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ANALYSIS OF POST TENSIONED TRANSFER GIRDER IN G+11 STORY BUILDING USING FEM BASED SOFTWARE ETABS

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Abstract — *Transfer girder is used to transfer the load from the above story to the column which is support the transfer girder. Provide big space at the base levelusing floating column and transfer girder. And in architectural and aesthetic view of tall building it give important role. In now a day it is necessary to study the behavior of the girder because it is completely different to the beam. G+11 story building is modeled using Etabs software and doing complete analysis by change of the position of the transfer girder in plan and also change in the position of the shear wall. Using Etabs also done the construction stage analysis and comparison of the construction stage analysis and conventional analysis. Also doing the study of the flexural behavior of the beam which is exactly lies on the post tension transfer girder and the column which is supported the transfer girder.*

Keywords- *Post-tensioned, Floating Column,E-tabs*

I. INTRODUCTION

In tall building column is discontinued at ground and first floor level to facilitate larger opening at ground level to make access comfortable to the public area at the base. In 1950's and 1960's, some Eastern Europe scholars proposed the soft base level to achieve the large openings at the bottom level. A frame is constructed at bottom level to support the upper structure in this kind of structure. It is considered that this kind of structure has better performance during earthquake, but according to the current experiences, it has been proven that the concept is wrong. In 1978, many this kind of building collapsed during the Romania earthquake. A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which ends at lower level (termination level) of the building. due to architectural requirement and its rest on beam. The beams in turn transfer the load to other columns below it. In practice, the true columns below the termination level [usually the stilt level] are not constructed with care and more liable to failure. Nowadays larger opening at the ground floor level is achieved by use of transfer girder to collect the vertical and lateral load from the high-rise building component and then distribute them to the widely spaced column. However in the analysis of the transfer girder, consideration of the effect of interactive force in the overall analysis is beyond the range of the development of simple and approximate formula and requires proper modeling in order to have greater understanding the structural behavior and analysis. In past, transfer girder was designed as RC member. But since last many year the transfer girder is designed as PC member because of its advantages 2 over the RC member. For floating columns, the transfer girder and columns supporting transfer girder needs special attention. If load factor needs to be augmented for transfer girder and its columns to have additional safety of structure, shall be adopted. In the given system, floating columns need not be treated to carry any earthquake forces. Therefore earthquake forces are resisted by column/shear wall without considering contribution of floating column. This way the overall system as some breathing safety during earthquake. However, floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions with very minimum deflection. Though the floating column is unsafe especially under lateral loading, there are many projects in which they are adopted. Transfer girder must be design and detailed properly, especially in earthquake zones. If there are no lateral load, the design and detailing is not difficult. To understand proper behavior of transfer girder, its 3-D analysis must be done and must be very careful at the joint where the floating column meets the transfer girder.

PRESTRESSED CONCRETE

Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to a desired degree. In reinforced concrete member, the pre-stress is commonly introduced by tensioning the steel reinforcement. The earliest example of Prestressed:

- Construction of wooden barrel by forcing fitting of metal band
- Shrink fitting of metal tyres on wood wheel
- Tensioning of spoke of bicycle's wheel

Above example indicating the skill of prestressing has been practiced from ancient time.The tensile strength of plain concrete is only fraction of its compressive strength and the problem of it being deficient in tensile strength appears to have been driving factor in the development of the composite material known as reinforced concrete. The development of early cracks in reinforced concrete due to incompatibility in the strain of steel and concrete was possibly the starting point in the development of new material like prestressed concrete. The application of permanent compressive stress to a material like concrete, which is strong in compression but weak in tension, increases the apparent tensile strength of that material, because the subsequent application of tensile stress must first nullify the compressive prestress.

Post-Tensioning Systems

In post-tensioning systems, the ducts for the tendons (or strands) are placed along with the reinforcement before the casting of concrete. The tendons are placed in the ducts after the casting of concrete. The duct prevents contact between concrete and the tendons during the tensioning operation. Unlike pre-tensioning, the tendons are pulled with the reaction acting against the hardened concrete. If the ducts are filled with grout, then it is known as
bonded post-tensioning. The grout is a neat cement paste or a sand-cement mortar containing suitable admixture. If the ducts are left empty, then it is known as Unbonded post-tensioning. The Fig. 1.1 shows a schematic representation of a grouted post-tensioned member. The profile of the duct depends on the support conditions. For a simply supported member, the duct has a sagging profile between the ends. For a continuous member, the duct sags in the span and hogs over the support.

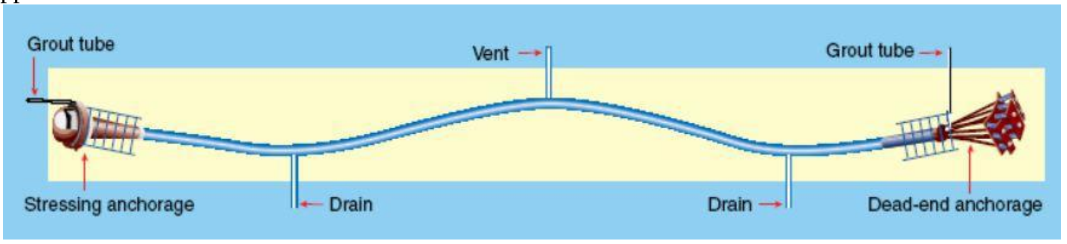
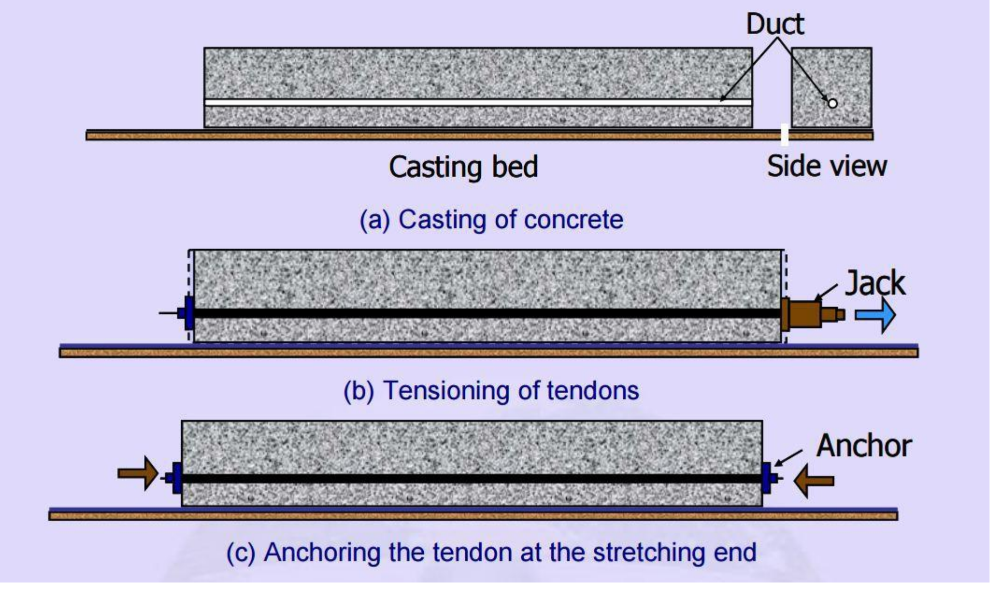


Fig. 1 Post Tensioning system

The various stages of the post-tensioning operation are summarized as follows.

- Casting of concrete.
- Placement of the tendons.
- Placement of the anchorage block and jack.
- Applying tension to the tendons.
- Seating of the wedges.
- Cutting of the tendons.

The stages are shown schematically in the following figure.



NEEDS OF THE PRESENT STUDY

As the demand of tall building with larger opening at lower level are increasing day by day, the provision of transfer girder has become the need of the time. Also the loading on transfer girder is stage wise increasing as well as the behavior of the frame having transfer girder undergoes changing forces in pattern and magnitude with the advancement of the construction which need in-depth analysis and design of transfer girder. So it is worthwhile to have in-depth knowledge about its behavior and various parameters which influenced the design of transfer girder. Also the building with floating column is very critical in earthquake event.

OBJECTIVE OF PRESENT STUDY

Following are the overall objective of the present study:

- To carried out in depth analysis of post-tensioned transfer girder using FEM software
- To understand seismic behaviour of building with transfer girder
- Evaluating detailed design of Post-Tensioned transfer girder

Investigation of various parameters related to Post-Tensioned transfer girder such as section size, size of supporting column and amount of post-tensioning.

FORMULATION OF THE PROBLEM

The building plan shown in the fig below. It is consider for the present work. This is user define grid and the dimension of structural element is decided by analyzing the model in ETABS

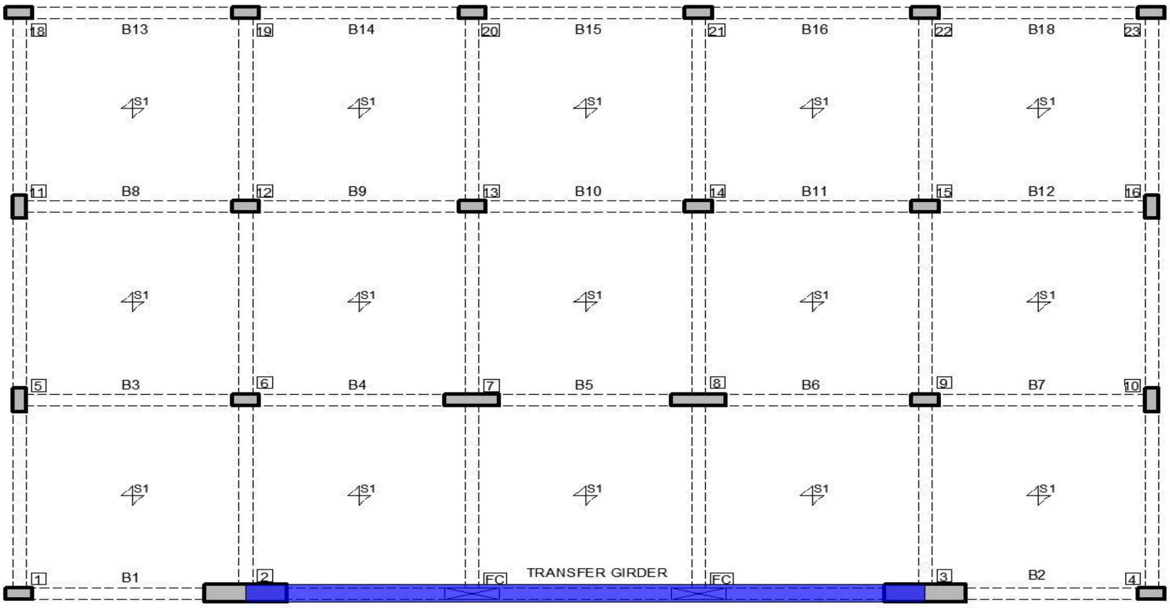


Fig.2 Structural Plan

MODELING IN ETABS 2016

ETABS is used for deciding the initial dimension of structural element of proposed building. Figure 4.2 shows ETABS model of proposed building. The model is analysed for the gravity loads and lateral load.

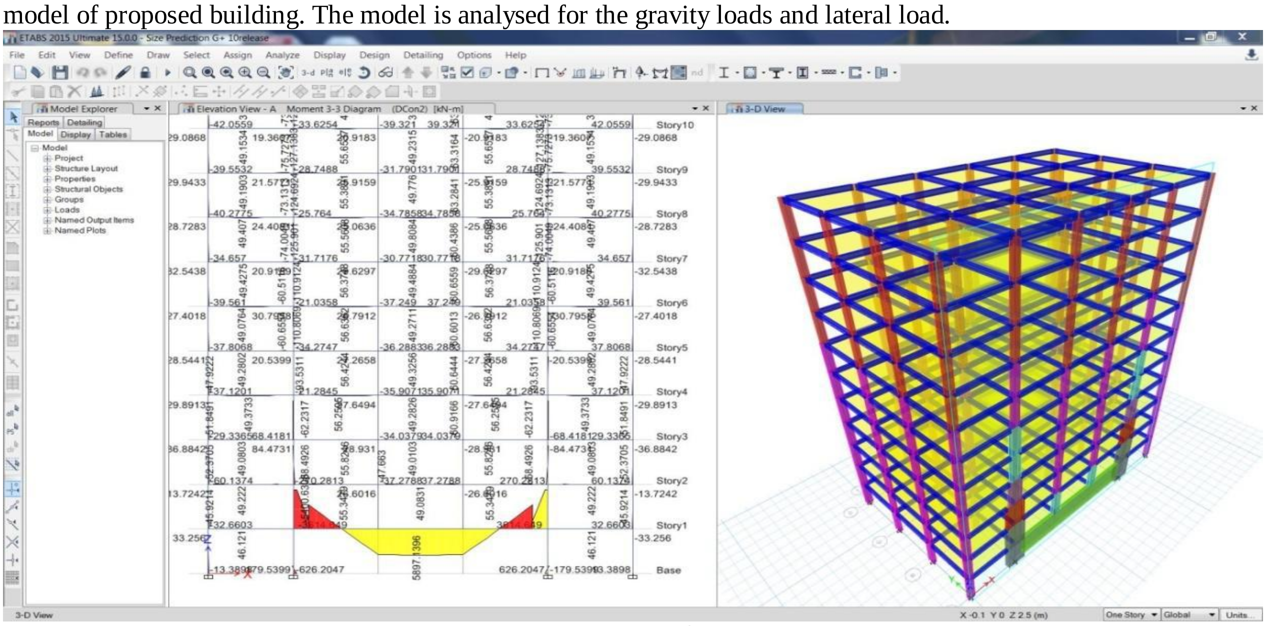


Fig. 3 ETABS model of present building

ETABS Input data

- Floor Finish: 1.5 kN/ m2
- Live load: 3 kN/ m2
- Initial Beam size: 230 mm x 375 mm
- Initial Transfer Girder size : 300 mm x 2500 mm
- Floating column terminate at 1st level.
- Floating column is released at termination level (at transfer girder level)
- Considered 230 mm thick brick wall on periphery of the building.
- Considered 1m high parapet wall at terrace level.
- Earthquake Load parameter are as follow:

Soil type	Medium
Earthquake zone	Zone-3
Response Reduction factor	5
Importance factor	1

Table 1 Different cases considered for present study

Case-1	G+11 building with transfer girder located at first floor on outer grid of building.
Case-2	G+11 building with transfer girder located at first floor on outer grid of the building and with L-shape shear wall located on four corner of the building.
Case-3	G+11 building with transfer girder located at first floor on inner grid of building.
Case-4	G+11 building with transfer girder located at first floor on inner grid of the building and with L-shape shear wall located on four corner of the building.
Case-5	G+11 building with transfer girder located at first floor on inner grid of the building and with shape shear wall located on either side of the transfer girder

