Analysis Of Cable-Stayed Bridges

Pinkal Gohel[1], Patel Sweta[2], Pandey Vipul[3], Nikunj Patel[4]
[1, 2, 3, 4] Sardar Patel College of Engineering - Bakrol

Abstract- *Structural design requires a full understanding and knowledge of all the components comprising the structure. A cable stayed bridge is a type of bridge in which the deck (the load-bearing portion) is hung below suspension cables on vertical suspenders. The design of modern cable stayed allows them to cover longer distances than other types of bridges. The main lement of a cable suspended bridge is the cable system. Bridges are normally designed for dead load, live load and other occasional loads. All loading and unloading conditions in analysis and design are provided as per IRC codal specifications. The whole modelling of the suspension parts of the bridge was done by using STAAD Pro software. Cable stayed bridge having 40 m span with single lane road, the intensity of road is given has 20 numbers of vehicles each loaded with 350KN (heavy loading class A-A track load) is analysed by STAAD Pro software. The output of the software presents results including moments, axial loads, shear force and displacements. Moreover, moments and axial load at each node and at any point within the element can be easily obtained from the software output. This thesis examines issues analysis and design calculation in over a structure will safe under all conditions.*

Keywords- Cable stayed bridge , STAAD Pro software., Software Output, Design Calculations.

I. INTRODUCTION

A cable-stayed bridge has one or more *towers* (or *pylons*), from which cables support the bridge deck. A distinctive feature is the cables which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines. This is in contrast to the modern suspension bridge, where the cables supporting the deck are suspended vertically from the main cable, anchored at both ends of the bridge and running between the towers. The cable-stayed bridge is optimal for spans longer than cantilever bridges and shorter than suspension bridges. This is the range where cantilever bridges would rapidly grow heavier if the span were lengthened, while suspension bridge cabling would not be more economical if the span were shortened.

Figure no.1: suspension cable stayed bridge

Cable-stayed bridges have been known since the 16th century and used widely since the 19th. Early examples often combined features from both the cable-stayed and suspension designs, including the famous Brooklyn Bridge. The design fell from favor through the 20th century as larger gaps were bridged using pure suspension designs, and shorter ones using various systems built of reinforced concrete. It once again rose to prominence in the later 20th century when the combination of new materials, larger construction machinery, and the need to replace older bridges all lowered the relative price of these designs.

II. HISTORY

Cable-stayed bridges date back to 1595, where designs were found in Machine Novae, a book by Venetian inventor Fausto Veranzio. Many early suspension bridges were cable-stayed construction, including the 1817 footbridge Dryburgh Abbey Bridge, James Dredge's patented Victoria Bridge, Bath (1836), and the later Albert Bridge (1872) and Brooklyn Bridge (1883). Their designers found that the combination of technologies created a stiffer bridge. John A. Roebling took particular advantage of this to limit deformations due to railway loads in the Niagara Falls Suspension Bridge.

The earliest known surviving example of a true cable-stayed bridge in the United States is E.E. Runyon's largely intact steel or iron Bluff Dale Suspension bridge with wooden stringers and decking in Bluff Dale, Texas (1890), or his weeks earlier but ruined Barton Creek Bridge between Huckabay, Texas and Gordon, Texas (1889 or 1890). In the twentieth century, early examples of cable-stayed bridges included A. Giscard's unusual Cassagnes bridge (1899). in which the horizontal part of the cable forces is balanced by a separate horizontal tie cable, preventing significant compression in the deck, and G. Leinekugel le Coq's bridge at Lézardrieux in Brittany (1924). Eduardo Torrojadesigned a cable-stayed aqueduct at Tempul in 1926. Albert Caquot's 1952 concrete-decked cable-stayed bridge over the Donzère-Mondragon canal at Pierrelatte is one of the first of the modern type, but had little influence on later development. The steel-decked Strömsund Bridge designed by Franz Dischinger (1955) is, therefore, more often cited as the first modern cable-stayed bridge.

Other key pioneers included Fabrizio de Miranda, Riccardo Morandi, and Fritz Leonhardt. Early bridges from this period used very few stay cables, as in the Theodor Heuss Bridge(1958). However, this involves substantial erection costs, and more modern structures tend to use many more cables to ensure greater economy.

Figure no .2 cable stayed bridge

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- **Comparison of suspension bridge**

Cable-stayed bridges may appear to be similar to suspension bridges, but in fact, they are quite different in principle and in their construction.

