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EARTHQAKE ANALYSIS OF MULTI-STORIED BUILDINGS WITH FLOATING COLUMNS

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Abstract - *Rapid civilization leads to construction of thousands of buildings in urban areas. Now days, multi-storied R.C. framed structures are common in urban regions in the cities like Hyderabad, Bangalore, New Delhi, Chennai, Maharashtra, Pune etc. Due to thickly populated urban regions the buildings are extending vertically or going high or becoming more slender. Decades are evident that traffic volume in urban regions is high when compared to semi urban or rural regions. Therefore, the parking of vehicles is significant issue in urban regions leading to consider the parking storey in a building itself. Hence, parking is unavoidable in multi-storey buildings in urban regions in turn leading to create vertically irregular building (floating column buildings). To study the effect of vertically irregularity in buildings created due to parking or by some other instance. 6 mathematical Models of R.C. framed structures are created in ETAB 2015 version. From literature it can be observed that buildings which are having floating columns are more sustainable due to earthquake loading as compared to conventional R.C framed structure and unable to transfer the inertia forces safely to the ground. To study the effect of earthquake on this kind of buildings, Equivalent linear static and linear dynamic i.e. Response spectrum analysis have been considered. The parameters like fundamental natural time period, fundamental mode shapes with modal mass participation factor, storey displacements, storey drifts, and base shear have been studied in detail.*

INTRODUCTION

A characteristic Column is a perpendicular structural member which upkeep to plane structural members by means of their weights, moments, shear force, axial load etc., to retain the structure in safe condition and handover these loads to the ground. But now a days some columns are intended in such a manner that it does not extent to the ground, because of numerous architectural aspects. In those cases the columns handover above loads as a point load on a beam. This kind of column is termed as "Floating column". This Point load rises to abundant bending moment on beam so that area of steel required will be additional in such cases. While earthquake arises, the building with floating columns harms more as compared to the building without any floating columns because of discontinuity of structure & load transfer path.

The complete size, shape and geometry of a structure play a very vitalpart to keep structure safe while earthquake arises. As theory and practical study on buildings speaks that, earthquake forces established at different floor levels in a building requests to be taken down along the height to the ground by the shortest path; any deviation of discontinuity in this load transfer path results in poor performance of the building. In Earthquake study the main retort parameters are storey displacement, Storey drift, storey shear. These parameters are assessed in this paper and critical position of floating column building is observed. In this critical position the effect of cumulative section of beam and column in irregular building and regular building has been detected.

Floating column

The Columns whose junior end does not extend to the ground and handovers the above loading on a beam as a point load, such type of column are called as **Floating Columns.** Floating columns arises in use to bid extra open space for assembly hall of parking purpose. The floating column building does not generate any problem under only vertical loading condition but it rises susceptibility in lateral loading (earthquake loading) condition, due to vertical discontinuity. During the earthquake the lateral forces established in higher storey have to be transmitted by the proposed cantilever beams due to this the overturning forces are established over the column of the ground floor. A column is supposed to be a vertical member beginning from foundation level and shifting the load to the ground. The term floating column is also a vertical component which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn assign the load to other columns below it.

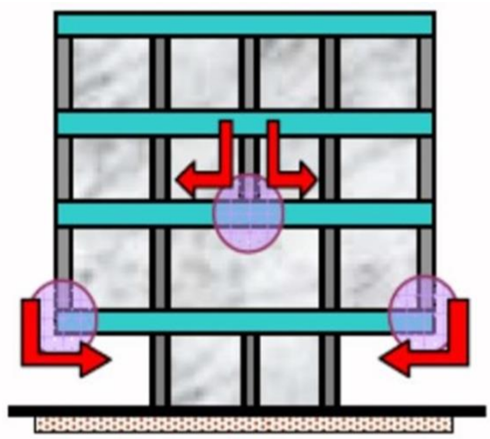


Fig.1: Floating Column

There are numerous projects in which floating columns are implemented, particularly above the ground floor, where transmission girders are hired, so that additional exposed space is obtainable in the ground floor. These exposed spaces may be essential for assembly hall or parking purpose. The transmission girders have to be intended and detailed suitably, precisely in earth quake zones. The column is a concentrated load on the beam which cares it. As far as analysis is worried, the column isoften assumed pinned at the base and is therefore taken as a point load on the transmission beam STAAD Pro, ETABS and SAP2000 can be used to do the scrutiny of this type of structure.

