

# RESPONSE OF HIGH-RISE RC BUILDING WITH TRANSFER SLAB AND FRICTION DAMPERS UNDER INDEPENDENT TIME HISTORY DATAS

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**Abstract** - This study investigates the High-rise reinforced concrete buildings are highly vulnerable to lateral forces such as earthquakes and wind. The presence of transfer slabs introduces vertical irregularities that influence the dynamic response of the structure during seismic events. This study evaluates the seismic performance of a G+20 RC building with transfer slabs placed at different levels. Finite Element Analysis is carried out using Modal Analysis, Equivalent Static Analysis, Response Spectrum Analysis, and Time History Analysis. Models are developed with and without friction dampers and a central core shear wall. Key response parameters such as fundamental time period, base shear, storey displacement, storey drift, and acceleration are evaluated and compared according to IS 1893:2016 provisions.

**Key Words:** Modal analysis, Response spectrum analysis, Shear Wall, Peak ground acceleration

## 1. INTRODUCTION

High-rise buildings are tall multi-storey structures constructed to efficiently utilize limited urban land for residential, commercial, or mixed-use purposes. As building height increases, structures become more susceptible to lateral loads such as wind and earthquakes. To maintain stability and safety, effective lateral load-resisting systems are required. Transfer slabs are commonly used in high-rise buildings to redistribute loads where the column arrangement changes between floors. Although they provide architectural flexibility, transfer slabs introduce stiffness irregularities that influence seismic performance. Shear walls are widely used to improve structural stiffness and resist lateral forces. In addition, dampers are installed to dissipate seismic energy and reduce structural vibrations. The combined use of transfer slabs, shear walls, and dampers enhances the seismic resistance of high-rise buildings. Proper structural analysis is necessary to ensure safety, serviceability, and efficient performance under earthquake loading.

### 1.1 Classification of structural system

The structural models considered in the study are classified based on the location and combination of transfer slabs and

the base condition of the building. Four main configurations are modelled: a building with a transfer slab at the 5th floor (20DT5), and buildings with transfer slabs at 10th floors (20DT10), floors and 15th floors (20DT15). Each configuration is analyzed under two base conditions: fixed-base and Friction Dampers systems. This classification allows comparison of the influence of transfer slab location and Dampers on the seismic response of the 20-storey RCC building

### 1.2 Objective of the study

The study aims to investigate the seismic performance of a high-rise reinforced concrete structure with a transfer slab. It focuses on evaluating the effect of vertical mass and stiffness irregularities introduced by the transfer slab on the structural response during earthquakes. Response Spectrum Analysis is carried out in accordance with IS 1893 to determine important parameters such as storey displacement, storey drift, base shear, and natural time period. In addition, nonlinear Time History Analysis is performed using suitable earthquake ground motion records to assess the dynamic behavior of the building. The study also examines the effectiveness of seismic dampers in reducing displacement, drift, acceleration, and base shear. Finally, the research aims to identify the optimum level of the transfer slab with dampers that provides improved seismic performance and enhanced structural safety.

## 2. PRELIMINARY DATA CONSIDERED FOR ANALYSIS

### Building Models and Geometry

This study investigates the seismic performance of a G+20 high-rise reinforced concrete building using ETABS software by varying the position of the transfer slab. The building has a total height of 60 m with a plan dimension of 40 m × 40 m and consists of 20 storeys, each with a uniform storey height of 3 m. The structural system includes reinforced concrete beams, columns, slabs, and a central core shear wall extending throughout the building height to provide lateral stiffness and stability. Transfer slabs are introduced at different storey levels to create architectural flexibility and open spaces, resulting in vertical irregularity in the structure. The transfer slab redistributes loads from discontinuous upper columns to supporting members below. Column

spacing above the transfer slab is maintained at 4 m, while below it increases to 8 m. The normal slab thickness is 150 mm, whereas the transfer slab thickness is taken as 1500 mm. To improve seismic performance, friction dampers are installed up to the 10th floor in a zig-zag configuration at external corners. The structure is subjected to a live load of 4 kN/m<sup>2</sup> and a superimposed dead load of 1.5 kN/m<sup>2</sup>. Seismic analysis is performed according to IS 1893:2016 for Zone IV conditions. Modal, Equivalent Static, Response Spectrum, and Time History analyses are carried out to evaluate parameters such as time period, base shear, storey displacement, drift, and top floor acceleration. abbreviations in the title or heads unless they are unavoidable.

