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A REVIEW ON CABLE STAYED STRUCTURE

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ABSTRACT

In recent years, cable-stayed bridges have received more attention than any other bridge, especially in the United States, Japan and Europe, as well as in third world countries, due to their ability to span large spans. Cable-stayed bridges can cross almost 1000 m (Tatara Bridge, Japan, Norman the Bridge, France) Few cable-stayed bridges are being built in India and some are underway. Like the Bandra Worli maritime link, the second Hoogly Bridge is the best example of cable-stayed bridge application in India. Cable-stayed bridges for roads and bridges have emerged in Bangalore and Chennai, and a cable-stayed bridge is being proposed in several smaller emerging cities. There is still scope for innovation in cable-stayed bridge techniques. Here detailed studies of design consideration and comparison about cable stayed bridge along with its components and types of cables were studied.

***Keywords** – Bridge, Development, Structure, Steel cables*

1.1 INTRODUCTION

A long span structure is one that has a span greater than 60 feet (18 metres). Long-span structures are most commonly used to shape and support the roofs of large, open floor spaces for a variety of building types, including sports arenas, theatres, swimming pools, auditoriums, exhibition halls, warehouses, industrial and manufacturing facilities, aeroplane hangars, and other facilities that require a large expanse of column free space. They can also be used to support building floors if a large space is embedded within the structure.

In cable structure the cable serves as the primary means of support in cable structures. Because cables have a high tensile strength but no resistance to compression or bending, they can only be used in tension. When subjected to concentrated loads, a cable's shape is made up of straight-line segments.

Among all bridge types, the cable-stayed bridge is preferred for its large spans and aesthetics. In almost two decades, both conceptually and practically, the seismic design of the cable-stayed bridge has merged as the most powerful performance. Bridges with cable stays are considered indefinite structures.

Cable-stayed bridges in seismically active areas are also being developed, and additional efforts are being made to address the problematic structure with the development of the continents' natural economy. For spans of up to 1000m, wired bridges are considered the most cost-effective, with simpler construction methods. For these reasons. The first bridge structure was a suspension and cable system. Cable-stayed bridges are constructed along the building system, with a deck connected to the tower at the main pier by cables.

1.2 LITERATURE REVIEW

1.2.1 Research Paper By Ishita Arora, Er. Rajinder Singh, Ashwani, Parasram Pandit, On Study Of Cable Stayed Bridges, Published In International Research Journal Of Engineering And Technology (Irjet), Volume: 04, 07 July 2017. Was Reviewed By Us

The research paper starts off with introducing what bridges are? It also gives a gist a of Himalayan bridge in India as an example. The development in bridge engineering from timber or arches to model cable stayed bridges. The entire study focuses on learning the evolution of cable stayed bridges as an efficient structure.

It mentions components of cable stayed bridges i.e towers, types of cables and cable arrangement.

Different types of cables are

Fan type

Harp type

Mixed type.

In the literature review section of the paper, various case studies related to the topic are been discussed where gist of per case studies is given which is categorised into: introducing the brigde, total length and deck width and the number of cables used.

1.2.2 Research Paper By Lawrence A. Kloiber, P.E., David E. Eckmann, Aia, S.E., P.E., Thomas R. Meyer, S.E., And Stephanie J. Hautzinger, Aia, On The Design Considerations In Cable-Stayed Roof Structures Published In North American Steel Construction Conference (Nascc,2004). Was Reviewed By Us

This article discusses numerous unique characteristics of cables and cable-stayed structures, as well as some of the specific design concerns that structural engineers should address.

A brief understanding of cable stayed structures is given, stating that: cable-stayed structures are "structures where cables stabilize vertical or sloped compression members (usually called masts or pylons) and serve as tension-only members". A section of the paper presents the configuration of the cables used in these structures. They comprise of one or more groups of wires, strands or ropes.

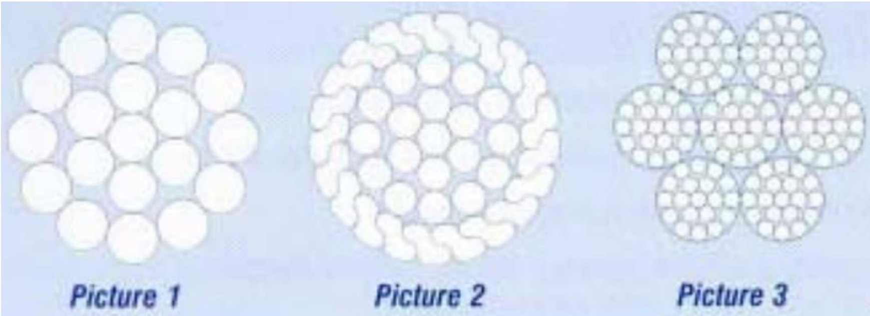

Figure 1 Picture 1 is a "strand"—an assembly of wires wound around a central core. Picture 2 is a Z-lock cable, composed of Z-shaped cold-drawn or cold-rolled wires at the perimeter of the strand which lock together to "seal" the strand. Picture 3 is a wire "rope"

Source: Pfeifer Catalog, 2000.

