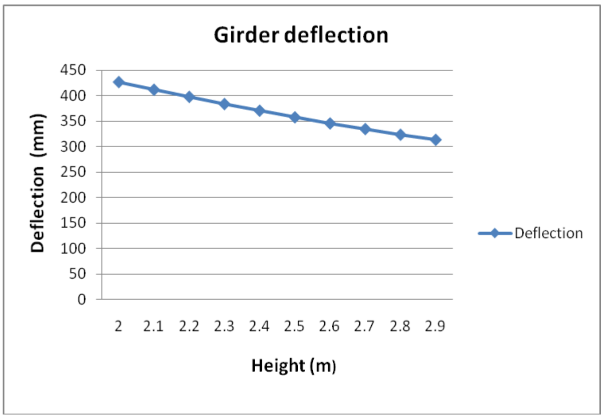

Fig 5: comparison of girder deflection and height of girder.

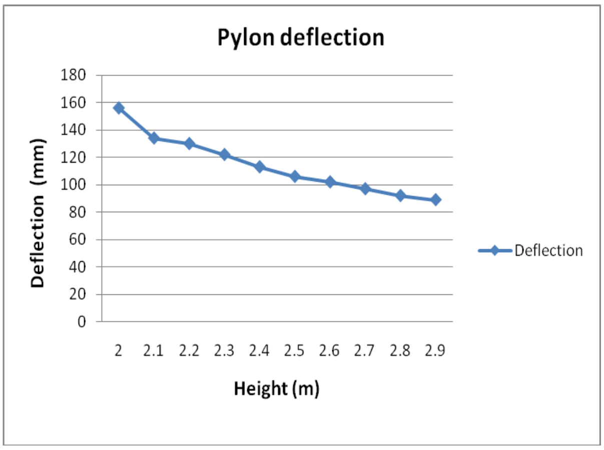

Fig 6: comparison of pylon deflection and height of girder.

B. Pylon bending stiffness

In this part the influence of the bending stiffness of pylon in longitudinal direction of the bridge is checked. The bending stiffness of pylon is varied by increasing the cross sectional area of pylon. The variation of bending moment and deflection is shown in graph.

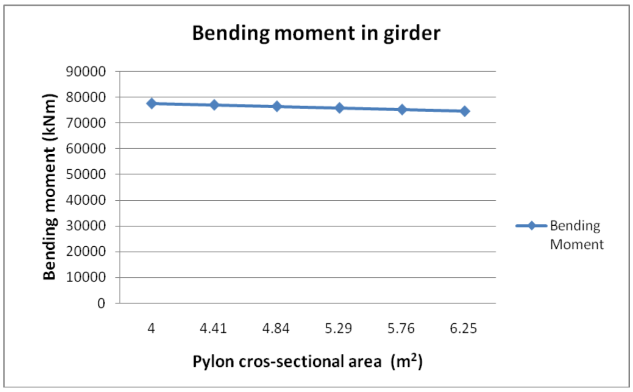

Fig 7: comparison of bending moment and area of pylon.

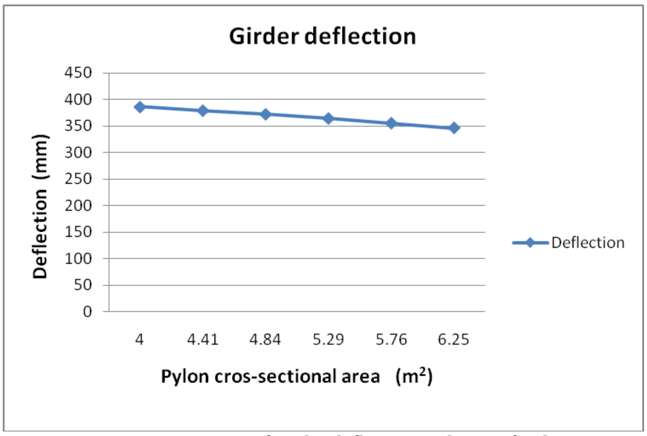

Fig 8: comparison of girder deflection and area of pylon.

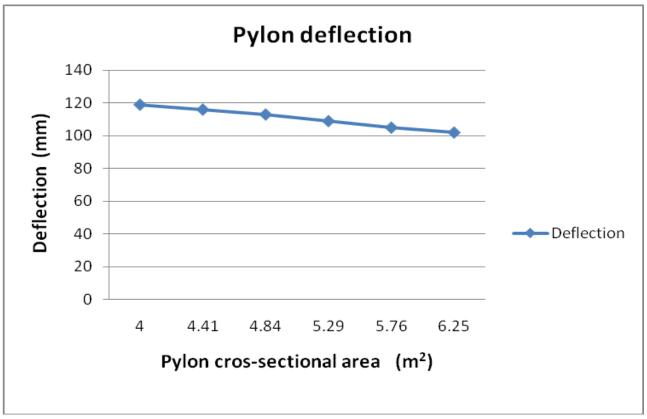

Fig 9: comparison of pylon deflection and area of pylon.