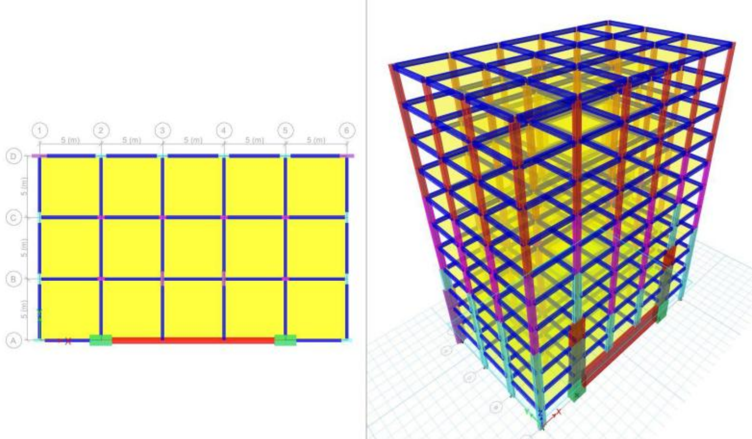


Fig. 4 Configurations for Case-1

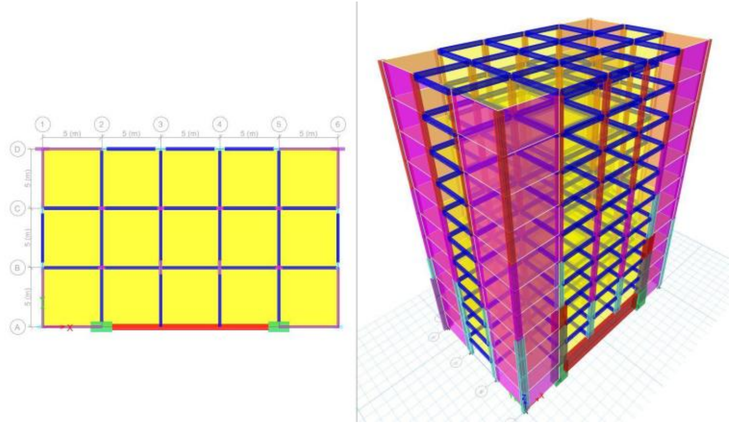


Fig. 5 Configurations for Case-2

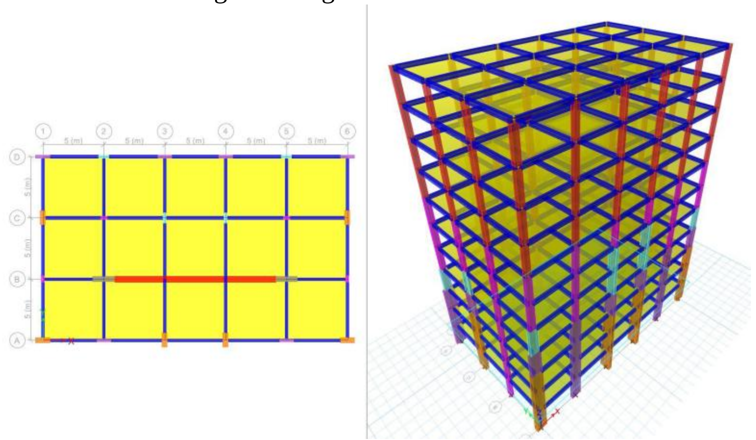


Fig. 6 Configurations for Case-3

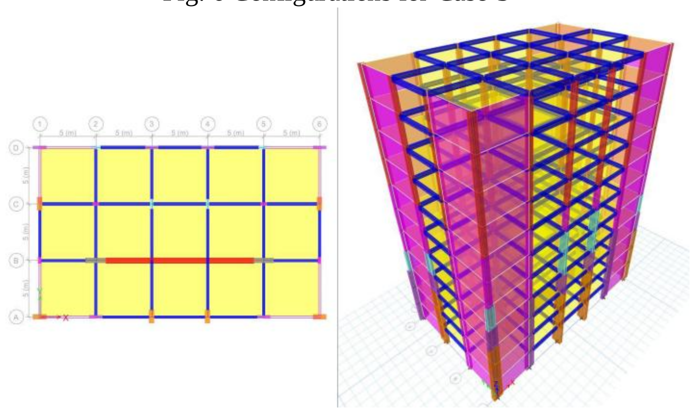


Fig. 7 Configuration for Case-4

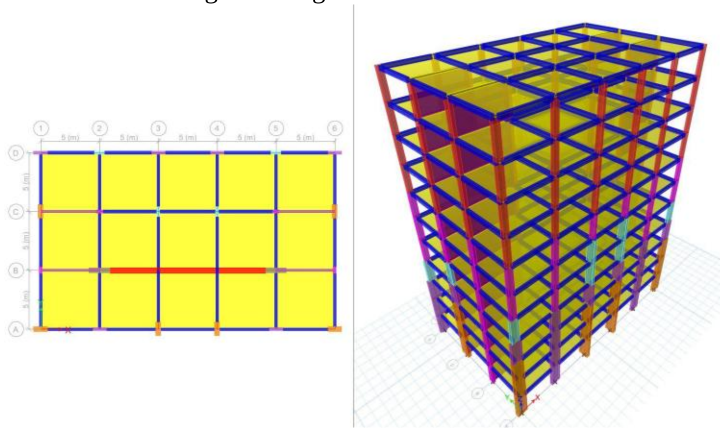


Fig. 8 Configuration of Case-5

SIZES OF STRUCTURAL ELEMENT

All beams having size of 230 mm x 375 mm are passed in analysis result of ETABS.

- All slabs are having the depth of 150 mm in all cases.
- Thickness of Shear wall provided in the case-2, case-4 and case-5 is of 180 mm.
- Column sizes for case-1 and case-2 is same and is given in Table 4.2.
- Column sizes for case-3, case-4 and case-5 are same and is given in Table 4.3

Table 2 Dimension of column for Case-1 and Case-2

Floor level	**COLUMN NO.**					
	C2, C3	FC1, FC2	C1,C4,C5, C10,C11, C16, C19 TO C21	C6, C9 C12 To C15	C17, C22	C7, C8
GF	900 X 1800	-	450 X 800	300 X 600	500 X 1000	500 X 1000
1st	700 X 1700	450 X 800	450 X 800	300 X 600	500 X 1000	400 X 1000
2nd	650 X 1600	450 X 800	450 X 800	300 X 600	500 X 1000	450 X 800
3rd	600 X 1500	450 X 600	450 X 800	300 X 600	450 X 800	300 X 600
4th	450 X 800	300 X 600	300 X 600	300 X 600	450 X 800	300 X 600
5th	450 X 800	300 X 600	300 X 600	300 X 600	300 X 600	300 X 600
6th	300 X 600	300 X 600	300 X 600	300 X 600	300 X 600	300 X 600
7th	300 X 600	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530
8th	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530
9th	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530
10th	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530
11^{th}	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530	300 X 530

Table 3 Dimension of column for Case-3, Case-4 and Case-5

Floor level	**COLUMN NO.**								
	C1, C4	FC1, FC2,C 5,C10, C15,C 20	C7, C8	C2, C3	C11, C16	C6,C9	C17,C 19,C20 ,C22	C13,C14	C18,C21
GF	500 x 1150	300 x 600	500 x 1150	500 x 1000	500 x 1150	700 x 1500	500 x 1000	450 x 800	450 x 800
1st	500 x 1150	300 x 600	500 x 1150	500 x 1000	500 x 1150	700 x 1500	500 x 1000	450 x 800	450 x 800
2nd	500 x 1150	300 x 600	500 x 1150	500 x 1000	500 x 1150	550 x 1100	500 x 1000	450 x 800	450 x 800
3rd	500 x 1000	300 x 600	500 x 1000	500 x 1000	500 x 1000	450 x 800	450 x 800	450 x 800	300 x 600
4th	450 x 800	300 x 600	450 x 800	300 x 600	450 x 800	300 x 600	300 x 600	300 x 600	300 x 600
5th	300 x 600	300 x 600	450 x 800	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600
6th	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600	300 x 600
7th	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530
8th	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530
9th	300 x	300 x	300 x	300 x	300 x	300 x	300 x	300 x	300 x

	530	530	530	530	530	530	530	530	530
10th	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530
11th	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530	300 x 530

ANALYSIS RESULTS

In the present study, a structure is modelled with and without shear wall and see what happen in the behaviour of the post tension transfer girder and whole structure with using the convention analysis and construction stage analysis.

COMPARISON BETWEEN CONSTRUCTION STAGE & CONVENTIONAL ANALYSIS

In the present study building is analyzed by two different method of analysis i.e. construction stage analysis and convention analysis. Reason behind doing this is to know the complete behaviour of whole building with transfer girder at every stage of construction. Conventional analysis is carried out by considering the full live load and dead load similarly conventional analysis is also done.

Construction stage	Bending Moment		Shear Force		Deflection (mm)
	Positive (kN.m)	Negative (kN.m)	at Support (kN)	at Floating column (kN)	
1-level	517.32	333.49	256.37	106.6	0.687
2-level	694.77	505.84	344.14	193.31	0.937
3-level	869.67	675.23	432.29	280.83	1.182
4-level	1012.61	813.11	503.56	352.23	1.38
5-level	1152.73	948.06	573.38	422.17	1.58
6-level	1290.4	1080.74	642	490.89	1.774
7-level	1427.34	1212.73	710.26	559.25	1.966
8-level	1560.74	1341.3	776.14	625.85	2.15
9-level	1694.22	1469.95	846.26	692.46	2.34
10-level	1828.22	1599.09	910.03	759.35	2.52
11-level	1972.77	1729.11	977.24	829.67	2.71
12-level	2120.43	1860.24	1045.023	894.31	2.91
Conventional analysis	1953.05	1801.4	995.05	839.5	2.64
Percentage Difference	5%	1%	3%	3%	5%

Table 4 Forces in transfer girder for Case-1

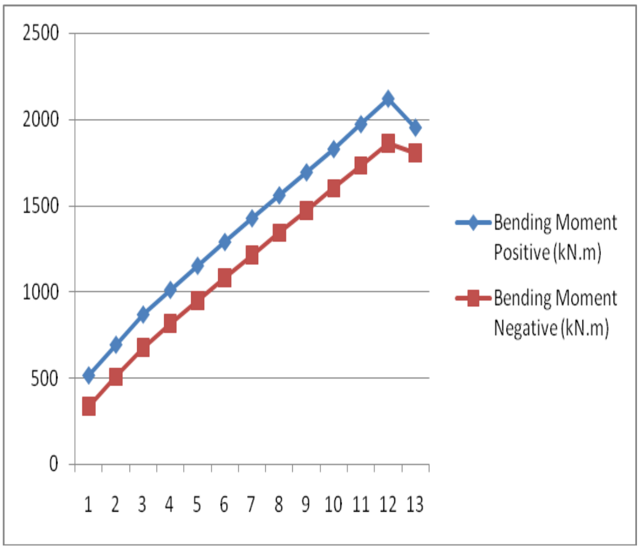


Fig. 9 Bending Moment in Transfer Girder for case-1

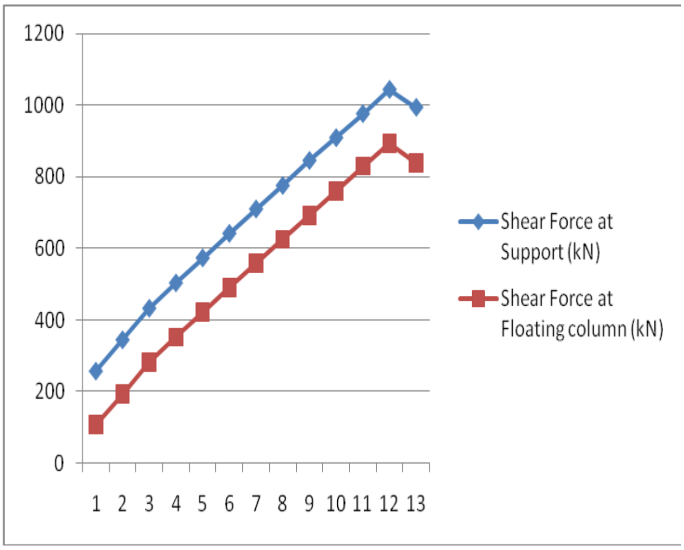


Fig. 10 Shear force in transfer Girder for case-1

Table 5 Forces in transfer girder for Case-2

	CASE-1				
Construction stage	Bending Moment		Shear Force		Deflection (mm)
	Positive (kN.m)	Negative (kN.m)	at Support (kN)	at Floating column (kN)	
1-level	481.24	373.28	259.49	106.89	0.624
2-level	650.42	554.58	349.21	194.11	0.85
3-level	816.85	736.56	437.47	282.47	1.087
4-level	952.49	885.24	509.53	354.61	1.27
5-level	1086.17	1031.38	580.44	425.88	1.45
6-level	1217.76	1175.07	650.19	495.39	1.64
7-level	1347.83	1310.89	719.08	564.35	1.82
8-level	1473.97	1454.42	785.88	631.22	1.99
9-level	1599.18	1590.9	852.17	697.58	2.16
10-level	1688.88	1726.47	918.02	763.51	2.39
11-level	1820.45	1861.25	983.48	829.1	2.51
12-level	1951.71	1995.27	1048.56	894.25	2.68
Conventional analysis	1784.9	1900.47	984.63	829.1	2.41
Percentage Difference	5%	1%	3%	3%	5%

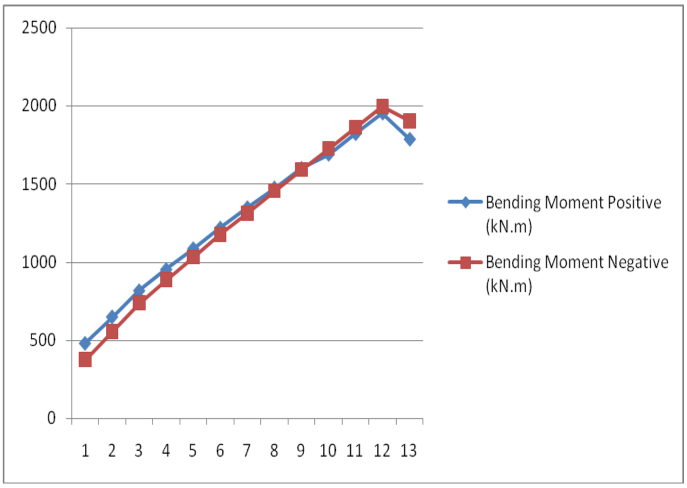


Fig. 11 Bending moment in transfer Girder for case-2

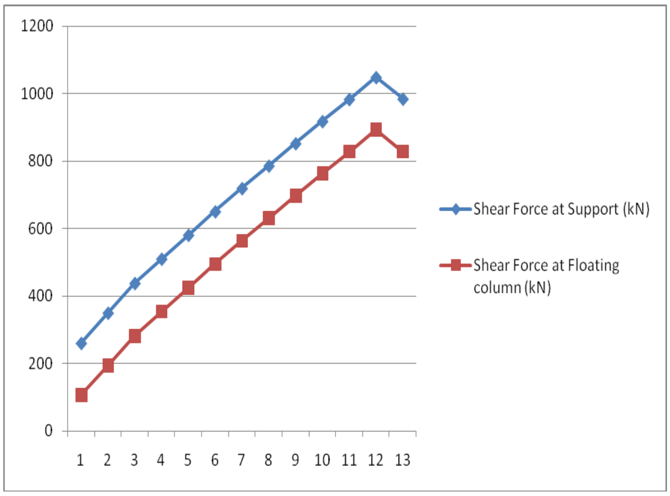


Fig. 12 Shear force in transfer Girder for case-2

Table 6 Forces in transfer girder for Case-3

	CASE-3				
Construction stage	Bending Moment		Shear Force		Deflection (mm)
	Positive (kN.m)	Negative (kN.m)	at Support (kN)	at Floating column (kN)	
1-level	492.27	304.5	227.88	107.76	1.004
2-level	715.35	547.73	355.29	235.63	2.018
3-level	988.92	784.23	478.65	359.34	2.48
4-level	1259.44	1003.89	593.48	474.53	2.89
5-level	1502.63	1201.2	696.68	578.05	3.3
6-level	1740.3	1394.25	797.58	679.24	3.66
7-level	1950.25	1594.25	886.73	768.63	4.01
8-level	2153.99	1730.23	973.25	855.37	4.35
9-level	2354.44	1892.89	1058.31	940.63	4.69
10-level	2551.71	2052.96	1142.02	1024.52	5.02
11-level	2746.02	2210.6	1224.46	1107.13	5.35
12-level	2937.51	2365.96	1305.71	1188.53	5.48
Conventional analysis	2516.83	2098.96	1144.82	1026.36	4.43
Percentage Difference	5%	1%	3%	3%	5%

