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Analysis and Behaviour of G+10 Building with Transfer Girder

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Abstract—*A Transfer Girder is used to transfer point load of column from the above storeys and transfer them to the supporting column. Transfer girder give good architectural aesthetic view to the tall structure. Behavior and design of transfer girder is very unconventional compare to normal beam, so it is necessary to study the behavior and design of the transfer girder in detail. To understand the same in the present study, G+10 storey building is structurally modeled in which the columns are float at different level. The analysis of transfer girder considering dynamic loading i.e. seismic load is done in ETAB. The complete behavior of the transfer girder will be studied by doing construction stage analysis in ETABS. Also the effect of transfer girder on the above structure will be studied out under gravity and lateral load. In this present study, influence of shear wall on the transfer girder will be studied. We found that there is considerable variation in the value of deflection, bending moment and shear force in transfer girder when we do the construction stage analysis in respect to conventional analysis of whole building as complete structural system. The forces generated in the beams exactly above transfer girder keep varying as construction progresses, which need to be taken into account while designing.*

1. 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. This 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 below. 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. For Floating columns, the Transfer Girder and columns supporting Transfer Girder needs special attention. Also the influenced of transfer girder on other structural element must be checked.

2. METHODOLOGY

ETAB is a structural analysis and design computer program originally developed by Computer and Structure, Inc.(CSI) Walnut creek, California. ETABS was used to create the mathematical model of the Burj Khalifa, currently the world's tallest building, designed by Chicago, Illinois-based Skidmore, Owings & Merrill LLP (SOM). Most of the structures are analyzed using conventional analysis (linear elastic) approach. In order to understand the true behavior of transfer girder the building must be analyzed using construction stage analysis instead of conventional approach. In the present paper ETAB 2015 is used to analyze G+10 storeyed building with transfer girder. Fig shows the structural plan used for present study. The transfer girder is placed on the inner grid of the building as shown in fig. The transfer girder support two floating column which terminate at first floor. As analysis part concern, the floating column is released at termination level in order to simply transfer point load on transfer girder. Following two cases are considered for the present paper:

i. G+10 building without Shear wall (shown in fig.1)

ii. G+10 building with L-shape shear wall on all four corner of the building (shown in fig.2)

Following load consider for present paper:

Floor finish	1.5 kN/m^2
Live Load	3 kN/m^2
Wall load (on the periphery only)	14 kN/m
Parapet wall load	6.4 kN/m^2

Following Earthquake parameter assign to the ETAB model :

Location	Surat
Seismic zone	III
Soil Type	Medium
Importance Factor	1
Response Reduction Factor	5

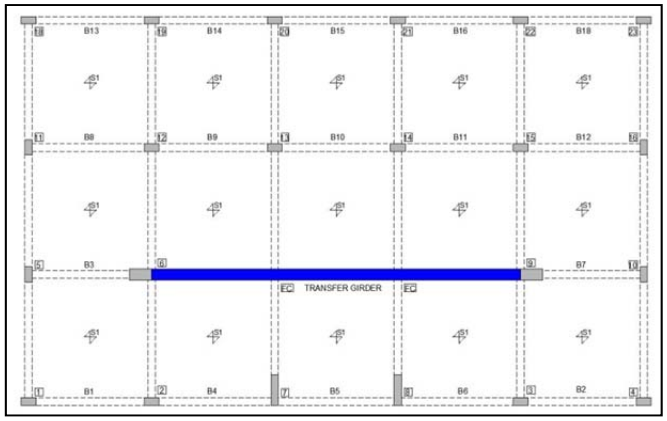

Fig. 1. G+10 building without shear wall

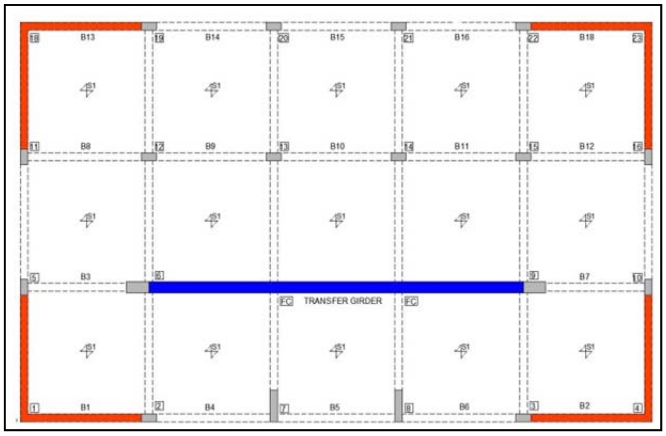

Fig. 2. G+10 building with L-shape shear wall

3. RESULTS

The building is analyzed using two different method i.e. construction stage analysis and conventional (linear elastic) approach. Various parameters such as bending moment and shear force of transfer girder were comparing that for construction stage analysis and conventional analysis. Comparative graph of bending moment, shear force and deflection for two different approaches that obtained from ETAB are shown here.

