Analysis of Cable Stayed Bridge Using CSiBridge Software

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Abstract - *Cable stayed bridges have developed as the prevailing basic framework for long range connect intersections during the previous thirty years. This achievement is because of a blend of specialized headway's and satisfying feel properties. The connection of the different basic parts brings about an effective structure which is ceaselessly advancing and giving new techniques to build such long span bridges.*
The objective of this project is to analyse the cable stayed bridge for moving loads as per IRC code specifications. The results were evaluated in terms of Reactions of pylon, bending moment of the deck, shear force of the deck, cable forces, displacement of the deck and displacement of the pylon. For analysing the bridge CSiBridge software is used due to its advanced modelling features.

Key Words: **Cable stayed bridge, CSiBridge software, Modelling, Analysing, Moving loads, Displacement, Cable forces**

1.INTRODUCTION

In the ongoing years cable stayed bridges have gotten more consideration than some other bridges basically, in the United States, Japan and Europe just as in third-world areas because of their capacity to cover enormous ranges. cable stayed can cross practically 1000m (Tatara Bridge, Japan, Norman pass on Bridge, France) In India not many of the cable stayed bridges are built and several them are in progress. Like Bandra-Worli ocean connect, Second Hoogly Bridge are the best case of utilization of cable stayed connect in India. cable stayed bridge for street over extension in Bangalore and Chennai have come up and a cable stayed street over bridge is proposed in different littler developing urban communities. There is still spot for advancement in Cable-stayed connect procedures. The accomplishment of man has been credited to how huge; long and tall he can make the structures around him. From the earliest starting point of humankind, he has been attempting to demonstrate that he can make some shocking and astounding structures around him, similar to Pyramids of Egypt. After finish of World War II there was deficiency of development materials like steel and concrete consequently need to acquire ideal auxiliary execution from these materials got fundamental. New frameworks and advancements were developed to meet these prerequisites.

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 bridge 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 in welding technology and progress of structural analysis and new construction methods as well as 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 favours cable-stayed bridges in free spans of up to 1000m. In the twentieth century the development and research has taken 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 is used as a structural load resisting element.

Fig -1: Cable Stayed Bridge, Goa

1.1 Objectives

1. Creating the model of Cable stayed bridge using CSiBridge software.
2. Study the displacement of cable stayed bridge deck and pylon under the combined action of Dead loads and Moving loads.
3. Check the response of Cable stayed bridge deck under moving loads.

1.2 Methodology

Methodology of the project is shown in the flowchart.

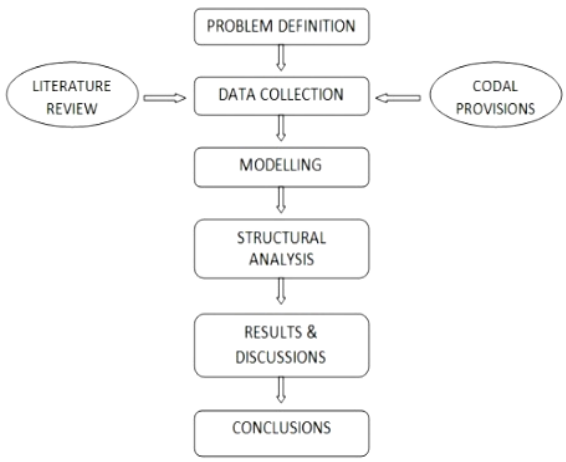

Fig -2: Methodology

2. MODELLING AND DETAILS OF STRUCTURE

The modelling and analysing of cable stayed bridge is done using CSiBridge software.