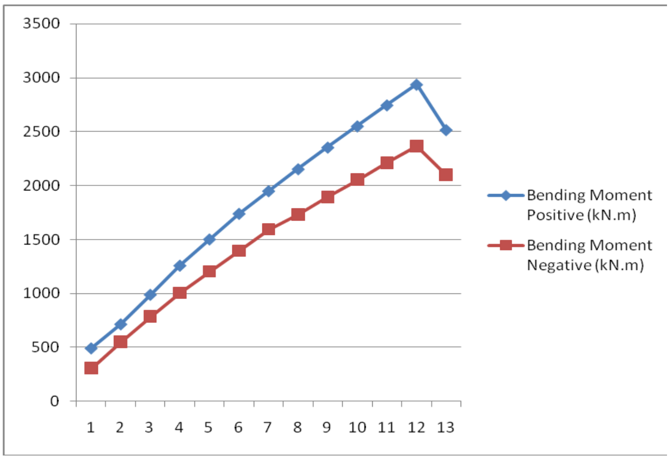


Fig. 13 Bending moment in transfer Girder for case-3

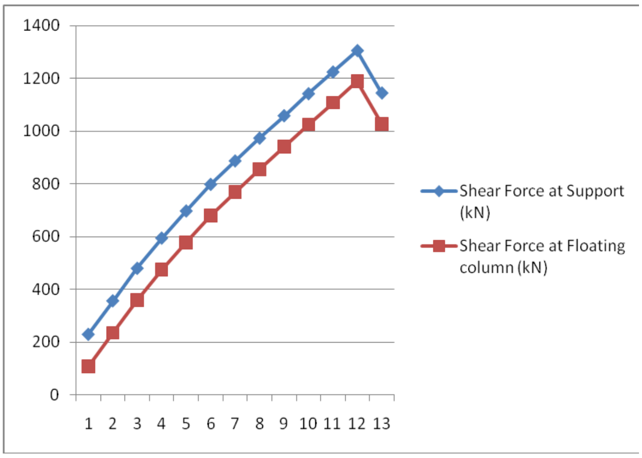


Fig. 14 Shear force in transfer Girder for case-3

Table 7 Forces in transfer girder for Case-4

Construction stage	CASE-4				
	Bending Moment		Shear Force		Deflection (mm)
	Positive (kN.m)	Negative (kN.m)	at Support (kN)	at Floating column (kN)	
1-level	492.62	303.96	228.29	107.83	1.005
2-level	715.57	547.15	355.8	235.63	1.52
3-level	989.45	783.61	479.32	359.34	2.019
4-level	1260.16	1003.54	594.44	474.53	2.48
5-level	1503.49	1201.17	697.91	578.05	2.89
6-level	1741.44	1394.38	799.08	679.24	3.305
7-level	1951.67	1565.02	888.48	768.63	3.66
8-level	2155.67	1730.58	975.22	855.37	4.013
9-level	2356.17	1893.2	1060.42	940.63	4.35
10-level	2553.26	2053.03	1144.16	1024.52	4.693
11-level	2747.02	2210.15	1226.48	1107.13	5.625
12-level	2947.53	2364.62	1307.41	1188.53	5.35
Conventional analysis	2511.04	2093.68	1143.65	1026.36	4.42
Percentage Difference	5%	1%	3%	3%	5%

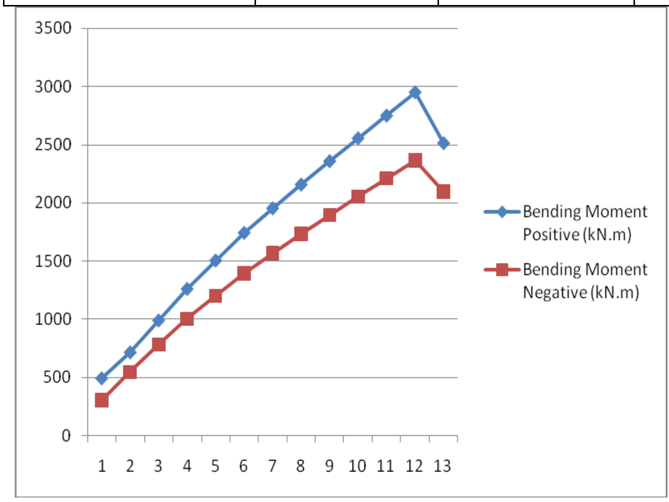


Fig. 15 Bending moment in transfer Girder for case-4

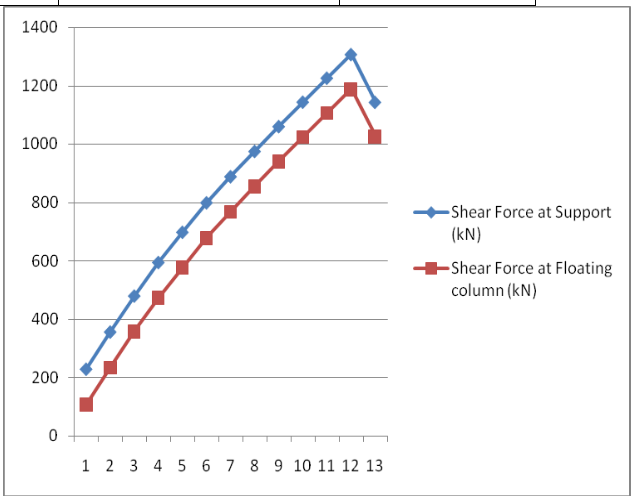


Fig. 16 Shear force in transfer Girder for case-4

Table 8 Forces in transfer girder for Case-5

	CASE-5				
Construction stage	Bending Moment		Shear Force		Deflection (mm)
	Positive (kN.m)	Negative (kN.m)	at Support (kN)	at Floating column (kN)	
1-level	434.47	367.66	230.38	108.62	0.85
2-level	642.09	635.19	358.93	237.6	1.32
3-level	897.5	897.5	483.94	364.94	1.77
4-level	1145.095	1142.34	600.76	480.07	2.192
5-level	1372.68	1362.72	705.91	585.46	2.57
6-level	1594.41	1577.87	808.56	688.36	2.93
7-level	1790.52	1767.11	898.4	778.92	3.26
8-level	1979.29	1949.67	986.07	866.3	3.57
9-level	2162.39	2127.61	1071.07	951.51	3.88
10-level	2342.82	2301.07	1153.91	1034.5	4.18
11-level	2517.58	2469.97	1234.6	1115.42	4.47
12-level	2687.73	2634.42	1313.16	1194.17	4.75
Conventional analysis	2310.11	2304.296	1145.77	1027.83	3.955
Percentage Difference	5%	1%	3%	3%	5%

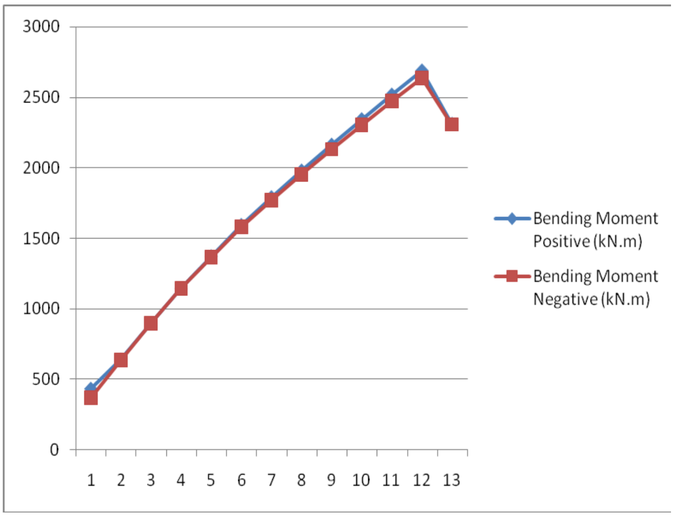


Fig. 18 Bending moment in transfer Girder for case-5

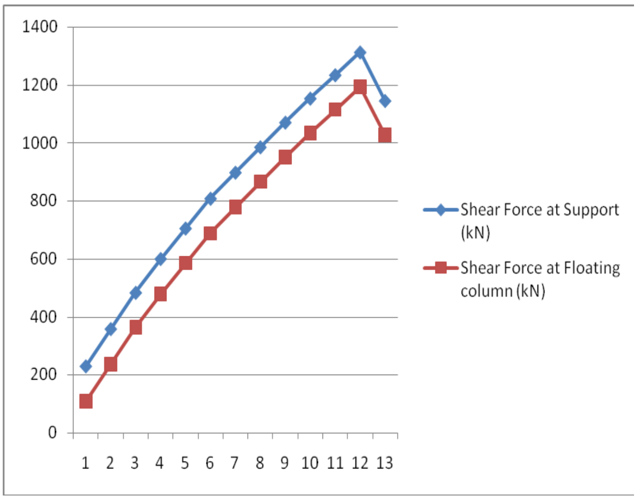


Fig. 19 Shear force in transfer Girder for case-5

BEHAVIOUR OF BEAM FOR THE VARYING DEPTH OF TRANSFER GIRDER

The beam which located above the transfer girder whose behavior must be investigated at the every stage of construction. Because forces in the beam goes changing as the deflection in girder is increased.

CASE-1					
Girder size - 450 mm X 2500 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	-4.35	0.91	-3.45	-9.33	10.59
3-level	-2.28	5.93	-4.86	-8.06	11.74
4-level	-0.66	-6	-6.06	-7.12	12.67
5-level	0.92	-7.12	-7.12	-6.17	13.58
6-level	2.48	-8.21	-8.21	-5.26	14.47
7-level	4.02	-9.29	-9.29	-4.35	15.35
8-level	5.5	-10.33	-10.33	-3.48	16.2
9-level	6.98	-11.36	-11.36	-2.6	17.04

10-level	8.46	-12.4	-12.4	-1.73	17.88
11-level	9.94	-13.43	-13.43	-0.86	18.72
12-level	11.42	-14.47	-14.47	0.0053	19.57
Conventional analysis	13.26	-15.77	-15.77	1.16	20.66

Table 9 Forces in Beam-39 for Case-1 and girder depth 2500 mm

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The bending moment at the right end of the beam B-39 is 67% more when construction stage is up to level-2 compare to conventional analysis of building.
- The bending moment at the left end of the beam B-39 is 61% less when construction stage is up to level-2 compare to conventional analysis of building.

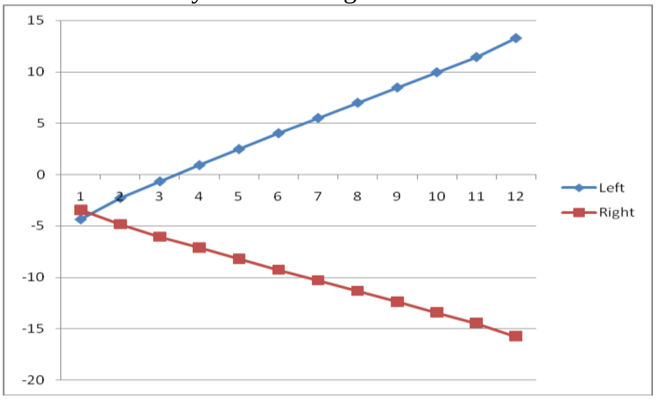


Fig. 20 Bending moment in Beam B-39 for Girder depth 2500 mm

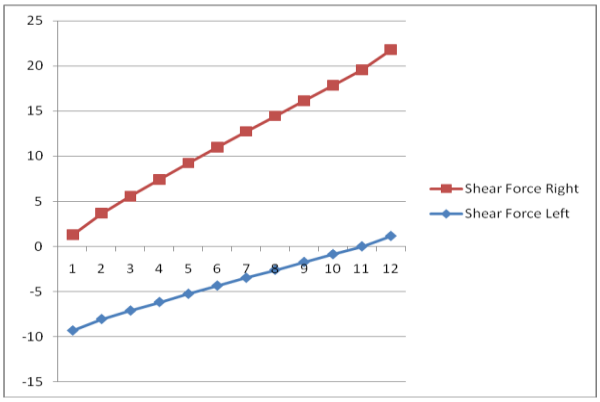


Fig. 21 Shear force in Beam B-39 for Girder depth 2500 mm

Table 10 Forces in Beam-37 & B-39 for Case-1 and girder depth 2000mm

CASE-1					
Girder size - 450 mm X 2000 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	-3.59	-6.1	-4.77	-10.76	10.39
3-level	-4.99	-6.12	-2.66	-11.9	9.032
4-level	-6.13	-6.23	-1.007	-12.83	7.99
5-level	-7.24	7.24	0.628	-13.73	6.96
6-level	-8.32	8.32	2.21	-14.61	5.96
7-level	-9.39	9.39	3.79	-15.489	4.96
8-level	-10.43	10.43	5.31	-16.32	4.01
9-level	-11.46	10.46	6.83	-17.16	3.05
10-level	-12.49	12.49	8.34	-17.99	2.1
11-level	-13.52	13.52	9.86	-18.83	1.15
12-level	-14.56	14.56	11.38	-19.67	0.195
Conventional analysis	-13.66	12.49	9.89	-17.39	0.11

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The direction of the bending moment at the right end of the beam B-39 is changed from the negative to positive as construction stage increasing step by step.
- The bending moment at the left end of the beam B-39 is 67% less when construction stage is up to level-2 compare to conventional analysis of building.

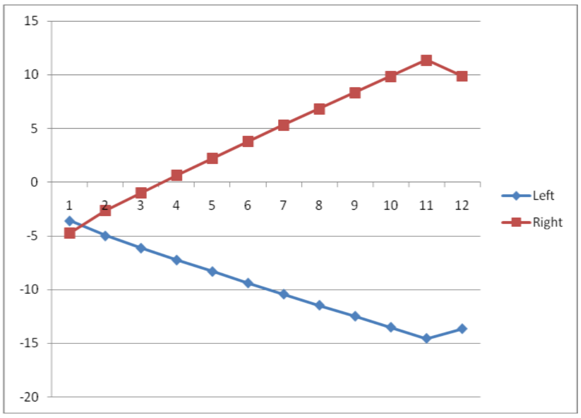


Fig. 22 Bending moment in Beam B-39 for Girder depth 2000 mm

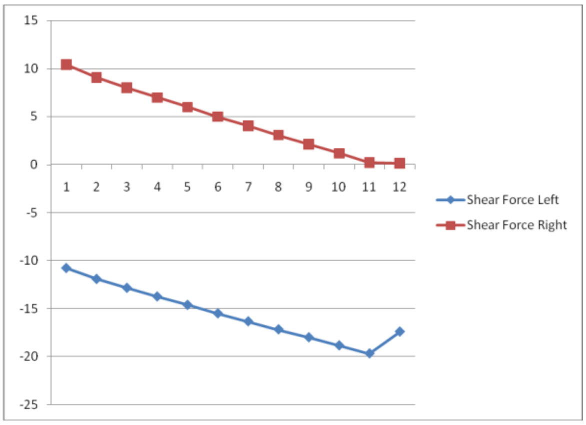


Fig. 23 Shear force in Beam B-39 for Girder depth 2000 mm

Table 11 Forces in Beam-37 & B-39 for Case-1 and girder depth 1500mm

CASE-1					
Girder size - 450 mm X 1500 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	-2.71	-6	-6	11.55	-8.44
3-level	0.71	-6.9	-6.9	13.48	-6.39
4-level	3.38	-8.77	-8.77	15.01	-4.84
5-level	5.94	-10.55	-10.55	16.48	-3.35
6-level	8.39	-12.25	-12.25	17.88	-1.92
7-level	10.78	-13.91	-13.91	19.25	-0.52
8-level	13.07	-15.5	-15.5	20.55	0.81
9-level	15.32	-17.07	-17.07	21.83	2.13
10-level	17.55	-18.67	-18.67	23.1	3.43
11-level	19.76	-20.15	-20.15	24.37	4.72
12-level	21.97	-21.97	-21.97	25.63	6.01
Conventional analysis	22.26	22.26	-22.26	25.8	6.33

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The direction of the bending moment at the right end of the beam B-39 is changed from the negative to positive as construction stage reach to the 7th level.
- The bending moment at the left end of the beam B-39 is 75% less when construction stage is up to level-2 compare to conventional analysis of building.

