International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Dynamic Analysis of Seismic Response in Structures Incorporating Lower-Storey Transfer Systems

Yarkhan Amjad Jameel Yarkhan[1], Dr. R. S Londhe[2]

[1]*M.E. Student (Structural Engineering) Government College of Engineering, Aurangabad, Maharashtra, India.*

[2] *Professor and HOD, Department of Applied Mechanics. Government College of Engineering, Aurangabad, Maharashtra, India.*

---***---

Abstract - In contemporary construction, increasingly complex and variable architectural planning requirements often hinder the vertical continuity of columns from the foundation to the top storey. This discontinuity necessitates the introduction of a transfer storey to accommodate vertical irregularities in the structural system. To effectively channel the substantial loads from upper storeys to the foundation, structural elements such as transfer slabs or transfer girders are implemented. These components form a critical part of the load-transfer mechanism in high-rise buildings. However, their inclusion introduces significant structural challenges, requiring advanced analytical approaches and a deep understanding of structural engineering principles. This study focuses on evaluating the key structural parameters of multi-storey buildings with and without transfer levels through both static and dynamic analysis. Transfer structures represent one of the most complex aspects in the design and execution of high-rise construction.

Key Words: Transfer floor, transfer girder, dynamic analysis, static analysis, vertical irregularity, high-rise structures.

1.INTRODUCTION

In multi-storey buildings, architectural and functional requirements often vary from one floor to another, leading to discontinuities in vertical load-bearing elements such as columns or walls. This vertical irregularity necessitates the use of transfer structures—typically located at one or more intermediate storeys—to facilitate the redistribution of vertical and lateral loads between the upper and lower portions of the building. The introduction of a transfer level results in a significant alteration of the load path, which must be carefully analyzed, particularly under seismic loading, where such irregularities can critically influence structural performance.

This study investigates the behavior of a G+14 (Parking + 14 Storeys) RC frame structure incorporating a transfer level, using the finite element-based software STAAD.Pro for modeling and analysis. The primary objective is to compare key structural performance parameters—such as storey drift, base shear, displacement, and member forces—for structures with and without a transfer system, and to present the findings in a tabulated format.

Transfer structures are extensively employed in both low-rise and high-rise buildings to enable diverse architectural layouts above and below the transfer level. These systems may function as flexural or shear transfer elements and are responsible for transmitting substantial loads from upper-level columns or walls to the supporting structure below. Common forms of transfer systems include transfer plates, deep transfer girders, and transfer trusses. High-rise residential and commercial buildings often incorporate transfer slabs or girders, while medium-rise buildings tend to utilize transfer girders more frequently. In scenarios involving extensive column removal or severe load redistribution, deep transfer trusses—spanning one or two storeys—may offer an optimal solution. In reinforced concrete structures, this typically demands additional slab thickness and reinforcement to accommodate the increased load demands and maintain structural integrity.

2. METHODOLOGY & SYSTEM GENERATION

Parking+14 storey four models of residential multistorey building with total height around 45meters (less than 50m) is selected to perform this comparative analysis, named as Model-A, Model-B, Model-C, Model-D. In which, Model A, B, C contains the transfer level at 1st floor level, while Model-D has no any transfer level. In Model-A the location of transfer floor is taken at 1st floor level modelled in finite element solid modelling in STAADpro software, from which floating columns will be erect & will continue above full building height. In Model-B the location of transfer floor is chosen at 1st floor level Modelled in Finite Element Plate Meshing in software, from which new floating columns is erected & continued above full building height up to terrace. In Model-C has transfer Beam Girder taking new floating columns are modelled at 1st floor leve. And in model-D No any transfer level is taken, all columns are continuous from foundation to terrace floor.

The building adopted is symmetric & square in plan to overcome torsional effects. The area of the building is 18.0 m x 18.0 m where the spacing between the columns under the transfer level is 6.0 m and above the transfer floor level / first floor level it is 3.0meters. The typical height of storey is 3.0 m. Geometrical details of the building is shown figure 1. The purpose of the current research work is to compare these model's global response.

