ANALYSIS OF TRANSFER GIRDER IN HIGHRISE STRUCTURE USING ETABS & SAFE

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Abstract - *Now days multi-storey buildings constructed for the purpose of residential, commercial, industrial etc., with an open ground storey has become a common feature. For the sake of parking, the ground storey is kept free without any constructions, except for the columns which transfer the building weight to the ground. For this purpose use of floating column is become common phenomenon now days. This concept is applicable for high-rise structures, in which load is resisted by shear walls instead of columns. Shear walls are structural elements especially important in high rise buildings subjected to lateral wind and seismic forces. They provide adequate strength and stiffness to the whole lateral displacement. This project deals with study of behavior and analysis of G+30 story structure with floating shear walls for seismic as well as wind analysis. In second part, study the behavior and analysis of transfer beam, on which floating shear wall is rest. The whole analysis is done with the help of ETABS 2017 and design of transfer girder is verify using SAFE software. This study will help us to know the structural response and behavior of tall structure with floating shear wall. And provide solution to design concrete transfer girder.*

1. INTRODUCTION

India is a developing country with rapid industrialization and urbanization is taking place at very fast rate. This urbanization puts undue burden on land and fruitful land is lost to accommodation and industries. To overcome this problem, cities should grow upward instead of sideward. Tall buildings are required due to rise in population especially in urban areas. But growing higher has its own advantages and disadvantages. Structural engineers in the seismic regions across the world often face the pressure to design high rise buildings with stiffness irregularities, even though they know these buildings are vulnerable under seismic loading. Improving the structural systems of tall buildings can control their dynamic response. With more appropriate structural forms such as shear walls and tube structures and improved material properties. The floor system carries vertical loads and, acting as a diaphragm, lateral loads to the walls for transfer to the foundation. Lateral forces of wind and earthquake are usually resisted by shear walls which are parallel to the direction of lateral load. These shear walls, by their shearing resistance and resistance to overturning, transfer the lateral loads to the foundation.

1.1 SCOPE OF PROJECT

- The main objective of this thesis is to provide exact practical and user-friendly solution to analysis transfer girder system in RCC structure using ETABS software.
- Solve the transfer girder using ETABS and SAFE.

1.2 OBJECTIVES

- Study analysis of transfer girder for high rise RCC structure (G+30) system with floating or hanging lateral load resisting system.
- Study transfer girder system using ETABs 2017, compare results with SAFE 12.2.0 software.
- Provide methodology to design transfer girder using software results.

2. LITERATURE REVIEW

Prof. P.S. Lande, Pariskhit Takale modeled transfer girder at different level to check the behavior of storey shear, moment to know best suited level of girder. A prototype model was selected to be analyzed in this study by using linear response spectrum analysis using ETABS 2016 software. The building has floor plan of 28m x 48m. A 10 storey model was analyzed with transfer slab at different floors along the building height. Building has a shear wall structure above the transfer floor and long spacing columns below the transfer floor. An analytical study was conducted to investigate vertical position of transfer floor in high rise building. A number of building models were analyzed using elastic response spectrum, the silent conclusions obtained from the study,

Yagnesh A. Italia, Dipali Y. Patel and Hiren G. Desai studied behavior of transfer girder with the help of G+10 story ETABS model analysis. For higher accuracy they consider loading of construction progress for analysis with two cases 1) Building without shear wall and 2) building with L shape corner shear wall. They concluded that, 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. Also, the maximum bending moment in transfer girder is 11% more when construction stage analysis is used compare to conventional analysis and the maximum shear force in transfer girder is 9% more when construction stage analysis is used compare to conventional analysis.

Dr. Londhe Rajabhau Subarao focused on shear present in transfer girder. The primary objective of research is to built up shear resisting capacity in RC beams of high depth/s. For research study, an extensive experiments incorporating the strength of concrete, percentage longitudinal steel, percent vertical steel and varying shear span-to-depth ratio have been carried out. The results from the experiments have been processed suitably to come out with empirical expressions for estimating shear capacity of beams..

