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Energy Conversion on Cable-stay Bridge (with the Concept of Hinge Support Design)

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***Abstract:-* Energy Conversion plays a major role in any engineering field either it may be civil engineering or it may be mechanical engineering, the concept with which we are dealing with the energy conversion makes us the futuristic engineers to maintain the eco-system life style. This concept of energy saving project gives you the study details of the energy conversion of the cable-stay bridge & it also deals with the new concept of hinge support design with single span on the cable-stay bridge. As the designs of bridge will be at higher altitude where wind velocity will be high, the design encompasses utilization of wind turbines & also for the utilization of solar energy for power generation, to utilize such freely available natural wind & solar resource. This paper studies wind turbines & solar panels mounted on bridge to generate electricity which can be utilized for lightings & other purpose for the bridge. This work involves designing of cable-stayed bridge for its concept of single hinge support design which can be considered as the best aesthetic view & good landmark in the transportation system.**

***Keywords:--* Cable-stayed bridge, Energy conversion, Hing support design, Single span, Solar panels, Wind turbines.**

I. INTRODUCTION

Cable stayed bridges are indeterminate structures. The superstructure behaves as a continuous beam elastically supported by the cables, which are connected to one or two towers. The structural system consists of three main structural sub-systems: Stiffening girder, tower, and inclined cables. The interrelation of these components makes the structural behavior of cable-stayed bridges efficient for long-span structures, in addition to providing an aesthetic pleasant solution. The cable-stayed system has become a very effective and economical system during the last century. It is mainly used to cover large spans area. The improvement of this structural bridge system is due to advances in materials, engineering analysis and design, and construction methodology. The structural components of a cable-stayed system behave in the following manner: The stiffening girder transmits the load to the tower through the cables, which are always in tension. The stiffening girder is subjected to bending and axial loading. The tower transmits the load to the foundation under mainly axial action. This paper gives you the study of the hinge support design in the cable-stayed bridges which has not yet been made, this hinge support is separated by two major symmetric axis which holds the both side deck perfectly, this hinge support will balances the all load which are acting upon the deck, This design also gives the study of the utilization of natural sources of wind & solar energy which encompasses over the bridge deck area. There is the good improvement with the cable bridge design, by this concept of hinge design it is suitable for the coastal & humid conditions also the design gives the good architectural view in the transportation system.

II. STRUCTURAL ASSESSMENT

As one of the most competitive bridge in modern times, the cable-stayed bridge is usually a hub for transportation projects. Once destroyed in all kinds of adverse natural conditions, it will result in enormous economic losses. Consequently, the reliability of the overall structure and the complexity of the dynamic characteristics should be fully taken into consideration when the cable-stayed bridge structure is designed. And thus the wind resistance studies, a seismatic design and maintenance of the bridge can be carries out rightly. Modal parameters are the main parameters of structural dynamic characteristics. Therefore, modal analysis is important for the study of dynamic characteristics.

Structural Studies to be Focused on

- Geology.
- Testing bored pile foundations.
- Design of the pier and deck.
- Meteorological records.
- Wind load & wind pressure.
- High performance concrete design.
- Seismicity.
- Maintenance and operation.
- User’s behavior.
- Building methods.

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- Construction management.
- Cost analysis.
- Hydraulic studies.
- Archaeology.

III. PROJECT OVERVIEW

For the necessary design data preparation, quantifiable properties and design data are effectively taken into account. To develop a safe and effective long-span cable stayed bridge, it is very important that modeling of proposed bridge is conceded within the defined structural stipulations and plans, the below values are approximate just for the research purpose for the cable-stay bridge.

- The bridge has 5 main components i.e. pylon, road deck, Y-frame (mast), high tensioned cables & hinge support (center area).
- This bridge tower pylon can be constructed up to a height of 50 to 75 meters for the single pier support & weights about 100 tons.
- Steel deck i.e. formation of road way can be up to width of 30 meters & weighs 5,500 tons approx. entailing a 2x2 lane highway with a 2.5 to 3 meter shoulder about its length can be placed up to 400 meters, about its height is 3.5 meters for the single pier support.
- The 2 hinged girder mechanisms is truly with the roller support by which both hinge supports are rigidly fixed to the concrete pylon which can be seen in the design.
- The longitudinal Y-frame (mast) peaks about 100 to 200 meters above deck, with steel girder.
- Approximately it requires 12,000 m3 of concrete for foundation.
- Since the road way is to be constructed at a higher altitude, we have designed the components of bridge structure as aerodynamic, wind screens are provided to protect the vehicles which is of 2 to 3 meter in height.

