FINITE ELEMENT ANALYSIS OF INTEGRAL BRIDGE USING DIFFERENT SPAN LENGTH USING STADD PRO

[1]CHOUHAN ANKIT SINGH
M.TECH SHOLAR SIRTS BHOPAL

[2]DEEPAK KUMAR BANDEWAR
ASST. PROF. SIRTS BHOPAL

[3]NEHA SRIVAS
ASST. PROF. TIT BHOPAL

[4]JYOTI NAGJI
M.TECH SCHOLAR

[5]SACHIN NAGAYACH
DESIGN ENGINEER

ABSTRACT

Integral bridges (IBs) are jointless bridges where the deck is continuous and connected monolithically with the abutment wall with a moment-resisting connection. With the desire to design and construct longer span bridges with skew and non-skew alignments, and to evaluate of the performance of these bridges during seismic excitation, a new, more integrated analysis and design tool is necessary. This paper describes the implementation of a full 3D finite element (FE) model of an integrated bridge system which explicitly incorporates the nonlinear soil response behind the abutment walls and adjacent to the supporting piles. Using commercially available finite-element code GTSTRUDL (1991), the nonlinear soil behavior is handled using nonlinear springs at the abutment wall and pile nodes. This FE implementation streamlines the analysis and design of IAB systems and is capable of analyzing both skew and non-skew bridge orientations, and should be able to evaluate seismic response. An Integral Bridge of length 50m is adopted for this study. Three bridge models are prepared having single span, two span and three spans. Single span bridge is of 50m length, two spans of length 25m each and three spans of 16.67 each. Three steel girders Integral Bridge has modeled, in which the deck is modeled as reinforced concrete deck. Three Integral Bridge models are selected for this study. It is found that The bending moment in Integral Bridge can be reduced drastically by increasing number of spans and Converting an Integral Bridge into two spans results in reduction of BM upto 75% whereas a three span bridge results in 88% reduction. Converting an Integral Bridge into two spans result in reduction SF 50% whereas a three span bridge results in 66% reduction

Keywords: Integral bridges (IBs), non-skew alignments, span bridges, seismic excitation, deck, jointless bridges, abutment wall.

CHAPTER 1

INTRODUCTION

1.1 BRIDGES

Bridges are structures meant to support rail road traffic, highway traffic or pedestrian loads across openings or crossings or another set or rail or highway traffic or across any natural or artificial obstacles. Based on the type of traffic for which they are provided, bridges may be classified into- (i) Highway bridges (ii) Railway bridges (iii) Foot bridges for pedestrian traffic. We also at times come across combined Highway and Railway bridges.

Bridges may be made of timber, masonry, reinforced concrete, prestressed concrete and steel. Timber bridges are generally provided for small spans and sometimes as a temporary bridge. For permanent bridges or small spans not exceeding 12 m, masonry bridges may be provided. For greater spans, the dead load of masonry becomes large and hence masonry bridges work out to be uneconomical. Reinforced concrete bridges are found to be economical for spans exceeding 12 m. Prestressed concrete bridges have been constructed for spans up to 60 m. Arched concrete bridges have been built for still greater spans. Since steel possesses a high working stress compared to other materials, steel bridges work out to be economical for large spans. Steel bridges are very common for small as well as long spans in railways. Fabricated components of a steel bridge can be easily transported to the site and assembled, thus considerably reducing the construction time. A bridge forms mainly the super structure spanning the required length and it comprises of the floor system, the trusses or girders system, support arrangement and lateral bracing system. The floor system provides a satisfactory surface to afford easy movement of traffic over it. The floor system transmits its weight and loads due to vehicular traffic to the supporting trusses or girders. The trusses and girders in turn transmit all loads received by them to the abutments or supporting piers.

Trusses and girders are provided with end shoe device to safely transmit the reactions to the supporting abutments. Such an arrangement also makes provision for slight longitudinal movements due to temperature changes. A lateral bracing system is provided to the bridge, which not only provides adequate stiffness but also minimizes vibrations. Such bracing system also resists lateral forces transmitted by wind action on the structure as well as the moving vehicles.

1.1.1 Types of Steel Bridges:

A brief description of some types of steel bridges is given below:

(i) Beam and Slab Bridge:

(ii) Box-Girder Bridges:

(iii) Trussed Bridges or Open Web Girder Bridges:

1.2 INTEGRAL BRIDGE

Integral bridges are constructed without any joints between spans or between span and abutments. The superstructure along with abutments acts as single structural element. The use of „integral bridge" construction has grown to cover a large proportion of new-build highway bridge construction in the UK. Indeed, consideration of integral construction is required by highway authorities [1] for all bridges with an overall length up to 60m and no more than 30° skew. This article provides a general overview of integral construction for composite bridges.

1.2.1 Types of Integral Bridges

Integrals bridges are classified into four types based on abutments types as follows:

1. Integral Bridge with Frame Abutments
2. Integral Bridge with Flexible Support Abutments
3. Integral Bridge with Bank Pad Abutments
4. Integral Bridge with Semi Integral End Screen Abutments

1. Integral Bridge with Frame Abutments

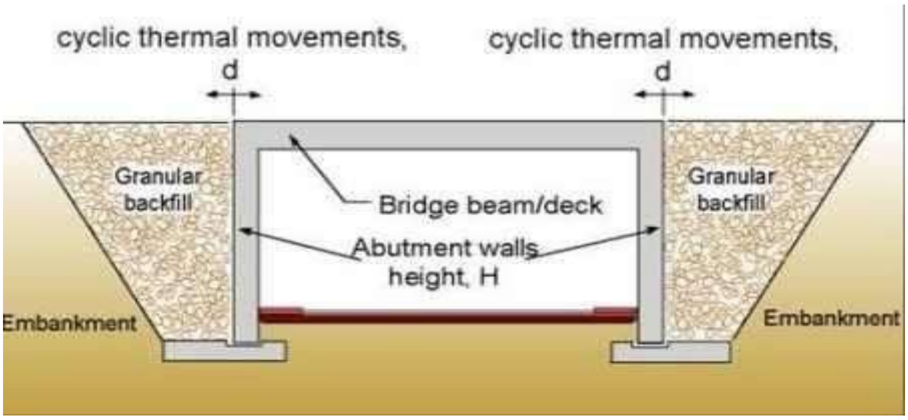


Fig 1. 2*: Integral Bridge with Framed Abutments*

2. Integral Bridge with Flexible Support Abutments

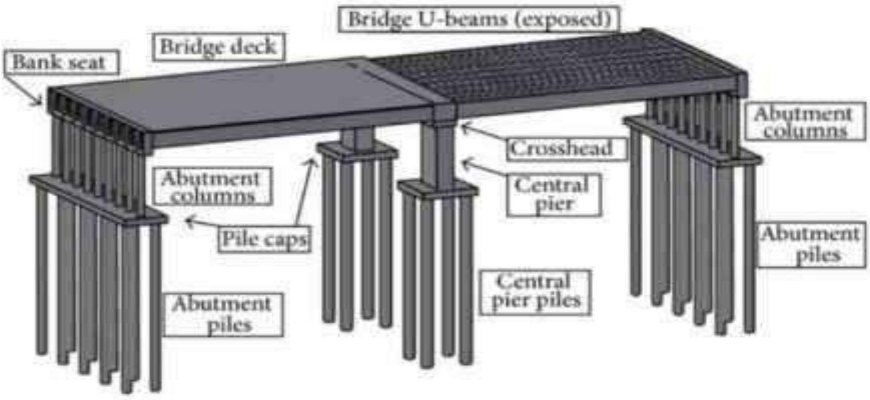


Fig 1. 3*: Flexible Support Abutments*

3. Integral Bridge with Bank Pad Abutments

.

Fig 1. 4*: Integral Bridge with Bank Pad Abutments*

4. Integral Bridge with Semi-integral End screen Abutments

Fig 1. 5*: Integral Bridge with End Screen Abutments*

1.2.2 Advantages of Integral Bridges

The advantages of integral bridges over normal bridges are as follows:

- When compared to conventional bridges, construction costs and maintenance costs are much lower.
- Construction of integral bridges is simple and rapid.
- Lesser tolerance restriction due to elimination of bearings and expansion joints.
- If integral bridge is constructing in place of existing old bridge, the foundation of old bridge can be used as foundation for integral bridge. Hence cost of project reduces.
- Elimination of water leakage on critical structural elements can be done using drainage layer provided behind the integral abutments.
- The vehicle riding quality on integral bridge is more comfortable and smoother sincethere are no expansion joints.

Fig 1. 6*: Intermediate Supports of Integral Bridge*

1.2.3 Limitations of Integral Bridges

Following are some limitations to be considered while designing integral bridges.

- Integral bridges are not suitable in zones where there is chance of expansion/contraction of more than 51mm during temperature variations.
- They are not preferred when subsoil or embankments are of poor strength.
- Geometry of the bridge and material used for the construction play key role in case of integral bridges. They are responsible for the displacement affects in the bridge.
- There is a chance of formation of plastic hinges in piles due to high stresses of expansion and contractions results in reduction of axial load capacity of piles. The foundation should be designed considering this point.
- Integral abutments are suitable for the bridges up to the length of 40 m for steel girder bridges and length up to 50 m for concrete girder bridges.

CHAPTER 2

RESEARCH METHODOLOGY

PROBLEM IDENTIFICATION

Integral Bridges can be described as bridges generally built their superstructures integral with the abutments, without expansion or contraction joints for the entire length of the superstructure. The structural system offered by bridges made integral between superstructure and abutments can provide structural efficiencies as well as enables the elimination of bearings and expansion joints. In some circumstances the durability of the bridge is improved and maintenance costs reduced. These bridges are single span or multiplane bridges. The abutments, being cast integral with the superstructure so as to avoid the expansion joints and movement bearings that otherwise require regular maintenance. The piers for Integral Abutment Bridges may be constructed either integrally with or independently. The benefits of Integral Bridges are principally the elimination of expansion joints and bearings, leading to simpler structures that are easier and less expensive to maintain.

METHODOLOGY USED

1. Before starting our work, we first review the literature related to our work.
2. Next step is we will make the models as per different arrangement in STAAD Pro and assigning member and material properties as per the design.
3. Description of the bridge considered with span of 200 m. The deck width is 10 m. The height of bridge is 65 m.
4. In our work the load considered are dead load, Imposed Loads and Wind Loads.
5. And finally, we will make the comparison of different cases.

