International Journal of Engineering & Technology, *7 (2.33) (2018) 36-40*

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Seismic behavior of transfer girder in multi-story building

Samrat Guptaa [1], P. R. Kannanra jkumar [2] *, P. T. Ravichandran [3], L.Krishnaraj [4]

[1] *Former PG Student Department of Civil Engineering, SRM Institute of Science and Technology, Kattankulathur - 603203, Tamil Nadu*
[2] *Associate Professor Department of Civil Engineering, SRM Institute of Science and Technology, Kattankulathur - 603203, Tamil Nadu*
[3] *Professor Department of Civil Engineering, SRM Institute of Science and Technology, Kattankulathur - 603203, Tamil Nadu*
[4] *Asst. Professor Department of Civil Engineering, SRM Institute of Science and Technology, Kattankulathur - 603203, Tamil Nadu*
**Corresponding author E-mail: tokannanonly@gmail.com*

Abstract

Urbanization had led to many housing problems in India. Scarcity of land is one such biggest problem in India. This issue is one of the most pivotal issues that need to be provided with a swift and efficient solution if we want to grow as a nation whilst achieving the goals we are aiming at. Hence, there is a rise in many Multi storey and Highrise structure. Rise in car park and open column free space for auditoriums. The study focuses on the study of seismic assessment of the Multi-storey structure with transfer girder. The use of transfer girders in a building will help to a greater extent to minimize the issue regarding the lack of space for car parking. A building prototype model with transfer girder at different level was analyzed using elastic linear response spectrum. Different results such as Base Shear, Time Period, Interstorey Drift and Displacement had been analysed in different model and optimum modeling of Multi storey RC Frame building with transfer girder system using SAP 2000 and also comparison on performance of Multi storey building by placing the transfer girder in different level has been carried out.

Keywords: base Shear; Time Period; Inters Torey Drift; Maximum Top Story Deflection; Transfer Girder.

1. Introduction

Our Indian Subcontinent has had its share of major and devastating earthquakes. The high frequency earthquakes are caused by the movement of the Indian plate into Asia at a rate of approximately 47 mm/year. Geographical statistics shows that about (54–60)% of land in India is prone to earthquakes.[1]Generally, Transfer Girder carries the heavy loads from the upper storeys, and also creates open column free space for highrise building, auditoriums etc in ground or any other floor. In other words to think in terms of Vertical load Path. If we are able to align all the columns, top to bottom, then there is no necessity of transfer girder, but if we want to shift our vertical load path, we need transfer beam as a structural member [2].
Different researches had been studied in which method for structural system of coupled shear walls supports on continuous transfer girder framing into columns had been discussed and detailed finite element analysis had been conducted using finite element method [3].Analysis and behaviour of transfer beam and shear wall due to the interaction between shear wall and transfer beam-had been reviewed [4]. General understanding of the Seismic response of concrete buildings with transfer girder in Low-to-moderate seismicity regions followed by Chinese National Standard (2001) to check the effect of Earthquake Spectrum [5] had also been discussed earlier where El Centro and Taft earthquake records had been utilized for shaking table tests and building with transfer girder had been numerically analysed.Study regarding Multi storey structure model using various bracing system with base isolation technique had also been done which will help in greater extent regarding the performance of the building in seismic prone area and also been said that earthquake being natural phenomenon is itself not a disaster but the ground movement due to surface wave on the structure standing on top of the ground make it sometimes violent [6], [7]. In this report comparative study had been made on the behaviour of transfer girder in a regular multi storey structure. Table 1 depicts the size of members.The illustration of the position (elevation) of Transfer Girder is shown in figure 1. The shaded beam denotes transfer girder (TG) and it shows creating a column free space below the lower part of the frame. The dimensions are shown in figure 1.To perform comparative study on seismic performance of the multi storey building, position of transfer girder is varied in the 1^{st}, 5^{th}, 10^{th}, 15^{th}, 24^{th}storey level of 25 storey structure both in X and Y direction and then analyzed with SAP2000 using Indian codal provisions.

