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Dynamic Analysis of Cable Stayed Bridge for Various Cable Patterns

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Abstract – *This paper deals with the study of dynamic analysis of cable stayed bridge for various cable patterns. It is to be shows in prominent aspect for this analysis of cable Stay Bridge. In cable stay bridge cable transmitted the reaction forces of deck to pylon. Pylon transmitted the load of cable to foundation. There used same criteria for pylon height. Various Types of Patterns of CSB i.e. semi fan, fan & harp arrangement were considered. With the help of using STAAD software modelling & analysis are done. Various parameter like cable forces, axial forces, displacement, bending moment etc. are analyzed for three types of cable patterns. Also the results are compared of three models of cable stayed bridge.*

Keywords- Cable patterns, Cable configuration, IRC-6-2016, STAAD Pro.

INTRODUCTION

It is a type of bridge which has one or more towers (or pylons), it has cable support to the bridge deck, cables hold the deck by connecting it towers, and these bridge is called as cable stayed bridge. These bridge are very economical for long spans. A distinctive feature are the cables or stays. Which run directly from the tower to the deck, it normally forming fan like pattern. It is similar to the suspended bridge. Where the cable supporting the deck are suspended vertically from the main cable, it anchored at the both ends of bridge running between the towers. The cable stayed bridge is optimal for span longer than cantilever bridges and shorter than the suspension bridge. As traffic pushes down on the road way is attached, transfer load to the towers, compression force which act on the towers, tension is acting on the cables which are stretched because they are attached to the RCC deck or roadway.

Cables are made of high strength steel and it covers in a plastic or steel. Steel covering that is filled with grout and fine grained form of concrete for protection against corrosion.

A cable may be composed one or more structural ropes, structural strands, locked coil strands or parallel strands. A strand is an assembly of wire formed helically around center wire in one or more symmetrical layers. A strand can be used as an individual load carrying member, where the radius or curvature is not major requirement.it is component in the manufacture of the structural rope.

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.

METHODOLOGY

- Creating model of cable stayed bridge in STAAD Pro.
- Defining material & sectional properties to all members of cable stayed bridge.
- Creating a load case 1 for adding self weight after analyzing self weight analysis from menu bar run analysis.
- Defining roadway to bridge deck. Go to mode bridge deck from menu bar & select deck after create deck as a name deck 1.define new road way. Selecting custom enter length of bridge and orientation, creating the curb on lane & see lane on roadway.
- Applying vehicle definition from menu bar select vehicle data base, enter IRC Class A wheel loading and IRC Class 70 R wheel loading.

- Going to post processing mode and see the result of maximum displacement value & check the reactions , node no. where supports are assign direction & effect (+ve or –ve) click ok.
- Applying all load combination & response spectrum factors as per IRC6: 2016 & IS 1893:2016 Part 1.
- After completing load generation click on ok & go to modelling, expand all load case details

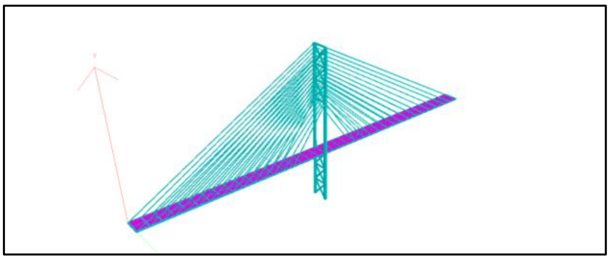

Fig 1: Model of CSB semi fan type(3D View)

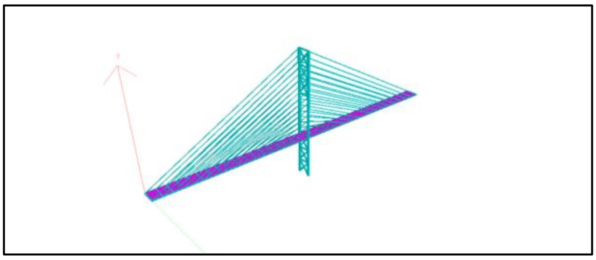

Fig 2: Model of CSB Harp Type (3D View)