Y.M. Abdlebasset, F.Y. Sayed-Ahmed, S.A. Mourad: In many high-rise buildings, architectural requirements may result in a variable configuration for the vertical structural elements between the stories of the building. To accommodate such vertical elements' discontinuity, a "transfer" floor conveying vertical and lateral loads between upper and lower stories must be introduced. A drawback of the transfer floor is the sudden change in the building's lateral stiffness at its level: the structure becomes susceptible to the formation of a soft-storey mechanism under moderate to severe earthquakes. These buildings generally showed conventional elastic behavior for frequent earthquake but suffer extensive crack in the vicinity of transfer floors for rare earthquake

Y, Zhua, R.K.L. Sub: The introduction of transfer structures between the high zone and the low zone of a high-rise building has become popular and sometimes even inevitable in modern building developments. Under earthquake actions, concentrated stresses and large lateral displacement may occur at those locations where stiffness changed significantly either on plan or in elevation. In this study, based on the results of the previous shaking table test and numerical analyses, general seismic behavior of transfer structures is identified. The mechanisms for the formation of soft story below the transfer floors, the abrupt change in inter-story drift in the vicinity of transfer story and shear concentration due to local deformation of transfer structures are summarized. This study can improve the general understanding of the seismic response of concrete buildings with transfer structures in low to moderate seismicity regions.

3. METHODOLOGY

Transfer girder in system means it permits parking area at lower levels. Architectural layout with 3 level puzzle parking is adopted. G+30 Story building modeled for residential loading. Seismic and wind loads are applied for structure. The modeling is done in ETABS software. Types of analysis adopted are - Linear static, Response spectrum, wind analysis using gust factor, construction sequence analysis. As the structure design for Mumbai location and undergo high rise category complete analysis is done for same using ETABS. The transfer girder level is combination of transfer beam and transfer plate system as discussed before. The behavior of its combine effect is taken into account. Analysis and behavior of this level is studied as described in previous section. Soft story mechanism is considered. Transfer girder level is exported into SAFE software. This software provide good results for gravity load system. By exporting transfer level from ETABS software all analysis results are exported to SAFE for further analysis. As per literature review, analysis of transfer girder is done using FEM method. The software we adopted is using FEM method to analyze model. Results of ETABS for transfer girder and transfer plate will compare with SAFE software – Bending moments, shear forces, punching of floating column. From bending moment and shear forces we can design any type of structure manually. SAFE provide design for plate or slab elements. This method to design transfer plate girder make job faster compare to other methods.

4. RESULT AND DISCUSSION

Modal mass participation ratio for structure

Model is go under rotation at 2nd mode which is less than 50 % that is allowable.

Model is in translation at 1st & 3rd mode and greater than 60% mass is participate in these mode which means structure will not collapse for seismic forces.

Total mass participation of structure is greater than 90% which satisfies code provision.

TABLE 6: Modal Participating Mass Ratios								
Case	Mode	Period	UX	UY	Sum UX	Sum UY	RZ	Sum RZ
		sec						
Modal	1	3.032	0.0408	0.6024	0.0408	0.6024	0.1134	0.1134
Modal	2	2.891	0.0593	0.1069	0.1001	0.7093	0.4583	0.5717
Modal	3	2.343	0.6338	0.0045	0.7338	0.7138	0.0862	0.6579
Modal	4	0.768	0.098	0.0041	0.8318	0.7179	0.0411	0.699
Modal	5	0.66	0.0029	0.1097	0.8347	0.8276	0.0005	0.6995
Modal	6	0.65	0.0422	0.0002	0.8769	0.8278	0.1096	0.8091
Modal	7	0.403	0.0503	0.0003	0.9272	0.8281	0.0068	0.8159
Modal	8	0.312	0.0113	0.0021	0.9385	0.8302	0.041	0.8569
Modal	9	0.299	2.368E-05	0.0545	0.9385	0.8847	0.0021	0.859
Modal	10	0.267	0.0241	0.0002	0.9626	0.8849	0.0081	0.8671
Modal	11	0.201	0.0146	0.0001	0.9772	0.885	0.0035	0.8707
Modal	12	0.183	0.0007	0.0002	0.9779	0.8852	0.0317	0.9024

With the help of RCC drawing numbering as shown in figure 13 moments for transfer plate are worked out using finite element analysis of software. Average moments from software are enlisted below.