Table 1:. Member Sizes

Section	Abbreviation	Dimension(Width X Depth) mm^2
Columns	C_1	1500 × 1500
	C_2	500 × 500
Transfer Girder	TB	1000 × 1500
Primary Beam	PB	500 × 750
Secondary Beam	SB	400 × 500
Shear Wall	SW	Thickness = 300mm
Slab	SB	Thickness = 150 mm

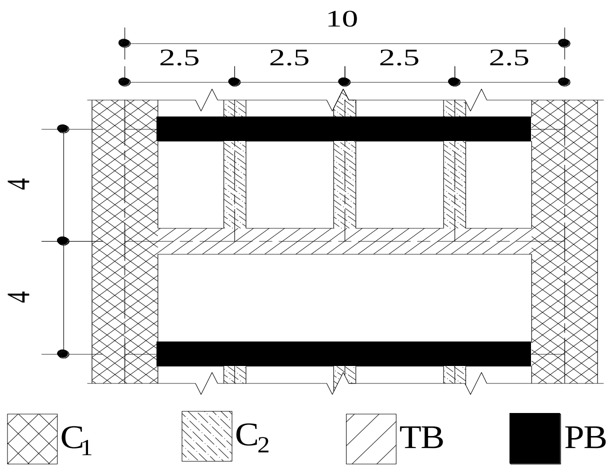
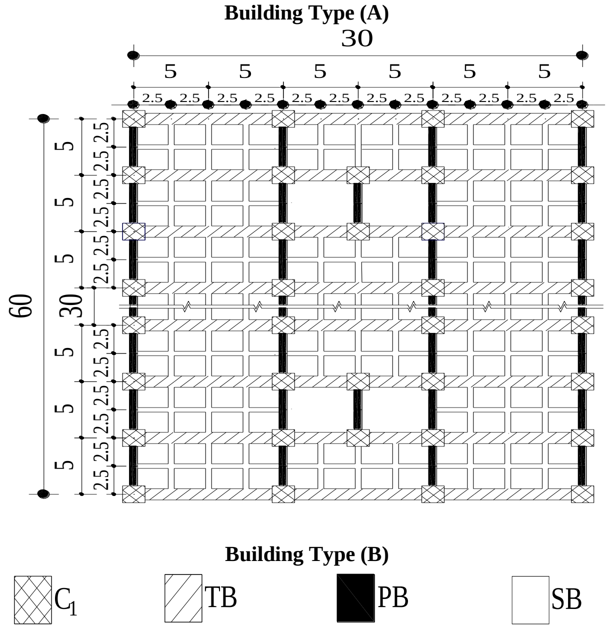


Fig. 1: Position of Transfer Girder (All Dimensions Are in M).

2. Building profile

In this study a rectangular symmetrical commercial building consisting of G+ 25 storeys is considered. The plan of the building is considered as 30m × 60m with change in the position of transfer girder at 1st, 5th, 10th, 15th, 20th, 24th floor level. The total height of the building is 87.5m with the typical floor height being4m. The other factors such as thickness of the slab is 150mm;thickness of exterior wall 230mm; thickness of interior wall 125mm; Seismic zone III; Zone factor 0.16; Soil type I (Rock or, Hard Soil); Importance factor (I) 1.5; Response Reduction factor, 5; Loads on floor finish is taken as1 kN/m^2;Live load 4 kN/m^2[7,8].Grade of concrete is taken as M60 for all the columns and beams and M40 for the slab and shear wall, Grade of Reinforced steel as Fe 415, Density of concrete is 25 kN/m^3, Density of Brick Masonry as 20 kN/m^3, Damping Ratio as 5%.Building type (A) in figure 2 represents the transfer girder plan when placed in Y – Axis and Building type (B) in figure 2 represents the transfer girder floor plan when placed in X – Axis. Dimensions of all the members are shown below in Table 2.

