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Analysis of a High-Rise Building Frame Considering VibrationalRail Load using ETABS

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ABSTRACT

In past situation ground vibration isn't considered in structures close by to rail line paths, which makes serious harms the constructions even reason death toll. These vibrational stacking is expected to settle down to give safe planning of these designs. Here in this concentrate on we are thinking about a contextual investigation of Rani Kamlapati railroad station situated at Bhopal city which is India's first private rail route station redeveloped by bansal bunch. In this station they proposed business complex and designs close by rail route station. In forecast of train-initiated vibrations, numerous exploratory and hypothetical techniques have been proposed. To concentrate on the vibration close to the rail line in Bhopal, a 3D limited component investigation was utilized for demonstrating the train development and its impact on the nearby structure. The approval of the mathematical model was finished by the fast train running estimations. In the exploratory examination, two cases are thought about where one construction is arranged close to a rail route track which endures vibration and other case is a customary design ETABS represent Extended Three Dimensional Analysis of Building Systems. ETABS incorporates each part of the designing plan process. In the current state of the development business, the designs built are being observed and shows importance inspiration, as a general rule, those with the most ideal results which are alluded to as individuals like shafts and segments in multi stories R.C structures. This product is principally utilized for structures like tall structures, steel and substantial designs. The examination intends to break down an elevated structure of 19 stories (G+18) by thinking about seismic, dead and live loads. The plan rules for tall structures are strength, usefulness and security. The rendition of the product utilized is ETABS 2016. Near boundaries were deciding the impacts of horizontal burdens on minutes, shear force, pivotal power, base shear, most extreme dislodging and tractable powers on underlying framework are oppressed and furthermore contrasting the outcomes for both the two cases.

Keywords : Train-Initiated Vibration, Limited Component Technique, Damping, Vibration Level, Tall Design, Seismic Burden, Force, Dislodging.

I. INTRODUCTION

In past decades, the numbers of buildings constructed close to roadway or railway are increasing due to high-density urbanization and rapid development of infrastructures in urban districts. This causes some problems in surrounding structures due to the traffic-induced ground motion effect on neighboring buildings and their influences on the normal operations of high-tech facilities. The induced ground vibration cover a range of almost 2-200 Hz on the surface or underground. The vibration level generally depends on several factors such as vehicle weight and speed, suspension system and soil characteristics. This vibration caused by adjacent to the underground, ground and elevated railway systems influences on the safety of buildings, the daily life of people and the operation of high-tech devices. Therefore, it is necessary to investigate the induced vibration owning to the importance of the research field.

Over population and rare construction land led to the construction close to the railway lines; also, overpopulation led to vertical expansion resulting in high-rise buildings (HRBs) which have a complex response for different kinds of vibrations especially those induced by moving trains near them. The effect of repeated vibrations from the trains passing near HRBs may affect the survival of such structures as a destructive factor. The distance between the high-rise building and the railway is the most effective factor which may affect the values of vibrations up to the structure. The soil is the most effective component in the system of transient vibrations from the railways to the buildings. The techniques to protect the buildings from the danger of vibrations induced by moving trains varies for each kind of building. The most famous techniques are the open and the filled trenches which are easy to implement and cheap.

Fig 1. Structure nearby railway track Methods of analysis of structure

The seismic investigation ought to be completed for the structures that have absence of protection from quake powers. Seismic investigation will consider seismic impacts henceforth the specific examination now and then become mind boggling.

Anyway for straightforward standard designs comparable direct static examination is adequate one. This sort of investigation will be completed for ordinary and low ascent structures and this strategy will give great outcomes for this kind of structures. Dynamic examination will be completed for the structure as indicated by code IS 1893-2002 (part1). Dynamic investigation will be completed either by Response range technique or site explicit Time history strategy. Following strategies are taken on to do the investigation method.

- Equivalent Static Analysis
- Linear Dynamic Analysis
- Response Spectrum Method
- Time History Analysis
- Pushover Analysis
- Non Linear Static Analysis
- Non Linear Dynamic Analysis

Problem Identification

No detailed study on suitability of building nearby railway station and related technique has been done in past researches were conducted on different materials including RCC, flyash cement concrete and panels (glass and aluminum) however information on techno economic feasibility of vibrational induced structure to be used in tall structures is lacking.

- This study will provide a suitability criteria for tall structures nearby railway station.
- This study will provide a reference to designer for providing suitability and lateral load resisting technique using induced structures.

Objectives of the study

The main objective of high rise structure:

1. To analyse the building as per code IS 1893 criteria for earthquake resistant structure. Dynamic analysis of the building using response spectrum method.
2. To determine vibrational induced structure efficiency compared to conventional structure.
3. To perform dynamic analysis of structure considering vibrational loading effect of rail.

II. LITERATURE REVIEW

Saeed Hesami et al (2015) in the research paper, a 2D finite element analysis was done to determine the effect of the train-induced vibration in building at a populated area near the Qaemshahr railway. The train-ground dynamic model has been primarily validated using the field measurements. Based on the results, the vibration level with the increase in track centerline to building distance attenuated significantly due to geometrical and material damping. This is more notable for the increase the distance from 12 to 18 meters. The train-induced vibration in the ground and building increases as the train speed increases. The vertical vibration level in the ground and building floors is higher than of the lateral vibrations. Velocity level in terms of Lv is also adopted for vibration assessment. A decrease is observed in the value of the velocity level with increasing distance from the track centerline. An increase in the train speed cause a negligible effect on the velocity level but wagon weight has significant effect on the velocity level increasing. It is probably due to the train length effects on the calculation of the vibration responses.

Abrar Ahmad et al (2020) research paper focused on seismic behaviour of high-rise buildings. Building understudy was Fortune One Tower located at Jinnah Avenue Sector F9 Islamabad (Seismic zone 2B) having 22 Stories with 04 basements. The project aimed at finding the economical sizes of structural members and provide safety, stability and serviceability in the proposed building. The building was modelled in ETABS 2016 (Extended Three-Dimensional Analysis of Building System Version 2016). Linear Static and Linear Dynamic Analysis were performed on the selected building. The equivalent Lateral Force method was used as static analysis while Response Spectrum Analysis was used as Dynamic Analysis. Building Code of Pakistan (BCP), Universal Building Code (UBC-97) and American Concrete Institute (ACI 318-14) codes were followed for the design of the building.