DESCRIPTION OF BRIDGE

An Integral Bridge of length 50m is adopted for this study. Three bridge models are prepared having single span, two span and three spans. Single span bridge is of 50m length, two spans of length 25m each and three spans of 16.67 each. The width of the bridge is taken 10.5m. With two lanes of width 3.75m each. The intermediate piers constitute of three columns, over which a pier cap is provided to rest the main longitudinal girders. The abutment walls and pier columns are considered fixed at the base. Three steel girders Integral Bridge has modeled, in which the deck is modeled as reinforced concrete deck. Three Integral Bridge models are selected for this study. Details of the bridge and constituent material are given below:

Table 2.1: Description of Structure

Description	**Value**
Length bridge	80 m
Width of deck	20 m
Height of bridge	8 m
Deck slab thickness	0.3 m
Dia. of column	1 m
Grade of concrete	M30
Grade of steel	Fe415
Main girder	w36 x 160

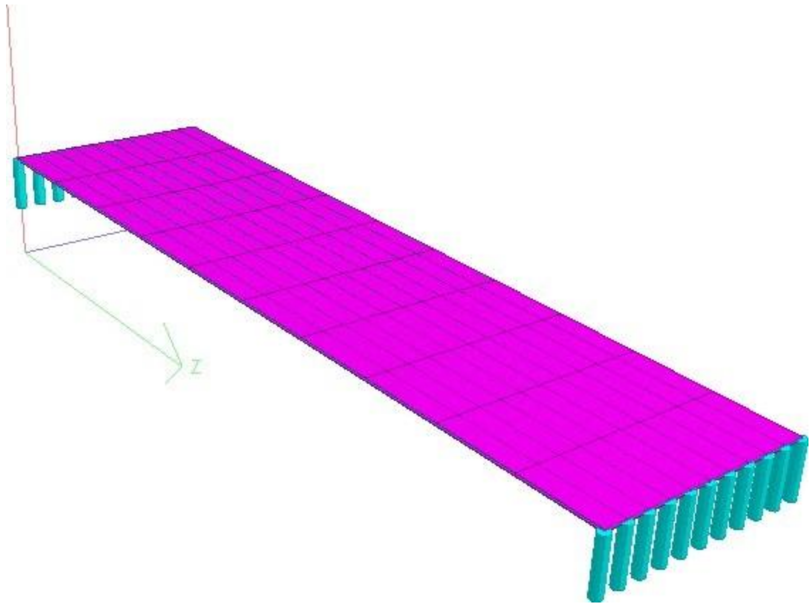


Fig. 2.1: 3-D View of Single Span Integral Bridge

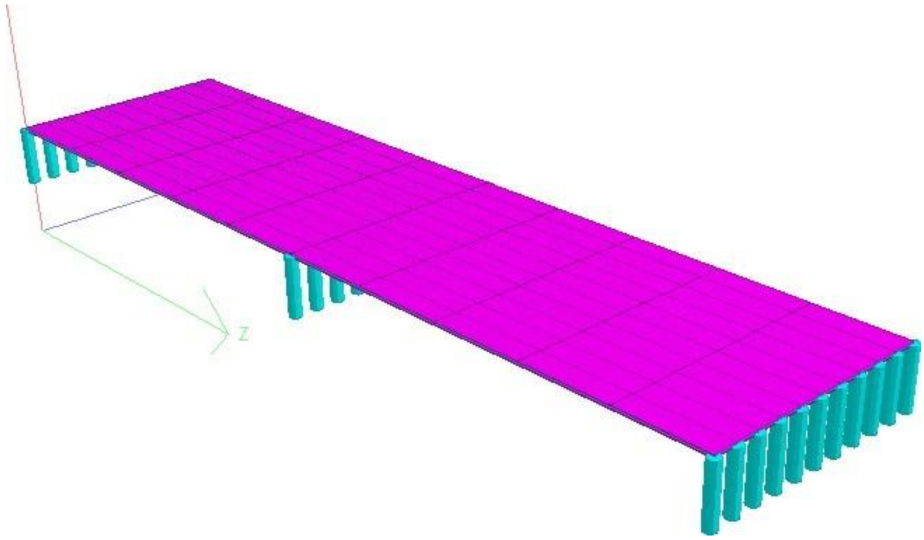


Fig. 2.2: 3-D View of double span integral bridge

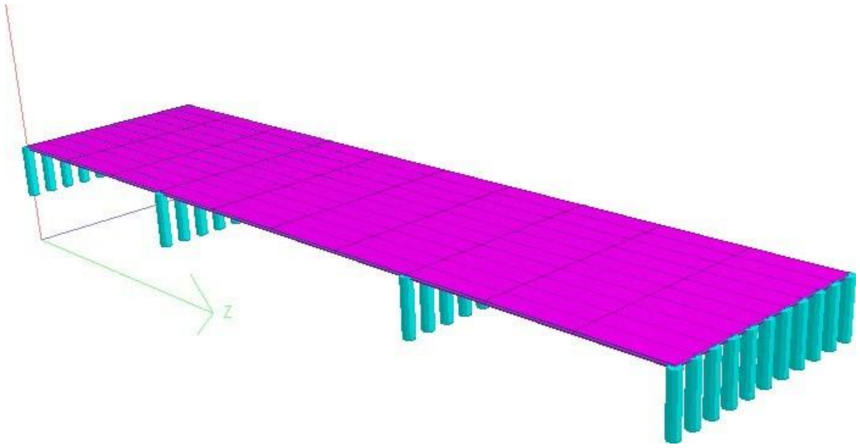


Fig. 2.3: 3-D View of three span integral bridge

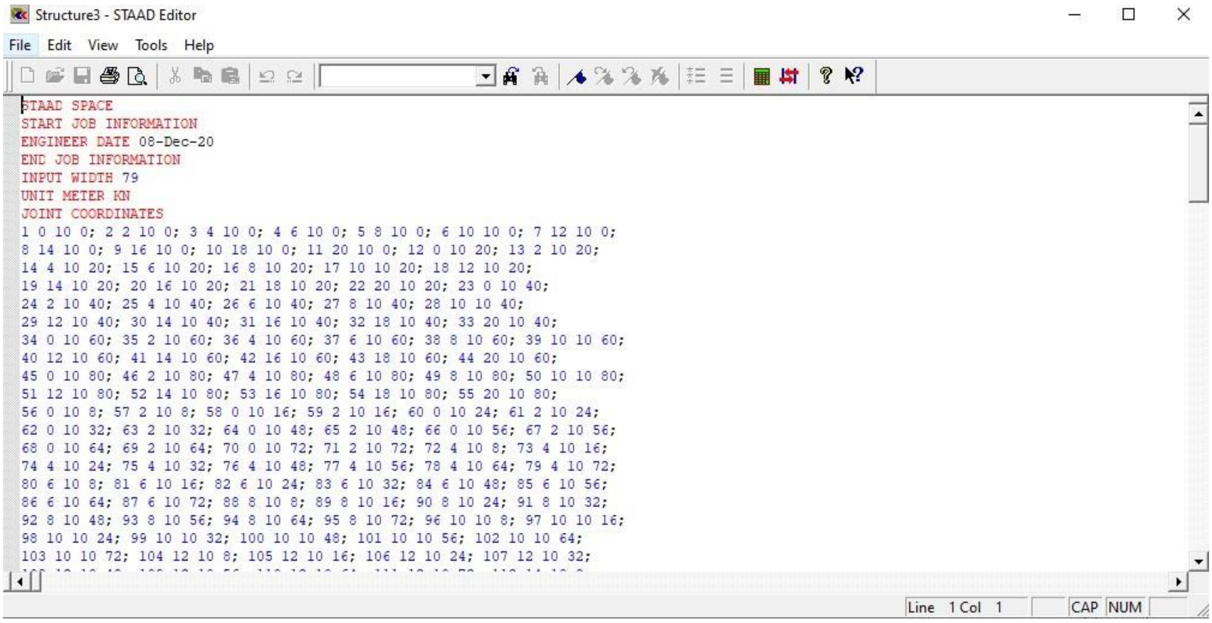
The above three finite element models are developed to present the characteristics of the analyses:1) Dead loading2) Live loading i.e., IRC70R, IRC Class A loading. All finite element models were developed using the software Staad Pro V8i.

CHAPTER 3

BRIDGE MODELING AND ANALYSIS

INPUT GENERATION

STD input file contains some sort of instructions that are done chronologically. The guidelinescontain either commands or data concerning to analysis and/or design. This type of file fundamentally generates or we can edit it from an option available under text editor or the GUI Modelling capability. All-purpose, any text editor may be employed to edit/create the STD input file. The GUI Modelling capability creates the input file through a collaborating menu-driven graphics concerned with procedure.



```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 08-Dec-20
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 10 0; 2 2 10 0; 3 4 10 0; 4 6 10 0; 5 8 10 0; 6 10 10 0; 7 12 10 0;
8 14 10 0; 9 16 10 0; 10 18 10 0; 11 20 10 0; 12 0 10 20; 13 2 10 20;
14 4 10 20; 15 6 10 20; 16 8 10 20; 17 10 10 20; 18 12 10 20;
19 14 10 20; 20 16 10 20; 21 18 10 20; 22 20 10 20; 23 0 10 40;
24 2 10 40; 25 4 10 40; 26 6 10 40; 27 8 10 40; 28 10 10 40;
29 12 10 40; 30 14 10 40; 31 16 10 40; 32 18 10 40; 33 20 10 40;
34 0 10 60; 35 2 10 60; 36 4 10 60; 37 6 10 60; 38 8 10 60; 39 10 10 60;
40 12 10 60; 41 14 10 60; 42 16 10 60; 43 18 10 60; 44 20 10 60;
45 0 10 80; 46 2 10 80; 47 4 10 80; 48 6 10 80; 49 8 10 80; 50 10 10 80;
51 12 10 80; 52 14 10 80; 53 16 10 80; 54 18 10 80; 55 20 10 80;
56 0 10 8; 57 2 10 8; 58 0 10 16; 59 2 10 16; 60 0 10 24; 61 2 10 24;
62 0 10 32; 63 2 10 32; 64 0 10 48; 65 2 10 48; 66 0 10 56; 67 2 10 56;
68 0 10 64; 69 2 10 64; 70 0 10 72; 71 2 10 72; 72 4 10 8; 73 4 10 16;
74 4 10 24; 75 4 10 32; 76 4 10 48; 77 4 10 56; 78 4 10 64; 79 4 10 72;
80 6 10 8; 81 6 10 16; 82 6 10 24; 83 6 10 32; 84 6 10 48; 85 6 10 56;
86 6 10 64; 87 6 10 72; 88 8 10 8; 89 8 10 16; 90 8 10 24; 91 8 10 32;
92 8 10 48; 93 8 10 56; 94 8 10 64; 95 8 10 72; 96 10 10 8; 97 10 10 16;
98 10 10 24; 99 10 10 32; 100 10 10 48; 101 10 10 56; 102 10 10 64;
103 10 10 72; 104 12 10 8; 105 12 10 16; 106 12 10 24; 107 12 10 32;
```

Fig 3.1: STAAD input file

GENERATION OF THE STRUCTURE

Input file makes the generation structure easy or revealing the coordinates in the GUI also generates structure. After required input necessary for the GUI generation presented in fig. below.