Columns are spaced 5m centre to centre in X direction and 10m centre to centre below transfer beam in Y direction and all the primary beams are placed in between two columns and the secondary beams are between two primary or transfer beams. Various building models are then analysed by changing the position of transfer girder in 1st, 5th, 10th, 15th, 20th and 24th floor. The direction of the transfer beam is then changed to X direction and once again analysed.Columns and beams were modelled as frame elements while Slab is taken as Shell (thin) element and shear wall is modelled as membrane element. At respective floor levels, the slabs have beenassumed to be rigid diaphragms. Rotation and translation in the vertical column elements has been restrained at foundation and a fixed support has been provided and response spectrum function for 5% damping ratio is considered.Table 2 shows the overall dimensions of the buildingand Table 3 denotes the position of Transfer girder in different building models.



C$_1$ = Column 1 **TB = Transfer Beam** **PB = Primary Beam** **SB = Secondary Beam**

Fig. 2: Floor Plan of Building (All Dimensions are in M).

Table 2: Building Dimensions

No. of Stories =25	Storey Height = 4m
No. of Bays, X = 12	Bay Width, X = 2.5m
No. of Bays, Y = 24	Bay Width, Y = 2.5m

3. Results and discussions

3.1. Base shear

Base Shear for all the building due to linear static Analysis is 12784.365 kN both in X and Y direction. Since base shear is a function of mass and stiffness of building, there is no significant change in the base shear as the base of the structure is fixed [8]. The value of Base shears due to linear Response spectrum analysis in X and Y direction had been adjusted with the scale factor as per codal provision. Table 4 shows the value of base shear considered for linear Response spectrum analysis in X and Y direction for different building model.

Table 3: Position of Transfer Girder

Building Model	Abbreviation	Position of Transfer Girder (TB)
Building 1	B1	TB Placed in 1st floor
Building 2	B2	TB placed in 5th floor
Building 3	B3	TB placed in 10th floor
Building 4	B4	TBplaced in 15th floor
Building 5	B5	TB placed in 20th floor
Building 6	B6	TBplaced in 24th floor
Building 7	B7	TBplaced in 1st floor
Building 8	B8	TBplaced in 5th floor
Building 9	B9	TBplaced in 10th floor
Building 10	B10	TBplaced in 15th floor
Building 11	B11	TBplaced in 20th floor
Building 12	B12	TBplaced in 24th floor

3.2. Time period

It is one of the important factors which are necessary for the designers before designing any building. As per IS 1893:2002 [9], buildings with simple and regular geometry and uniform distributes mass and stiffness in both plan and elevation suffers a damage of lower magnitude than buildings with irregular. IS 1893:2002 determines empirical expression for fundamental time period of vibration, $T_a = \frac{0.09h}{\sqrt{d}}$ (in seconds) for brick infilled RC moment resisting frame where, h= Height of building, in meter and d = Base dimension of the building at the plinth level, in m, along the direction in which the lateral force has been considered [9]. Table V shows the fundamental time period of each building 1 to 6 of Mode 1 to Mode 12 when the transfer girder is placed in Y direction and at different levels, whereas Table 6 shows the Fundamental time period of Mode 1 to Mode 12 of each building from 7 to 12 when transfer girder is placed in X direction and at different levels.

Table 4: Base Shear Due to Response Spectrum Analysis in X and Y Direction

Base Shear	RSX (kN)	RSY (kN)
B1	12873.169	12888.164
B2	12807.221	12910.072
B3	12908.488	12794.298
B4	12790.784	12865.279
B5	12797.033	12890.321
B6	12789.28	12993.011
B7	12788.003	12985.378
B8	12999.193	12971.678
B9	12956.937	12825.117
B10	13027.665	12848.073
B11	12963.087	12843.165
B12	12855.866	12837.913

