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ANALYSIS OF HIGH RISE BUILDING FOR STOREY DISPLACEMENT AND STOREY DRIFT WITH AND WITHOUT TRANSFER FLOOR SYSTEM

G. C. Jawalkar[1], Jadhav Bhagyashri Balasaheb[2]

[1]Assistant Professor, Dept of Civil engineering, N.B.N Sinhgad College of Engineering, Solapur, Maharashtra, India.

[2]P G Student , Dept of Civil engineering, N.B.N Sinhgad College of Engineering, Solapur, Maharashtra, India.

ABSTRACT

Innovative architectural design merged with the advanced and powerful structural numerical analysis stimulated a new generation of super-structures and mega- tall buildings. Furthermore, discontinued vertical elements (columns and shear walls) within high-rise buildings are no longer considered as a design mistake. Consequently, the architectural demands for high-rise buildings in which columns may have different arrangement between levels become familiar. The immense change in building at transfer floor from shear wall system to column girder system may create a soft (or weak) storey. If storey mechanism might occur, the collapse could be unavoidable for buildings in moderate earthquake also. Many high-rise buildings are currently constructed with this kind of vertical irregularity where a transfer floor is provided to account for the discontinuous columns and shear walls. As such, a transfer floor is known to be the floor system which supports the vertical and lateral load resisting elements and transfer their loading actions to a different underneath structural system. The transfer system itself may take the form of a transfer girders or slabs. The vertical position of the transfer system with respect to the building height is investigated. The numerical analysis is carried out to investigate which floor system improves the global behavior of structure. For this seismic response of buildings such as storey displacement and storey drift were numerically evaluated.

Keywords: Transfer slab, Response spectrum analysis, Seismic loads, Storey displacement, Storey drift.

1. INTRODUCTION

The need to have buildings with various operational demands has been increased in large populated cities. To accommodate the multiple architectural requirements, the location, orientation, and dimensions of the vertical and lateral load resisting elements vary every certain number of stories. In such cases, a transfer floor is commonly used to solve this persistent structural-architectural conflict. Transfer slab can redistribute the loads from superstructure above transfer plate to widely spaced columns and core walls below transfer slab. They easily facilitate incorporation of architectural layout to provide a column free open space area at lower stories, Because of such advantages, there is extensive use of transfer plate in high rise building especially in areas where seismic hazards are not considered. A transfer floor is the floor system which supports a system of vertical and lateral load resisting elements and transfers its straining action to a different underneath system. Transfer systems are generally used in multifunction structures, in which the lower stories of the building usually are used as open public areas, while floors above that transfer system could accommodate typical residential or office spaces. Several structural systems could be used for such buildings as the lateral resisting system below/above the transfer floor may be moment-resisting frames, core walls and structural walls.

2. LITERATURE REVIEW

Li et al [2006] has presented the “Seismic performance of transfer plate in high rise building pseudo dynamic test”. In ASCE Journal of Structural Engineering.The 18 storey building with transfer plate tested in this study with no seismic provisions. They carried out pseudo dynamic test with history records. And concluded that shear wall remains elastic throughout loading history, whereas transfer plate is severely damaged when subjected to dynamic loading. Main damage occurred at transfer plate. So, transfer plate may have sufficient strength to resist possible earthquake actions. High-rise buildings with transfer floors generally suffer minor cracks 8(conventional elastic behavior) when subject to frequent (minor) earthquake. However, severe cracking in the vicinity of the transfer floor is encountered when these buildings are subjected to rare (medium to major) earthquakes. Currently, reduced stiffness for cracked columns and walls is normally adopted for strength design of these buildings while full stiffness adopted for serviceability and drift design.