C. Cable stiffness

The influence of cable stiffness (EA) is found out by varying modulus of elasticity and cross sectional area. The modulus of elasticity changes with type of cable used. Four cable types are used in cable supported bridges:

- Parallel wires E = 205000 N/mm^2
- Parallel strands E = 190000 N/mm^2
- Full locked coil E = 150000 N/mm^2
- Cable spiral strand E = 140000 N/mm^2

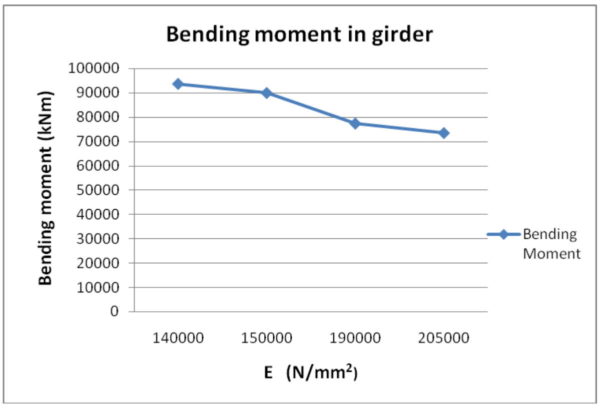

Fig 10: comparison of bending moment in girder and modulus of elasticity

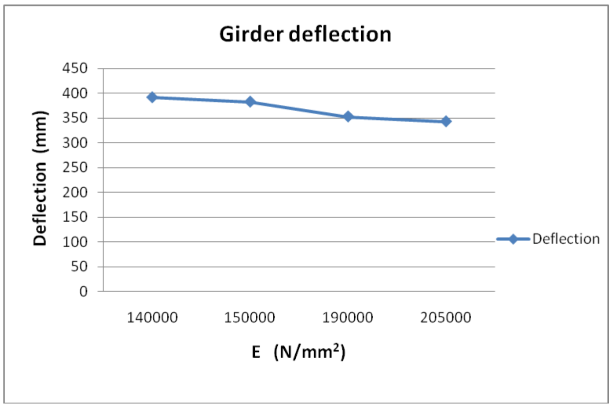

Fig 11: comparison of girder deflection and modulus of elasticity

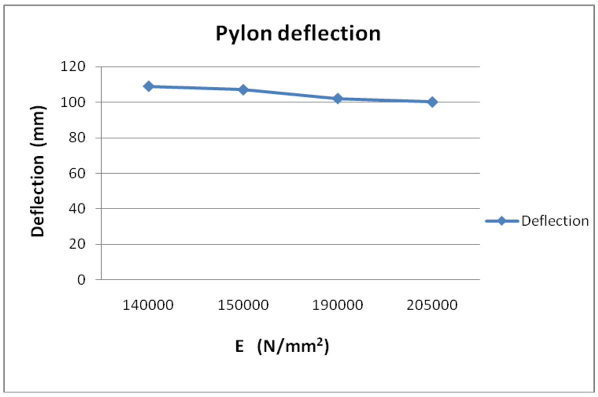

Fig 12: comparison of pylon deflection and modulus of elasticity

The diameter of main cable is varied from 300mm to 390mm. The variation in bending moment and deflection is shown below.

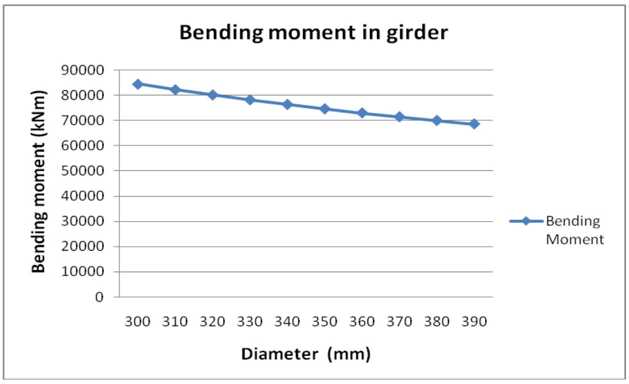

Fig 13: comparison of bending moment in girder and diameter of main cable.

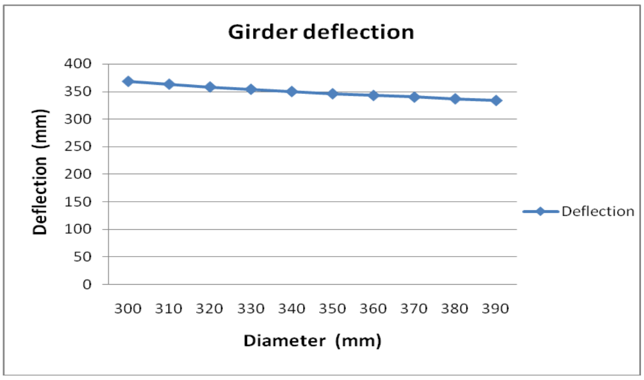

Fig 14: comparison of girder deflection and diameter of main cable.