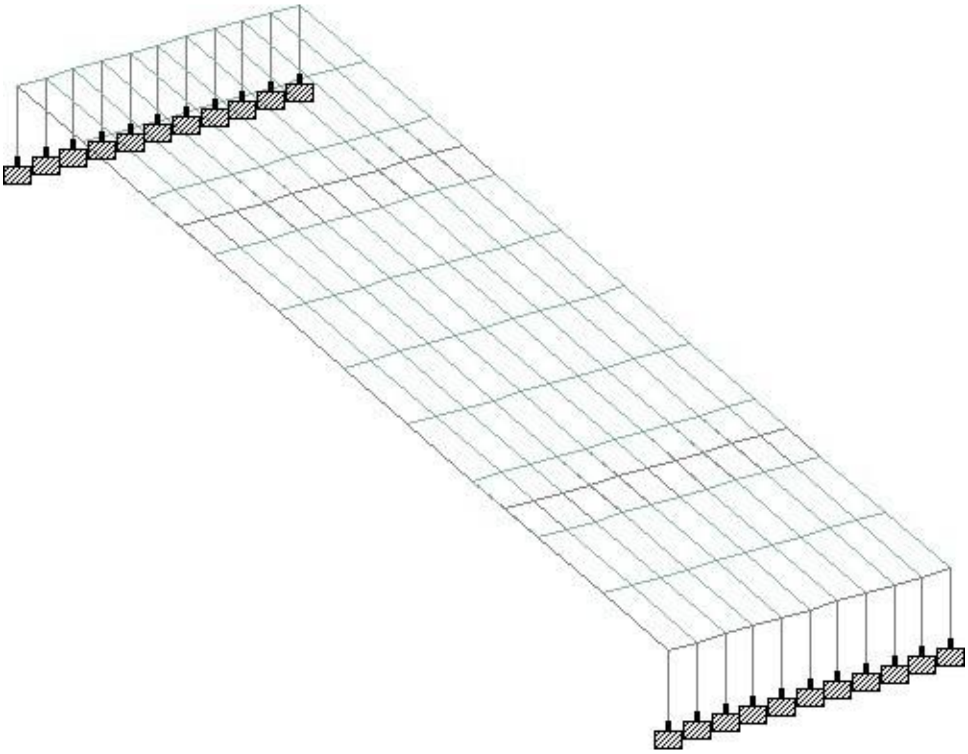


Fig 3.2: 2-D View of Single Span Integral Bridge

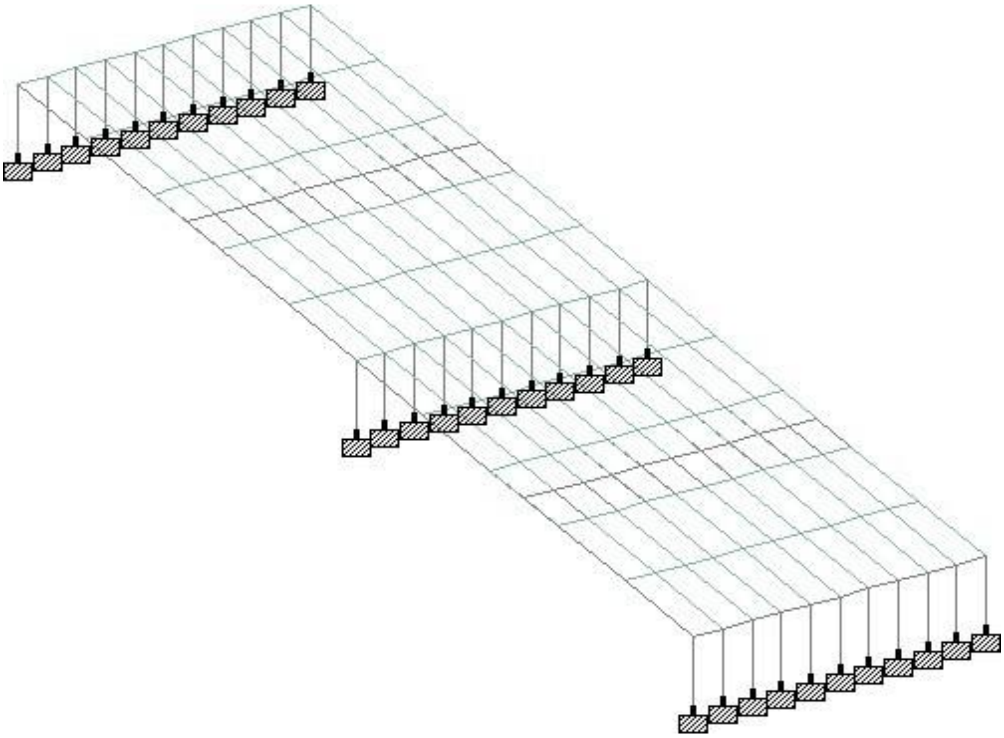


Fig 3.3: 2-D View of double span integral bridge

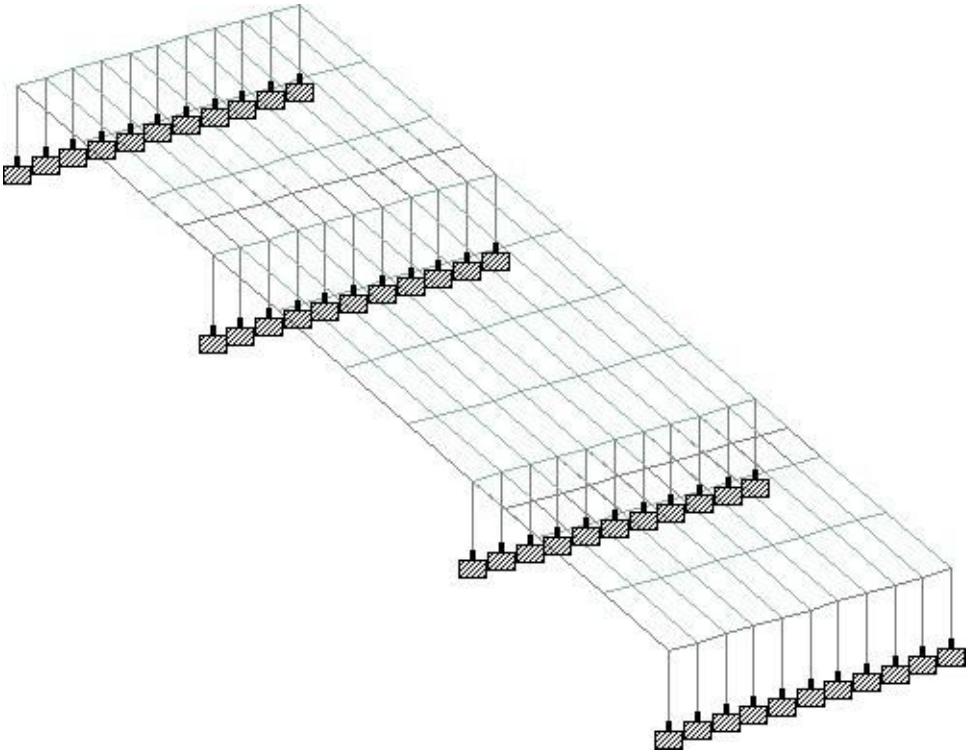


Fig 3.4: 2-D View of three span integral bridge

SUPPORTS

We can provide different end conditions for example supports such as fix, pin etc. When we talk about pinned support translational and rotational movement are not allowed. In other words, we can say that this type of support will have reactions for all forces but will resist no moments. A fixed support has zero degree of freedom. Other supports such as translational and rotational can also be utilized. The springs are characterized with respect to spring constants. When a force displaced a joint whatever it maybe we can call as translational support.

ASSIGNING PROPERTIES

Before analysis begins, we have to assign different members in our design models. Assign different members in respect of material and size.

Since Staad pro is user friendly hence we can easily assign member material properties. In Staad pro four different materials such as concrete, steel, stainless steel and aluminum are already defined. According to requirements we can easily define other materials also.

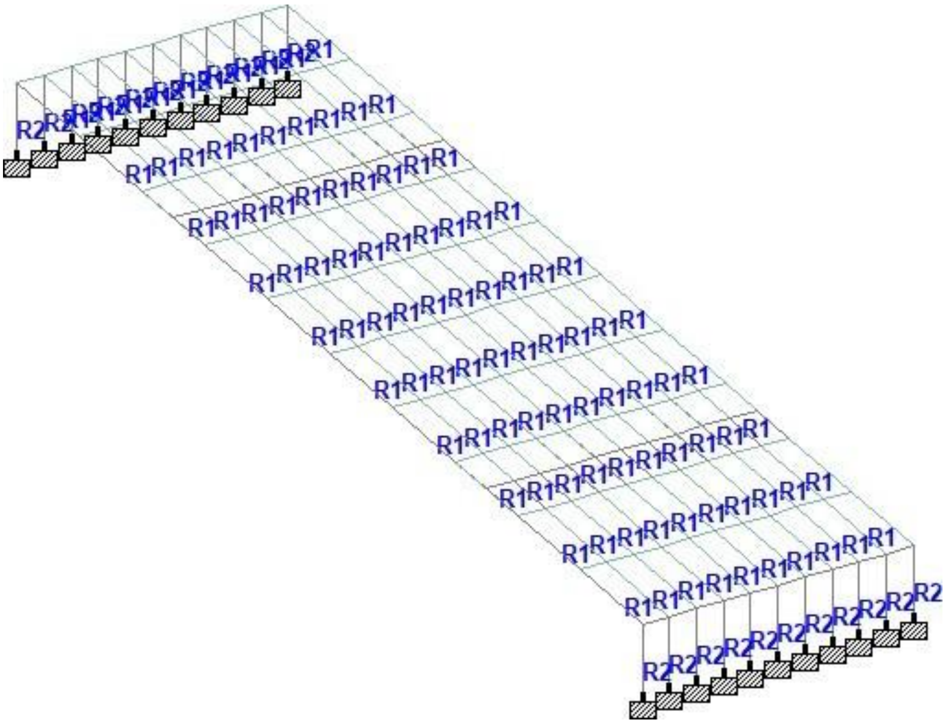


Fig. 3.5: Assigning properties (single span)

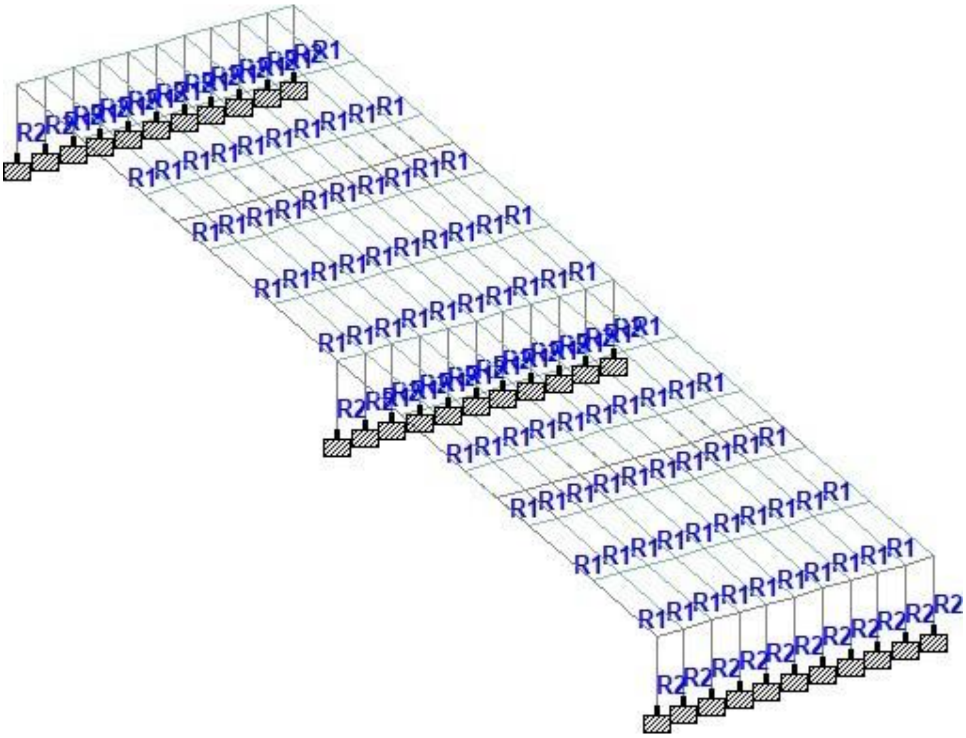


Fig. 3.6: Assigning properties (double span)

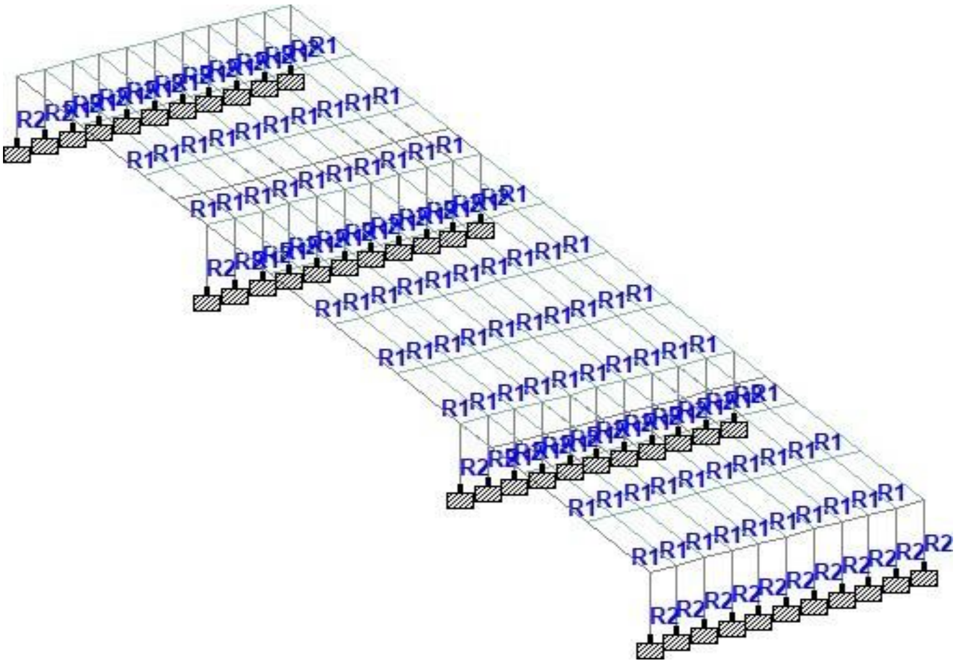


Fig. 3.7: Assigning properties (three span)

LOAD CONSIDERATION

Loads in a structure can be particular as joint load, member load, temperature load etc. As we all know that Staad also can generate the self-weight of the structure and use it as uniformly allotted member loads in evaluation. Any fraction of this self-weight can also be applied in any desired direction.

