Design And Analysis of Suspension Bridges

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Abstract - Suspension Bridges are one of the most iconic and elegant structures in civil engineering and used for larger spans. The main purpose of this report is to understand the basic concept of suspension bridge and Dynamic Time History Analysis [Dynamic Analysis] for different models of suspension bridge. The analysis of suspension bridge is carried out by SAP2000 Software. In this study, we have considered eight different models of different Aspect ratio with different types of Hangers and analyzed them in SAP2000 Software. From the work carried by SAP2000 the Modal Analysis results it was observed that, the time period (Sec) is higher for suspension bridges with vertical hangers compared to inclined hangers.

Key Words - SAP 2000 Software, Suspension Bridge, Inclined Hangers, Vertical Hangers

I. INTRODUCTION

Bridges is a structure built to hold the roadway, railway or path etc. across a road, valley or other obstacles. There are many types of bridge designs that every serve a specific cause subjecting to the exclusive situations. Consequently, for longer span purpose, suspension and cable stayed bridges are very much appropriate. A suspension bridge is a sort of bridge which has cables (suspension cables) running among two pylons and from them a chain of vertical hangers (suspender cables) that hold the deck. In their best form suspension bridges had been more often than not crafted from timber and rope. But contemporary suspension bridges are made from a box section roadway carried by high tensile strength cables. The distinction between suspension bridge and cable stayed bridge is that, in suspension bridge the cables supporting the deck are suspended vertically from main cables where as in cable stayed, deck assisting cables are connected directly from towers. Suspension bridges is most expensive to build, but this type is most appropriate for very long span bridges. And represents more than 20 longest span bridges in the world. As these are long and flexible structures most exposed to dynamic loading. The vibration analysis become very significant in predicting the behaviour of bridge under various dynamic loads such as wind load, vehicular load and Earthquake load. Suspension bridges can span distances from 2000ft to 7000ft longest than any other type of bridges. The world's longest suspension bridge is Akashi-kaikyo Bridge in Japan, having main span of 1991m. It has 6 lanes with a complete length of 3911m. And the smallest suspension bridge is Wiggly Bridge in York, England.

II. METHODOLOGY

1. Description of Bridge

The present analysis is carried out for Suspension Bridge with different center span to height ratio namely 150 meters to 60 meters height and 150 meters to 40 meters height The width of Deck is 10m with 2 lanes. The vertical and inclined hanger arrangements are used for the analysis. And pylons with truss and portal shapes are modelled. The results obtained from the bridge models after the analysis are tabulated and compared using graphs. The whole procedure is carried out using SAP 2000 Bridge Software.

2. Properties of Structural Members

Material properties

Thickness of Deck slab – 200 mm
Density of Concrete – 25 kN/m^3
Density of Steel – 78.5 kN/m^3
Grade of Steel – Fe345
Reinforcing Steel – Fe550
Grade of concrete – M60
Cables Diameter – 0.5 m

Structural Members Dimensions

Cross Section of Beams – 1m × 1m
Cross section of Pylon (top) – 2m × 1m
Cross section of Pylon (bottom) – 2m × 1m
Distance between the hangers – 10 m
Bridge Deck – 10 m with 2 lanes

3. Loads Considered in Design

As per Indian Road Congress the following loads are considered in analysis and design

Table 1. Primary Load Cases

Load Case No.	Load cases
1	Dead Load
2	Live Load (Class 70R)
3	Super Imposed Dead Load
4	Seismic Load for Zone 2

Gravity loads are considered as per IRC IRC6-2000 and seismic loads are considered as per IS 1893-2016.