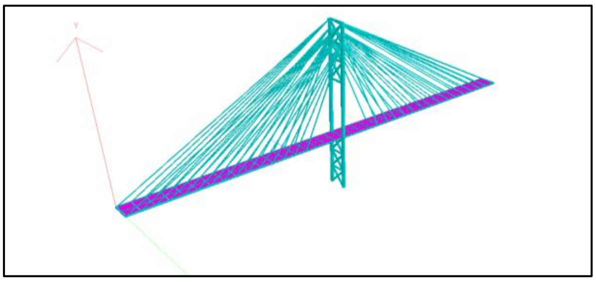

Fig3: Model of CSB Fan Type (3D view)

Model Specification:

1. Total Span of Cable stayed bridge = 200m

2. Carriage way width = 8m

3. Height of Pylon above deck slab level= 60m.

4. Height of Pylon Below deck slab level =30m

5. c/c distance between cross girder=5.72m

6. Dimension of Components

1. Diameter of Pylon = 1m

2. Cross Section of longitudinal Girder =0.40x0.60m

3. Cross Section of cross girder = 0.40 x 0.80m

4. Thickness of deck slab = 0.3 m

5. Diameter of cable = 0.3 m

6. Dimension of Components

1. Diameter of Pylon = 1.5m
2. Cross Section of longitudinal Girder = 0.40x0.60m
3. Cross Section of cross girder = 0.40x0.80m
4. Thickness of deck slab = 0.3 m
5. Diameter of cable = 0.3 m

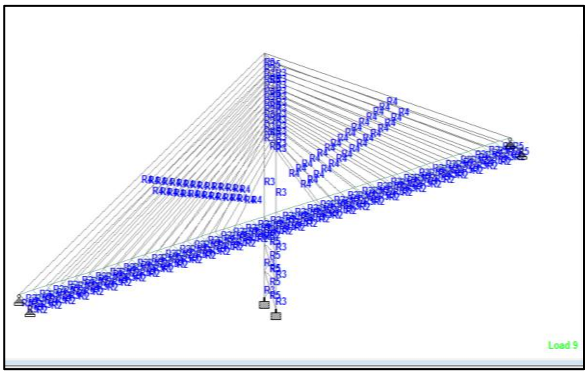

Fig4: Applying Section Property

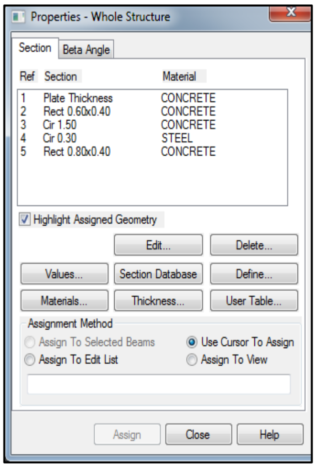

Fig4: Defining Section Property

Wheel load arrangement as per IRC:

For bridge classified under clause the design live load shall consist of standard wheeled or tracked vehicles or trains of vehicle.

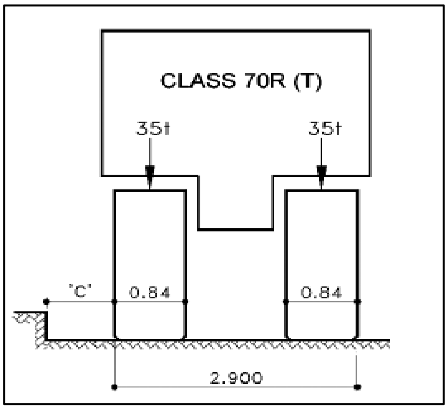

Fig9: Width of Class 70R Vehicle

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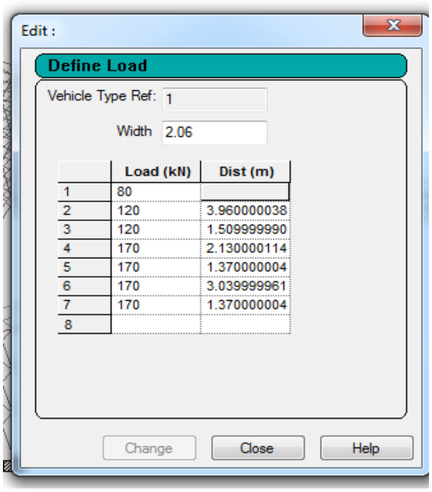