Paulay and Priestley[2002] presented “Seismic design of reinforced concrete and masonry building New York USA”.argued earlier that it is preferable to consider forces generated by earthquake induced displacements rather than traditional loads in structural design for earthquake resistance. Furthermore, in ductile response of buildings to earthquakes, high compression strains are expected in vertical elements due to the combined effect of the axial force and bending moment. Thus, unless adequate, closely

Prof. P.S. Lande, Parikshit D Takale,[2018] have presented “Analysis of high rise building with transfer floor.” in

International Research Journal of Engineering and Technology (IRJET) Introduction of the transfer floor in the lower part of the structure is better than having it is at higher location. For girder type of transfer system there is reduction in storey moment and storey shear values below the transfer level as compared to slab type transfer system. Girder type transfer system improves the global behavior of the structure. The displacement distribution shown in displacement graph reveals that every building has a flexural behavior mode up to its transfer floor level. At this level, a large inertial force hit the building due to the significant mass of the transfer level which results a large displacement.

Yoshimura et al [2014] have presented "A Nonlinear Analysis of a Reinforced Concrete Building with a Soft First Storey Collapsed by the 1995 Hyogoken-Nanbu Earthquake." In Electronic Journal of Structures.He argued that the immense change in the lateral stiffness at the transfer floor from a stiff shear wall system above to a relatively flexible column-girder system below may create a soft (or weak) storey and violates the seismic design concept of "strong column weak beam". Yoshimura (1997) also concluded that "if first storey mechanism might occure, the collapse could be unavoidable even for buildings with base shear strength of as much as 60% of the total weight"

Zhang Ling Abdelbasset et al [2011] have presented "Dynamic analysis of elastoplastic performance of tall building with arch transfer floor subjected to sever earthquake." in Journal of Beijing Jiaotang University.a direct consequence of such irregularity is that the deformation of a soft-storey mechanism under moderate to severe earthquakes or lateral wind loads imposes high ductility demands on the elements in the vicinity of the transfer floors.

Tassios T.P et al[2009] have presented paper on "Seismic Response of Reinforced Concrete Frames with Strength and Stiffness Irregularities". In ACI Structural Journal.In which two six-story, three-bay, reinforced concrete frames, one having a tall first story, and the other a discontinuous interior column were designed and discussed structural effects of these particular irregularities and state that, the transfer floor level, the building almost acts as a free cantilever with its fixation located at the transfer floor level with the rest of the building under the transfer floor approximately acts like a fixed-fixed flexural member.

3. METHODOLOGY

Taking into the consideration the need and objectives of dissertation,

1. A 10 storey and 20 storey building is taken into account and the analysis is carried out by using response spectrum analysis.

2. Considering earthquake loads as loading for the structure according to Indian standards, IS1893:2016 by using structural analysis software.

3.The analysis results such as storey shear and storey moment are evaluated for validation. 4.The vertical position of transfer slab with respect to building height is investigated.

5 . The analysis and comparison of building with transfer slab and building without transfer slab are studied to investigate the seismic behavior of high rise building with transfer floor.

4. SEISMIC RESPONSE OF ANALYSED BUILDING

A 10 storey and 20 storey building is taken into account and the analysis is carried out by using response spectrum analysis considering earthquake loads as loading for the structure according to Indian standards, IS1893:2016 by using structural analysis software. The analysis results are performed for building such as storey displacement, and storey drift. The vertical position of transfer slab with respect to building height is investigated. The analysis and comparison of building with transfer slab and building without transfer slab are studied to investigate the seismic behavior of high rise building with transfer floor.

4.1 Storey Displacement for 10 and 20 storey building.

The following graph shows storey displacement for 10 and 20 storey building model with transfer slab provided at different floor levels as 1st floor to 6th floor and 1st floor to 7th floor respectively

Table 1.1 Storey Displacement

Storey No.	Without transfer floor	With transfer floor at level					
		1st slab	2nd slab	3rd slab	4th slab	5th slab	6th slab
10	3.059	2.803	3.032	2.924	3.855	1.966	1.858
9	2.827	2.672	2.902	2.798	2.717	1.832	1.738