Various factors like climatic conditions, cable material properties, coating systems such as galvanizing and stainless steel, and use of cable sheathing and high-performance paints that influence the life expectancy of cables are mentioned. Recommendations on analysis of the elastic nature of the cables is discussed in this paper. Cables are not completely elastic when they are first produced, and they are frequently pre-stretched. If they are not pre-stretched, they will stretch in elastically as the cable is tensioned and individual wires settle into their final positions. Pre-stretching cables to a high percentage of their minimum breaking strength allows the wires to find their final position, with well-defined elastic characteristics. After highlighting the key points on technical details of cables, the reader is provided with a brief information on the socket terminal fittings or connections and their design.

The paper also provides a reference of the ASCE 19-96 publication by the American Society of Civil Engineers (ASCE) which offers recommendations for design drawings and specifications, design considerations, material properties, fittings, protective coatings, and fabrication and erection of cable structures.

This paper also includes a case study on **The University of Chicago Ratner Athletics Center**, a recently completed cable-stayed structure that celebrates 150,000 square feet of health, fitness, and sporting activity space. The $51 million state-of-the-art athletics facility includes a competition gymnasium, an Olympic-sized natatorium, and a myriad of other spaces that accommodate virtually any athletic activity. Designed by internationally renowned architects Cesar Pelli & Associates, and engineered by OWP/P Structures in Chicago, the project features a first-of-its-kind asymmetrically supported cable-stayed system that gracefully suspends S-shaped roofs that float over the large volume gymnasium and natatorium spaces. This innovative structure utilizes 10-story tall composite masts and a series of splayed cables that support shallow curved steel roof members. The thin roof framing is cold-bent to shape, and delicately suspended over the 160-foot spans. The tapered masts are stabilized by back-stay cables anchored in place by massive concrete counterweights that counteract the weight of the roof.

Figure 2 The University of Chicago Ratner Athletics Center

Source: pcparch.com

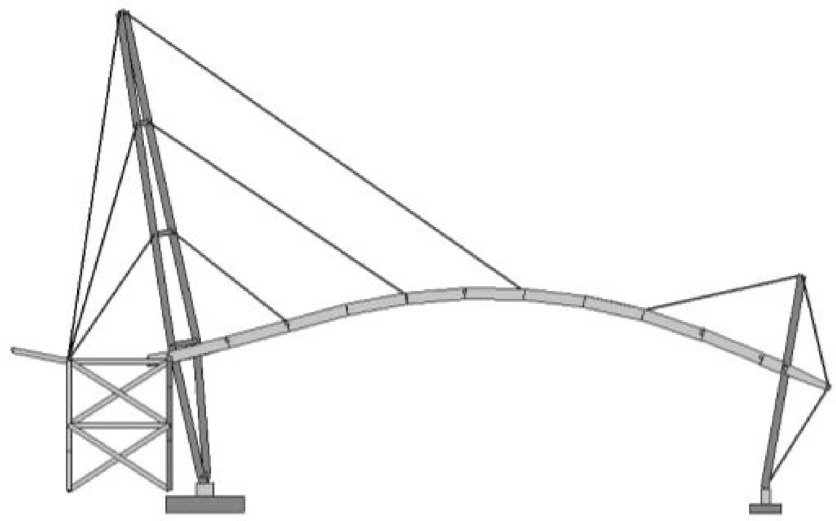

Figure 3 Gymnasium Section

Source: Design Considerations in Cable-Stayed Roof Structures, 2004

Figure 4 Composite Mast

Source: Design Considerations in Cable-Stayed Roof Structures, 2004

1.2.3 Research Paper By Kumudbandhu Poddar , Dr. T. Rahman, On Comparative Analysis Of Cable Stayed, Suspension And Composite Bridge Published International Journal Of Innovative Research In Science, Engineering And Technology(An Iso 3297: 2007 Certified Organization)Vol. 4, Issue 9, September 2015 Was Reviewed By Us

The study was carried out for computational analysis of cable stayed bridge, suspension bridge and two types of composite type bridge. It introduces a new composite bridge model where the long span deck is supported by stay cables and suspension cables at different portions along the whole longitudinal section of span. It includes comparative studies among these bridges. The geometries of these three bridges are same besides of some necessary structural components i.e. stay cables, suspension cables and hangers. For the comparison of these bridge models structural symmetries are considered. Static and dynamic effects of loads are taken into consideration for the analysis of these bridges. Analysis has been performed with the help of MIDAS CIVIL Software. Results indicate the changes come in performance and response of various members of bridge due to the change in hanging fashion of superstructure.