The results stated that in Dynamic Analysis values of Storey Drifts are 18% less than Static Analysis. Storey displacement increases gradually along the height of the building with highest displacement on the top of the building in both X and Y directions. Dynamic Analysis gives 23% less values for Storey Displacement as compared to Static Analysis. Axial loads in Dynamic Analysis at the Corner and Peripheral columns are 4 to 7% less than Static Analysis. However axial load for the interior column is not reduced significantly by Dynamic Analysis. Bending moments in beams are 3 to 4% less in Dynamic Analysis than Static Analysis. All the critical parameters like story drift, story displacement, the bending moment in beams and axial load on columns show significant low values in Dynamic Seismic Analysis as compared to Static Seismic Analysis. The precise estimation of seismic forces and structural response in the dynamic analysis is accounted for a reduction in all critical parameters. So, it is highly.

III. METHODOLOGY

Step 1 Defining the Grid as G+18 storey is considered with typical storey height is 3.2 m and bottom storey height is 3.2 m.

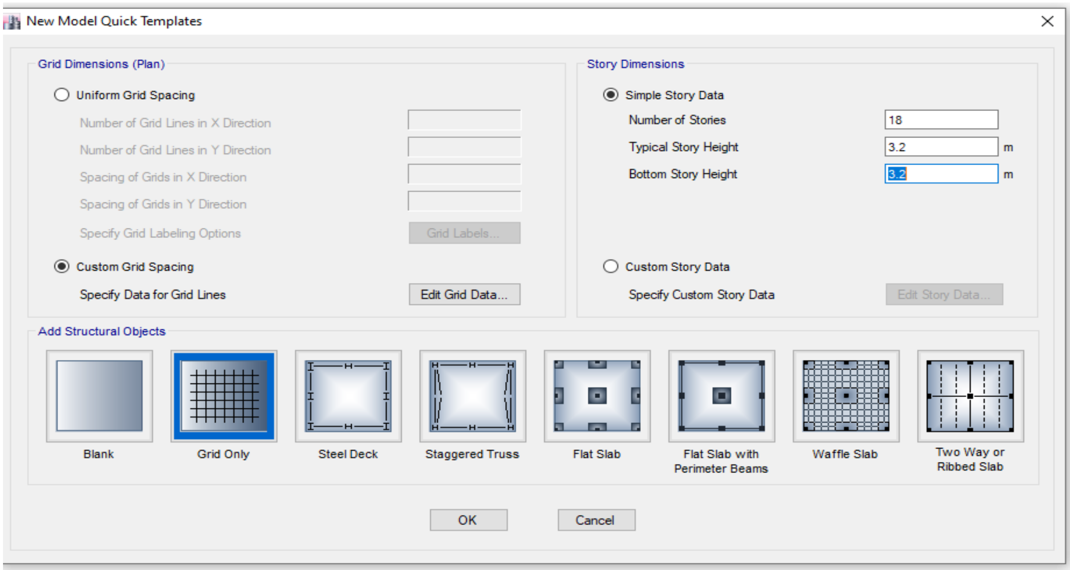


Fig 2 Defining the storey grid

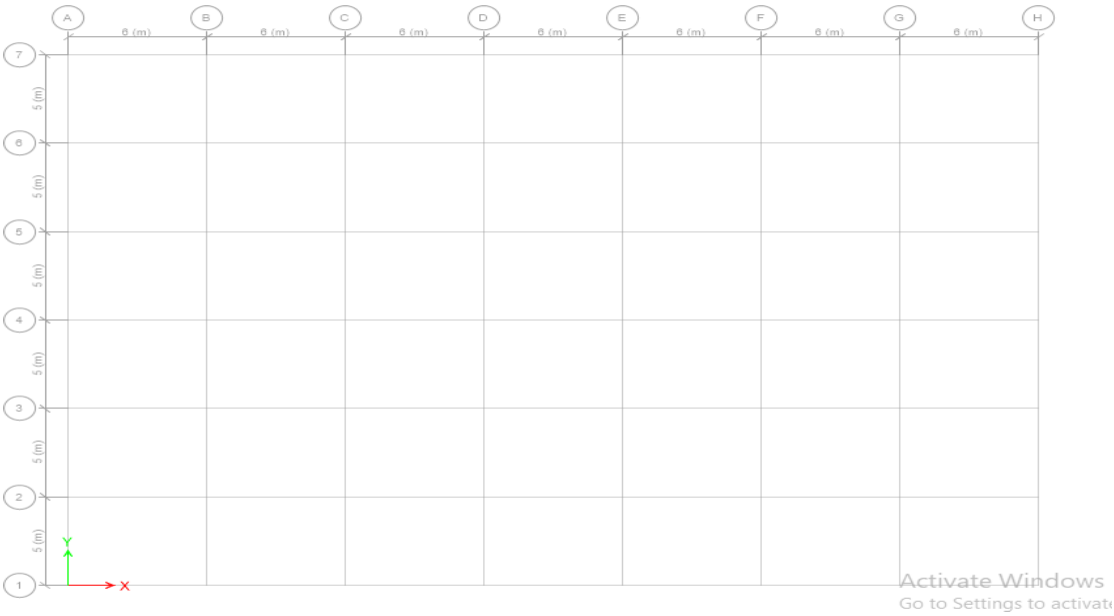


Fig 3 Floor Grid

Step 2 Defining the grid coordinates in X and Y axis. In ETABS it is generally assigned as A,B,C,B….. And 1,2,3,4….. For the other axis.This pop up provides the suitability to customize the spaces in between the grids. Which in mentioned in the diagram below.

