

TIME HISTORY ANALYSIS OF BALANCED CANTILEVER BRIDGE

¹Abdul Hameed, ²Abdul Rahman Khan,
³Mohammed Safiuddin, ⁴Mohammed Khaja Moinuddin,

¹M.Tech Structures, Lords Institute of Engineering and Technology, Hyderabad, India

²Asst. Professor, Lords Institute of Engineering and Technology, Hyderabad, India

³H.O.D Civil Engineering, Lords Institute of Engineering and Technology, Hyderabad, India

⁴Asst. Professor, AL- Habeeb College of Engineering and Technology, Hyderabad, India

Abstract - Infrastructures are nowadays a huge requirement in metro cities like Hyderabad, Chennai, Delhi, Mumbai and Bangalore etc. The days are evident that the traffic volume intensity has been increased like anything in the recent times. Hyderabad city is a real-time instance of traffic volume which leads to construct the flyovers in the various parts of the city. Generally the flyovers are either simply supported or rigid in nature (Example: PVNR Express Hyderabad, Punjagutta Flyover Hyderabad). These flyovers are known as segmental bridge; they have been meant for small spans and extended for huge length. The areas like traffic intersection this segmental bridge is not adequate where the lengths are prolonged in the particular instances a large span bridge or flyover has to be selected where the traffic intersection should not be disturbed. The best suitable bridge for this particular case is balanced cantilever (two overhangs with mid-span). To study the behavior of balanced cantilever bridge for a span of 100 m, a bridge is considered and a FEM mathematical model has been generated in CSI Bridge V15. The bridge is assumed to be subjected to real time earthquake in the form of Time History acceleration (Elcentro). The particular bridge is having 100 m total span in which each overhang is of 25 m and mid-span is of 50 m and width of the bridge is about 15.5 m. The parametric profile of the bridge is parabolic. The bridge is having 2 lane and 4 lane of traffic flow and it is subjected to IRC Class AA vehicular load HSN- 44 ASHTO Vehicular load. The bridge is having intermediate supports of bent and bent cap made up of bent beams and bent columns (3 columns).

I INTRODUCTION

World had an extra figure of earth tremble danger in last decade. India northern part causes enormous hammering of persons, buildings, bridges etc thus, nationwide seismic exposure evaluation of accessible structure. Instance to instance codes has been revising to alleviate seismic zone regions. So we know bridge be ethical Strand of carry in each nation in past years numbers of bridges are planned with no seismic services unpaid near which existence of structure reduces. Therefore, it be required near propose the ability of connection against seismic forces. The intention of a link must live definite in these master plans a link must be “safe, functional, economical, and good looking”.

The main objective of this study is:

- The main principle of this project is to analyse balance cantilever Bridge using Time History analysis by using CSI bridge Software
- Mathematical modeling of balance cantilever bridge including pre stress tendons.
- Time History analysis by using CSI bridge Software
- Knowing the model behavior of bridge.
- To see the overall behavior of bridge when subjected to tracked loading and class AA vehicle load.

CLASSIFICATION OF BRIDGES:

The basic cause of a link is to bear traffic of vehicles, trains etc over an aperture. An opening can happen in excess of a highway, a river, a valley, or any other type of physical obstacle. The must to bear transfer above such an aperture defines the goal of a overpass. Hence, the course of construction a link be not initiated by the bridge engineer. Just like transportation and extra type of transportation, a link is a part of a carrying system and a carrying system is a part of a city's development efforts. The intention of a link must live definite in these master plans a link must be “safe, functional, economical, and good looking”. Based on types bridges are classified into further categories:

- (i) Simply Supported Bridge.
- (ii) Continuous Bridge.
- (iii) Cantilever Bridge.
- (iv) Balanced Cantilever Bridge.
- (v) Cable Stayed Bridge.
- (vi) Suspension Bridge.

II METHOD OF ANALYSIS

TIME HISTORY ANALYSIS: In instance story revise the structural answer is compute at variety of sequent instance instant. In extra terms, instance account of the structural response to a provided effort is obtained as an effect. In reply range psychiatry the occasional progress of reaction cannot live computed. Generated Loads may be worn on behalf of

simple Sine and Cosine function. The generate option also allows for those functions to be assigned Ramp Up functions at the beginning of the pattern, or Coast Down functions at the finish of the outline. These functions can adjust how both the rate of recurrence and enormity change with time.

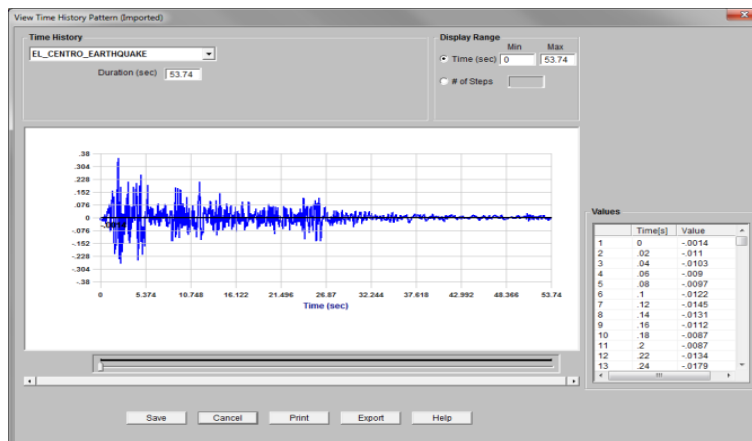


Figure 1: Graphical Representation of EL_CENTRO

LOADS ON BRIDGES:

Highway bridge loads and load allocation as particular into the AASHTO LRFD (Load and Resistance Factor Design) link devise provision (AASHTO, 2012) and IRC loadings (Indian Road Congress) are discussed in this part and IRC 21, IRC 6 is also being used and studied in this project work.

