International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378 (Online), Volume-6 Issue-9, April 2020

Seismic Study of Multistorey Building using Floating Column

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Abstract: Columns rest on the beam without foundation are called floating column. They are used commonly in multi-storey buildings which are purposed to hold parking at ground floor or open halls at higher floors. Discontinuation within the load transfer path is seen in this column. Thus they are designed for gravity loads. But these structures aren't designed for earthquake loads. In present scenario structures with floating column may be a common characteristic in urban India. However in tectonic areas, this type of structure is not preferred due to discontinuity of load transfer path i.e. whole earthquake load on the structure is shared by the shear walls without any loads on the floating columns. This paper review the nature of a multi-storey building under quake forces with and without of floating columns. This analysis focus the importance of specially identifying the presence of the floating column within the study of the struture, establish its correlation with the building without a floating column using designing software Extended three dimensional analysis of building systems (ETABS). This paper also discusses the performance of structure having floating column in seismically active areas. Besides these various parameter such as maximum displacement, effect on number of storey on drift, base shear are also studied.

Keywords : Floating columns, Equivalent static analysis, Storey displacement, Storey drift , Base shear , Etabs

I. INTRODUCTION

A. General

The vertical part of structure is called column which is used to carry structural load and transmit it through beams [1] while floating column is the one which rest on beam.In floating column the beam which support column act as a foundation and it should not go beyond foundation [2] as shown in Fig 1. They have disruption in the load shift direction.In Floor space index (FSI-the ratio of built up area to the plot area) balconies are not counted as per building laws.Therefore building having balconies extend outwards within the top stories apart from the footprint area at the bottom storey projects up to 1.2 to 1.5 m in plan[3].Floating columns are given along the overhanging perimeters of the buliding. The periphery of columns of the bottom storey are discarded within top storey.

In the present paper effect of floating column on construction of multi-storey building has been studied. The results on with and without floating column compared. Various parameters such as maximum displacement, effect on number of storey on drift, base shear are discussed. The material properties and section properties considered for analysis are shown in Table I & II. Similarly, the seismic parameter details considered as per IS code[4,5] is shown in table III.

Manuscript Received on April 2, 2020.
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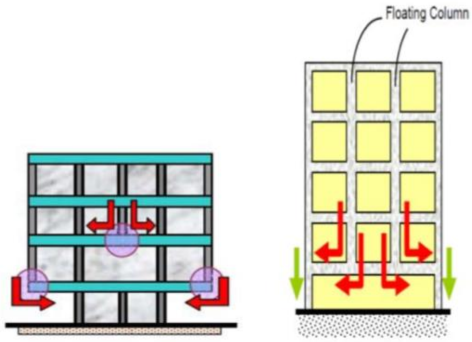
B. Floating Column

In floating column transfer of load to the column below it by the beam.The transfer of load in floating column changes from vertical to horizontal within the intermittent frame. In many cases these columns are choosen specially above bottom floor. Thus more open spaces is offered within ground floor which can be used for auditorium or parking intention[6].Thus floating column is additionally used in construction practice and it is avoided due to excess of beams.To maintain the stability of building the joint among beam and floating column are treated as critical.Main cause of collapse of this type of structure is the failure of large beam column specimens occurs in the joint in concrete moment resisting frame[7].The geometry of the considered model is shown in table IV.



(a) (b)

Fig 1: Buildings with floating column

a) at Ist and 2nd floor [1][2][6][7]

b) the column is discontinued at a lower level [8]

II. METHODOLOGY

1. Using ETABS [9] 2016 software G+5 storey structure is modeled and studied.
2. Equivalent static analysis of structures and Response spectrum analysis (dynamic) is done. (Details of methods are given in section III)

A. BUILDING CONFIGURATIONS

For analysis three models considered as follows:

MODEL1- In model 1 structure without floating column is considered and is analyzed for zone 4. (Fig 2 & Fig 3)