2.1 Typical Data for All Model-A, B, C, D (For ESA & RSA)

Table 1 : Typical Data for All Model

Column Sizes upto Transfer Level (Found. To 1st floor)	900 mm x 900 mm
Column Sizes above Transfer Level (1st to 7th floor)	750 mm x 750 mm
Column Sizes Above 7th Floor to Terrace	600 mm x 600 mm
Beam Sizes at Plinth / Ground Level	300 mm x 750 mm
Beam sizes at typ. floor level above transfer Floor Level	230 mm x 600 mm
Central Core RCC Lift Wall thickness	230 mm Thick
Typical Slab thickness above transfer level storey	150 mm thick
Dead floor weight of slab	3.75 kN/m^2
Dead floor weight of Floor finish	1.25 kN/m^2
Live Load (all floors)	2.5 kN/m^2
Wall load considered over all typical floor beams (150mm thick with 18kN/m^3 density=0.15x3x18=8.1=say 8.0kN/m	8.0 kN/m
Parapet Wall load considered over Terrace outer beams (230mm thick wall with 1.0m ht.)=0.23x1.1x18=4.55kN/m	4.55 kN/m
Models– A & B	
Size of Transfer level - Transfer Thick Slab	900mm Thick
Column Spacing Below transfer level	6 meters
Column Spacing Above transfer level	3 meters
Model - C	
Size of Transfer level - Beam Transfer Girder	900mm x 900mm
Column Spacing Below transfer level	6 meters
Column Spacing Above transfer level	3 meters
Model - D	
Size of Transfer level Beam / Slab	No transfer slab/Beam
Column Spacing from foundation to terrace throughout	3 meters

2.2 Seismic Definitions

Equivalent Static analysis (ESA) is carried out using following seismic definitions & Response spectrum (dynamic) analysis (RSA) is also conducted on all models to evaluate the behavior of the structure incorporating the dynamic modes using the SRSS combining sequence [2].

- Seismic Zone II is considered (Zone factor=0.1, IS 1893:2016 table 3)
- Response Reduction factor: 3 (IS 1893:2016 table 9)
- Importance factor (Occupancy more than 200): 1.2 (IS 1893:2016 table 8)
- Soil type: Medium soil
- Structure Type: RCC Framed Structure
- Damping Ratio: 5%
- Dynamic Scale factor: 0.02

2.3 Loads & Load Combinations

Load no.	**Load Case**	**Load n**	**Load Case**
1	EQX (EQ force in X-Dir.)	13	1.5(DL-EQZ)
2	EQZ (EQ force in Z-Dir.)	14	0.9DL+1.5EQX
3	DL (Dead Loads)	15	0.9DL-1.5EQX
4	LL (Live Loads)	16	0.9DL+1.5EQZ
5	1.5(DL+LL)	17	0.9DL-1.5EQZ
6	1.2(DL+LL+EQX)	18	DL+LL
7	1.2(DL+LL-EQX)	19	DL+EQX
8	1.2(DL+LL+EQZ)	20	DL+EQZ
9	1.2(DL+LL-EQZ)	21	DL+0.8LL+0.8EQX
10	1.5(DL+EQX)	22	DL+0.8LL-0.8EQX
11	1.5(DL-EQZ)	23	DL+0.8LL+0.8EQX
12	1.5(DL+EQX)	24	DL+0.8LL-0.8EQX

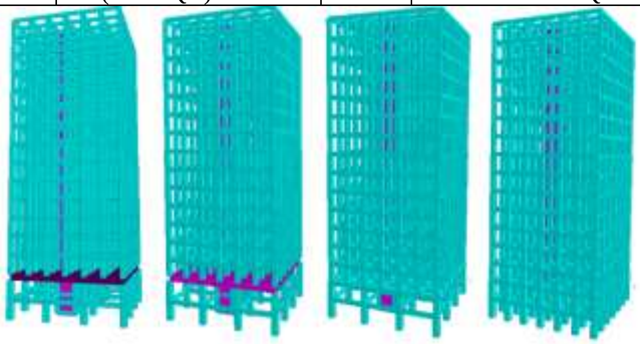

Fig. 1 : Modelled frames A, B, C and D respectively

3.0 RESULTS & DISCUSSION

3.1 Graphs of Equivalent Static Analysis

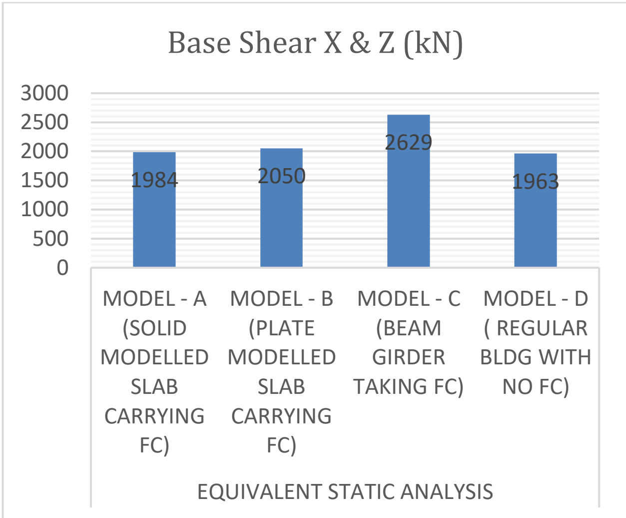

Fig. 2 : Base Shear in X & Z (kN)