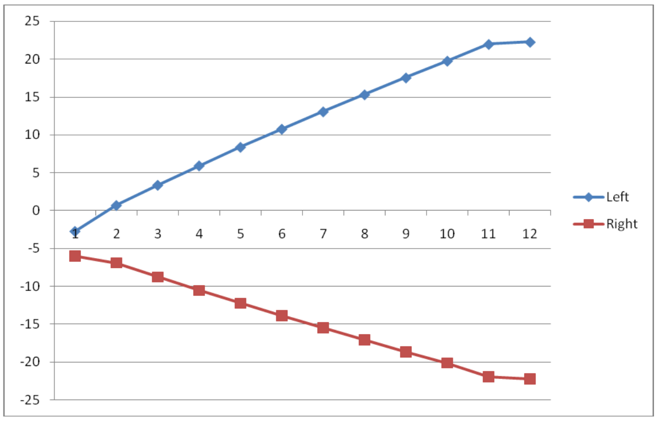


Fig. 24 Bending moment in Beam B-39 for Girder depth 1500 mm

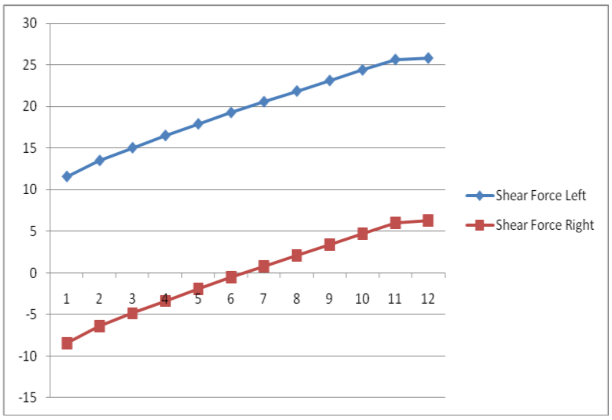


Fig. 25 Shear force in Beam B-39 for Girder depth 1500 mm

Table 12 Forces in Beam-37 & B-39 for Case-1 and girder depth 1000mm

CASE-1					
Girder size - 450 mm X 1000 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	0.875	-7.32	-7.32	-6.55	15.11
3-level	7.31	-11.81	-11.81	-2.81	18.87
4-level	12.12	-15.22	-15.22	-0.07	21.74
5-level	16.54	-18.34	-18.34	2.46	24.36
6-level	20.63	-21.23	-21.23	4.8	26.79
7-level	24.47	24.47	-23.94	7.01	29.06
8-level	28.03	28.03	-26.45	9.05	31.17
9-level	31.44	31.44	-28.86	11.01	33.19
10-level	34.72	34.72	-31.17	12.89	35.13
11-level	37.9	37.9	-33.41	14.71	37.01
12-level	40.98	40.98	-35.59	16.48	38.83
Conventional analysis	41.37	42.91	-37.61	17.66	39.22

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The direction of the bending moment at the right end of the beam B-39 is from the negative to positive as construction stage increased from level-2 to level-3.
- The bending moment at the left end of the beam B-39 is 80% less when construction stage is up to level-2 compare to conventional analysis of building.

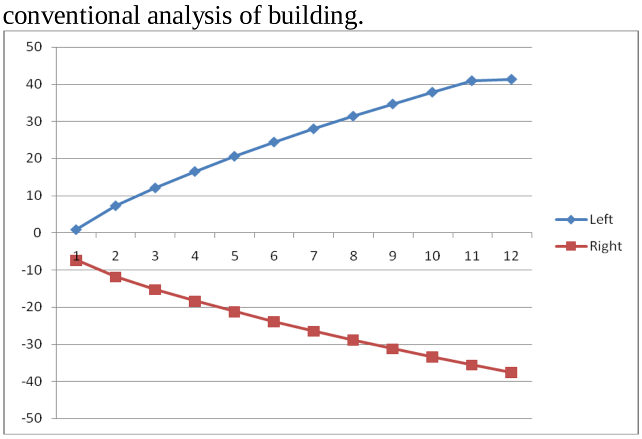


Fig. 26 Bending moment in Beam B-39 for Girder depth 1000 mm

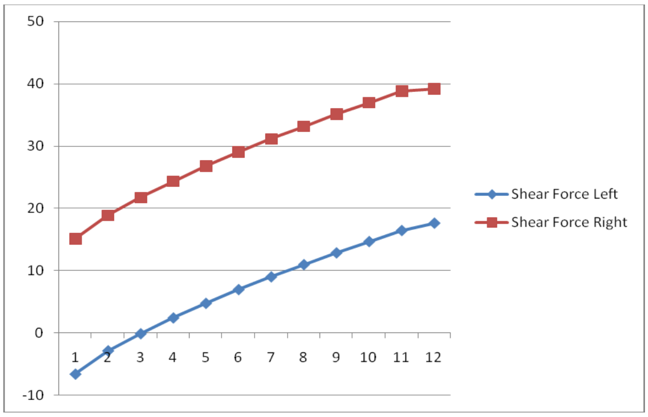


Fig. 27 Shear force in Beam B-39 for Girder depth 1000 mm

Table 13 Forces in Beam-37 & B-39 for Case-3 and girder depth 2500 mm

CASE-3					
Girder size - 450 mm X 2500 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	-6.37	11.1	-7.02	-16.63	18.51
3-level	-4.39	11.04	-8.05	-15.28	19.57
4-level	-2.54	11.01	-10.21	-14.06	20.59
5-level	-0.87	-11.61	-11.61	-12.96	21.52
6-level	0.76	-12.99	-12.99	-11.88	22.41
7-level	2.2	-14.2	-14.2	-10.93	23.21
8-level	3.61	-15.39	-15.39	-10	23.99
9-level	5.004	-16.56	-16.56	-9.09	24.77
10-level	6.37	-17.72	-17.72	-8.18	25.52
11-level	7.73	-18.86	-18.86	-7.29	26.28
12-level	9.07	-19.96	-19.98	-6.41	27.02
Conventional analysis	10.17	20.89	-20.89	-5.58	27.56

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The bending moment at the right end of the beam B-39 is 76% more when construction stage is up to level-2 compare to conventional analysis of building.
- The bending moment at the left end of the beam B-39 is 64% less when construction stage is up to level-2 compare to conventional analysis of building.
- Also the shear force at the one end of the beam is decreasing as construction stage increase and vice versa.

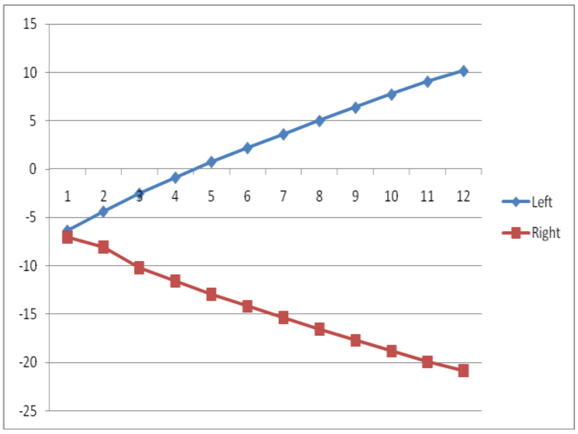


Fig. 28 Bending moment in Beam B-39 for Girder depth 2500 mm

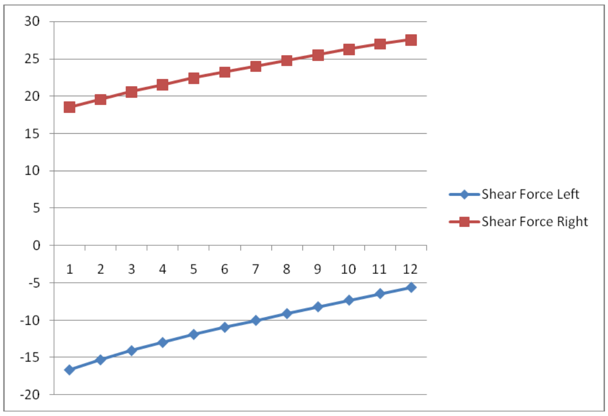


Fig. 29 Shear force in Beam B-39 for Girder depth 2500 mm

Table 14 Forces in Beam-37 & B-39 for Case-3 and girder depth 2000 mm

CASE-3					
Girder size - 450 mm X 2000 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	-5.51	11.1	-7.68	-16.07	18.94
3-level	-2.77	11.03	-9.92	-14.2	20.39
4-level	-0.23	-12.03	-12.03	-12.52	21.77
5-level	2.03	-13.91	-13.91	-11.02	22.99
6-level	4.25	-15.75	-15.75	-9.55	24.19
7-level	6.19	-17.36	-17.36	-8.27	25.24

8-level	8.07	-18.91	-18.91	-7.03	26.26
9-level	9.91	-20.44	-20.44	-5.82	27.26
10-level	1.72	-21.94	-21.94	-4.63	28.25
11-level	13.49	-23.42	-23.42	-3.45	29.21
12-level	15.24	-24.87	-24.87	-2.3	30.166
Conventional analysis	15.43	-25.04	-25.04	-2.09	30.24

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The direction of the bending moment at the right end of the beam B-39 is changed from the negative to positive as construction stage increasing step by step.
- The bending moment at the left end of the beam B-39 is 69% less when construction stage is up to level-2 compare to conventional analysis of building.
- Also the shear force at the one end of the beam is decreasing as construction stage increase and vice versa.

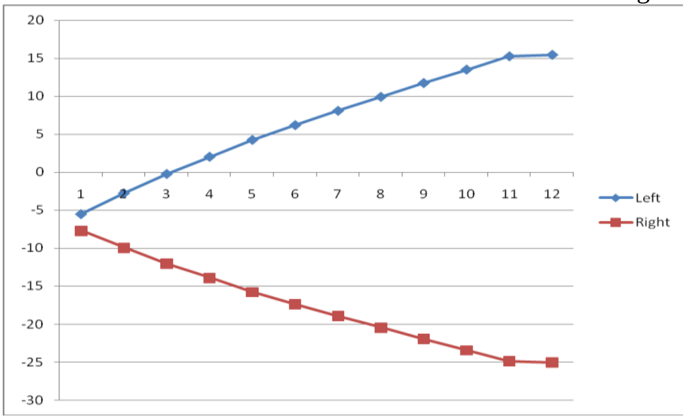


Fig. 30 Bending moment in Beam B-39 for Girder depth 2000 mm

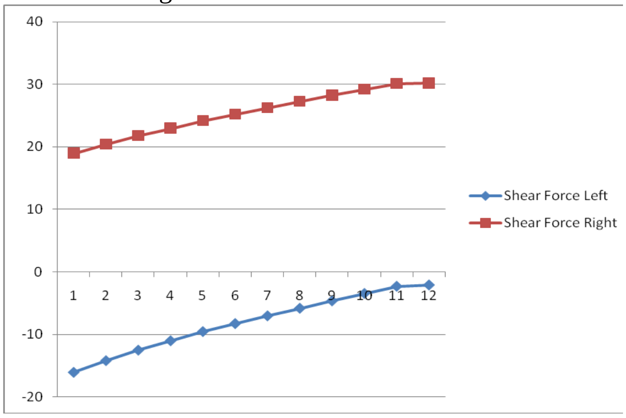


Fig. 31 Shear force in Beam B-39 for Girder depth 2000 mm

Table 15 Forces in Beam-37 & B-39 for Case-3 and girder depth 1500 mm

CASE-3					
Girder size - 450 mm X 1500 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	-3.79	-11.08	-9.03	-14.93	19.81
3-level	0.45	-12.48	-12.48	-12.06	22.03
4-level	4.3	-15.64	-15.64	-9.5	24.08
5-level	7.69	-18.42	-18.42	-7.24	25.88
6-level	10.94	-21.08	-21.08	-5.1	27.61
7-level	13.76	-23.39	-23.39	-3.22	29.11
8-level	16.45	-25.6	-25.6	-1.44	30.54
9-level	19.06	-27.74	-27.74	0.28	31.94
10-level	21.61	-29.83	-29.83	1.96	33.24
11-level	24.1	-31.86	-31.83	3.6	34.62
12-level	26.5	-33.86	-33.8	5.21	35.91
Conventional analysis	23.99	-31.88	-31.88	3.62	34.61

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The direction of the bending moment at the right end of the beam B-39 is changed from the negative to positive as construction stage reach to the 7th level.
- The bending moment at the left end of the beam B-39 is 75% less when construction stage is up to level-2 compare to conventional analysis of building.

- Also the shear force at the left end of the beam is 35% less and at the right end of the beam is 55% more when construction stage is up to level-2 compare to whole building.