MODEL2- In model 2 floating column is introduced at 1st floor at the outer section of the plan. This model is analyzed for zone4. (Fig 4 & Fig 5)

MODEL 3- In model 3 floating column is introduced at 5th floor at the outer section of the plan. This model is analyzed for zone4. (Fig 6 & Fig 7)

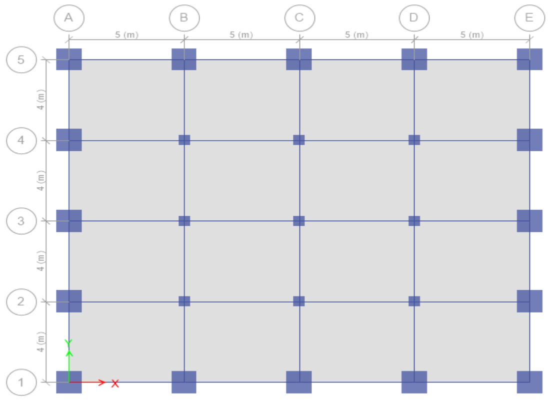


Fig 2 : Plan without floating column (Model 1)

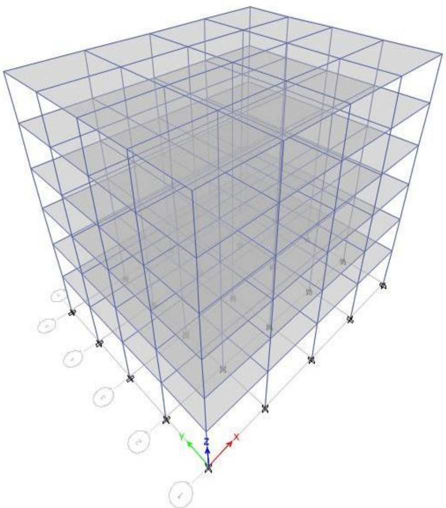


Fig 3: Three-dimensional view without floating column (Model 1)

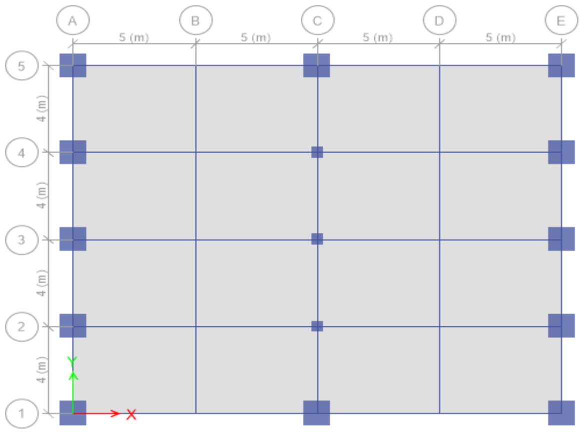


Fig 4 : Plan by floating column at Ist floor (Model 2)

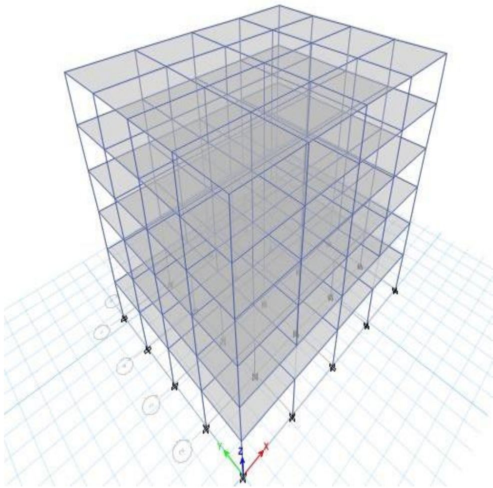


Fig 5 : Three-dimensional view by floating column at Ist floor (Model 2)

