Design & Analysis of Precast Concrete Bridge Structure Using Software

Mr. Yashodip Bhamare[1], Dr. D.P. Joshi[2]
[1]Dept of civil Engineering
[2]Assistant Professor, Dept of civil Engineering
[1, 2] Late G. N. Sapkal College of Engineering, Nashik 422213

Abstract- *a bridge management system is a method of managing bridges throughout the design, operation, building, and maintenance phases of the bridge's lifecycle. When funding becomes more difficult to come by, road management authorities all over the world have had to deal with challenges related to bridge management as well as an increase in the number of maintenance requests for large infrastructure assets in their jurisdictions. The system of bridge management assists agencies in achieving objectives such as inventory construction, maintenance planning, bridge inspection, and repair and rehabilitation interventions in the most systematic manner, increasing the safety of bridge users, and optimizing the allocation of financial resources.*

The most important task associated with bridge management is the collection of inventory data; condition evaluation and strength; inspection, repair, prioritization of funds allocation; and replacement of bridge elements. Moreover, business management is regarded as a method of managing information about a bridge for the aim of designing maintenance programs within the constraints of a budgetary constraint. The business management also includes four parts, including degradation and cost, data storage, analysis and optimization models, and updating functions, amongst other things.

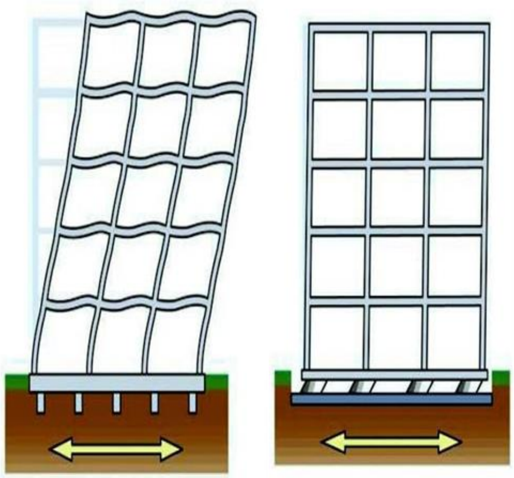
Keywords- Bridge, Precast, Staad Pro Connect Software, Operations, Models

I. INTRODUCTION

Concept of base isolation

Base isolation is the separation of the base or substructure from the superstructure. It is also called Seismic isolation.

Instinctively, the conceptXof extrication the superstructure from the substructure to avoid earthquake damage is relatively simple to understanding. At the time of earthquake, the ground moves and this ground movement which induces the inertial forces on the structures from both directions which cause most of the harm to structures. An airplane flying over an earthquake is not affected. So, the fundamental theory is quite simple.Separate the superstructure from the substructure. The sub-structure will move but the structure will not move. Base Isolation falls into the overall class of Passive Energy Dissipation.



Conventional bridge under ground motion (a) Base isolated bridge under ground motion (b)

The basic principle of base isolation is to transform the response of the bridge so that the ground can move Below the Bridge without transferring these motions into the bridge. The assumption of the ideal system is a complete separation between ground and structure. In actual practice, there is a contact between the structure and the ground surface.

Bridges with a perfectly stiff diaphragm have a nil fundamental natural time period. The ground motion induces acceleration in the structure which will be equivalent to the ground acceleration and there will be nil relative displacements between the structure and the grounds. The structure and substructure move with the same amount. A Bridge with a perfectly stretchy diaphragm will have an immeasurable period. For particular type of structure, when the ground beneath the structure travels there will be zero acceleration induced in the structure and the relative displacement between the structure and ground will be equivalent to the ground displacement. In this case, structure will not change but the substructure will move.

Incorporation of the isolator into bridge construction:

When it comes to earthquake safety, the first issue that comes to mind for a structural engineer is when to use isolation in the bridge. The simple answer is when it gives a more effective and economical alternative to other methods of employ for earthquake safety. In some cases, base isolation may be practicable if the design for earthquake loads necessitates the use of strength or detailing that would otherwise be insufficient for other load circumstances.

The easiest technique to determine whether a structure is suited for isolation when evaluating structures that fit this fundamental condition is to go through a checklist of items that make isolation more or less effective depending on the structure

The Weight of the Structure:

The base isolation system is more efficient for the structures which have heavy masses. To effective isolation can be achieved with the help of the long period of the response. As we know the period is an inherent property of the structure which is relative to the square root of the mass M and contrariwise proportional to the square root of the stiffness K.

To achieve an effective isolated time period, a heavy mass must be associated with a low stiffness. Devices that are used for isolation do not have an infinite range of stiffness.

For example, elastomeric bearings need to have a minimum diameter to ensure that they remain stable under seismic displacements. This minimum plan size sets a smallest practical stiffness

Sliding systems do not have time period restraint and so low weight bridges may be intelligent to be isolated with sliding systems. However, even these incline not to be cost-effective for light bridges for different reasons. Regardless of the weight of the bridge, the movement is the same for a given effective period and so the size of the slide plates, the most expensive part of sliding bearings, is the same for a heavy or a light structure. In real terms, this usually makes the isolators more expensive as a proportion of the first cost for light bridges. There have been systems proposed to isolate light bridges. However, the fact remains that there are few instances of successful isolation of light structures such as detached residential dwellings

Location of the isolator in bridges

The paramount requirement for installation of a base isolation system is that the bridge is able to move horizontally relative to the ground, usually at least 100 mm and in some instances up to 1 meter. A plane of separation must is selected to permit this movement. Final variety of the location of this plane depends on the structure but there are a few things to consider in the process.

The most common configuration is to install a diaphragm immediately overhead the isolators. This permits earthquake loads to be spread to the isolator's according to their stiffness. For a bridge without a basement, the isolators are mounted on foundation pads and the structure constructed above them, as shown in Figure.