### Modeling Description

In all structural models, reinforced concrete is used for beams, columns, slabs, and shear walls. The grade of concrete adopted is M30 for beams, columns, and shear wall components, while Fe500 grade steel is used as reinforcement. Normal floor slabs are modeled with a thickness of 150 mm, and the transfer slab is modeled with 1500 mm as a deep slab with increased thickness to effectively transfer loads from discontinuous upper columns to lower supporting members. The floor slabs are designed to resist gravity loads and are assumed to act as a rigid diaphragm in the structural analysis, ensuring efficient transfer of lateral seismic forces to the vertical resisting elements. The entire structural system is modeled and analyzed in ETABS in accordance with IS 1893 2016 part :1 provision to accurately capture the seismic behavior of the building.

**Table 1: Section Property**

SL. No	Name	Value
1	Dimension	40 x 40 m
2	No. of storey's	20 Storey
3	Story height	3 m
4	Beam	300 x 600 mm
5	Normal Slab	150 mm
6	Transfer Slab	1500 mm
7	Column After Transfer Slab	600 x 600 mm
	Column Before Transfer Slab	1200 x 1200

As per Indian standard code provision, IS 875 (Part 2) [19], Live Load considered are 4 kN/m<sup>2</sup>, Super Imposed Dead load considered 1.5 kN/m<sup>2</sup> and IS 1893:2016 has been used to define seismic load on the building with seismic zone factor Z = IV; Importance factor I = 1; Response reduction factor R=5, External wall load Considered are 12.648 kN/m and Internal Wall load are 6.324 kN/m.

### Properties of Friction Dampers

The Friction damper used in all models along one longitudinal direction and restrained in other two transverse directions, in its local coordinate system. Non linearity is considered along the active direction U1. Rotational inertia is

zero and rotation is restrained. Following values have been used to model the damper

Non-linear dynamic analysis has been performed to study the effect of Friction Damper on seismic behavior of structure. Response spectrum function has been defined using IS 1893: 2016 for a damping of 5% [14].

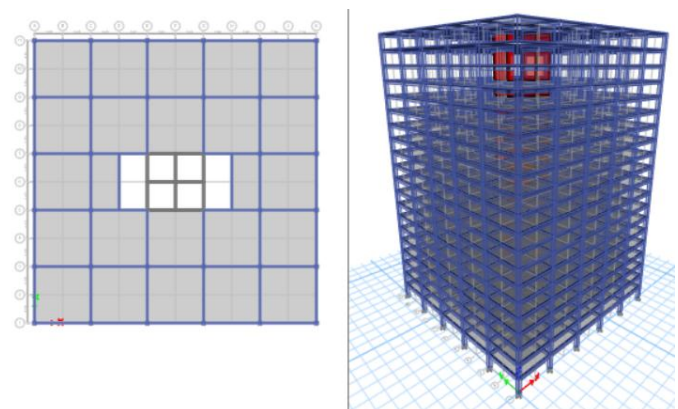
**Table 3: Damper properties used in modeling**

Link Type	Plastic (Wen)
Mass (kg)	429.3
Weight (kN)	4.2116
Effective Stiffness (kN/m)	23772.85
Effective Damping (kNs/m)	0
Yield Strength = Slip Load(kN)	700
Post yield stiffness ratio	0.0001
Post yield stiffness ratio	10

