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Comparison of Two Planes and Three Planes Cable Configuration Of Cable Stayed Bridge

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Abstract – *The cable stayed bridges are the most economical bridges for the span range of 250-800m. They are classified depending upon the shape of the pylon, longitudinal cable configuration and transverse cable configuration. Based on the transverse cable configuration cable stayed bridges are classified as two planes and three planes cable configuration. For the bridges carrying more than four lanes of traffic we can go of either of these cable configuration. In this comparison of these two bridges are made to find of the most economical bridge for the six traffic lanes.*

Key Words: **Cable stayed bridge, Two plane cable configuration, Three plane cable configuration, Long span bridges.**

1. INTRODUCTION

Cable stayed bridge works on the principle that deck of the bridge can be supported by the inclined members which are stretched from the tower and acts as the tension members to carry the load coming over the bridge and transfer the load into the sub structure through the towers. The concept of cable stayed bridge was first published by the French engineer Navier in the year 1823. He did lot of studies over the bridge deck supported by the wrought iron chains. The wrought iron chains provide the additional stiffness to the bridge deck. But Navier work remained as the paper work since no one implemented it in practise. In 1938 Dischinger studied on cable stayed bridge in which the outer part of the bridge deck in longitudinal direction is connected by the cable at the top of the tower similar to that of Navier's work. But he did some changes in the centre span of the bridge where cables are connected between the towers and deck as the combination of suspension and cable stayed bridge. But even this system didn't used for construction as this system had structural behaviour discontinuity and even the discontinuity in the appearance of the bridge. So Dischinger proposed a new system which can be called as the pure cable stayed bridge system. This system was adopted in the construction of the Stromsund Bridge thus Dischinger can be called as "the father of modern cable stayed bridge". In the year 1955 construction of Stromsund Bridge completed thus becoming the first ever modern cable stayed bridge constructed. After Stromsund Bridge the next modern cable stayed bridge was constructed across the river Rhine at Dusseldorf and it was designed by the Leonhardt. The bridge was named as Theodor Heuss Bridge which was inaugurated in the year 1957. These two bridges were very stiff, aesthetically appealing, economical and relatively simple to erect. The way was open for further wide and successful application.

1.1 Brief Description of Cable Stayed Bridge

Cable stayed bridges are the bridges having numerous intermediate elastic supports to support the stiffened girder. These numerous elastic supports are due the inclined cables which are stretched from the vertical tower to the stiffened girder. The vertical tower is placed at the intermediate point in the span of the stiffened girder. The structural members of this kind of bridge include flexural and tension members so cable stayed bridges are also called as hybrid structures. The cable stayed bridge system consists of three main structural components they are towers or pylons, deck system and cable system supporting the deck.

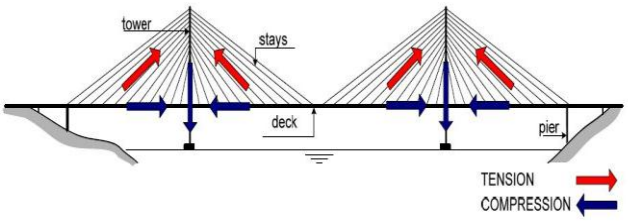

Fig 1 Figure Showing the Behaviour of Cable Stayed Bridge

1.2 General Layout of Cable Stayed Bridge Considered for Comparison

The both two plane and three plane cable configuration bridges are kept of same dimensions expect that an additional plane is inserted in the middle of the longitudinal plane which consists of longitudinal beam two pylons and cable stays. The bridge considered is having a main span of 168m and two side spans of 72m on either side of the span. The bridge is kept symmetrical on either side. The pylon is of total height of 87m in total in which 72 m is above the deck level and 15 m is below the deck level which is ground clearance level. Width of the bridge deck is 30.5m which includes the six lane traffic; the total roadway is of 21m that is 10.5m of roadways carrying traffic in opposite directions and also footpath is provided on either side which is of 3.5m and divider is of width 2.5m. The deck is of composite type having concrete slab supported by the steel beams. The steel

beams are spaced at every 3m which are of length 30.5m and they are in turn supported by the two longitudinal beams. The cable pattern selected is harp pattern in which cables are placed parallel to each other. Cables are placed at every 3m span.