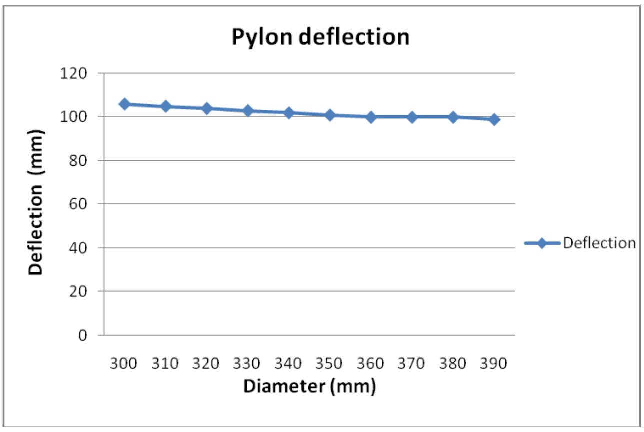

Fig 15: comparison of pylon deflection and diameter of main cable.

D. Hanger pattern

The two types of hanger patterns are straight and inclined. The comparison of two patterns is made with respect to deflection and bending moment in girder.

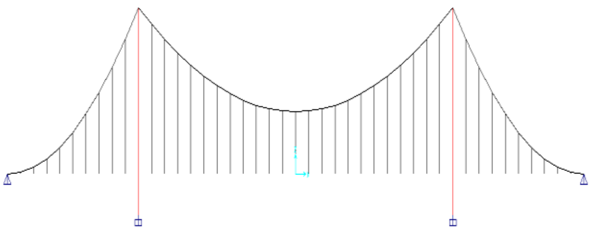

Fig 16**:** self anchored suspension bridge with straight hangers

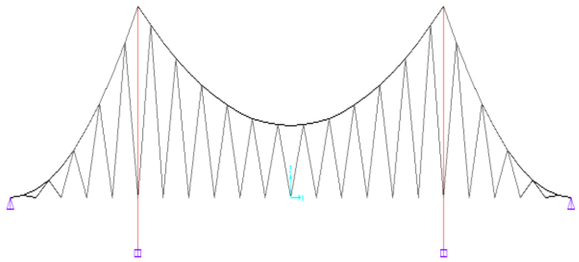

Fig 17: self anchored suspension bridge with inclined hangers

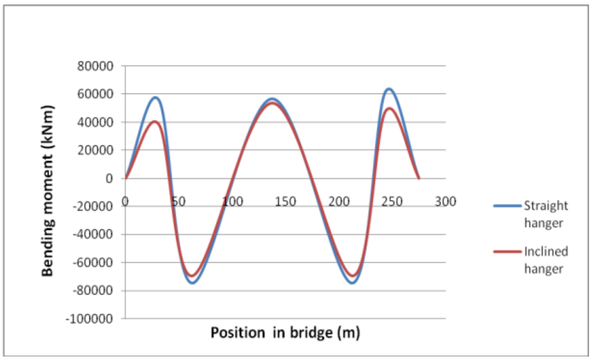

Fig 18: variation of girder bending moment along bridge deck

Fig 19: Maximum deflection of girder

E. Sag of main cable

The influence of sag is determined by modelling self anchored suspension bridges with various main cable sag values. The influence of sag is determined by comparing the bending moment and deflection in girder.