**Table 3: Description of the Models and their Nomenclature**

SL. No	Model	Nomenclature
1	Without Transfer Slab, Without Dampers	20BF
2	Without Transfer Slab, With Dampers	20D
3	Transfer Slab – 5 <sup>th</sup> floor, Without Damper	20T5
4	Transfer Slab – 5 <sup>h</sup> floor, With Damper	20DT5
5	Transfer Slab – 10 <sup>th</sup> floor, Without Damper	20T10
6	Transfer Slab – 10 <sup>th</sup> floor, With Damper	20DT10
7	Transfer Slab – 15 <sup>th</sup> floor, Without Damper	20T15
8	Transfer Slab – 15 <sup>th</sup> floor, With Damper	20DT15

### FE ANALYSIS OF MODELS SHOWN BELOW



**Fig no.1: 3D & Plan of 20BF**

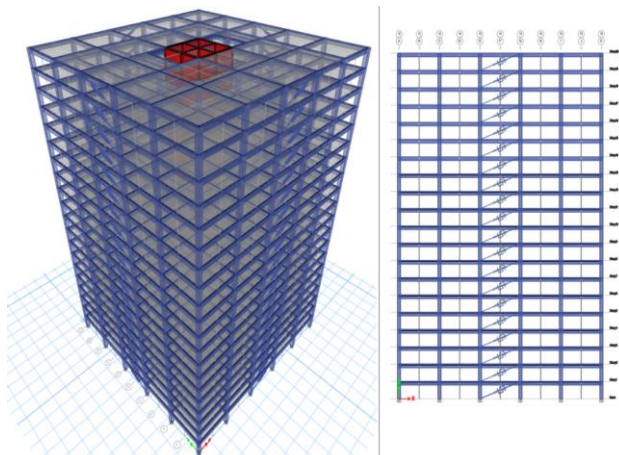


Fig 2: (a) 3D View (b) Elevation of Regular structure (20D)

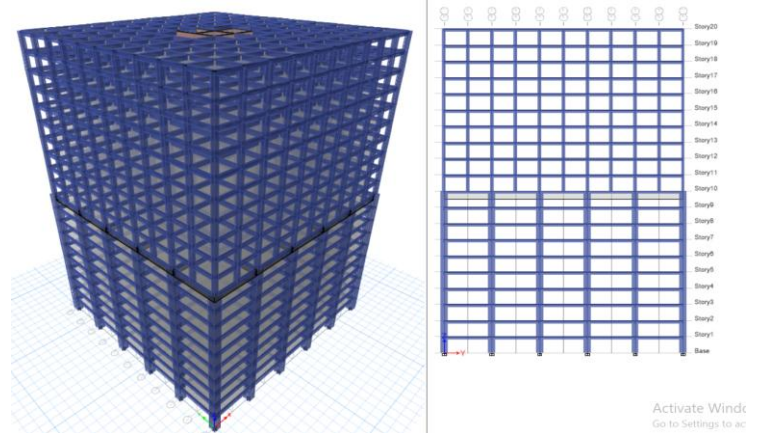


Fig 5: (a) 3D View (b) Elevation of Regular structure (20T10)

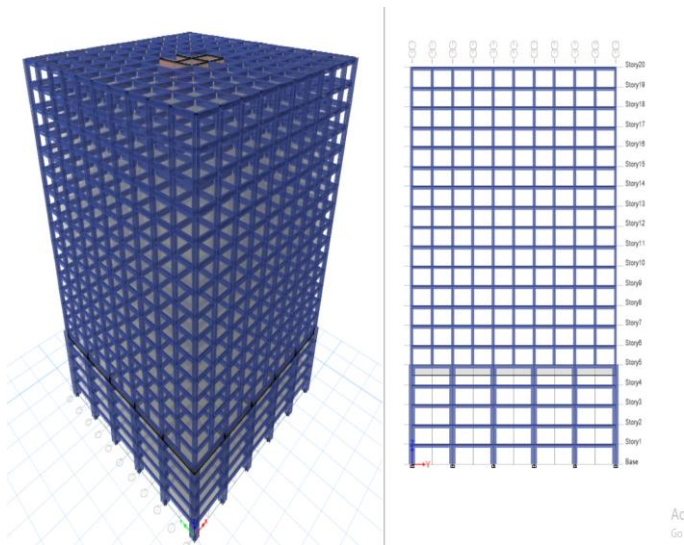


Fig 3: (a) 3D View (b) Elevation of Regular structure (20T5)

