EARTHQUAKE RESPONSE OF TALL BUILDINGS HAVING DIFFERENT SPACING OF COLUMN BAY

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Abstract - *Nowadays 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 a hotel or commercial building, where the lower floors contain banquet halls, conference rooms, lobbies, show rooms or parking areas, large interrupted space is required for the movement of people or vehicles. The columns which are closely spaced in the upper floors are not advisable in the lower floors. So, to avoid this problem, floating column concept has come into existence.*

In the present work, the RCC Tall building which is regular in shape is analyzed by Response Spectrum Method. Further the investigation is carried to know the contribution of building having different spacing of column bays and to understand the Earth quake response of buildings having floating columns with different spacing of column bay. Software used for the analysis is ETABS 9.7.

Key Words: Tall Buildings, Earthquake resistant buildings, Floating columns, Response spectrum analysis, column bay.

1. OBJECTIVES:

The objectives of this study are as follows

1. To study the Earth quake response of RCC Tall Buildings with different spacing of column bay.
2. To study the Earth quake response of RCC Tall Building with floating columns in different spacing of column bay.
3. To find out the best method to optimize the earth quake response of tall building with floating columns.

2. RESPONSE SPECTRUM ANALYSIS

2.1 INTRODUCTION

The procedure to compute the peak response of structure during the earthquake directly from the earthquake response spectrum without the need of time history analysis is called response spectrum analysis. A typical design response spectrum (IS-1893:2002) is shown below in Figure.

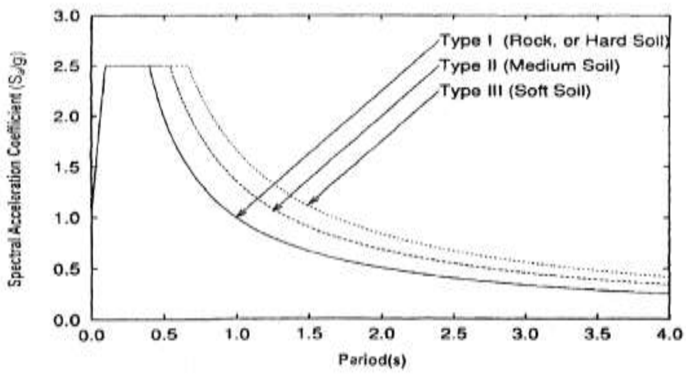


Fig.- 2.1: Design response spectrum

Response spectrum is a plot of maximum response of an SDF for various value of the period for a given input. The IS-1893 gives an average Response spectrum can be employed in earthquake resistant design.

2.2 Structural Model

For this study, 3 models of 6 story buildings without floating columns and 3 models of 6 story building with floating columns and 3 models with floating columns but with decreasing wall densities over height are considered. The dimensions of buildings are 15m X 40m, 21m X 40m and 30m X 40m. The structural models have the same story height of 3. m. Building plans, elevation and 3d model are shown is below fig.2.2 a, b, c, d, e, f, g, h, i, j, k, l respectively.