DIFFERENT TYPES OF LOADINGS:

- (i) Permanent Loads.
- (ii) Vehicular Live Loads.
- (iii) IRC Loading.
- (iv) HS 20-44 Loading.

DESIGN TRAFFIC LANE:

Kerb to Kerb Width	No of Lanes
20 to 30 ft	2
30 to 42 ft	3
42 to 54 ft	4
54 to 66 ft	5
66 to 78 ft	6
78 to 90 ft	7
90 to 102 ft	8
102 to 114 ft	9
114 to 126 ft	10

Table 1: AASHTO Specifications

III DESCRIPTIONS OF MODELS

The bridge is sustained by three-span pre-stressed concrete box girders. Dimensions are as follows size of the link is 15.5 m, total extent span of 100 m. Two columns are placed at 25m and 75m correspondingly. At each column point 3 piers are provided with a diameter of 1.5m, parametric sight at equally tops points begin at 0.45 m prolongs to 1.5 m. Then in between two piers parametric view is the 0.45 m as shown below. Bents are sketched as per replicas which took three column and pier cap for bent design. Three columns are of 12m height and diameter 1.5 m. Bent cap is pinched with 1.5m width, length 15.5 in rectangular in shape column is circular in shape. Tendons are additional to desk which is precast of length 100m in parabolic in shape.

Different Models Studied in the current study is as follows:

MODEL – 1 Balanced Cantilever Bridge with four lane :

A Balanced Cantilever bridge is modeled in the software as 4 Lane Bridge with 3 spans and piers at each column/pier joint by curved limit on it. Then pre-stressed deck slab is located on bent cap with parabolic variations and tendons in it. Abutments are used with the help of bearings which are fixed at equally the ends. Diaphragms are also assigned on the bridge.

MODEL 2 Balanced Cantilever Bridge with two lane :

A Balanced Cantilever Bridge is modeled in the software as 2 Lane Bridge with 3 spans and piers at each column/pier joint with bent cap on it. Then pre-stressed deck slab is placed on bent cap with parabolic variations and tendons in it. Abutments are used with the help of bearings which are fixed at equally the ends. Diaphragms are also assigned on the bridge.

The following parameters considered in the study are:

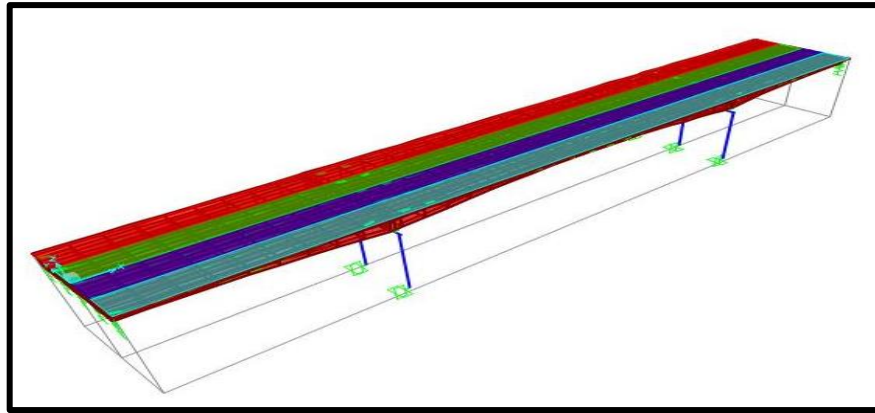


Figure 2: 3D view of 4-Lane Balanced Cantilever Bridge Modeled in software.