Design Loads

- Live traffic load
- Dead load
- Super Imposed Dead Loads
- Wind Load.
- Temperature Load
- Other Load

By significant amounts of concrete involved in the design one of the most important loads to be taken i.e. associated with creep of concrete. For the high altitude bridge pier construction of any changes in height, causes uneven across the piers would lead to unfavorable effects as well as theoretically aesthetic problems. [1]

Design Components.

Y-frame

The tower Y-shape is mainly selected for aesthetic reasons, and is refined based on proportions, materials, and restrictions associated with the tower design. A considerable variety of tower shapes exist. In general, the shape of the tower is governed by the required height and the environmental loading conditions, such as seismic zones and wind criteria. The towers are classified according to the basic forms

Box-sections are most frequently used for the towers. They can be fabricated out of steel or reinforced or pre-stressed concrete. Concrete towers are more common than steel towers because they allow more freedom of shaping, and are more economical, by considering the below image we have designed the Y-frame for this bridge. [6]

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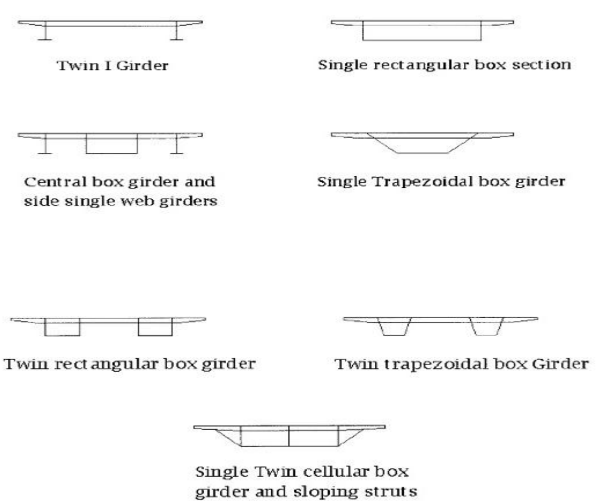
Deck

Aerodynamic instabilities arise from a complex dynamic interaction between the changes in aerodynamic forces and the dynamic response of the structure. Aerodynamic instability of the structure can be thought of as negative damping, where the energy input per cycle of oscillation is larger than that absorbed by structural damping, thus leading to a divergent amplitude response. Instabilities are characterized by a critical wind speed, above which the structure is unstable.

The instability boundary of the stonecutter's bridge deck was established by performing aero-elastic testing in the wind tunnel. The section model was spring-mounted on a rig, stiffness and masses adjusted to adhere to the scaling laws. For classical flutter, a coupled response of vertical and torsional modes, the critical wind speed reduces the closer the two frequencies f_T (torsion) and f_V (vertical bending) are. A range of frequency ratios (f_T/f_V) should be tested [2]. The economic solution for the suspension bridge is a least weight deck section. As such, cable-stayed bridge deck forms have been developed as.

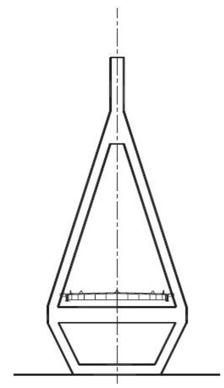
- A steel section incorporating an orthotropic road deck.
- A concrete section.
- A composite steel and concrete section. [1]

Selection of the deck was considered after the study of the below deck design.