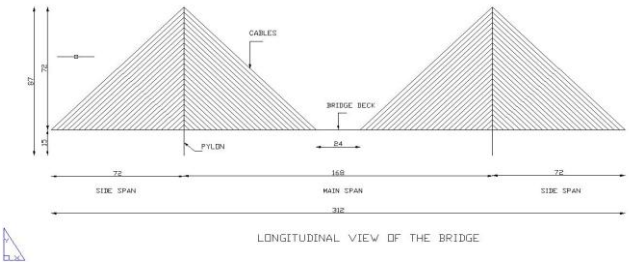

Fig 2 Longitudinal Section of Cable Stayed Bridge

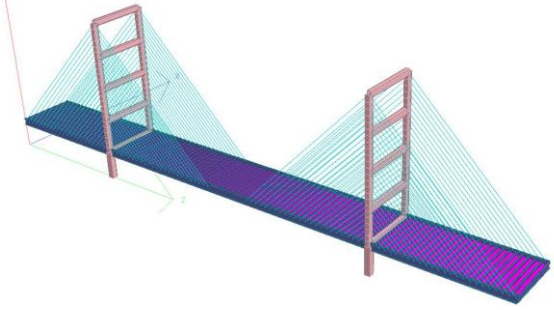

Fig 3 STAAD pro 3-D Model of Two Planes Cable Configuration

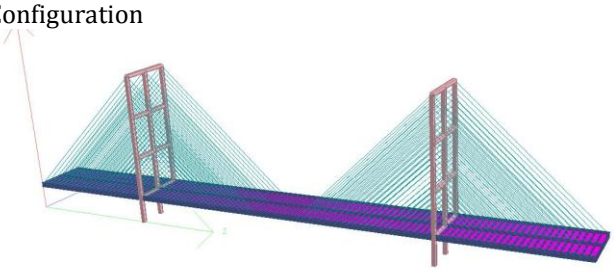

Fig 4 STAAD pro 3-D Model of Three Planes Cable Configuration

2. Results and Discussions

The analysis of the cable stayed bridge is done using the STAAD pro software which works on the principle of finite element method. Loading considered for the analysis are dead load, live load due to vehicular movement, wind load and seismic load. All the loads are considered as per Indian standard specifications. While analyzing the cable stayed bridge certain assumptions are made to cover come the limitations of STAAD pro for the analysis of these kind of bridges

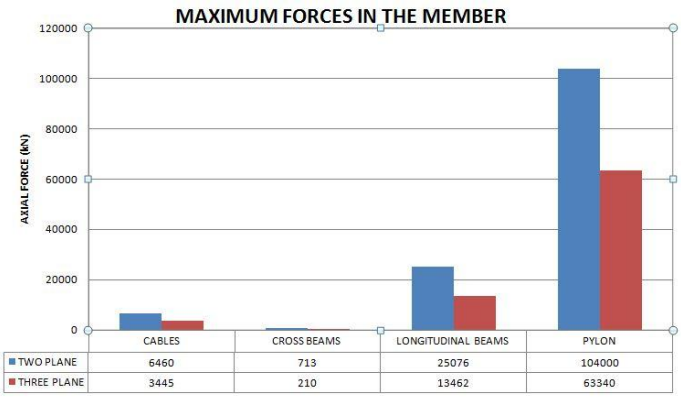

Chart-1: Comparison of Maximum Forces in 2planes and 3planes Cable Configuration of Cable Stayed Bridge.

From the above graph it can be seen that the maximum forces of 3 planes cable configuration structure comes out to less as compared to that of 2 plane cable configuration. Since cost of the steel structures are more compared to that of the reinforced concrete structure less forces in the member means lesser cross section of the member and less will the quantity of the steel.

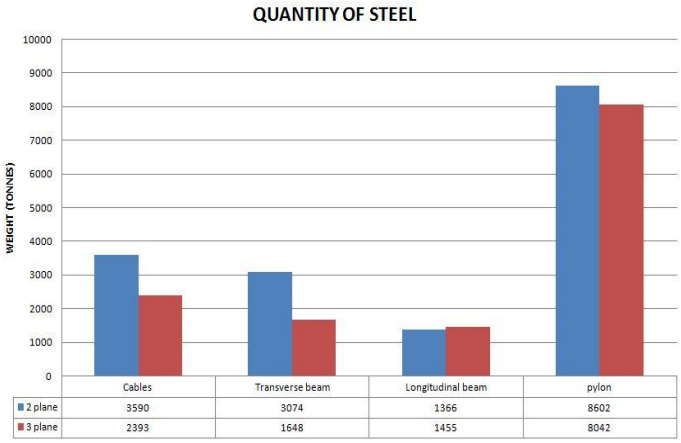

Chart-2: Comparison of Quantity of Steel Required

Form the above graph it can be seen that the quantity of steel required for the three planes cable configuration comes out to less in total that is 13540 tonnes where as for the two plane cable configuration the total quantity of steel comes out to be 17633 tonnes and hence we can say that three plane cable configuration of cable stayed bridge is economical as compared to that of two plane cable configuration of cable stayed bridges.

3. CONCLUSIONS

In this study, the comparison is made between the two plane and three plane cable configuration of cable stayed bridge to find out the best suitable bridge in terms structural feasibility and also to find out which takes lesser quantity of steel for construction. First the modelling of the both bridges are made using STAAD pro and are analyzed and designed. Based on the comparison

of results obtained from the analysis following conclusions are obtained

- The forces for which cables needs to be designed is about 50% less in case of three plane cable configuration.
- The quantity of steel required for the cable is 33% less in case of three plane cable configuration, instead of having more number of cables when compared to that of two plane cable configuration.
- There has been found major difference is the forces and moments developed in pylon which are 40% and 50% lesser respectively for the three plane cable configuration. Hence there is a saving of about 17% in the quantity of steel required for the pylon.
- In case of transverse beam since the effective length has been reduced by 50% forces and hence the quantity of steel is reduced by 50% for three plane cable configuration.
- The foundation needs to design for the 30% lesser loads as compared to that of two plane cable configuration. This in turn reduces the foundation cost, quantity of material required for the foundation.

Hence we can conclude that three plane cable configuration of cable stayed bridge is economical for the bridges having more width as compared to that of two plane cable configuration.

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