PARAMETRIC COMPARISON OF SUSPENSION BRIDGE AND CABEL-STAYED BRIDGE

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Abstract
The paper presents dead load analysis of Suspension Bridge and Cable-Stayed Bridge by keeping the parameters such as Main Span, Side Span, Pylon Height, Bridge deck and material properties same. By analysis the optimum sag for suspension bridge at which minimum value of deflection is obtained. Then Suspension bridge is modeled with the optimum sag value and the diameters of main cables are changed and resulted deflection of bridge deck is noted. The diameter for which minimum value of deck deflection is obtained gives the optimum value. The quantity of steel for the resulted optimum sag and optimum diameter is noted. Similar process of changing diameter of cable of Cable-Stayed Bridge is done and optimum diameter is noted. The bridges are modeled in CSI-Bridge Software. The result shows that cable stayed bridge of same length when compared to Suspension bridge uses less steel and also resulting deflection is less.

Keywords: *Suspension Bridge, Cable-Stayed Bridge, Sag, CSI-Bridge Software.*

INTRODUCTION

In recent time the requirement of long span bridges has increased considerably. With the introduction of cable supported bridges in modern-day bridge engineering to overcome such long spans. With the implementation of cable-supported bridges the span in the range of 200m to 2,000 m (and beyond) are covered, which covers 90% of present span range[1].

Cable-supproted bridges are devided in to two types: Cable-Stayed and Suspension bridges. Altough both are cable supported bridges they are diffrentiated by their structural configuration and geometry. Cable-Stayed bridges are superior to classical Suspenison bridges in terms economy, aesthetic behaviour and aerodnamically for the spans range 700-1500m [2][3].

In this paper by performing dead load analyis of Suspenison Bridge and Cable-Stayed Bridge is performed to find their optimum configuration. Further the quantity of steel used in the optimum configuration is compared.

OBJECTIVES OF WORK

1. Finding optimum sag for Suspension bridge
2. Finding optimum diameter that gives minimum value of deflection by performing dead-load analysis for the obtained value of sag for suspension bridge
3. Finding optimum diameter of cable stayed-bridge which gives minimum value of deck deflection
4. Comparison of quantity of steel required for Suspension Bridge and Cable-Stayed Bridge.

METHODOLOGY

Suspension Bridge:
For Suspension bridge the objective is to find optimum sag and optimum diameter of main cables and suspenders so that minimum deflection of deck can be obtained.

For that the bridge is modeled with different sag value ranging from 26 m to total depth of pylon 100 m and the resulted deflection is noted and from that the optimum value which give least defection in the bridge span is selected.

After finding the optimum-sag, optimum diameter of main cables giving least value of deflection is found by keeping others parameters same and only the diameter of main cable is changed.

Cable-Stayed bridge
For cable-Stayed bridge, Fan type configuration of cables is modeled and keeping common parameters of bridge same, and finding the optimum diameter of cables which give min deflection of the deck.

DESIGN PARAMETERS OF BRIDGE

The design parameters which are common for both Suspension bridge and Cable-Stayed bridge are listed below:

- Span of bridge 1800 m (400m+1000m+400m)
- Total width of deck 10.98 m
- Deck type Concrete girder – Ext. slope girders
- Cable spacing 10 m
- Main span 1000 m
- Side span 400 m
- Pylon height 120 m (100m above deck level)
- Height of bridge from ground level 20 m
- Cable steel – A416Gr250
- Concrete – M 30