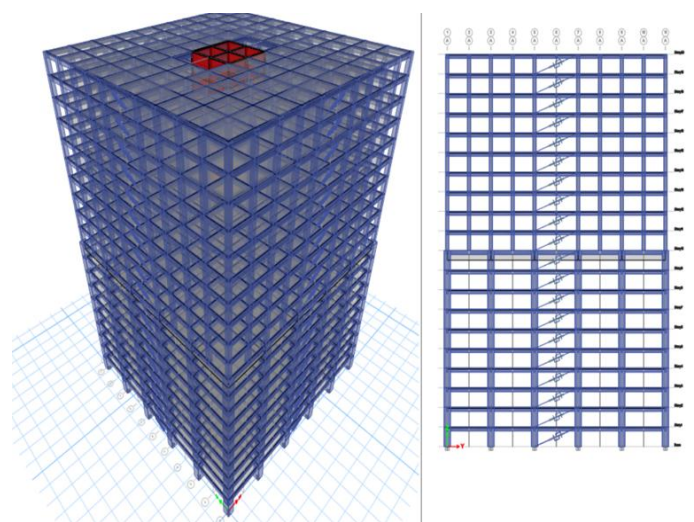


Fig 6: (a) 3D View (b) Elevation of Regular structure (20DT10)

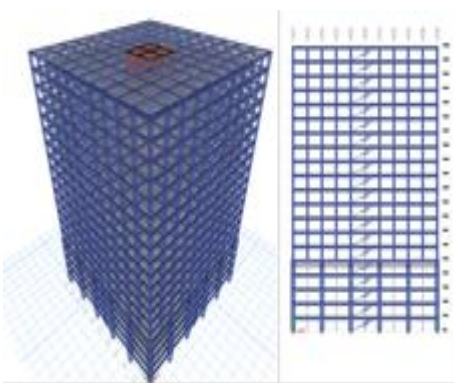


Fig 4: (a) 3D View (b) Elevation of Regular structure (20DT5)

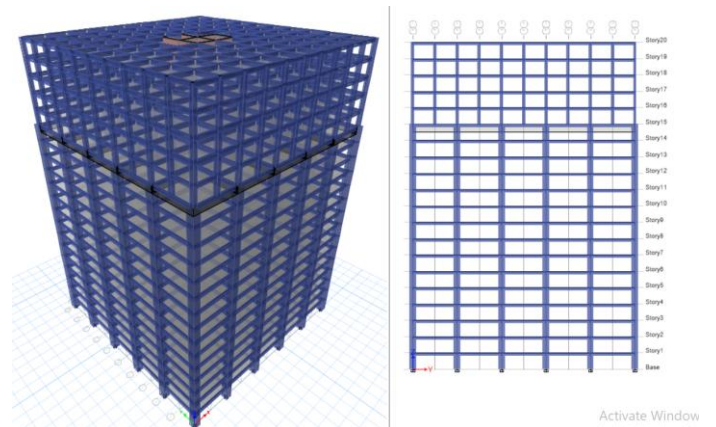


Fig 7: (a) 3D View (b) Elevation of Regular structure (20T15)