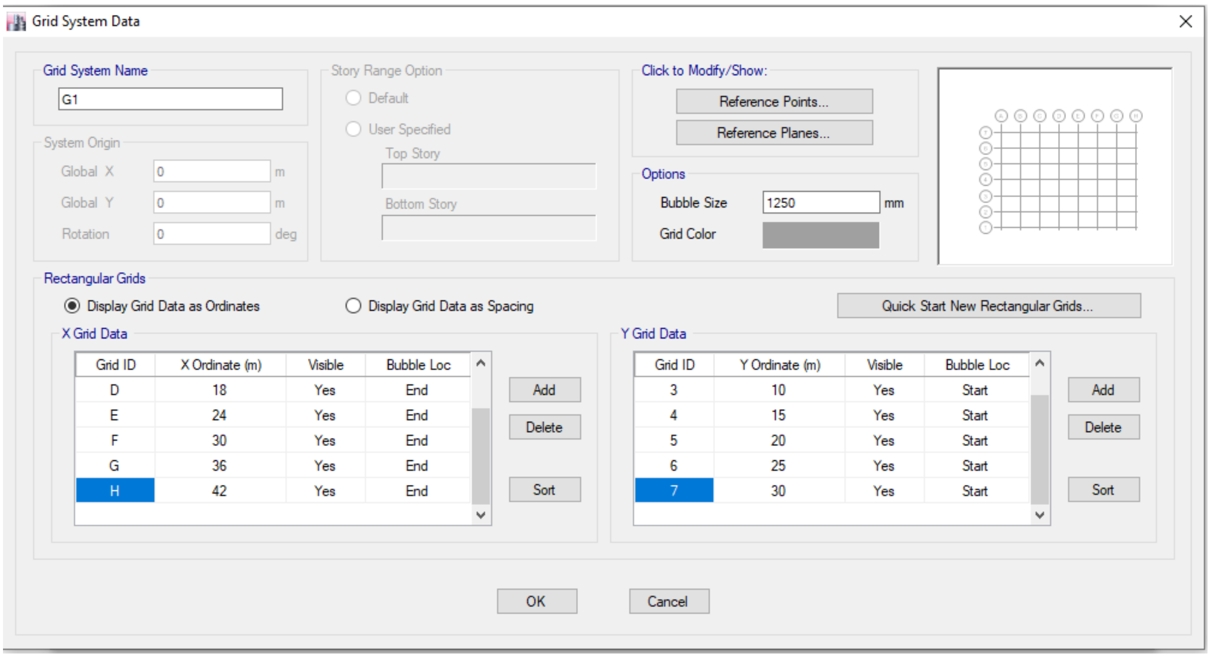


Fig 4 Defining Grid System

Step 3 Defining materials properties of beam and column. Here in this case defining the properties of grade of concrete and steel.

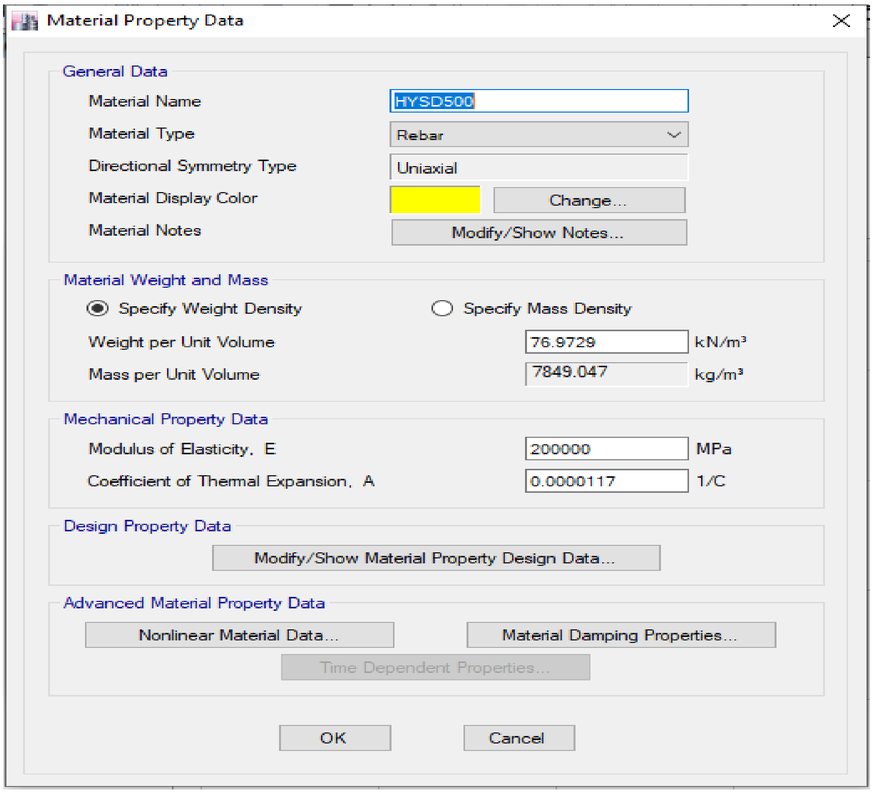


Fig 5 Defining properties of rebar.

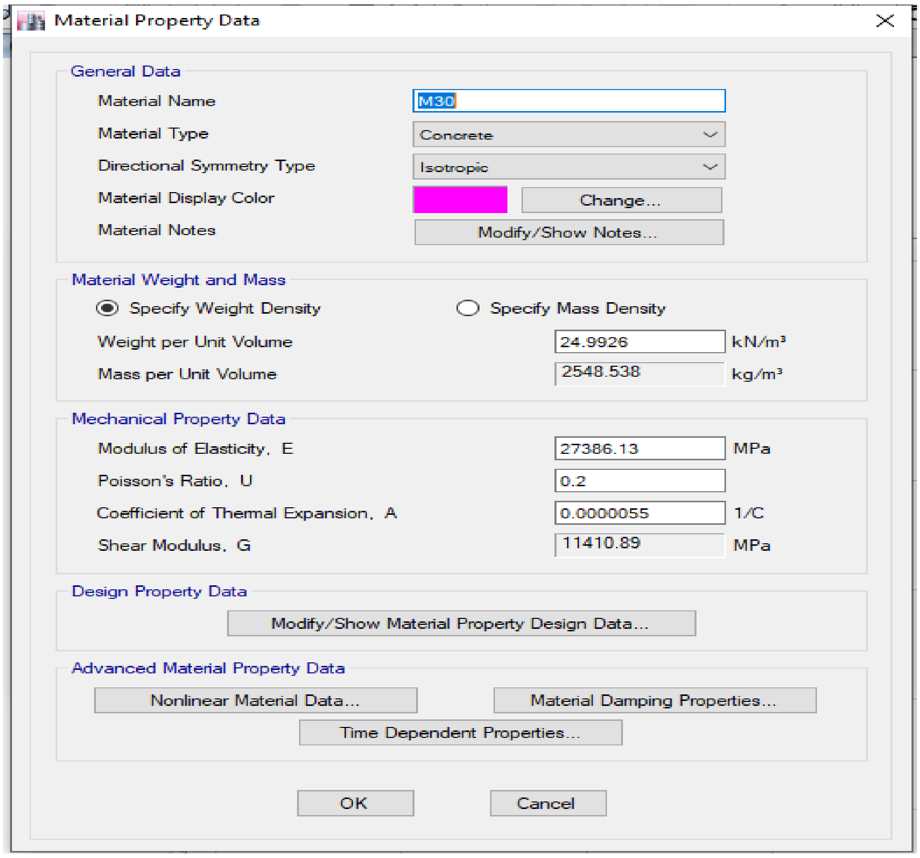


Fig 6 Defining the properties and grade of concrete.

Step 4 Defining section properties of the elements namely beam, column and slab. Size of column is considered as 500x400mm, Size of beam 400x300mm and thin slab size with thickness 150 mm.