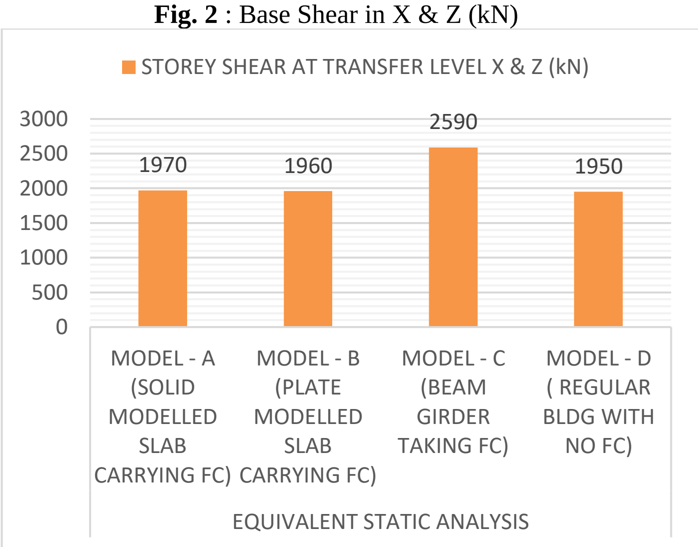

Fig.3 : Storey Shear at Transfer Level X and Z (kN)

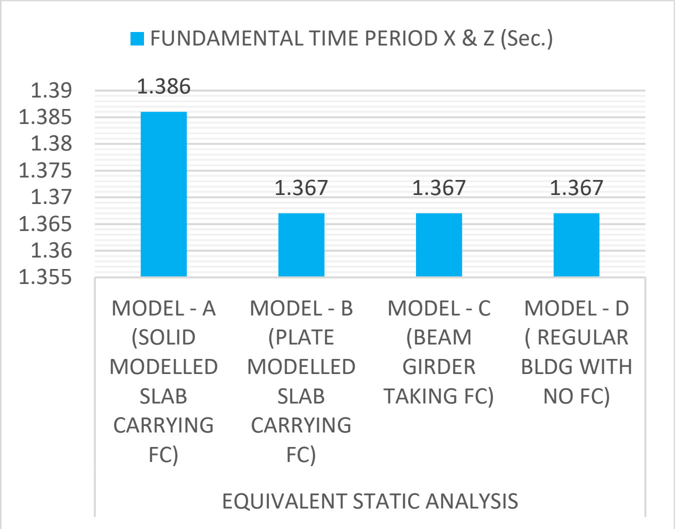

Fig. 4 : Fundamental Time Period at Transfer Level x and z (kN)

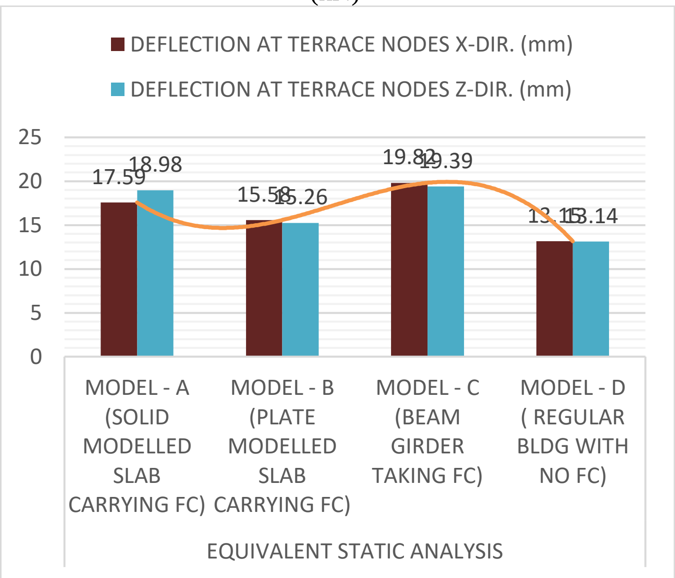

Fig. 5 : Comparison of Deflection at Terrace Nodes between X and Z direction (mm)