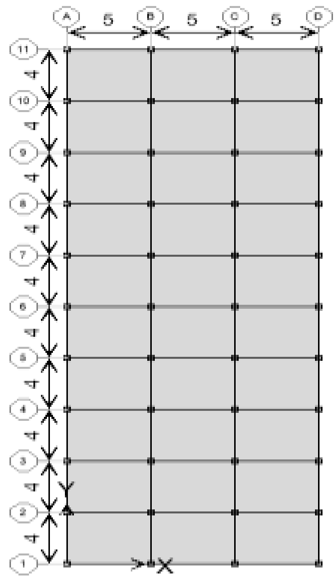


Fig.- 2.2 a: Plan of Type 1 model

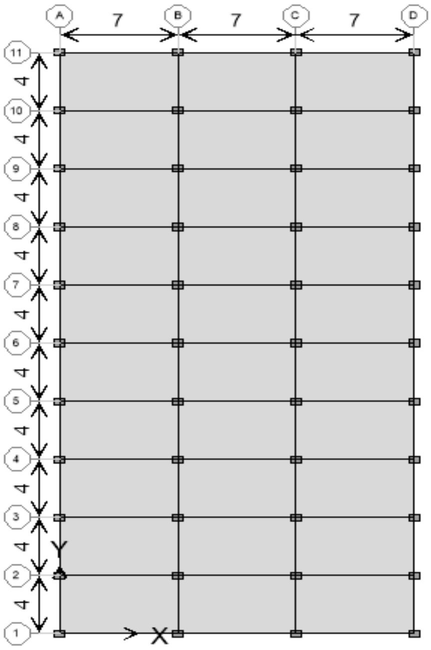


Fig.- 2.2 b: Plan of Type 2 model

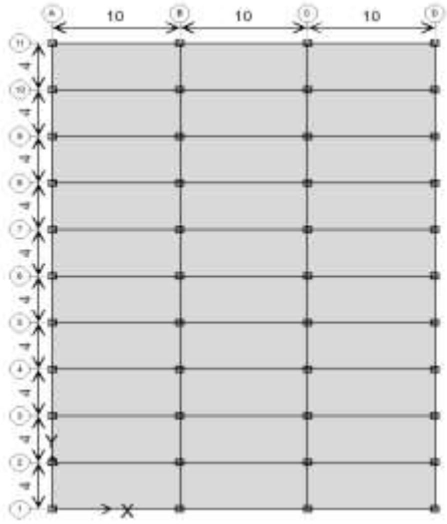


Fig.- 2.2 c: Plan of Type 3 model

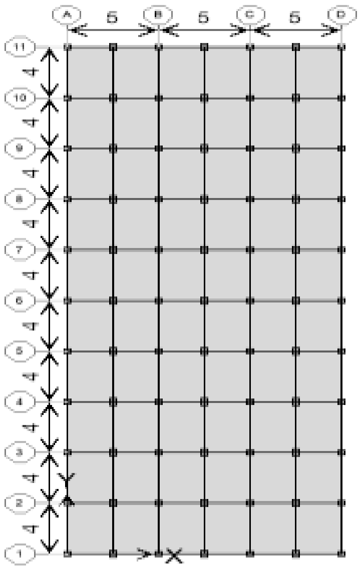


Fig.- 2.2 d: Plan of Type 4 model

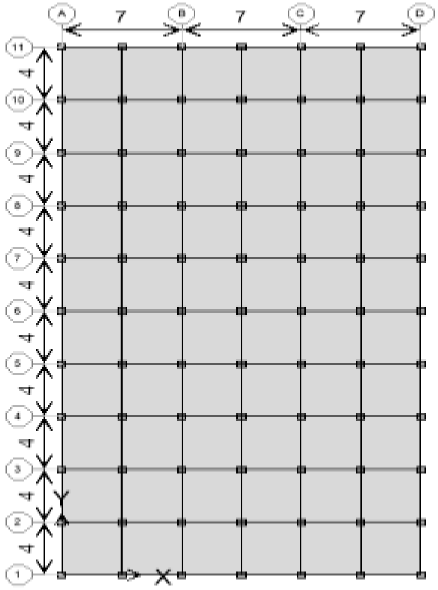


Fig.- 2.2 e: Plan of Type 5 model