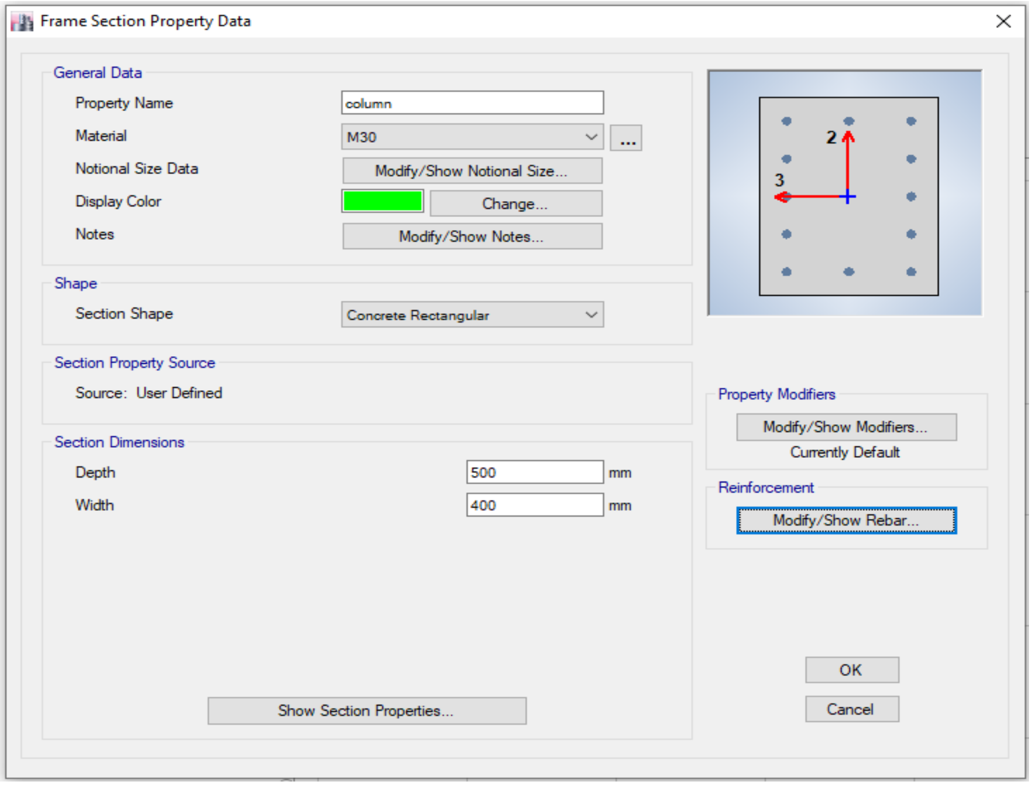
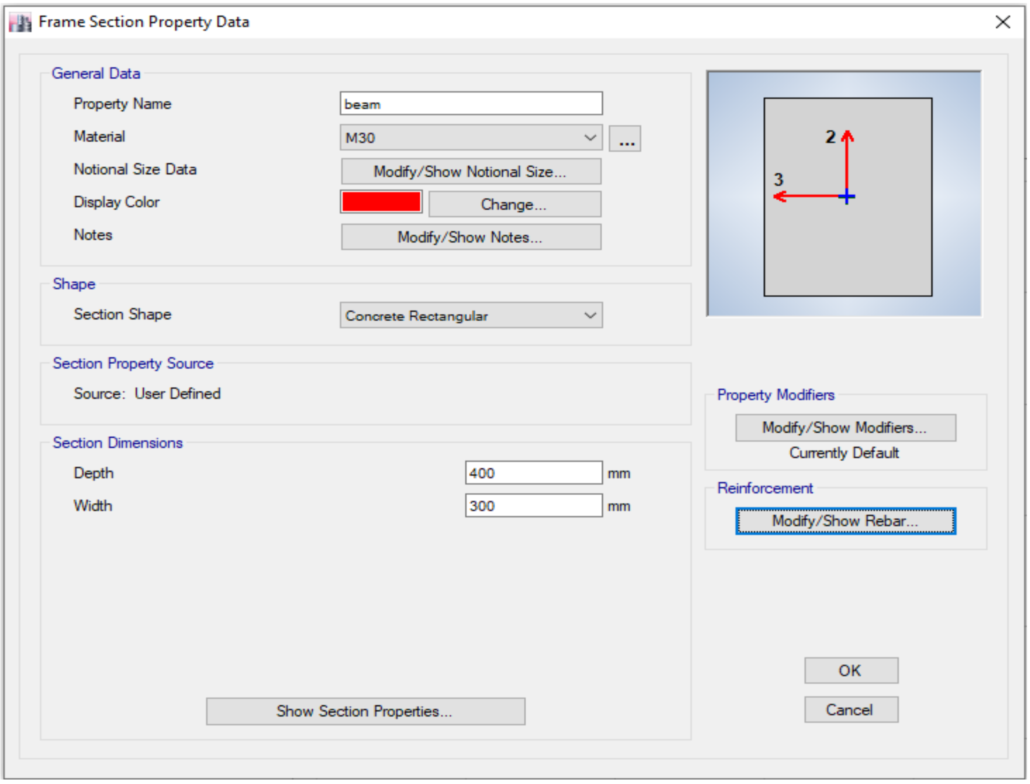


Fig 7 defining section size of the column for depth and width.