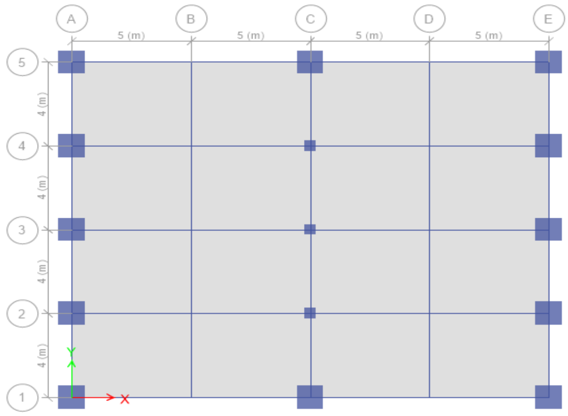


Fig 6: Plan by floating column at 5th floor (Model 3)

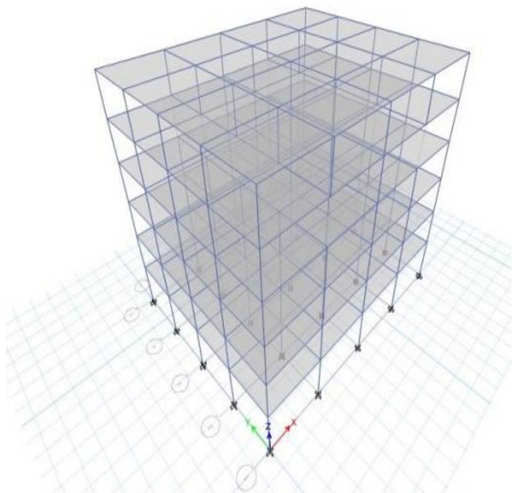


Fig 7 : Three-dimensional view by floating column at 5th floor (Model 3)

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DOI: 10.35940/ijese.G2334.046920
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B. MATERIAL PROPERTIES

Table I: Properties of material

Properties	Values
Characteristic compressive strength of concrete, fck	25 MPa
Yield stress for steel, fy	415 MPa
Elastic modulus of Steel, Es	20,0000 MPa
Elasticity modulus of concrete, Ec	25000 MPa

C. SECTION PROPERTIES

Table II: Building data [7]

Parameters	Structure without floating column (Model 1)	Structure with floating column at I[st] floor (Model 2)	Structure with floating column at 5[th] floor (Model 3)
Length in X-direction	20	20	20
Length inY-direction	16	16	16
No. of storeys	Six (G+5)	Six (G+5)	Six (G+5)
Beam at exterior	230×550 mm M20 grade concrete	230×550 mm M20 grade concrete	230×550 mm M20 grade concrete
Beam at interior	230×500 mm M20 grade concrete	230×500 mm M20 grade concrete	230×500 mm M20 grade concrete
Transfer beam	-	1.2m × 1 m M45 grade concrete	1.2m × 1 m M45 grade concrete
I[st] Column	1.1m×1.1m M35 grade concrete	1.1m×1.1m M35 grade concrete	1.1m×1.1m M35 grade concrete
2[nd] Column	500×500mm M35 grade concrete	500×500mm M35 grade concrete	500×500mm M35 grade concrete
Slab	125mm M20 grade concrete	125mm M20 grade concrete	125mm M20 grade concrete
Live load	3kN/m^2	3kN/m^2	3kN/m^2
Roof live	1.5 kN/m^2	1.5 kN/m^2	1.5 kN/m^2
Wall load	12.42 kN/m^2	12.42 kN/m^2	12.42 kN/m^2
Parapet load	2.484 kN/m^2	2.484 kN/m^2	2.484kN/m^2

D. SEISMIC PARAMETERS DETAILS

Table III: Seismic parameters details [8]

Struture type	Multi storied RC rigid jointed plane frame (SMRF)
Type of soil	Medium; Type-II
Zone	IV
Damping in structure	5%
Importance factor	1
Scale Factor	1.962
Time period	1
Response reduction factor(R)	5

Table IV: Geometry of the considered model [8]

No. of storey's	No of opening in X direction	X direction bay width	No. of opening in Y direction	Y direction bay width	Height of bottom storey	Height of storey
6	5	5	4	4	3.5	3