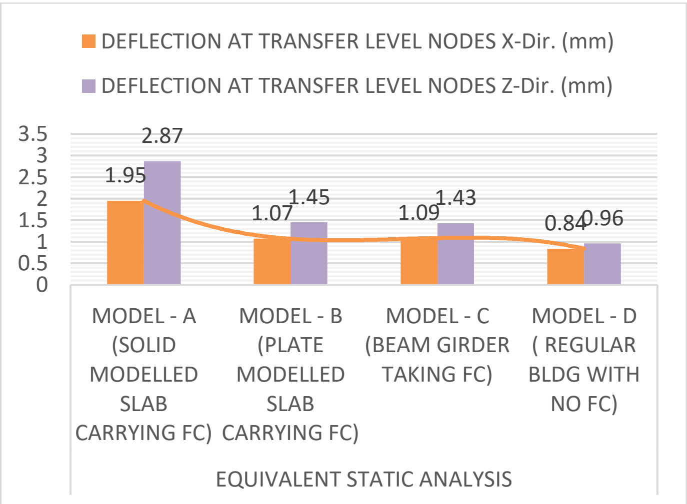

Fig. 6 : Comparison of Deflection at Transfer Level between X and Z direction (mm)

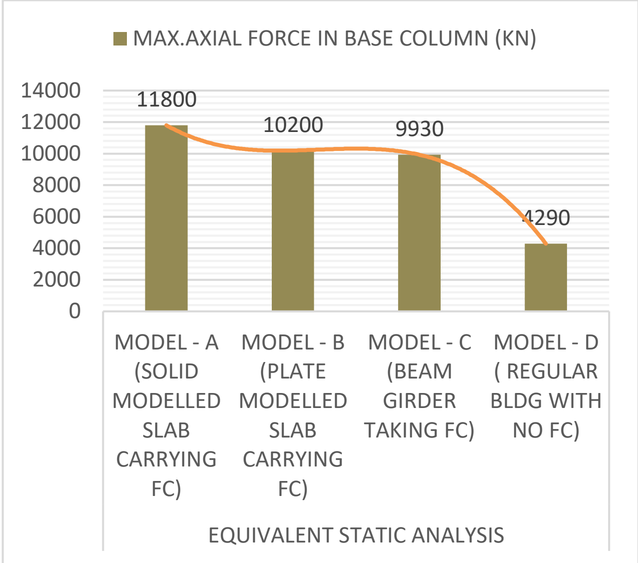

Fig. 7 : Maximum Force in Base Column (kN)

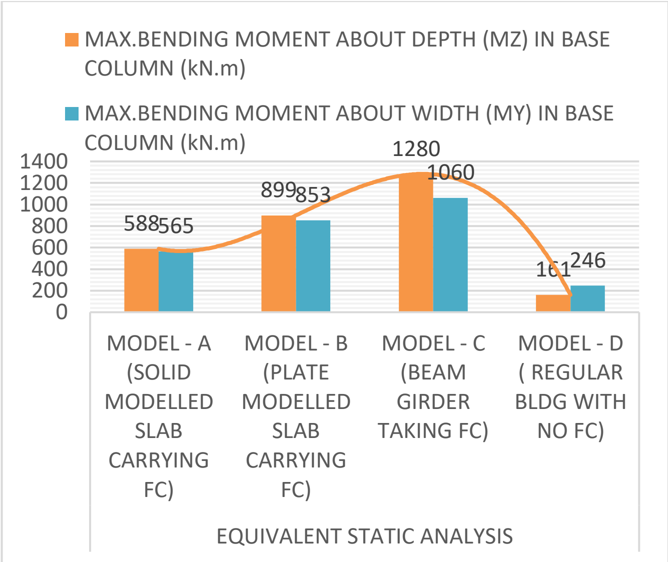

Fig. 8 : Comparison of max Bending Moment about width & depth in Base Column (kN.m)

Above all figures/graphs shows the comparative results of various parameters in equivalent static analysis such as Seismic base shear, storey shear at transfer level, fundamental time period of structures in both directions, storey drift ratio, lateral deflection of structures at important levels such as transfer level & terrace levels, Maximum axial forces & flexural bending moments about depth & width of the base columns carrying transfer storey.

And Following further graphs/figures shows all same parameters comparison for dynamic response spectrum analysis. In the graph of storey drift it can be clearly seen that, sudden change is occurring at the transfer storey level which is main objective of this paper to present.