Fig10: Wheel load assign

Class A Loading:

This is adopted on all roads on which permanent bridges and culverts are constructed .It consist of wheel load train comprising a driving vehicle and two trailers of specified axle loading varying from 2.7 to 11.4 tones .

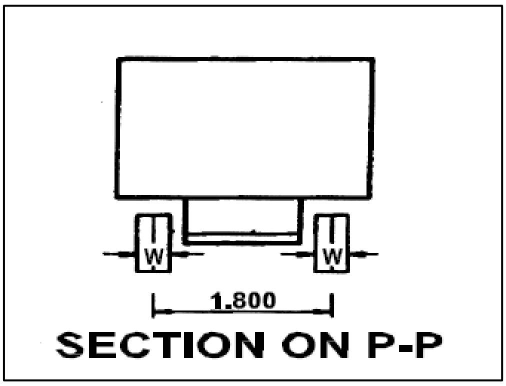


Fig11:Class A Loading

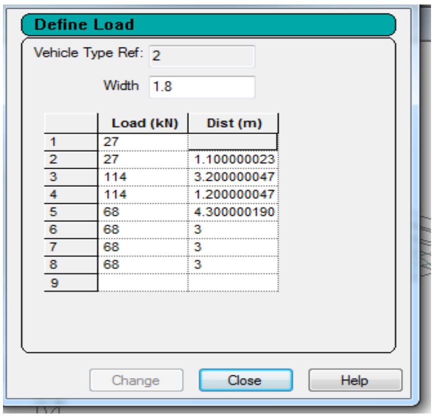


Fig 12; Wheel load assign

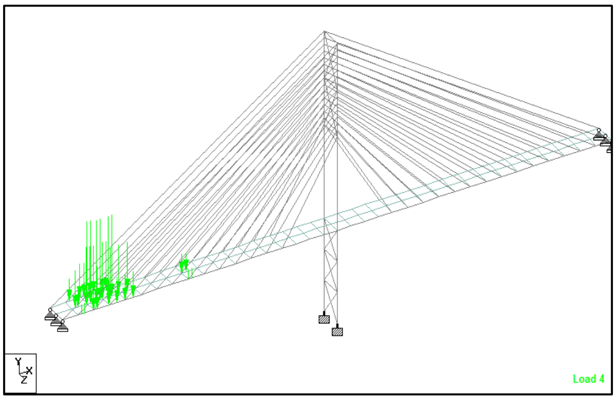


Fig 13: Moving load on lane

Wind force Calculation:

The wind load is calculated as per IRC: 6-2016 Clause 209.3.3 page no. 35

Therefore, $F_T = P_z \times A_1 \times G \times C_D$

$= 729 \times 200 \times 8 \times 0.3 \times 2 \times 1.1$

$= 769$ kN/ m

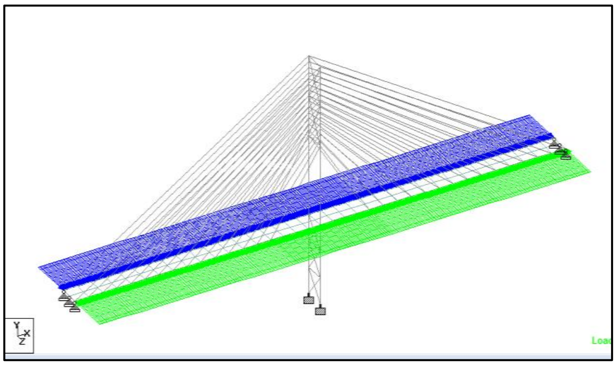


Fig 14: Wind force Apply on Deck Slab

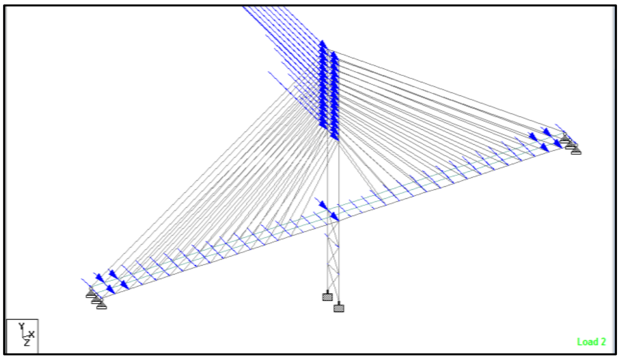


Fig 15: Seismic force apply on bridge

Seismic Force Parameters as per IS 1893:2016:

Zone II= 0.10 (zone factor)

Importance factor = 1.5

Type of structure = 1

Damping ratio= 0.05

Load combinations:

In the limit state design of reinforced and prestressed concrete structures, the following load combinations shall be accounted for as per IS 1893:2016::

1) 1.5 (DL +LL)
2) 1.2 (DL+LL+EQZ)
3) 1.5(DL+EQZ)
4) 0.9 DL+1.5EQZ

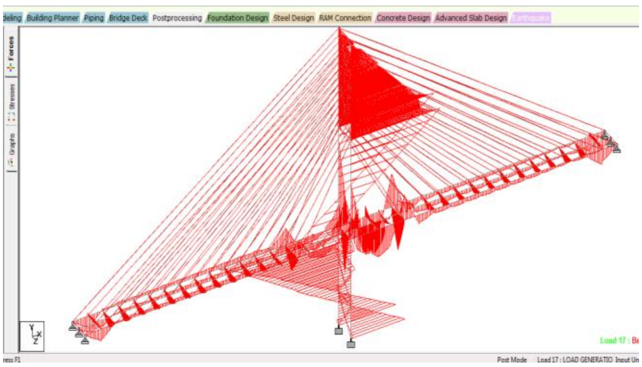


Fig 16: Bending Moment Diagram(M-01)

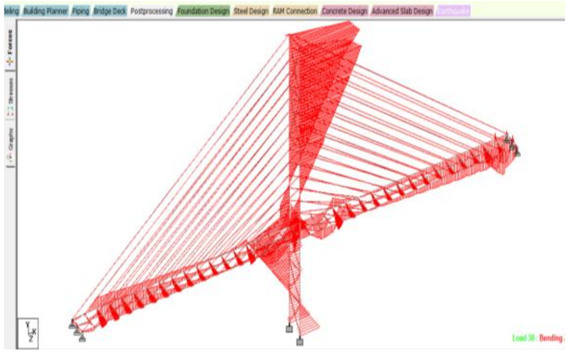


Fig 17: Bending Moment Diagram (M-02)

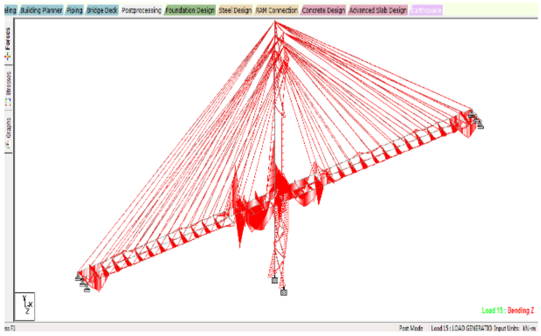


Fig 18: Bending Moment Diagram (M-03)

Result Analysis And Graphical Representation:

1. Maximum and Minimum Axial Force in Pylon in Semi Fan Type Pattern Bridge:

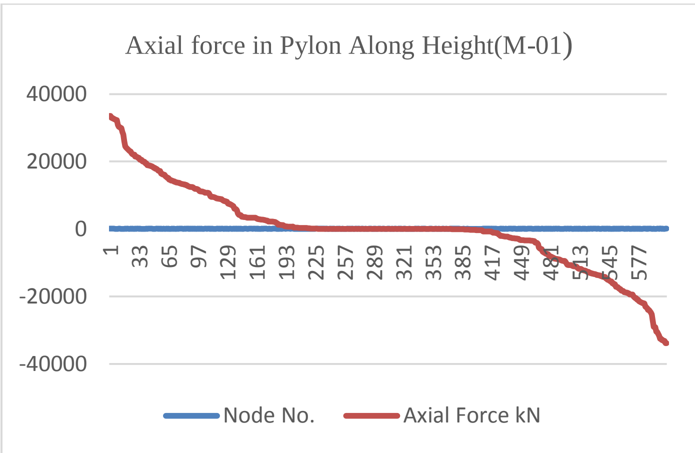


Fig 19. Axial Force In Pylon (M-01)

Maximum Axial Force: 37576.35 kN

Minimum Axial Force: -37853.9 kN

2. Maximum and Minimum Axial Force in Pylon in Harp Type Pattern Bridge:

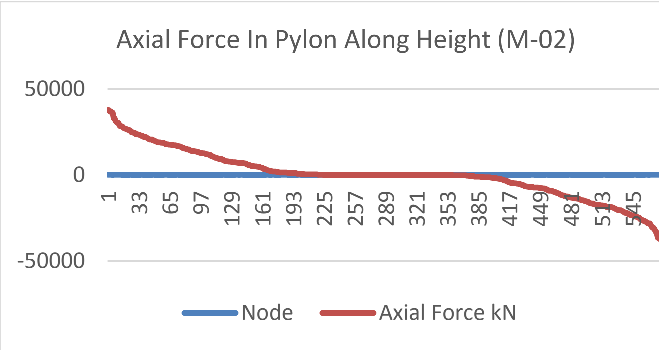


Fig20. Axial Force in pylon (M-02)

Maximum Axial Force: 37576.35 kN

Minimum Axial Force: -37853.9 kN

3.Maximum and Minimum Axial Force in Pylon in Fan Type Pattern Bridge:

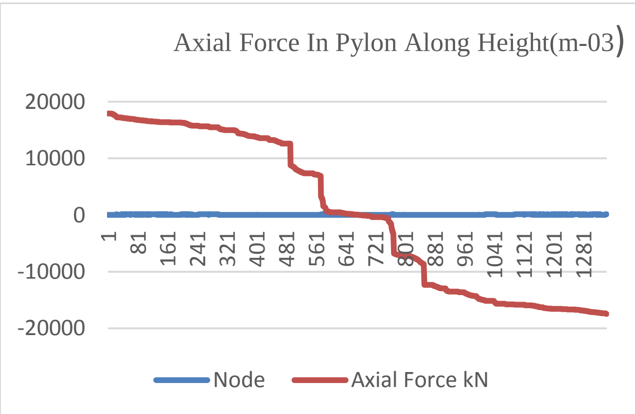


Fig21. Axial Force in pylon (M-03)

Maximum Axial Force: 17921.02kN

Minimum Axial Force: -17469.4 kN

MODEL- 01		MODEL-02		MODEL-03	
Beam No.	Mz. kNm	Beam No.	Mz. kNm	Beam No.	Mz. kNm
3	-4251.23	3	18670.87	3	475.012
296	40.235	61	0	272	32.747
45	8681.525	3	18670.87	6	1232.846
45	-8467.66	3	-18382.9	136	1353.05
					8
126	0	80	-382.283	7	0
4	-0.001	3	0	3	0
90	9080.145	169	-187.658	6	1470.007
90	-9090.34	169	-183.367	136	-737.633
90	0	3	0	3	0
90	0	12	0.001	3	0
38	18942.45	4	22426.41	8	2536.59
38	-18930.2	4	-22596.7	8	-2483.11