III. SEISMIC ANALYSIS OF STRUCTURE

A. EQUIVALENT STATIC ANALYSIS

The method is done based on code IS 1893(part 1)-2002[10]. For entire building the design base shear is calculated.Computed results are assigned alone the elevation of structure.Lateral forces obtained are delivered to individual load resisting elements[11].The theoretical calculation part is as follows:

1) Design base shear $V_B = A_h W$

Where, W=Seismic weight of building

A_h= Horizontal tectonic coefficient

Horizontal tectonic coefficient $A_h = \frac{Z\,I\,S_a}{2\,R\,g}$

Where, Z = Zone factor

I = Importance factor

R = Response reduction factor

S_a/g = Average response acceleration coefficient

2) Vertical distribution of base shear

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Where , Q_i= Design lateral force

W_i= Seismic weight of floor

h_i=Height of floor measured from base of structure

n= No of storeys

3) Horizontal distribution of base shear

$$F_{ij} = \frac{K_{ij}}{\sum_{k=1}^{nk} K_{ik}} F_i$$

Where, F_{ij}= Force acting on the lateral force resisting line j at floor level i

nk= No of lateral force resisting element

K_{ij}, K_{ik}= Storey stiffness of lateral force resisting element line k and j at level i
F_i= Tectonic force acting at floor

4) Determination of drift, overtuning moment and P-delta effect.

$$\text{Drift storey} = \frac{\text{Variance in deflection between two adjoining floors}}{\text{Height of storey which divides the floor}}$$

- Overtuning moment and P- delta effect

Overturn of struture occur due to moment generate by equivalent static lateral force.Therefore it must be checked since dead weight of buildng is inadequate to resist .

Stability Coefficient $\Theta = \frac{P_i \Delta_i}{V_i h_i}$

P_i= Weight of structure above storey
Δ_i= Design storey drift
V_i= Total sum of lateral tectonic design forces acting above storey
h_i= Storey drift

B. RESPONSE SPECTRUM METHOD

Dynamic evaluation ought to be completed with a view to obtain the design seismic force and its distribution to different level along height of the structure and to distinctive lateral load resisting components. There are theoretical benefits in the use of the seismic analysis response spectrum approach to predict. This approach includes the measurement of only the maximal values of the displacements and of the component forces in each mode of vibration using a smooth design spectra that is the sum of many earthquake movements[12].Code used for analysis of multi-story building IS:1893 (Part 1)-2002[10].

IV. RESULTS AND DISCUSSIONS

A. STATIC ANALYSIS

a. Storey displacement

Displacement of storey relative to base of struture is called storey displacement.Most significant and most clearly evident point of contrast for structure is deflected shape[11]. The utmost displacements of building in different stories for all models have been compared. The results are taken for zone 4 with medium soil condition.The results are shown in table V as floor wise. Storey displacement variations are shown in fig no 8. From graph it can be conclude that model 1 is showing min displacement and model 2 and 3 showing max displacement.

Table V: Comparison of displacement with and without floating columns

	Model 1	Model 2	Model 3
Storey	U_Y in mm	U_Y in mm	U_Y in mm
6	5.811	6.614	6.612
5	4.815	5.495	5.541
4	3.699	4.241	4.225
3	2.524	2.914	2.868
2	1.398	1.614	1.582
1	0.489	0.527	0.552
Base	0	0	0

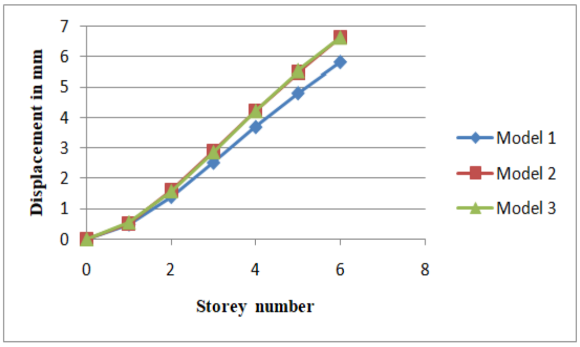

Fig 8: Comparison of displacement with and without floating columns

b. Storey Drift

Displacement of one storey relative to other storey is called storey drift[11]. The results are taken for zone 4 with medium soil condition.The results are shown in table VI as floor wise.Storey drift variations are shown in fig no 9. From graph it can be conclude that model 1 is showing min drift and model 2 and 3 showing max drift.