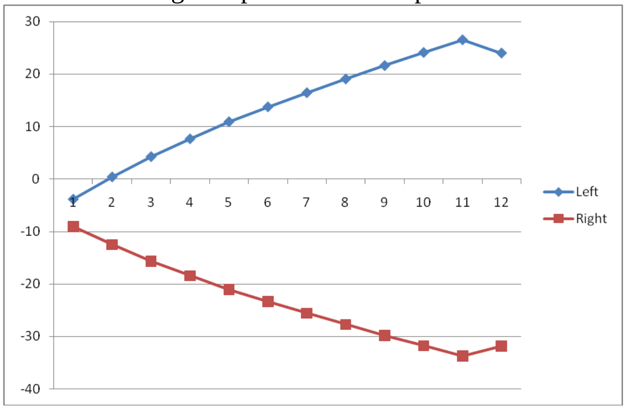


Fig. 32 Bending moment in Beam B-39 for Girder depth 1500 mm

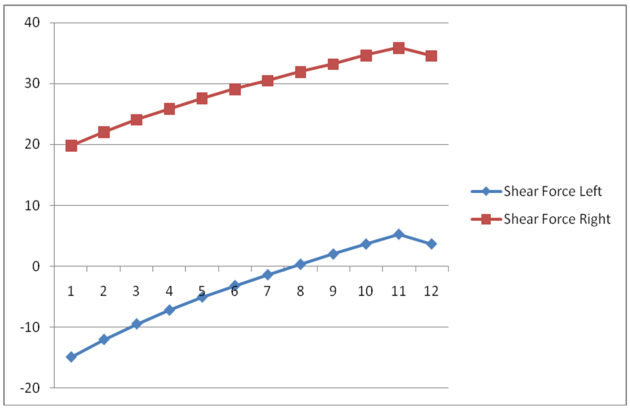


Fig. 33 Shear force in Beam B-39 for Girder depth 1500 mm

Table 16 Forces in Beam-37 & B-39 for Case-3 and girder depth 1000 mm

CASE-3					
Girder size - 450 mm X 1000 mm					
Construction stage	Bending Moment			Shear Force	
	Left	Max positive	Right	Left	Right
2-level	0.516	18.27	18.27	-12.05	22.06
3-level	8.33	-12.57	-12.57	-6.76	26.14
4-level	15.08	-18.95	-18.95	-2.25	29.7
5-level	20.79	-24.5	-24.5	1.56	32.707
6-level	26.08	-29.14	-29.14	5.1	35.5
7-level	30.54	-33.55	-33.55	8.08	37.89
8-level	34.72	-37.22	-37.22	10.87	40.07
9-level	38.69	-43.66	-43.66	13.51	42.17
10-level	42.49	-47.06	-47.06	16.05	44.19
11-level	46.15	50.08	-50.08	18.48	46.13
12-level	49.68	-53	-53	20.84	48.01
Conventional analysis	37.96	-43.5	-43.5	13.05	41.93

- There is a minor change in the value of the maximum positive bending moment in beam B-39 while comparing results of the construction stage analysis with the conventional analysis.
- The major change is observed in the value of the support bending moment in beam B-39 as construction stage increases.
- The direction of the bending moment at the right end of the beam B-39 is from the negative to positive as construction stage increased from level-3 to level-4.
- The bending moment at the left end of the beam B-39 is 79% less when construction stage is up to level-2 compare to conventional analysis of building.
- Also the shear force at the left end of the beam is 49% less and at the right end of the beam is 94% more when construction stage is up to level-2 compare to conventional analysis of building.

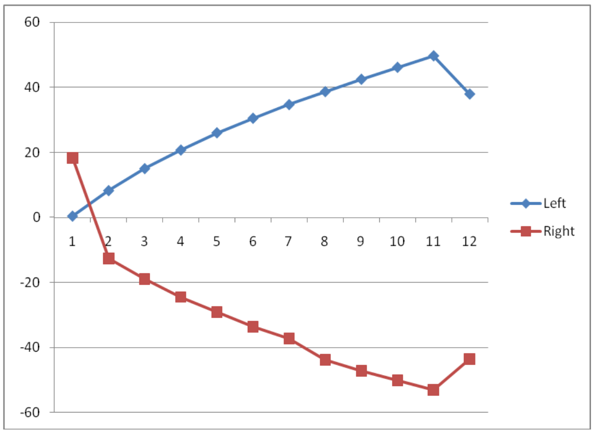


Fig. 34 Bending moment in Beam B-39 for Girder depth 1000 mm

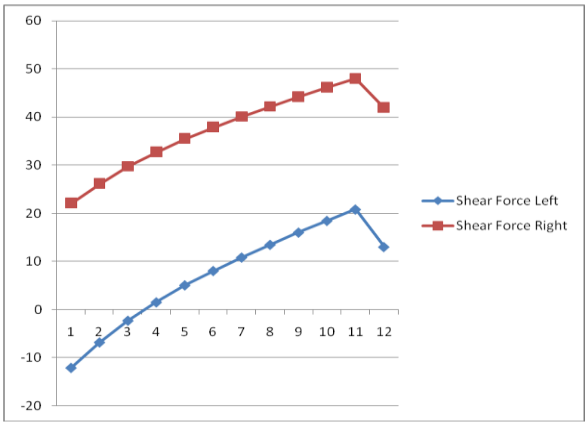


Fig. 35 Shear force in Beam B-39 for Girder depth 1000 m

FORCES IN TRANSFER GIRDER HAVING VARYING DEPTH

Table 17 Forces in Transfer girder of varying depth for Case-1

FORCE		GIRDER DEPTH(450MM)							
		2500mm		2000mm		1500mm		1000mm	
BENDING MOMENT AT MID	CONVETIONAL	1911.97	5%	1458.1	6%	952.53		379.46	
	CONSTRUCTION	2104.87		1658.87		1180.39	9%	592.41	20
BENDING MOMENT AT SUPPORT	CONVETIONAL	1801.4	1%	1741.38	4%	1429.38		821.13	
	CONSTRUCTION	1860.24		1894.21		1697.32	9%	1166.12	20
SHEAR FORCE	CONVETIONAL	991.64	3%	879.84	5%	708.63		447.81	
	CONSTRUCTION	1046.05		959.79		828.06	9%	605.7	14
DEFLECTION	CONVETIONAL	2.64		3.64		5.42		8.19	
	CONSTRUCTION	2.91	5%	4.14	7%	6.64	10	12.07	21

- The percentage difference between the result of construction stage analysis and conventional analysis for transfer girder is increased as the girder depth reducing.
- The positive bending moment in the transfer girder is reduced up to 45% when the girder depth reduced from 2500 mm to 1000 mm.
- The negative bending moment in the transfer girder is increased when girder depth reduced up to 1500 mm.
- For further reduction in the depth of girder cause the reduction in negative bending moment in transfer girder.
- Also the deflection in transfer girder is increased about 85% when girder depth reduced from 2500 mm to 1000 mm.
- The shear force in the transfer girder is also reduced as girder depth reducing.

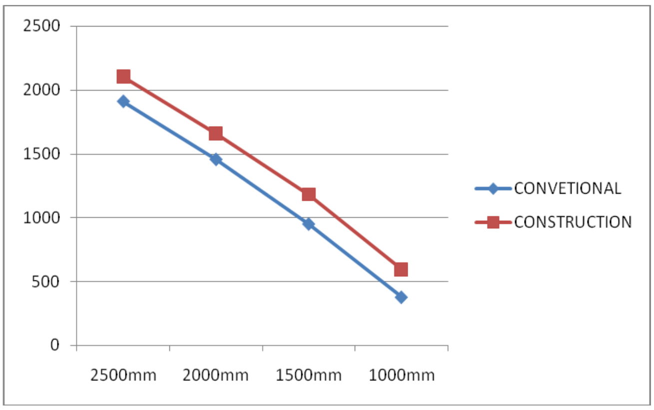


Fig. 36 Positive bending moment in transfer girder of varying depth (Case-1)

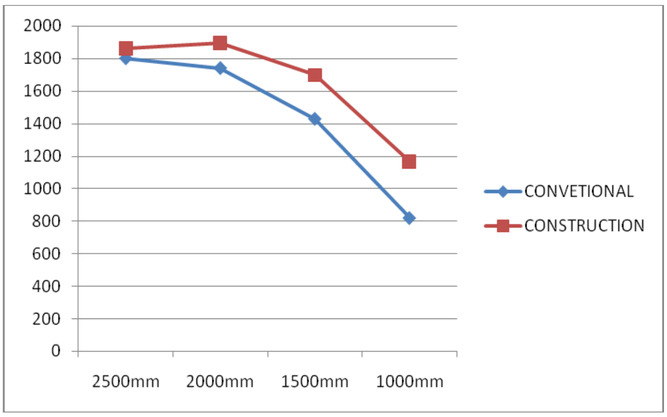


Fig. 37 Negative bending moment in transfer girder of varying depth (Case-1)

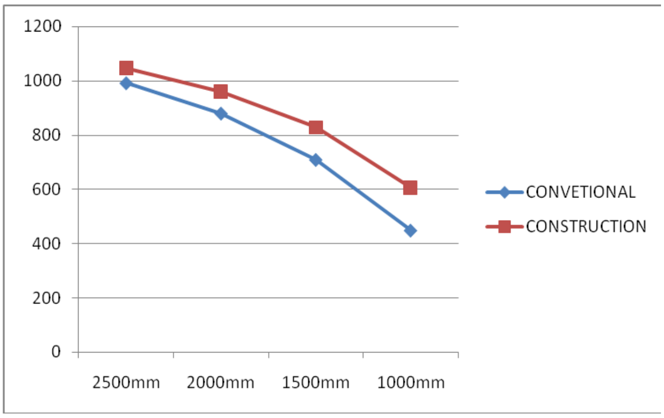


Fig. 38 Shear force in transfer girder of varying depth (Case-1)

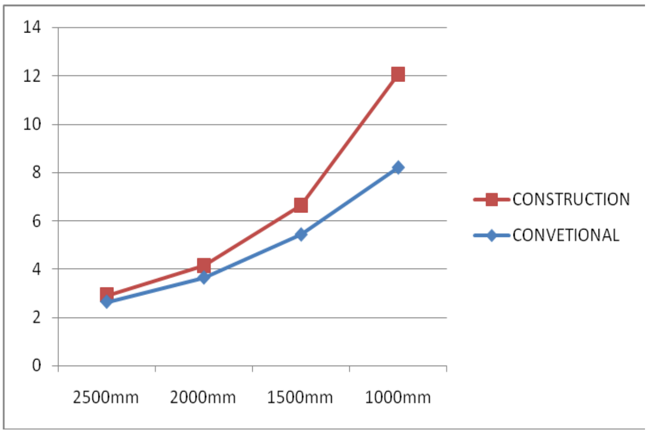


Fig. 39 Deflection in transfer girder of varying depth (Case-1)

Table 18 Forces in Transfer girder of varying depth for Case-2

FORCE	GIRDER DEPTH(450MM)								
		2500mm	%	2000mm	%	1500mm	%	1000mm	%
BENDING MOMENT AT MID	CONVETIONAL	1773.85		1378.89		909.82		360.28	
	CONSTRUCTION	1960.69	5	1581.82	6	1145.18	17	577.94	22
BENDING MOMENT AT SUPPORT	CONVETIONAL	1911.94		1782.03		1418.14		791.09	
	CONSTRUCTION	2007.73	2	1971.06	5	1719.34	10	1157.8	22
SHEAR FORCE	CONVETIONAL	985.78		870.45		694.28		431.83	
	CONSTRUCTION	1049.26	4	960.77	6	825.37	10	599.26	22
DEFLECTION	CONVETIONAL	2.41		3.39		5.119		7.56	
	CONSTRUCTION	2.66	6	3.87	8	6.35	11	11.72	22

- The percentage difference between the result of construction stage analysis and conventional analysis for transfer girder is increased as the girder depth reducing.
- The positive bending moment in the transfer girder is reduced up to 43% when the girder depth reduced from 2500 mm to 1000 mm.
- The negative bending moment in the transfer girder is increased when girder depth reduced up to 2000 mm.
- For further reduction in the depth of girder cause the reduction in negative bending moment in transfer girder.
- Also the deflection in transfer girder is increased about 85% when depth of girder reduced from 2500 mm to 1000 mm.
- The shear force in the transfer girder is also reduced as girder depth reducing.

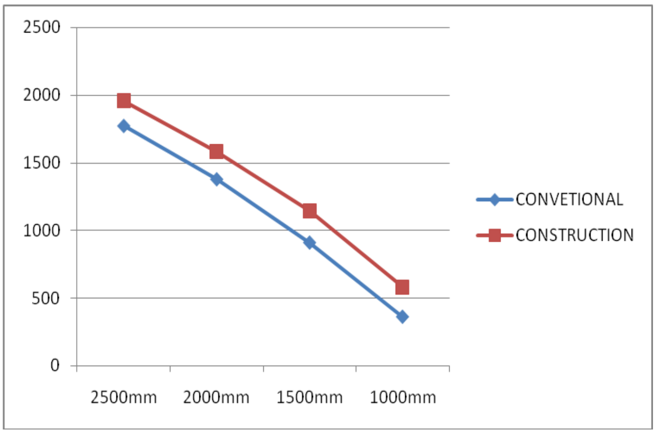


Fig. 40 Positive bending moment in transfer girder of varying depth (Case-2)

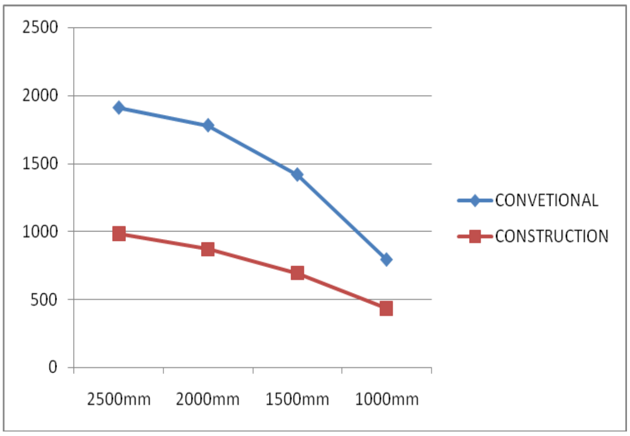


Fig. 42 Shear force in transfer girder of varying depth (Case-2)

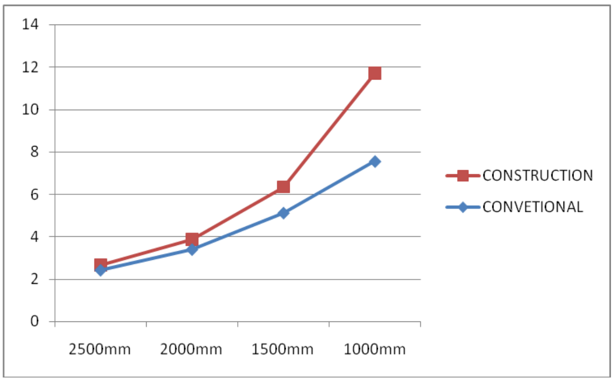


Fig. 43 Deflection in transfer girder of varying depth (Case-2)

Table 19 Forces in Transfer girder of varying depth for Case-3

FORCE	GIRDER DEPTH(450MM)								
		2500mm	%	2000mm	%	1500mm	%	1000mm	%
BENDING MOMENT AT MID	CONVETIONAL	2484.31		1795.79		954.93		296.26	
	CONSTRUCTION	2970.31	11	2158.92	12	1344.94	18	575.49	29
BENDING MOMENT AT SUPPORT	CONVETIONAL	2943.26		2398.87		1905.05		1272.87	
	CONSTRUCTION	3388.96	4	2828.14	8	2364.95	15	1808.9	29
SHEAR FORCE	CONVETIONAL	1272.68		1134.63		929.46		602.19	
	CONSTRUCTION	1417.15	8	1310.72	10	949.44	15	860.09	28
DEFLECTION	CONVETIONAL	3.74		4.85		6.65		9.42	
	CONSTRUCTION	4.4	11	6.012	14	8.941	17	15.305	29

- The percentage difference between the result of construction stage analysis and conventional analysis for transfer girder is increased as the girder depth reducing.
- The positive bending moment in the transfer girder is reduced up to 55% when the girder depth reduced from 2500 mm to 1000 mm.
- The negative bending moment in the transfer girder is increased when girder depth reduced up to 1500 mm.
- For further reduction in the depth of girder cause the reduction in negative bending moment in transfer girder.
- Also the deflection in transfer girder is increased about 81% when depth of girder reduced from 2500 mm to 1000 mm.
- The shear force in the transfer girder is also reduced as girder depth reducing.