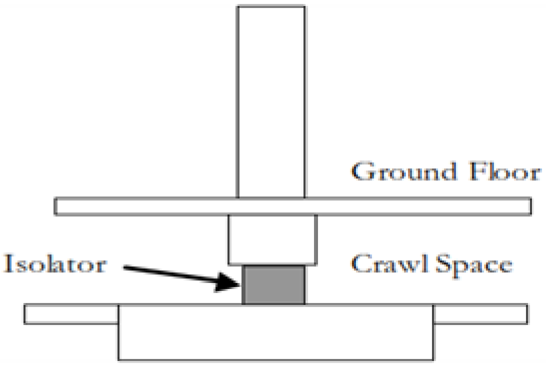


Figure1.2: Isolation in bridge with no basement

Uncertainty the bridge has a basement then the options are to install the isolators at the top, bottom or mid-height of the basements columns and walls, as shown in Figure.

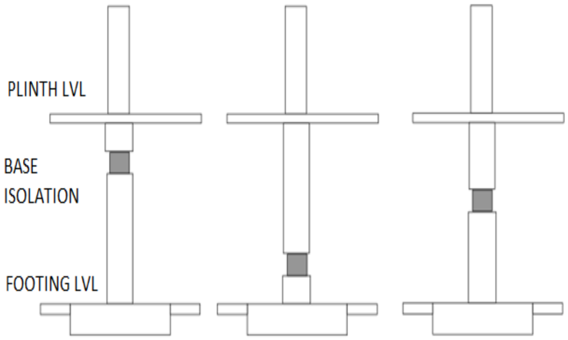


Figure: Isolation in the basement

For the options at the top or bottom of the column/wall then the element will need to be designed for the cantilever moment developed from the maximum isolator shear force. This wills often require substantial column sizes and may require pilasters in the walls to resist the face loading.The mid-height location has the advantage of splitting the total moment to the top and bottom of the component.

III. RESEARCH METHODOLOGY

Aim

"This study aimed to evaluate study of precast Concrete Bridge structure with economical aspect of the use with length variations. The analytical calculations were carried out based on the applicable standards of bridge design".

Objectives

- To evaluate and comparatively study of monolithic and precast Concrete Bridge structure with economical aspect of the use with length variations.
- To analyze the structural parameters like base shear, acceleration, time period, displacement.
- To design and analyze structural components of bridge deck slab,I beam girder, pier.
- To check and study cross section for pre-stressed concrete decks constructed by cantilever method.

Problem Statement

Design a bridge to span a given distance while supporting a maximum load and study various parameters such as deck slab, pier, I section beam, isolated footing etc.

Methodology

- Bridge span= 12 m
- Roadway= 12 m
- Single Pier
- Pier dia= 2m
- Trapezoidal section of beam
- Upper portion= 10m x 1.5m
- Bottom portion= 1.8m x 1.2m
- Plate Girder of
- Longitudinal Beam (X-Dir 1mx1m)
- Longitudinal Beam (Z-Dir 1mx1m)
- Tapered Section (1.2 mx1.6 m)
- Deck Slab= 400 mm
- Bearing size 0.8m x 0.8mx0.75 m
- Height- 8 m
- Width-8 m
- Loading:
- Dead Load
- Earthquake Load as per 1893:2002

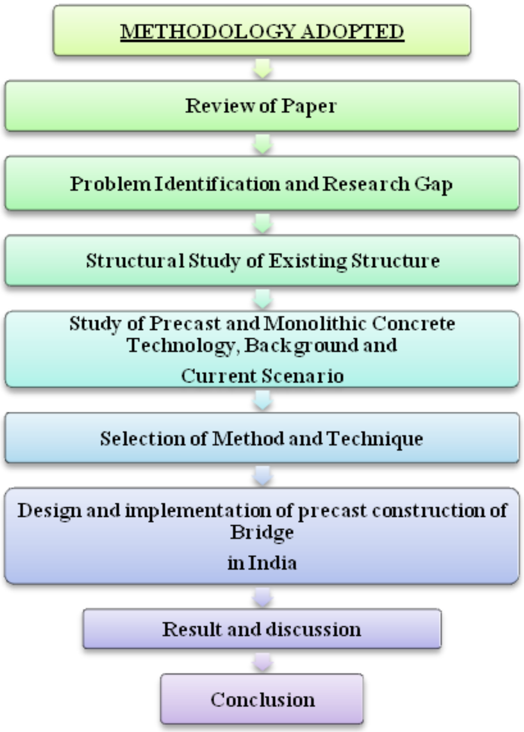


Figure1.1: Methodology Flow

IV. DESIGN AND MODELLING

GeometryCreation

Bridge model geometry is analyzed by using different sketching and modeling tools available. The slab cross section is sketched on one of the planes and dimensioned it as per the bridge model slab cross section dimension.