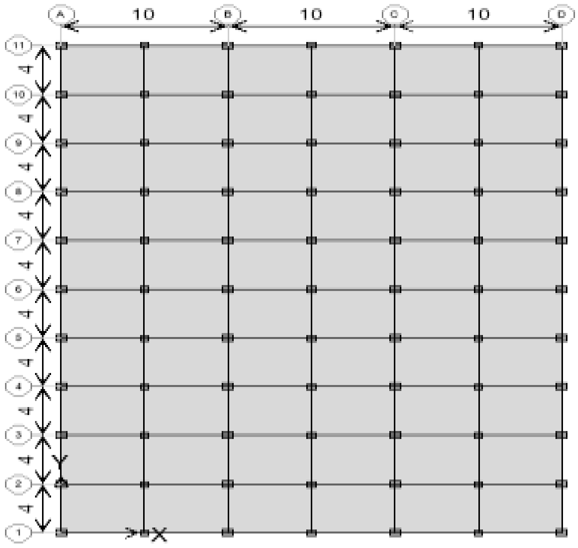


Fig.- 2.2 f: Plan of Type 6 model

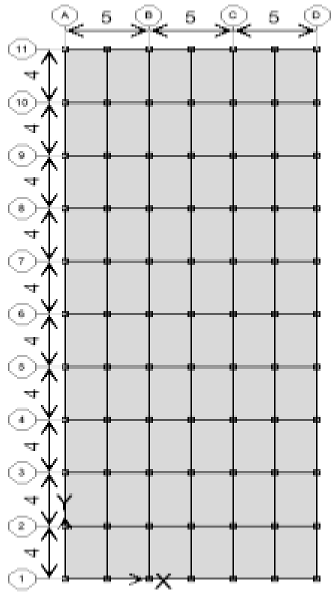


Fig.- 2.2 f: Plan of Type 4.5 model (with floating columns)

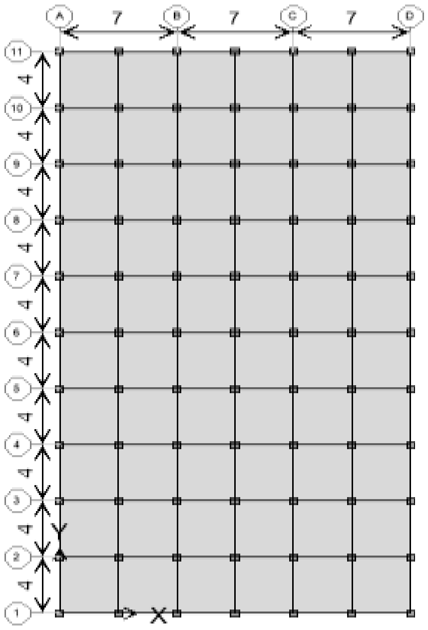


Fig.- 2.2 f: Plan of Type 5.5 model (with floating columns)

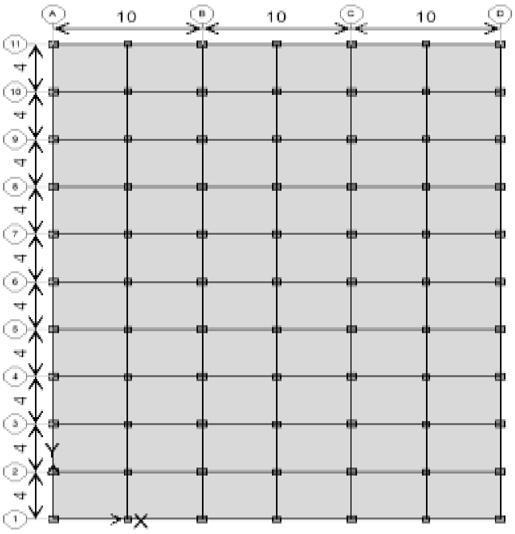


Fig.- 2.2 g: Plan of Type 6 model (with floating columns)

