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Analysis and Design of Cable Stayed Bridge.

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Abstract – Cable Stayed Bridges are one of the most fascinating icons in the field of Engineering and are commonly used bridge typologies for spans between 200m and 1100mm due to their structural efficiency, cost and aesthetics. The basic structural form of a cable-stayed bridge is a series of overlapping triangles comprising the pylon, the cables, and the girder. All these members are under predominantly axial forces, with the cables under tension and both the pylon and the girder under compression. Axially loaded members are generally more efficient than flexural members. This contributes to the economy of the bridge. In this project, we have made an attempt to analyses a 200m span Cable Stayed Bridge using the STAAD Pro software based on the design parameters which includes the bending moment, shear force and displacement, Reaction Graph, Total Quantity Materail, etc.

Key Words: Cable Stayed Bridges, Unknown Load Factor Optimization, Construction Stage Analysis, Influence Line Diagram (ILD), SFD BMD Diagram, Analysis Design.

1.INTRODUCTION

In the recent years cable stayed bridges have received more attention than any other bridge mainly, in the United States, Japan and Europe as well as in third-world counties due to their ability to cover large spans. Cable-stayed can cross almost 1000m (Tatara Bridge, Japan, Norman die Bridge, France) In India few of the cable stayed bridges are constructed and a couple of them are underway. Like Bandra - Worli sea link, Second Hoogly Bridge are the finest example of application of cable stayed bridge in India. Cable stayed bridges for road over bridge in Bangalore and Chennai have come up and a cable stayed road over bridge is proposed in various smaller emerging cities. There is still place for innovation in Cable-stayed bridge techniques. The achievement of man has been attributed to how large; long and tall he can create the structures around him. From the very beginning of the human race he has been trying to prove that he can create some very astonishing and amazing structures around him, like Pyramids of Egypt. After end of World War II there was shortage of construction materials like steel and cement thereby need to obtain optimum structural performance from these materials became necessary. New systems and technologies were evolved to meet these requirements

What is a Cable-Stayed Bridge?

A cable-stayed bridge is a cable supported bridge in which one or multiple pylons are installed in the middle of the bridge and girder segments are connected to the pylons by a cable. In cable-stayed bridges, the shape of pylons, the shape of girders, and the cable arrangement can be freely designed; therefore, various structural systems can be applied.

Cable stayed bridges are constructed along a structural system which comprises of a deck and continuous girders which are supported by stays in the form of cables attached to tower located at the main piers. Stiffness of the overall structure can be provided by stiff towers or can be stiffened by taking backstays to individual or by employing intermediate tension piers or combination of the stiffness of the main span, the tower and the back span, credited to several advantages over suspension bridges, predominantly being associated with the relaxed foundation requirements, with the introduction of high-strength steel, development of welding technology and progress in structural analysis and new construction technique which is very much in vogue. The development and application of computers opened up new and practically unlimited possibilities for the exact solution of these highly statically indeterminate systems and for precise statically analysis of their three-dimensional performance. This leads to economic benefits which can favor cable-stayed bridges in free spans of up to 1000m. In the twentieth century the development and research has take place enormously in the field of the bridge engineering to fulfil the need of the very long span bridges. With development of new materials and techniques for analysis of very long span cable supported structures came into practice. For very long span bridges the high strength steel cable are used as a structural load resisting elements. Some importance of cable supported bridges is illustrated here

1.2 OBJECTIVES

1. To Study Need of Cable Stayed Bridge is illubrasted along with the structural components.
2. Analysis of cable stayed bridge using STAAD Pro.
3. Study the displacement of cable stayed bridge, deck slab and pylon under the combined action of seismic loads and imposed loads
4. Analysis of bridge in Static condition.

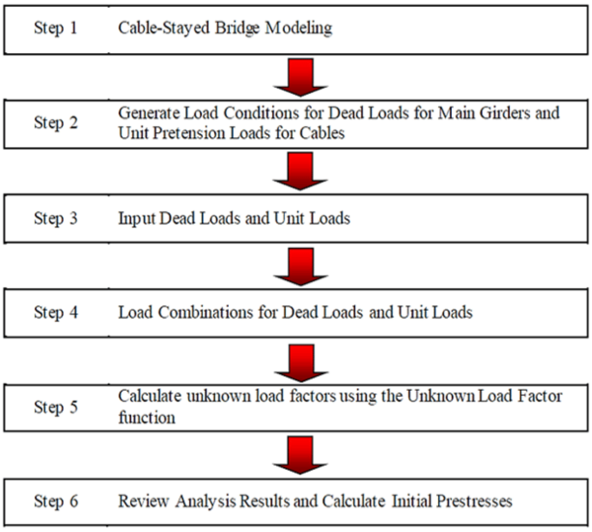
2. METHODOLOGY

A cable-stayed bridge is a remarkable engineering marvel. In this bridge form, the weight of the deck is supported by a number of nearly straight diagonal cables in tension, which run directly to one or more vertical towers. These towers then transfer the cable forces to the foundations through vertical compression.