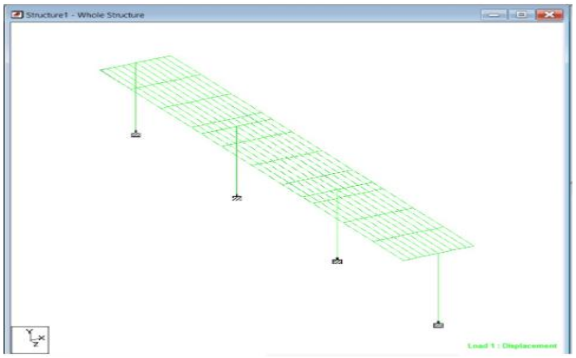


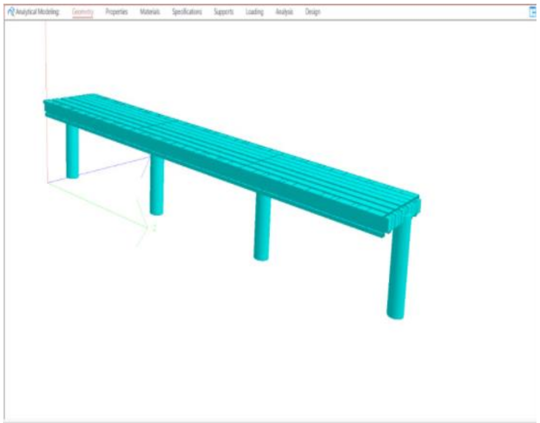
Figure 1.2: Bridge section

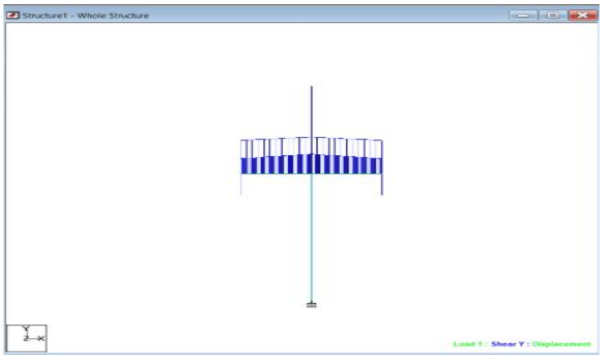
Then slab cross section is extruded in the normal direction to the sketching plane for the required length. On the lower surface of the modeling, a cross section on column of bridge is sketched and is extruded normal to the slab surface for the required column length. The Linear pattern is used to make the multiple copies of the column by specifying the number of copies and spacing between each column. On the lower surface of the column foundation block cross section sketch is created and by using extrude command material is added in the normal direction for the required length. Multiple copies of the foundation blocks are created by using the linear patterncommand.

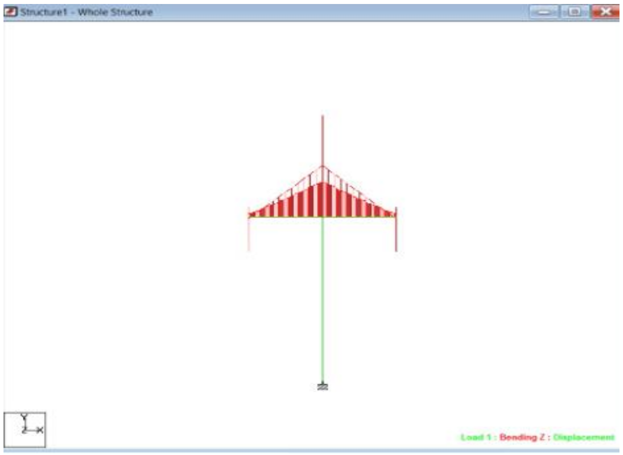
Defining the Physical properties of Bridge slab section / Applying the material

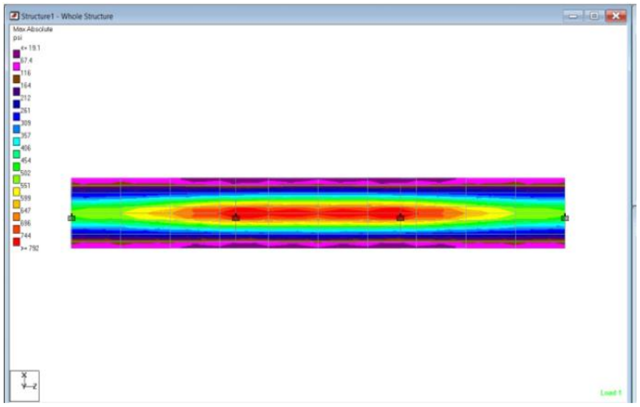
Concrete material behavior for the bridge material, the properties of which are as below, The following are the basic steps required to perform the analysis,

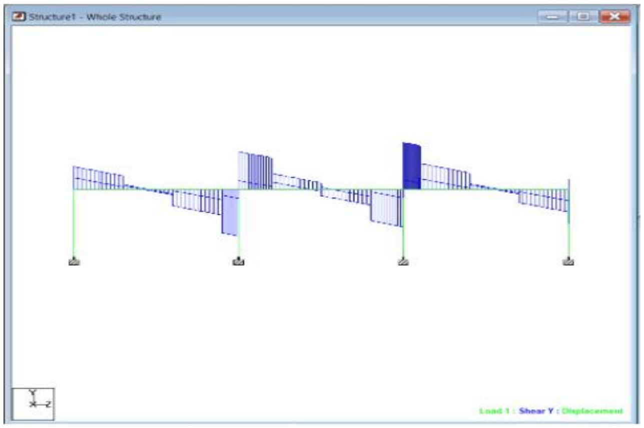
- Set the analysispreference.
- Create or import model.
- Define element attributes (element types, real constants, and materialproperties)
- Mesh the model.
- Specify the analysis type, analysis options, and the loads to beapplied.
- Solve the analysisproblem.
- Post process theresult