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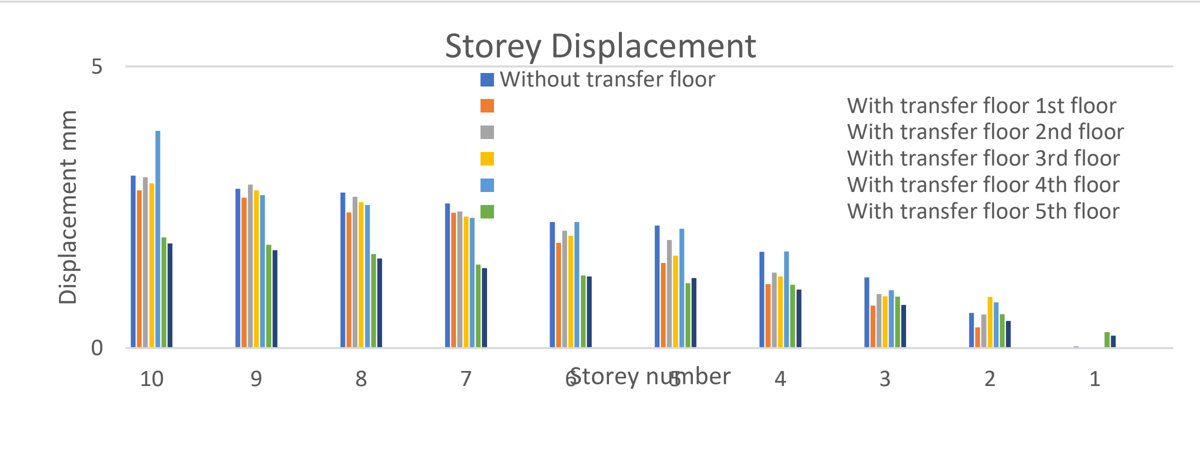
8	2.760	2.406	2.689	2.591	2.539	1.667	1.59
7	2.569	2.405	2.425	2.334	2.310	1.480	1.422
6	2.236	1.867	2.082	1.995	2.236	1.290	1.272
5	2.178	1.510	1.920	1.639	2.116	1.153	1.243
4	2.012	1.137	1.343	1.272	1.715	1.127	1.040
3	1.256	0.754	0.961	0.918	1.026	0.915	0.768
2	0.623	0.369	0.594	0.910	0.812	0.602	0.484
1	0.005	0.001	0.005	0.006	0.009	0.284	0.222



Graph 1.1 Storey displacement for 10 storey

Table 1.2 Storey Displacement for 20 storey

Storey No.	Without transfer floor	With transfer floor at level						
		1st slab	2nd slab	3rd slab	4th slab	5th slab	6th slab	7th slab
20	5.80	3.938	2.750	2.550	2.870	2.133	2.150	2.070
19	5.50	3.831	1.962	1.941	1.960	2.018	2.034	2.308
18	5.19	3.719	1.844	1.823	1.841	1.899	1.914	2.985
7	4.87	3.605	1.724	1.020	1.720	1.776	1.791	2.698
16	4.55	2.487	1.600	1.579	1.595	1.651	1.665	2.105
15	4.21	2.368	1.475	1.453	1.469	1.524	1.537	1.896
14	3.87	2.247	1.348	1.323	1.339	1.395	1.409	1.759
13	3.53	2.128	1.223	1.199	1.214	1.268	1.281	1.408

