DESIGN AND ANALYSIS OF G+12 WITH AND WITHOUT FLOATING COLUMNS USING E-TABS

BHUKYA NAGARAJU,
(M.Tech Structural)
Mandava Institute Of Engineering & Technology
Vidya Nagar, Jaggayyapeta, Krishna(Dt)

M.SUNEETHA Asst. Prof.
M.Tech (Structural)
Mandava Institute Of Engineering & Technology
Vidya Nagar, Jaggayyapeta, Krishna(Dt)

ABSTRACT

The columns which are supported on a beam instead of rigid foundation are called as floating columns. Many of the buildings in India are constructed with floating columns. This is primarily beam adopted to accommodate parking or reception lobbies in the first story. The earthquake force generated at different floor level of the building need to be carried out to the foundation by the shortest possible way which may not be the case when floating columns are provided. Providing floating columns may satisfy some of the functional requirements but structural behavior changes abruptly due provisions of floating columns. The flexural and shear demand of the beams which supports floating columns are much higher than surrounding beams, this leads to stiffness irregularities at a particular joint. In present scenario buildings with floating column is a typical feature in the modern multi-storey G+12 construction in urban India. Such features are highly undesirable in building built in seismically active areas. This study highlights the importance of explicitly recognizing the presence of the floating column in the analysis of building. Alternate measures, involving stiffness balance of the first storey and the storey above, are proposed to reduce the irregularity introduced by the floating columns. The component backbone modeling for the concrete columns also had to change so that convergence could be reached in the ETABS and the Perform-3D models. To prevent a backbone with negative stiffness, a conservative backbone was used, in which the nominal capacity was taken at the onset of steel yielding, and then a line was drawn to the peak moment capacity. At this point, the column was assumed to have lost any significant capacity. Because the rotational demand was relatively small for the columns in this project, this ultimate point of rotation was never reached.FEM codes are developed for 2D multi storey frames with and without floating column to study the responses of the structure under different earthquake excitation having different frequency content keeping the PGA and time duration factor constant. The time history of floor displacement, inter storey drift, base shear, overturning moment are computed for both the frames with and without floating column.

INTRODUCTION:

Many urban multi-storey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height.

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 storey 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. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Buhl earthquake. Buildingswith columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

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) rests on a beam which is a horizontal member

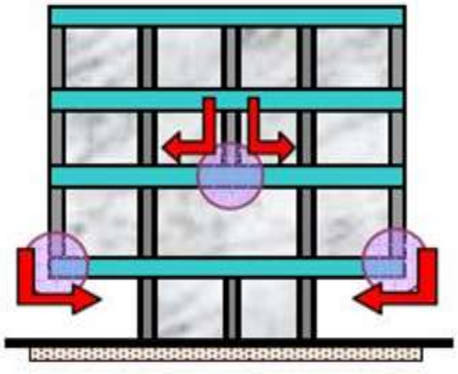


Fig 1.1 Hanging or floating columns

OBJECTIVE AND SCOPE OF PRESENT WORK:

The objective of the present work is to study the behaviour of multi-storey buildings with floating columns under earthquake excitations.Finite element method is used to solve the dynamic governing equation. Linear time history analysis is carried out for the multi-story buildings under different earthquake loading of varying frequency content. The base of the building frame is assumed to be fixed.

2.0 REVIEW OF LITERATURES:

[1] Maison and Neuss (1984) Members of ASCE have preformed the computer analysis of anexisting forty four story steel frame high-rise Building to study the influence of various modeling aspects on the predicted dynamic properties and computed seismic response behaviours. The predicted dynamic properties are compared to the building's true properties as previously determined from experimental testing. The seismic response behaviours are computed using the response spectrum (Newmark and ATC spectra) and equivalent static load methods.

[2] Maison and Ventura(1991) Members of ASCE computed dynamic properties and response behaviours OF THIRTEEN-STORY BUILDING and this result are compared to the true values as determined from the recorded motions in the building during two actual earthquakes and shown that state-of-practice design type analytical models can predict the actual dynamic properties.

[3] Arlekar, Jain &Murty, (1997) said that such features were highly undesirable in buildingsbuilt in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. They highlighted the importance of explicitly recognizing the presence of the open first storey in the analysis of the building, involving stiffness balance of the open first storey and the storey above, were proposed to reduce the irregularity introduced by the open first storey.

[4] Awkar and Lui (1997) studied responses of multi-story flexibly connected frames subjectedto earthquake excitations using a computer model. The model incorporates connection flexibility as well as geometrical and material nonlinearities in the analyses and concluded that the study indicates that connection flexibility tends to increase upper stories' inter-storey drifts but reduce base shears and base overturning moments for multi-story frames.