2.1 Advantages of cable stayed bridge

- Used for larger span.
- Greater stiffness that suspension bridge, so deformation of deck under live load is reduced.
- Cantilever type of construction is followed.
- Cables act as both temporary and permanent support.

- Symmetrical bridge, the horizontal forces are balance hence no large ground anchorage needed.



3. ANALYSIS USING STAAD PRO SOFTWARE

Present work involves parametric study of cable-stayed bridge with fix common parameters. Analysis is done in computer aided software Staad Pro as per Indian Standards. This bridge is analyses for span of 200 m,

Description	Data
Total Span Of Bridge	200m
Width Of Bridge	16m
Number Of Cables	78
Beam Size	0.75×0.40m
Thickness	0.3m
Support Types	Fixed Support

3.1 The analysis steps for a cable-stayed bridge include :

- Deck design formation
- Deck erection
- Static analysis
- Modeling of the cable stayed bridge
- Dynamic analysis
- Designing of the pylon dimensions
- Designing of the steel girder
- Designing of the deck slab
- Side span to main span ratio
- Upper strut height
- Cable system
- Number of cables per plane
- Cable diameter

3.3. MODELING

1. Draw the geometry of the bridge by inserting coordinates.
2. Define the materials and sections for the members.
3. Define the loading values to be applied on the structures.
4. Now assign the defined section as the members.
5. After assigning everything, set the analysis to be carried out and press run analysis.
6. STAAD Pro will generate the various results like joint displacements, joint behaviors of the different shapes of pylon forces, joint reactions, base reactions, deck force, axial forces in cables and pylons, bending moment in pylon, shear force in pylon, mode shapes etc.

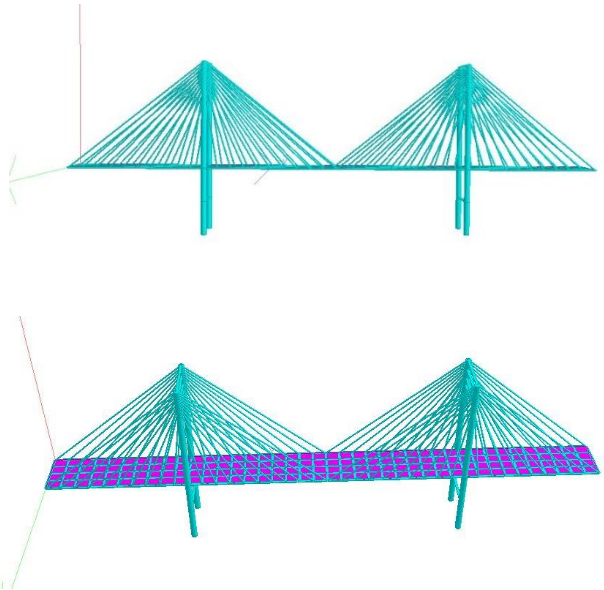


Fig No 1 3D view / Rendering.

4. RESULTS AND DISCUSSION

4.1 Steel Take Off

Total Volume of prismatic steel section = 376.80 cu.m

STEEL TAKE-OFF:

PROFILE	LENGTH(M)		WEIGHT(KN)
ISA150X150X16	3916.34		28945.316
	TOTAL	=	28946

4.2 Concrete Take Off

(For Beams, Columns And Plates Designed Above)

NOTE: CONCRETE QUANTITY REPRESENTS VOLUME OF CONCRETE IN BEAMS, COLUMNS, AND PLATES DESIGNED ABOVE.

Reinforcing Steel Quantity Represents Reinforcing Steel In Beams And Columns Designed Above

TOTAL VOLUME OF CONCRETE = 405.1 CU.METER

Bar Dia (In mm)	Weight (In New)
8	60679
10	106197
12	165284
16	87231
20	88271
Total =	279356