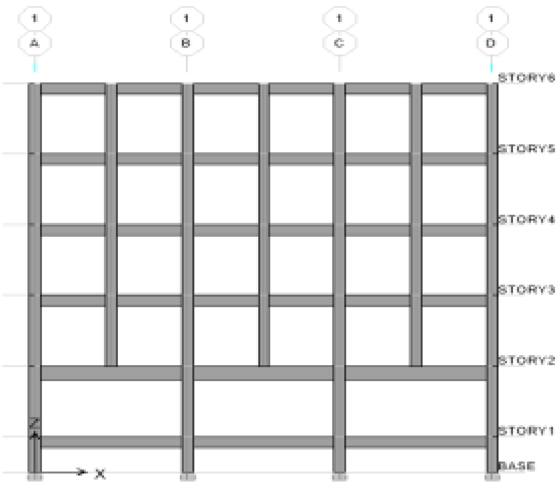


Fig.- 2.2 h: Elevation of G+6 story building with floating columns

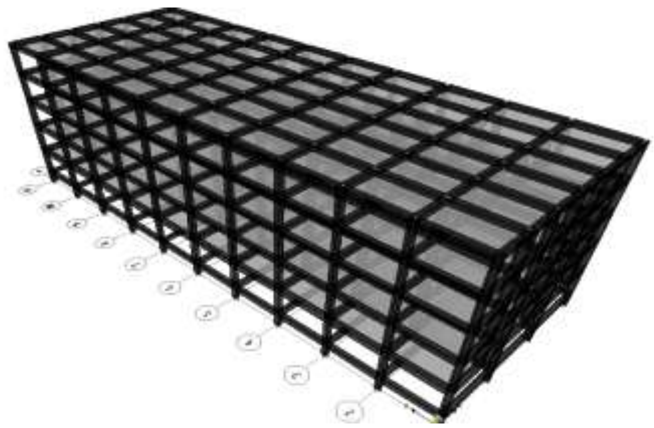


Fig.- 2.2 h: 3D view of building with floating column

2.3 Input data

Table -1: Structural section details

	COLUMN	FLOATING COLUMN	BEAM	GIRDER BEAM
TYPE 1	450mm X 600mm	NA	400mm X 400mm	NA
TYPE 2	450mm X 600mm	NA	400mm X 400mm	NA
TYPE 3	450mm X 600mm	NA	400mm X 400mm	NA
TYPE 4	450mm X 450mm	350mm X 350mm	350mm X 450mm	200mm X 350mm
TYPE 5	450mm X 450mm	350mm X 350mm	350mm X 450mm	200mm X 350mm
TYPE 6	450mm X 450mm	350mm X 350mm	350mm X 450mm	200mm X 350mm
TYPE 4.5	450mm X 450mm	350mm X 350mm	350mm X 450mm	200mm X 350mm
TYPE 5.5	450mm X 450mm	350mm X 350mm	350mm X 450mm	200mm X 350mm
TYPE 6.5	450mm X 450mm	350mm X 350mm	350mm X 450mm	200mm X 350mm

Table -2: Seismic loading zone as per IS 1893: 2002

DETAIL	VALUE
R	3
I	1
Z	0.1
Sa/G	TYPE 2

Table -3: Material properties

SL. NO	STRUCTURAL ELEMENTS	MATERIAL PROPERTY
1	COLUMN	M40
2	BEAM	M25
3	SLAB	M25
4	HYSD BAR	Fe500

Table -4: Analysis input

Importance factor, R	3
Spectrum case	Func1
Damping ratio	0.05
Model combination	CQC
Directional combination	SRSS
Eccentricity ratio	0.05

2.4 TYPES OF MODELS

TYPE 1 MODEL- RCC tall Building with column bay spacing 5m
TYPE 2 MODEL- RCC tall Building with column bay spacing 7m
TYPE 3 MODEL- RCC tall Building with column bay spacing 10m
TYPE 4 MODEL- RCC tall Building with floating column in bay spacing 5m
TYPE 5 MODEL- RCC tall Building with floating column in bay spacing 7m
TYPE 6 MODEL- RCC tall Building with floating column in bay spacing 10m
TYPE 4.5 MODEL- RCC tall Building with floating column in bay spacing 5m and varying density of wall material in increasing order over height of building
TYPE 5 .5 MODEL- RCC tall Building with floating column in bay spacing 7m and varying density of wall material in increasing order over height of building
TYPE 6 .5 MODEL- RCC tall Building with floating column in bay spacing 10m and varying density of wall material in increasing order over height of building

2.5 Static Load Assignment

The loads considered are Dead Load, Live Load, Floor Finish, Wall Load and Earth Quake Load. All models consist of these loads.