Table 1 Forces in transfer girder

Construction stage	Bending Moment		Shear Force		Deflection (mm)
	Positive (kN.m)	Negative (kN.m)	at Support (kN)	at Floating column(kN)	
1st-level	1097.98	423.22	442.11	-	1.3
2nd-level	1662.74	809.11	674.05	462.34	2
3rd-level	2210.3	1191.92	901.03	689.32	2.7
4th-level	2747.9	1563.58	1122.87	911.16	3.3
5th-level	3273.62	1927.41	1339.9	1128.19	4
6th-level	3788.17	2283.51	1552.32	1340.61	4.6
7th-level	4294.65	2634.05	1761.42	1549.71	5.2
8th-level	4789.67	2976.64	1965.77	1754.07	5.8
9th-level	5276.11	3313.29	2166.59	1954.88	6.4
10th-level	5754.76	3644.56	2364.19	2152.49	7
11th-level	**6221.51**	**3967.56**	**2556.87**	**2345.17**	**7.5**
Conventional analysis	5562.34	3808.64	2357.26	2145.55	6.7
Percentage Difference	11%	4%	8%	9%	11%

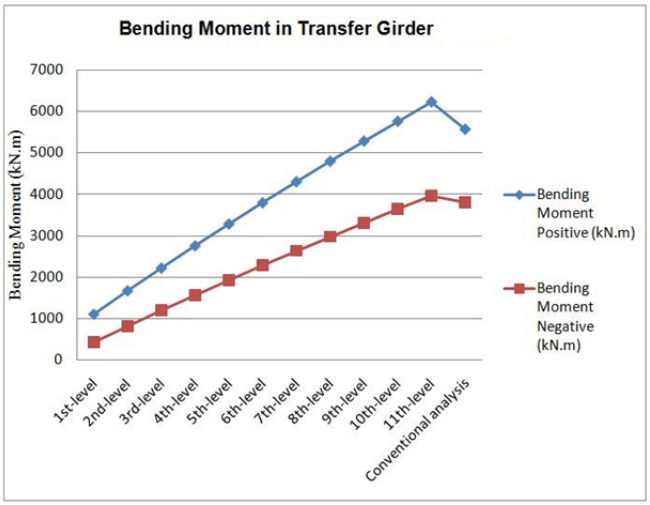

Fig. 3. Graph of bending moment in transfer girder

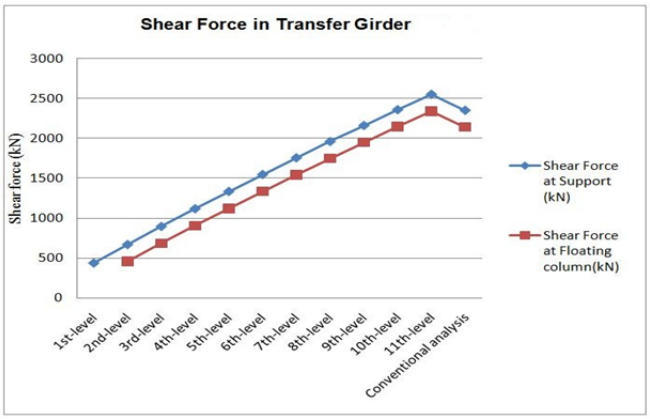

Fig. 4. Graph of Shear force in transfer girder

The behavior of beam which lies exactly above the transfer girder is changing as the construction stage is progress. The following graph shows the change in bending moment of the beam B-18 for two different depth of girder i.e. 2500 mm and 2000 mm.