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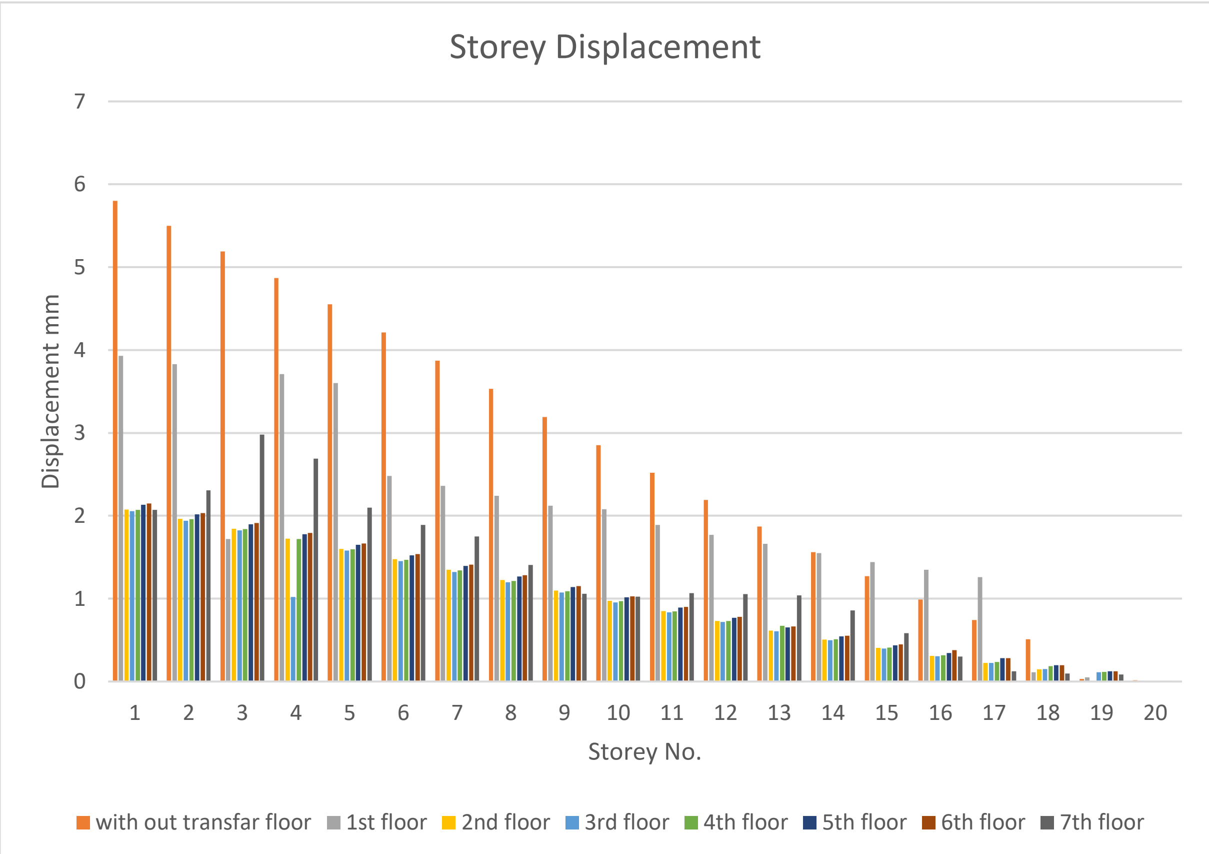
12	3.19	2.008	1.097	1.076	1.090	1.141	1.153	1.058
11	2.85	1.890	0.973	0.954	0.968	1.015	1.027	1.025
10	2.52	1.773	0.850	0.834	0.847	0.891	0.902	1.068
9	2.19	1.660	0.731	0.717	0.730	0.770	0.781	1.054
8	1.87	1.551	0.616	0.605	0.674	0.654	0.664	1.038
7	1.56	1.448	0.507	0.498	0.510	0.543	0.553	0.057
6	1.27	1.351	0.404	0.398	0.409	0.438	0.449	0.055
5	0.99	1.261	0.309	0.306	0.317	0.343	0.378	0.043
4	0.74	0.181	0.223	0.223	0.234	0.282	0.283	0.042
3	0.51	0.111	0.148	0.151	0.184	0.197	0.197	0.038
2	0.032	0.052	0.008	0.113	0.114	0.122	0.122	0.035
1	0.015	0.008	0.005	0.005	0.005	0.006	0.008	0.005