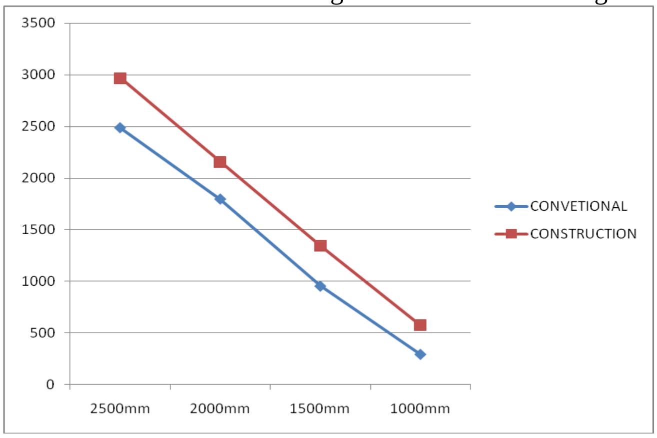


Fig. 44 Positive bending moments in transfer girder of varying depth (Case-3)

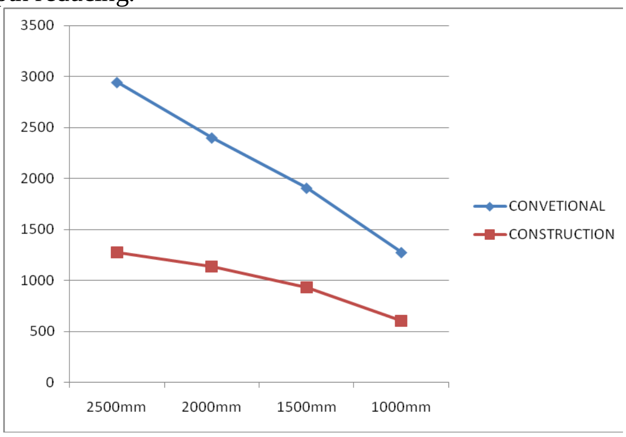


Fig. 45 Negative bending moment in transfer girder of varying depth (Case-3)

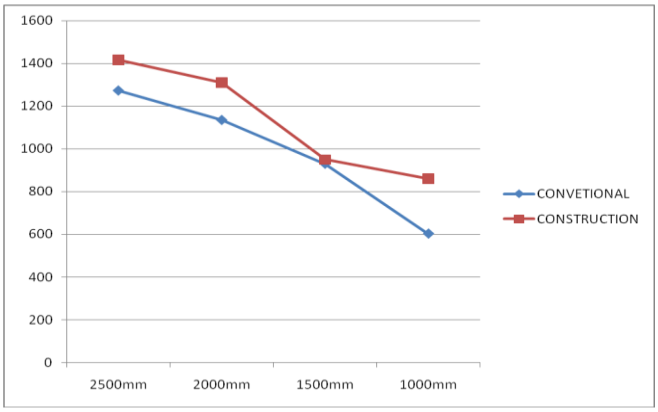


Fig. 46 Shear force in transfer girder of varying depth (Case-3)

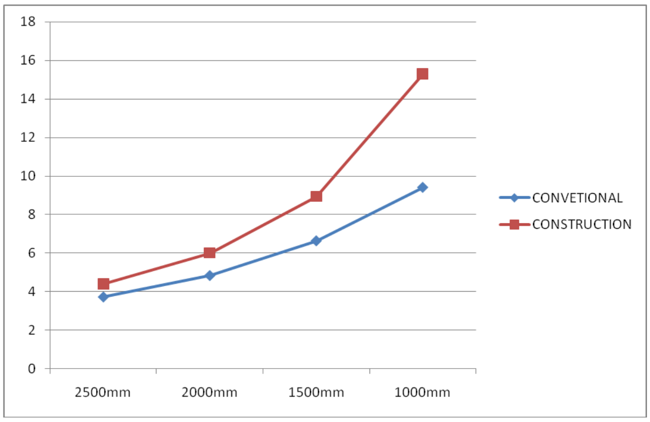


Fig. 47 Deflection in transfer girder of varying depth (Case-3)

Table 20 Forces in Transfer girder of varying depth for Case-4

FORCE	GIRDER DEPTH(450MM)								
		2500mm		2000mm		1500mm		1000mm	
BENDING MOMENT AT MID	CONVETIONAL	2476.35		1710.51		952.01		295.32	
	CONSTRUCTION	2967.92	10	2157.41	12	1344.2	17	575.23	29
BENDING MOMENT AT SUPPORT	CONVETIONAL	2936.44		2393.48		1900.65		1268.59	
	CONSTRUCTION	3388.81	4	2828.24	9	2366.19	15	1810.31	29
SHEAR FORCE	CONVETIONAL	1271.57		1133.44		928.23		601.13	
	CONSTRUCTION	1419.007	8	1312.36	10	1150.76	15	860.94	28
DEFLECTION	CONVETIONAL	3.73		4.84		6.63		9.39	
	CONSTRUCTION	4.44	11	6.008	14	8.91	18	15.306	30

- The percentage difference between the result of construction stage analysis and conventional analysis for transfer girder is increased as the girder depth reducing.
- The positive bending moment in the transfer girder is reduced up to 54% when the girder depth reduced from 2500 mm to 1000 mm.
- The negative bending moment in the transfer girder is increased when girder depth reduced up to 1500 mm.
- Also the deflection in transfer girder is increased about 81% when girder depth reduced from 2500 mm to 1000 mm.
- The shear force in the transfer girder is also reduced as girder depth reducing.

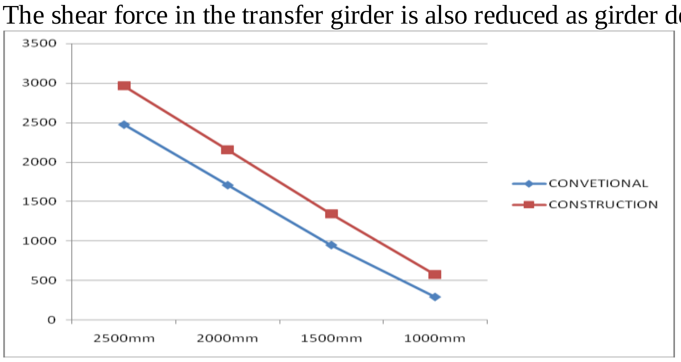


Fig. 48 Positive bending moment in transfer girder of varying depth (Case-4)

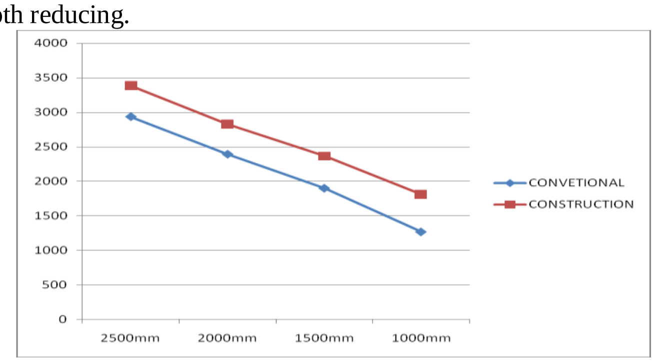


Fig. 49 Negative bending moment in transfer girder of varying depth(Case-4)

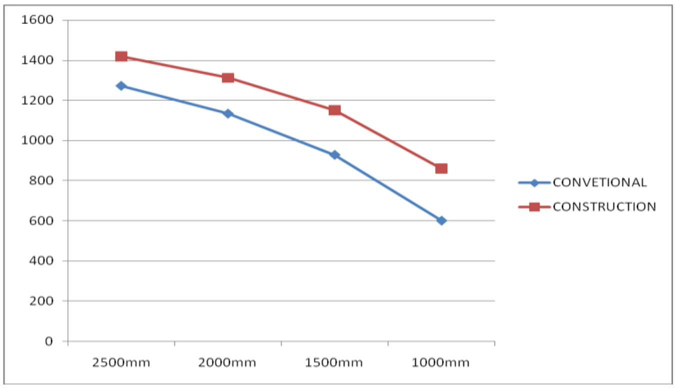


Fig. 50 Shear force in transfer girder of varying depth (Case-4)

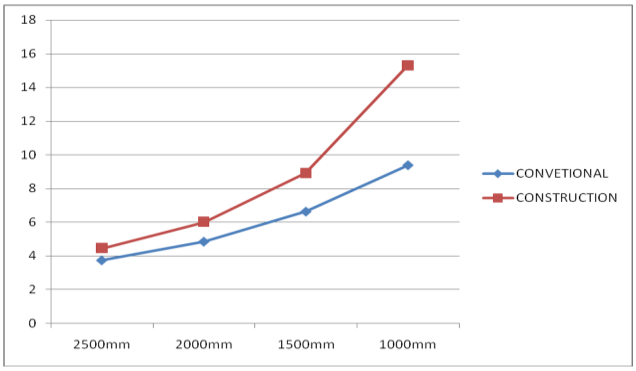


Fig. 51 Deflection in transfer girder of varying depth (Case-4)

Table 21 Forces in Transfer girder of varying depth for Case-5

FORCE	GIRDER DEPTH(450MM)								
		2500mm	%	2000mm	%	1500mm	%	1000mm	%
BENDING MOMENT AT MID	CONVETIONAL	2234.4		1593.89		911.44		285.51	
	CONSTRUCTION	2656.24	11	1993.53	9	1285.26	17	563.77	30
BENDING MOMENT AT SUPPORT	CONVETIONAL	2643.98		2307.98		1862.89		1228.94	
	CONSTRUCTION	3030.94	5	2690.83	13	2389.14	16	1780.69	29
SHEAR FORCE	CONVETIONAL	1276.55		1137.26		925.17		590.98	
	CONSTRUCTION	1424.17	8	1318.63	11	1154.48	16	859.84	29
DEFLECTION	CONVETIONAL	3.26		4.37		6.2		8.97	
	CONSTRUCTION	3.85	13	5.37	13	8.31	18	14.28	30

- The percentage difference between the result of construction stage analysis and conventional analysis for transfer girder is increased as the girder depth reducing.
- The positive bending moment in the transfer girder is reduced up to 53% when the girder depth reduced from 2500 mm to 1000 mm.
- The negative bending moment in the transfer girder is increased when girder depth reduced up to 1500 mm.
- For further reduction in the depth of girder cause the reduction in negative bending moment in transfer girder.
- Also the deflection in transfer girder is increased about 81% when girder depth reduced from 2500 mm to 1000 mm.
- The shear force in the transfer girder is also reduced as girder depth reducing.

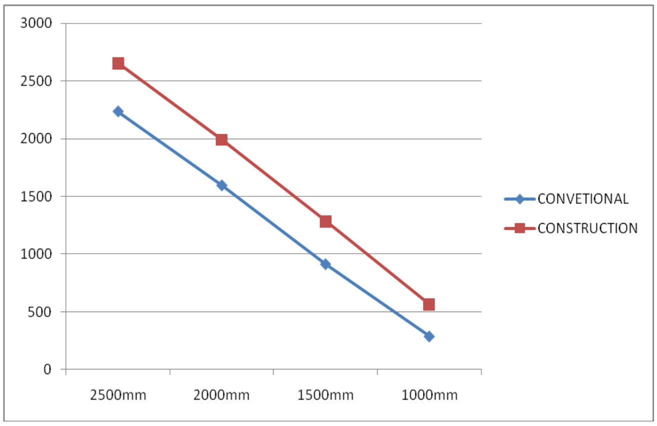


Fig. 52 Positive bending moment in transfer girder of varying depth (Case-5)

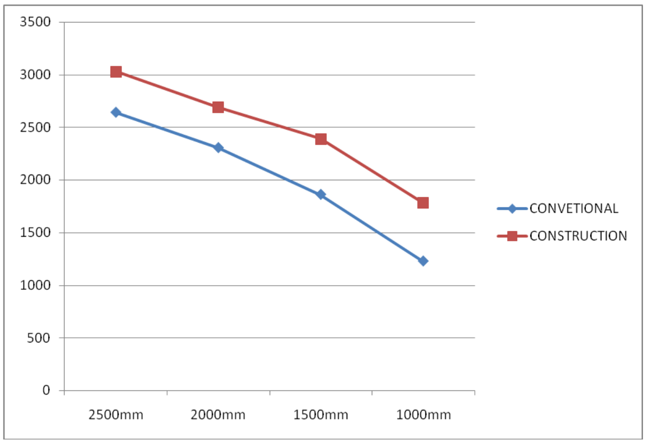


Fig. 53 Negative bending moment in transfer girder of varying depth (Case-5)

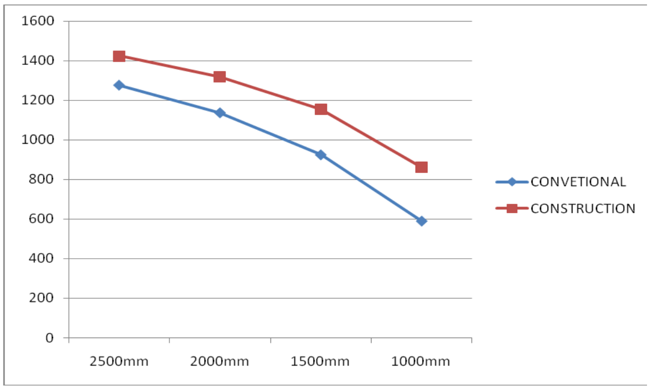


Fig. 54 Shear force in transfer girder of varying depth (Case-5)

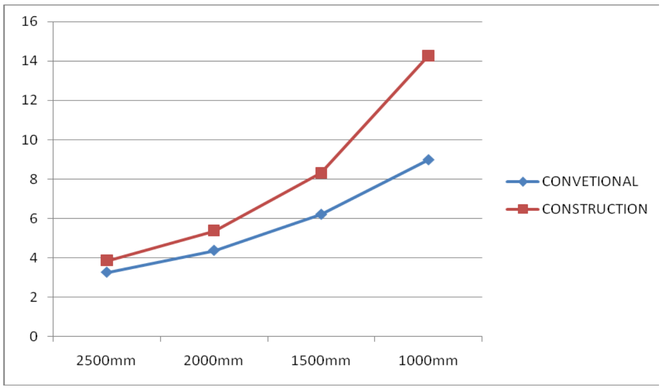


Fig. 55 Deflection in transfer girder of varying depth (Case-5)

FORCES IN SUPPORTING COLUMN OF TRANSFER GIRDER HAVING VARYING DEPTH

a) CASE-1 & CASE-2

Table 22 Forces in Column C-2 at first floor for Case-1

COLUMN C2 AT 1ST FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT MAJOR	SHEAR FORCE (KN)
2500	CONSTRUCTION STAGE	1506.91	963.54	294.41
	CONVETIONAL STAGE	1355	847.1	263.23
2000	CONSTRUCTION STAGE	1506.71	963.95	294.52
	CONVETIONAL STAGE	1355.12	847.21	263.19
1500	CONSTRUCTION STAGE	1585.63	784.67	241.1
	CONVETIONAL STAGE	1405.92	751.87	236.21
1000	CONSTRUCTION STAGE	1445.4	326.43	102.1
	CONVETIONAL STAGE	1347.4	375.2	119.87

Table 23 Forces in Column C-2 at first floor for Case-2

COLUMN C2 AT 1ST FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT MAJOR	SHEAR FORCE (KN)
2500	CONSTRUCTION STAGE	2598.27	664.46	443.95
	CONVETIONAL STAGE	2529.55	810.05	541.08
2000	CONSTRUCTION STAGE	2597.78	664.43	879.27
	CONVETIONAL STAGE	2529.01	809.79	540.92
1500	CONSTRUCTION STAGE	2508.15	725.09	363.14
	CONVETIONAL STAGE	2452.51	957.71	479.52
1000	CONSTRUCTION STAGE	2171.73	315.77	140.82
	CONVETIONAL STAGE	2230.31	534.23	239.13

- The variation in value of axial force and shear force is minor when used construction stage analysis compare to conventional analysis.
- The provision of shear wall (case-2) causes the drastic reduction within the axial force in the column C-2 when compared to building without shear wall (case-1).
- Also the Axial force in the column C-2 is increased as the depth of girder reduced from 2500 mm to 1000 mm.
- The bending moment in column C-2 is increased as girder depth change from 2500 mm to 2000 mm and further reduction in depth of girder causes the reduction in bending moment.
- The shear force in the column C-2 is reduced as the depth of girder is reduced.