BRIDGE MODELLING

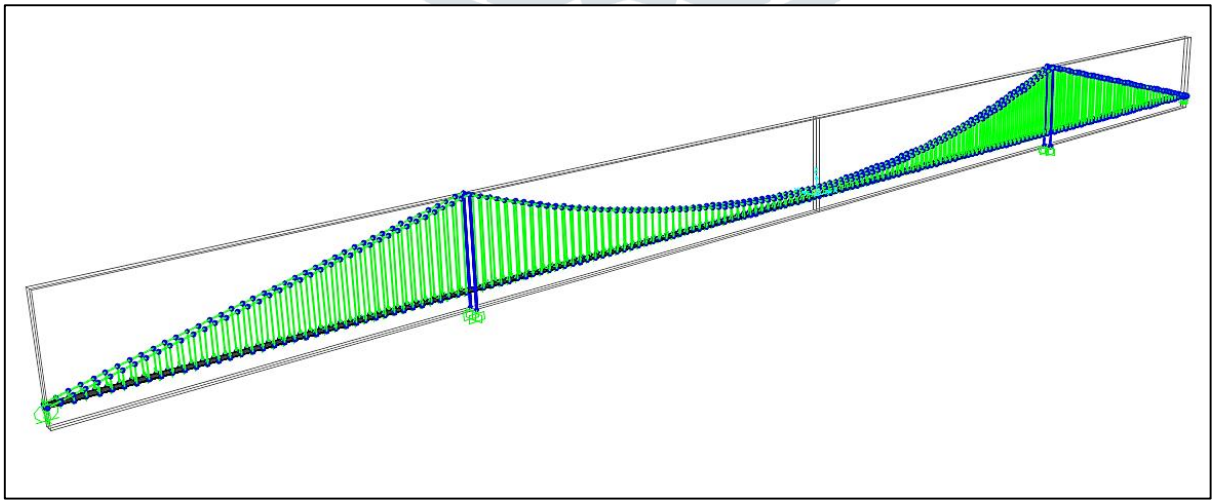

Figure 1 *Suspension bridge modeled in CSI-Bridge Software*

The bridge is modeled in CSI-Bridge Software in such a way that the spacing between suspenders/ hangers of Suspension bridge is 10 m which implies that side span has 40 suspender cables on each sides and main span has 100 suspending cables as shown in Fig. 1.

Sag Optimization

Sag is measured as the vertical distance between the lowest point of the main cable and the top to pylon where the cable is connected to pylon.

To obtain optimum sag for Suspension Bridge is modeled for different Max Vertical sag values such as 26 m, 30 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m & 100 m shown in Table 1. (–ve) values of deflection indicate downward deflection of deck.

Main cable diameter for this is taken as 1.0 m and that of suspenders is 0.03 m. The suspenders are placed at a distance of 10 m as shown in Fig 1.

The corresponding span deflection for the sag values, as mention above, is obtained and corresponding graph is plotted shown in Fig. 2.

Table 1 *Sag Vs Deflection Of Main Span*

Sr. No	Dia	Sag	Deflection	
	m	m	Max	Mid-point
1	1.0	26	-31.978	-31.978
2	1.0	30	-28.56	-28.56
3	1.0	40	-19.87	-19.87
4	1.0	50	-13.7	-13.7
5	1.0	60	-9.64	-9.64
6	1.0	70	-6.9	-6.9
7	1.0	80	-4.98	-4.98
8	1.0	90	-3.827	-3.69
9	1.0	100	-3.25	-2.04