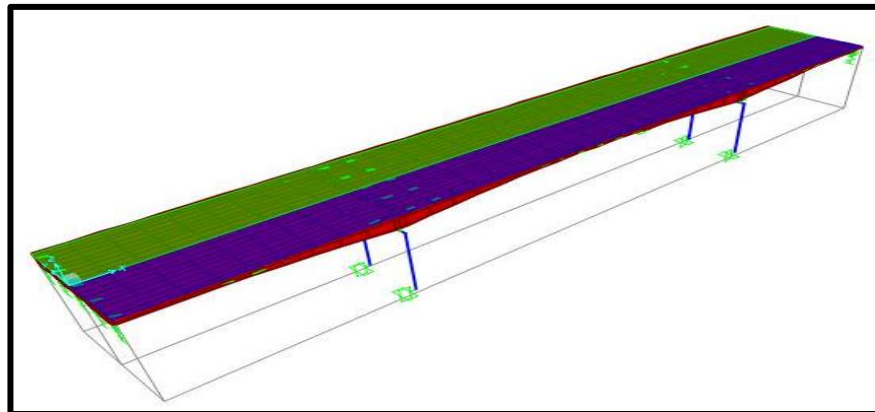


Figure 3: 3D view of 2-Lane Balanced Cantilever Bridge Modeled in software

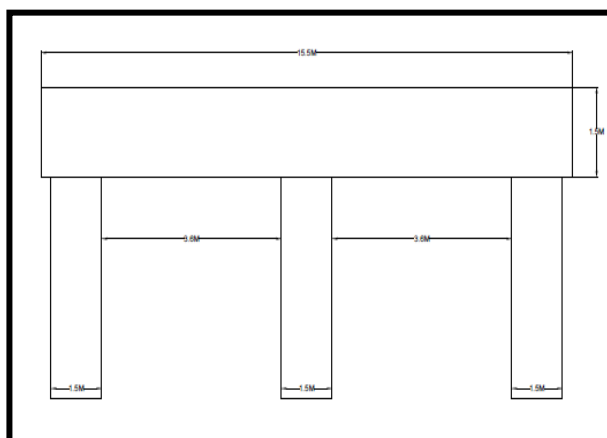


Figure 4: View of Bent Cap with Piers/Column

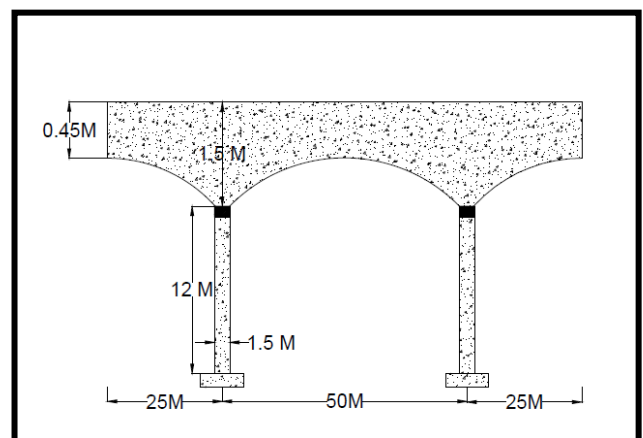


Figure 5: Elevation of Balanced Cantilever Bridge

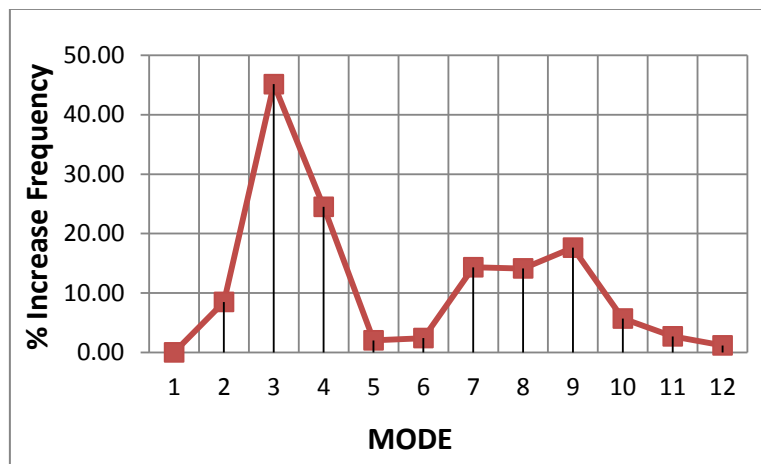
	Bridge Details	4 Lane	2 Lane
1	Number of Span	3	3
2	Centre to Centre Length of first and last Span of Bridge	25 m	25 m
3	Centre to Centre Length of intermediate Span of Bridge	50 m	50 m
4	Width of Bridge	15.5 m	15.5 m
5	Number of Main Girders	5 No's	5 No's
6	Height of Pier/Column	12 m	12 m
7	Total depth	1.5 m	1.5 m
8	Slab thickness (average)	0.45 m	0.45 m
9	width of tiring Coat	100mm	100mm
10	Longitudinal Girder Size	0.45m X 1.5m	0.45m X 1.5m
11	Type of Loading	IRC class AA	IRC class AA
12	Loads	DL+HS44+TH+RS	DL+HS44+TH+RS
13	Compressive Strength of Concrete (fck) (M60)	60000 KN/m ²	60000 KN/m ²
14	Modulus of Elasticity E=5000√fck E=5000√60 = 0000 N/mm ²	38729833 KN/m ²	38729833 KN/m ²
15	Poisson's Ratio of Concrete	0.2	0.2
16	Density of Reinforced Concrete	25 KN/m ³	25 KN/m ³
17	Grade of Concrete	M-60	M-60
18	Type of vehicular load	IRC Class A-A Track vehicle	IRC Class A-A Track vehicle
19	Importance Factor (I)	1	1
20	retort fall feature (R)	5	5
21	Poisson's Ratio of Concrete	0.2	0.2
22	Seismic Zone	Zone V	Zone V
23	Seismic Zone Factor	0.36	0.36

Table No 2: Description of Bridge Materials used in Modeling.

TIME PERIOD AND FREQUENCY:

Step Type	Mode No	Period (Sec)		Frequency (Cyc/Sec)		% Increase Frequency	
		2 Lane	4 Lane	2 Lane	4 Lane	2 Lane	4 Lane
Mode	1	0.36	0.36	2.74	2.74	0.00	0.00
Mode	2	0.33	0.33	3.00	3.00	8.49	8.49
Mode	3	0.18	0.18	5.47	5.47	45.14	45.14
Mode	4	0.14	0.14	7.24	7.24	24.50	24.50
Mode	5	0.14	0.14	7.39	7.39	2.03	2.03
Mode	6	0.13	0.13	7.57	7.57	2.41	2.41
Mode	7	0.11	0.11	8.84	8.84	14.32	14.32
Mode	8	0.10	0.10	10.29	10.29	14.13	14.13
Mode	9	0.08	0.08	12.50	12.50	17.63	17.63
Mode	10	0.08	0.08	13.25	13.25	5.70	5.70
Mode	11	0.07	0.07	13.62	13.62	2.70	2.70
Mode	12	0.07	0.07	13.78	13.78	1.17	1.17

Table No 3: Details of % Increased Frequency



% Increased Frequency VS Mode

MODAL MASS PARTICIPATION:

An instant phase denotes by 'T' is the instant required pro finishing lone cycle of vibration to exceed a set spot. As the frequency of a wave increase, the instant period of the wave decrease. The unit is 'seconds'. Frequency and time Period are in a reciprocal association to canister be uttered scientifically as $T = 1/f$ or as: $f = 1/T$.