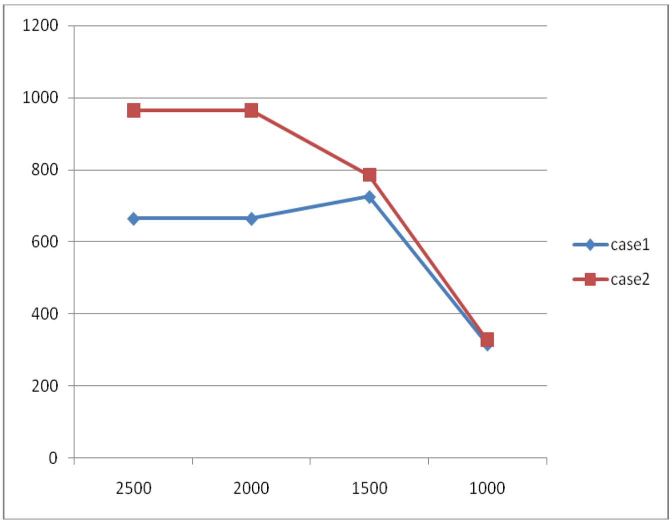


Fig. 56 Bending moment in column C-2 at 1st floor for case-1 & case-2

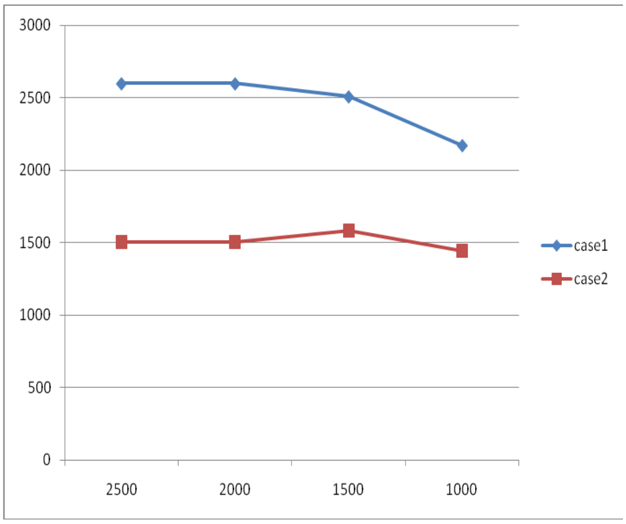


Fig. 57 Axial force in column C-2 at 1st floor for case-1 & case-2

Table 25 Forces in Column C-2 at Ground floor for Case-1

COLUMN C2 AT GR FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT	SHEAR FORCE (KN)
			MAJOR	
2500	CONSTRUCTION STAGE	2598.27	664.46	443.95
	CONVETIONAL STAGE	2529.55	810.05	541.08
2000	CONSTRUCTION STAGE	2597.78	664.43	879.27
	CONVETIONAL STAGE	2529.01	809.79	540.92
1500	CONSTRUCTION STAGE	2508.15	725.09	363.14
	CONVETIONAL STAGE	2452.51	957.71	479.52
1000	CONSTRUCTION STAGE	2171.73	315.77	140.82
	CONVETIONAL STAGE	2230.31	534.23	239.13

Table 26 Forces in Column C-2 at Ground floor for Case-2

COLUMN C2 AT Gr FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT	SHEAR FORCE (KN)
			MAJOR	
2500	CONSTRUCTION STAGE	2471.43	222.3	370.75
	CONVETIONAL STAGE	2501.72	280.86	439.3
2000	CONSTRUCTION STAGE	2409.71	374.89	335.9
	CONVETIONAL STAGE	2450.04	480.39	415.9
1500	CONSTRUCTION STAGE	2314.57	431.42	262.11
	CONVETIONAL STAGE	2369.2	597.4	355.75
1000	CONSTRUCTION STAGE	2174.23	318.43	142.34
	CONVETIONAL STAGE	2235.25	538.61	241.5

- The bending moment in column C-2 at ground floor is increased 85 % more in case-2 when compare to case-1.
- The provision of shear wall (case-2) causes the reduction in the axial force about 49% in the column C-2 at ground floor when compared to building without shear wall (case-1).
- The variation in bending moment in case-1 is very large as depth of girder is reduced from 2500 mm to 1000 mm.
- Also the Axial force in the column C-2 is decreased as the depth of girder reduced from 2500 mm to 1000 mm.
- The bending moment in column C-2 is increased as girder depth change from 2500 mm to 2000 mm and further reduction in depth of girder causes the reduction in bending moment.
- The shear force in the column C-2 is reduced as the depth of girder is reduced.

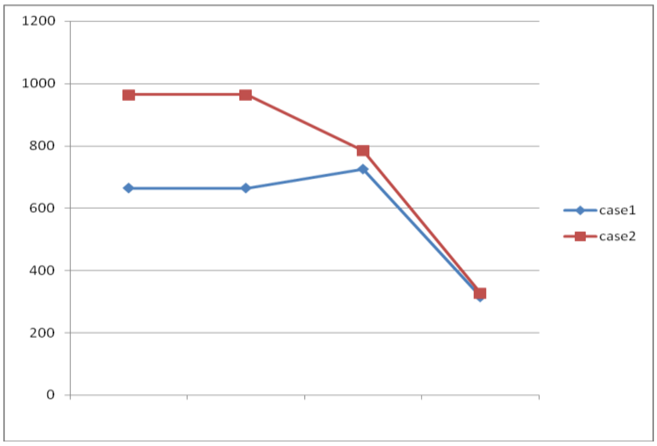


Fig. 58 Bending moment in column C-2 at ground floor for case-1 & case-2

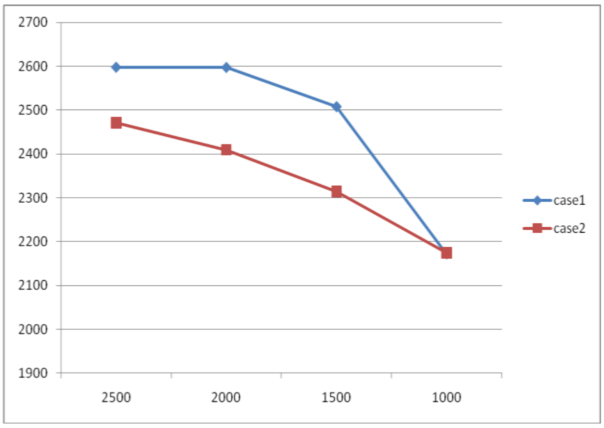


Fig. 59 Axial forces in column C-2 at ground floor for case-1 & case-2

b) CASE-3, CASE-4 & CASE-5

Table 28 Forces in Column C-2 at first floor for Case-3

COLUMN C2 AT 1ST FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT MAJOR	SHEAR FORCE (KN)
2500	CONSTRUCTION STAGE	1391.91	1470.54	484.92
	CONVETIONAL STAGE	1366.57	1357.48	449.33
2000	CONSTRUCTION STAGE	1424.62	1417.25	467.37
	CONVETIONAL STAGE	1387.68	1379.99	457.01
1500	CONSTRUCTION STAGE	1478.95	1173.99	387.95
	CONVETIONAL STAGE	1425.51	1238.85	412.37
1000	CONSTRUCTION STAGE	1572.23	710.53	239.7
	CONVETIONAL STAGE	1500.56	870.345	298.04

Table 29 Forces in Column C-2 at first floor for Case-4

COLUMN C2 AT 1ST FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT MAJOR	SHEAR FORCE (KN)
2500	CONSTRUCTION STAGE	1302.1	1487.94	494.44
	CONVETIONAL STAGE	1301.26	1375.52	458.75
2000	CONSTRUCTION STAGE	1334.52	1433.23	476.46
	CONVETIONAL STAGE	1322.34	1396.45	466.32
1500	CONSTRUCTION STAGE	1388.41	1188.3	396.27
	CONVETIONAL STAGE	1360.17	1254.96	421.28
1000	CONSTRUCTION STAGE	1480.94	722.35	246.45
	CONVETIONAL STAGE	1435.27	884.43	305.81

Table 30 Forces in Column C-2 at first floor for Case-5

COLUMN C2 AT 1ST FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT	SHEAR FORCE (KN)
			MAJOR	
2500	CONSTRUCTION STAGE	1016.98	1003.01	318.73
	CONVETIONAL STAGE	1047.62	926.71	292.02
2000	CONSTRUCTION STAGE	1050.28	930.51	294.99
	CONVETIONAL STAGE	1065.43	908.34	286.14
1500	CONSTRUCTION STAGE	1109.93	747.41	235.8
	CONVETIONAL STAGE	1103.9	795.24	250.39
1000	CONSTRUCTION STAGE	1209.13	443.89	139.81
	CONVETIONAL STAGE	1181.97	552.88	176.46

- The variation in the value of bending moment in column C-2 between case-3, case-4 and case-5.
- The provision of shear wall on either side of transfer girder (case-5) causes the reduction in the axial force about 49% in the column C-2 at first floor when compared to building without shear wall (case-3).
- Also the axial force in the column C-2 is increased as the depth of girder reduced from 2500 mm to 1000 mm.
- The bending moment in column C-2 is increased as girder depth change from 2500 mm to 2000 mm and further reduction in depth of girder causes the reduction in bending moment.
- The shear force is reduced about 28% in the column C-2 at first floor in case-3 when compare to the case-5.

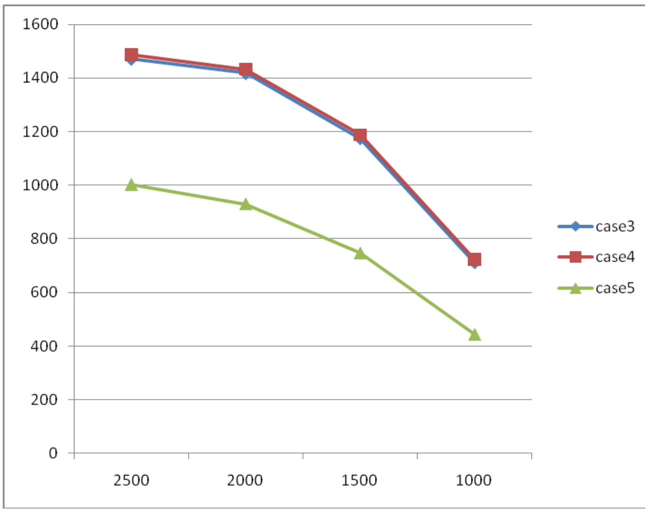


Fig. 60 Bending moment in column C-2 at first floor for case-3, case-4 & case-5

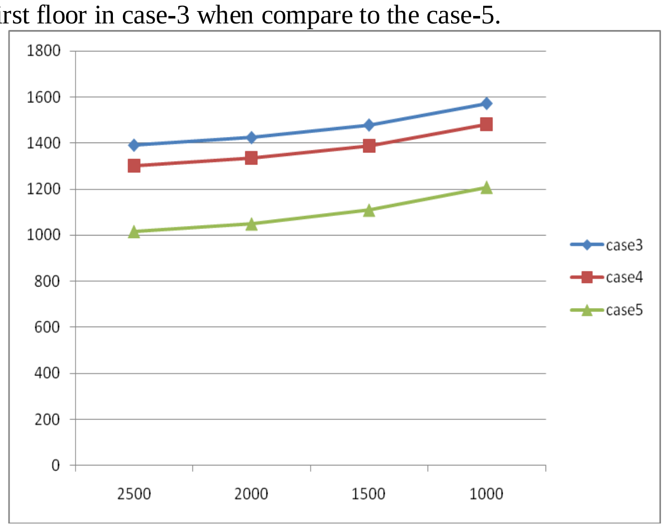


Fig. 61 Axial forces in column C-2 at first floor for case-3, case-4 & case-5

Table 31 Forces in Column C-2 at ground floor for Case-3

COLUMN C2 AT GR FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT	SHEAR FORCE (KN)
			MAJOR	
2500	CONSTRUCTION STAGE	2834.2	449.63	449.03
	CONVETIONAL STAGE	2956.98	560.77	564.77
2000	CONSTRUCTION STAGE	2730.1	657.38	438.25
	CONVETIONAL STAGE	2873.67	867.05	578.03
1500	CONSTRUCTION STAGE	2580.76	742.56	371.28
	CONVETIONAL STAGE	2753.01	1072.09	536.04

1000	CONSTRUCTION STAGE	2349.45	984.08	233.63
	CONVETIONAL STAGE	2544.71	1011.22	404.48

Table 32 Forces in Column C-2 at ground floor for Case-4

COLUMN C2 AT GR FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT	SHEAR FORCE (KN)
			MAJOR	
2500	CONSTRUCTION STAGE	2741.64	448.01	448.01
	CONVETIONAL STAGE	2891.31	560.66	560.66
2000	CONSTRUCTION STAGE	2637.17	654.08	436.05
	CONVETIONAL STAGE	2807.76	866.01	577.34
1500	CONSTRUCTION STAGE	2487.26	737.53	368.76
	CONVETIONAL STAGE	2686.75	1069.56	534.78
1000	CONSTRUCTION STAGE	2255.1	578.52	231.41
	CONVETIONAL STAGE	2477.93	1007.29	402.91

Table 33 Forces in Column C-2 at ground floor for Case-5

COLUMN C2 AT GR FLOOR				
GIRDER DEPTH	ANALYSIS TYPE	AXIAL FORCE	BENDING MOMENT	SHEAR FORCE (KN)
			MAJOR	
2500	CONSTRUCTION STAGE	2295.1	306.31	271.97
	CONVETIONAL STAGE	2462.81	392.34	342.77
2000	CONSTRUCTION STAGE	2219.11	414.34	252.94
	CONVETIONAL STAGE	2405.35	553.56	336.04
1500	CONSTRUCTION STAGE	2096.71	434.65	204.15
	CONVETIONAL STAGE	2309.01	641.04	298.96
1000	CONSTRUCTION STAGE	1902.54	316.12	119.71
	CONVETIONAL STAGE	2123.46	572.19	215.63

- The variation in value of axial force and shear force is minor when used construction stage analysis compare to conventional analysis.
- The provision of shear wall on either side of transfer girder (case-5) causes the reduction in the axial force about 30% in the column C-2 when compared to building without shear wall (case-3).
- Also the axial force in the column C-2 is increased as the depth of girder reduced from 2500 mm to 1000 mm.
- The bending moment in column C-2 is reduced about 68% in case-3 compare to the case-5.
- The variation in the value of bending moment in column C-2 between case-3 & case-4 is minor when compare with the case-5.
- The shear force in the column C-2 is reduced as the depth of girder is reduced.