4.3 Pylon

Diameter of Pylon = 3500mm

4.4 Cables

Diameter of each Cable =7mm

No of strands cables =55

Total Number of cables =78

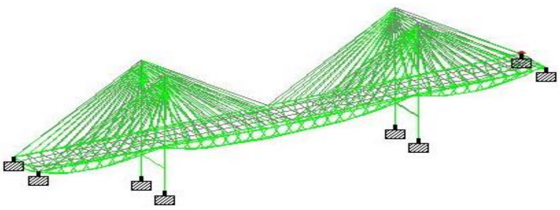


Fig No 2 Displacment

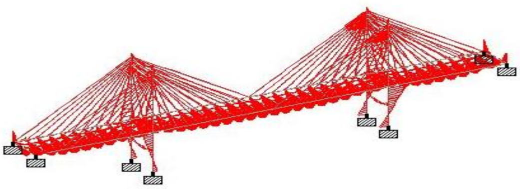


Fig No 03 Bending Z

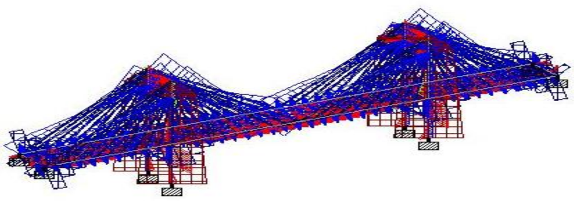


Fig No 04 Torsion : Axial Force : Share Z : Share Y: Bending Z :Bending Y

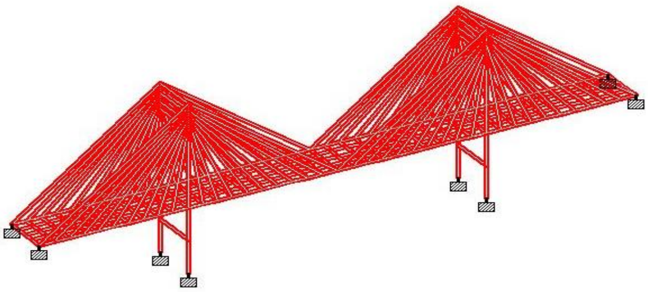


Fig No 04 Self Weight

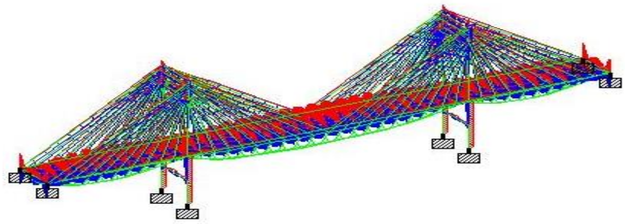


Fig No 05 : Beam Stress

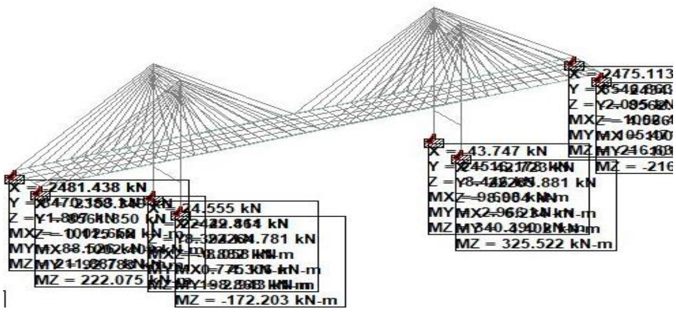


Fig No 06 Reaction

5. VALIDATION OF RESULT MANUALLY

For validation we are Validate Result For manually calculation data as per given in model Beam no 1 Parameter is Given below for validation

Given Data : 1)Mu = 619.01KN.m

2) Fy =190.47 KN.m

Solution :

$$Mu=0.87.Fy\times Ast\times d[1-\frac{Ast.Fy}{bd\times fck}]$$

$$619.01=0.87\times 500\times Ast\times 370[1-\frac{Ast\times 500}{(370\times 750\times 30)}$$

Ast = 6029.32 mm^2 (required)

Ast = 6197.16 mm^2 (provided)

After the validation we are Validate Our Answer to Staad pro Result and Its Validate Correct to Staad Pro Calculation And Manually Calculation Is Done.

6.CONCLUTION

1. As per the details above calculation we got to know overall depth of deck, Number of cables and the load occurrence on the bridge.
2. We also got to know if there would be regular bridge deck span it would be cost more and also time consuming hence cable styed bridge provide more longer span and less support which offer less time in construction and less cost due to which the life of structure increases
3. The cable stayed bridges has much greater stiffness than the suspension bridges, so that deformation of deck are reduced.
4. Cable stayed bridges were highly statically indeterminate structures and in order to find out exact solution of these highly indeterminate systems and analyses the cable stayed bridge.
5. Cable stayed bridges have much greater stiffness since the cables can handle more pressure.
6. Here different cables, towers and cable arrangements are considered for the study.
7. The difference between cable stayed bridge and suspension bridge lies in how the cables are connected to the towers.
8. In cable stayed bridge cables are directly connected to an incline to bridge tower.

9. Loading is transmitted to the foundation in sequence as:

- To the deck
- To the stay cable
- To the bridge tower
- And lastly to the foundation.

10. In suspension bridge the cable rides freely across the tower transmitting the load to the anchorages at either end.

11. For the future scope of this project, the obtained bending moment and shear force data can be used to design the different components of the structure.

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