Modal Participating Mass Ratios									
Output Case	Step Type	Step No	Period	UX	UY	UZ	RX	RY	RZ
MODAL	Mode	1	0.36	0.00	0.00	0.17	0.00	0.00	0.00
MODAL	Mode	2	0.33	0.00	0.81	0.00	0.01	0.00	0.00
MODAL	Mode	3	0.18	0.59	0.00	0.00	0.00	0.08	0.00
MODAL	Mode	4	0.14	0.29	0.00	0.00	0.00	0.00	0.00
MODAL	Mode	5	0.14	0.00	0.00	0.00	0.00	0.00	0.73
MODAL	Mode	6	0.13	0.00	0.00	0.00	0.32	0.00	0.00
MODAL	Mode	7	0.11	0.00	0.00	0.41	0.00	0.00	0.00
MODAL	Mode	8	0.10	0.08	0.00	0.00	0.00	0.56	0.00
MODAL	Mode	9	0.08	0.00	0.00	0.00	0.00	0.00	0.00
MODAL	Mode	10	0.08	0.00	0.13	0.00	0.02	0.00	0.00
MODAL	Mode	11	0.07	0.00	0.01	0.00	0.22	0.00	0.00
MODAL	Mode	12	0.07	0.00	0.00	0.00	0.02	0.00	0.01

Table No 4: Modal Mass Participation

MODE SHAPES:

Mode shapes are used to develop or determine the reply of the makeup when subjected to loading such as earthquake has induced ground motion. Modes shapes are one of the important phenomena considered while designing the structure for earthquake resistant design. Modes shapes are the first shapes obtain by the structure when induced or subjected to loading.

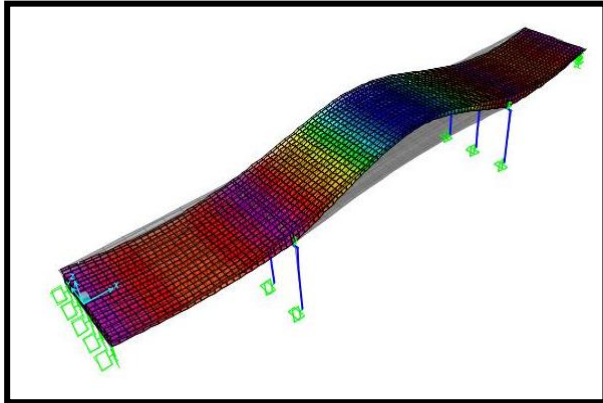


Figure 6: Mode-1 of 2-Lane Bridge (0.36sec)

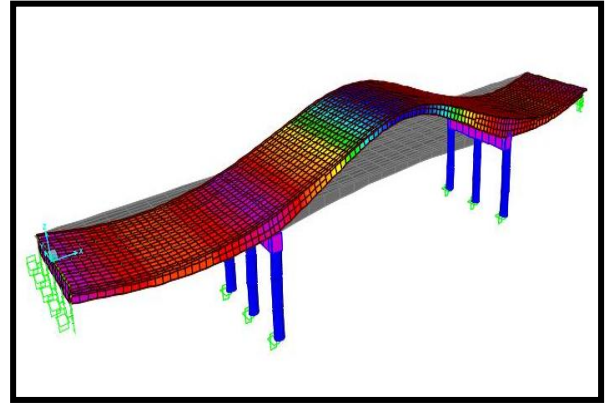


Figure 7: Mode-1 of 4-Lane Bridge (0.36sec)

JOINT REACTIONS:

Due to application of loads which are useful on the construction then the activities of the construction observed with inside forces which are developed on the joints owed to masses is acknowledged as joint reactions. These be the forces considered while designing of the structure.

Joint	F1 (KN) Lane		F2 (KN) Lane		F3 (KN) Lane		M1 (KN-M) Lane		M2 (KN-M) Lane		M3 (KN-M) Lane	
	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane
1391	29.33	54.92	1.32	2.35	15.34	19.58	0.71	0.84	102.8	121.4	4.56	8.21
1393	62.84	116.0	0.00	0.00	16.47	21..4	0.00	0.00	107.0	126.6	0.00	0.00
1395	29.33	54.92	1.73	2.08	15.34	19.58	0.67	0.77	102.8	121.4	6.03	7.29
1399	40.14	48.94	1.76	2.06	15.38	19.65	0.75	0.89	103.3	121.8	6.13	7.22
1401	85.28	102.8	0.00	0.00	16.53	21.12	0.00	0.00	107.5	127.2	0.00	0.00
1403	40.14	48.94	1.39	2.34	15.38	19.65	0.71	0.82	103.3	121.8	4.81	8.18
3	62.28	71.12	16.53	21.87	222.7	301.9	0.00	0.00	102.4	146.2	8.27	10.93
4	41.95	48.86	2.78	3.11	372.8	499.3	0.00	0.00	171.6	239.7	1.39	1.55
6	43.01	60.41	0.00	0.00	370.5	495.9	0.00	0.00	170.5	237.9	0.00	0.00
8	41.95	48.86	2.62	2.69	372.8	499.3	0.00	0.00	171.6	239.7	1.31	1.31
10	62.28	71.12	15.24	20.81	222.6	301.9	0.00	0.00	102.4	146.2	7.62	10.41
22	65.92	71.30	13.06	18.15	213.9	291.3	0.00	0.00	98.13	142.1	6.53	9.08
24	35.96	43.69	2.35	2.35	361.6	486.0	0.00	0.00	166.1	234.7	1.17	1.17
26	40.20	44.93	0.00	0.00	359.2	482.5	0.00	0.00	165.0	232.8	0.00	0.00
28	35.96	43.69	2.48	2.78	361.6	486.0	0.00	0.00	166.1	234.7	1.24	1.39
30	65.92	71.30	14.2	18.92	213.9	291.3	0.00	0.00	98.13	142.1	7.10	9.46