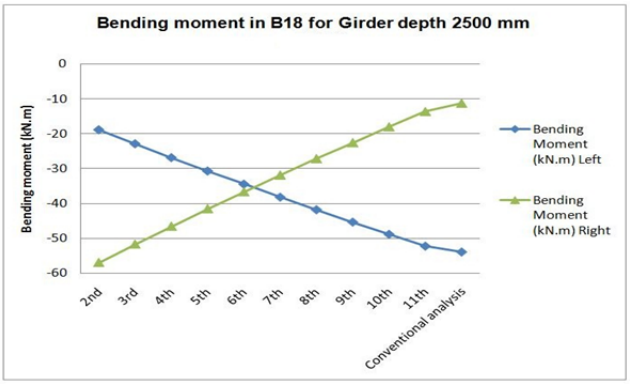

Fig. 5. Graph of bending moment in beam B-18 for girder depth 2500 mm

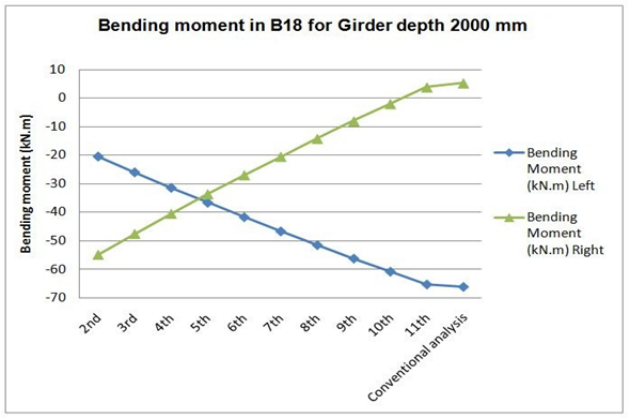

Fig. 6. Graph of bending moment in beam B-18 for girder depth 2000 mm

The building with shear wall is also considered for the present study. The benefits in the behavior of transfer girder due to the provision of shear wall under earthquake must be checked. The following table and graph show the forces in transfer girder for the earthquake load.

Table 2 Forces in transfer girder for earthquake load

Forces in Transfer Girder				
	EQ-X		EQ-Y	
	Bending moment (kN.m)	Shear force (kN)	Bending moment (kN.m)	Shear force (kN)
CASE-1	2721.02	426.2	2.93	0.69
CASE-2	443.55	68.91	1.16	0.36

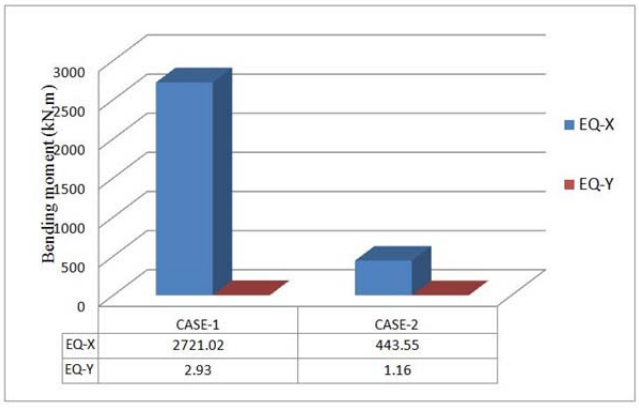

Fig. 7. Graph of bending moment in transfer girder for earthquake load

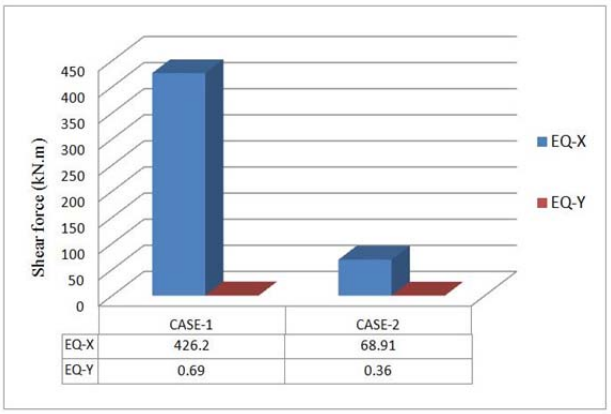

Fig. 8. Graph of Shear force in transfer girder for earthquake load

4. DISCUSSION

The fig. 3. and fig. 4. Shows the bending moment and shear force in transfer girder for two different method of analysis. The value of bending moment and shear force in transfer girder is increased linearly as the construction stage progresses. There is considerable variation in forces of transfer girder for two different approaches i.e. construction stage analysis and conventional analysis.

Also the behavior of the beam above transfer girder is changing from hogging to sagging as construction stage progresses. The behavior of the beam is change due to the larger deflection of the transfer girder.

Forces in the transfer girder are reduced drastically when comparing building without shear wall with building having shear wall. So, the Table-2 indicate that shear wall prove to be beneficial for transfer girder under seismic event.

5. CONCLUSION

- Construction stage analysis in structure is necessary to improve the analysis accuracy in terms of displacement, axial force, bending moment and shear force in transfer girder and column near of it and also for structure as whole.
- The maximum bending moment in transfer girder is 11% more when construction stage analysis is used compare to conventional analysis.
- The maximum shear force in transfer girder is 9% more when construction stage analysis is used compare to conventional analysis.

- Bending moment and shear force in transfer girder are higher in construction stage analysis which must be consider in design phase for avoiding cracking of the beam and column due to sequence effect.
- In case of displacement, structure analyzed using construction stage analysis indicates considerable larger displacement which is reality in comparison to conventional analysis in which structure is conceptualized as whole and loaded simultaneously after construction which is not reality.
- The provision of shear wall improves the behavior of transfer girder under earthquake load.
- The maximum reduction in bending moment is about 85% due to the application of the shear wall under earthquake load.
- The beam above the transfer girder shows drastic change in flexural behavior as we construct the floor stage wise, it changes from hogging to ultimately sagging which needs to be taken care while designing the beams above the transfer girder.
- In conventional analysis these flexural behavior change is not get reflected this may result into the flexural cracking if beam are design considering conventional analysis.

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