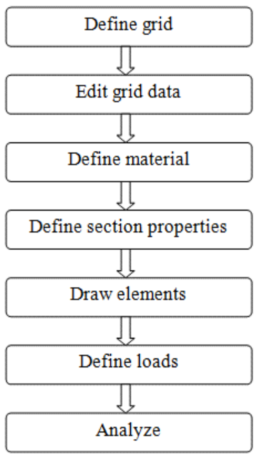

Fig -3: Steps in Modelling

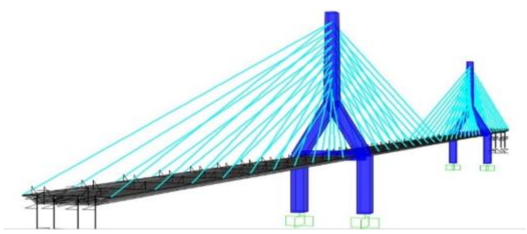

Fig -4: 3D Model

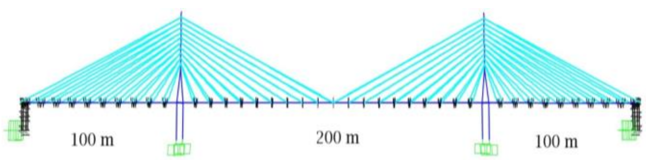

Fig -5: Bridge Spans

2.1 Deck Details

Type	:	Concrete Box Girder (Sloped)
Bridge length	:	400 m
Span	:	100m+200m+100m
Width	:	11.5 m.
Depth	:	1.8 m.
Top Slab	:	0.3 m.
Bottom Slab	:	0.2 m.
Exterior Girder	:	0.3 m.
Interior Girder	:	0.3 m.
Lane	:	2 Nos. (3.75m Each)
Side Walk	:	1.5 m.

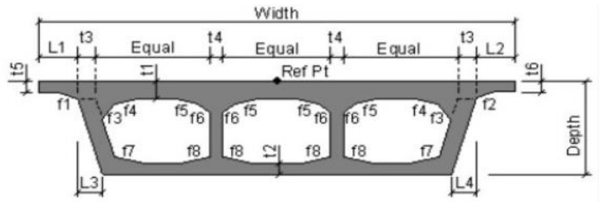

Fig -6: Deck Details

2.2 Pylon Details

Type	:	A – Shape
Material	:	Concrete
Total Height	:	70m (20m+50m)
Pylon Bottom	:	(3m X 3m)
Intermediate	:	(3m X 3m)
Tapered section	:	(2.5m X 2.5m)

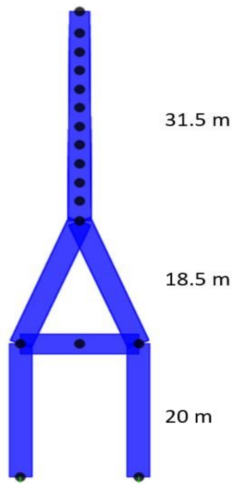

Fig -7: Pylon Details

2.3 Cable Data

Type	:	Fan Type
Dia. of Tendon	:	0.2 m
Dia. of Wires	:	3 mm

The cables are placed at an angle between 25°- 65°.
The cables are connected to Deck at an interval of 10m.
The cables are connected to Pylon at an interval of 2.8m.

2.4 Loads

1 Dead Load
2 Moving Load (Live Load)
- IRC Class-A
- IRC Class-AA Tracked

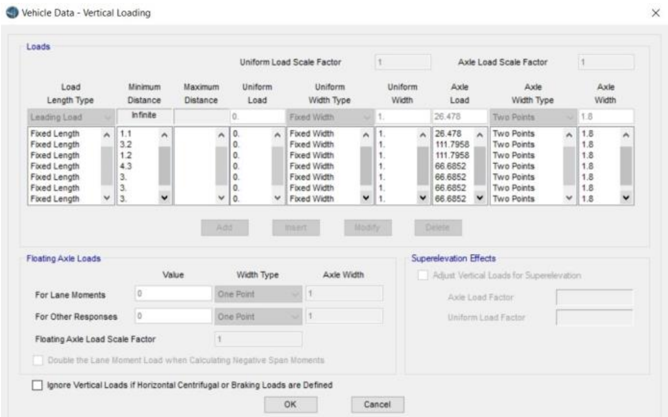

Fig -8: IRC Class-A Vehicle Loading in Software

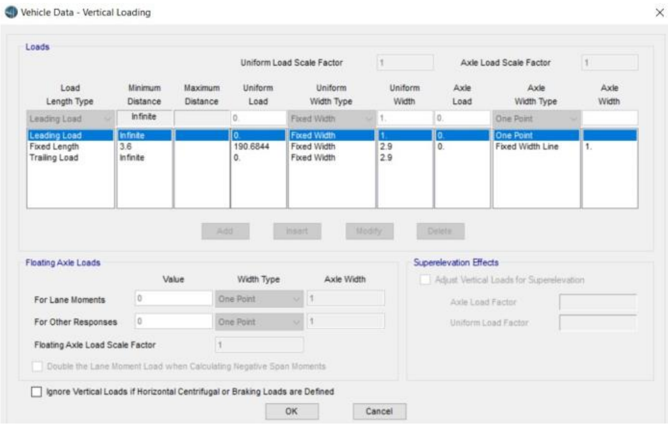

Fig -9: IRC Class- AA Tracked Vehicle Loading in Software

2.5 Load Combinations

DL+ML(A)
DL+ML(AA)
DL+1.5 ML(A)
DL+1.5 ML(AA)
1.35 DL+1.5 ML(A)
1.35 DL+1.5 ML(AA)

Where, DL is the Dead load
ML is the Moving load
AA is the IRC Class AA tracked loading
A is the IRC Class A loading

3. RESULTS AND DISCUSSION

Results are proposed to investigate the behavior of cable stayed bridge. As per the objective of this report the displacements of deck must be within the allowable limit.