Table VI : Comparison of drift with and without floating columns

	Model 1	Model 2	Model 3
Storey	Drift Y in mm	Drift Y in mm	Drift Y in mm
6	0.000336	0.000377	0.000371
5	0.000372	0.000418	0.000443
4	0.000392	0.000445	0.000454
3	0.000376	0.000436	0.00043
2	0.000304	0.000375	0.000345
1	0.00014	0.000151	0.000158
Base	0	0	0

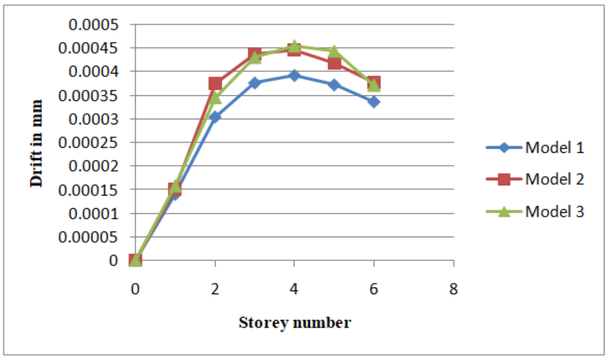

Fig 9: Comparison of drift with and without floating columns

c. Base Shear

Approximate calculation of maximum anticipated lateral force at the base against quake load is called base shear. Wherever structure is fixed base shear will act[11].The results are taken for zone 4 with medium soil condition.

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Results are shown in table VII as floor wise.Storey drift variations are shown in fig no 10. From graph it can be conclude that base shear is more for buildings without floating column and decreases for building with floating column

Table VII: Comparison of base shear with and without floating columns

	Model 1	Model 2	Model 3
Storey	V_X in kN	V_X in kN	V_X in kN
6	273.35	293.36	252.07
5	534.42	573.53	670.10
4	704.20	755.74	814.49
3	802.27	860.98	904.93
2	848.18	946.54	947.16
1	862.08	960.34	959.97
Base	0	0	0

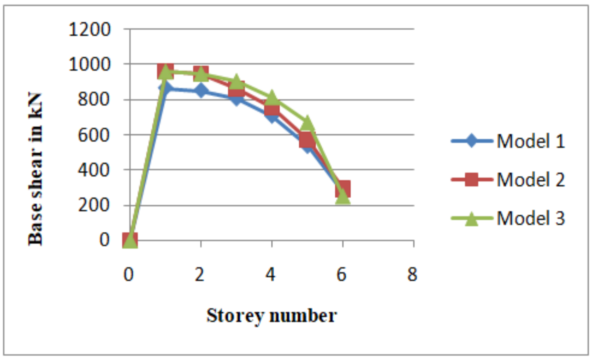

Fig 10: Comparison of base shear with and without floating columns

B. RESPONSE SPECTRUM ANALYSIS

a. Storey displacements

The results are taken for zone 4 with medium soil condition.The results are shown in table VIII as floor wise. Storey displacement variations are shown in fig no 11. From graph it can be conclude that model 1 is showing min displacement and model 2 and 3 showing max displacement.