Fig.2 Park Avenue South in New York, United States

ADVANTAGES AND DISADVANTAGES OF FLOATING COLUMNS

Advantages

i) By overwhelming floating columns huge purposeful space can be providing which can be tilizing for storing and parking.

ii) In specific conditions floating columns may attest to be inexpensive in some cases.

iii)The floated column is significant for allocation the rooms and some portion can increase deprived of whole area.

Disadvantages

i) Not appropriate in lofty seismic zone since speedy modification in stiffness was detected.

ii) Pre requisite vast size of girder beam to sustenance floating column.

iii) Floating columns hints to stiffness misdeeds in building.

iv) Stream of load path rises by providing floating columns. The load from structural members shall be transferal to the foundation by the shortest conceivable path.

OBJECTIVE AND SCOPE

Objective

The objective of the current work is to revise:

i) The performance of multistory buildings with floating columns under earthquake excitations.

ii) Influence of soft story on structural performance of high rise building.

iii) To detect the structural enactment of the building having comparable diagonal strut and floating columns with soft storey when imperiled to lateral loads.

iv) Seismic retort of soft story structure with various shapes of shear wall.

Scope

In present study, an attempt has been made to study following aspects

i) Modeling of multi-story structure frames with and without floating column using finite element software, E-tabs.

ii) The column magnitudes having different dimensions are modeled from ground level to the upper storey level

iii) Dynamic analysis is done by Time History method is conceded out for all the models

iv) Comparative study is equipped for all frames with and without floating column

METHOD OF ANALYSIS

Linear analysis methods spring a clad proposition of flexible ability of the structures and specify where first resilient will rise. The linear static technique of analysis is limited to stunted, consistent buildings. Structural analysis is the method to evaluate a structural system to prediction its retorts and actions by using physical rules and mathematical calculation. The foremost detached of structural analysis is to govern core forces, stresses and deformation of structures under numerous load effect.

Equivalent Lateral force technique is one in which all the lateral masses at each floor are planned substantially. Then the structure performance is recognized by smearing the lateral masses acting at every story in X and Y directions. These lateral loads are designed by bearing in notice the various factors comparable the Response reduction factor(R), Zone factor (Z), Importance factor (I), Horizontal acceleration coefficient (Ah), Structural response factor (Sa/g) and Total seismic weight of building (W) as per the IS code 1893-2002.

LINEAR DYNAMIC

Dynamic analysis of structure is a slice of structural analysis in which comportment of stretchy structure endangered to lively loading is studied. Dynamic load constantly changes with time. Dynamic load comprises of wind, live load, earthquake load etc. Thus in general we can say virtually all the real life problems can be studied dynamically.

If active loads deviations regularly the structures response may be approximately by a static analysis in which inertia forces can be deserted. But if the dynamic load changes swiftly, the retort must be resolute with the help of dynamic analysis in which we cannot negligence inertial

Where, $[mm]$= mass matrix

$[kk]$= stiffness matrix

$[cc]$= damping matrix

$\{II\}$= unit vector

$xxg\ddot{g}(tt)$= ground acceleration

The mass matrix of every component in global route can be initiate out using following manifestation:

$$m = [T^T]\,[m_e]\,[T]$$

$$[m_e] = \frac{\rho A L}{420}\begin{bmatrix} 140 & 0 & 0 & 70 & 0 & 0 \\ 0 & 156 & 22L & 0 & 54 & -13L \\ 0 & 22L & 4L^2 & 0 & 13L & -3L^2 \\ 70 & 0 & 0 & 140 & 0 & 0 \\ 0 & 54 & 13L & 0 & 156 & -22L \\ 0 & -13L & -3L^2 & 0 & -22L & 4L^2 \end{bmatrix}$$

$$[T] = \begin{bmatrix} C & S & 0 & 0 & 0 & 0 \\ -S & C & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & C & S & 0 \\ 0 & 0 & 0 & -S & C & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

The resolution of comparison of motion for any itemized forces is tough to succeed, primarily due to link variables {x} in the fleshly coordinate. In genre superposition analysis a group of normal coordinate's i.e. principal coordinate is distinct, such that, when uttered in those

force which is equal to mass time of acceleration (Newton's 2nd law).

Mathematically F = M x a Where F is inertial force, M is inertial mass and a is acceleration.

TIME HISTORY ANALYSIS

A linear time history analysis disables all the drawbacks of modal response spectrum analysis, provided non-linear activities is not complex. This way necessitates greater computational exertions for scheming the response at distinct time. One interesting benefit of such practice is that the comparative symbols of retort abilities are conserved in the response histories. This is significant when interface effects are reflected in design among stress resultants.

