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Seismic Analysis of Multistory Building with Floating Column

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Abstract : *The term floating column is a vertical member which ends at its lower level rests on a beam which is a horizontal member. The beams in turns transfer the load to other column below it. In present scenario buildings with floating column is a typical feature in the modern multistory construction in India. Such features are highly undesirable in building built in seismically active areas. In the unavoidable circumstance floating columns are adopted in building. Brief analysis will be made for the structure with and without floating column. Floating columns are placed different story levels and different position in the structure, for different seismic excitation by changing the frequency of vibration using ETABS standard Finite element analysis package. Final results for maximum story displacement, maximum inter-story drift, story base shear, overturning moment are compared with different seismic excitation. The most safer and economical method to reduce the cost of floating column beam is suggested.*

Keywords - *Dynamic Loading, ETABS, Finite Element model, Floating column, Seismic analysis.*

I. Introduction

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few stores wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity.

Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/site situation) at its lower level (termination Level) rest on a beam which is a horizontal member. The beam in turn transfers the load to other columns below it.

Floating column model

II. Methodology

2.1 GENERAL

The design of structure consists of two parts, determination of forces called structural analysis and design of suitable section to resist these forces is called structural design.

High rise building means the building are tall say, "more than twelve storey's" or in present context, high-rise building is defined as a structure "if height more than 35 meter" says tall building.

Analysis and design of this building was done by using the design software package ETABS which is an integral finite element nonlinear analysis and design program. ETABS will eliminate the countless man-hours required to properly load the structure by automating the forces caused by wind, earthquakes, snow, or vehicles.

With an array of advanced analysis capabilities including linear static, response spectra, time history, cable, pushover and non-linear analyses,

2.2 ARCHITECTURAL DETAILS

To study the behavior of high rise building, a typical residential building plan with car parking as ground floor was selected with area covering 38.5 m x 31.2 m.