[5] Balsamoa, Colombo, Manfredi, Negro & Prota(2005) performed pseudo dynamic tests onan RC structure repaired with CFRP laminates. The opportunities provided by the use of Carbon Fibre Reinforced Polymer (CFRP) composites for the seismic repair of reinforced concrete (RC) structures were assessed on a full-scale dual system subjected to pseudo dynamic tests in the ELSA laboratory. The aim of the CFRP repair was to recover the structural properties that the frame had before the seismic actions by providing both columns and joints with more deformation capacity. The repair was characterized by a selection of different fiber textures depending on the main mechanism controlling each component. The driving principles in the design of the CFRP repair and the outcomes of the experimental tests are presented in the paper. Comparisons between original and repaired structures are discussed in terms of global and local performance. In addition to the validation of the proposed technique, the experimental results will represent a reference database for the development of design criteria for the seismic repair of RC frames using composite materials.

3.0 METHODOLAGY

PERFORM 3D MODEL ANALYSIS BY USING ETABS SOFTWARE:

ETABS:

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS features an intuitive and powerful graphical interface coupled with unmatched modelling, analytical, and design procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of geometrical nonlinear behaviors, making it the tool of choice for structural engineers in the building industry.

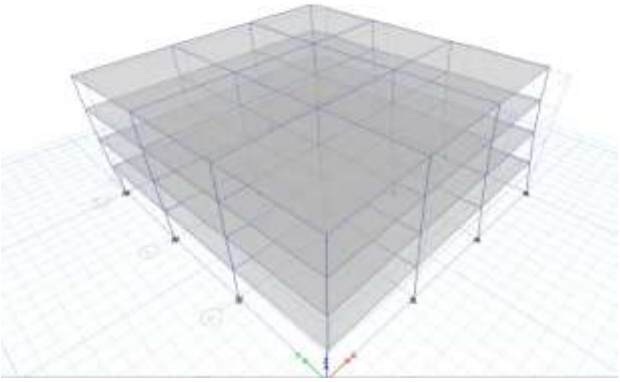


Fig 3.1 Perform-3D Model

RUNNING ANALYSIS

Number of joints = 98

With restraints = 34

With mass = 18

Number of frame/cable/tendon element = 158

Number of shell elements = 36

Number of constraints/welds = 4

Number of load patterns = 13

Number of acceleration loads = 6

Number of load cases = 4

4.0 ANALYSIS IN ETABS

The first step in ETABS is to set the grid dimensions. This includes setting number of lines in X direction, Y direction and the spacing between grid lines. Then the storey data is defined which includes setting the number of stories, height of typical and bottom storey. The type of slab is also mentioned in the grid data.

LINEAR EQUATION SOLUTION

Forming stiffness at zero (unstressed) initial conditions

Total number of equilibrium equations =240

Number of non-zero stiffness terms= 4107

Number of Eigenvalues below shift = 0

LINEAR STATIC CASES

Using stiffness at zero (unstressed) initial conditions

Total number of cases to solve = 1

Number of cases to solve per block = 1

EIGEN MODAL ANALYSIS:

case: modal

using stiffness at zero (unstressed) initial conditions

Number of stiffness degrees of freedom = 240

Number of mass degrees of freedom = 12

Maximum number of eigen modes sought = 50

Minimum number of eigen modes sought = 1

Member of residual-mass modes sought = 0

Number of subspace vectors used = 12

RESULT AND DISCUSSION

The behavior of building frame with and without floating column is studied under static load, free vibration and forced vibration condition. The finite element code has been developed in ETABS software.

The following are the input data of the test specimen:

Size of beam – 0.1 X 0.15 m

Size of column – 0.1 X 0.125 m

Span of each bay – 3.0 m

Storey height – 3.0 m

Modulus of Elasticity, E = 206.84 X 10^6kN/m^2

Support condition – Fixed

Loading type – Live (3.0 kN at 3rd floor and 2 kN at 4th floor)

Global deflection at each node for general frame obtained in present FEM

Node	Horizontal	Vertical	Rotational
	X mm	Y mm	rZ rad
1	0	0	0
2	0	0	0
3	0	0	0
4	1.6	0	0
5	1.6	0	0
6	1.6	0	0
7	3.8	0	0
8	3.8	0	0
9	3.8	0	0
10	5.8	0	0
11	5.8	0	0
12	5.8	0	0
13	6.7	0	0
14	6.7	0	0
15	6.7	0	0