PLATE BOTTOM MOMENTS			
Transfer	ETABS	SAFE	VARIATION IN (IN %)
TP1	8945.111	8784.444	1.796
TP2	8543 6205	8808.889 6304	3.112 1.595
TP3	1646.222	1706	3.631
TP4	1625.111	1683.667	3.603
TP5	6232.111 8335.778	6115.444 8660	1.872 3.890
TP6	8795	8837	0.478
TP7	6405	6199.455	3.209
TP8	5906	5989.5	1.414
		AVG	2.460

PLATE TOP MOMENTS @ SUPPORT			
Support	ETABS	SAFE	VARIATION IN IN %)
C4	7082.444	6540.556	7.6512
C13	2166.889	2363	9.0504
C5	7268.444	6590.556	9.3265
		AVG	8.6760

BEAM BOTTOM MOMENTS			
Transfer Beam No.	ETABS	SAFE	VARIATION IN (IN %)
TB1	2615	2966	11.834
TB2	2726.8	3300	17.370
TB3	3191.95	3795	15.891
TB4	3726.03	3686	1.074
TB5	3838.5	4330	11.351
TB6	3054	3546	13.875
TB7	3566.56	4270	16.474
TB8	3467.15	4146	16.374
		AVG	13.030

- From above results of transfer plate, the variation in bottom moment is less than 5% and for support moment it is less than 10%. The support moment variation compare to bottom moments is maximum which again cross verify correctness in analysis. Since support assigned in SAFE are provided for 1 level only while in ETABS complete geometry behavior take in consideration. So that this variation is expected in analysis.

- For transfer beam variation in moment is less than 20%. The moments in SAFE model is higher compare to ETABS model. There is not any risk to adopt SAFE results for design.

- In RCC transfer plate provide upto 5% relaxation for bottom steel and 10% relaxation in support steel. We can adopt SAFE for transfer floor design.

- For transfer beam SAFE provide higher results compare to ETABS. To adopt SAFE design is not risk factor. Or we can use ETABS for design of transfer girder as it provides design for this member.

5. CONCLUSIONS

Numerical analyses for live project building with a transfer floor have been performed. An equivalent static loading, a response spectrum, wind load and construction sequence load were adopted in the analysis. G+30 Story RCC structure is used for experimental study with transfer floor. The following concluding remarks are made;

- Analysis for G+30 story RCC structure with RCC transfer load system is done successfully using ETABS software.
- The all parameters like story displacement, story drift, story shear are within permissible limits.

Though we introduced transfer floor, use of correct material and member properties as per IS code, following specifications as per IS 1893:2016, IS13920:2016, IS16700: 2017 for modeling RCC high-rise structure result in correct analysis.

- SAFE is software we can adopt for analysis of RCC transfer girder system. Since it provide similar results like ETABS.
- SAFE designs horizontal slab system, which is not possible in ETABS. Use of SAFE is very easy. There are simple and user friendly option available to find out steel in slab as per our requirement. It also provide detailing drawings.

Scope of study

- Different type of methods, theories and software are available to design PT girder, truss girder, etc. but these members are not economical and not easily available for general residential construction. Special analysis, consultant and engineers required.
- Use of completely RCC structure is regular practice of consultant, provision of RCC transfer girder in low rise structure easily using work experience. It don't code provision.
- RCC girder in high rise structure is always combined with composite structure, PT members, outrigger system, trusses etc. Because of frequent use of floating columns in RCC high rise, it is needed to study structural behavior of completely RCC transfer girder.
- Complete RCC member is favorite for all consultant because of its construction flexibility. Lot number of engineers will adopt the procedure if get invented.
- This project is small try to set direction to design completely RCC transfer girder.

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