Dead Load: The dead load of the structure is obtained from Table 1, Page 8, of IS 875 – Part 1 – 1987. The permissible value for unit weight of reinforced concrete varies from 24.80kN/m^3 to 26.50 kN/m^3. From the table, the unit weight of concrete is taken as 25kN/m^3. ETABS has an inbuilt Dead Load calculator.

Self-weight of the structural elements
Floor finish = 2 kN/m^2

Imposed Load: The imposed load on the floor is obtained from Table 1 of IS 875 (Part 2) – 1987. The uniformly distributed load on the floor of the building is assumed to be 4.0 kN/m^2 (for assembly areas, corridors, passages, restaurants business and office buildings, retail shops etc.)

On roof 1.5 kN/m^2, and
On floors 4.0 kN/m^2

Earth Quake Load: The structure is assumed to be in Zone-II as per IS 1893 – 2002. So, the zone factor is taken as per Table 2 of IS 1893 – 2002. The damping is assumed to be 5%, for concrete as per Table 3 of IS 1893-2002. Importance factor is taken as 1 as per Table 6 of IS 1893 – 2002.

Zone II, Soil type II, Importance factor =1

Response Reduction Factor, in this case the value of R=3 is used.

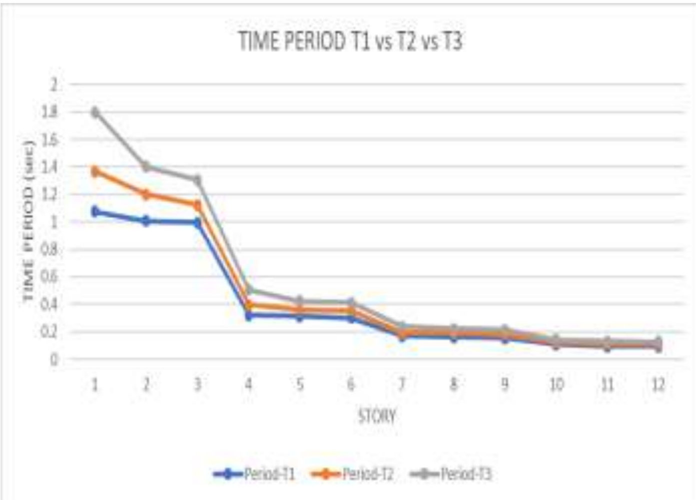
Load combinations: The load combinations are obtained from page no. 13, clause 6.3.1.2 of. IS 1893 – 2002.
DL EQX=1.2 (DL+LL+SPECX)
DL EQY=1.2(DL+LL+SPECY)

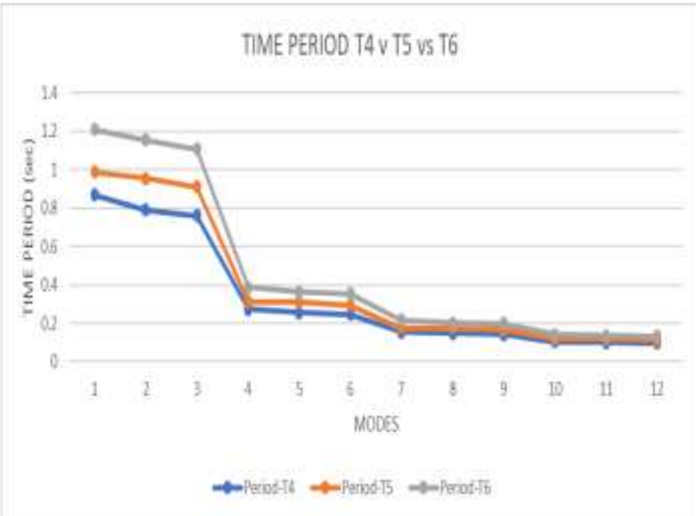
3. Analysis and Result:

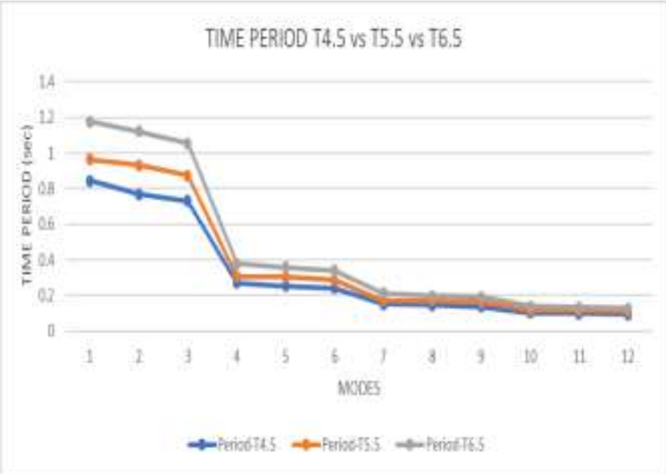
3.1 TIME PERIOD

The value of T depends on the building flexibility and mass; more the flexibility, the longer is the period and more the mass, the longer is the period.

It is seen that with the increase in bay spacing, time period increases.







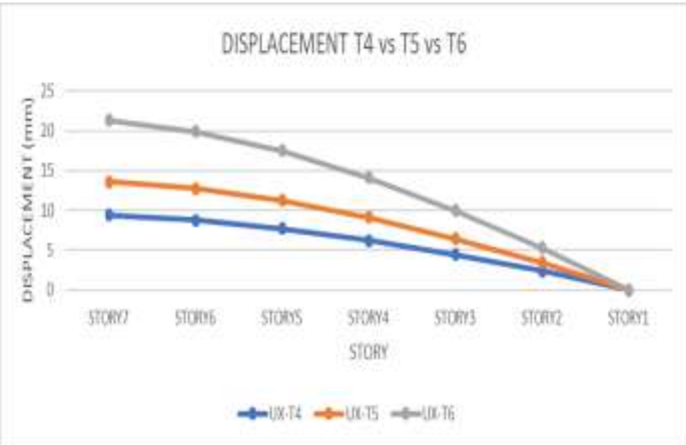
3.2 DISPLACEMENT (mm)

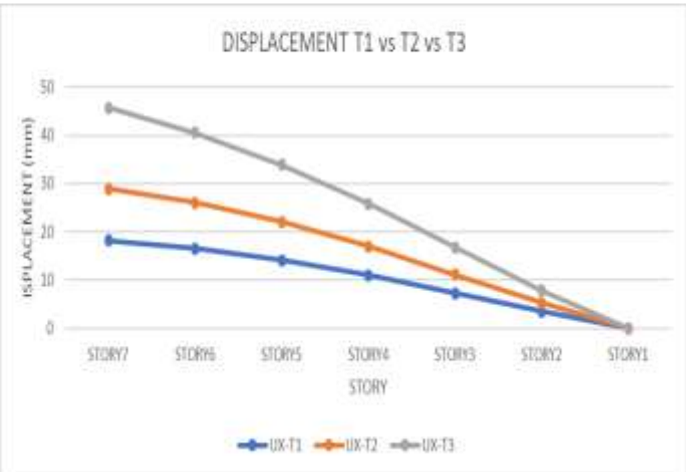
The displacement is of interest with regard to structural stability, strength and human comfort. The displacement of prefabricated model is less than the basic model. It means that structure is more stable.