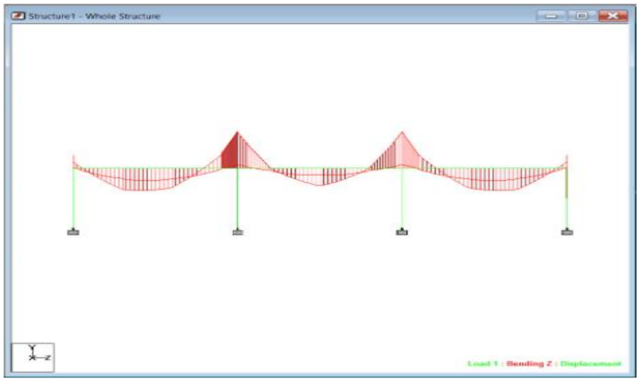


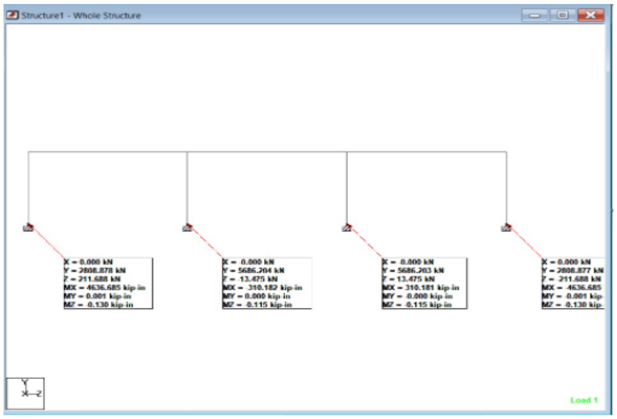


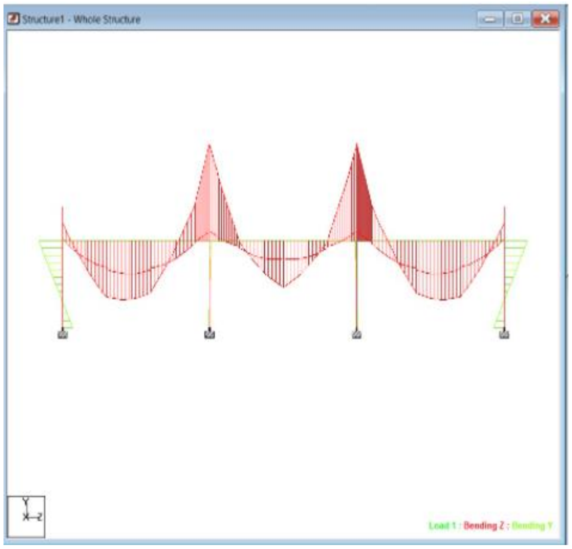












V. RESULT & DISCUSSION

Modelling Results

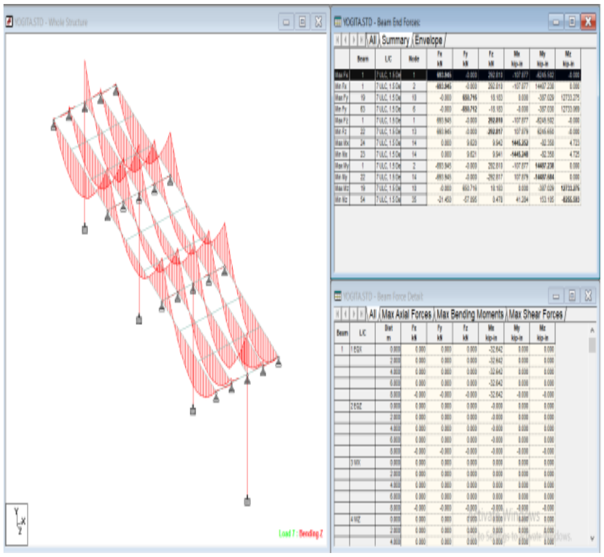


Figure1.2: BEAM BMD COL BMD

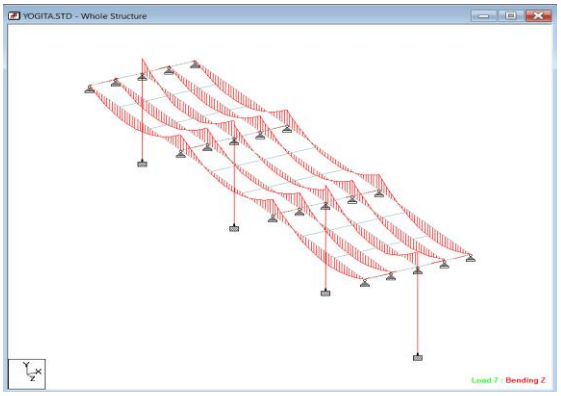


Figure1.3: BMD Diagram

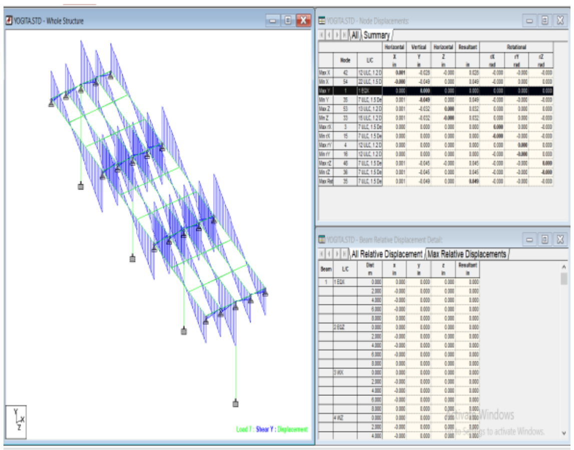


Figure1.4: Displacement due Load Combination

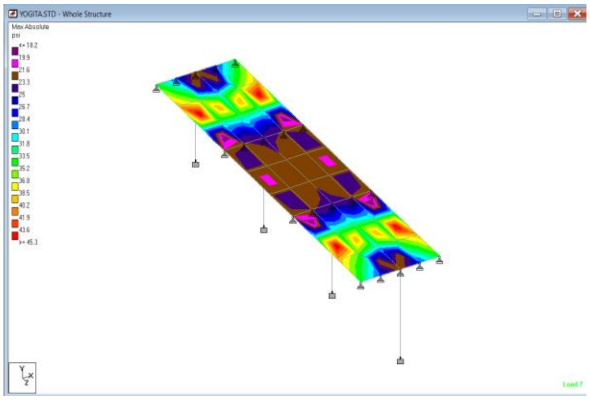


Figure1.5: Maximum Stresses

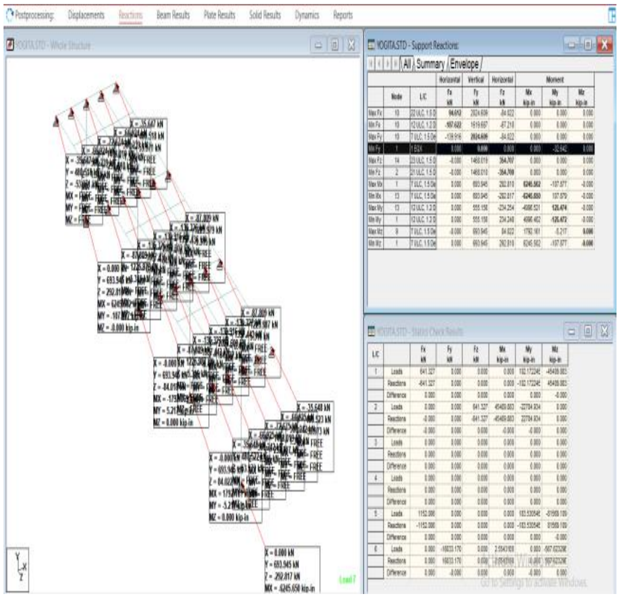


Figure1.6: Reaction at Support

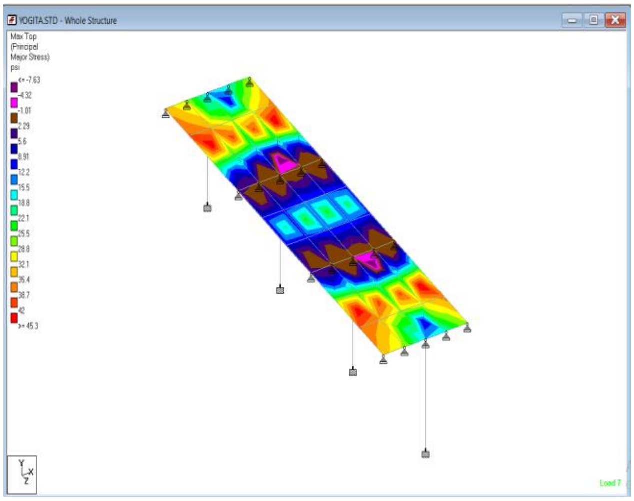
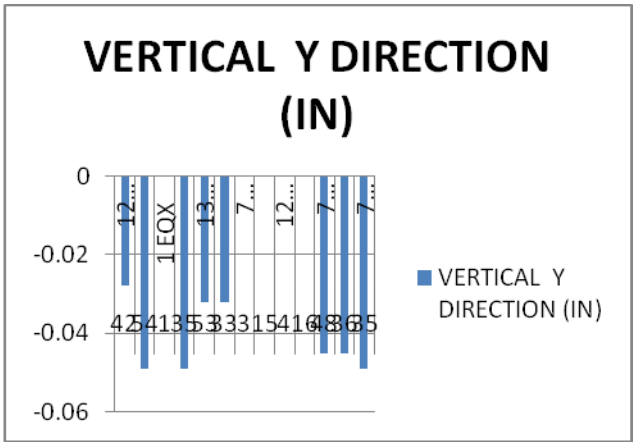


Figure1.7: Stresses due to Load Combinations

MAX DISPLACEMENT FOR LAOD COMBINATION IN BRIDGE

Table1.1: Max Displacement for Load Combination in Bridge

Max / Min	**Node**	**Load Combination**	**Vertical Y Direction (IN)**
Max X	42	12 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic	-0.028
Min X	54	22 ULC, 1.5 Dead + -1.5 Seismic (1)	-0.049
Max Y	1	1 EQX	0
Min Y	35	7 ULC, 1.5 Dead + 1.5 Live	-0.049
Max Z	53	13 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic (2)	-0.032
Min Z	33	15 ULC, 1.2 Dead + 1.2 Live + -1.2 Seismic (2)	-0.032
Max rX	3	7 ULC, 1.5 Dead + 1.5 Live	0
Min rX	15	7 ULC, 1.5 Dead + 1.5 Live	0
Max rY	4	12 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic (1)	0
Min rY	16	12 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic (1)	0
Max rZ	48	7 ULC, 1.5 Dead + 1.5 Live	-0.045
Min rZ	36	7 ULC, 1.5 Dead + 1.5 Live	-0.045
Max Rst	35	7 ULC, 1.5 Dead + 1.5 Live	-0.049