Here dynamic response of the plane frame model to quantified time history well-suited to IS code spectrum and Electro (EW) has been assessed.

The equation of motion for a multi degree of freedom system in matrix form can be conveyed as

$[mm]\{x\ddot{x}\}+ [cc]\{x\dot{x}\}+[kk]\{xx\}=-xxg\ddot{g}(tt)[mm]\{II\}$

coordinates, the equations of motion suits undid. The physical coordinate {x} may be linked with normal or principal coordinates {q} from the alteration expression as,

$\{ xx \} = [\Phi]\ \{ \}$

$[\Phi]$ is the modal matrix

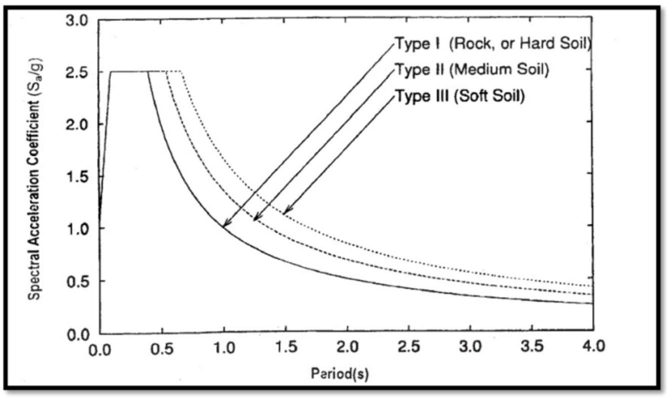
Time derivative of { } are, $\{x\dot{x}\} = [\Phi]\ \{q\dot{q}\}$

$\{x\ddot{x}\} = [\Phi]\ \{q\ddot{q}\}$

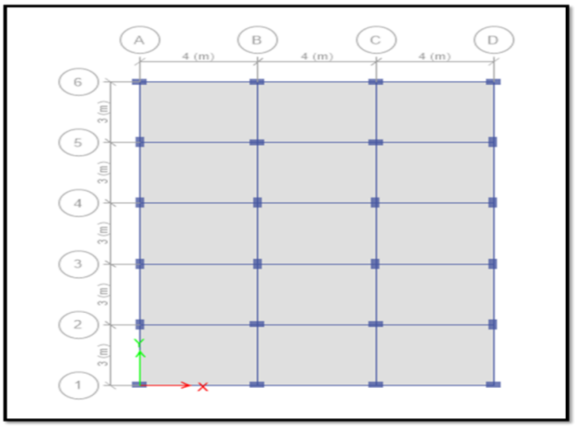
Switching the time derivatives in the equation of motion, and pre-multiplying by $[\Phi]$T results in,

$[\Phi]TT[mm][\Phi]\{\ddot{q}\}+[\Phi]TT[cc][\Phi]\{q\dot{q}\}+[\Phi]TT[kk][\Phi]\{q\}=(-xxg\ddot{g}(tt)[\Phi]TT[mm]\{II\})$

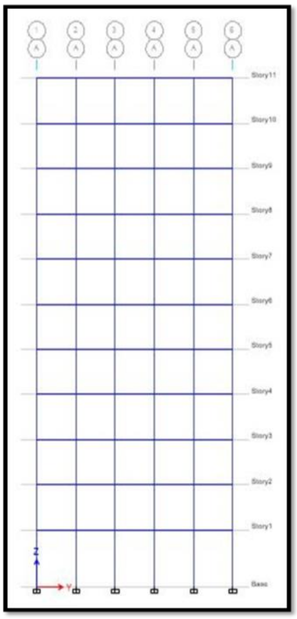
Further clearly it can be signified as follows:

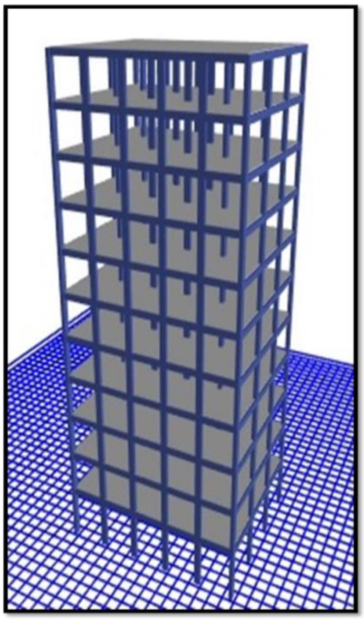


Building	G +10
Typical storey Height	3.15m
Plan Dimensions	12m x 15m
Rectangular Column	350mm x 600mm
Size of Beams	300mm x 450mm
Slab thickness	125mm
Thickness of Wall	200mm
Shear wall thickness	230mm
Unit weight of RCC	30 KN/m^2
Unit weight of Masonry	20 KN/m^2
Live Load Intensity on Floor	3 KN/m^2
Weight of Floor finish	1 KN/m^2
Earthquake load	As per IS 1893
Seismic Zone	II
Importance factor	1.5
Response reduction factor	5
Concrete Grade Mix for Slabs, Beams, columns	M30
Grade of Rebar Used	Fe500



PLAN OF THE BUILDING





ELEVATION **3D VIEW**

MODELLING OF STRUCTURE

SOFTWARE SYNOPSIS

E-TABS is an engineering software invention that outfits to multi-story structure analysis and plan. Modeling tools and templates, code-based load prescriptions, analysis procedures and solution techniques, all coordinate with the grid-like geometry exclusive to this class of structure. Basic or radical systems under static or dynamic conditions may be assessed using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history investigates may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and united sorts sort uses of any complexity useful to appliance.

ETABS categories persuasive and totally integrated basics for plan of equally steel and reinforced concrete structures .The program affords the manipulator with selections to generate, adapt, consider and plan structural models, all from within the similar operator interface. The program delivers a cooperating atmosphere in which the operator can revise the stress conditions, sort appropriate deviations, such as revising member properties, and re-examine the results short of the essential to re-run the analysis. The yield in together graphical and tabulated presentations can be gladly printed. In this project seismic analysis of six dissimilar models is evaluated using E-TABS-2015. The assessments of outcomes are in terms of storey displacement, Storey drift, lateral forces, Fundamental Time period, storey shear, modes shapes etc.

RESULTS AND DISCUSSIONS

The Following features have been considered and the results are selected from the computer program

- Storey Displacement
- Storey Drift
- Base shear
- Fundamental Time Period
- Mode Shapes

CHAPTER6

RESULTS ANDDISCUSSIONS

6.1 GENERAL

In this chapter we will debate around the outcomes which we attained from ETABS after evaluating the models and results have been specified in a tabular system and graphical illustration for well empathetic.

The Following features have been considered and the results are selected from the computer program

- Storey Displacement
- Storey Drift
- Base shear
- Fundamental Time Period
- Mode Shapes

6.1.1 STOREY DISPLACEMENT:

Storey displacement is the lateral effort of the building produced by lateral force. The bent shape of a building is utmost vital and most visibly point of evaluation for any building. No other factor of assessment can contribute a superior idea of activities of the structure than comparison of storey displacement. The Displacement should be identical less in a structure or else the structure may ruin an the entire strength will be condensed and there will be no human comfort.

Model 1:

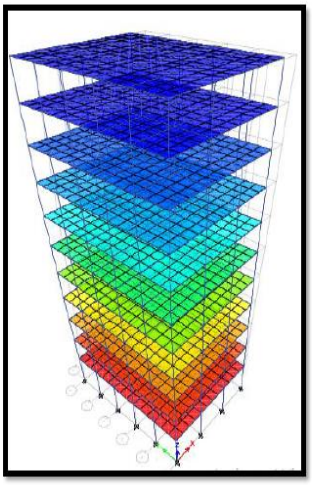


Fig-30: Mode-1 Time period 1.972 sec

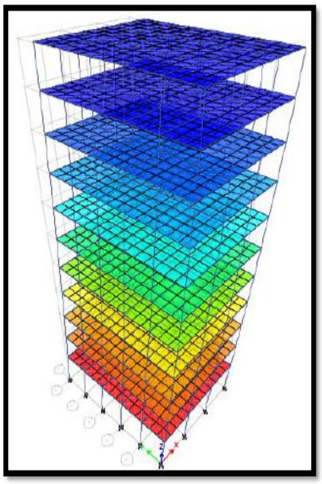


Fig-31: Mode-2 Time period 1.789 sec

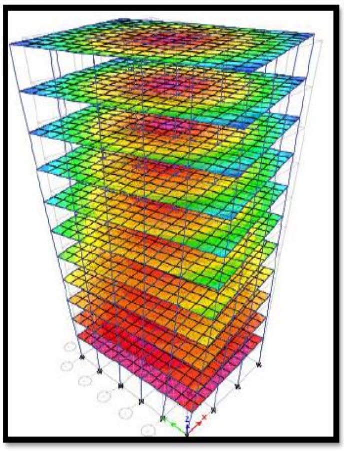


Fig-32: Mode-3 Time period 1.542 sec

Model 2:

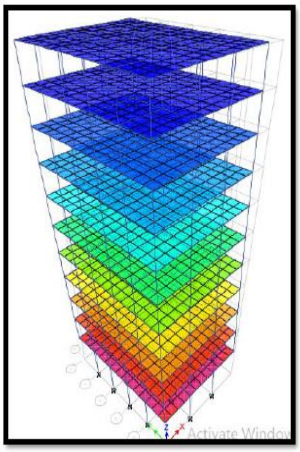


Fig-33: Mode-1 Time period 1.857 sec

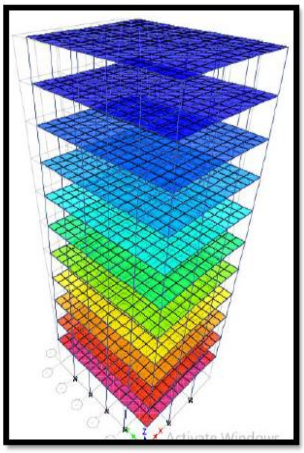


Fig-34: Mode-2 Time period 1.66 sec

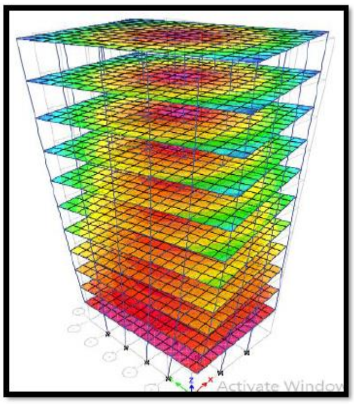


Fig-35: Mode-3 Time period 1.43 sec

CHAPTER 7

CONCLUSIONS&SCOPE FOR FUTURESTUDY

7.1 CONCLUSIONS

[1].Displacement analysis reveals that models with brick infill panels shows huge reduction in overall displacements when we compare with all other building models. Therefore consideration of brick infill panel in turn increases the stiffness of the building and should be handling carefully for vertically irregular buildings.

[2]. Brick infill panel cannot be ignored for practical design purposes as far as vertically irregular buildings are concern.

[3]. When we study Model 2,3,4 we conclude that, the storey with floating columns are very much flexible in transferring the inertia forces generated by seismic loading.

[4]. Storey with floating columns is always weak therefore special concentration should be given when we are handling any floating columns.

[5]. Brick infill panels play a vital role in transformation of seismic forces throughout the building, this indicates by storey drift analysis of Model 6when compared to Model 1, 2, 3, & 4.

[6]. When we study for base shear analysis we conclude that Model 1, 2, 3 & 4 are showing nearly same responses. When we see Model 5 & 6 the base shears are considered large enough. Therefore we could say that vertical stiffeners like core wall and brick infill panels will impart huge resistant to seismic loading in turn improves the overall response.

[7]. The fundamental natural time period is huge enough for Model 1 when we compare with mathematical models. Model 6 showing substantially least amount of fundamental natural time period for all the 3 modes of the building. Therefore, we can conclude the fundamental natural time period drastically reduce when we consider the impact of vertical and lateral stiffening elements.

[8]. Vertically irregular building models are showing nearly same response as of Model 1.

[9]. When we evaluate modal mass participation analysis for fundamental modes i.e. 1, 2, 3. Model 5th and Model 6th are showing non-linear performance due to presence of brick and core wall in the Model 6th and core wall in Model 5th and floated columns in the ground storey. Though the fundamental 1st mode Modal Mass Participation is 33.98% in Y-translation & 49.04% torsion for Model 5 and 32.69% Y-translation & 65.56% torsion for Model 6. Therefore it can be conclude that ground storey floated columns are more dangerous to transfer the lateral load safely ground.

SCOPE FOR FUTURE STUDY

[1]. The study can be extended for future works when the buildings are situated in weak soil zone in which the soil structure interaction can be done.

[2]. It can also be extended for future work where the buildings are situated in highly terrain areas.

[3]. It can also be extended for non-linear seismic analysis such as time history & push over analysisin which overall performance of buildings are predicted in a better sense.

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