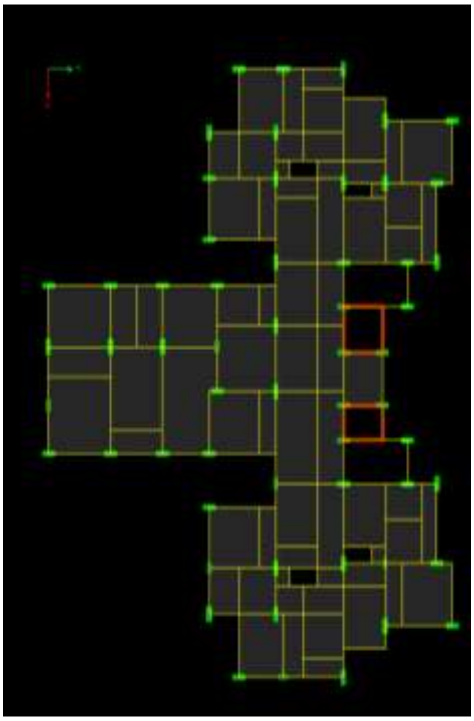

Fig. 3.2 Typical Floor Beam Framing Plan

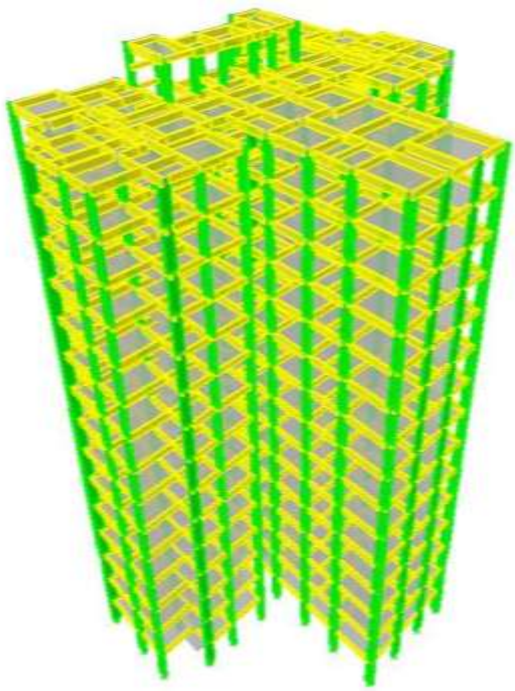

Fig. 3.3 Model in 3D View

2.3 GENERAL DATA

i) Type of structure - Rigid jointed frames
ii) Number of stories – Ground floor + Car Parking+14 stories + Terrace
iii) Floor Area
Ground floor and Car Parking floor – 700.00sq.m.
Typical floors – 700.00sq.m.
iv) Floor to floor height
Ground floor and Car Parking floor - 2.85m
Typical floors – 3.00m
iv) Materials
Concrete – M35
Steel - Fe 500
v) Loadings: As per IS 875 Part-1,2 & 5.
vi) Slab thickness
Ground floor and Car Parking floor – 175mm
Typical floors – 150mm
vii) Wall thickness
Main wall thickness – 230mm
Secondary wall thickness – 115 mm
viii) Concrete design code – IS 456-2000
ix) FOS (concrete) – 1.5
x) FOS (steel) – 1.15

2.4. MODELLING

Modelling is very important step involved in analysis of structure. Modelling is done prior to analysis. In this step the structure is stimulated as it is in plan. Draw a series of point, line and area objects that represent your building using the various drawing tools available within the graphical interface. Assign structural properties of sections and material properties to objects.

Assign meshing parameters to area objects if they are not horizontal membrane slab or deck/plank sections that the program will automatically mesh into the elements needed for the analysis model.

2.5 PROJECT BRIEF

Structure was first analyzed and designed without floating column. Then to study the detail behavior of floating column some columns are purposely introduced as floating column in various locations in the same structure. Due to the provision of floating column in the structure, strength of the structure gets reduced. To strengthen the structure, floating column and respective beam below floating column various methods adopted. They are

Normal R.C.C. section

Steel section

Composite section

FIG. 3.4 PROVIDED FLOATING COLUMN LOCATION

2.5.1 NORMAL R.C.C. SECTION

Formally the multi-story buildings in India were constructed with R.C.C framed structure or Steel framed structure. Depending on the quality and proportion of the ingredient used in the mix, the properties of concrete vary almost as widely as different kinds of stones. Concrete has enough strength in compression, but very little in tension. The steel bars as steel reinforcement embedded in concrete, takes the tensile stress.

2.5.2 STEEL SECTION

Steel has always been more preferred to concrete because steel offers better tension and compression thus resulting in lighter construction. Usually structural steel uses three dimensional trusses hence making it larger than its concrete counterpart. The most commonly found steel beam is the. I beam or the wide flanged beam. Structural steel is durable and can be well molded to give the desired shape to give an ultimate look to the structure that has been constructed.

2.5.3 COMPOSITE SECTION

Steel columns in multi-storey buildings need protection from fire. This is often provided by encasement in concrete. The presence of the concrete is allowed for in two ways. It is assumed to resist a small axial load, and to reduce the effective slenderness of the steel member, which increases its resistance to axial load. Resistance to bending moment is assumed to be provided entirely by the steel.

2.6 DEFINING PARAMETERS

Defining the parameters for the model is to assign the different conditions and data's in the model. Basic steps for defining the parameters:

2.6.1 ASSIGN SUPPORT CONDITION

Supports are specified as PINNED, FIXED, or FIXED with different releases (known as FIXED BUT). Here I use fixed support at bottom for all models. A fixed support has restraints against all directions of movement.

2.7 LOADS CONSIDERED

2.7.1 DEAD LOADS

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m" and 25 kN/m" respectively.

2.7.2 IMPOSED LOADS

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. .