3.1 Pylon Reactions

Table -1: Pylon Reactions

Load Combination	Reaction in kN
DL+ML A	44442
DL+ML AA	44609
DL+1.5ML A	44816
DL+1.5ML AA	45067
1.35DL+1.5ML A	60108
1.35DL+1.5ML AA	60359

3.2 Bending Moments of the Deck

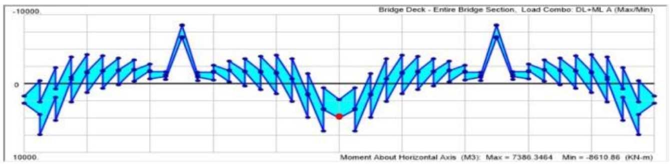

Fig -10: BMD for (DL+ML A)

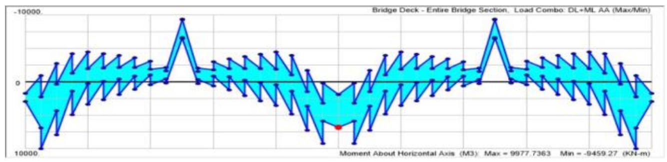

Fig -11: BMD for (DL+ML AA)

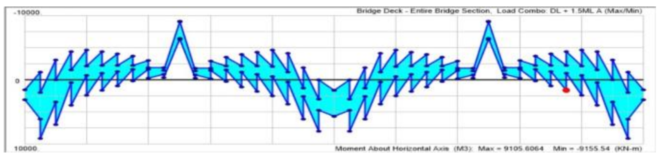

Fig -12: BMD for (DL+1.5ML A)

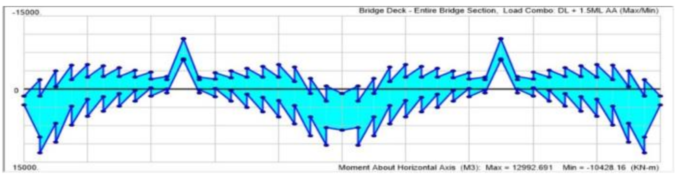

Fig -13: BMD for (DL+1.5ML AA)

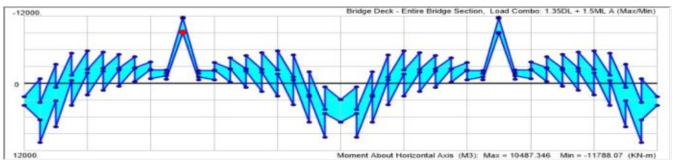

Fig -14: BMD for (1.35DL+1.5ML A)

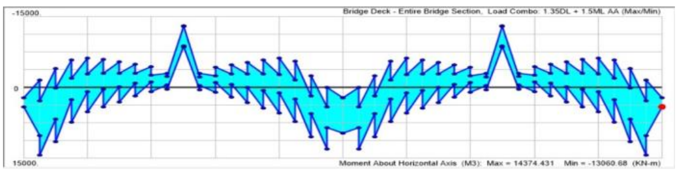

Fig -15: BMD for (1.35DL+1.5ML AA)

Table -2: Bending Moments of the Deck

Load Combination	BM in kN-m	
DL+ML A	Max.	7386.35
	Min.	-8610.86
DL+ML AA	Max.	9977.74
	Min.	-9459.27
DL+1.5ML A	Max.	9105.61
	Min.	-9155.54
DL+1.5ML AA	Max.	12992.69
	Min.	-10428.16
1.35DL+1.5ML A	Max.	10487.35
	Min.	-11788.07
1.35DL+1.5ML AA	Max.	14374.43
	Min.	-13060.68

3.3 Shear Force of the Deck

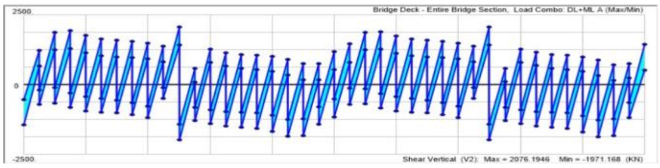

Fig -16: SFD for (DL+ML A)