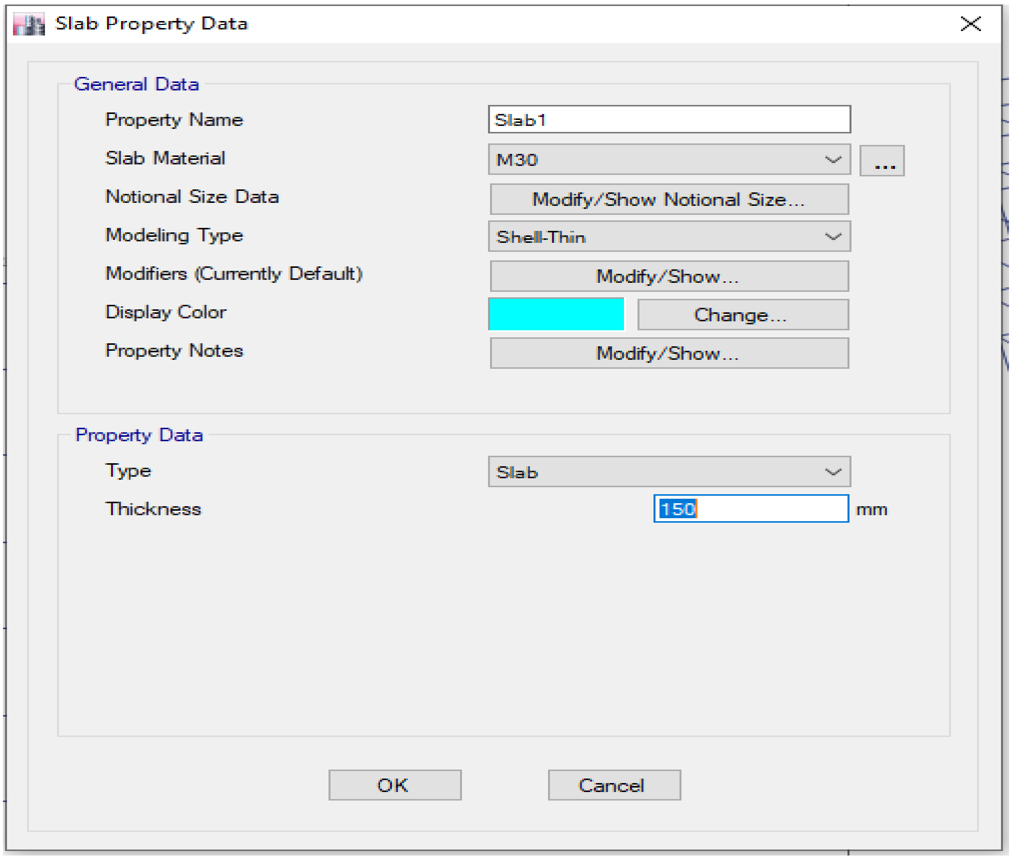
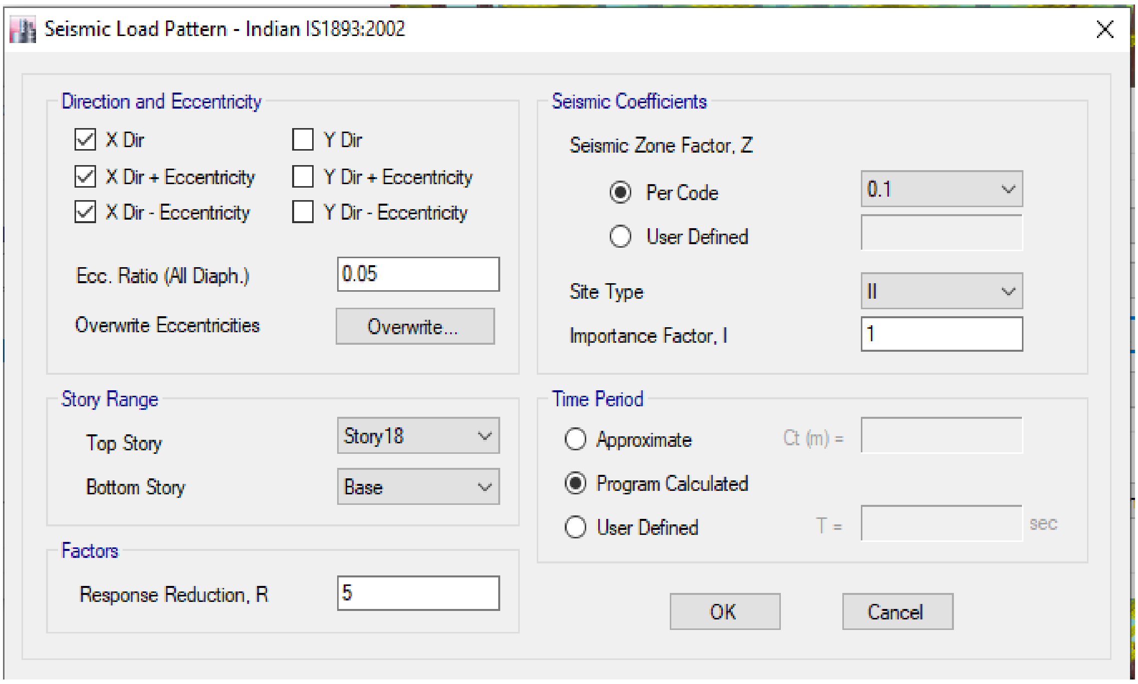


Fig 8 Defining section size of the beam.

Fig 9 Defining size of the slab

Step 5. Defining loading conditions where the static and dynamic load combinations are considered. Seismic load is considered as per IS 1893:2002 where the important factor is 1