4. Suspension Bridge Models in SAP 2000 Software

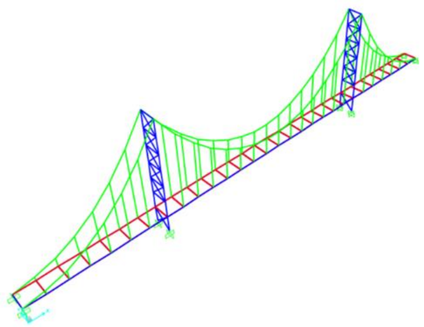

Fig.1 3D View of Suspension Bridge with vertical Hangers with braced pylons

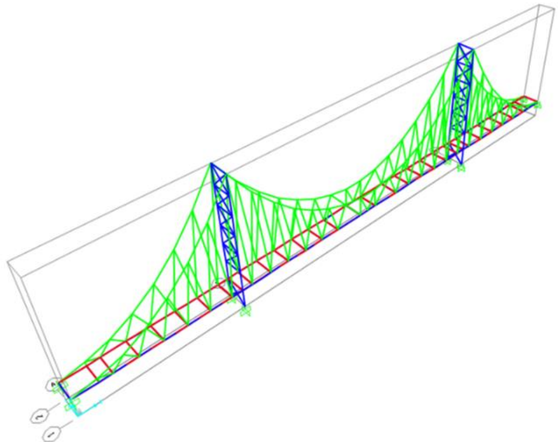

Fig.2 3D View of Suspension Bridge with Inclined Hangers with braced pylons

III. RESULTS AND DISCUSSIONS

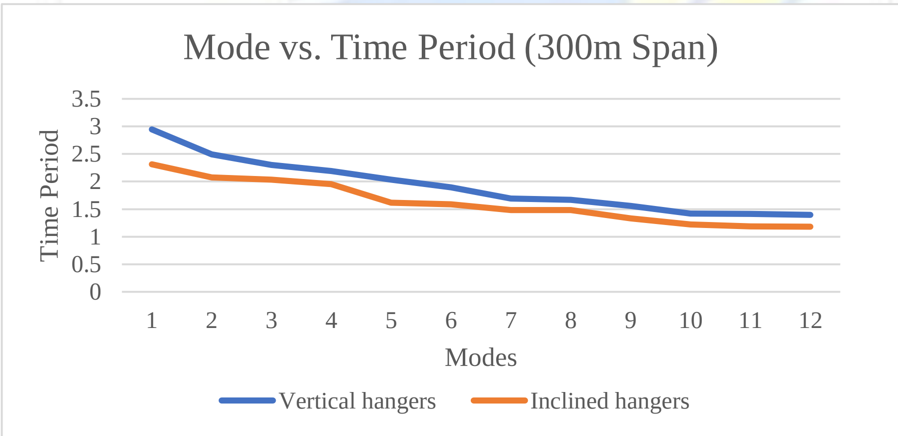

Fig.3 Mode vs. Period (300m) Unbraced 40m

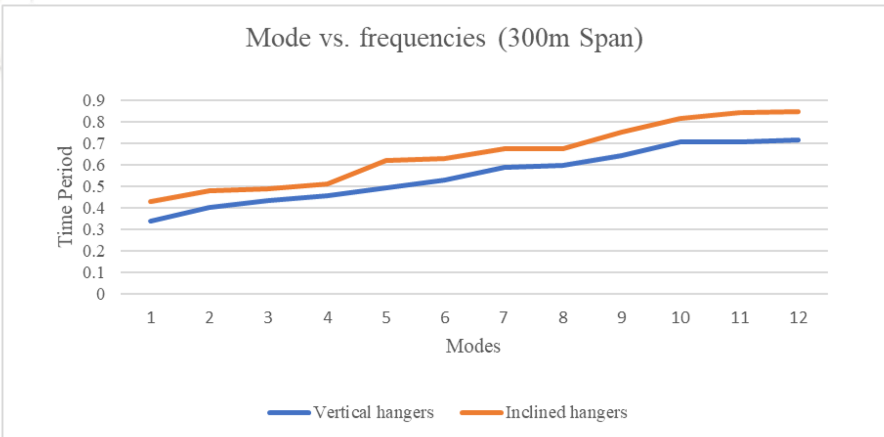

Fig.4 Mode vs. frequencies (300m) Unbraced 40m

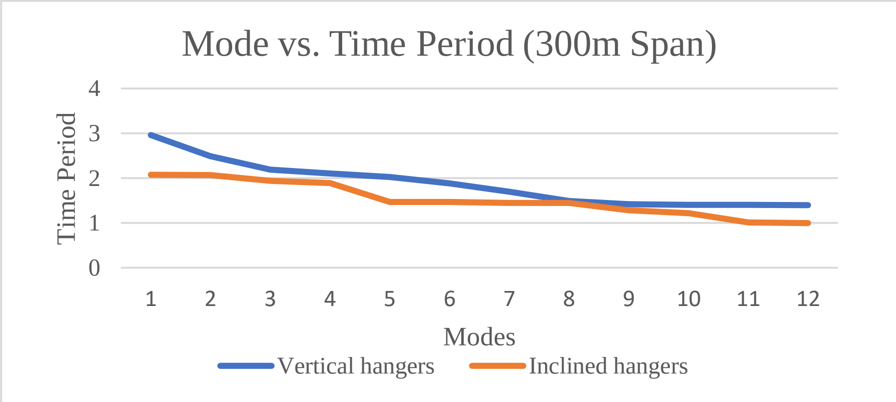

Fig.5 Mode vs. Period (300m) Braced 40 m

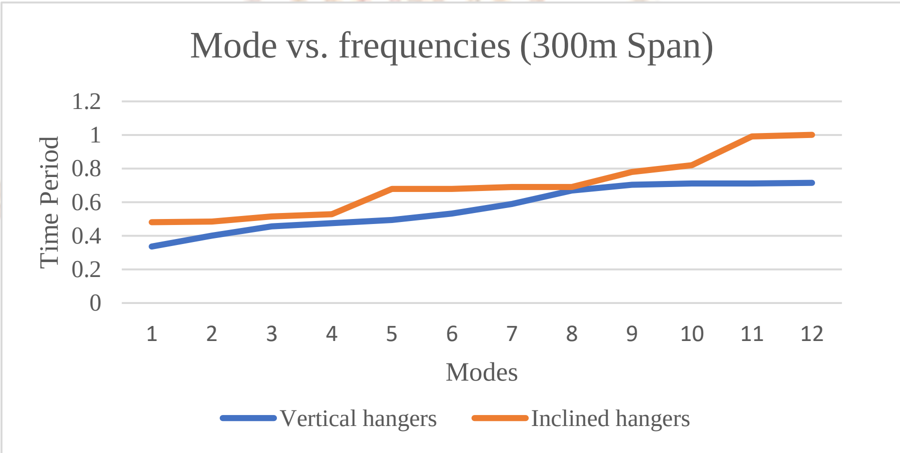

Fig.6 Mode vs. frequencies (300m) Braced 40 m