- **Joint loads**
- **Member load**
- **Area/floor load:**
- **Load Generator – Moving load, Wind & Seismic:**

POST PROCESSING FACILITIES

All results obtained from the STAAD may be employed for additional processing by the STAAD.Pro GUI.

Code Checking:

The determination of code examination is to confirm whether the definite section is accomplished to sustaining valid design code requirements. The code examination is established on the IS: 800 (1984) necessities. Forces and moments at quantified sections of the members are exploited for the code examination calculations. If no sections are specified, the code checking is based on forces and moments at the member ends.

CHAPTER 4

RESULTS AND DISCUSSION

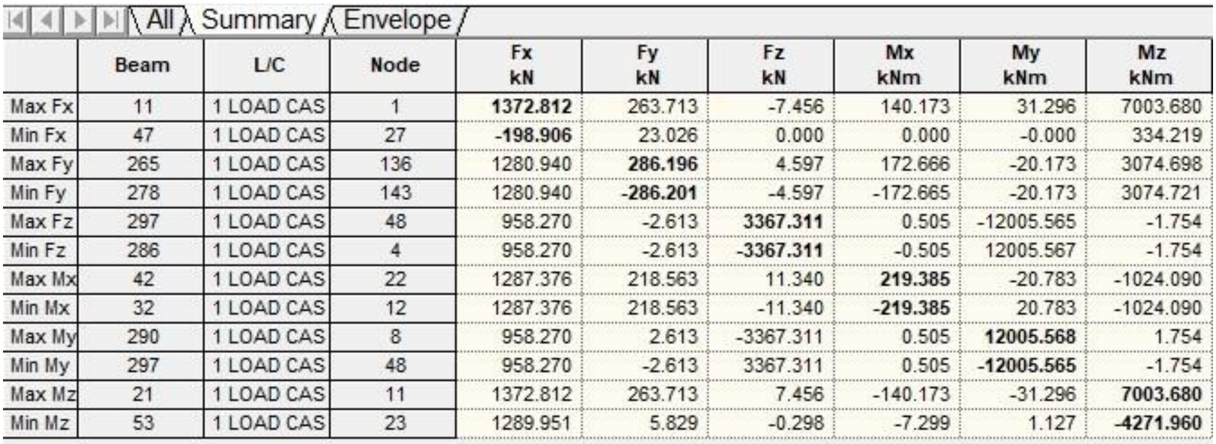
In the present work, the variation of bending moments (BM), shear forces (SF), axial forces and the extreme fiber stresses in the superstructure (deck slab) for different spans have been studied. Bridges are modeled and analyzed for dead load, live load (IRC70R, IRC class A). The effect of these loading on the parameters with respect to max positive BM, maximum negative BM in the superstructure (deck slab), max positive SF, maximum negative SF, maximum axial force in the deck has been observed and discussed.

EFFECT OF DEAD AND LIVE LOAD

The variation in BM, SF, and axial forces in the superstructure due dead loads only for the three different spans (50m, 25m &16.67m) are represented in the form of graphs below.

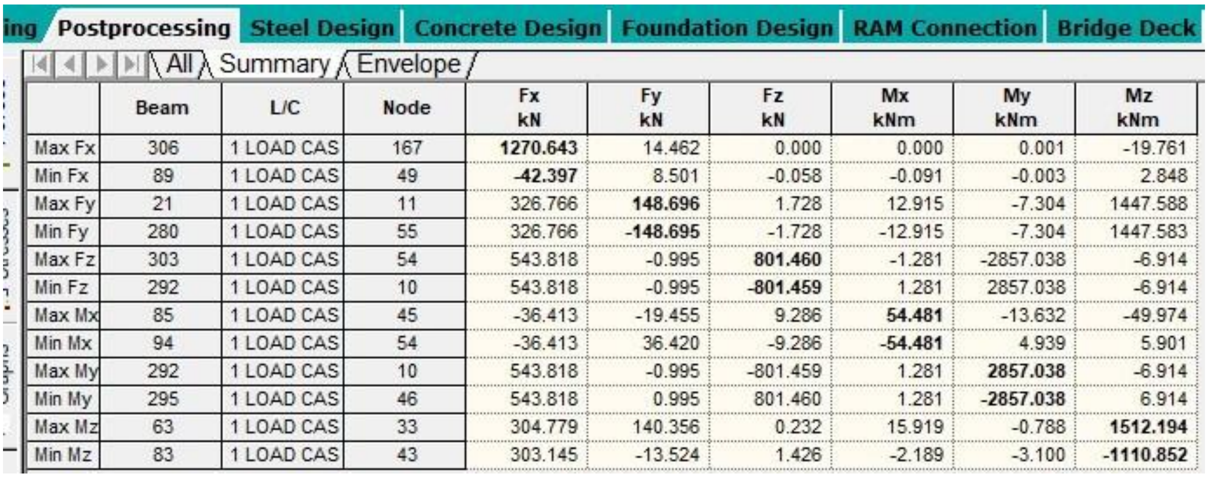
BENDING MOMENT VARIATION

From results obtained, magnitude of maximum BMare presented in figure number 4.1, it is observed that in this comparative study maximum max. Bending moment is in single span whereas three span shows minimum bending moment value which results in balanced section.



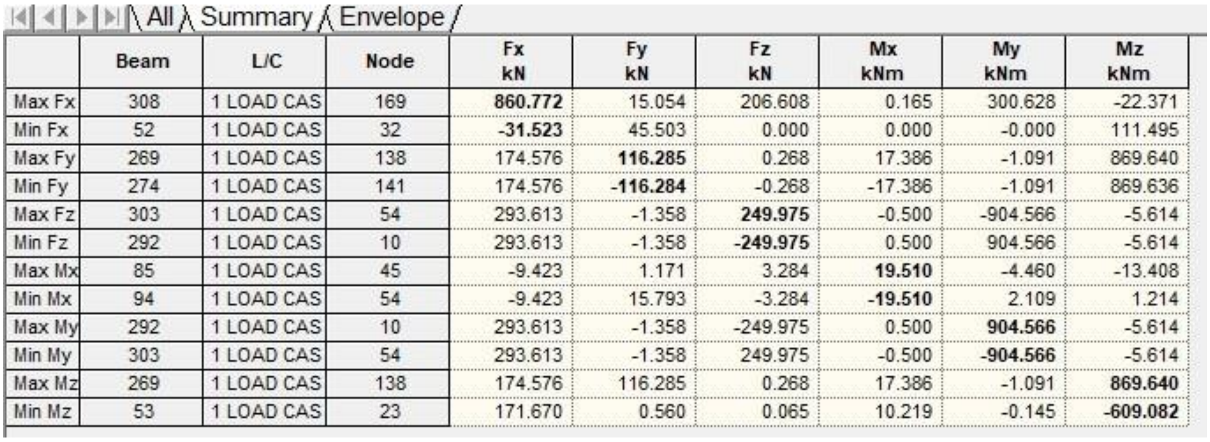
	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	11	1 LOAD CAS	1	**1372.812**	263.713	-7.456	140.173	31.296	7003.680
Min Fx	47	1 LOAD CAS	27	**-198.906**	23.026	0.000	0.000	-0.000	334.219
Max Fy	265	1 LOAD CAS	136	1280.940	**286.196**	4.597	172.666	-20.173	3074.698
Min Fy	278	1 LOAD CAS	143	1280.940	**-286.201**	-4.597	-172.665	-20.173	3074.721
Max Fz	297	1 LOAD CAS	48	958.270	-2.613	**3367.311**	0.505	-12005.565	-1.754
Min Fz	286	1 LOAD CAS	4	958.270	-2.613	**-3367.311**	-0.505	12005.567	-1.754
Max Mx	42	1 LOAD CAS	22	1287.376	218.563	11.340	**219.385**	-20.783	-1024.090
Min Mx	32	1 LOAD CAS	12	1287.376	218.563	-11.340	**-219.385**	20.783	-1024.090
Max My	290	1 LOAD CAS	8	958.270	2.613	-3367.311	0.505	**12005.568**	1.754
Min My	297	1 LOAD CAS	48	958.270	-2.613	3367.311	0.505	**-12005.565**	-1.754
Max Mz	21	1 LOAD CAS	11	1372.812	263.713	7.456	-140.173	-31.296	**7003.680**
Min Mz	53	1 LOAD CAS	23	1289.951	5.829	-0.298	-7.299	1.127	**-4271.960**

Max and Min bending moment for single span



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	306	1 LOAD CAS	167	**1270.643**	14.462	0.000	0.000	0.001	-19.761
Min Fx	89	1 LOAD CAS	49	**-42.397**	8.501	-0.058	-0.091	-0.003	2.848
Max Fy	21	1 LOAD CAS	11	326.766	**148.696**	1.728	12.915	-7.304	1447.588
Min Fy	280	1 LOAD CAS	55	326.766	**-148.695**	-1.728	-12.915	-7.304	1447.583
Max Fz	303	1 LOAD CAS	54	543.818	-0.995	**801.460**	-1.281	-2857.038	-6.914
Min Fz	292	1 LOAD CAS	10	543.818	-0.995	**-801.459**	1.281	2857.038	-6.914
Max Mx	85	1 LOAD CAS	45	-36.413	-19.455	9.286	**54.481**	-13.632	-49.974
Min Mx	94	1 LOAD CAS	54	-36.413	36.420	-9.286	**-54.481**	4.939	5.901
Max My	292	1 LOAD CAS	10	543.818	-0.995	-801.459	1.281	**2857.038**	-6.914
Min My	295	1 LOAD CAS	46	543.818	0.995	801.460	1.281	**-2857.038**	6.914
Max Mz	63	1 LOAD CAS	33	304.779	140.356	0.232	15.919	-0.788	**1512.194**
Min Mz	83	1 LOAD CAS	43	303.145	-13.524	1.426	-2.189	-3.100	**-1110.852**

Max and Min bending moment for double span



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	308	1 LOAD CAS	169	**860.772**	15.054	206.608	0.165	300.628	-22.371
Min Fx	52	1 LOAD CAS	32	**-31.523**	45.503	0.000	0.000	-0.000	111.495
Max Fy	269	1 LOAD CAS	138	174.576	**116.285**	0.268	17.386	-1.091	869.640
Min Fy	274	1 LOAD CAS	141	174.576	**-116.284**	-0.268	-17.386	-1.091	869.636
Max Fz	303	1 LOAD CAS	54	293.613	-1.358	**249.975**	-0.500	-904.566	-5.614
Min Fz	292	1 LOAD CAS	10	293.613	-1.358	**-249.975**	0.500	904.566	-5.614
Max Mx	85	1 LOAD CAS	45	-9.423	1.171	3.284	**19.510**	-4.460	-13.408
Min Mx	94	1 LOAD CAS	54	-9.423	15.793	-3.284	**-19.510**	2.109	1.214
Max My	292	1 LOAD CAS	10	293.613	-1.358	-249.975	0.500	**904.566**	-5.614
Min My	303	1 LOAD CAS	54	293.613	-1.358	249.975	-0.500	**-904.566**	-5.614
Max Mz	269	1 LOAD CAS	138	174.576	116.285	0.268	17.386	-1.091	**869.640**
Min Mz	53	1 LOAD CAS	23	171.670	0.560	0.065	10.219	-0.145	**-609.082**