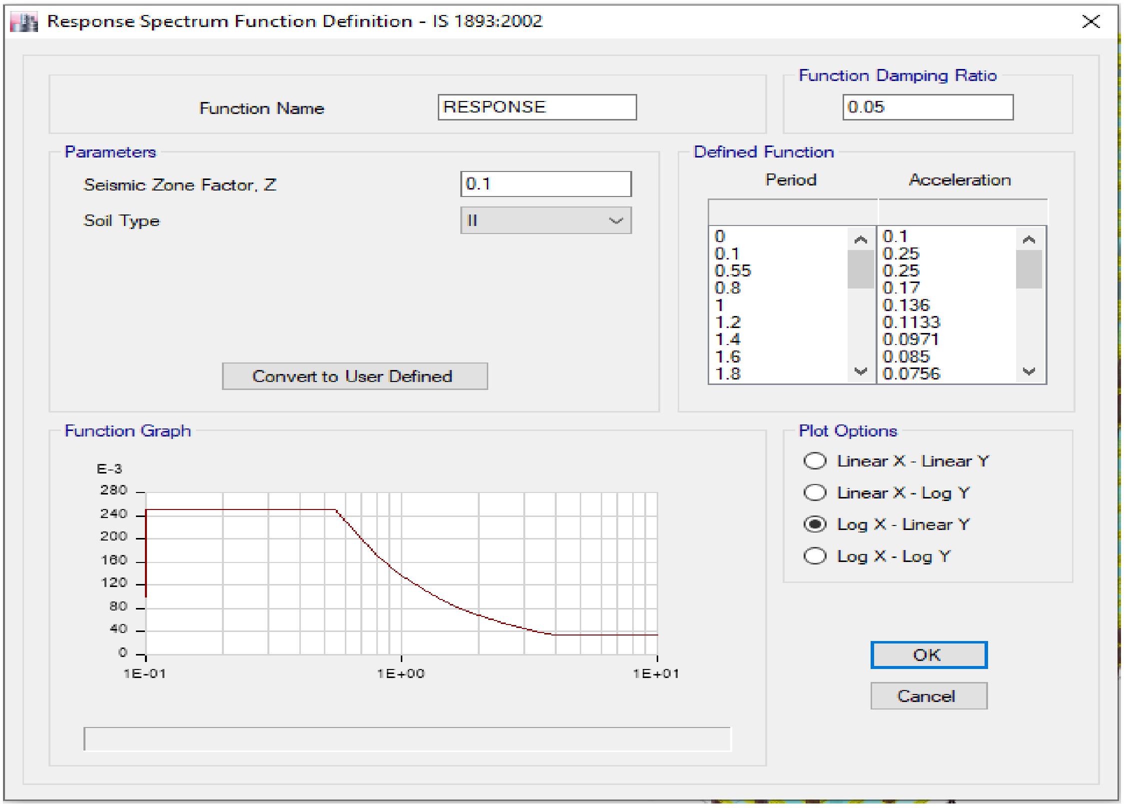
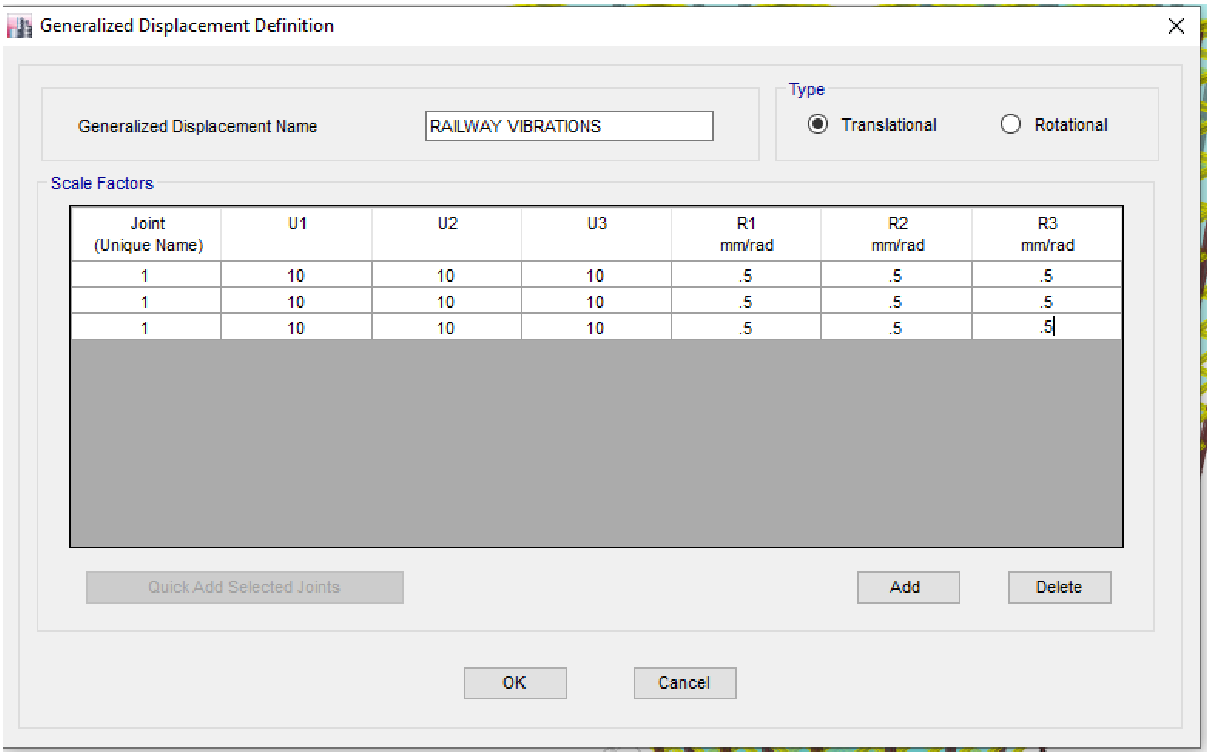


Fig 10 defining loading condition (Seismic Loading as per IS 1893:2016)

Fig 11 Response Spectrum Function



Step 6 Application of Railway Vibration.

Fig 12 Generalized Displacement due to Railway Vibration

Step 7 Analysing the structure and generating the results.