3.2 Graphs of Response Spectrum Analysis (Dynamic Analysis)

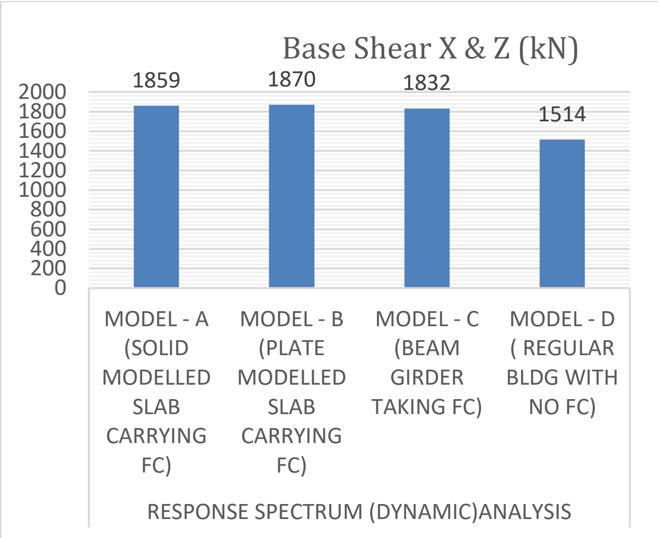

Fig. 9 : Comparison of base shear in X & Z direction (kN)

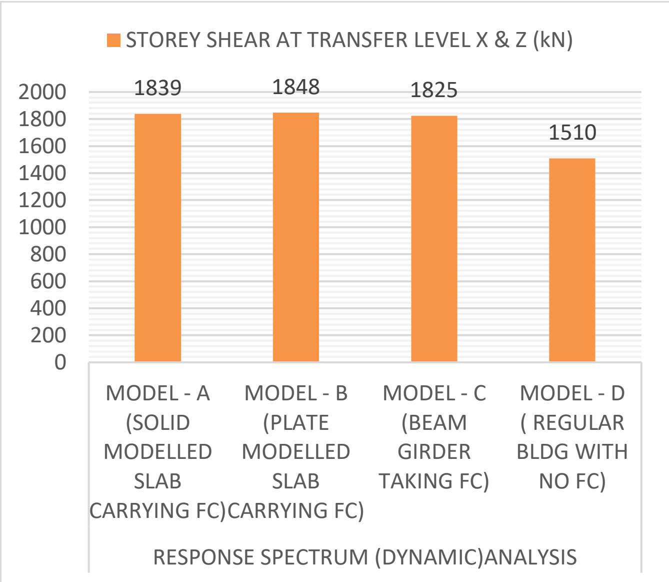

Fig. 10 : Comparison of Storey Shear in X & Z direction (kN)

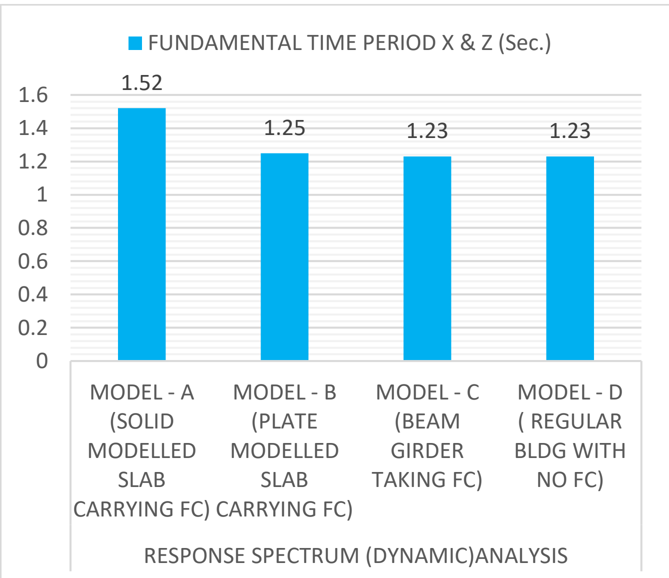

Fig. 11 : Comparison of Fundamental Time Period in X & Z direction (sec)