Max and Min bending moment for three span

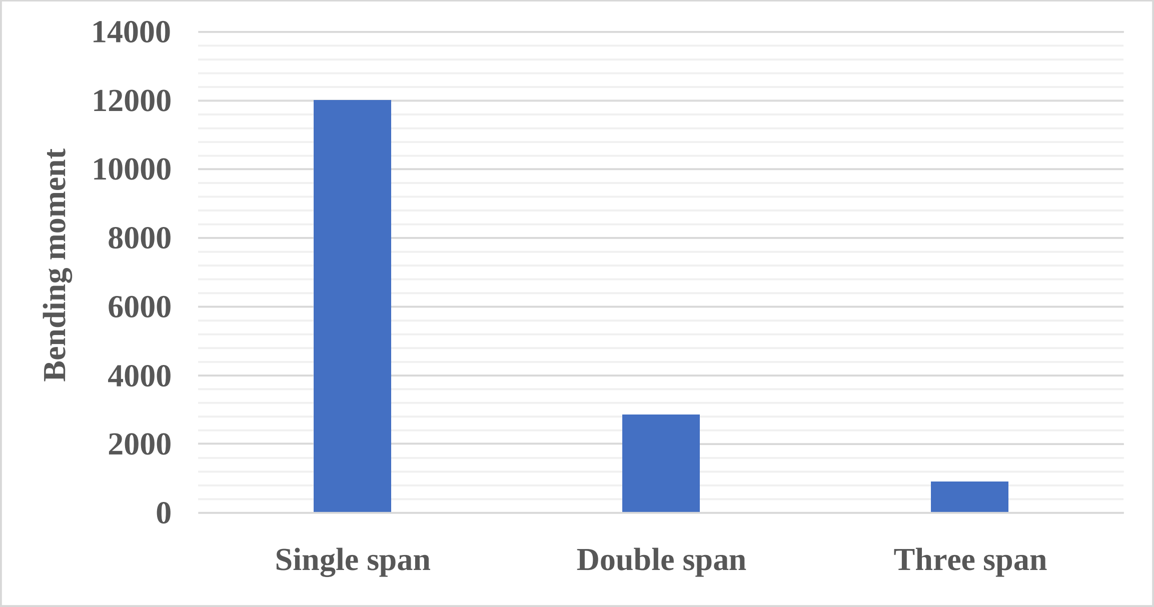
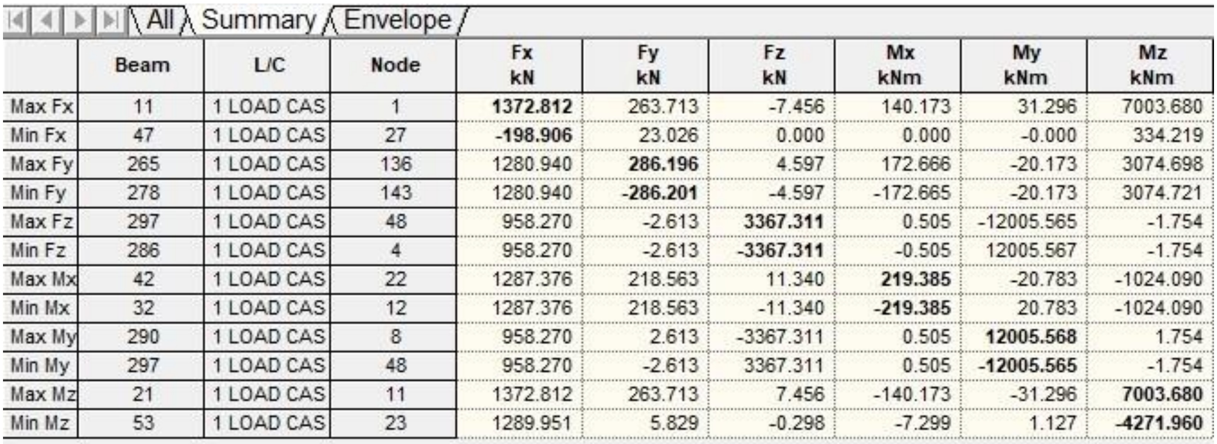


Fig. 4.1: Bending moment variation

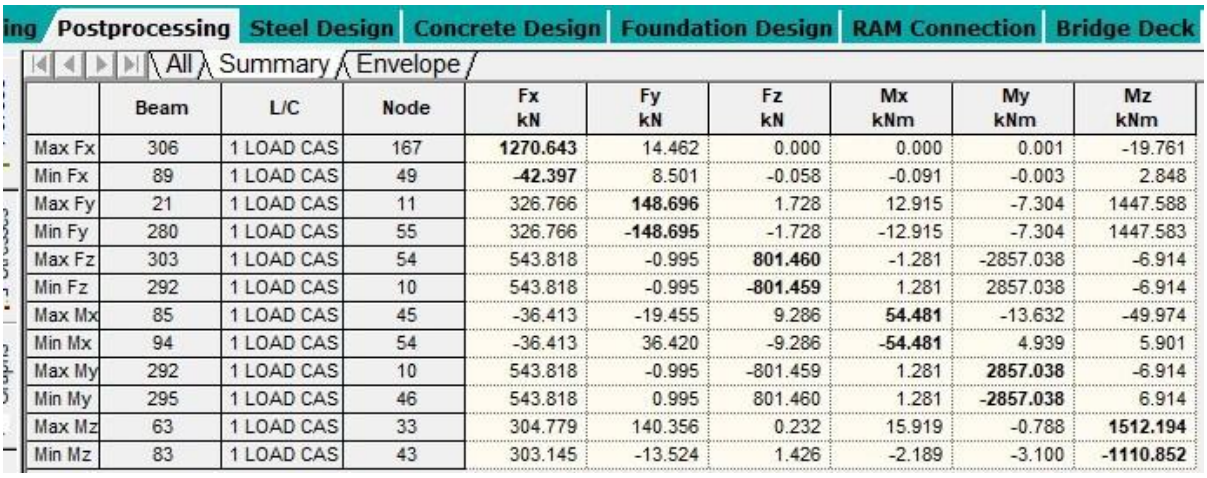
SHEAR FORCE VARIATION

From results obtained, magnitude of maximum SF is presented in figure number 4.2, it is observed that in this comparative study maximum max. Shear force is in single span whereas three span shows minimum shear force value which results in balanced section.



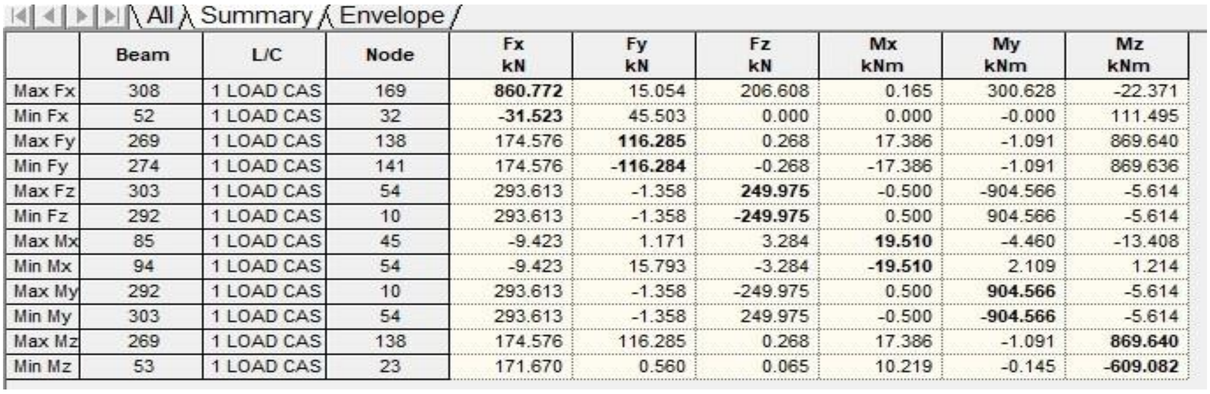
	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	11	1 LOAD CAS	1	**1372.812**	263.713	-7.456	140.173	31.296	7003.680
Min Fx	47	1 LOAD CAS	27	**-198.906**	23.026	0.000	0.000	-0.000	334.219
Max Fy	265	1 LOAD CAS	136	1280.940	**286.196**	4.597	172.666	-20.173	3074.698
Min Fy	278	1 LOAD CAS	143	1280.940	**-286.201**	-4.597	-172.665	-20.173	3074.721
Max Fz	297	1 LOAD CAS	48	958.270	-2.613	**3367.311**	0.505	-12005.565	-1.754
Min Fz	286	1 LOAD CAS	4	958.270	-2.613	**-3367.311**	-0.505	12005.567	-1.754
Max Mx	42	1 LOAD CAS	22	1287.376	218.563	11.340	**219.385**	-20.783	-1024.090
Min Mx	32	1 LOAD CAS	12	1287.376	218.563	-11.340	**-219.385**	20.783	-1024.090
Max My	290	1 LOAD CAS	8	958.270	2.613	-3367.311	0.505	**12005.568**	1.754
Min My	297	1 LOAD CAS	48	958.270	-2.613	3367.311	0.505	**-12005.565**	-1.754
Max Mz	21	1 LOAD CAS	11	1372.812	263.713	7.456	-140.173	-31.296	**7003.680**
Min Mz	53	1 LOAD CAS	23	1289.951	5.829	-0.298	-7.299	1.127	**-4271.960**

Max and Min shear force for single span



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	306	1 LOAD CAS	167	**1270.643**	14.462	0.000	0.000	0.001	-19.761
Min Fx	89	1 LOAD CAS	49	**-42.397**	8.501	-0.058	-0.091	-0.003	2.848
Max Fy	21	1 LOAD CAS	11	326.766	**148.696**	1.728	12.915	-7.304	1447.588
Min Fy	280	1 LOAD CAS	55	326.766	**-148.695**	-1.728	-12.915	-7.304	1447.583
Max Fz	303	1 LOAD CAS	54	543.818	-0.995	**801.460**	-1.281	-2857.038	-6.914
Min Fz	292	1 LOAD CAS	10	543.818	-0.995	**-801.459**	1.281	2857.038	-6.914
Max Mx	85	1 LOAD CAS	45	-36.413	-19.455	9.286	**54.481**	-13.632	-49.974
Min Mx	94	1 LOAD CAS	54	-36.413	36.420	-9.286	**-54.481**	4.939	5.901
Max My	292	1 LOAD CAS	10	543.818	-0.995	-801.459	1.281	**2857.038**	-6.914
Min My	295	1 LOAD CAS	46	543.818	0.995	801.460	1.281	**-2857.038**	6.914
Max Mz	63	1 LOAD CAS	33	304.779	140.356	0.232	15.919	-0.788	**1512.194**
Min Mz	83	1 LOAD CAS	43	303.145	-13.524	1.426	-2.189	-3.100	**-1110.852**