Table No 5: Joint Reactions for Time History Case for both 2 and 4 Lane

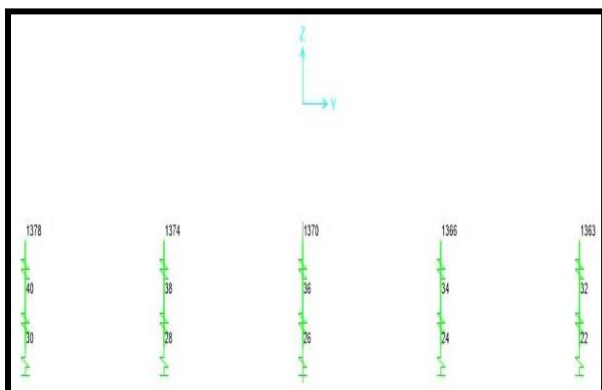


Figure 8: Reference Points for Joint Reactions for 2 Lane

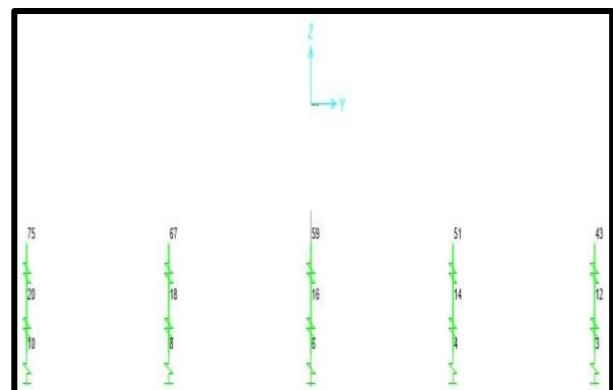


Figure 9: Reference Points for Joint Reactions for 4 Lane

Joint	F1 (KN) Lane		F2 (KN) Lane		F3 (KN) Lane		M1 (KN-M) Lane		M2 (KN-M) Lane		M3 (KN-M) Lane	
	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane
1391	76.86	76.85	3.42	3.42	17.03	17.03	0.83	0.83	128.9	128.9	11.85	11.85
1393	163.2	163.2	0.00	0.00	18.41	18.40	0.00	0.00	134.3	134.3	0.00	0.00
1395	76.86	76.85	3.42	3.42	17.03	17.03	0.83	0.83	128.9	128.9	11.85	11.85
1399	75.27	75.27	3.34	3.33	17.10	17.09	0.88	0.87	129.4	129.4	11.57	11.56
1401	159.6	159.6	0.00	0.00	18.49	18.49	0.00	0.00	134.9	134.9	0.00	0.00
1403	75.27	75.27	3.34	3.33	17.10	17.09	0.88	0.87	129.4	129.4	11.57	11.56
3	38.91	38.91	10.49	10.48	145.5	145.4	0.00	0.00	72.75	72.74	5.24	5.24
4	32.10	32.10	1.51	1.50	239.9	239.9	0.00	0.00	119.9	119.9	0.75	0.75
6	33.53	33.52	0.00	0.00	238.2	238.2	0.00	0.00	119.1	119.1	0.00	0.00
8	32.10	32.10	1.51	1.50	239.9	239.9	0.00	0.00	119.9	119.9	0.75	0.75
10	38.91	38.91	10.49	10.49	145.5	145.4	0.00	0.00	72.75	72.74	5.24	5.24
22	39.66	39.65	9.10	9.09	140.8	140.8	0.00	0.00	70.41	70.41	4.55	4.54
24	32.76	32.75	1.35	1.34	234.1	234.1	0.00	0.00	117.0	117.1	0.67	0.67
26	34.20	34.20	0.00	0.00	232.3	232.3	0.00	0.00	116.1	116.1	0.00	0.00
28	32.76	32.75	1.35	1.34	234.1	234.1	0.00	0.00	117.0	117.0	0.67	0.67
30	39.65	39.65	9.09	9.09	140.8	140.8	0.00	0.00	70.41	70.41	4.54	4.54

Table No 6: Joint Reaction for Response Spectrum Case for both 2 and 4 Lane

Joint	F1 (KN) Lane		F2 (KN) Lane		F3 (KN) Lane		M1 (KN-M) Lane		M2 (KN-M) Lane		M3 (KN-M) Lane	
	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane	2-Lane	4-Lane
1391	275.6	399.1	8.90	14.89	3.00	5.43	1.70	2.56	29.20	56.26	33.80	56.48
1393	445.6	765.9	4.90	8.36	2.80	5.54	2.00	2.92	28.70	57.05	21.70	35.26
1395	281.6	399.1	1.40	2.17	3.00	5.43	1.70	2.40	29.20	56.26	8.20	11.65
1399	269.0	399.2	8.90	14.86	2.40	4.57	1.60	2.33	35.80	67.78	33.60	56.41
1401	447.6	765.0	4.90	8.35	2.40	4.69	2.00	2.89	34.40	68.54	21.70	35.22
1403	282.6	399.2	1.30	2.16	2.50	4.57	1.70	2.52	36.00	67.78	8.10	11.57
3	205.4	243.5	11.10	14.25	74.30	108.9	0.00	0.00	11.50	19.17	5.60	7.13
4	180.5	286.5	5.10	7.95	71.30	127.7	0.00	0.00	12.20	21.89	2.50	3.97
6	248.9	298.8	7.10	7.57	69.30	112.3	0.00	0.00	10.00	19.89	3.50	3.79
8	195.7	286.5	9.80	10.10	71.20	127.7	0.00	0.00	12.00	21.89	4.90	5.05
10	206.2	243.5	3.20	4.57	74.50	108.9	0.00	0.00	11.30	19.17	1.60	2.29
22	172.5	243.3	8.60	13.69	23.00	38.33	0.00	0.00	34.40	54.40	4.30	6.85
24	186.1	286.9	6.10	7.49	24.30	43.69	0.00	0.00	35.60	63.93	3.10	3.75
26	271.5	298.8	6.40	7.24	20.00	39.64	0.00	0.00	36.70	56.27	3.20	3.62
28	199.1	286.9	8.90	9.52	24.00	43.69	0.00	0.00	35.70	63.93	4.50	4.76
30	207.3	243.3	2.80	4.29	22.50	38.33	0.00	0.00	37.30	54.40	1.40	2.15

Table No 7: Joint Reaction for Moving Load Case for both 2 and 4 Lane

DEFLECTIONS:

Payable to heaps drama on the part the behavior or lateral moments observed in the member is identified as deflection. Change in the shape of the part due to various load behavior on it is identified as deflection.