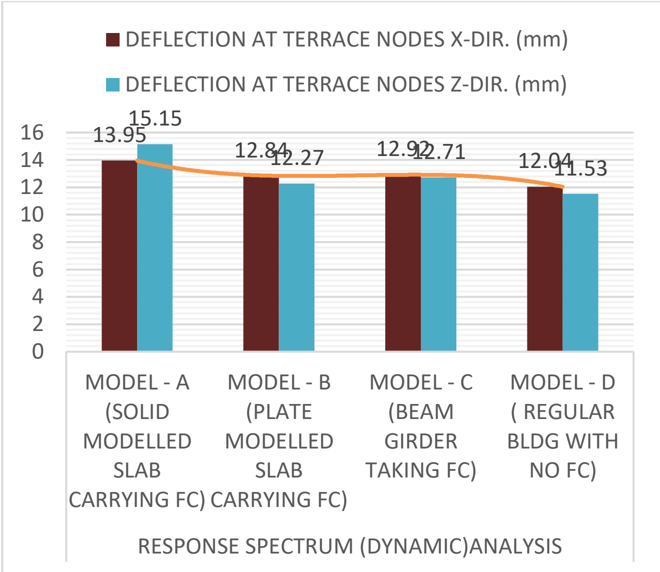

Fig. 12 : Comparison of Deflection at terrace Nodes in X & Z direction (mm)

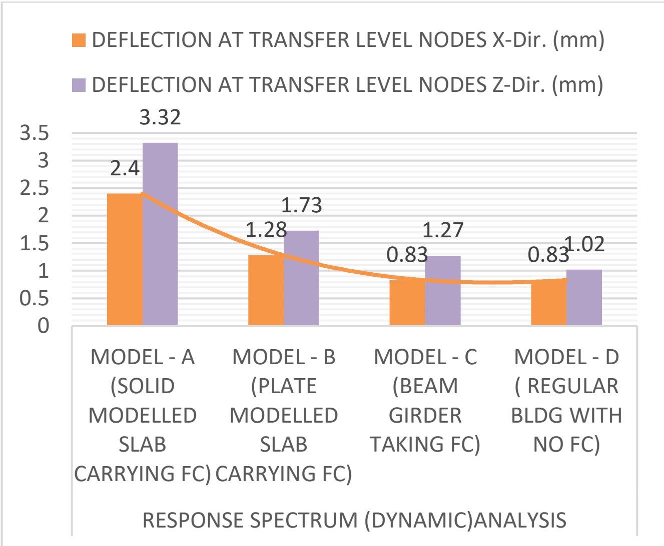

Fig. 13 : Comparison of Deflection at Transfer level Nodes in X & Z direction (mm)

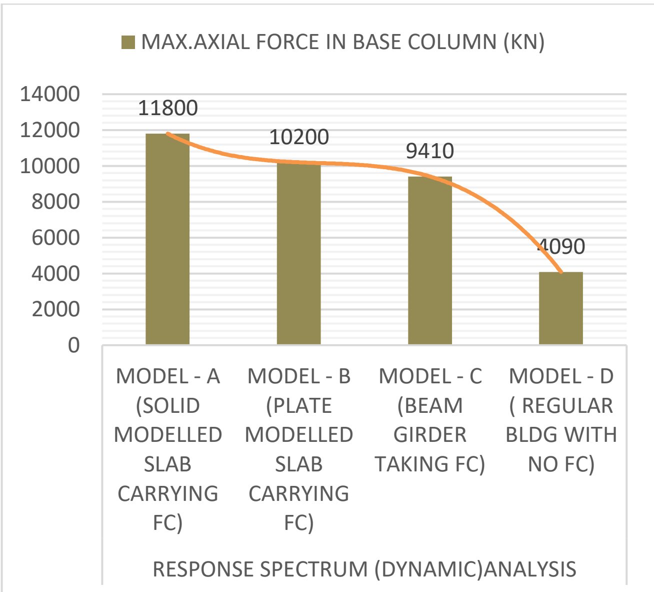

Fig. 14 : Comparison of Maximum Axial force in Base column (kN)

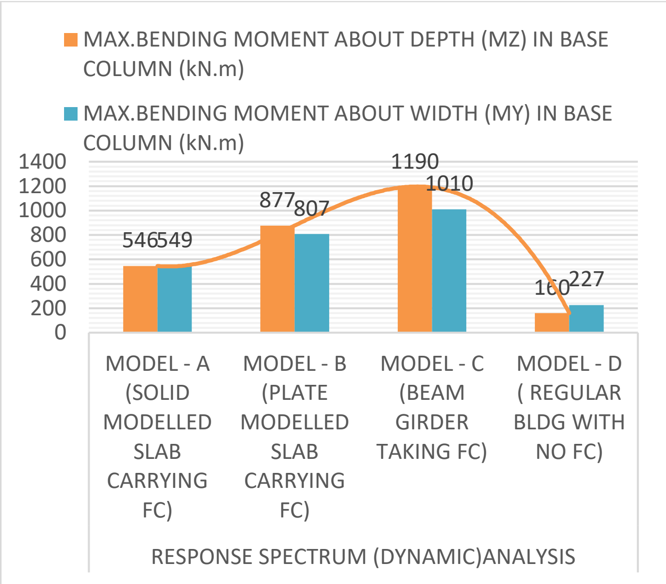

Fig. 15 : Comparison of Max Bending Moments about width & Depth in Base column (kN.m)