3.3. Maximum joint displacement

Type A Building (B1 to B6) consists of transfer girder placed in Y direction at storey level 1st, 5th, 10th, 15th, 20th, 24th respectively, whereas type B Building (B7 to B12) consists of transfer girder placed in X direction at storey level 1st, 5th, 10th, 15th, 20th, 24th respectively. Since the second moment of inertia for type (A) building is more in Y direction therefore the stiffness of type (A) building is also higher in Y direction and since stiffness is indirectly proportional to deflection hence deflection in Y direction shows less top storey deflection as compared to X direction.Similarly, the second moment of inertia for type (B) building is more in X direction therefore the stiffness of type (B) building is also more in X direction and stiffness is indirectly proportional to deflection hence deflection due to X direction shows less top storey deflection as compared to earthquake in Y direction.Maximum Joint Displacement at the top of each storey level had been shown in figure 3 -7 had been compared due to Linear static method and response spectrum method for type A and type B building both in X and Y direction.

3.4. Comparison of different building models

Various graphs showed in figure 3–7shows the relationship between Joint displacement and number of storeysfor typical buildings3, 5, 7, 10 and 11. The relationship between Storey Drift and Storey Level had also been shown for the respective building model. Storey drift is the relative displacement between the two adjacent floors which iscalculated as a difference between the adjacent storey displacements per unit storey height [10].The figure 3–7 shows little change in the pattern of deflection of each building. Following are the results analysed from the data shown above.

- Building 3 shows minimum Storey deflection due to EQY and RSY when transfer girder is placed in Y direction in 10th floor as shown in figure 3.
- Building 5 shows minimum storey deflection due to EQX and RSX when transfer girder is place in Y direction at 20th floor as shown in figure 4.
- Building 7 shows minimum storey deflection due to RSX when transfer girder is placed in X direction at 1st floor as shown in figure 5.

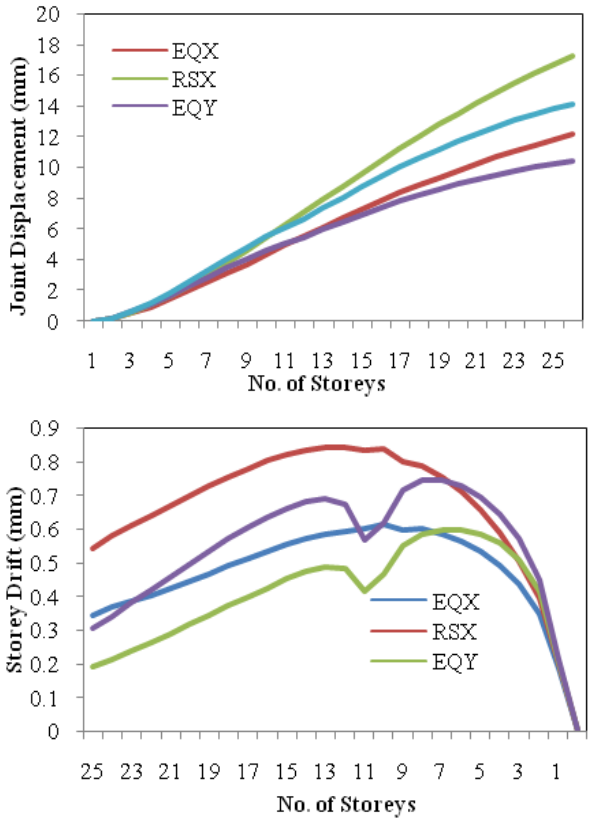


Fig. 3: Joint Displacement, Storey Drift vs. No. of Storey for Building 3

- Building 10 shows minimum storey deflection due to EQX and EQY when transfer girder is placed in X direction at 15th floor as shown in figure 6.
- Building 11 shows the minimum storey deflection due to RSY when transfer girder is placed in X direction at 20th floor as shown in figure 7.