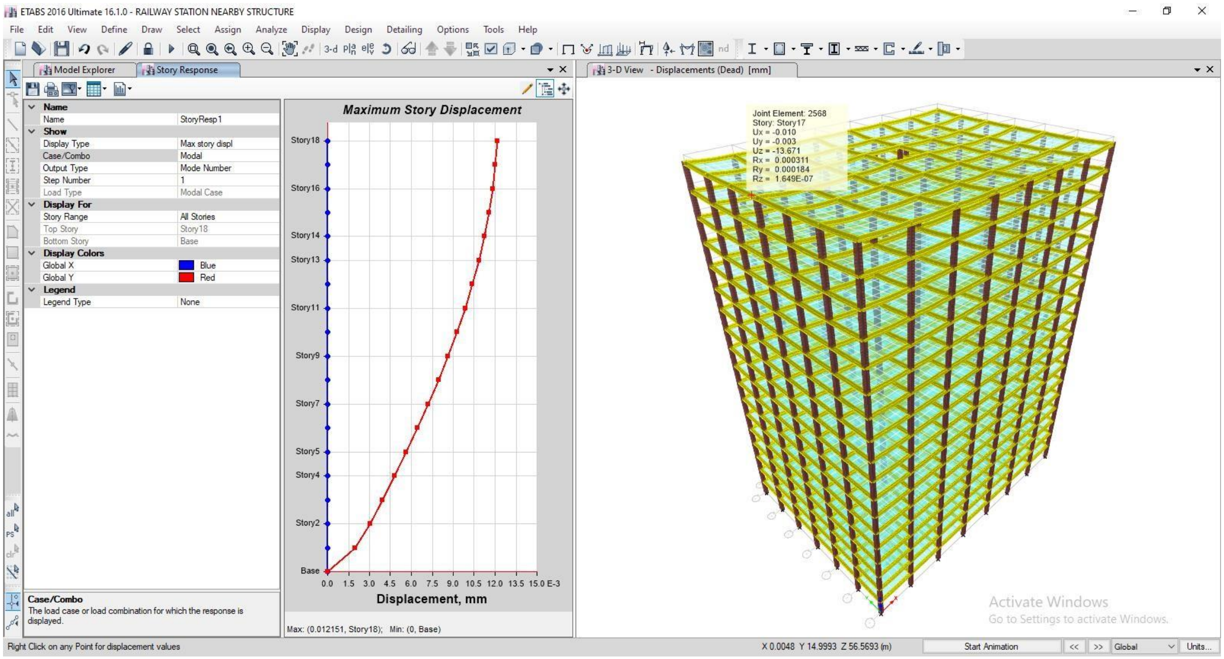


Fig 13 Stress Analysis

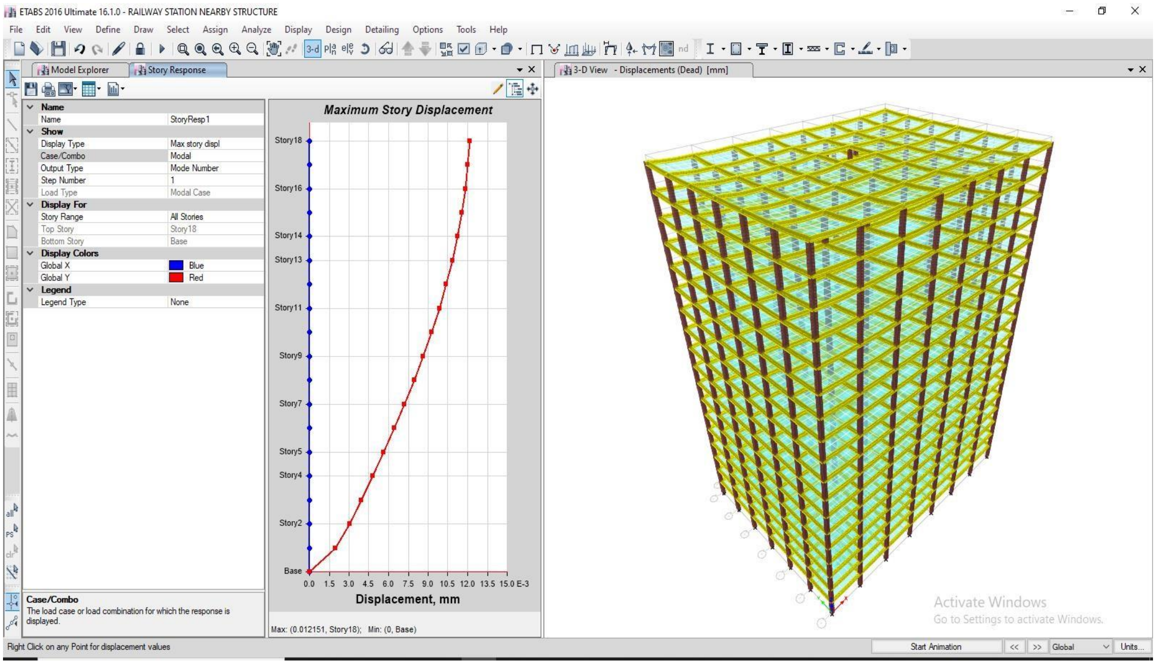


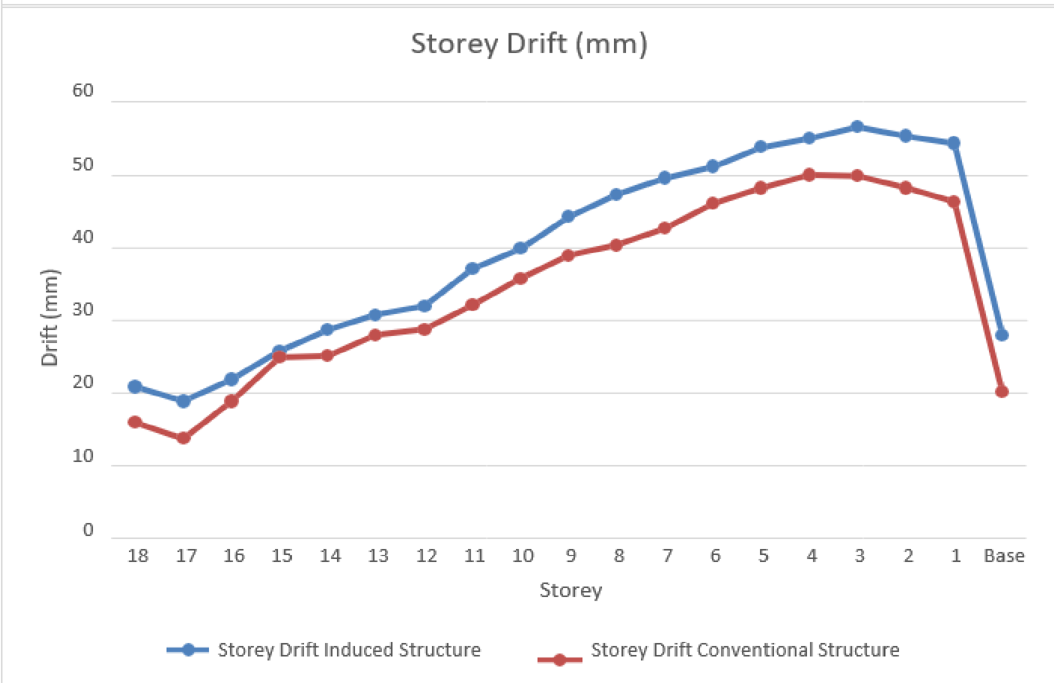
Fig 14 Value of Displacement.