The analysis was carried out using The Quincy Bayview Bridge as a reference for cable-stayed bridge model. The bridge is composed of 56 nos. of stay cables. The total length of the bridge L = 541.8 m.

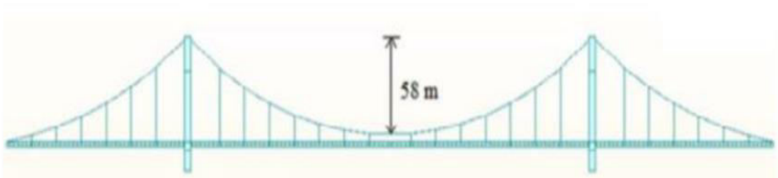

Figure 5 modelling of suspension bridge

Figure 6 modelling of composite type 1 bridge

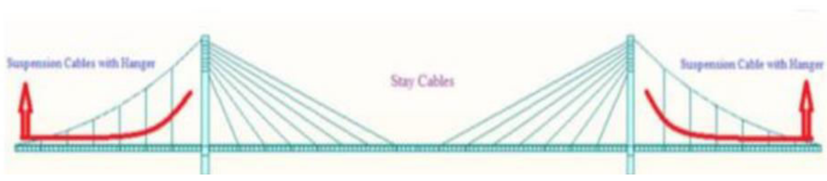

Figure 7 modeling of composite type 2 bridge

1.2.4 Parameters used for Analysis:-

- Displacements in steel girder in vertical direction
- Displacements of concrete pylon in longitudinal direction of girder or in x-direction..
- Axial force on stay cables, suspension cables and hangers over cantilever span.
- Axial force on stay cables of cable stayed and composite type 1 bridge.
- Axial force on suspension cables of suspension and composite type 2 bridge.
- Axial force on hangers of suspension and composite type 2 bridge.
- Axial force on stay cables, suspension cables and hangers over middle span.
- Axial force on stay cables of cable stayed and composite type 2 bridge.
- Axial force on suspension cables of suspension and composite type 1 bridge.
- Axial force on hangers of suspension and composite type 1 bridge.
- Bending moment in steel girder.
- Bending moment in concrete pylon.

The mathematical analysis carried out help to derive conclusion based on comparing;

- Maximum displacements in steel girder.
- Displacement at base and top point or throughout the pylon length.
- Tensile force in stay cables and e tensile force in suspension cables and hangers due to cantilever span and middle span.
- Bending moment at the centre of cantilever span, middle span and pylons

of cable stayed, cable suspension, composite type 1 and 2.

1.3 A CASE STUDY IN CABLE-STAYED STRUCTURE - THE RUSSKI ISLAND BRIDGE VLADIVOSTOK, RUSSIA

Figure 8 Rusky Island Bridge

Source: https://www.roadtraffic-technology.com/projects/russky-island-bridge/

Location: Russky Island, Russia

Project type: Cable stayed road bridge

Bridge dimensions: Length: 1,885m, width: 29.5m, longest span: 1,104m, vertical clearance: 70m

Opened: July 2012

1.3.1 Project overview

Russky Island Bridge is the longest cable-stayed suspension bridge in the world. The 1,885m (3,887ft) bridge connects Russky Island with the city of Vladivostok. The bridge crosses the Eastern Bosphorus Strait, linking with the mainland and island.

The bridge has 11 spans, which include two at 60m, two at 72m, six at 84m and one 1,104m central span. Its pylons are made of steel-inclined wall box sections and reinforced concrete slab.

1.3.2 Design challenges

Design of the bridge needed to incorporate the extreme climatic conditions of the area, with temperatures varying from -310 to +370. The cables are composed of 13 to 85 parallel individually corrosion protected strands, which in turn are made up of seven galvanised steel wires enclosed in high-density polyethylene sheathing.

1.3.4 Future scope

Cable Stayed Bridges have much greater stiffness since the cables can handle more pressure. They are also much more resistant to environmental changes such as the frequent occurrences of earthquakes. Such types of bridges take less time to construct and are economical too since they require fewer materials and less building hours. Cable Stayed Bridges are preferred over conventional steel suspension mainly because of the reduction in moments in the stiffening girders.

1.4 Conclusion

Cable-stayed Bridges structures can create dramatic structures that enclose large volume column-free spaces, and still provide opportunities for architectural design freedom .Russky Island Bridge is one of the world's longest cable-stayed bridges. The bridge links the Siberian port of Vladivostok with Russky Island. It was built with Hunnebeck's modular self-climbing formwork (SCF).

1.5 References

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