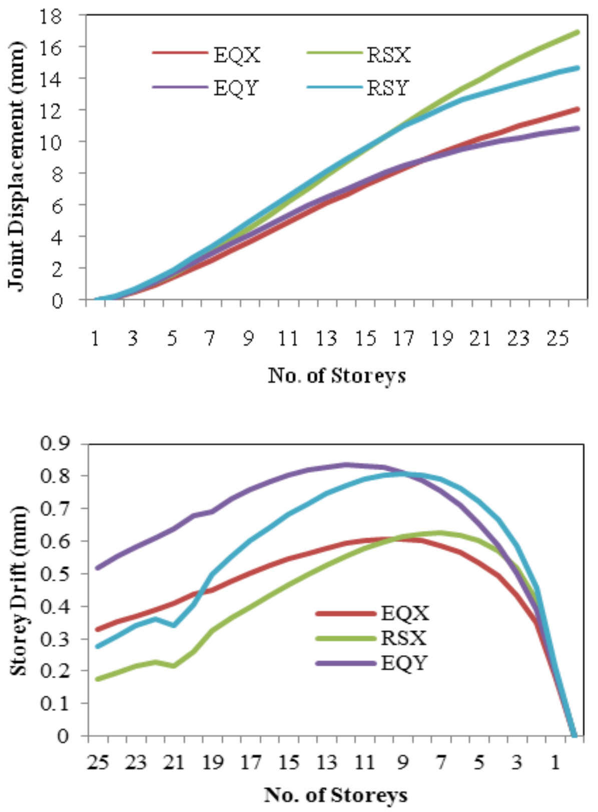
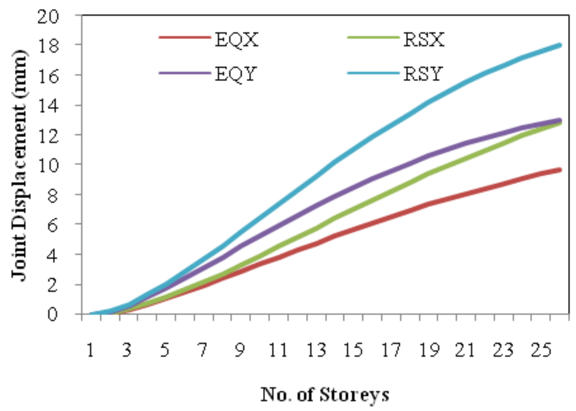


Fig. 4: Joint Displacement, Storey Drift vs. No. of Storey for Building 5.



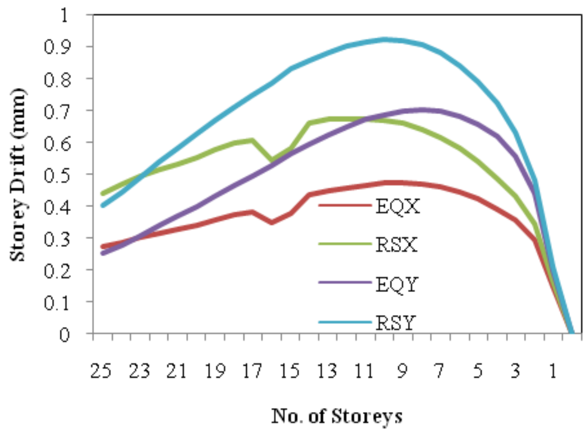


Fig. 6: Joint Displacement, Storey Drift vs. No. of Storey for Building 10.