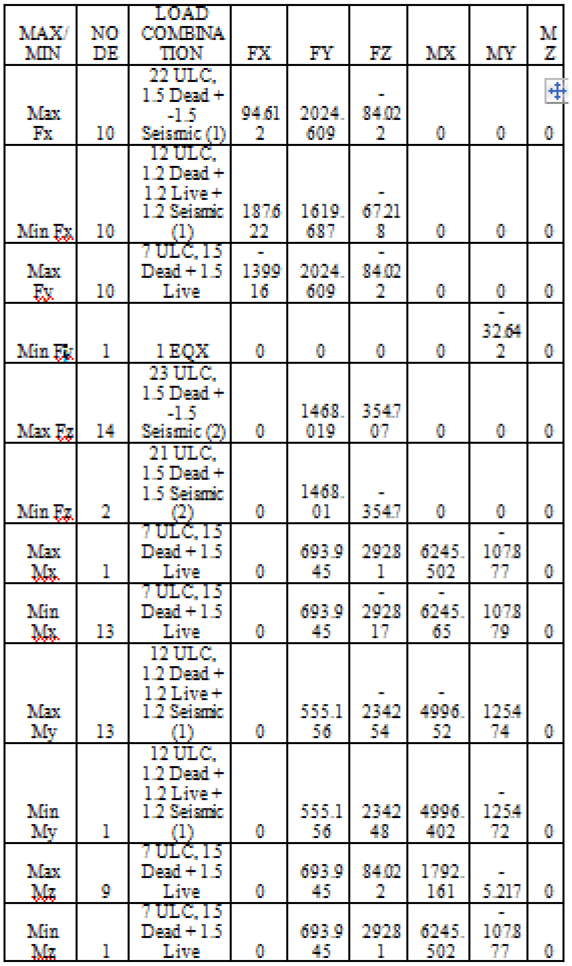


Graph1.1: Max Displacement for Load Combination in Bridge

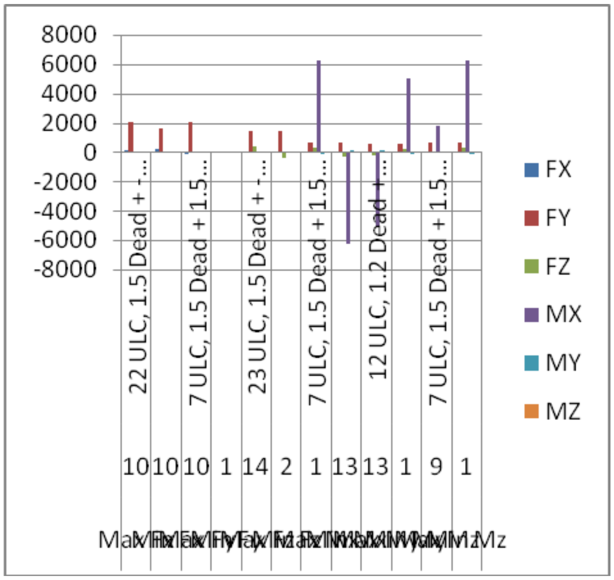
MAX AND MIN SUPPORT REACTIONS AT JOINTS

Table1.2: Max and Min Support Reactions at Joints

Graph1.2: Max and Min Sup port Reactions at Joints



MAX/ MIN	NODE	LOAD COMBINATION	FX	FY	FZ	MX	MY	MZ
Max Fx	10	22 ULC, 1.5 Dead + -1.5 Seismic (1)	94.612	2024.609	-84.022	0	0	0
Min Fx	10	12 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic (1)	187622	1619.687	-67218	0	0	0
Max Fy	10	7 ULC, 1.5 Dead + 1.5 Live	-139916	2024.609	-84.022	0	0	0
Min Fy	1	1 EQX	0	0	0	0	-32.642	0
Max Fz	14	23 ULC, 1.5 Dead + -1.5 Seismic (2)	0	1468.019	354707	0	0	0
Min Fz	2	21 ULC, 1.5 Dead + 1.5 Seismic (2)	0	1468.01	-3547	0	0	0
Max Mx	1	7 ULC, 1.5 Dead + 1.5 Live	0	693.945	29281	6245.502	-107877	0
Min Mx	13	7 ULC, 1.5 Dead + 1.5 Live	0	693.945	-292817	-6245.65	107879	0
Max My	13	12 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic (1)	0	555.156	-234254	-4996.52	125474	0
Min My	1	12 ULC, 1.2 Dead + 1.2 Live + 1.2 Seismic (1)	0	555.156	234248	4996.402	-125472	0
Max Mz	9	7 ULC, 1.5 Dead + 1.5 Live	0	693.945	84.022	1792.161	-5.217	0
Min Mz	1	7 ULC, 1.5 Dead + 1.5 Live	0	693.945	29281	6245.502	-107877	0

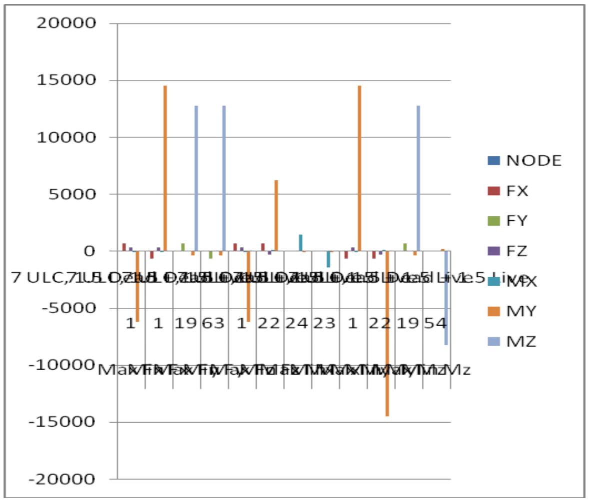


MAX AND MIN BEAM REACTION ON THE BRDIGE

Table1.3: Max and Min Beam Reaction On The Bridge

MAX/ MIN	BEAM	LOAD COMBINATION	NODE	FX	FY	FZ	MX	MY	MZ
Max Fx	1	7 ULC, 1.5 Dead + 1.5 Live	1	693.945	0	292.81	-107.877	-6245.5	0
Min Fx	1	7 ULC, 1.5 Dead + 1.5 Live	2	-693.945	0	292.81	-107.877	14487.24	0
Max Fy	19	7 ULC, 1.5 Dead + 1.5 Live	10	0	650.716	18.183	0	-387.029	12733.28
Min Fy	63	7 ULC, 1.5 Dead + 1.5 Live	6	0	-650.712	-18.183	0	-387.03	12733.07
Max Fz	1	7 ULC, 1.5 Dead + 1.5 Live	1	693.945	0	292.81	-107.877	-6245.5	0
Min Fz	22	7 ULC, 1.5 Dead + 1.5 Live	13	693.945	0	-292.817	107.879	6245.65	0
Max Mx	24	7 ULC, 1.5 Dead + 1.5 Live	14	0	9.62	9.942	1445.252	-82.358	4.723
Min Mx	23	7 ULC, 1.5 Dead + 1.5 Live	14	0	9.621	9.941	-1445.25	-82.358	4.725
Max My	1	7 ULC,	2	-69	0	292.8	-107	14487.	0