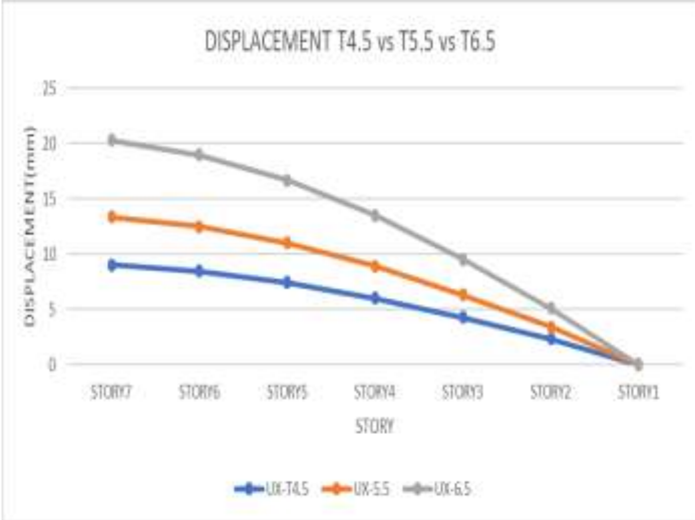
Chance of Structural Strength reduction is less.

Human comfort is good.

It is seen that with the increase in bay spacing, displacement increases.





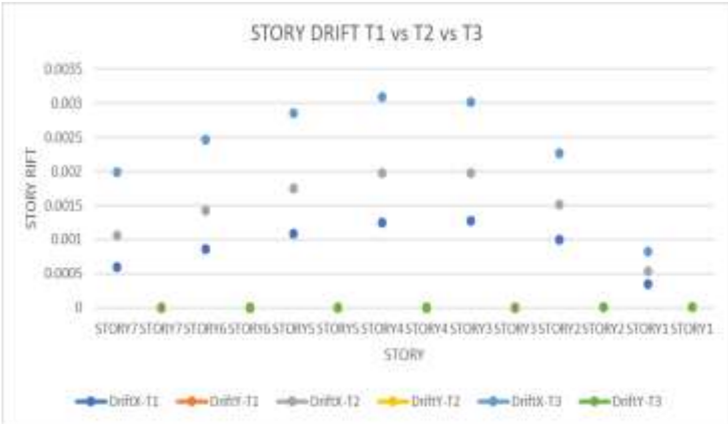


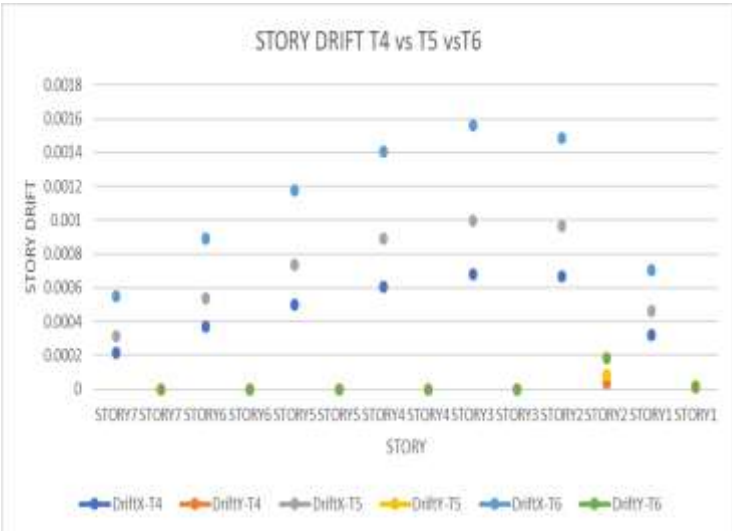
3.3 STORY DRIFT RATIO

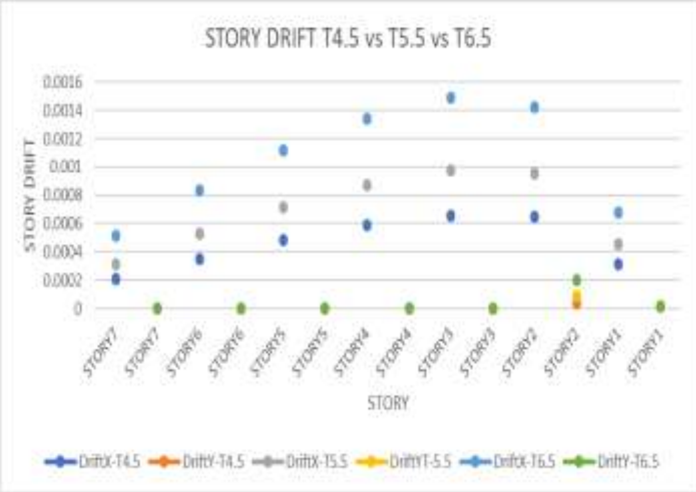
It is the displacement of one level relative to the other level above or below.