Max and Min shear force for double span



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	308	1 LOAD CAS	169	**860.772**	15.054	206.608	0.165	300.628	-22.371
Min Fx	52	1 LOAD CAS	32	**-31.523**	45.503	0.000	0.000	-0.000	111.495
Max Fy	269	1 LOAD CAS	138	174.576	**116.285**	0.268	17.386	-1.091	869.640
Min Fy	274	1 LOAD CAS	141	174.576	**-116.284**	-0.268	-17.386	-1.091	869.636
Max Fz	303	1 LOAD CAS	54	293.613	-1.358	**249.975**	-0.500	-904.566	-5.614
Min Fz	292	1 LOAD CAS	10	293.613	-1.358	**-249.975**	0.500	904.566	-5.614
Max Mx	85	1 LOAD CAS	45	-9.423	1.171	3.284	**19.510**	-4.460	-13.408
Min Mx	94	1 LOAD CAS	54	-9.423	15.793	-3.284	**-19.510**	2.109	1.214
Max My	292	1 LOAD CAS	10	293.613	-1.358	-249.975	0.500	**904.566**	-5.614
Min My	303	1 LOAD CAS	54	293.613	-1.358	249.975	-0.500	**-904.566**	-5.614
Max Mz	269	1 LOAD CAS	138	174.576	116.285	0.268	17.386	-1.091	**869.640**
Min Mz	53	1 LOAD CAS	23	171.670	0.560	0.065	10.219	-0.145	**-609.082**

Max and Min shear force for three span

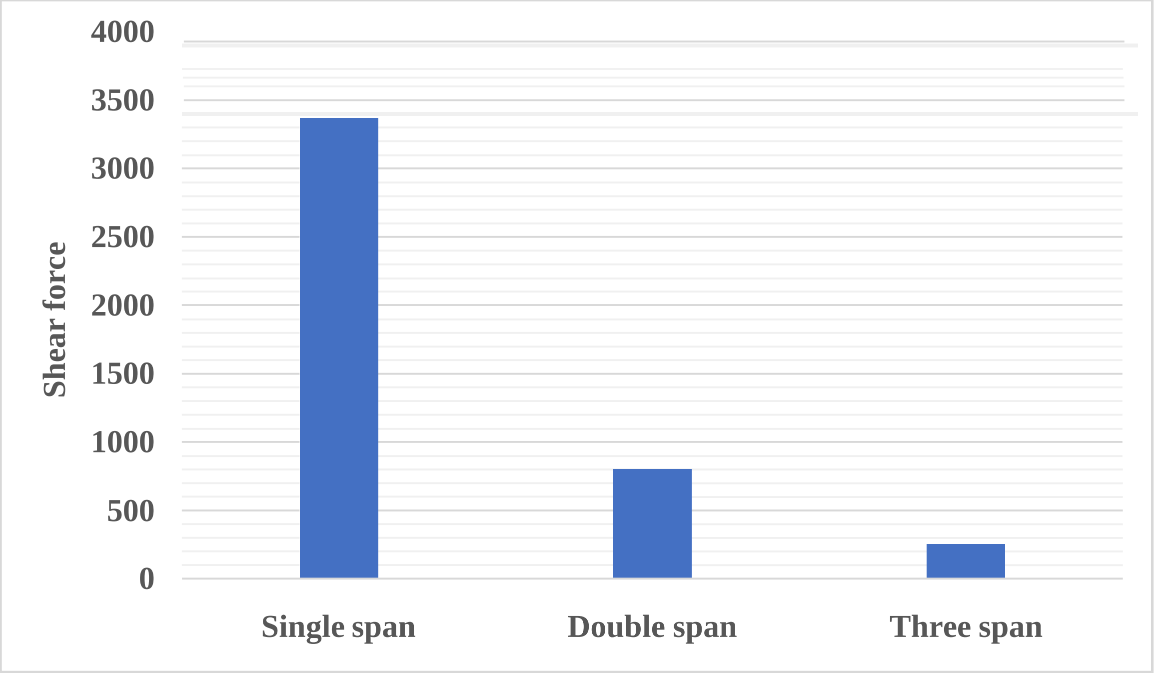
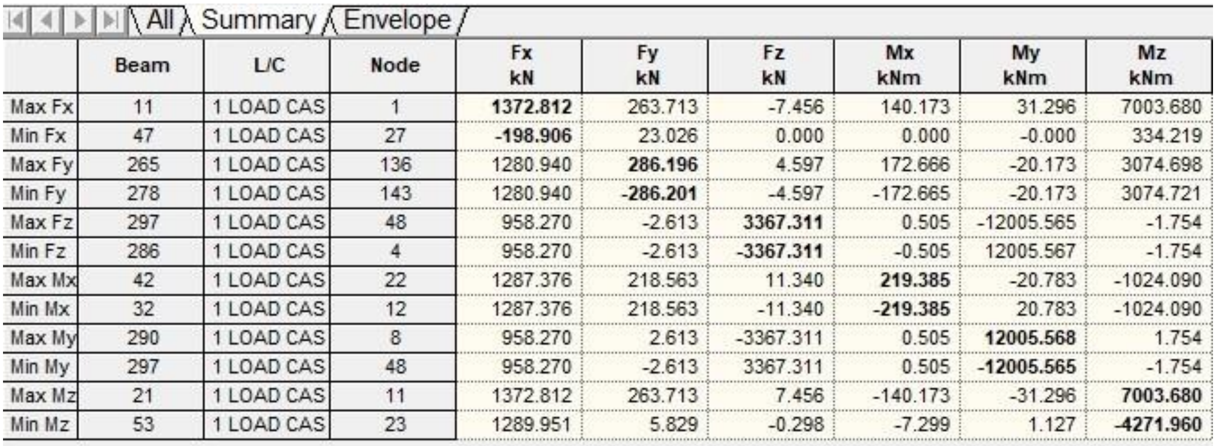


Fig. 4.2: Shear force variation

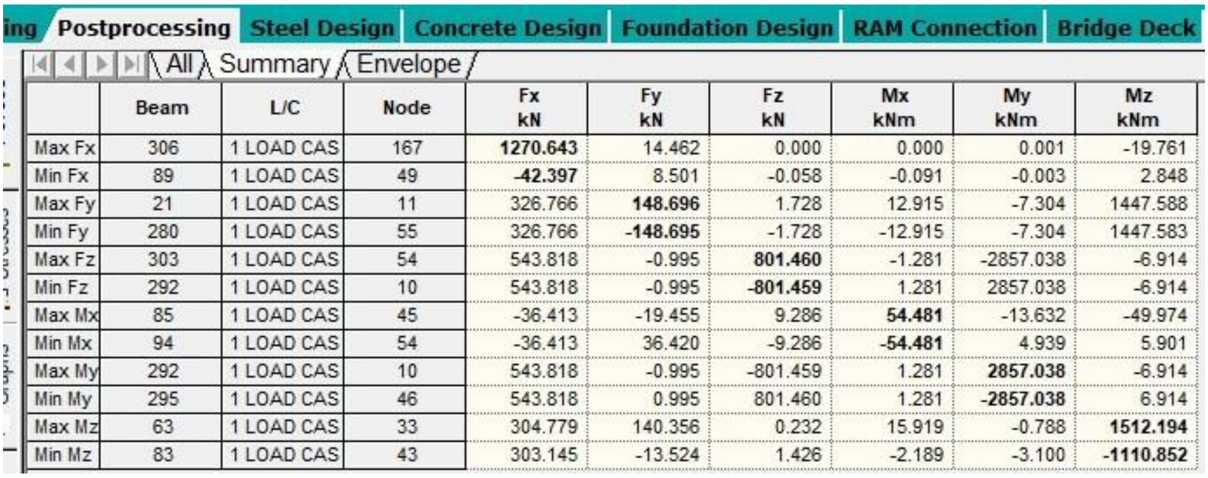
AXIAL FORCE VARIATION

From results obtained, magnitude of maximum axial force is presented in figure number 4.3, it is observed that in this comparative study maximum max. axial force is in single span whereas three span shows minimum axial force value which results in balanced section.



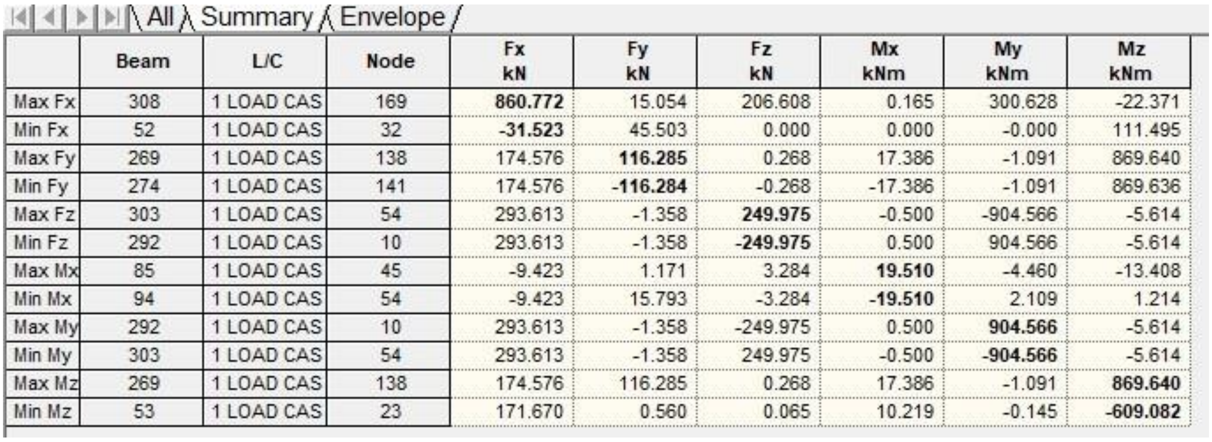
	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	11	1 LOAD CAS	1	**1372.812**	263.713	-7.456	140.173	31.296	7003.680
Min Fx	47	1 LOAD CAS	27	**-198.906**	23.026	0.000	0.000	-0.000	334.219
Max Fy	265	1 LOAD CAS	136	1280.940	**286.196**	4.597	172.666	-20.173	3074.698
Min Fy	278	1 LOAD CAS	143	1280.940	**-286.201**	-4.597	-172.665	-20.173	3074.721
Max Fz	297	1 LOAD CAS	48	958.270	-2.613	**3367.311**	0.505	-12005.565	-1.754
Min Fz	286	1 LOAD CAS	4	958.270	-2.613	**-3367.311**	-0.505	12005.567	-1.754
Max Mx	42	1 LOAD CAS	22	1287.376	218.563	11.340	**219.385**	-20.783	-1024.090
Min Mx	32	1 LOAD CAS	12	1287.376	218.563	-11.340	**-219.385**	20.783	-1024.090
Max My	290	1 LOAD CAS	8	958.270	2.613	-3367.311	0.505	**12005.568**	1.754
Min My	297	1 LOAD CAS	48	958.270	-2.613	3367.311	0.505	**-12005.565**	-1.754
Max Mz	21	1 LOAD CAS	11	1372.812	263.713	7.456	-140.173	-31.296	**7003.680**
Min Mz	53	1 LOAD CAS	23	1289.951	5.829	-0.298	-7.299	1.127	**-4271.960**

Max and Min axial force for single span



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	306	1 LOAD CAS	167	**1270.643**	14.462	0.000	0.000	0.001	-19.761
Min Fx	89	1 LOAD CAS	49	**-42.397**	8.501	-0.058	-0.091	-0.003	2.848
Max Fy	21	1 LOAD CAS	11	326.766	**148.696**	1.728	12.915	-7.304	1447.588
Min Fy	280	1 LOAD CAS	55	326.766	**-148.695**	-1.728	-12.915	-7.304	1447.583
Max Fz	303	1 LOAD CAS	54	543.818	-0.995	**801.460**	-1.281	-2857.038	-6.914
Min Fz	292	1 LOAD CAS	10	543.818	-0.995	**-801.459**	1.281	2857.038	-6.914
Max Mx	85	1 LOAD CAS	45	-36.413	-19.455	9.286	**54.481**	-13.632	-49.974
Min Mx	94	1 LOAD CAS	54	-36.413	36.420	-9.286	**-54.481**	4.939	5.901
Max My	292	1 LOAD CAS	10	543.818	-0.995	-801.459	1.281	**2857.038**	-6.914
Min My	295	1 LOAD CAS	46	543.818	0.995	801.460	1.281	**-2857.038**	6.914
Max Mz	63	1 LOAD CAS	33	304.779	140.356	0.232	15.919	-0.788	**1512.194**
Min Mz	83	1 LOAD CAS	43	303.145	-13.524	1.426	-2.189	-3.100	**-1110.852**