Loading Type	2 lane (mm)	4 Lane (mm)
Dead Load	34.00	34.00
Response Spectrum (X)	0.84	0.86
Response Spectrum (Y)	3.00	3.00
Time History (X)	0.77	0.77
Time History (Y)	3.00	3.00
Moving Load-1	4.00	8.00
Moving Load-2	10.00	17.00
Pre-stress	0.91	0.91

Table No 8: Deflection Details

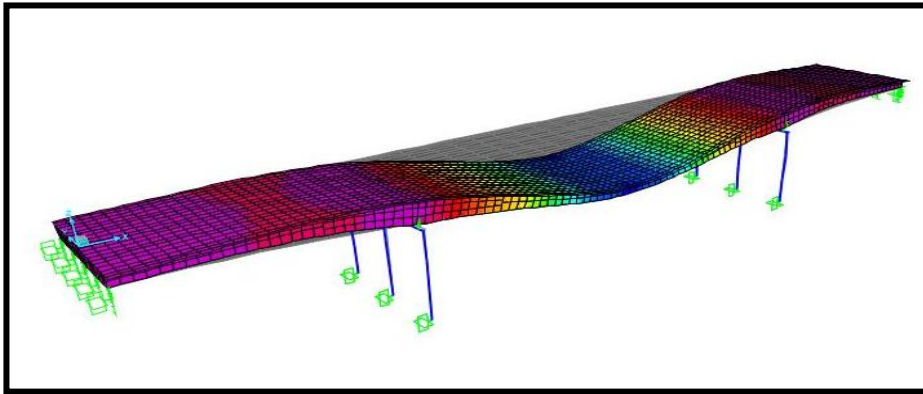


Figure 10: Deflection of Bridge for Dead Load with maximum value of 34mm

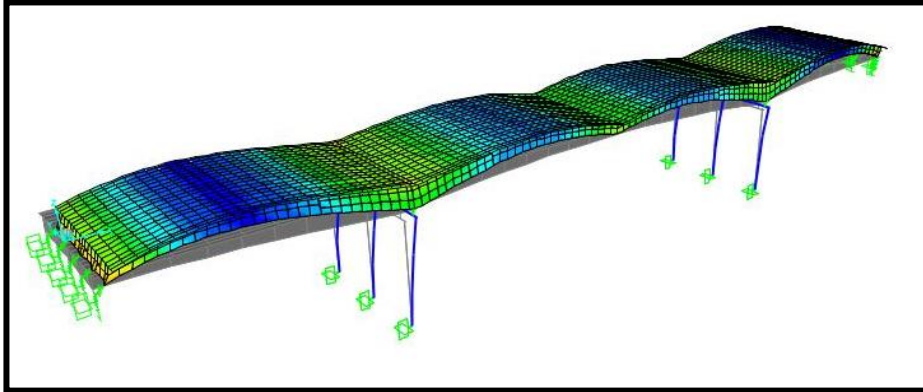


Figure 11: Deflection of Bridge for Response Spectrum with maximum value of 3mm.

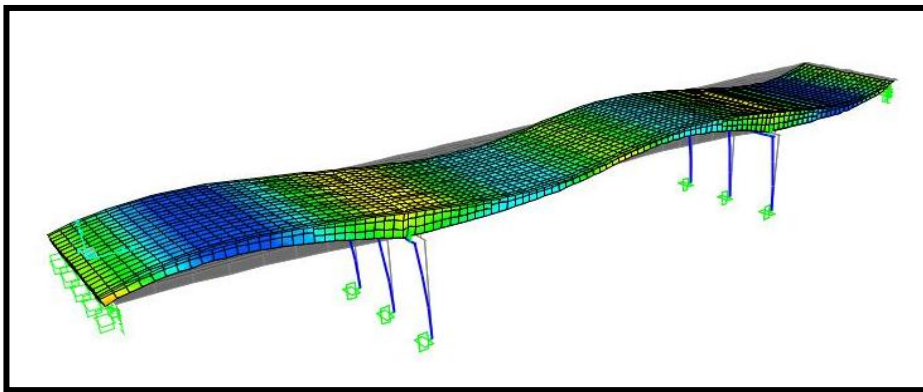


Figure 12: Deflection of Bridge for Time History Case with maximum Value of 3mm

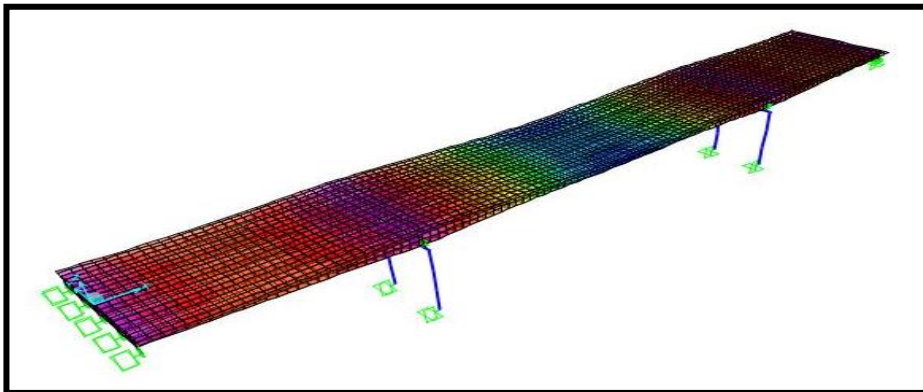


Figure 13: Deflection of Bridge for Moving load Case with maximum value of 17mm.