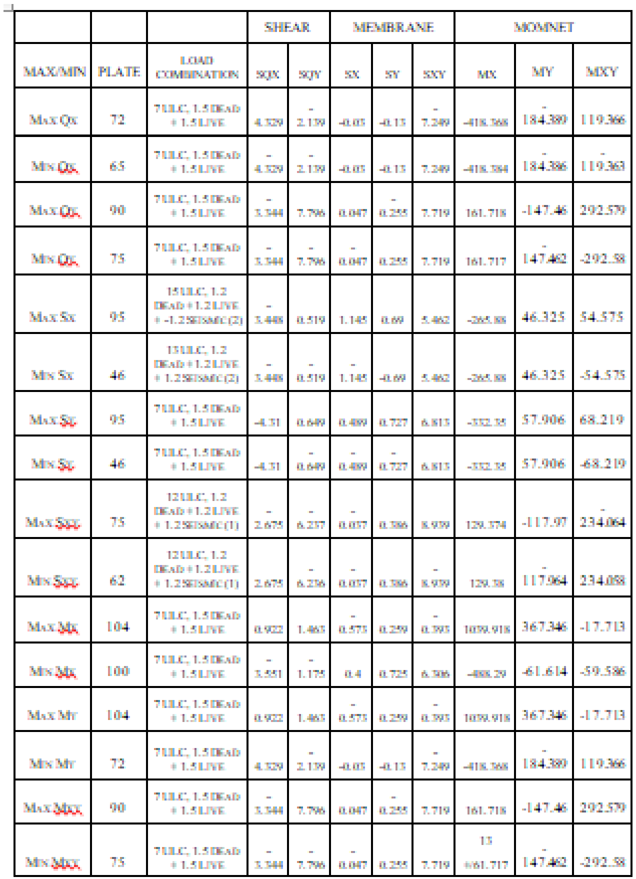
		1.5 Dead + 1.5 Live		3.945		1	.877	24	
Min My	22	7 ULC, 1.5 Dead + 1.5 Live	14	-693.945	0	-292.817	107.879	-14487.6	0
Max Mz	19	7 ULC, 1.5 Dead + 1.5 Live	10	0	650.716	18.183	0	-387.029	12733.28
Min Mz	54	7 ULC, 1.5 Dead + 1.5 Live	35	-21.45	-57.095	0.478	41.284	153.105	-8255.59



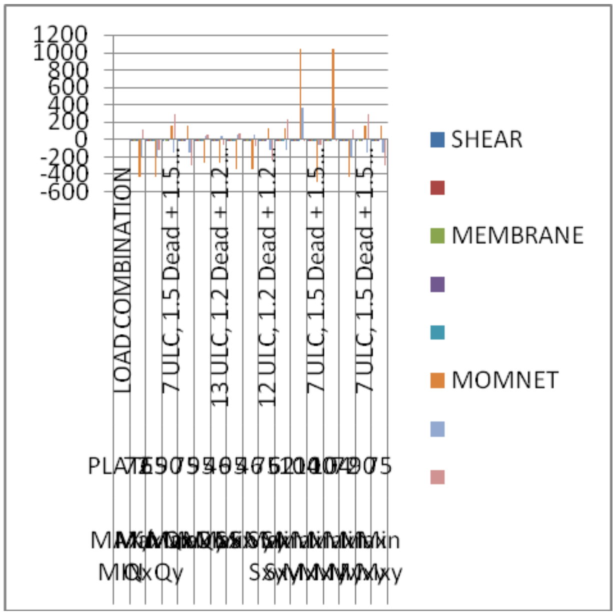
Graph1.3: Max and Min Beam Reaction On the Bridge

1.4 PLATE CENTER STRESSES

Table1.4: Plate Center Stresses



			SHEAR		MEMBRANE			MOMNET		
MAX/MIN	PLATE	LOAD COMBINATION	SQX	SQY	SX	SY	SXY	MX	MY	MXY
Max Qx	72	7 ULC, 1.5 DEAD + 1.5 LIVE	4.329	-2.139	-0.05	-0.15	-7.249	-418.368	-184.389	119.366
Min Qx	65	7 ULC, 1.5 DEAD + 1.5 LIVE	-4.329	-2.139	-0.05	-0.15	7.249	-418.364	-184.386	-119.363
Max Qy	90	7 ULC, 1.5 DEAD + 1.5 LIVE	-3.344	7.796	0.047	-0.255	7.719	161.718	-147.46	292.579
Min Qy	75	7 ULC, 1.5 DEAD + 1.5 LIVE	-3.344	-7.796	-0.047	0.255	7.719	161.717	-147.462	-292.58
Max Sx	95	15 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 SEISMIC (2)	-3.448	0.519	1.145	0.69	5.462	-265.88	46.325	54.575
Min Sx	46	13 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 SEISMIC (2)	-3.448	-0.519	-1.145	-0.69	5.462	-265.88	46.325	-54.575
Max Sy	95	7 ULC, 1.5 DEAD + 1.5 LIVE	-4.31	0.649	0.489	0.727	6.813	-332.35	57.906	68.219
Min Sy	46	7 ULC, 1.5 DEAD + 1.5 LIVE	-4.31	-0.649	-0.489	-0.727	6.813	-332.35	57.906	-68.219
Max Sxy	75	12 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 SEISMIC (1)	-2.675	-6.237	-0.037	0.386	8.939	129.374	-117.97	-234.064
Min Sxy	62	12 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 SEISMIC (1)	2.675	-6.236	-0.037	0.386	-8.939	129.38	-117.964	234.058
Max Mx	104	7 ULC, 1.5 DEAD + 1.5 LIVE	0.922	1.463	-0.575	0.259	-0.393	1039.918	367.346	-17.713
Min Mx	100	7 ULC, 1.5 DEAD + 1.5 LIVE	-3.551	-1.175	0.4	0.725	6.306	-488.29	-61.614	-59.586
Max My	104	7 ULC, 1.5 DEAD + 1.5 LIVE	0.922	1.463	-0.575	0.259	-0.393	1039.918	367.346	-17.713
Min My	72	7 ULC, 1.5 DEAD + 1.5 LIVE	4.329	-2.139	-0.05	-0.15	-7.249	-418.368	-184.389	119.366
Max Mxy	90	7 ULC, 1.5 DEAD + 1.5 LIVE	-3.344	7.796	0.047	-0.255	7.719	161.718	-147.46	292.579
Min Mxy	75	7 ULC, 1.5 DEAD + 1.5 LIVE	-3.344	-7.796	-0.047	0.255	7.719	13 161.717	-147.462	-292.58