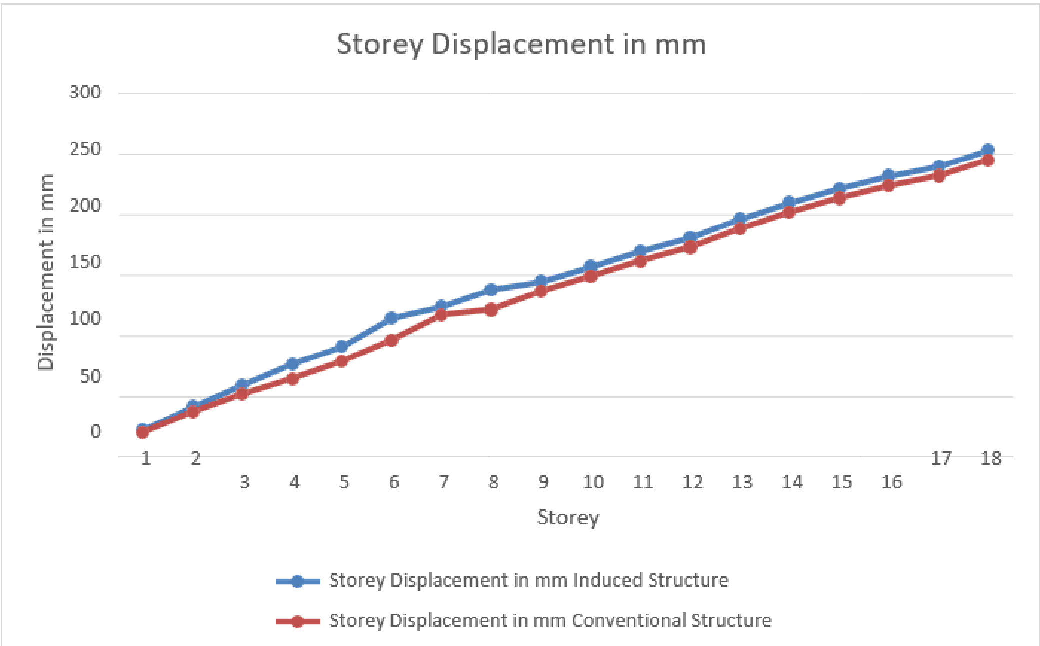
Table 1 Building Details

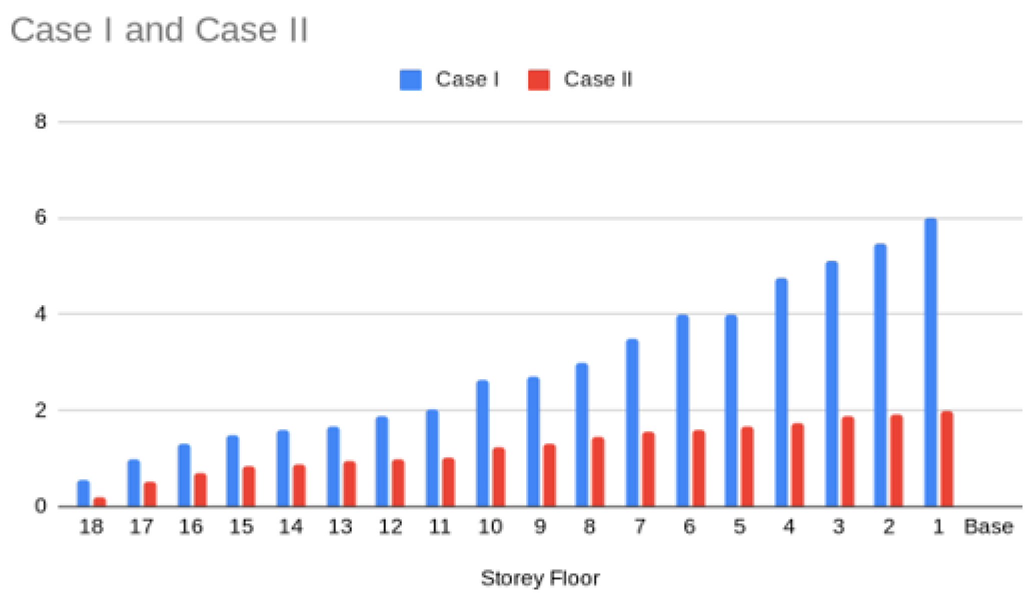
Building Details	
PARAMETERS	VALUE
Dimension of Beam	300mm x 450mm
Dimension of Column	450mm x 600mm
Thickness of Slab	150 mm
Thickness of outside wall	220 mm
Height of each storey	3m
Height of bottom storey	3.5m
Total height of Building at Roof level	45m
Dimension of Building	25m x 28m
Approximate Floor Area	700 m²
Live Load	4kN/m²
Floor Finish	1.5kN/m²
Grade of Concrete	M30
Grade of Reinforcing Steel	Fe-500
Density of Concrete	25kN/m²

Seismic Intensity	Moderate
Importance Factor	1
Zone Factor	0.16
Damping Ratio	5%

IV. Analysis Result







V. CONCLUSION

Story Displacement:

The near outcomes expressed that story dislodging was tracked down greatest in the event that I (structure inciting vibrations because of railroad tracks) and case II (customary construction). The maximum story removal was found at story 19 on the off chance that I as 253.2865 mm and case II was 245.1767376. As per code, most extreme or reasonable actuated vibration and at fourth floor for ordinary construction (0.005019) case II.

Story Shear:

The shear force acting at various story levels. Story shear is a power that follows up on any story toward a path opposite to its augmentation and is estimated in 'kN". For both the designs it is most noteworthy at base and it diminishes straightly towards top. For ordinary design Case II, most extreme story shear is 177.21kN (ground floor) and for structure initiated story dislodging should be equivalent to or under 0.4% vibration Case I, greatest story shear is 206.65kN

of complete structure tallness. Thus here the passable most extreme story removal = (0.4/100 x 45000) = 180 mm. For case II model, it is not exactly the cutoff (163.6 mm at rooftop level) while for case I model it is surpassing the breaking point (181.6 mm at rooftop level).The story dislodging continuously increments with expansion in story stature.

Story Drift:

The variety of story floats between various floors of both the models. Story float is the float of one level of a multi-story building comparative with the level underneath. Here the story floats differs along these lines for the two instances of designs. Greatest story float is seen at second floor (0.005862) for structure (ground floor).

Story Stiffness:

The variety of story firmness at various floor levels of both the models. Seismic tremor loads in structures by and large increment with the thickness of the structure. Yield strength is greatest level burden that can be applied to a structure. Story firmness is the flat power disseminated all through a structure separated by coming about sidelong shear strain in the structure (as a rule called float). Here story solidness changes non - directly for both the designs. For Case II, most extreme story solidness is 94.27kN/m (first floor and second floor) and for Case I structure greatest story firmness is 78.75kN/m (first floor and second floor).

Story Overturning Moment:

The variety of story upsetting minutes at various floor levels of both the models. Story toppling snapshot of a structure is the snapshot of energy fit for disturbing the story; that is where the story has been exposed to an adequate number of unsettling influences that it stops to be steady, it upsets, overturns, breakdowns, brings down and in the long run the construction fizzles. Here both the designs are protected, since there are no certain upsetting minutes and just unimportant negative toppling second towards base (- 0.0184kN/m for regular construction at ground floor and - 0.0279kN/m for structure incited vibration case II at ground floor level) the two of which can be approximated to nothing. Consequently it very well may be expected that both the designs have zero upsetting minutes and are henceforth protected.

Contrasted with ordinary structure, more removals, story floats and story shears were noticed for the structure initiated vibrations which suggests that structure close to rail line track shows most extreme relocation and story float.

By and large, the removals increments directly with stature of the structure; greatest story float is seen at second floor for Case I structure and at fourth floor for Case II construction; most extreme story shear force was seen between ground floor and second floor for regular design and at ground floor for Case I structure and the worth reductions straightly with tallness; story firmness changes non - straightly for both the designs with most extreme qualities at ground floor. Additionally there is unimportant or zero toppling minutes.

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