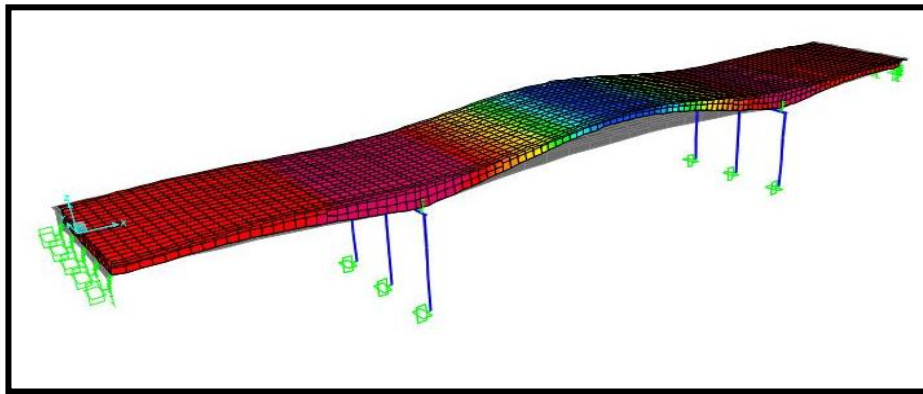


Figure 14: Deflection of bridge for Pre-Stress with maximum value of 0.91mm.

SHEAR FORCE:

Loading Type	Shear Force (KN) 2 Lane		Shear Force (KN) 4 Lane	
	Positive	Negative	Positive	Negative
Dead Load	6971.30	6790.73	6971.30	6790.73
Pre-stress	348.58	300.84	348.58	300.84
Moving Load-1	611.01	611.23	1221.60	1221.79
Moving Load-2	1339.04	1331.22	2660.63	2660.91

Table No 9: Details of Shear Force for Respective Load Cases

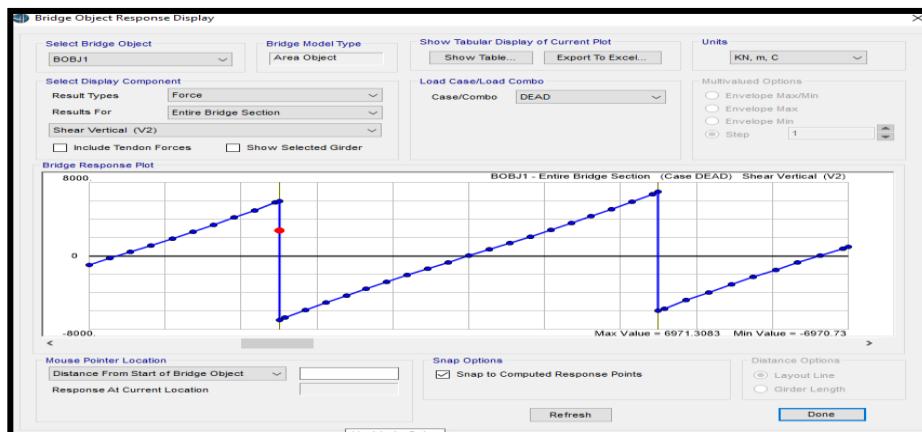


Figure 15: Shear Force for Dead Load Case

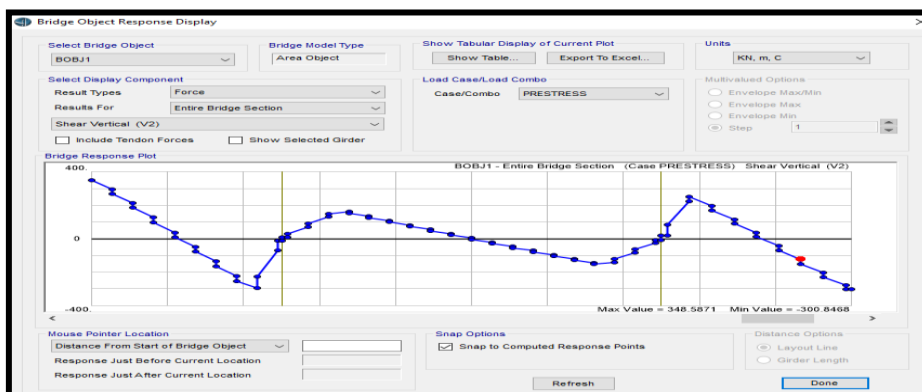


Figure 16: Shear Force for Pre-Stress Case

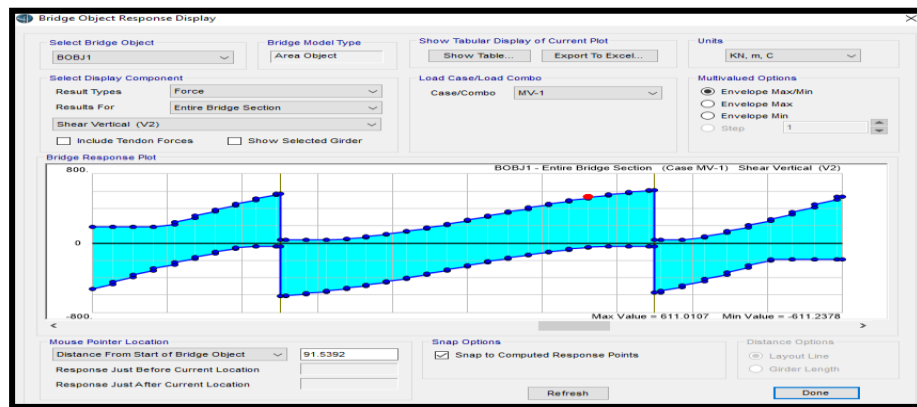


Figure 17: Shear Force for Moving Load case

BENDING MOMENT:

Loading Type	Bending Moment (KN-M) 2 Lane		Bending Moment (KN-M) 4 Lane	
	Positive	Negative	Positive	Negative
Dead Load	22847.81	60321.80	22847.81	60321.80
Pre-stress	2208.53	776.62	2208.53	776.62
Moving Load-1	3103.42	4606.03	6182.95	9175.63
Moving Load-2	7487.45	10070.61	14924.43	20058.80