Graph1.4: Plate Center Stresses

1.5 PRINCIPLE STRESSES

Table1.5: PRINCIPLE STRESSES

MAX/MIN	PLATE	LOAD COMBINATION	TOP	BOTTOM
Max Principal (top)	59	7 ULC, 1.5 Dead + 1.5 Live	45.306	-16.011
Min Principal (top)	80	7 ULC, 1.5 Dead + 1.5 Live	-26.267	7.631
Max Principal (bottom)	65	7 ULC, 1.5 Dead + 1.5 Live	-7.631	26.267
Min Principal (bottom)	104	7 ULC, 1.5 Dead + 1.5 Live	16.011	-45.306
Max Von Mis (Top)	74	22 ULC, 1.5 Dead + -1.5 Seismic (1)	39.779	3.255
Min Von Mis (top)	42	3 WX	0	0
Max Von Mis (Bottom)	74	20 ULC, 1.5 Dead + 1.5 Seismic (1)	39.765	3.653
Min Von Mis (bottom)	42	3 WX	0	0
Max Tresca (top)	59	7 ULC, 1.5 Dead + 1.5 Live	45.306	-16.011
Min Tresca (top)	42	3 WX	0	0
Max Tresca (bottom)	104	7 ULC, 1.5 Dead + 1.5 Live	44.202	-15.536
Min Tresca (bottom)	42	3 WX	0	0

VI. CONCLUSION

- The chapter highlights the influence of temperature variation on the structural response of the bridge.
- To analyze this structural response of the bridge different methods of analysis are employed. In the above research methodology, two methods are used to analyze the response of the bridge structure.
- First is by collecting and analyzing the data obtained from strain gauges and temperature sensors fitted on the bridge.
- Second is by employing the analysis to get the temperature distribution across bridge section and to get the response of the structure for the applied thermal loadings.

REFERENCES

[1] Analytical prediction of the seismic behaviour of super elastic shape memory alloy reinforced concrete elements M.S. Alam, M.A. Youssef and M. Nehdi, 2019

[2] ANALYSIS FOR EARTHQUAKE-RESISTANT OF BRIDGE STRUCTURE SUBJECTED TWO EARTHQUAKES, LIU Chunguang, MDPI 2021

[3] An exhaustive research and analysis on seismic performance of prefabricated concrete shear wall structure,**Shuzhen Chen, Research Article, 2018**

[4] Arnkjell Løkke, Anil K. Chopra, Direct-Finite-Element Method for Nonlinear Earthquake Analysis of Concrete Dams Including Dam–Water–Foundation Rock Interaction, Pacific Earthquake Engineering Research Center, March 2019

[5] Advanced Sensor Dynamic Measurement and Heuristic Data Analysis Model for Bridge Health Monitoring System G. R. Vijay Shankar, S. Deepa, M. Arun, G.Vignesh, International Journal of Recent Technology and Engineering (IJRTE) July 2019

[6] Dynamic Behaviour of Bridge Girders with Trapezoidal Profiled Webs Subjected to Moving Loads,Zhiyu Wang, Yunzhong Shi, MDPI 2021

[7] Girder Longitudinal Movement and Its Factors of Suspension Bridge under Vehicle Load, Jianhua Hu, Haibo Liu, 01 Oct 2021

[8] “Investigation of Seismic Performance and Reliability Analysis of Pre-stressed Reinforced Concrete Bridges” M. Hosseinpour, M.Celikag,International Engineering Conference on Developments in Civil & Computer Engineering Applications 2018

[9] Numerical investigation of the behavior of precast concrete segmental columns subjected to vehicle collision 3 Tin V. Do, Thong M. Pham, and Hong Hao

[10] Quasi-Static Cyclic Test on a Concrete-Encased Frame-Reinforced Concrete Tube Bridge ModelLeiZeng, Hindawi 2018

[11] Review of annual progress of bridge engineering in 2019, Renda Zhao, Yuan Yuan,

[12] Seismic performance of precast bridge columns connected with grouted corrugated-metal duct through biaxial quasi-static experiment and modeling, Xia Zhanghua, Lin Shangshun, 16 July 2021

[13] Seismic Response of Resilient Bridges with SMA-Based Rocking ECC-Reinforced Piers, Xiaogang Li,Dong Yang, MDPI 2021

[14] Structural Dynamic Analysis Of Cable-Stayed Bridge Due To Cable Failure Under Unexpected Events, Bassam Mohammed Al-washali, ZhengYifeng, INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH MARCH 2021

[15] Experimental Study on the Seismic Behaviour of Reinforced Concrete Bridge Piers Strengthened by BFRP Sheets, Yong Li, Jing-Bo Liu, 18 Jun 2019