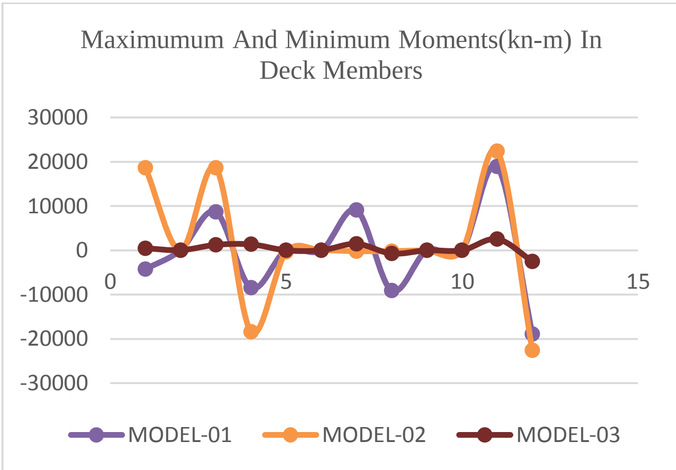
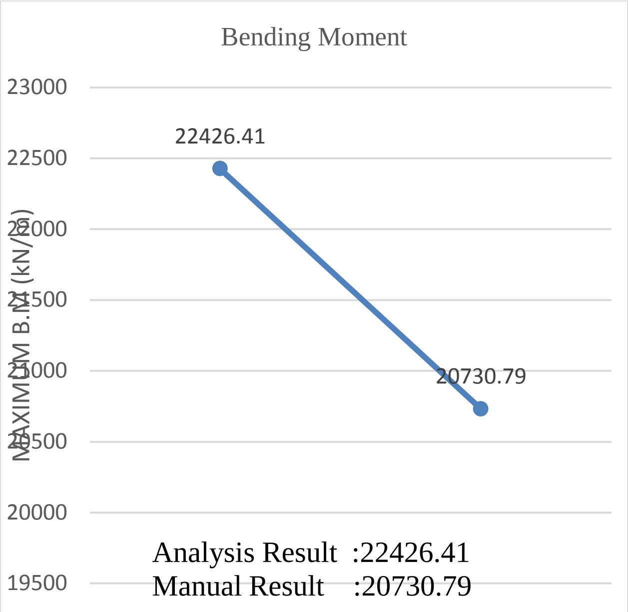


Fig21: Maximum and Minimum Moment (kN-m)

Variation of Tension Forces in Cables:

Cable No	M-01(Kn)	M-02(Kn)	M-03(Kn)
1	4150.84	3389	4805
2	527.13	636.43	434.29
3	1388.05	1383.11	1390.56
4	1150.96	1192.09	1114.03
5	1016.08	1085.85	982.08
6	966.92	1048.89	931.68
7	916.08	1021.00	888.59
8	864.07	991.19	832.83
9	806.11	958.49	789.55
10	752.17	941.04	712.66
11	697.413	929.44	709.84
12	646.41	919.75	640.56
13	605.36	852.57	618.54
14	326.26	1057.23	417.30
15	984.88	2966.67	965.68

Analysis of Bending Moment:



CONCLUSION

- As per IRC 6: 2016 standards all dimension of bridges are taken .
- The bridge is designed as per load case of IS:1893 :2016.
- The load cases are dead load , live load ,seismic load and wind load has been analyzed
- Wheel load combination is Class 70 R and Class A is used as per IRC6:2016.
- Compared result of three various types of cable patterns bridge by graphical representation.
- Variation of cable forces are analyzed for various cable patterns.
- Bending moment diagrams are analyzed.
- Maximum and Minimum axial force are analyzed for pylon along height for various cable patterns.
- Wind force applying on bridge as per Clause of IRC 6: 2016 as per clause 209.3.3.
- The analysis provides complete guidelines for STAAD pro analysis .This properly used for various types of cable pattern bridges.
- STAAD pro gives quick result of analysis.
- The Maximum Bending Moment on deck slab compared to software result and manual calculation.
- The analysis of Cable Stayed Bridge is carried out by using STAAD Pro. These result including displacement, axial force, bending moment and tension forces in cables.

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