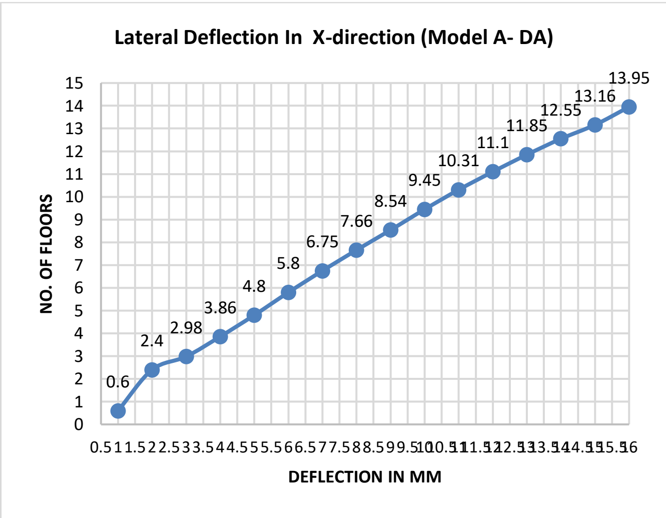

Fig. 16 : Lateral deflection in X-direction (Model A- Response Spectrum Analysis)

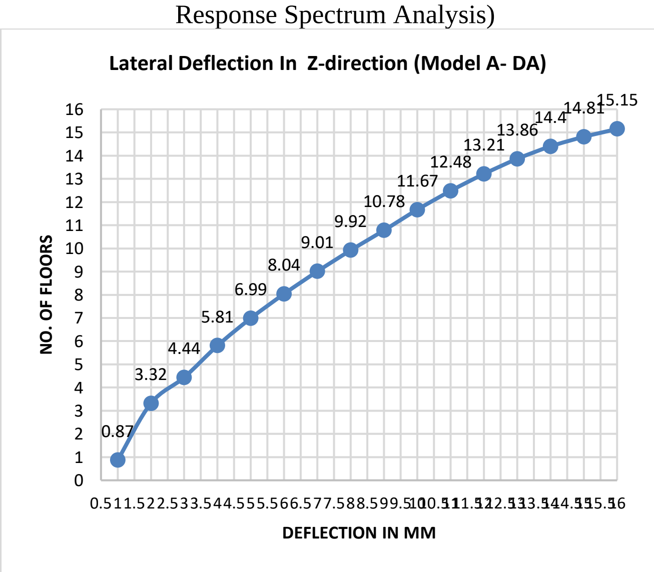

Fig. 17 : Lateral deflection in Z-direction (Model A- DA)