2.7.3 WIND LOAD

Wind load in X and Y direction (WL- X and Y)
Basic wind speed – 50 m/s (Chennai)
Terrain category – 3 (Obstruction height up to 10m only)
Structure class – B
Risk factor (k1) - 1
Terrain factor (k2) – 1.09
Topography factor (k3) - 1

2.7.4 SEISMIC LOAD

DESIGN LATERAL FORCE

Earth quake load in X and Y direction (EQ - X and Y)
Earthquake zone – II, III & IV
Zone factor – 0.10, 0.16 & 0.24
Importance factor – 1 (Ordinary building)
Response reduction factor – 3 (OMRF)
Soil type – I (Hard soil)

2.7.5 DESIGN SEISMIC BASE SHEAR

The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:
Vb = Ah W

2.7.6 FUNDAMENTAL NATURAL PERIOD

The approximate fundamental natural period of vibration (Ta), in seconds, of a moment-resisting frame building without brick in the panels may be estimated by the empirical expression:
Ta=0.075 h0.75 for RC frame building
Ta=0.085 h0.75 for steel frame building

This excludes the basement storey's, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storey's, when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:
T = (0.09 x H)/d0.5 (For R.C.C. Frame)
T = 0.693 Sec.
Natural frequency = 2π/Ta
= 2x π/0.693
= 9.062 Hz.

2.8 DEFINED LOAD COMBINATIONS

TABLE 3.1 LOAD COMBINATIONS

COMBINATION OF EQ LOADS	COMBINATION OF WIND LOADS
DL+0.25LL	1.5(DL+LL)
1.2(DL+LL+EQ(+)X)	1.2(DL+LL+WL(+)X)
1.2(DL+LL+EQ(-)X)	1.2(DL+LL+ WL (-)X)
1.2(DL+LL+EQ(+)Y)	1.2(DL+LL+ WL (+)Y)
1.2(DL+LL+EQ(-)Y)	1.2(DL+LL+ WL (-)Y)
1.5(DL+EQ (+)X)	1.5(DL+WL (+)X)
1.5(DL+EQ (-)X)	1.5(DL+WL (-)X)
1.5(DL+EQ (+)Y)	1.5(DL+WL (+)Y)
1.5(DL+EQ (-)Y)	1.5(DL+WL (-)Y)
0.9DL+1.5EQ(+)X	0.9DL+1.5WL(+)X
0.9DL+1.5EQ(-)X	0.9DL+1.5WL(-)X
0.9DL+1.5EQ(+)Y	0.9DL+1.5WL(+)Y
0.9DL+1.5EQ(-)Y	0.9DL+1.5WL(-)Y

2.9 ANALYSIS
2.9.1 CODAL CRITERIA FOR THE BUILDING TO BE EXAMINED

Structures are designated as structurally regular or irregular. A regular structure has no significant discontinuities in plan, vertical configuration, or lateral force resisting systems. An irregular structure, on the other hand, has significant discontinuities such as horizontal irregularities and vertical irregularities.Regular and symmetrical structures exhibit more favorable and predictable seismic response characteristics than irregular structures. Therefore, the use of irregular structures in earthquake-prone areas should be avoided if possible. However, the IBC does not prohibit irregular structures. Instead, it contains specific design requirements for each type of irregularity. In some cases of irregularity, the static lateral force procedure as described in this lesson is not permitted, and a dynamic procedure is required.

a) Regular buildings –Those greater than 40 m in height in Zones IV and V and those Greater than 90 m in height in Zones II and III required dynamic analysis.

b) Irregular buildings – All framed buildings higher than 12m in Zones IV and V and those greater than 40m in height in Zones II and III required dynamic analysis.

2.9.2 CHECK FOR STATIC OR DYNAMIC ANALYSIS?

PLAN IRREGULARITY

Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction.

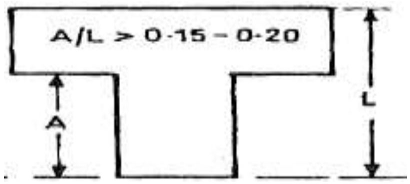

Fig 3.9 Condition for Plan Irregularity As Per Is-1893

(17.5/31.2)>0.15 to 0.20

0.56 > 0.15 to 0.20

So there was plan irregularity in taken plan.

2.9.3 DYNAMIC ANALYSIS

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following Buildings.