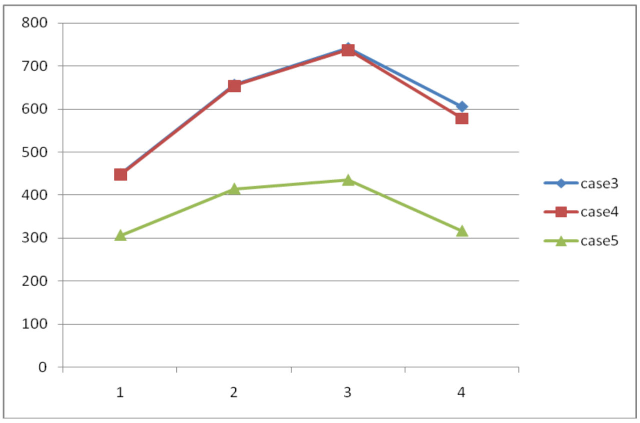


Fig. 62 Bending moments C-2 at ground floor for case-3, case-4 & case-5

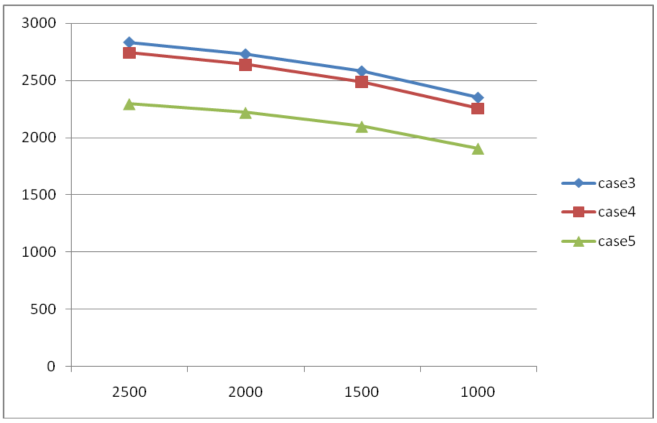


Fig. 63 Axial force C-2 at ground floor for case-3, case-4 & case-5

BEHAVIOUR OF TRANSFER GIRDER UNDER EARTHQUAKE FORCES

The behavior of transfer girder under lateral loading i.e. earthquake loading must be investigated. The forces in transfer girder due to earthquake are compared between the building without shear wall and building with shear wall. The following results are derived based on seismic coefficient method.

Table 34 Forces in Transfer girder under Earthquake load

FORCE IN TRANSFER GRIDER				
	EQ-X		EQ-Y	
	BENDING MOMENT (KN M)	SHEAR FORCE (KN)	BENDING MOMENT (KN M)	SHEAR FORCE(KN)
CASE1	836.24	182.96	226.4	112.96
CASE2	398.67	84.04	113.83	55.1
CASE3	1138.5	259.77	8.8	3.61
CASE4	307.19	72.26	5.4	2.13
CASE5	413.69	104.32	2.44	51.38

- The bending moment in transfer girder due to earthquake force in X-direction is 81 % more in case of case-1 compare to case-2.
- The shear force in transfer girder due to earthquake force in X-direction is 80% more in case of case-1 compare to case-2.
- The bending moment in transfer girder due to earthquake force in Y-direction is 89 % more in case of case-1 compare to case-2.
- The shear force in transfer girder due to earthquake force in Y-direction is 89% more in case of case-1 compare to case-2.
- The bending moment in transfer girder due to Earthquake force in X-direction is 84 % more in case of case-3 compare to case-4.
- The shear force in transfer girder due to earthquake force in X-direction is 84% more in case of case-3 compare to case-4.
- The shear wall at corner of the building (case-4) prove beneficial compare to the shear wall provided on either side of the girder (case-5).
- The bending moment and shear force generated due to earthquake force in Y-direction in case-3, case-4 and case-5 is very less.

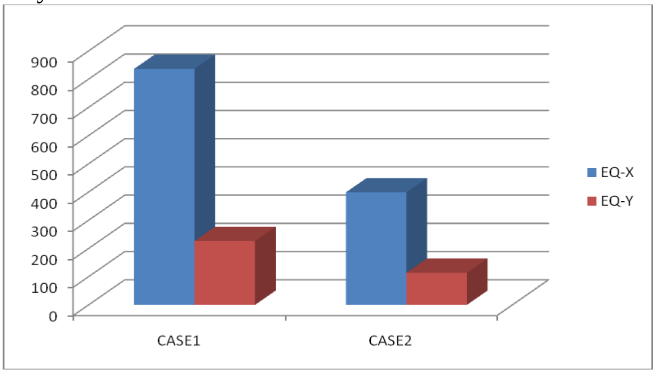


Fig. 64 Bending moment in transfer girder due to earthquake force-1

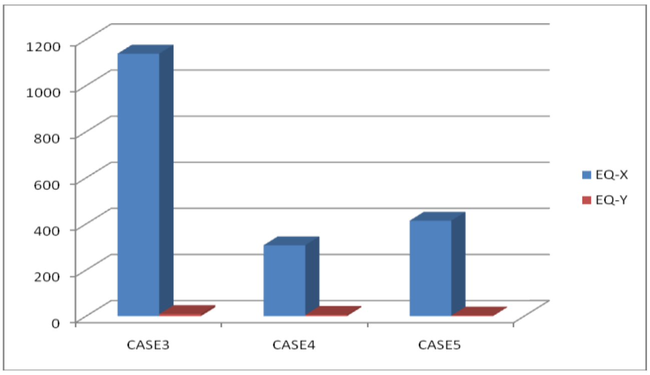


Fig. 65 Bending moment in transfer girder due to earthquake force-2

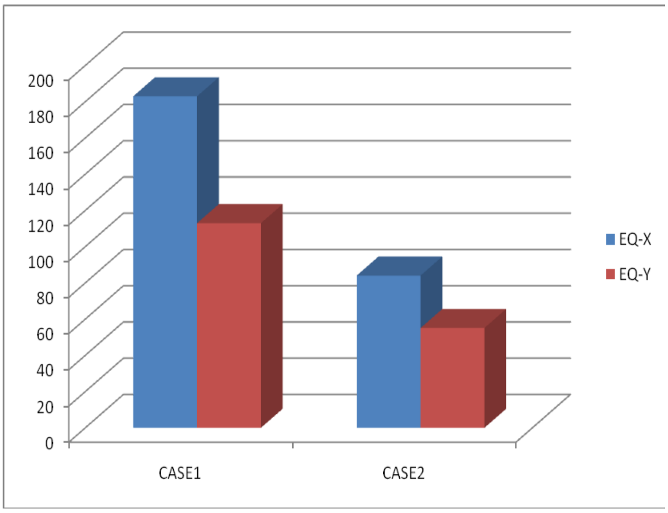


Fig. 66 Shear force in transfer girder due to earthquake force-1

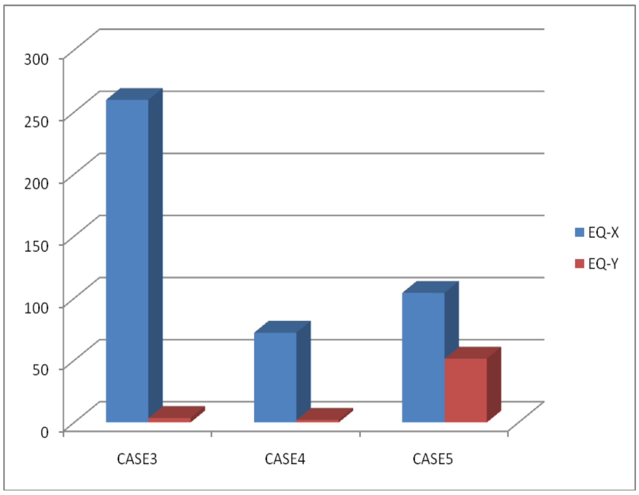


Fig. 67 Shear force in transfer girder due to earthquake force-2

FORCES IN SUPPORTING COLUMN OF TRANSFER GIRDER DUE TO EARTHQUAKE

The behavior of supporting column of transfer girder under lateral loading i.e. earthquake loading must be investigated. The forces in supporting column of transfer girder due to earthquake are compared between the building without shear wall and building with shear wall.

Table 35 Forces in supporting column of transfer girder under earthquake

FORCE IN TRANSFER GRIDER						
		EQ-X			EQ-Y	
	AXIAL FORCE (KN)	BENDING MOMENT (KN M)	SHEAR FORCE (KN)	AXIAL FORCE (KN)	BENDING MOMENT (KN M)	SHEAR FORCE(KN)
CASE1	175.72	261.94	143.43	175.72	201.94	143.43
CASE2	1693.59	393.92	139.12	882.08	23.82	0.19
CASE3	251.19	202.55	202.55	4.88	2.23	2.23
CASE4	46.13	28.28	28.28	33.23	0.176	0.176
CASE5	1036.01	78.28	34.82	8.67	0.97	1.49

- The axial force in supporting column due to earthquake is higher in case-2 compare to case-1 because of the shear wall is connected with supporting column.
- Though the axial force is increased due to provision of shear wall for case-2 there is drastic reduction in bending moment and shear forces in supporting column in building with shear wall compare to building without shear wall The overall reduction in bending moment is 85 % due to provision of shear wall.
- Cae-4 and Case-5 both have building with shear wall but its location is different.
- In the case of transfer girder inside the building the provision of shear wall on all four corner of the building is proved to be a beneficial than providing shear wall on either side of transfer girder.
- The overall reduction in bending moment is 85 % due to provision of shear wall.
- The increased in axial force in supporting column is 76% for transfer girder on outer face of building due to provision of shear wall.
- The reduction in axial force in supporting column is 88% for transfer girder placed inside the building due to provision of shear wall.

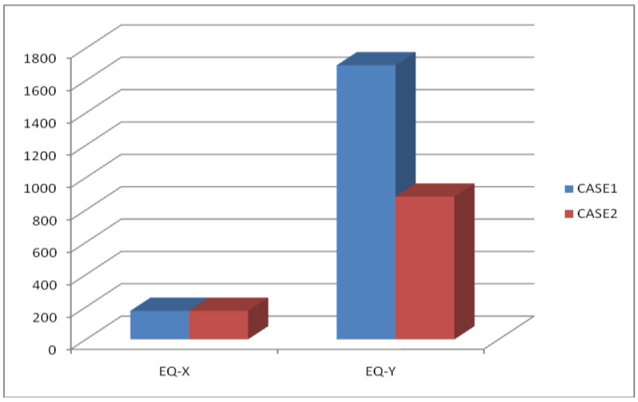


Fig. 68 Axial forces in supporting column for case-1 and case-2 due to Earthquake

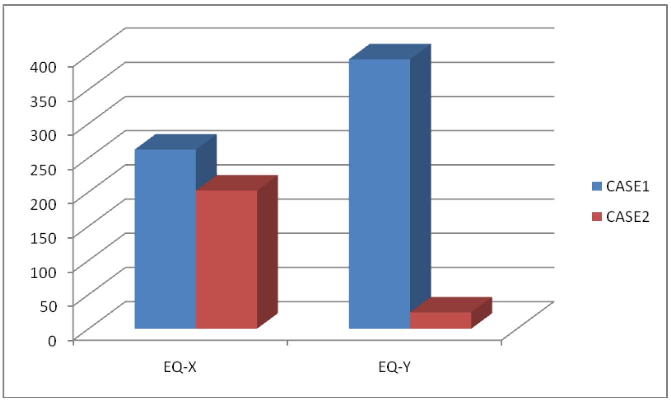


Fig. 69 Bending moments in supporting column for case-1 and case-2 due to earthquake

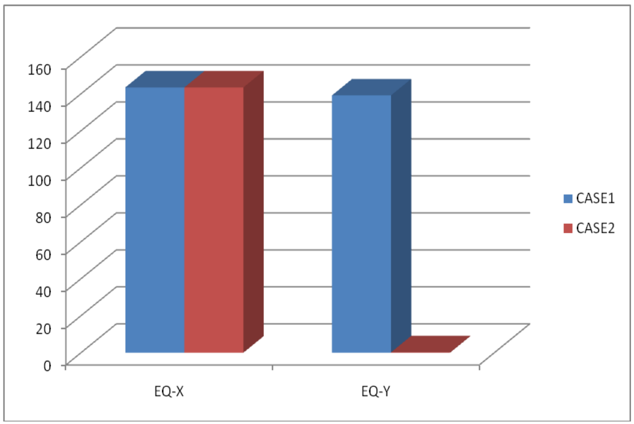


Fig. 70 Shear forces in supporting column for case-1 and case-2 due to Earthquake

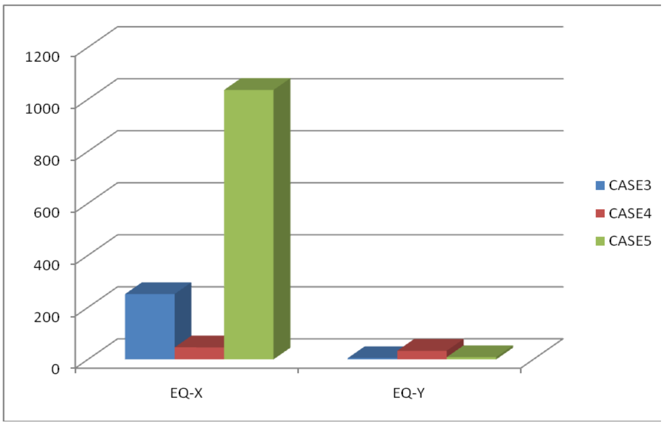


Fig. 71 Axial forces in supporting column for case-3, case-4 and case-5 due to earthquake

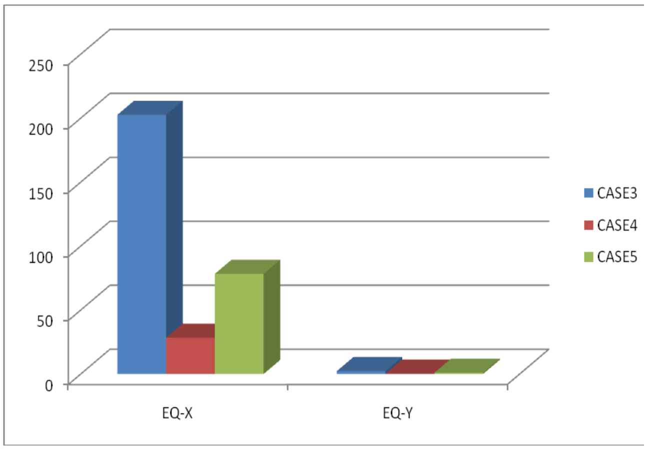


Fig. 72 Bending moments in supporting column for case-3, case-4 and case-5 due to earthquake

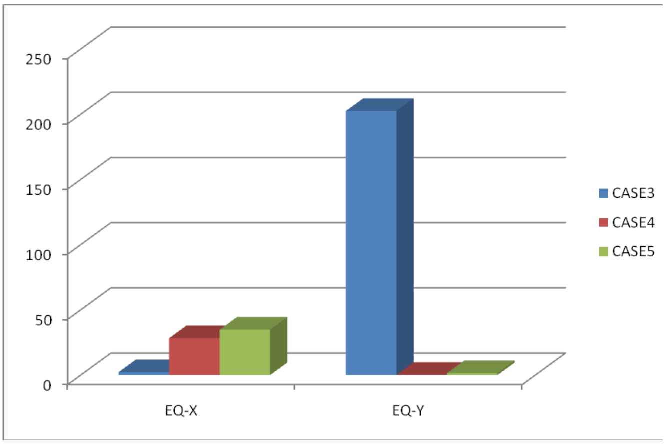


Fig. 73 Shear forces in supporting column for case-3, case-4 and case-5 due to earthquake

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