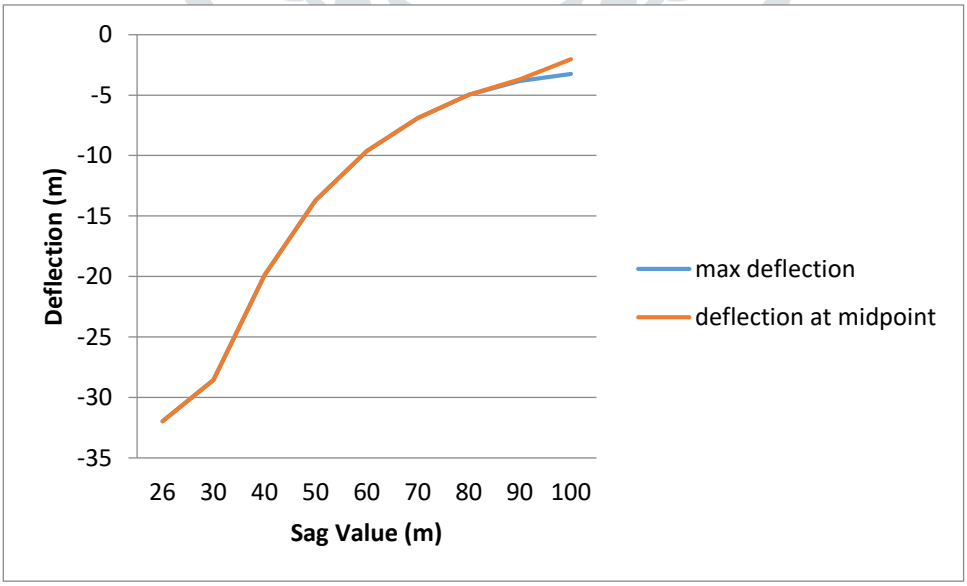

Figure 2 *Sag Vs Max Deflection & Span midpoint deflection*

Form the graph it can be seen that the minimum deflection is obtained for sag of 100 m value, but it can be observed there is differential deflection of span at mid point it gives minimum value (-2.04 m) but a deflection of -3.25 m is observed at other place.
So the sag of 90 m is considered as optimum because nearly same value of deflection is obtained in this case as shown in Fig. 3.

This value can also be expressed in term to ratio that is taking the height of lowest point of main cable from the deck to the total height above the deck

Sag Ratio = 10/100 = 0.1

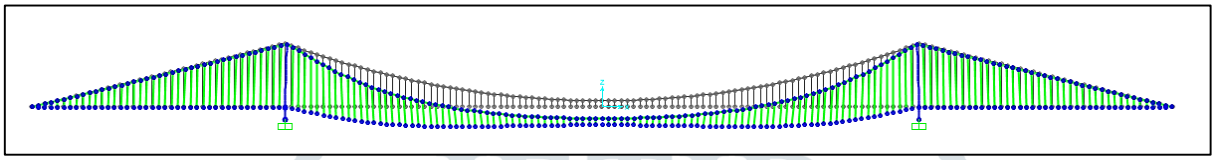

Figure 3 *Deflection of Bridge at 90 m Sag value*

Diameter Optimization

After finding the optimum sag, the bridge was modeled for optimum sag value and by changing the diameter of main cable the min value of main span deflection gives the optimum diameter.

