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SEISMIC ANALYSIS OF MULTISTORY BUILDING WITH STUB COLUMN

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Abstract: -
In present scenario buildings with Stub column is a typical feature in the modern multistory 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 Stub column in the analysis of building. Alternate measures, involving stiffness balance of the first story and the story above, are proposed to reduce the irregularity introduced by the Stub columns. FEM codes are developed for 2D multi story frames with and without Stub 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 story drift, base shear, overturning moment are computed for both the frames with and without Stub column.

INTRODUCTION

Many urban multistory buildings in India today have open first story as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first story. 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. Many buildings with an open ground story intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate story and do not go all the way to the foundation, have discontinuities in the load transfer path.

Stub Column: 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. The beams in turn transfer the load to other columns below it.

OBJECTIVE & SCOPE

The objective of the present work is to study the behavior of multistory buildings with Stub columns under earthquake excitations.

Finite element method is used to solve the dynamic governing equation. Linear time history analysis is carried out for the multistory buildings under different earthquake loading of varying frequency content. The base of the building frame is assumed to be fixed. Newmark's direct integration scheme is used to advance the solution in time.

FINITE ELEMENT FORMULATION

The finite element method (FEM), which is sometimes also referred as finite element analysis (FEA), is a computational technique which is used to obtain the solutions of various boundary value problems in engineering, approximately. Boundary value problems are sometimes also referred to as field value problems. The field value problems in FEM generally has field as a domain of interest which often represent a physical structure. The field variables might include heat flux, temperature, physical displacement, and fluid velocity depending upon the type of physical problem which is being analyzed.

A) Static analysis

i) Plane frame element:

The plane frame element is a two-dimensional finite element with both local and global coordinates. The plane frame element has modulus of elasticity E, moment of inertia I, cross-sectional area A, and length L. Each plane frame element has two nodes and is inclined with an Angle of θ measured counterclockwise from the positive global X axis as shown in figure. Let C= cosθ and S= sinθ.

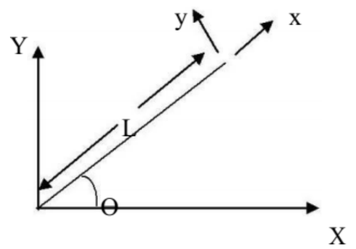

Fig. 3.1 The plane frame element

It is clear that the plane frame element has six degree of freedom – three at each node (two displacements and a rotation). The sign convention used is that displacements are positive if they point upwards and rotations are positive if they are counter clockwise. Consequently, for a structure with n nodes, the global stiffness matrix K will be 3n X 3n (since we have three degrees of freedom at each node). The global stiffness matrix K is assembled by making calls to the MATLAB function Plane Frame Assemble which is written specially for this purpose.

Once the global stiffness matrix K is obtained, we have the following structure equation:

$$[K]\{U\} = \{F\}$$

Where [K] is stiffness matrix, {U} is the global nodal displacement vector and {F} is the global nodal force vector. At this step boundary conditions are applied manually to the vectors U and F. Then the matrix equation (3.1) is solved by partitioning and Gaussian elimination. Finally, once the unknown displacements and reactions are found, the nodal force vector is obtained for each element as follows:

$$\{f\} = [k]\ [R]\ \{u\}$$

Where {f} is the 6 X 1 nodal force vector in the element and {u} is the 6 X 1 element displacement vector.

B) Dynamic analysis

Dynamic analysis of structure is a part of structural analysis in which behavior of flexible structure subjected to dynamic loading is studied. Dynamic load always changes with time. Dynamic load comprises of wind, live load, earthquake load etc. Thus, in general we can say almost all the real-life problems can be studied dynamically.

If dynamic loads changes gradually the structure's response may be approximately by a static analysis in which inertia forces can be neglected. But if the dynamic load changes quickly, the response must be determined with the help of dynamic analysis in which we cannot neglect inertial force which is equal to mass time of acceleration (Newton's 2nd law). *Mathematically,* $F = M \times a$

Where F is inertial force, M is inertial mass and 'a' is acceleration.

Furthermore, dynamic response (displacement and stresses) are generally much higher than the corresponding static displacements for same loading amplitudes, especially at resonant conditions.

EXPERIMENTAL STUDY

Example 1 :-

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

Story height – 3.0 m

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

Support condition – Fixed

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

Fig. 4.1 and Fig.4.2 show the sketchmatic view of the two frame without and with floating column respectively. From Table 4.1 and 4.2, we can observe that the nodal displacement values obtained from present FEM in case of frame with floating column are more than the corresponding nodal displacement values of the frame without floating column. Table 4.3 and 4.4 show the nodal displacement value obtained from STAAD Pro of the frame without and with floating column respectively and the result are very comparable with the result obtained in present FEM.