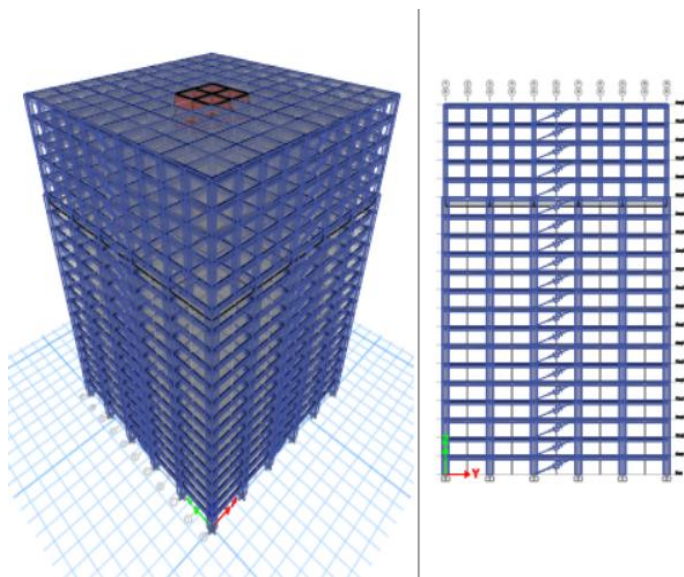


Fig 8: (a) 3D View (b) Elevation of Regular structure (20DT15)

### 3. RESULTS AND DISCUSSION

#### 3.1 TIME PERIOD

The basic time period for all models is calculated by carrying out modal analysis based on the mass and stiffness characteristics of the structure.

The Fundamental Time Period as per IS 1893 (Part 1):2016, is given by the following formula:

$$T_a = 0.075h^{0.75}$$

where h is the building height in meters.

$$T_a = 0.075(60)^{0.75} = 1.61s$$

The comparison of fundamental time periods obtained from modal analysis and IS code values is presented in Table 6.1, and the graph of models vs. time period is presented in Figure 6.1

Table 4: Time Period for All Models (Sec)

MODELS	Time Period (sec)	
	Program Calculated	IS 1893
20BF	2.515	1.61
20D	1.083	
20T5	1.886	
20DT5	0.989	
20T10	2.182	
20DT10	0.985	
20T15	2.38	
20DT15	0.871	

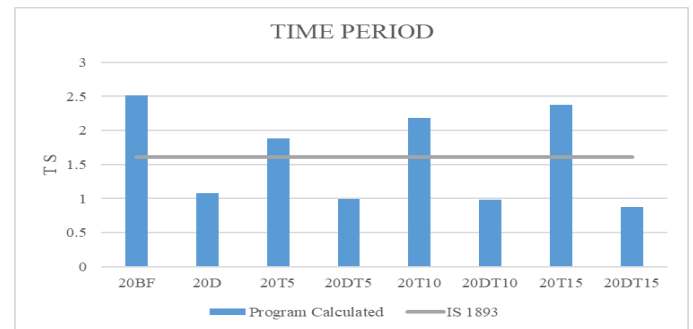


Fig 9: Time period (Sec)

#### 3.2 BASE SHEAR

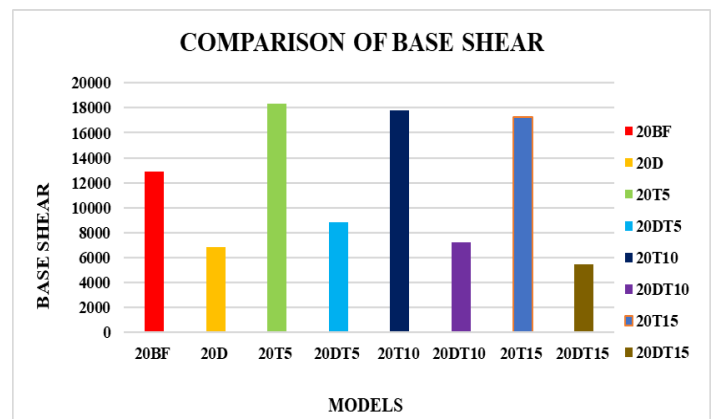


Fig 10: Comparison of Base Shear (EQX/RSX)

Table 5: Base Shear for All Models (kN)