Max and Min axial force for double span



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	308	1 LOAD CAS	169	**860.772**	15.054	206.608	0.165	300.628	-22.371
Min Fx	52	1 LOAD CAS	32	**-31.523**	45.503	0.000	0.000	-0.000	111.495
Max Fy	269	1 LOAD CAS	138	174.576	**116.285**	0.268	17.386	-1.091	869.640
Min Fy	274	1 LOAD CAS	141	174.576	**-116.284**	-0.268	-17.386	-1.091	869.636
Max Fz	303	1 LOAD CAS	54	293.613	-1.358	**249.975**	-0.500	-904.566	-5.614
Min Fz	292	1 LOAD CAS	10	293.613	-1.358	**-249.975**	0.500	904.566	-5.614
Max Mx	85	1 LOAD CAS	45	-9.423	1.171	3.284	**19.510**	-4.460	-13.408
Min Mx	94	1 LOAD CAS	54	-9.423	15.793	-3.284	**-19.510**	2.109	1.214
Max My	292	1 LOAD CAS	10	293.613	-1.358	-249.975	0.500	**904.566**	-5.614
Min My	303	1 LOAD CAS	54	293.613	-1.358	249.975	-0.500	**-904.566**	-5.614
Max Mz	269	1 LOAD CAS	138	174.576	116.285	0.268	17.386	-1.091	**869.640**
Min Mz	53	1 LOAD CAS	23	171.670	0.560	0.065	10.219	-0.145	**-609.082**

Max and Min axial force for three span

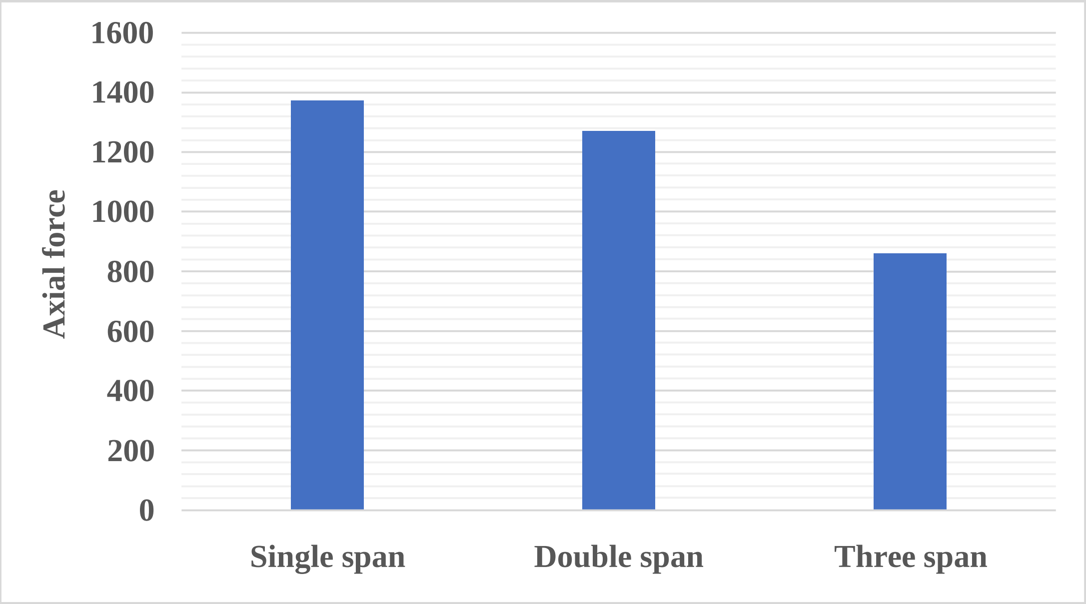
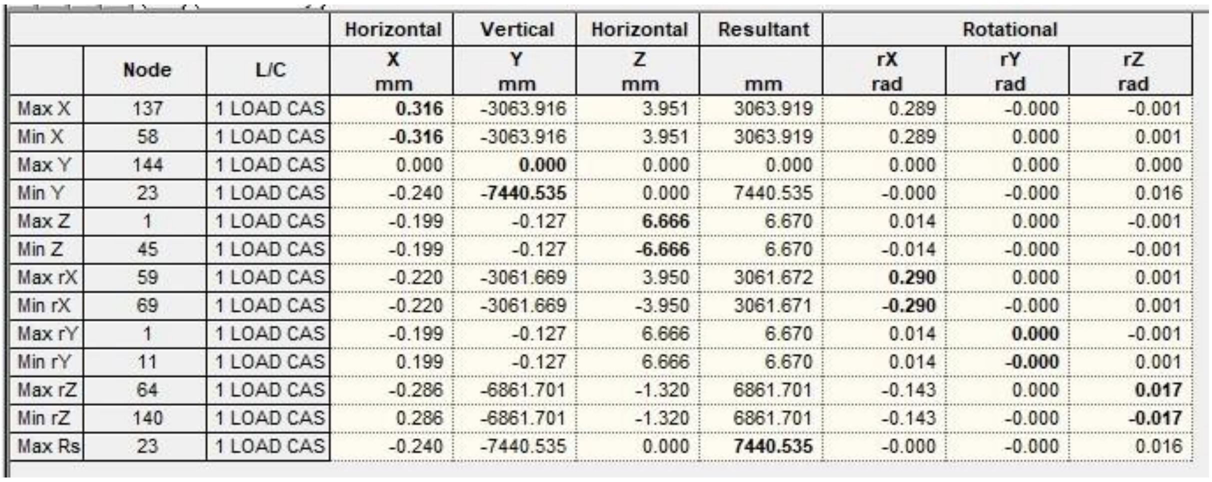


Fig. 4.3: Axial force variation

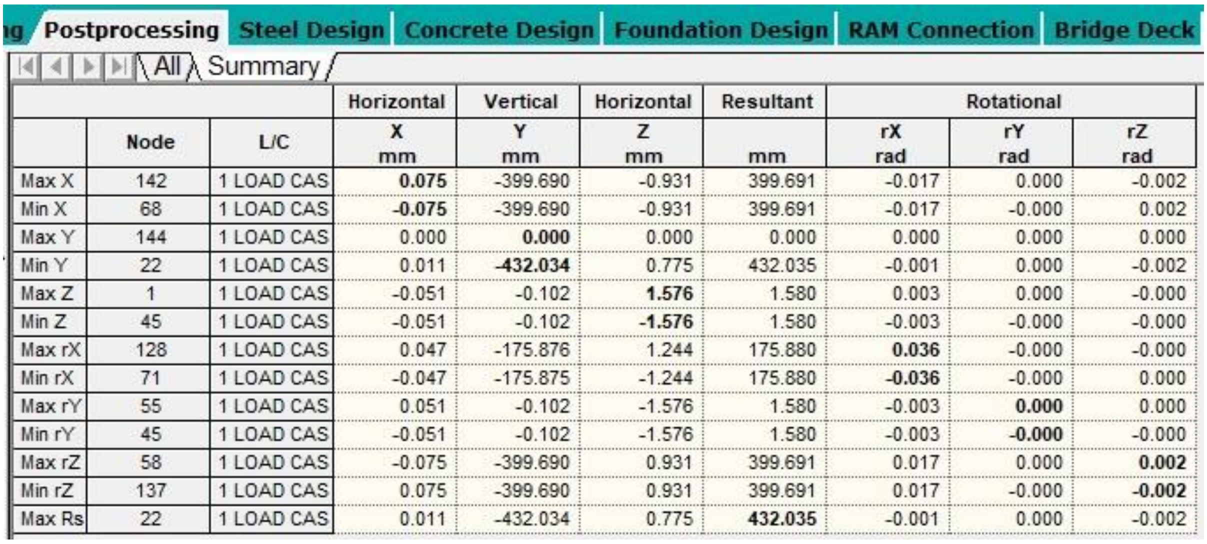
DISPLACEMENT VARIATION

From results obtained, magnitude of maximum displacement is presented in figure number 4.4, it is observed that in this comparative study maximum max. displacement is in single span whereas three span shows minimum displacement value.



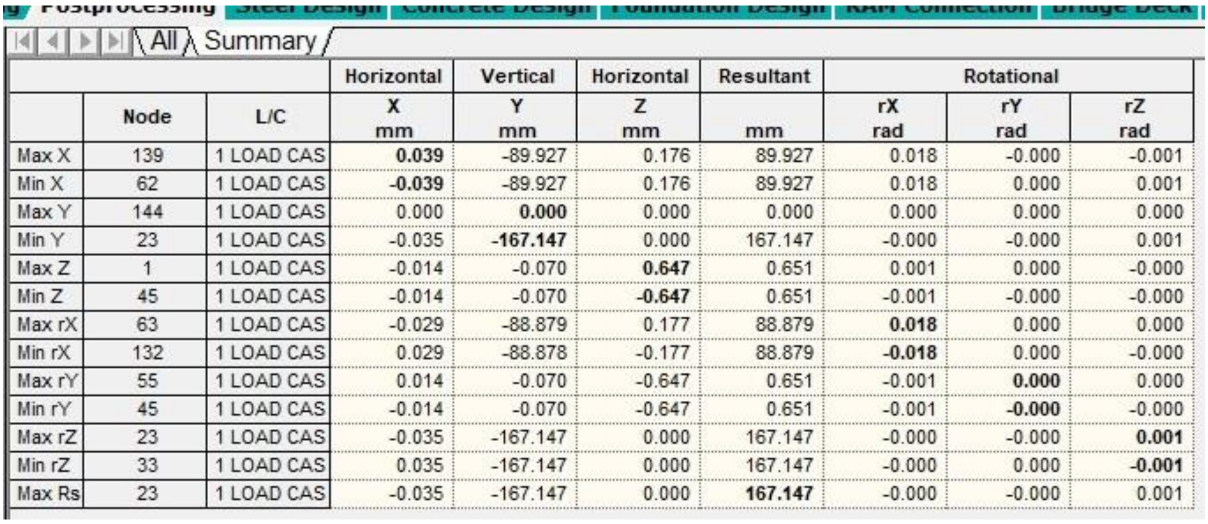
	Node	L/C	Horizontal	Vertical	Horizontal	Resultant	Rotational		
			X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	137	1 LOAD CAS	**0.316**	-3063.916	3.951	3063.919	0.289	-0.000	-0.001
Min X	58	1 LOAD CAS	**-0.316**	-3063.916	3.951	3063.919	0.289	0.000	0.001
Max Y	144	1 LOAD CAS	0.000	**0.000**	0.000	0.000	0.000	0.000	0.000
Min Y	23	1 LOAD CAS	-0.240	**-7440.535**	0.000	7440.535	-0.000	-0.000	0.016
Max Z	1	1 LOAD CAS	-0.199	-0.127	**6.666**	6.670	0.014	0.000	-0.001
Min Z	45	1 LOAD CAS	-0.199	-0.127	**-6.666**	6.670	-0.014	-0.000	-0.001
Max rX	59	1 LOAD CAS	-0.220	-3061.669	3.950	3061.672	**0.290**	0.000	0.001
Min rX	69	1 LOAD CAS	-0.220	-3061.669	-3.950	3061.671	**-0.290**	-0.000	0.001
Max rY	1	1 LOAD CAS	-0.199	-0.127	6.666	6.670	0.014	**0.000**	-0.001
Min rY	11	1 LOAD CAS	0.199	-0.127	6.666	6.670	0.014	**-0.000**	0.001
Max rZ	64	1 LOAD CAS	-0.286	-6861.701	-1.320	6861.701	-0.143	0.000	**0.017**
Min rZ	140	1 LOAD CAS	0.286	-6861.701	-1.320	6861.701	-0.143	-0.000	**-0.017**
Max Rs	23	1 LOAD CAS	-0.240	-7440.535	0.000	**7440.535**	-0.000	-0.000	0.016