Graph 1.2 Storey Displacement for 20 Storey

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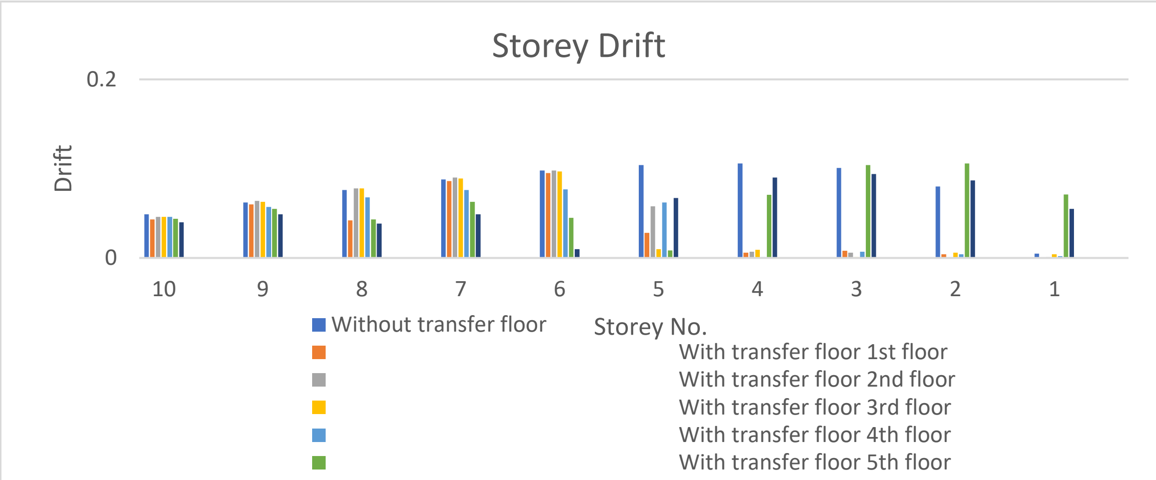
4.2 Storey Drift for 10 and 20 storey building.

The following graph shows storey drift for 10 and 20 storey building model with transfer slab provided at different floor levels as 1st floor to 6th floor and 1st floor to 7th floor respectively



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Graph 1.3 Storey Drift for 10 Storey

Table 1.3 Storey Drift for 10 Storey

Storey No.	Without transfer floor	With transfer floor at level					
		1st slab	2nd slab	3rd slab	4th slab	5th slab	6th slab
10	0.049	0.043	0.046	0.046	0.046	0.044	0.046
9	0.062	0.060	0.064	0.063	0.057	0.055	0.049
8	0.076	0.042	0.078	0.078	0.068	0.433	0.385
7	0.088	0.086	0.090	0.089	0.076	0.063	0.049
6	0.098	0.095	0.098	0.097	0.077	0.045	0.001
5	0.104	0.028	0.058	0.010	0.062	0.0005	0.067
4	0.106	0.006	0.007	0.009	0.0008	0.0707	0.090
3	0.101	0.008	0.006	0.0008	0.007	0.104	0.094
2	0.080	0.004	0.0003	0.006	0.004	0.106	0.087
1	0.005	0.0001	0.001	0.004	0.002	0.071	0.055

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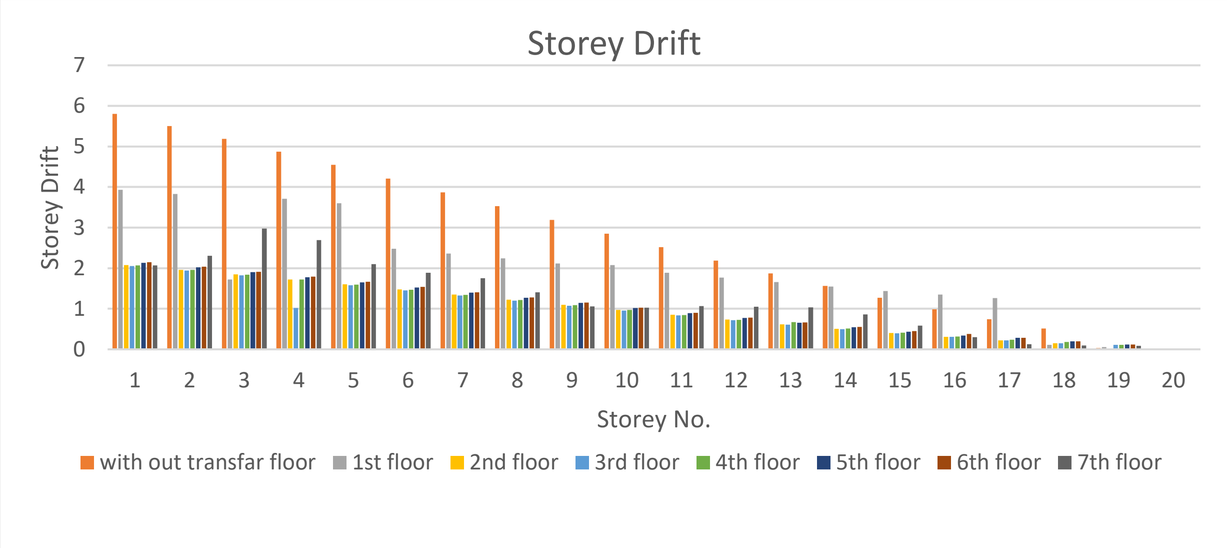