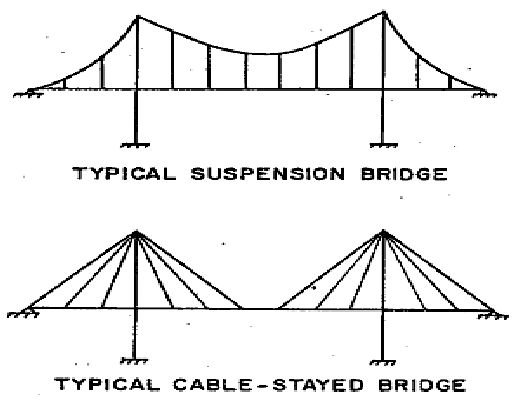
In suspension bridges, large main cables (normally two) hang between the towers and are anchored at each end to the ground. This can be difficult to implement when ground conditions are poor. The main cables, which are free to move on bearings in the towers, bear the load of the bridge deck. Before the deck is installed, the cables are under tension from their own weight. Along the main cables smaller cables or rods connect to the bridge deck, which is lifted in sections. As this is done, the tension in the cables increases, as it does with the live load of traffic crossing the bridge. The tensions on the main cables is transferred to the ground at the anchorages and by downwards tug on the towers.

In the cable-stayed bridge, the towers are the primary load-bearing structures which transmit the bridge loads to the ground. A cantilever approach is often used to support the bridge deck near the towers, but lengths further from them are supported by cables running directly to the towers. This has the disadvantage, compared to the suspension bridge, that the cables pull to the sides as opposed to directly up, requiring the bridge deck to be stronger to resist the resulting horizontal compression loads; but has the advantage of not requiring firm anchorages to resist the horizontal pull of the main cables of the suspension bridge. By design all static horizontal forces of the cable-stayed bridge are balanced so that the supporting towers do not tend to tilt or slide, needing only to resist horizontal forces from the live loads.

Key advantages of the cable-stayed form are as follows:

- much greater stiffness than the suspension bridge, so that deformations of the deck under live loads are reduced
- can be constructed by cantilevering out from the tower – the cables act both as temporary and permanent supports to the bridge deck
- for a symmetrical bridge (i.e. spans on either side of the tower are the same), the horizontal forces balance and large ground anchorages are not required.

- **Difference between types of bridges**



- **Types of Cable stayed Bridge**

i. Side-spar cable-stayed bridge

Puente de la Unidad, joining San Pedro Garza García and Monterrey, a Cantilever spar cable-stayed bridge

A side-spar cable-stayed bridge uses a central tower supported only on one side. This design allows the construction of a curved bridge.

ii. Cantilever spar cable-stayed bridge

Far more radical in its structure, the Puente del Alamillo (1992) uses a single cantilever spar on one side of the span, with cables on one side only to support the bridge deck. Unlike other cable-stayed types, this bridge exerts considerable overturning force upon its foundation and the spar must resist the bending caused by the cables, as the cable forces are not balanced by opposing cables. The spar of this particular bridge forms the gnomon of a large garden sundial. Related bridges by the architect Santiago Calatrava include the Puente de la Mujer (2001), Sundial Bridge (2004), Chords Bridge (2008), and Assut de l'Or Bridge (2008).

iii. Multiple-span cable-stayed bridge

Zhivopisny Bridge in Moscow is a multiple-span design.

Cable-stayed bridges with more than three spans involve significantly more challenging designs than do 2-span or 3-span structures.

In a 2-span or 3-span cable-stayed bridge, the loads from the main spans are normally anchored back near the end abutments by stays in the end spans. For more spans, this is not the case and the bridge structure is less stiff overall. This can create difficulties in both the design of the deck and the pylons. Examples of multiple-span structures in which this is the case include Ting Kau Bridge, where additional 'cross-bracing' stays are used to stabilise the pylons; Millau Viaduct and Mezcala Bridge, where twin-legged towers are used; and General Rafael Urdaneta Bridge, where very stiff multi-legged frame towers were adopted. A similar situation with a suspension bridge is found at both the Great Seto Bridge and San Francisco–Oakland Bay Bridge where additional anchorage piers are required after every set of three suspension spans – this solution can also be adapted for cable-stayed bridges.

iv. Extradosed bridge

The Twinkle-Kisogawa is an extradosed design, with long gaps between the cable supported sections.