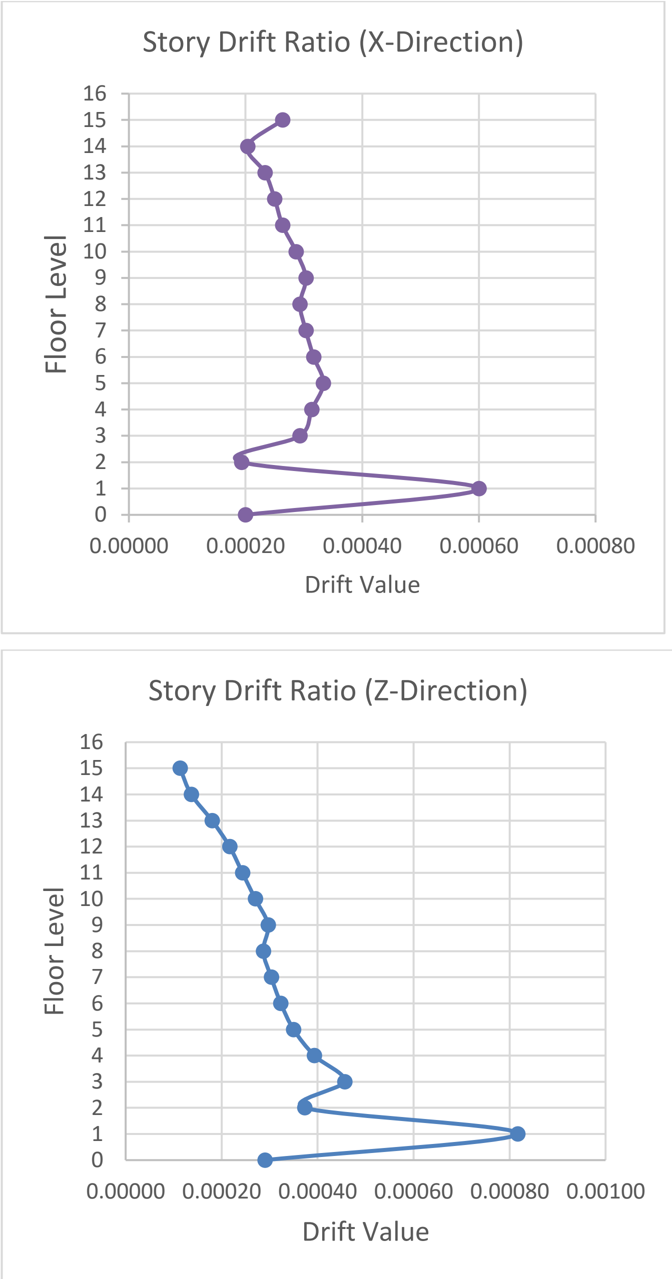

Fig. 18 : Storey Drift (Model A- DA)

4. CONCLUSION

- **Base shear, storey shear, lateral deflection, and storey drift** at the transfer level were observed to be higher in the beam girder transfer model under both static and dynamic analyses. This indicates that transfer beam systems exhibit more critical behavior during seismic events compared to transfer slab systems.
- The **fundamental time period** of the solid slab transfer model (Model-A) was slightly higher during seismic loading, although the variation in time period across the different models was not significant.
- The **lateral deflection at the transfer level** in the slab transfer model was approximately **200% higher** than that of the beam transfer girder model, indicating increased flexibility in slab-based systems.

- Under both static and dynamic loading conditions, the **self-weight of the structure** in slab-type transfer systems was greater than that of the beam-type transfer system. Since seismic forces are proportional to mass, this results in **higher force demands** in slab-type systems. Additionally, the **concrete volume and reinforcement** requirements are greater in slab-type systems, especially in the lower columns, leading to increased steel requirements and structural sizes, which adversely impacts the **overall economic efficiency**.
- From a seismic performance perspective, the **beam-type transfer girder system** exhibited more critical behavior, yet required **less concrete volume**, offering a **more economical solution**. However, due to planning constraints and architectural limitations, achieving column-to-column alignment with beam transfer systems is often not feasible. In such complex layouts, the **slab-type transfer system becomes more practical**. Furthermore, **formwork and shuttering requirements** for slab-type transfer systems are generally lower, potentially leading to **time savings during construction**.
- The structure **without a transfer level** consistently demonstrated **better performance across all parameters** and posed **fewer critical concerns**, ultimately leading to **cost and time efficiency**. Therefore, wherever possible, **transfer levels should be avoided** in multi-storey buildings to enhance both seismic performance and construction economy.

5. REFERENCES

1. Han-Seon Lee, Dong-Woo Ko, "Seismic response characteristics of high-rise RC wall buildings having different irregularities in lower stories," Elsevier, Engineering Structures 29, April 2007, pp. 3149–3167.
2. J.H. Li, R.K.L. Su, A.M. Chandler, "Assessment of low-rise building with transfer beam under seismic forces," Elsevier, Engineering Structures 25, May 2003, pp. 1537–1549.
3. Devesh P. Soni and Bharat B. Mistry, "Qualitative review of seismic response of vertically irregular building frames" ISET Journal of Earthquake Technology, Technical note, Vol. 43, No. 4, December 2006, pp.121-132.
4. Gentian Zhaoa, Xuting Kou "Analysis on Seismic Performance of Beam and Plate Converter Floor", Applied Mechanics and Materials Vols. 580-583 (2014), pp. 1551-1554.
5. Mohammed Abdul Sameer and M. A. Azeem "A Study on Seismic Performance of Tall Buildings with Transfer Plate", International Journal of Applied Engineering Research ISSN 0973-4562, Volume 14, Number 8 (2019), pp. 1849-1859.

BOOKS:

6. N. Subramanian, "Design of reinforced concrete structures", Design of Multi-Storey Buildings, Oxford University Press, Sixth Impression 2018, pp.790- 808.