In this example a two storey one bay 2D frame is taken. Fig.4.3 shows the sketchmatic view of the 2D frame. The results obtained are compared with Maurice Petyt[21]. The input data are as follows:

Span of bay = 0.4572 m

Storey height = 0.2286 m

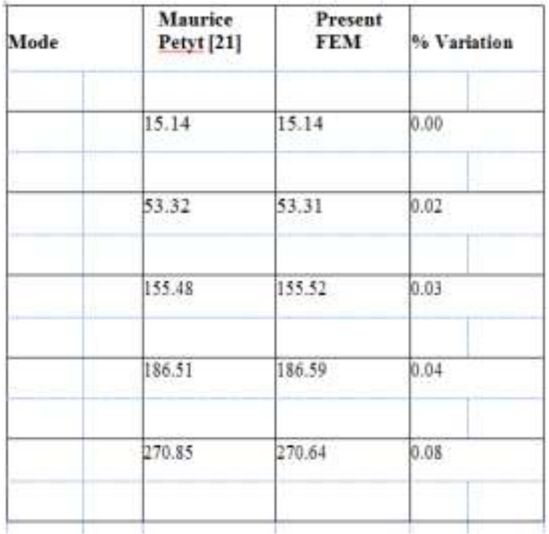
Size of beam = (0.0127 x 0.003175) m

Size of column = (0.0127 x 0.003175) m

Modulus of elasticity, E = 206.84 x10^6kN/m^2

Density, ρ = 7.83 x 10^3 Kg/m^3

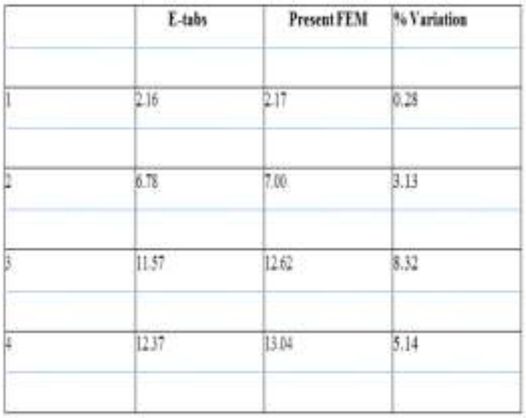
Free vibration frequency (Hz) of the 2D frame without floating column



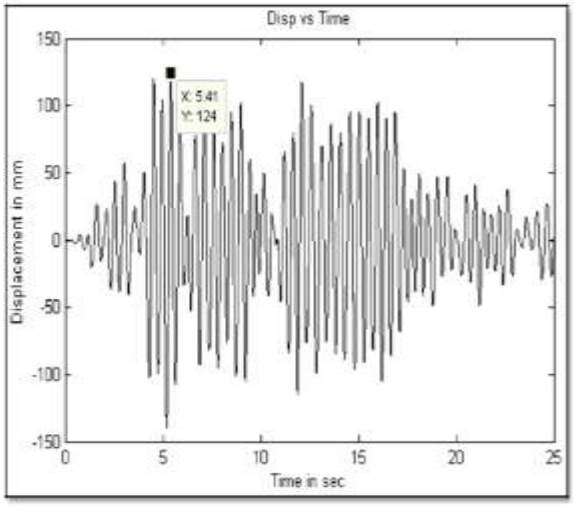
Mode	Maurice Petyt [21]	Present FEM	% Variation
	15.14	15.14	0.00
	53.32	53.31	0.02
	155.48	155.52	0.03
	186.51	186.59	0.04
	270.85	270.64	0.08

Fig. 4.4 Mode shape of the 2D framework

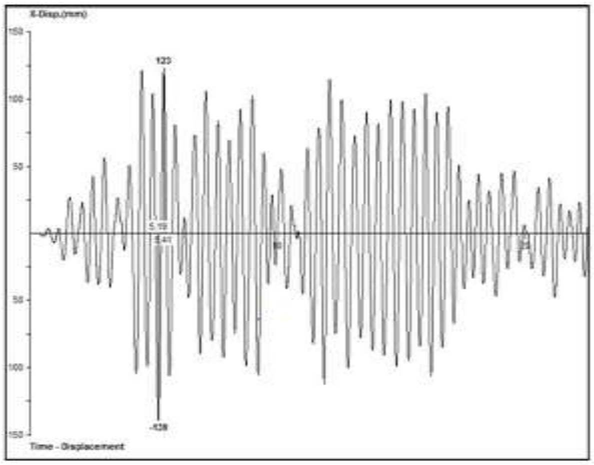
Comparison of predicted frequency (Hz) of the 2D steel frame with floating column obtained in present FEM and E-tabs.