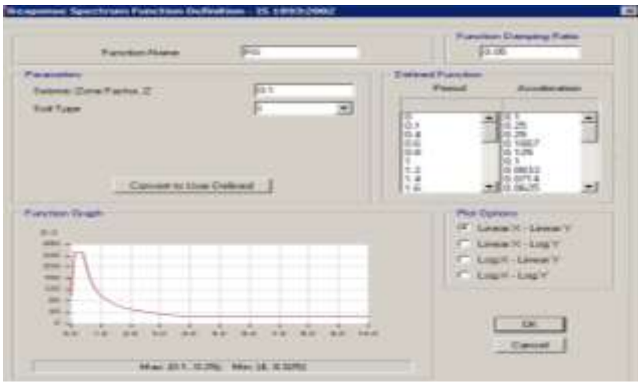

Fig 3.11 Response Spectrum Function As Per IS-1893

III. Result And Discussion

3.1 GENERAL

In this chapter the analytical results of all the structure with and without floating column and its respective beams with different types of seismic zones results are compared and discussed its behavior.

3.2 BENDING MOMENT IN FLOATING COLUMN-BEAM

From the model without floating column shows very less amount of bending moment value when compare to other models. From that graphs steel model gives lesser moment value when compare to composite model. Beam location no. 6 was an intermediate beam shows higher amount of bending moment value than beam location no.1 was an outer beam. Bending moment consideration steel beam shows better result than other models in zone II, III, and IV.

3.3 SHEAR FORCE IN FLOATING COLUMN-S BEAM

From the model without floating column shows very less amount of shear force value when compare to other models. From that graphs steel model gives lesser shear force value when compare to composite model. Composite model shows intermediate values between concrete and steel. Beam location no. 6 was an intermediate beam shows higher amount of shear force value than beam location no.1 was an outer beam. Shear force increment on concrete model beams from zone 2 to zone 4 as rapid incremental behavior when compare with steel and composite section. Shear force consideration steel beam shows better result than other models in zone II, III, and IV.

3.4 DEFLECTION IN FLOATING COLUMN- BEAM

From the deflection value in composite model shows higher value in all 3 defined seismic zones for beam in outer condition. But for beam in intermediate condition steel beam gives higher deflection in all 3 defined seismic zones. Beam without out floating gives very negligible amount of deflection in considered conditions. For deflection consideration concrete gives good result in both intermediate and outer beam condition.

3.5 STORY WISE DISPLACEMENT

From the model, in seismic zone – 2 concrete models gives maximum displacement for Earth quake in X direction. And all other models give merely same results for zone – 2 for direction X. In model composite and steel models gives maximum displacements and other model shows comparatively lesser value.

From the model, in seismic zone – 2 concrete models gives maximum displacement for Earth quake in Y direction. And all other models give merely same results for zone – 2 for direction Y. from model composite shows fewer displacements. For higher seismic zone steel and composite are quite suitable than concrete, because of the stiffness of steel is less than concrete.

IV. Summary And Conclusion

4.1 SUMMARY

In this chapter the analytical results of the structure with and without floating column and its respective beams for different types of seismic zones results are compared and its behavior was discussed.

4.2 CONCLUSION

For beams supporting the floating column member, among the different sections steel section is more suitable than other sections. From the shear force and bending moment consideration and it gives better result. In case of deflection criteria concrete gives very good result. But deflection in steel section was in permissible limit only. In case of high risk for fire and corrosion, composite section was preferable than steel section.

In concrete section the value increases by rapidly for increasing of seismic zones. But in case of steel and composite section shear force, bending moment and deflection values increase gradually for higher seismic zone. Based on the material behavior of the member on seismic action, concrete show least resistance compared with steel and composite section.

For floating column member from all 3 defined seismic zones composite gives higher moment value than other 2 models. Concrete model gives less value of bending moment than steel model. In case of shear force, steel gives better performance in all 3 defined seismic zones. Even concrete model also gives comparatively same results. In case of displacement for higher seismic zone steel and composite are quite suitable than concrete, because of the stiffness of steel is less than concrete.

The study on base shear variation indicates at zone 2 concrete members are sufficient for resisting seismic activities. For zone 3, due to the need of ductility steel sections are more preferable than concrete. For zone 4, steel or composite sections are necessary to resist huge seismic forces.

One of the demerits of including floating column was sudden rise in shear force and bending moment at the bottom story. But remaining stories will increase it values gradually.

Irregular mass concentration for different stories will cause unsymmetrical transpose loading during seismic activities.

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