Diamond pylon

The Diamond pylon is suitable for inclined stay arrangements and was first adopted for the Severins Bridge (Fischer, 1960). A variation of the A-frame is the inverted Y-frame where the vertical leg, containing the stay anchors, extends above the bifurcation point. Excessive land takes, due to the wide pylon footprint, can occur with this form of pylon, when a high navigation clearance to the deck is required. This has been overcome by breaking the pylon legs at or just below the deck to produce inward-leaning legs to the foundation to form a diamond configuration as shown in below figure. However, this modified arrangement is considerably less stiff when resisting transverse wind or seismic forces and this can result in a significant increase in the deflection of the pylon. This deflection can be mitigated only with a considerable increase in the stiffness of the lower section of the pylon leg below the deck. [6]

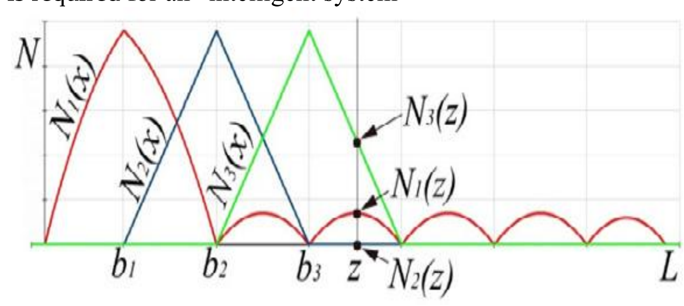


Modern Concept

Since the bridge will be at a higher altitude, design encompasses utilization of wind turbines & also for the utilization of solar energy for power generation, in order to utilize that wind & solar energy we have introduced the wind fans & solar panels below the deck to generate electricity.

Concept of "intelligent cables"

It is important to investigate how the tensile forces in cables should change when the point load is moving over the bridge in order to secure the desired bending moment diagram. Curves given in below Fig represent the vertical component of each cable tensile force. Such action of cables is required for an "intelligent system"



From these graphs we can conclude that in an "intelligent system" the adjustment of tensile forces is required only for

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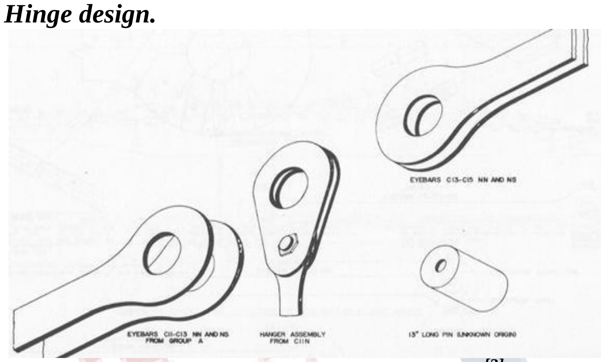
both ends of the panel in which the moving point load is located and for both shortest cables. This conclusion follows logically from the nature of the resulting bending moment diagram which changes its value only in three panels – both outer panels as well as the one in which the point load is located. Analysis shows an important conclusion: the desired effect can be obtain with tensioning of only some cables without necessity to loosen any other which could lead to the complete exclusion of these cables (in case with relatively low value of permanent loads) and thus – to the system's geometrical non-linearity.
Results show that integration of "intelligent" cable adjusting devices in observed system allows reducing the maximal bending moment in stiffening girder by approximately 10%. At the same time the maximal tension force in cables increases by 3%. [2]

Hinge design.



Example of the hinge support [3]

A hinge is a mechanical bearing that connects two solid objects, typically allowing only a limited angle of rotation between them. Two objects connected by an ideal hinge rotate relative to each about a fixed axis of rotation. Hinges may be made flexible material or of moving components. [4]
In the study of our design hinge mechanism plays the most important part in the cable-stay bridge, this hinge mechanism is symmetric in design which allows the free play movement for the bridge deck, which balances the either sides of the decks equally, this hinge mechanism can be adopted for the coastal & humid conditions as it has the good nature of deformation action this design also ensures the aesthetic view of the cable-stay bridge which can be noted for its best landmarks.

Types of hinge design

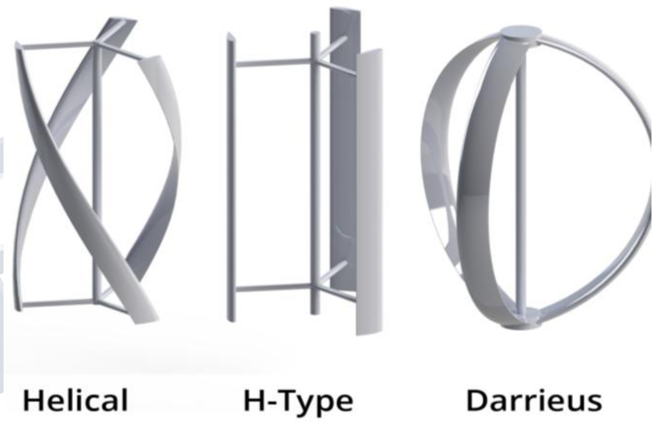
- Roller system
- Pinned or hinged system
- Fixed system &
- Simple system