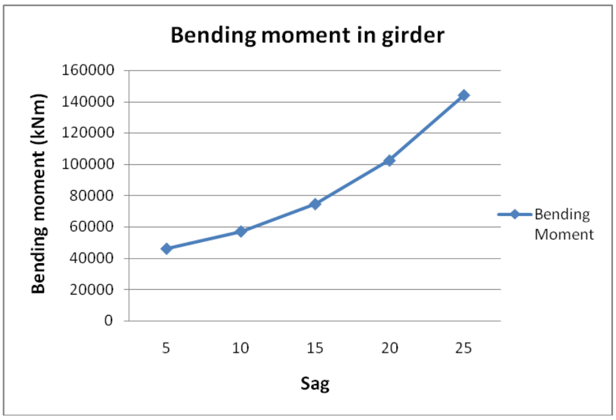

Fig 20: variation of girder bending moment with sag of main cable

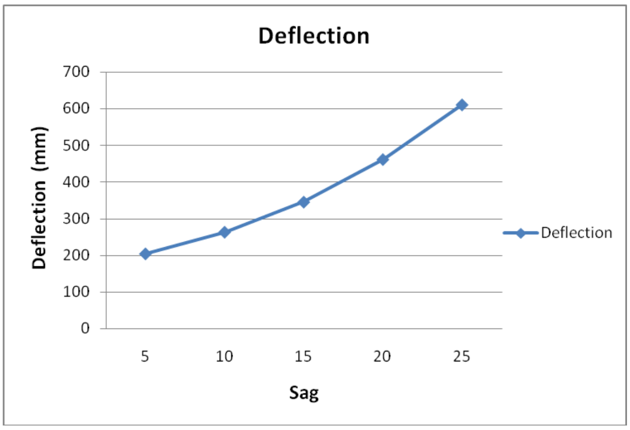

Fig 21: variation of girder deflection with sag of main cable

VIII. OPTIMIZED MODEL

From the parameter study an optimized model is made. The following are the selected parameter for optimized model:

- Height of girder = 2.0 m
- Pylon cross sectional area = 6.25 m^2
- Main cable modulus of elasticity = 205000 N/mm^2
- Main cable diameter = 370 mm
- Hanger pattern - straight
- Sag of main cable = 10 m

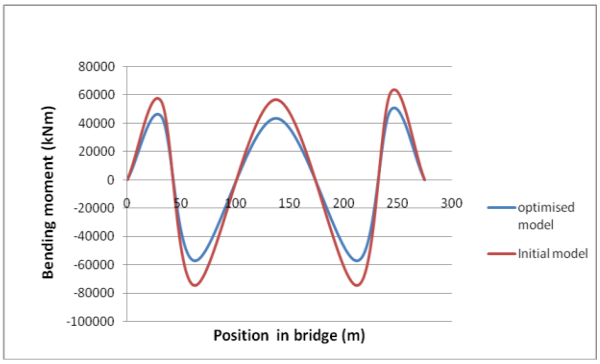

Fig 22: variation of bending moment along girder for optimized and initial models

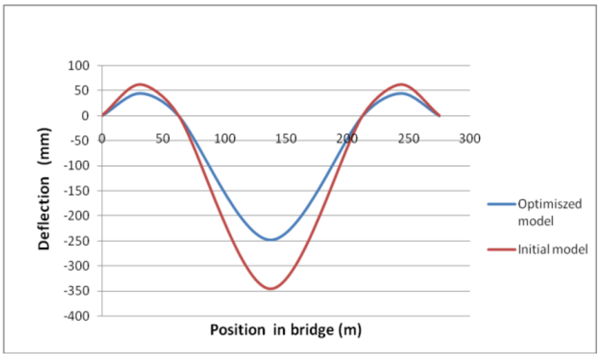

Fig 23**:** variation of deflection in girder for optimized and Initial models

IX. CONCLUSION

From the above parameter study the following conclusions are made:

1. Influence of deck bending stiffness

As the bending stiffness of deck decreases bending moment acting on girder also decreases by 50%. This is due to the fact that large part of total bending moment is carried by the girder and a small part is carried by main cable. Increase in the stiffness of deck also reduce girder and pylon deflection by 26%.

2. Influence of pylon bending stiffness

The influence of pylon bending stiffness doesnot have much influence on girder bending moment and deflection of pylon and girder.

3. Cable stiffness

With increase in axial stiffness (EA) of main cable the bending moment in girder decreases about 20% and deflection in girder decreases about 10%. This is due to the fact that with increase in axial stiffness of main cable carries a part of total bending moment.

4. Hanger pattern

Self anchored suspension bridge with inclined hangers have slightly more global stiffness as compared with Self anchored suspension bridge with straight hanger pattern.
But inclined hanger pattern are rarely adopted because of erection problem and fatigue in hanger.

5. Sag of main cable

As sag of main cable decreases the deflection of girder decreases about 40% and bendind moment in girder decrease about 44%.

REFERENCES

[1] Ghanshyam M. Savaliya., Dr. Atul K. Desai., Dr. Sandip A Vasanwala. (2013) “Analysis Of Differently Configured Cable Supported Bridges And Its Validation” *International Journal of Current Engineering and Technology,* Vol. 2 Issue 7

[2] Alvaro Aduna., Joni Lähde.,. (2012) “Suspension Bridges” *International Journal of Current Engineering and Technology,*

[3] Wenliang Qiu, Meng Jiang, Zhe Zhang (2009) “Research on Limit Span of Self-Anchored Suspension Bridge” *Computational Structural Engineering.*

[4] Buckland, G., (2003) “Increasing the load capacity of suspension bridges” *Journal of Bridge Engineering.*

[5] Majid Barghian1, Hadi Moghadasi Faridani2. (2011) “Proposing a New Model of Hangers in Pedestrian Suspension Bridges to Solve Hangers Slackness Problem” *Scientific research*.