Fig. 4.1 2D Frame with usual columns

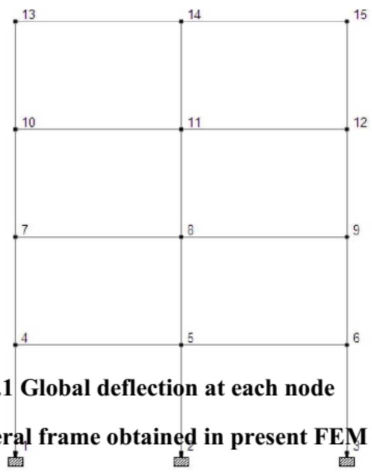

Table 4.1 Global deflection at each node for general frame obtained in present FEM

Fig.4.2 2D Frame with Floating column

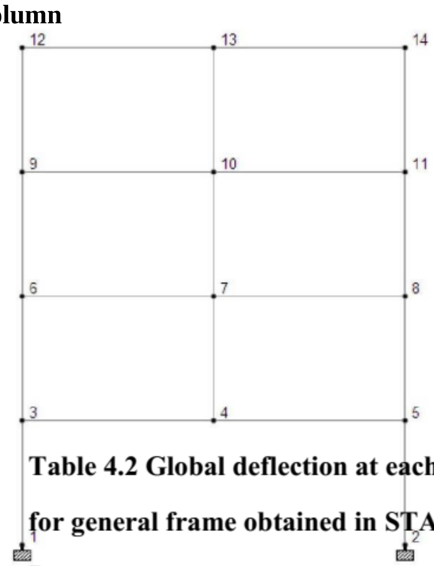

Table 4.2 Global deflection at each node for general frame obtained in STAAD Pro.

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

Node	Horizontal	Vertical	Rotational
	X mm	Y mm	rZ rad
1	0	0	0
2	0	0	0
3	0	0	0
4	1.4	0	0
5	1.4	0	0
6	1.4	0	0
7	3.6	0	0
8	3.6	0	0
9	3.6	0	0
10	5.6	0	0
11	5.6	0	0
12	5.6	0	0
13	6.8	0	0
14	6.8	0	0
15	6.8	0	0

Example 2: -

In this example a two story 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

Story 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 x10^6 kN/m^2

Density, ρ = 7.83 x 10^3 Kg/m^3

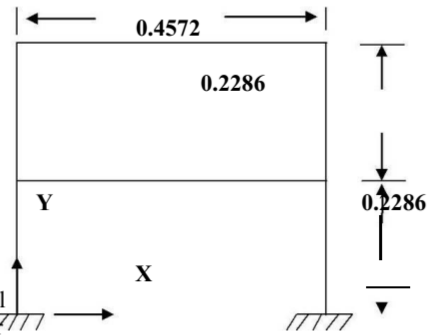

Fig. 4.3 Geometry of the 2 dimensional framework. Dimensions are in meter

Table 4.5 shows the value of free vibration frequency of the 2D frame calculated in present FEM. It is observed from Table 4.5 that the present results are in good agreement with the result given by Maurice Petyt [21].

Table 4.5 Free vibration frequency (Hz) of the 2D frame without floating column

Mode	Maurice Petyt [21]	Present FEM	% Variation
1	15.14	15.14	0.00
2	53.32	53.31	0.02
3	155.48	155.52	0.03
4	186.51	186.59	0.04
5	270.85	270.64	0.08

CONCLUSION

- The behavior of multistory building with and without Stub column is studied under different earthquake excitation.
- A finite element model has been developed to study the dynamic behavior 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 story drift values are reducing. The base shear and overturning moment vary with the change in column dimension.

REFERENCES

[1].**Agarwal Pankaj, Shrikhande Manish** (2009), “Earthquake resistant design of structures”, PHI learning private limited, New Delhi.
[2].**Arlekar Jaswant N, Jain Sudhir K. and Murty C.V.R,** (1997), “Seismic Response of RC
[3].Frame Buildings with Soft First Storeys”.
[4].**Awkar J. C. and Lui E.M,** “Seismic analysis and response of multistory semirigid frames”, Journal of Engineering Structures.
[5].**Chopra, Anil k.** (1995), “Dynamics of structures”, Prentice Hall.
[6].**Daryl L. Logan** (2007), “A First Course in the Finite Element Method”, Thomson, USA**.**
[7].**Fall H.G** (2006)**,** “Direct Stiffness Method For 2D Frames-Theory of structure”.
[8].**Hartley Gilbert and Abdel-Akher Ahmed,** “Analysis of building frames” Journal of Structural Engineering.
[9].**Krishnamoorthy CS,** Finite element analysis, TMH Publications, 1987**.**
[10]. **Paz Mario** (2010), “Structural dynamics”, CBS publishers.