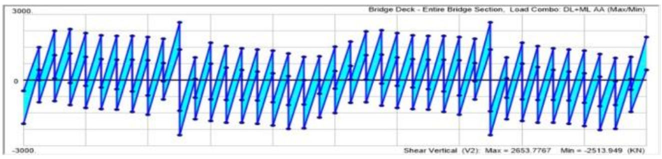

Fig -17: SFD for (DL+ML AA)

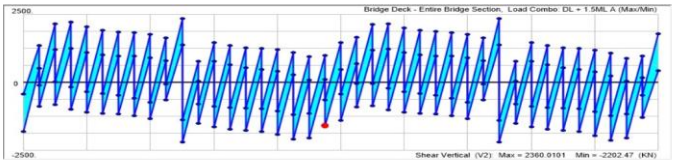

Fig -18: SFD for (DL+1.5ML A)

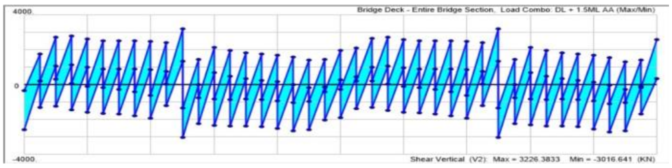

Fig -19: SFD for (DL+1.5ML AA)

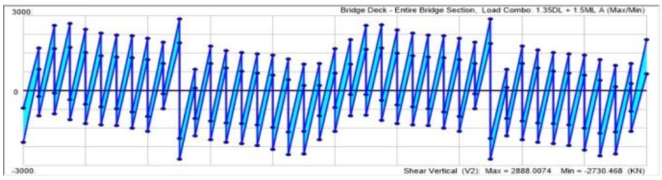

Fig -20: SFD for (1.35DL+1.5ML A)

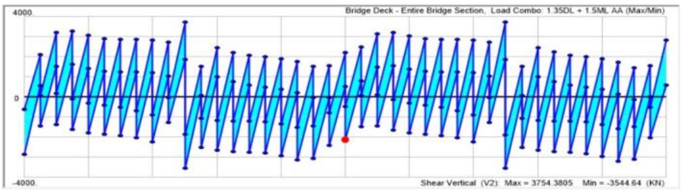

Fig -21: SFD for (1.35DL+1.5ML AA)

Table -3: Shear Forces of the Deck

Load Combination	SF in kN	
DL+ML A	Max.	2076.19
	Min.	-1971.17
DL+ML AA	Max.	2653.77
	Min.	-2513.95
DL+1.5ML A	Max.	2360.01
	Min.	-2202.47
DL+1.5ML AA	Max.	3226.38
	Min.	-3016.64
1.35DL+1.5ML A	Max.	2888.01
	Min.	-2730.47
1.35DL+1.5ML AA	Max.	3754.38
	Min.	-3544.64

3.4 Cable Force

Table -4(a): Cable Forces

S.No	Distance	DL+ML A	DL+ML AA
	m	kN	kN
1	0	-3017.2	-2750.0
2	10	-9826.4	-10180.2
3	20	-14967.2	-15351.3
4	30	-19748.4	-20126.1
5	40	-23912.3	-24278.1
6	50	-27462.0	-27821.8
7	60	-30433.8	-30792.6
8	70	-32835.7	-33194.8
9	80	-34576.0	-34935.4
10	90	-35182.6	-35544.2
11	100	-34036.3	-34504.1
12	110	-33481.5	-33959.0
13	120	-31749.0	-32225.9
14	130	-29373.6	-29865.9
15	140	-26391.2	-26899.6
16	150	-22736.7	-23245.5
17	160	-18337.8	-18812.3
18	170	-13226.1	-13619.3
19	180	-7857.3	-8150.9
20	190	-2768.9	-2953.5
21	200	-1486.6	-1315.0
22	210	-2768.9	-2953.5

23	220	-7857.3	-8150.9
24	230	-13226.0	-13619.3
25	240	-18337.8	-18812.3
26	250	-22736.7	-23245.5
27	260	-26391.2	-26899.6
28	270	-29373.6	-29865.9
29	280	-31749.0	-32225.9
30	290	-33481.5	-33959.1
31	300	-34036.3	-34504.1
32	310	-35182.6	-35544.2
33	320	-34576.0	-34935.4
34	330	-32835.7	-33194.8
35	340	-30433.8	-30792.6
36	350	-27462.0	-27821.8
37	360	-23912.4	-24278.1
38	370	-19748.4	-20126.1
39	380	-14967.2	-15351.3
40	390	-9826.4	-10180.2
41	400	-3017.2	-2750.0