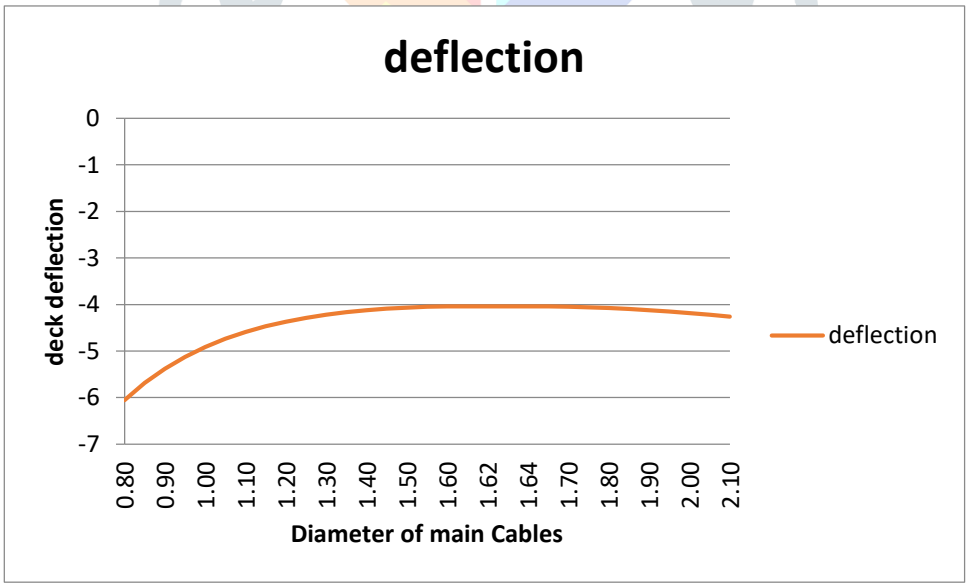

Figure 4 *Deflection Vs Diameter of main span cables*

As seen from the graph in Fig. 4 bridge was modeled for diameter value ranging from 0.8 m to 2.1 m. It is observed that deflection decrease with increase in diameter of Main cables from 0.8. The minimum deflection is obtained for the main cable diameter of 1.63 m (Fig 5.) and further increasing the diameter of main cable the deflection also increases.

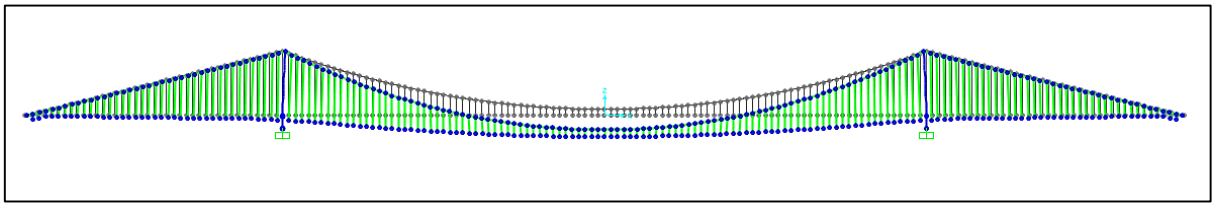

Figure 5 *Deflection of Main Span for Sag Ratio 0.1 and diameter of cable 1.63m*

Cable-Stayed Bridge

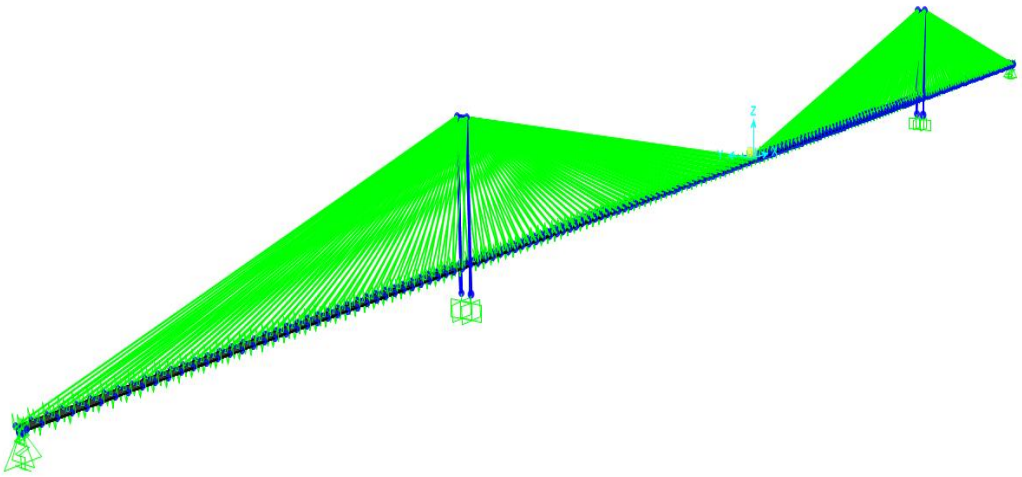

Figure 6 *Cable-Stayed Bridge Modeled in CSI-Bridge Software*

The Cable-Stayed bridge was modeled in FAN type configuration as shown in Fig 6. The cable spacing is 10 m as in the case of Suspension bridge. For Cable-Stayed bridges different diameter of main cables (0.2 m to 0.4 m) and side cables (0.2 m to 0.4 m) and the resulted deflection was plotted in tables. Table 2 shows the maximum deflection in main span for Side Cable diameter of 0.4 m and main cable diameter ranging from 0.1 m to 0.4 m.