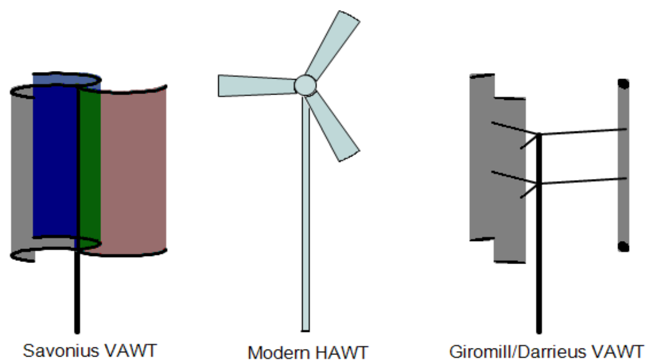
Wind Turbines

Wind turbines convert wind energy to electricity for distribution. Among all renewable energy systems wind turbines have the highest effective intensity of power-harvesting surface because turbine blades not only harvest wind power, but also concentrate is used to determine the optimum tower height, control systems, number of blades and blade shape. [1]

Types

Wind turbines can rotate about either a horizontal or a vertical axis, the former being both older and more common. They can also include blades (transparent or not) or be bladeless. [1]





Materials and durability

Currently serving wind turbine blades are mainly made of composite materials. These blades are usually made of a polyester resin, a vinyl resin, and epoxy thermosetting matrix resin and E-glass fibers, S- glass fibers and carbon fiber reinforced materials. Construction may use manual layup techniques or composite resin injection molding. As the price of glass fibers is only about one tenth the price of carbon fiber, glass fiber is still dominant. One of the predominant ways wind turbines have gain performance is by increasing rotor diameters, and thus blade length. Longer

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blades place more demands on the strength and stiffness of the materials. Stiffness is especially important to avoid having blades flex to the degree that they hit the tower of the wind turbine. Carbon fiber is between 4 and 6 times stiffer than glass fiber, so carbon fiber is becoming more common in wind turbine blades. [1]

IV. STRUCTURAL BEHAVIORS OF THE BRIDGE SECTIONS

Structural behavior of the girder

The behavior of the girder is defined by the cables arrangement and inclination, which provide elastic supports to the girder. The stiffening girder is generally subjected to two kinds of stresses; bending moments from vertical loads and normal forces from the horizontal components of the loads in the cables. The structural behavior of the girder is also a function of the supported conditions in the tower connection, which can be either fix or simple-supported.

The girder can be subjected to tension, compression or both. In general, its behavior is described by three properties: axial stiffness, bending stiffness, and in some cases torsional stiffness. [2]

Structural behavior of the cables

The cables are tension members that are modified by different factors. Their performance is classified as non-linear behavior. These factors are the change in the axial tension and reduction of the stiffness due to the sag effect. By switching the original modulus of elasticity to an effective modulus of elasticity called Ernst's equivalent modulus of elasticity, the non-linear behavior of the cables is considered. There are two approaches to determine the cable properties in the preliminary modeling stage; the strength based approach and the stiffness based approach, the first one takes into account the cable resistance as the first concern, while the second one considers the displacement limitations. The cables have to provide an initial tension obtained from the dead load of the superstructure to maintain static equilibrium requirements. In addition, due to cables low bending stiffness, its own weight is only balanced by taking a catenary form. [2]

The interrelation of the structural components

The interrelation between the main structural components of a cable-stayed bridge, the cables, girder, and tower, is important because it gives the overall behavior of the system. The total stiffness of the cable-stayed bridge is obtained by the interaction of the individual stiffness.