Table No 10: Details of Bending Moment

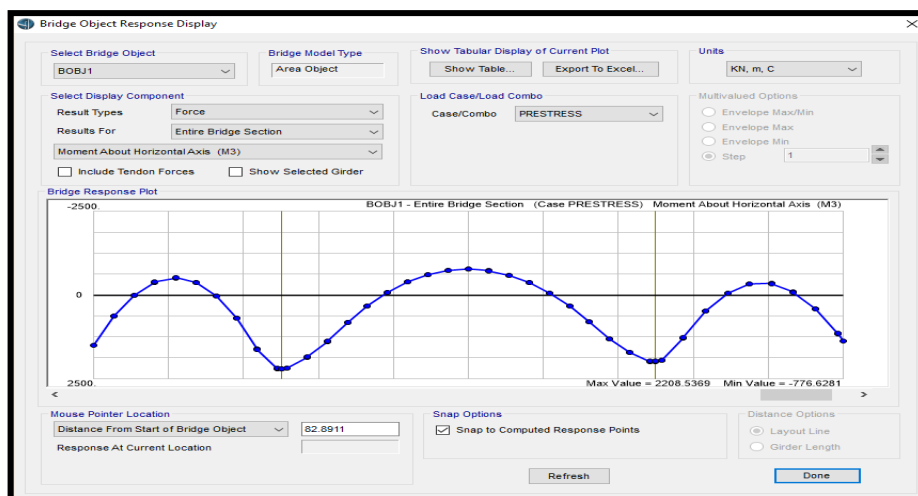


Figure 18: Bending Moment for Pre-stress

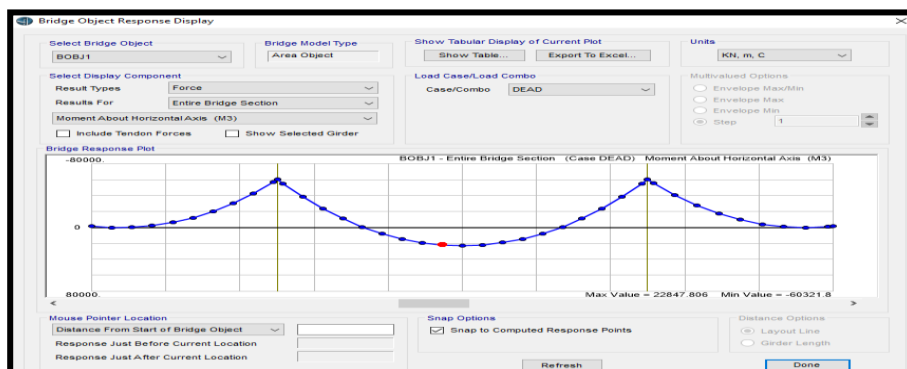


Figure 19: Bending Moment for Dead load

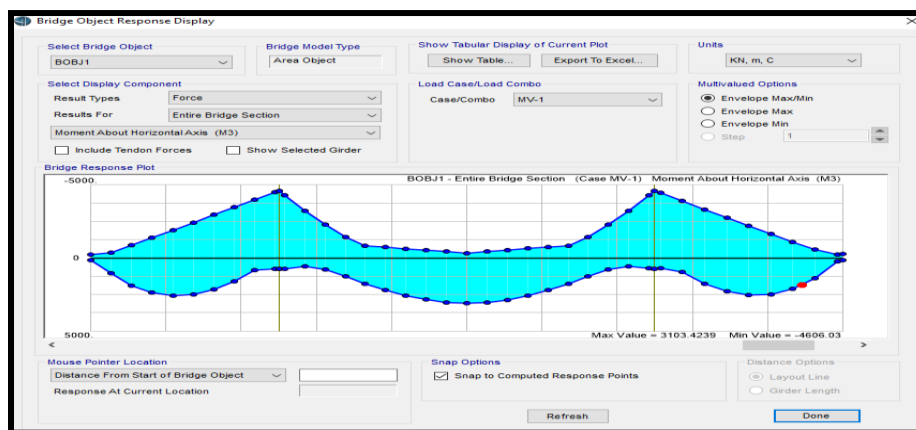


Figure 20: Bending Moment for Moving Load

IV CONCLUSIONS

- Pre-stress tendons have been assigned as same as twisting jiffy shape in deck for its entire length and meandering jiffy unpaid to this load case is as same as the meandering jiffy profile.
- The forces like twisting minute and shave power are max for DEAD LOAD case and for MOVING LOAD-2 case; therefore these load cases will govern the bridge design.
- Deflection in gravitational direction is max for Dead Load and Moving Load case-2 therefore these two load cases will be governing the serviceability criteria of the connection.
- The bridge has to be planned used for the combination of service load in the gravity direction so as near suit the serviceability criteria.
- The bridge is having the max of 34mm deflection that is within the acceptable limits.
- Modal analysis shows the impartial beam link is showing the essential accepted instance age of 0.36 sec for the 4 lane and 2 lane models and showing highest modal frequency for 3rd fundamental mode and the modal frequency goes on decreasing as higher modes considered.
- For better dynamic behavior higher mode boasts to be considered to enhance the quality of responses of bridges.
- Joint reactions considered for both X & Y direction for point account Case the percentage force and moment for 4 Lane is superior to 2 Lane (Refer Discussion). For following joints: 1391(F1) and 1391(M3) in X-Direction similarly 1403(F3) and 1399(M2) in Y-Direction.
- Joint reactions considered for both X & Y direction for Response Spectrum Case the percentage force and moment for 4 Lane is higher than 2 Lane (Refer Discussion). For following joints: 1391(F2) and 8(M3) in X-Direction similarly 1403(F3) and 1401(M1) in Y-Direction.
- Joint reactions considered for Moving Load 1 and 2 the percentage force and moment for 4 Lane is superior to 2 Lane (Refer Discussion). For following joints: 26(F3) and 1401(M2) in load case-1 similarly 1393(F3) and 1401(M2) in load case-2.

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