Table 2 *Cable Diameter Vs Deflection*

Side cables (m)	Main cable (m)	Maximum Deflection (m)
0.4	0.1	-3.733
0.4	0.11	-3.15
0.4	0.12	-2.75
0.4	0.13	-2.48
0.4	0.14	-2.317
0.4	0.15	-2.215
0.4	0.16	-2.166
0.4	0.17	-2.158
0.4	0.18	-2.185
0.4	0.19	-2.24
0.4	0.2	-2.321
0.4	0.25	-3.0009

0.4	0.3	-4.708
0.4	0.35	-5.4236

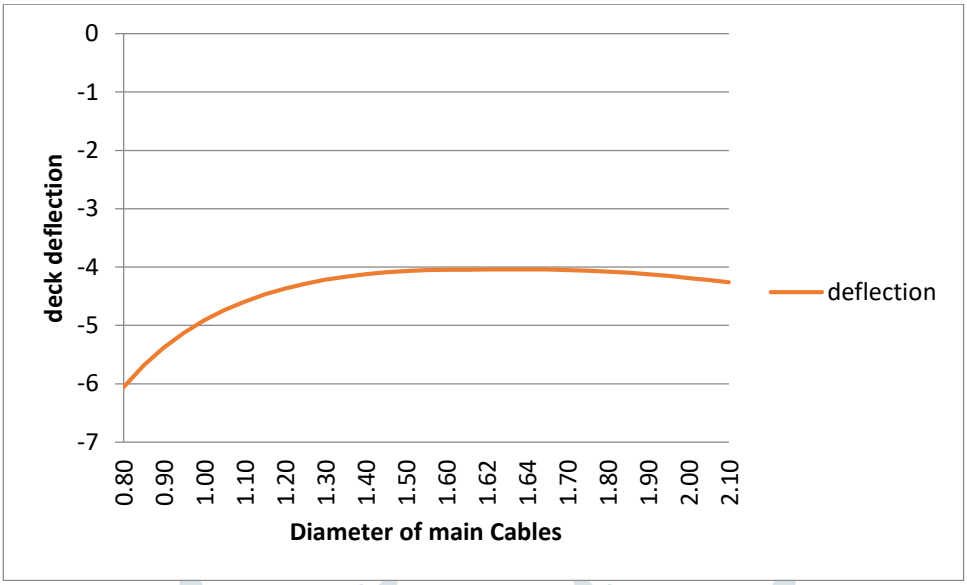

Figure 7 *Max Deflection Vs Cable Diameter*

It can be observed from the table 2, that the min value of deflection is obtained when the diameter of side span cables is 0.4 m and that of main span cables is increased from 0.1 m to 0.17 m deflection of deck decreases and further increasing the diameter of main span cables the deflection increases.

COMPARISON OF RESULTS

Table 3 *Comparison B/W Cable-Stayed & Suspension Bridge*

	Cable-Stayed Bridge	**Suspension Bridge**
Quantity of Steel (KN)	464253.2	593829.3
Maximum deflection (m)	2.158	4.0427

CONCLUSIONS

- For Suspension Bridges optimum Sag ratio can be taken as 0.1
- For Suspension Bridge optimum diameter of main cables for which minimum deflection of deck obtained is 1.63 m
- For Cable-Stayed Bridge the optimum diameter for which the minimum deck deflection value obtained are 0.40 m for Side Span cables and 0.17 for Main Span cables.
- By comparing the quantity of steel required in cables for Suspension bridge (main span cables & Suspenders) & Cable-Stayed Bridge it can be observed that Cable-Stayed bridge require 21.8 % less Steel as compared to Suspension bridges and also less deflection of deck is observed in case of Cable-Stayed Bridges.

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