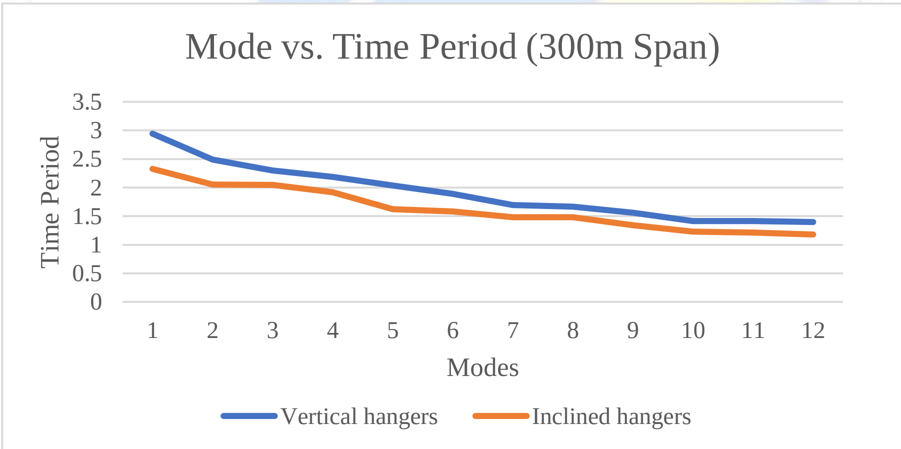

Fig.7 Mode vs. Period (300m) Unbraced 60 m

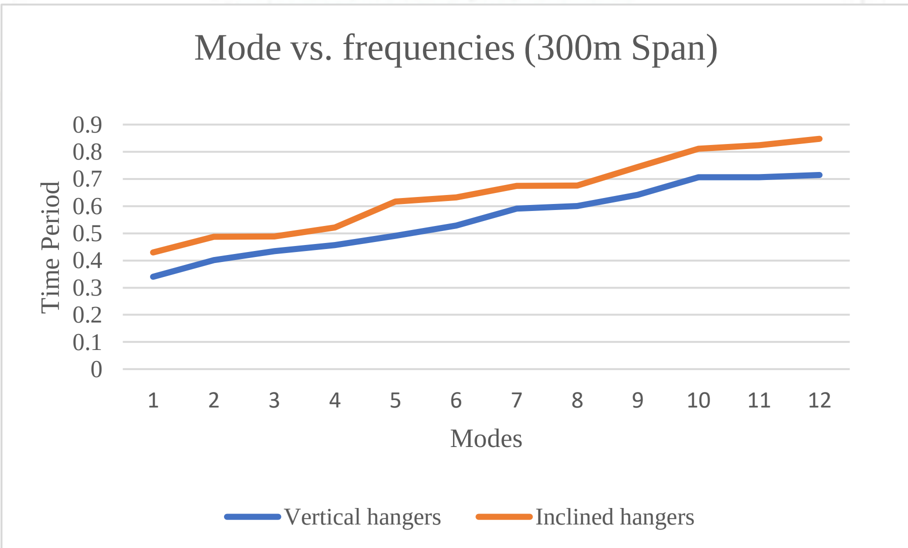

Fig.8 Mode vs. frequencies (300m) Unbraced 60m

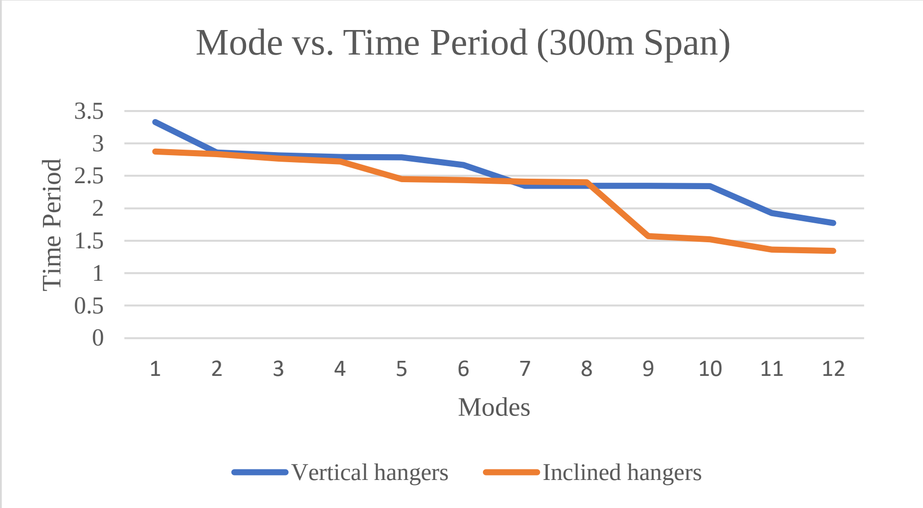

Fig.9 Mode vs. Period (300m) Braced 60 m

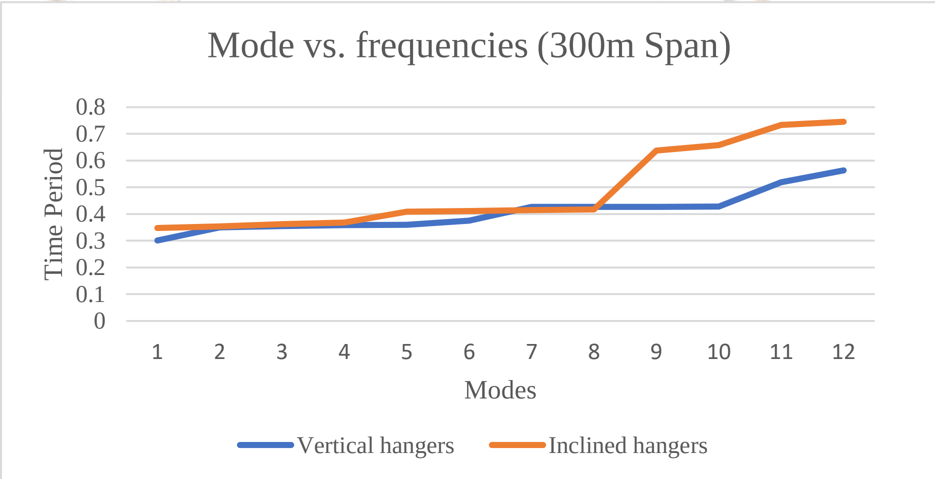

Fig.10 Mode vs. Frequencies (300m) braced 60 m

To comprehend the Suspension Bridge's vibrational properties, modal analysis has been done. Graphs are used to compare and clarify the data that were collected. The Time Period and Frequency responses for Suspension Bridge with vertical and inclined hanger designs for 300m spans are shown above. As seen in the figure above the time period is higher in vertical hangers than inclined hangers. For both types of hanger setups, frequency rises steadily.

IV. CONCLUSIONS

From the Modal Analysis results it can be shown that, the time period (Sec) is higher for suspension bridges with vertical hangers compared to inclined hangers. Hence vertical hangers can be recommended in area where time period of structure is needed to kept higher to avoid resonance and it is recommended that, for a large span suspension bridge, utilizing inclined hangers and a braced pylon can lead to improved performance and better overall results.

V. REFERENCES

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