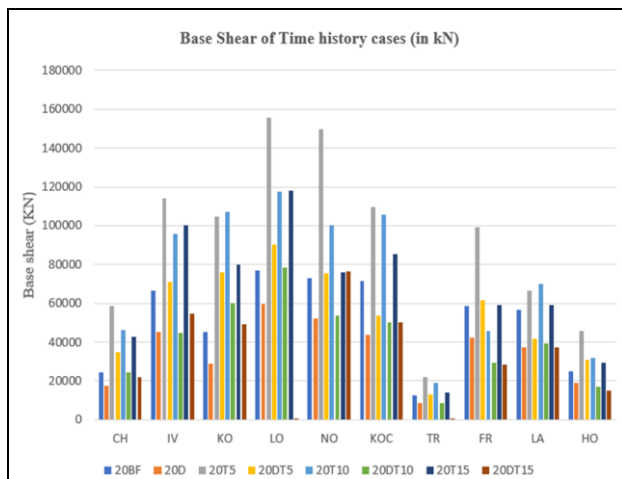
SL. No	MODELS	EQX/RSX (kN)
1	20BF Without Transfer Slab, Without Dampers	12880.9254
2	20D Without Transfer Slab, With Dampers	6812.4636
3	20T5 Transfer Slab - 5 <sup>th</sup> floor, Without Damper	18340.4662
4	20DT5 Transfer Slab - 5 <sup>th</sup> floor, With Damper	8801.5642
5	20T10 Transfer Slab - 10 <sup>th</sup> floor, Without Damper	17775.2859
6	20DT10 Transfer Slab - 10 <sup>th</sup> floor, With Damper	7178.8968
7	20T15 Transfer Slab - 15 <sup>th</sup> floor, Without Damper	17240.6835
8	20DT15 Transfer Slab - 15 <sup>th</sup> floor, With Damper	5448.3318

**Table 6: Base Shear of Time history cases (in kN)**

MODEL	CH	IV	KO	LO	NO	KOC	TR	FR	LA	HO
20BF	24523	66502	45352	77009	73122	71282	12681	58333	56792	24755
20D	17429	45161	29074	59720	52043	43602	8599	42045	37481	19125
20T5	58375	113973	104902	155541	149869	109498	22040	99014	66542	45749
20DT5	35018	71142	76029	90124	75235	53430	13176	61473	41526	31017
20T10	46011	95964	107060	117607	99985	105894	19033	45917	70120	31826
20DT10	24302	44875	60247	78448	53711	50255	8615	29321	39404	16786
20T15	42528	100221	79959	118065	76058	85368	14059	58910	58860	29261
20DT15	22028	54781	48914	387	76600	50146	387	28528	37306	14758