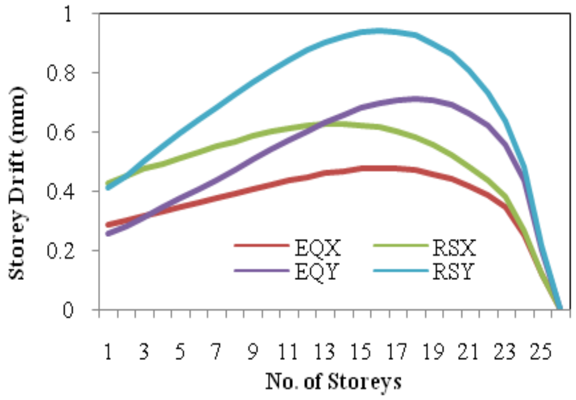
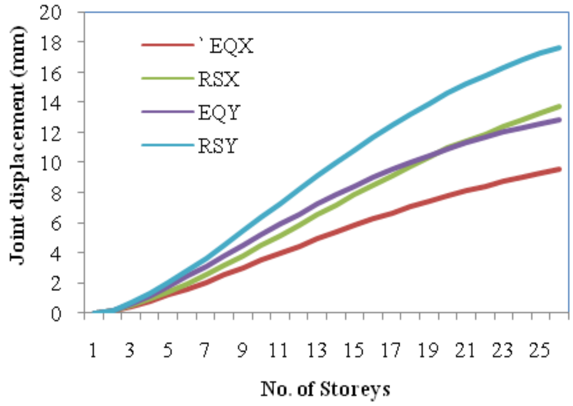
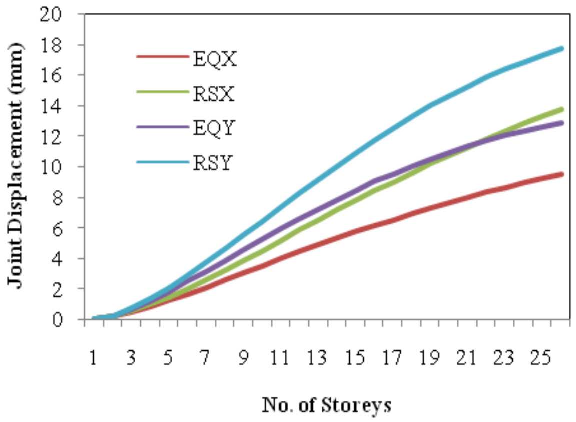


Fig. 5: Joint Displacement, Storey Drift vs. No. of Storey for Building 7.





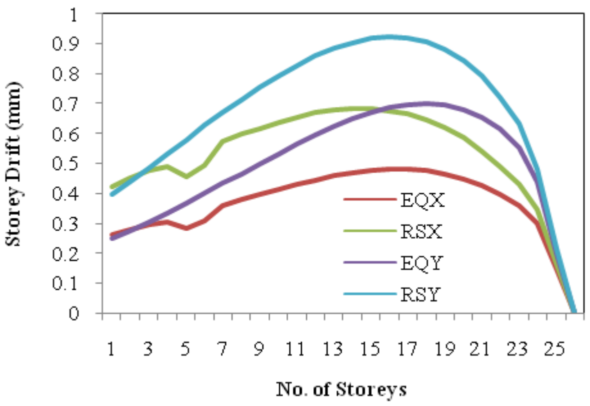


Fig. 7: Joint Displacement, Storey Drift vs. No. of Storey for Building 11.

Table 5: Time Period for Building 1 to 6 when Transfer Girder Placed in Y-Direction

Mode	B1	B2	B3	B4	B5	B6
1	0.489688	0.492866	0.488889	0.487494	0.487685	0.487987
2	0.472132	0.461783	0.459925	0.466635	0.47367	0.47682
3	0.37841	0.378363	0.375418	0.375485	0.37676	0.377826
4	0.143973	0.142291	0.146253	0.142978	0.140905	0.144144
5	0.139238	0.13967	0.140438	0.140471	0.139532	0.139363
6	0.111077	0.111256	0.112099	0.111591	0.110561	0.110995
7	0.075799	0.076738	0.074907	0.076446	0.075048	0.075405
8	0.07114	0.071266	0.071318	0.071402	0.07156	0.071231
9	0.056811	0.057117	0.056922	0.057188	0.057075	0.056893
10	0.054734	0.055852	0.055093	0.053812	0.052856	0.052804
11	0.049199	0.049883	0.049333	0.048758	0.04976	0.048917
12	0.048891	0.049315	0.048949	0.048624	0.048682	0.048642

Table 6: Time Period for Building 7 to 12 when Transfer Girder Placed in X-Direction