Table -4(b): Cable Forces

S.No	Distance	DL+1.5 ML A	DL+1.5 ML AA
	m	kN	kN
1	0	-2598.6	-2197.7
2	10	-10426.4	-10957.1
3	20	-15619.6	-16195.8
4	30	-20391.5	-20958.0
5	40	-24537.8	-25086.5
6	50	-28078.7	-28618.4
7	60	-31048.6	-31586.8
8	70	-33450.4	-33989.1
9	80	-35190.9	-35729.9
10	90	-35803.8	-36346.3
11	100	-34893.2	-35594.9
12	110	-34358.2	-35074.5
13	120	-32629.9	-33345.2
14	130	-30267.3	-31005.7
15	140	-27280.3	-28042.8
16	150	-23580.8	-24343.9
17	160	-19085.3	-19797.0
18	170	-13833.6	-14423.4
19	180	-8328.7	-8769.0
20	190	-3100.8	-3377.6
21	200	-1177.3	-919.9
22	210	-3100.8	-3377.6
23	220	-8328.7	-8769.1
24	230	-13833.6	-14423.4
25	240	-19085.3	-19797.1
26	250	-23580.8	-24344.0
27	260	-27280.2	-28042.8
28	270	-30267.3	-31005.7
29	280	-32629.9	-33345.2
30	290	-34358.2	-35074.5
31	300	-34893.2	-35594.9
32	310	-35803.8	-36346.3
33	320	-35190.9	-35730.0
34	330	-33450.4	-33989.1
35	340	-31048.6	-31586.8
36	350	-28078.7	-28618.4
37	360	-24537.9	-25086.5
38	370	-20391.5	-20958.0
39	380	-15619.6	-16195.8
40	390	-10426.4	-10957.1
41	400	-2598.6	-2197.7

Table -4(c): Cable Forces

S.No	Distance	1.35DL+1.5 ML A	1.35DL+1.5 ML AA
	m	kN	kN
1	0	-3947.6	-3546.8
2	10	-13445.6	-13976.3
3	20	-20401.4	-20977.6
4	30	-26853.3	-27419.8
5	40	-32469.3	-33018.0
6	50	-37258.7	-37798.4
7	60	-41270.1	-41808.3
8	70	-44512.6	-45051.3
9	80	-46862.1	-47401.1
10	90	-47682.8	-48225.3
11	100	-46206.0	-46907.7
12	110	-45463.0	-46179.3
13	120	-43125.4	-43840.8
14	130	-39922.4	-40660.9
15	140	-35894.8	-36657.4
16	150	-30947.8	-31710.9
17	160	-24980.3	-25692.0
18	170	-18037.4	-18627.3
19	180	-10748.8	-11189.1
20	190	-3837.6	-4114.4
21	200	-1914.1	-1656.7
22	210	-3837.6	-4114.4
23	220	-10748.8	-11189.2
24	230	-18037.4	-18627.3
25	240	-24980.3	-25692.0
26	250	-30947.8	-31711.0
27	260	-35894.8	-36657.4
28	270	-39922.4	-40660.9
29	280	-43125.4	-43840.8
30	290	-45463.0	-46179.3
31	300	-46206.0	-46907.7
32	310	-47682.8	-48225.3
33	320	-46862.1	-47401.1
34	330	-44512.6	-45051.3
35	340	-41270.1	-41808.3

36	350	-37258.7	-37798.4
37	360	-32469.3	-33018.0
38	370	-26853.3	-27419.8
39	380	-20401.4	-20977.6
40	390	-13445.6	-13976.3
41	400	-3947.7	-3546.8

3.5 Displacement of Deck

The maximum displacement of the deck is observed at 200m.

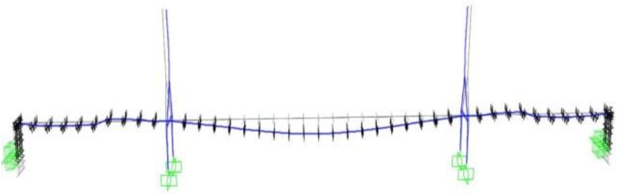

Fig -22: Deformed Shape of the Deck

Table -5: Vertical Displacement of the Deck

Load combination	Displacement in mm
DL+ML A	104
DL+ML AA	107
DL+1.5ML A	108
DL+1.5ML AA	112
1.35DL+1.5ML A	141
1.35DL+1.5ML AA	146

As per the code the allowable displacement for the deck under the moving loads is,

$$\delta_{all} = L/800 = (200 \times 1000)/800 = \mathbf{250\ mm}$$

The maximum vertical displacement of the deck is observed for load combination 1.35DL+1.5ML AA is 146mm which is less than the allowable displacement 250mm.