	E-tabs	Present FEM	% Variation
1	2.16	2.17	0.28
2	6.78	7.00	3.13
3	11.57	12.62	8.32
4	12.37	13.04	5.14



Displacement vs time response of the 2D steel frame with floating column



Displacement vs time response of the 2D concrete frame with floating column

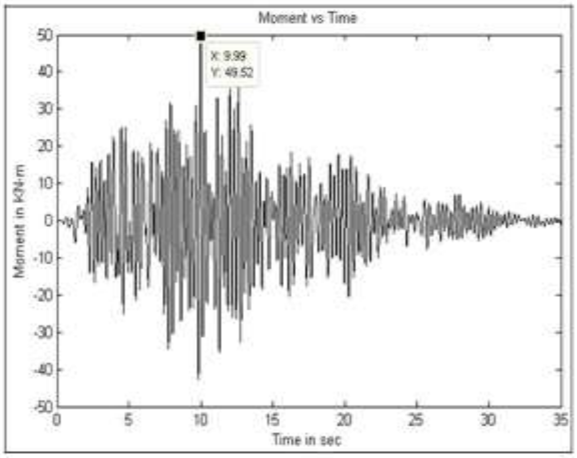
Comparison of predicted maximum top floor displacement (mm) of the 2D

concrete frame with floating column with size of ground floor column in increasing order

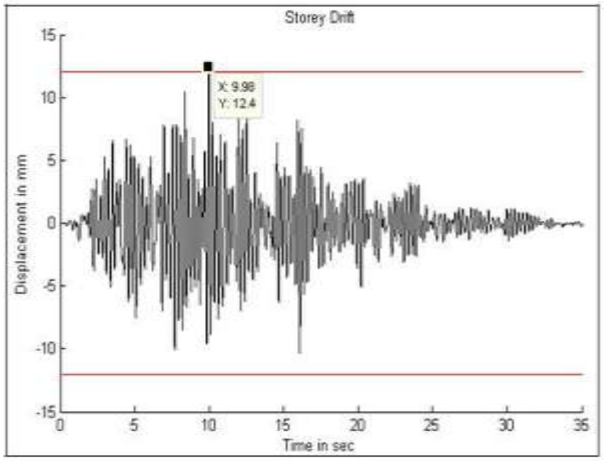
Sizeof ground floor column (m)	Time (sec)	Max displacement (mm)	% Decrease
0.25 x 0.3	10.01	17.14	-
0.25 x 0.35	9.99	15.19	11.37
0.25 x 0.4	7.72	12.5	27.07
0.25 x 0.45	7.7	11.58	32.44

The time history of base shear is obtained and presented in figures. The maximum base shear is obtained from the time history plot and tabulated in Table. It is observed that the maximum base shear decreases with strengthening the ground floor columns.

Comparison of predicted base shear (kN) of the 2D concrete frame with floating column with size of ground floor column in increasing order



Moment vs time response of the 2D concrete frame with floating column under IS code time history excitation (Column size- 0.25 x 0.35 m)



Storey drift vs time response of the 2D concrete frame with floating column under IS code time history excitation (Column size- 0.25 x 0.4 m)

5.0 CONCLUSION

The behavior of multi-storey building with and without floating column is studied under different earthquake excitation. The compatible time history and Electro earthquake data has been considered. The PGA of both the earthquake has been scaled to 0.2g and duration of excitation are kept same. A finite element model has been developed to study the dynamic behaviour of multi -story frame. The static and free vibration results obtained using present finite element code are validated. The dynamic analysis of frame is studied by varying the column dimension. It is concluded that with increase in ground floor column the maximum displacement, inter storey drift values are reducing. The base shear and overturning moment vary with the change in column dimension.

The ETABS and Perform-3D models had similar results. The effective period calculated from the Perform-3D model was in good agreement with the ETABS model that utilized cracked section properties from moment-curvature analysis, only 1.7% longer. The NSP in ETABS showed slightly better performance than the NSP in Perform-3D. Although the complexity in the two models thwarted expectations for exactly the same results, a property that could have affected the data output is the assignment of the rotation gage in Perform-3D. The rotation gage assignment for this study was based on the plastic hinge length anticipated at the wall's ultimate displacement capacity. In reality, the extent of hinging was constantly changing with respect to building response at each given displacement interval, and thus the rotational gages should theoretically change size in correlation to the changing extent of plasticity. Because maximum rotations were of the greatest interest in this project, the maximum anticipated extent of hinging was decided to be a reasonable estimate for an appropriate rotation gage length.

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