Mode	B7	B8	B9	B10	B11	B12
1	0.513843	0.514464	0.512102	0.511552	0.511798	0.511924
2	0.442239	0.43266	0.427744	0.427872	0.431045	0.433977
3	0.370117	0.354874	0.35154	0.352047	0.354248	0.356029
4	0.152497	0.152483	0.153307	0.15311	0.152403	0.15256
5	0.128223	0.124283	0.126588	0.125264	0.123221	0.124604
6	0.10846	0.103934	0.105378	0.104551	0.103183	0.103997
7	0.07821	0.078244	0.07825	0.078432	0.078484	0.078265
8	0.066627	0.065301	0.064364	0.065286	0.064712	0.064766
9	0.055853	0.055174	0.054677	0.053948	0.053683	0.053595
10	0.054147	0.053994	0.053374	0.053245	0.052349	0.052328
11	0.050173	0.050258	0.050195	0.050186	0.05036	0.050219
12	0.048549	0.049248	0.048856	0.047727	0.047068	0.047188

4. Summary

Various Model of a rectangular 25 storey structure had been analysed and many important data required for building had been compared using different models such as base shear, time period, Maximum Top storey deflection, Storey drift by placing the transfer girder in X and Y direction and placing the girder in 1^{st}, 5^{th}, 10^{th}, 15^{th}, 20^{th}, 24^{th}storey respectively due to Linear static analysis and Response spectrum analysis of the structure. It is clear from the comparison, that the value of Response spectrum analysis such as Deflection should be maximum than Linear static analysis.As the height of the each building is increasing, the deflection is also increasing. When the transfer girder is placed in Y and X direction, the minimum deflection occurs due to linear static analysis is when the transfer girder is placed atmid height of a building.

5. Conclusion

From the summary of this study,

- It is visualized that when the transfer girder which are positioned in the centre of the Multi storey structurereduces top storey deflection.
- No significant change in base shear since it is a function of mass and stiffness.
- The deflection in each building is in safe limit and it is learnt that placing the girder in the middle portion of a building gives less deflection when compared to other buildings.
- In case of Type ‘A’ building, when the transfer girder was placed in Y direction, the deflectiondue to earthquake in X direction of top storey was higher as compared to deflection in Y direction.
- In case of Type ‘B’ building, it was found out that the deflection in X direction was comparatively less than the deflection in Y direction when transfer girder was placed in X direction.
- In real practice it is very imperative to have an analysis of the building model before starting any building construction particularly for high rise structures.

References

[1] Cooperative Institute for Research in Environmental Sciences (CIRES), “Earthquake Hazards and the Collision between India and Asia”.

[2] UnnikrishnanPillai, DevdasMenon, “Reinforced Concrete Design”, 2005.

[3] Jawaharlal Puvvala**,** “Analysis andBehaviour of Transfer Girder System in Tall Buildings.”Hong Kong University of Science and Technology, 1996.

[4] OnhJiun Dar, “Analysis and design of shear wall transfer beam structure.” University of Malaysia, 2007.

[5] R.K.L. Su., “Seismic Behaviour of Buildings with Transfer Girder in Low-to- Moderate Seismicity Regions.” *EJSE International*, 2008.

[6] M.Vijayakumar, S.Manivel andA.Arokiaprakash “A Study on Seismic Performance of RCC Frame with Various Bracing Systems using Base Isolation Technique”, *International Journal of Applied Engineering Research (IJAER)*, 2016.

[7] Vijay.U.P, KannanRajkumar.P.R and Ravichandran.P.T, “Seismic Response Control of RC Structure using ViscoElastic Dampers”, *Indian Journal of Science and Technology*, Vol 8, No.28, (2015), pp.1-7.

[8] IS 875 (Part 2) – 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for buildings and Structures.

[9] IS 1893 (Part 1): 2002, Criteria for Earthquake Resistant Design of Structures, Part 1 General Provisions and Buildings.

[10] Rahul Ghosh, Rama Debbarma, “Seismic Vulnerability Assessment of RC Framed Building with Soft Ground Storey”, *International Journal of Engineering Technology, Management and Applied Sciences*, Volume 3 Special Issue, 2015.