Graph 1.4 Storey Drift for 20 Storey

Table 1.4 Storey Drift for 20 Storey

Storey No.	**Without transfer floor**	**With transfer floor at level**						
		1st slab	**2nd slab**	**3rd slab**	**4th slab**	**5th slab**	**6th slab**	**7thslab**
20	0.0990	0.0890	0.047	0.038	0.0382	0.0384	0.0386	0.0359
19	0.103	0.103	0.048	0.0393	0.0395	0.0397	0.0399	0.0371
18	0.106	0.104	0.050	0.0405	0.0407	0.0408	0.041	0.0383
7	0.106	0.109	0.051	0.0414	0.0416	0.0418	0.0419	0.0392
16	0.111	0.111	0.0528	0.042	0.0422	0.0424	0.0426	0.0398
15	1.219	0.118	0.0527	0.0423	0.0425	0.0427	0.0429	0.0401
14	0.113	0.123	0.0508	0.0421	0.0423	0.0424	0.0426	0.0399
13	0.113	0.113	0.0506	0.042	0.0422	0.0424	0.0426	0.0398
12	0.113	0.112	0.0501	0.0417	0.0419	0.042	0.0422	0.0395
11	0.112	0.110	0.049	0.041	0.0412	0.0413	0.0415	0.0388
10	0.11	0.110	0.047	0.0399	0.0401	0.0403	0.0404	0.0377
9	0.107	0.107	0.046	0.0385	0.0387	0.0388	0.039	0.36
8	0.103	0.103	0.043	0.0367	0.0368	0.037	0.0371	0.0345
7	0.098	0.097	0.041	0.0344	0.0346	0.0347	0.0346	0.007
6	0.091	0.092	0.037	0.0318	0.0319	0.0318	0.0237	0.0298
5	0.084	0.085	0.034	0.0288	0.0286	0.0205	0.0317	0.0268

4	0.0760	0.076	0.029	0.025	0.0169	0.0283	0.0288	0.0234
3	0.066	0.067	0.024	0.013	0.0246	0.0249	0.0249	0.0195
2	0.055	0.054	0.010	0.020	0.0207	0.0207	0.0208	0.015
1	0.038	0.039	0.017	0.015	0.015	0.0151	0.0151	0.002

5. CONCLUSIONS

Percentage reduction in storey displacement and storey drift for transfer floor system is maximum at 40% H and 35% H for both 10 storey and 20 storied buildings respectively.

In transfer floor system every building have flexural mode upto a transfer floor level. At this level, a large inertial force hit the building due to the significant mass of the

transfer level which results a less displacement.

Location of transfer floors with respect to total height of the building has a significant effect on high rise building; introduction of the transfer floor in the upper part of the structure (35-40% of the total height of the structure from its foundation) is better than having it in a lower location.

Transfer floor system affects the storey shear and storey moment due to weight of slab, but it provides stability to the structure and reduces storey drift, storey displacement as compared to building without transfer slab.

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