Three limit states can be considered to generalize this type of bridges

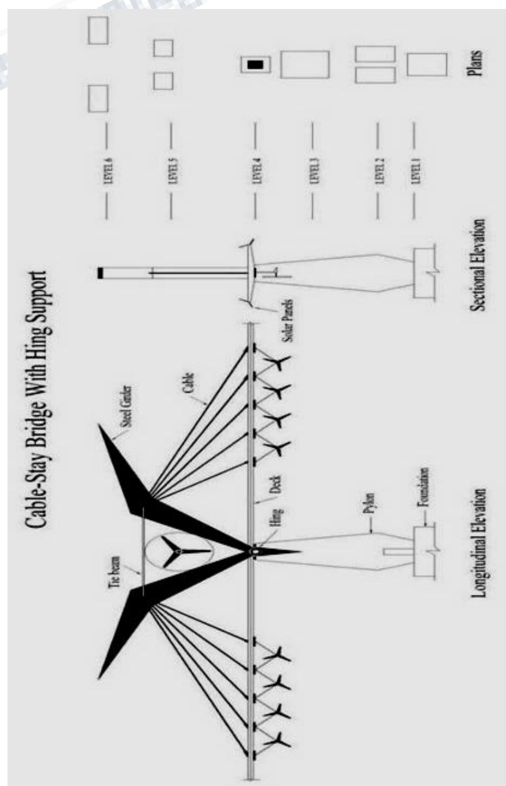
- Very stiff girder: Reduces the number of cables reduces the cross-section of the tower but the construction cost is extremely high.

- Very stiff tower: The tower takes all the longitudinal moments, thus, the cross-section of the girder decreases. This is a very convenient solution for multi-span bridges.

- Inclination and separation of the cables. The cables stabilize the system itself. The use of backstays, counter weight or tension piers is essential. [2]

Purpose Of The Project Review

1. To give a professional advice on the preliminary analysis on the cable-stay bridge system.
2. To propose new solutions & advanced methodology on the cable-stay bridge.
3. To set up a new & advanced working method for project development.
4. To implement the best working condition under all locations where the cable-stay bridge is suitable.
5. To give the best aesthetic view on the bridge by implementation with regard to the natural landscape in transportation system.
6. To reward the different designing teams.
7. Bridge Design



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V. CONCLUSION

Cable-stayed bridges are widely constructed all over the world. This type of bridge is very competitive economical for medium and long span. In comparison with other types of bridge, cable-stayed bridges are particularly pleasing to the visual senses. Moreover, this type of bridge fills the gap of efficient span range between conventional girder bridges and the very long span bridges. In this study, higher altitude up to 300 meters or more can be seen with the energy conversion concepts by adopting wind turbines & solar panels throughout the bridge sections therefore, this study would give some concept knowledge of the hinge support design for cable-stayed bridge with aerodynamic shape of tower and how to design it by architecturally & aerodynamic shapes with the best aesthetic view & good landmark in the transportation system. According to the design concept of this bridge, analysis results due to own weight, displacements and rotations are symmetric.

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REFERENCES

[1] Vinayak.Gourannavar, Chinmay.S.M “High Altitude Cable Bridge(with the concept of wind turbine)” © 2016 IJRTI | Volume 1, Issue 3 | ISSN: 2456-3315

[2] Elizabeth Davalos “Structural Behavior of Cable-stayed Bridges” @2000 Elizabeth Davalos. All rights reserved.

[3] Google images (pinned design for the cable-stay bridge).

[4] Wikipedia (hinge support).

[5] Liuchuang Weia, Heming Chenga, Jianyun Lia “Modal Analysis of a Cable-stayed Bridge” © 2011 Published by Elsevier Ltd.

[6] D. J. Farquhar Mott Macdonald “Cable stayed bridges” ICE Manual of Bridge Engineering © 2008 Institution of Civil Engineers, doi: 10.1680/mobe.34525.0357.

[7] G. MORGENTHAL, Y. YAMASAKI, “Aerodynamic Behaviour of Very Long Cable-Stayed Bridges during Construction” 1877–7058 © 2011 Published by Elsevier Ltd.

[8] S. Ponnuswamy, “Bridge Engineering” Tata McGraw-Hill Publishing Company Limited, 7 West Patel Nagar, New Delhi 110 008, 2nd ed., 2009

[9] Jagadish T.R. & Jayaram M.A, “Design of Bridge Structure” Prentice Hall of India, New Delhi.

[10] Holger Svensson, “Cable-Stayed Bridges: 40 years of Experience Worldwide. 3rdEd, 2012.

[11] Cristian, Bak, “Aerodynamic Design of Wind Turbine Blades & Materials” National Laboratory for Sustainable Energy, Technical University of Denmark, Woodhead Publishing Limited, 2010