The extradosed bridge is a cable-stayed bridge but with a more substantial bridge deck that, being stiffer and stronger, allows the cables to be omitted close to the tower and for the towers to be lower in proportion to the span. The first extradosed bridges were the Ganter Bridge and Sunniberg Bridge in Switzerland. A new extradosed bridge is also being planned to cross the St. Croix River between Bayport, Minnesota and Houlton, Wisconsin in the Twin Cities.

v. Cable-stayed cradle-system bridge

A cradle system carries the strands within the stays from the bridge deck to bridge deck, as a continuous element, eliminating anchorages in the pylons. Each epoxy-coated steel strand is carried inside the cradle in a one-inch (2.54 cm) steel tube. Each strand acts independently, allowing for removal, inspection, and replacement of individual strands. The first two such bridges are the Penobscot Narrows Bridge, completed in 2006, and the Veterans' Glass City Skyway, completed in 2007.

- **Related bridges types.**

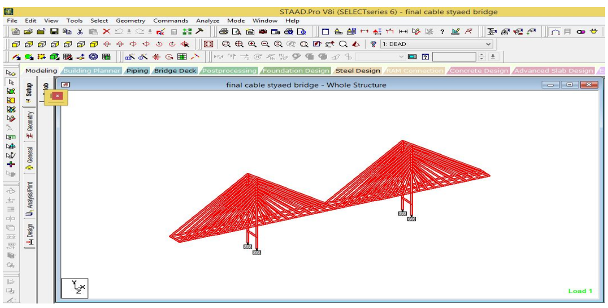
vi. Self-anchored suspension bridge

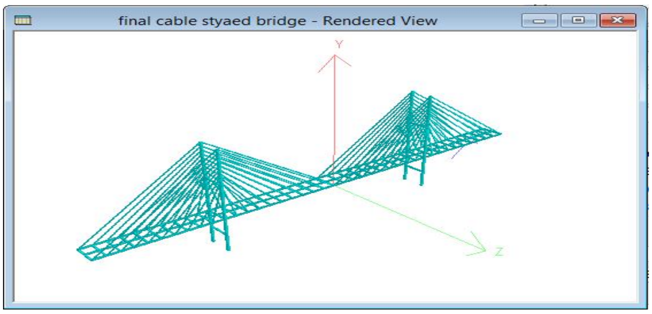
A self-anchored suspension bridge has some similarity in principle to the cable-stayed type in that tension forces that prevent the deck from dropping are converted into compression forces vertically in the tower and horizontally along the deck structure. It is also related to the suspension bridge in having arcuate main cables with suspender cables, although the self-anchored type lacks the heavy cable anchorages of the ordinary suspension bridge. Unlike either a cable-stayed bridge or a suspension bridge, the self-anchored suspension bridge must be supported by falsework during construction and so it is more expensive to construct.
Notable Cable- stayed bridges

See also: List of longest cable-stayed bridge spans and Category:Cable-stayed bridges

- Twin bridges constructed in 2005–2006 that cross over roads connecting to the Autostrada A1 motorway in Reggio Emilia, Italy.[14] In 2009, the European Convention for Constructional Steelwork gave the two bridges a European Steel Design Award, stating that the structures' original visual effects at different angles give the bridges "the aspect of huge musical instruments
- Brooklyn Bridge, famous as a suspension bridge, also has cable stays.
- Centennial Bridge, a six-lane vehicular bridge that crosses the Panama Canal with a total length of 1.05 kilometres (3,400 ft).

III. DESIGN CABLE STAYED BRIDGE





IV. CONCLUSION

Data collected in the tables show interesting points about cable bridges including: • About 57% of the defined cases were built after 2000. • The main span of cable bridges has reached 1000 meters recently. • Most cable bridges (about 60%) are defined as extra dosed cable bridges. • About 40 % of the considered bridges were built over water bodies. • In about 60 % of the cases, the ratio of main span to total length ratio is between 0.1 - 0.45. • United State and Japan are two countries which most cable bridges have built in.

V. SUMMERY

In this research by considering 103 cable bridges and according to the cable patterns, a classification has been defined in three groups including harp, fan and radial patterns. The main concern of the study was to define the relation between the cable patterns and the main span length. By analyzing the results it was concluded that the majority of cases defined are built with harp patterns. In addition to these data it may be concluded that fan patterns are used for implementing longer spans. The main reason is the high performance of this pattern in conducting forces.

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