3.6 Displacement of Pylon

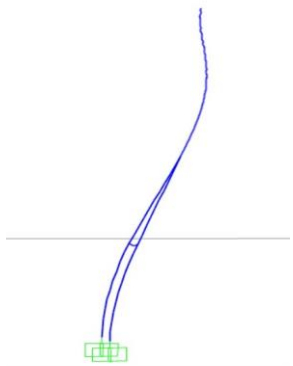

Fig -23: Deformed Shape of the Pylon

Table -6: Horizontal Displacement of the Pylon

Load combination	Displacement in mm
DL+ML A	34.8
DL+ML AA	37.0
DL+1.5ML A	38.9
DL+1.5ML AA	42.6
1.35DL+1.5ML A	48.2
1.35DL+1.5ML AA	51.7

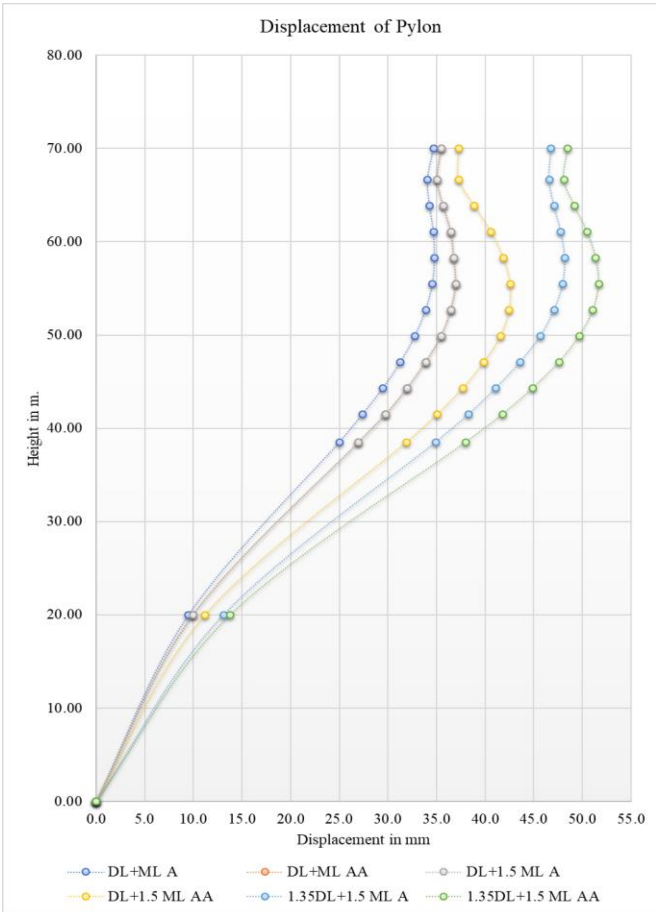

Chart -1: Displacement of the Pylon

4. CONCLUSIONS

1. Cable stayed bridges can handle more pressure due to its greater stiffness.
2. In this study the response and conduct of the cable stayed bridge under the action of moving loads is found by analysing the structure using CSiBridge software.
3. The cable stayed bridge is analysed for Class A and Class AA tracked Load.
4. The displacement of the cable stayed bridge deck under the action of the dead and moving loads is observed for different load combinations.

5. The displacement of the cable stayed bridge deck under the action of the dead and moving loads is observed to be 146mm for load combination (1.35DL+1.5ML AA) whereas the allowable displacement as per IRC code is 250mm, Hence the bridge performs safely under the action of dead and moving loads.
6. The horizontal displacement of the pylon/tower under the action of the dead and moving loads is observed to be 51.7mm for load combination (1.35DL+1.5ML AA).

5. SCOPE FOR FURTHER STUDIES

1. Behavior analysis of cable stayed bridge for different cable profiles.
2. Analysis of cable stayed bridge for various types of deck profiles.
3. Comparison between the behaviour of different types of pylon of cable bridge.
4. Construction stage analysis of the cable stayed bridge.
5. Dynamic analysis of the cable-stayed bridge.

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