Max and Min displacement for single span



	Node	L/C	Horizontal	Vertical	Horizontal	Resultant	Rotational		
			X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	142	1 LOAD CAS	**0.075**	-399.690	-0.931	399.691	-0.017	0.000	-0.002
Min X	68	1 LOAD CAS	**-0.075**	-399.690	-0.931	399.691	-0.017	-0.000	0.002
Max Y	144	1 LOAD CAS	0.000	**0.000**	0.000	0.000	0.000	0.000	0.000
Min Y	22	1 LOAD CAS	0.011	**-432.034**	0.775	432.035	-0.001	0.000	-0.002
Max Z	1	1 LOAD CAS	-0.051	-0.102	**1.576**	1.580	0.003	0.000	-0.000
Min Z	45	1 LOAD CAS	-0.051	-0.102	**-1.576**	1.580	-0.003	-0.000	-0.000
Max rX	128	1 LOAD CAS	0.047	-175.876	1.244	175.880	**0.036**	-0.000	-0.000
Min rX	71	1 LOAD CAS	-0.047	-175.875	-1.244	175.880	**-0.036**	-0.000	0.000
Max rY	55	1 LOAD CAS	0.051	-0.102	-1.576	1.580	-0.003	**0.000**	0.000
Min rY	45	1 LOAD CAS	-0.051	-0.102	-1.576	1.580	-0.003	**-0.000**	-0.000
Max rZ	58	1 LOAD CAS	-0.075	-399.690	0.931	399.691	0.017	0.000	**0.002**
Min rZ	137	1 LOAD CAS	0.075	-399.690	0.931	399.691	0.017	-0.000	**-0.002**
Max Rs	22	1 LOAD CAS	0.011	-432.034	0.775	**432.035**	-0.001	0.000	-0.002

Max and Min displacement for double span



	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	Rotational rY rad	Rotational rZ rad
Max X	139	1 LOAD CAS	**0.039**	-89.927	0.176	89.927	0.018	-0.000	-0.001
Min X	62	1 LOAD CAS	**-0.039**	-89.927	0.176	89.927	0.018	0.000	0.001
Max Y	144	1 LOAD CAS	0.000	**0.000**	0.000	0.000	0.000	0.000	0.000
Min Y	23	1 LOAD CAS	-0.035	**-167.147**	0.000	167.147	-0.000	-0.000	0.001
Max Z	1	1 LOAD CAS	-0.014	-0.070	**0.647**	0.651	0.001	0.000	-0.000
Min Z	45	1 LOAD CAS	-0.014	-0.070	**-0.647**	0.651	-0.001	-0.000	-0.000
Max rX	63	1 LOAD CAS	-0.029	-88.879	0.177	88.879	**0.018**	0.000	0.000
Min rX	132	1 LOAD CAS	0.029	-88.878	-0.177	88.879	**-0.018**	0.000	-0.000
Max rY	55	1 LOAD CAS	0.014	-0.070	-0.647	0.651	-0.001	**0.000**	0.000
Min rY	45	1 LOAD CAS	-0.014	-0.070	-0.647	0.651	-0.001	**-0.000**	-0.000
Max rZ	23	1 LOAD CAS	-0.035	-167.147	0.000	167.147	-0.000	-0.000	**0.001**
Min rZ	33	1 LOAD CAS	0.035	-167.147	0.000	167.147	-0.000	0.000	**-0.001**
Max Rs	23	1 LOAD CAS	-0.035	-167.147	0.000	**167.147**	-0.000	-0.000	0.001

Max and Min displacement for three span

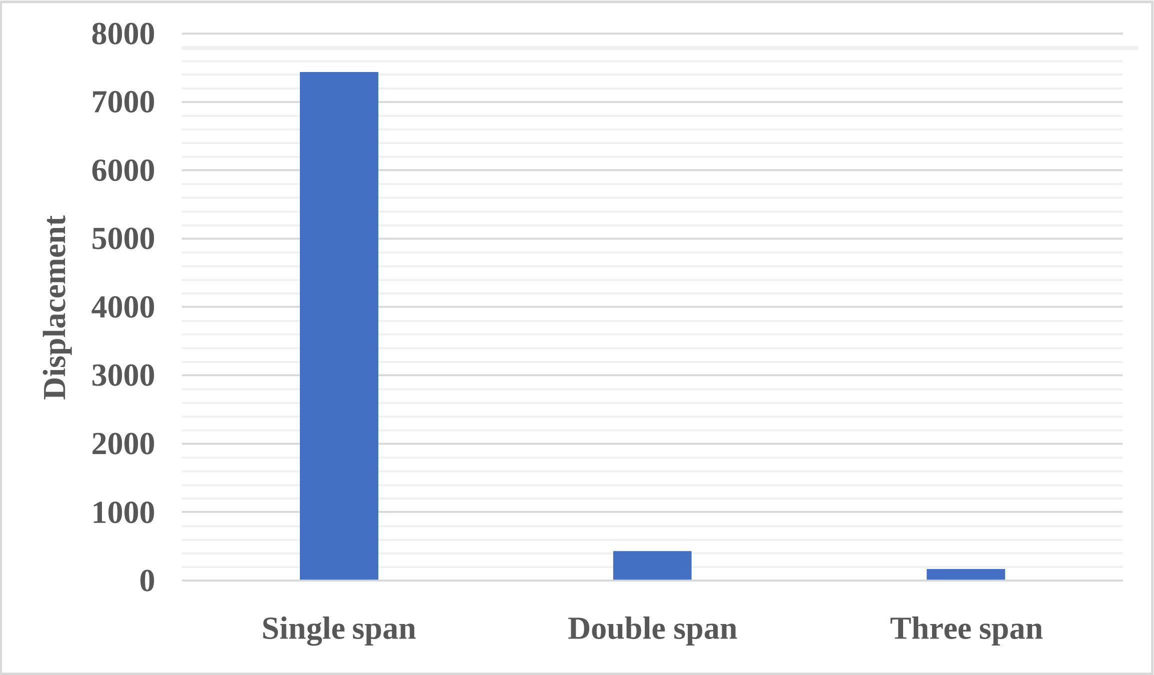


Fig. 4.4: Displacement variation

CHAPTER 5

CONCLUSIONS

We have considered various cases along with dead load & live load for the different span of bridge for analysis by using Staad-Pro software. Following are the notable points of our work-

1. The bending moment in Integral Bridge can be reduced drastically by increasing number of spans.
2. Converting an Integral Bridge into two spans results in reduction of BM upto 75% whereas a three span bridge results in 88% reduction
3. From Bending moment consideration, a two span Integral Bridge shall be preferred
4. The Shear force values for an Integral Bridge can be reduced drastically by increasing number of spans.
5. Converting an Integral Bridge into two spans result in reduction SF 50% whereas a three span bridge results in 66% reduction

REFERENCES

1. Malekjafarian, Abdollah, Luke J. Prendergast, and E. OBrien. "Use of mode shape ratios for pier scour monitoring in two-span integral bridges under changing environmental conditions." *Canadian Journal of Civil Engineering* 47, no. 8 (2020): 962-973.
2. Mahjoubi, Saeed, and ShervinMaleki. "Finite element modelling and seismic behaviour of integral abutment bridges considering soil–structure interaction." *European Journal of Environmental and Civil Engineering* 24, no. 6 (2020): 767-786.
3. Aizon, Nabila Huda, Azlan Adnan, MohdZamriRamli, NorazahArjuna, AsmawishamAlel, and Muhamad Ali Muhammad Yuzir. "Seismic performance of long cable-stayed bridge with various time history loading using finite element method." In *IOP Conference Series: Earth and Environmental Science*, vol. 479, no. 1, p. 012005. IOP Publishing, 2020.
4. Gautam, Kishan, and ShashikantShrivastava. "Skew Bridge Analysis using “ANSYS”."
5. Wan, Ling, Dongqi Jiang, and Jian Dai. "Numerical Modelling and Dynamic Response Analysis of Curved Floating Bridges with a Small Rise-Span Ratio." *Journal of Marine Science and Engineering* 8, no. 6 (2020): 467.
6. Han, Yan, Kai Li, C. S. Cai, Lei Wang, and Guoji Xu. "Fatigue reliability assessment of long-span steel-truss suspension bridges under the combined action of random traffic and wind loads." *Journal of Bridge Engineering* 25, no. 3 (2020): 04020003.
7. Reddy, B. Raghunath. "Seismic Performance Evaluation of a Fully Integral Concrete Bridge with End-Restraining Abutments."
8. Lin, Kaiqi, You- Lin Xu, Xinzheng Lu, Zhongguo Guan, and Jianzhong Li. "Cluster computing- aided model updating for a high- fidelity finite element model of a long- span cable- stayed bridge." *Earthquake Engineering & Structural Dynamics* 49, no. 9 (2020): 904-923.

9. Shoushtari, Elmira, M. SaiidSaiidi, Ahmad Itani, and Mohamed A. Moustafa. "Pretest analysis of shake table response of a two-span steel girder bridge incorporating accelerated bridge construction connections." *Frontiers of Structural and Civil Engineering* 14, no. 1 (2020): 169-184.

10. Zargar, Moein, Amir Kheirkhah, and SeyedNavidEbrahimzadeh. "The Soil-Pile Dynamic Interaction Effect on Bridges with Slab-Beam Deck by Using Finite Element Method."

11. Gharad, Anand M., and Ranjan S. Sonparote. "Dynamic soil–structure interaction effects on 3D integral railway bridge under high-speed moving loads." *CURRENT SCIENCE* 116, no. 6 (2019): 972.

12. Abdel-Fattah, Mohamed T., and Tarek T. Abdel-Fattah. "Behavior of Integral Frame Abutment Bridges Due to Cyclic Thermal Loading: Nonlinear Finite-Element Analysis." *Journal of Bridge Engineering* 24, no. 5 (2019): 04019031.

13. Yadav, Raghabendra, Binay Kumar Sah, Indra Narayan Yadav, and Dinesh Kumar Gupta. "Comparative Study of T Beam Bridge with Conventional Method and Finite Element Analysis." *Journal of the Institute of Engineering* 15, no. 1 (2019): 62-70.

14. Choi, Byung H., Lorenz B. Moreno, Churl-Soo Lim, Duy-Duan Nguyen, and Tae-Hyung Lee. "Seismic Performance Evaluation of a Fully Integral Concrete Bridge with End-Restraining Abutments." *Advances in Civil Engineering* 2019 (2019).

15. Gharad, Anand M., and R. S. Sonparote. "Study of Direct Finite Element Method of Analysing Soil–Structure Interaction in a Simply Supported Railway Bridge Subjected to Resonance." *Iranian Journal of Science and Technology, Transactions of Civil Engineering* 43, no. 2 (2019): 273-286.

16. Jozwiak, Matthew T. "Modeling the Effects of Turned Back Wingwalls for Semi-Integral Abutment Bridges." PhD diss., Ohio University, 2019.

17. Ma, Yafei, Guodong Wang, ZhongzhaoGuo, Lei Wang, Tianyong Jiang, and Jianren Zhang. "Critical region method-based fatigue life prediction of notched steel wires of long-span bridges." *Construction and Building Materials* 225 (2019): 601-610.

18. Prasad, Ashitha S., and V. N. Krishnachandran. "Comparitive Study on Integral and Conventional Bridges Subjected to Flood Loadings."