### 3.3 TIME HISTORY ANALYSIS

#### 3.3.1 Base Shear

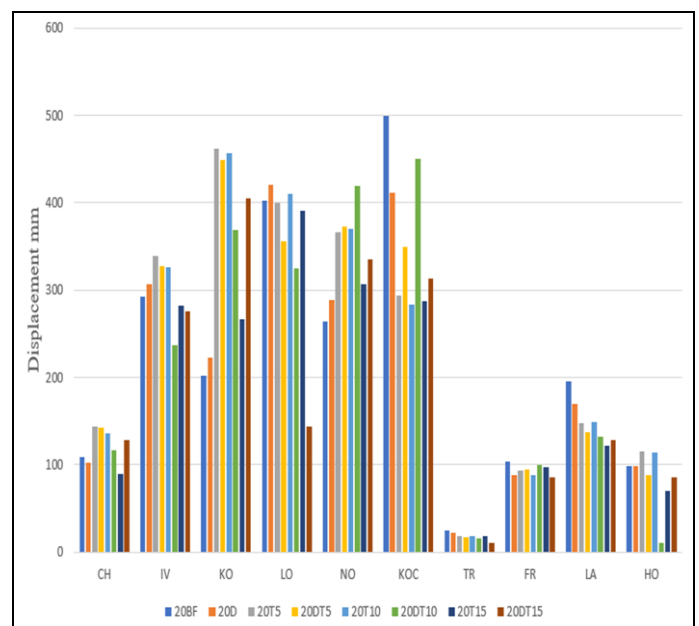


**Figure 11: Comparison of Base Shear of all models (THA)**

#### 3.3.2 STOREY DISPLACEMENT

**Table 7: Maximum roof displacement of all models**

MODEL	CH	IV	KO	LO	NO	KOC	TR	FR	LA	HO
20BF	108.4	293.1	201.6	402.02	264.34	500.11	25.39	103.2	195.3	98.21
20D	102	306.4	223.2	420.5	288.2	411.1	22.88	88.23	169.7	98.273
20T5	143.96	339.52	462	400.43	366.88	293.81	19.01	92.98	148.29	115.35
20DT5	142.6	327.3	449.7	356.11	373.03	350.01	16.46	95.09	137.5	88
20T10	136	325.9	457.4	410.21	369.64	283.88	18.99	88.52	148.54	114.17
20DT10	116.8	236.9	369.3	325.31	418.98	450.2	15.35	100.3	132.4	11.13
20T15	89	281.7	266.9	390.8	306.23	287.77	18.13	97.71	121.8	70.53
20DT15	128.4	276.2	405.2	143.78	335.08	313.69	11.08	86.07	128.9	85.89



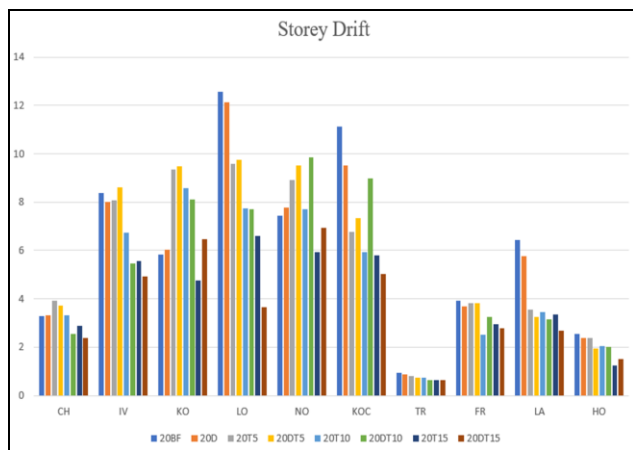
**Figure 12: Comparison of Maximum roof displacement of all models (THA)**

#### 3.3.3 DRIFT RESULT OF TIME HISTORY ANALYSIS

Story drift is the lateral deflection from one storey to the next when lateral Loads Are Applied, expressed as a ratio:  $\Delta/h$  Check against Code limits of:  $H/400$  to  $H/600$ , Limits exceeded lead to stiffening.

**Table 8: Comparison of Story Drift of all models, (THA)**

MODEL	CH	IV	KO	LO	NO	KOC	TR	FR	LA	HO
20BF	3.29	8.38	5.84	12.55	7.44	11.12	0.96	3.93	6.45	2.56
20D	3.32	8.01	6.03	12.13	7.78	9.5	0.89	3.7	5.78	2.4
20T5	3.92	8.06	9.34	9.57	8.9	6.78	0.8	3.81	3.57	2.4
20DT5	3.73	8.6	9.49	9.74	9.53	7.33	0.75	3.84	3.26	1.94
20T10	3.31	6.72	8.59	7.73	7.71	5.92	0.73	2.51	3.46	2.04
20DT10	2.54	5.48	8.12	7.71	9.86	8.98	0.63	3.27	3.15	2.01
20T15	2.87	5.57	4.77	6.6	5.93	5.79	0.63	2.95	3.34	1.26
20DT15	2.39	4.92	6.46	3.64	6.95	5.04	0.65	2.79	2.68	1.52