The building may collapse due to different response quantities. For ex., at local levels such as strains, curvatures, rotations and at global levels such as interior story drifts.

Story drift increases with the increase in bay spacing.



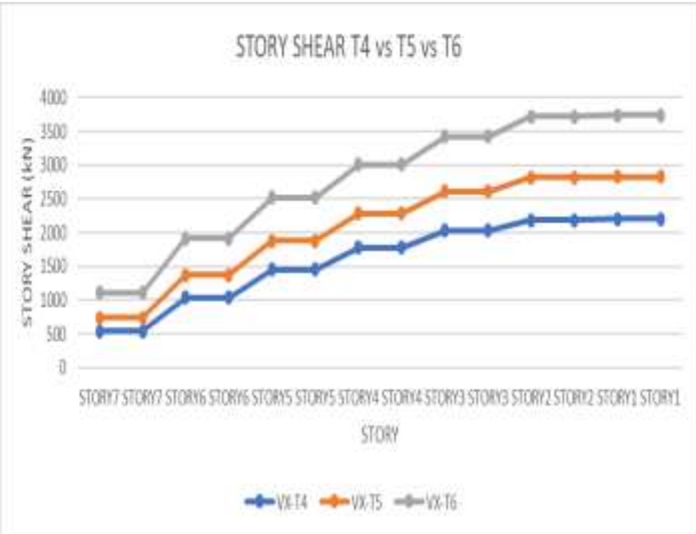


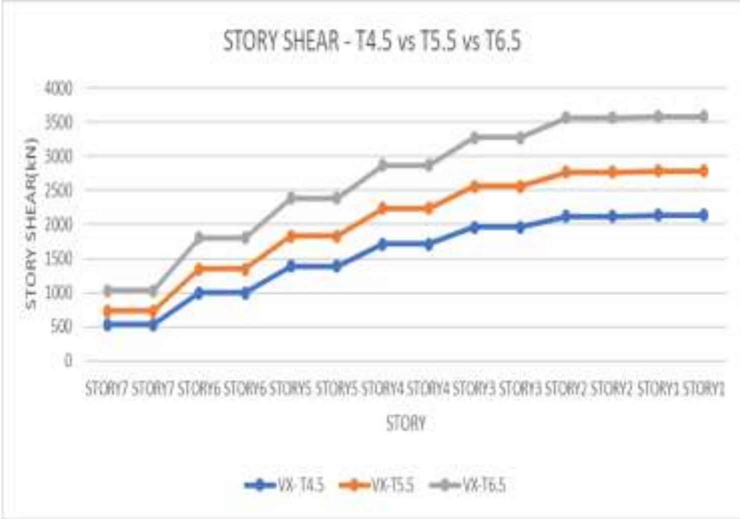


3.4 STORY SHEAR (kN)

It is the sum of design lateral forces at all levels above the story under consideration.

Story shear is seen to increase with the increase in bay spacing. Hence lower the bay spacing, lower is the story shear.





4. CONCLUSION:

1. In conventional buildings, the earthquake response of tall buildings increases with the increase in bay spacing of columns.
2. There is about 60% increase in displacement between type 1 and type 3 buildings, which are conventional buildings with bay spacing of 5m and 10m, respectively.
3. There is about 56% increase in displacement between type 4 and type 6 buildings, which are conventional buildings having floating columns in between main columns from story 2.
4. There is about 55% increase in displacement between type 4.5 and type 6.5 building, which are conventional buildings with floating column whose wall density decreases with the height of the structure, having floating columns in between main columns from story 2.
5. There is about 3% to 8% decrease in the earthquake response of a structure when bricks of lesser densities are used with increasing height of the structures.

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