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A Review on Shapes of Pylon for Cable-Stayed Bridge.

Mr. Ajinkya D. Raut[1], Prof. R.A. Dubal[2]
[1]*(M.E. (Structure) Student, Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade, Pune, Maharashtra-India)*
[2]*(Assistant Professor Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade, Pune, Maharashtra-India)*

Abstract : *The paper presents finite element approach for the geometric nonlinear aerostatic analysis of self anchored cable-stayed bridges with different pylon configurations along with vehicular interaction. In the recent years cable stayed bridges have received more attention than any other bridge mainly due to Cable stayed bridge are the most flexible bridge and getting popularity because of its economy for longer spans and aesthetics. The results showed that these factors have significant influence on the aerostatic behavior and should be considered in the aerostatic analysis of long span cable stayed bridges. Analysis results will be useful for the designers to consider the shape of pylon at the initial stage of design. Again the results indicate the significant influence of pylon shapes on aerostatic behavior of such long span bridges Cable stayed bridges have good stability, optimum use of structural materials, aesthetic, relatively low design and maintenance costs, and efficient structural characteristics. Therefore, this type of bridges are becoming more and more popular and are usually preferred for long span crossings compared to suspension bridges. A cable stayed bridge consists of one or more towers with cables supporting the bridge deck. In terms of cable arrangements, the most common type of cable stayed bridges are fan, harp, and semi fan bridges. Because of their large size and nonlinear structural behavior, the analysis of these types of bridges is more complicated than conventional bridges. In these bridges, the cables are the main source of nonlinearity. Obtaining the optimum distribution of post-tensioning cable forces is an important task and plays a major role in optimizing the design of cable stayed bridges. An optimum design of a cable-stayed bridge with minimum cost while achieving strength and serviceability requirements is a challenging task.*

Keywords– *cable stayed bridges, Linear Time-history ground motion, seismic response, pylon shapes, traffic loading.*

I. Introduction

The history of cable stayed bridges dates back to 1595, found in a book by the Venetian inventor (Bernard et al., 1988). Many suspension and cable-stayed bridges have been designed and developed since 1595 such as the Albert bridge and the Brooklyn bridge (Wilson and Gravelle, 1991), (Bernard et al., 1988). Cable-stayed bridges have been later constructed all over the world. The Swedish Stromsund bridge, designed in 1955, is known as the first modern cable-stayed bridge (Wilson and Gravelle, 1991). The total length of the bridge is 332 m, and its main span length is 182 m. It was opened in 1956, and it was the largest cable-stayed bridge of the world at that time. This bridge was constructed by Franz Dischinger, from Germany, who was a pioneer in construction of cable-stayed bridges (Tori et al., 1968).

The designers realized that cable stayed style requires less material for cables and deck and can be erected much easier than suspension bridges (Bernard et al., 1988), (Tori et al., 1968), (Wilson and Gravelle, 1991), (Simoes and Negrao, 1994), (Ren and Peng, 2005), and (Nieto et al., 2009). This is mainly due to advances in design and construction method and the availability of high strength steel cables. The Theodor Heuss bridge was the second true cable-stayed bridge and was erected in 1957 across the Rhine river at Dusseldorf. It had a main span of 260 m and side spans of 108 m which was larger than the Stromsund. It has a harp cable arrangement with parallel stays and a pylon composed of two free-standing posts fixed to the deck. The reason for choosing the harp style was aesthetics appearance. The Severins Bridge in Köln designed in 1961 was the first fan shape cable stayed bridge, which has a A-shape pylon. In this bridge, the cross section of the deck was similar to the one used in Theodor Heuss bridge (Bernard et al., 1988). The Flehe bridge was the first semi-fan type which was erected in 1979 in Dusseldrof, Germany over the Rhine river. The remarkable feature of this bridge was the reinforced concrete tower, which has the shape of an inverted Y (Bernard et al., 1988). In what follows, the main types of long span bridges are reviewed.

II. Study Undertaken

To better understand the effect of pylon system with conventional system, parametric studies are carried out. The varying parameters for the parametric study are listed as below. A long span bridge of total span of 1200m was considered to study the effect of various pylon shapes. Three cases of typical pylon arrangement in modern cable-stayed bridge are considered i.e. the H shape, A shape and inverted Y shape. In each case, linear and nonlinear analysis was carried out for a wind speed of 55m/s. The deck cross section of Norman die cable-stayed bridge has considered. The displacement aerostatic load, for all model, has been calculated by taking drag coefficient CD = 1.20, coefficient of lift CL=0.38. Hollow rectangular sections of steel are utilized for modeling the pylons Nonlinear Analysis This type of nonlinearity is based on the deformations of an elastic body and is possible in many instances.

Problems involving deformation that are large are called geometrically nonlinear. In dealing with the nonlinear behavior of the deformable bodies, such as beams, plates and shells, the relationship between the extensional strains and the shear strains on one hand, the displacement components on the other hand are taken to be nonlinear, resulting in nonlinear strain-displacement relations. As a direct consequence of this nonlinearity, the governing differential equations will turn out to be nonlinear. This is true in spite of the fact that the relationship between curvatures and displacement components can be assumed to be linear. Normally, an iterative procedure is required to solve the nonlinear equilibrium problem. In this paper, the Newton-Raphson method is employed with the linear solution as a first approximation. For successive iterations, the actual strain and stress are determined by taking into account both the linear and appropriate nonlinear contributions of the previous approximation. The tangent stiffness matrix and the external and internal force vectors are formed by using the usual assembly procedure for the current structural configuration. The improved trial solution for the $(i+1)^{th}$ iteration is obtained**.**

III. Conclusion

The finite element method is discussed to find out the efficient pylon configuration from comparison of analysis results during aerostatic analysis of cable stayed bridges. The following conclusions are deduced from the parametric results:

- Nonlinearity effect is predominant in long span bridges and gives approximately 20 to 60% higher results than linear analysis. In case of bi-stayed bridges also, the nonlinearity effect is considerably high.
- Apart from few results, for all types of bridges, the load combination DL+MFOUR+WP is found the governing load combination.
- The displacement due to wind is reduced by approximately 20 to 35% when live load due to IRC loads is considered.
- The concept of anchoring of top cable to the earth proved effective in reducing the forces in cables.
- The results show that both in self-anchored and bi-stayed bridges, the forces and moments are found minimum in A frame pylon configuration due to tripod action.
- The costs of cables are very high in case of cable-stayed bridges which can be reduced using the concept of partially earth anchored bridges.

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