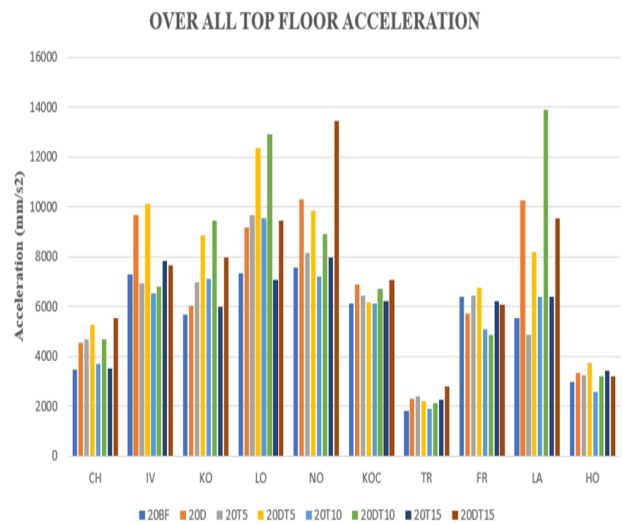
**Figure 12: Comparison of Story Drift of all models, (THA)**

**3.3.4 MAXIMUM TOP FLOOR ACCELERATION**

Maximum top floor acceleration is the peak acceleration at the roof of a building during an earthquake. It is important for evaluating possible damage to non-structural components in tall buildings. Due to higher vibration modes and response amplification, roof acceleration can become two to three times greater than the ground acceleration.

**Table 9: Maximum Top Floor Acceleration (mm/s<sup>2</sup>) of all models**

MODEL	EARTHQUAKE CONSIDERED									
	CH	IV	KO	LO	NO	KOC	TR	FR	LA	HO
20BF	3489	7288	5668	7319.4	7572.9	6104	1817	6374	5533	2975
20D	4548	9676	6022	9163.3	10306	6874	2297	5738	10266	3350
20T5	4687	6916	6957	9655.8	8135.1	6434	2389	6438	4880	3260
20DT5	5270	10101	8872	12375	9839.4	6161	2230	6759	8180	3758
20T10	3715	6546	7114	9542.7	7192.6	6102	1899	5104	6392	2570
20DT10	4693	6775	9439	12922	8895.4	6720	2131	4861	13904	3208
20T15	3535	7819	6008	7064.8	7946.1	6222	2265	6225	6401	3407
20DT15	5529	7671	7958	9428.2	13452	7048	2783	6086	9525	3193



**Fig 13: Comparison of Maximum Top Floor Acceleration**

**3. CONCLUSIONS**

**Structural Period and Stiffness**

The baseline model (20BF) demonstrates high flexibility, with a time period 56% higher than IS 1893 standards. Introducing fluid viscous dampers (20D) or higher-level transfer slabs significantly increases stiffness. The hybrid 20DT15 configuration (15th-floor slab with dampers) proves most effective, achieving a 65% reduction in time period, signaling maximum structural stability.

**Base Shear and Seismic Demand**

There is a stark contrast between slab-only models and hybrid damper models:

Slab-Only (20T5, 20T10, 20T15): These increase base shear by 34–120%, as the added mass of the transfer slab attracts higher seismic forces.

Hybrid Models: Combining dampers with transfer slabs dramatically mitigates this effect. The 20DT15 model reduces base shear by approximately 68% in static analysis and up to 94% in time history analysis compared to the bare frame.

**Displacement and Inter-Storey Drift**

The 20BF model exhibits the highest displacement and drift, particularly under intense ground motions like TR and LA. While lower-level slabs (20T5) are counterproductive increasing drift by up to 40% due to stiffness discontinuities shifting the slab higher (20T15) improves performance. The 20DT15 remains the optimal setup, reducing top-storey displacement by 56.4%.

**Top Floor Acceleration**

Unlike other parameters, top floor acceleration generally increases with the addition of dampers (by 20–40%), as they attract additional forces to the upper levels. Lower transfer

slab placements (20T5) show erratic acceleration, while higher placements (20T15) provide more stable behavior. Conclusion.

The analysis confirms that 20DT15 is the superior configuration. By placing the transfer slab at the 15th floor and integrating dampers, the structure achieves an ideal balance of high stiffness, low base shear, and minimal displacement

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