Table VIII: Comparison of displacements with and without floating columns

	Model 1	Model 2	Model 3
Storey	U_Y in mm	U_Y in mm	U_Y in mm
6	48.213	53.441	57.407
5	40.27	44.778	48.433
4	31.278	34.973	37.287
3	21.613	24.378	25.556
2	12.124	13.769	14.241
1	4.295	4.563	5.019
Base	0	0	0

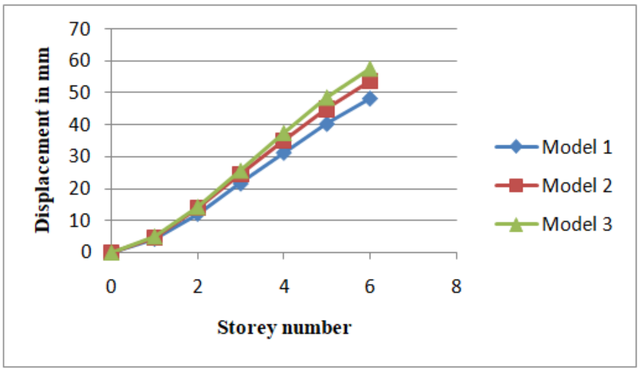

Fig 11: Comparison of displacement with and without floating columns

b. Storey Drift

The results are taken for zone 4 with medium soil condition.The results are shown in table IX as floor wise.Storey drift variations are shown in fig no 12. From graph it can be conclude that model 1 is showing min drift and model 2 and 3 showing max drift

Table IX: Comparison of drift with and without floating columns

	Model 1	Model 2	Model 3
Storey	Drift Y in mm	Drift Y IN mm	Drift Y in mm
6	0.002703	0.00295	0.003126
5	0.003015	0.003293	0.003769
4	0.003234	0.003571	0.00393
3	0.003169	0.003573	0.003786
2	0.002621	0.003177	0.003088
1	0.001227	0.001304	0.001434
Base	0	0	0

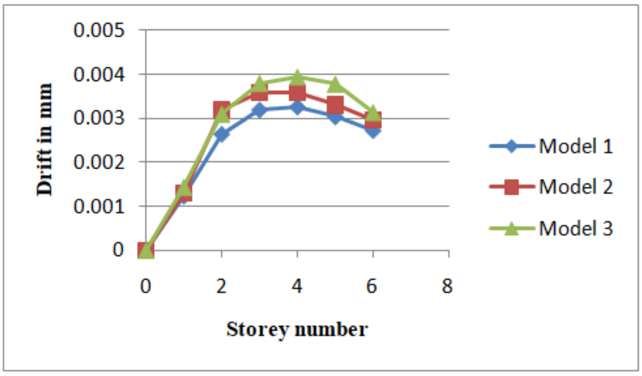

Fig 12: Comparison of drift with and without floating columns

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V. CONCLUSION

Now a days usage of floating column is increasing in multi-storey building structural design. This is due to space & aesthetic functional requirement are being fulfilled, thus notable to a raise in their necessity in residential and commercial buildings. However by analyzing seismic behavior of floating column, it can be concluded that seismic prone area, building with floating column exhibit higher storey drift and storey displacement compared to building without floating column. The detail of comparison with and without floating column are summarised below.

- Structure with floating column shows maximum displacement when compare to the structure without floating column
- With increase in storey number displacement increase, that is from lower to higher storey displacement increase
- When floating column is shifted towards higher storey lateral displacement increases
- Structure without floating column shows minimum storey drift while with floating column shows maximum storey drift.
- Structure without floating column shows minimum base shear while with floating column shows maximum base shear

Further it can be conclude that floating column at higher floor must be avoided in high rise building design.

REFERENCES

1. Jaswinder Singh, Kshipra Kapoor(2019), "Seismic Analysis of Multistoried Buildings with Floating Columns*", International Journal for Research in Applied Science & Engineering Technology, Volume 7 Issue III, ISSN: 2321-9653*
2. A.P. Mundada , S.G. Sawdatkar (2014), "Comparative Seismic Analysis of Multistorey Building with and without Floating Column" *International Journal of Current Engineering and Technology, Vol.4, No.5*
3. Avinash Pardhi, Parakh Shah, SatishYadav, Pundlik Sapat, Amit Kumar Jha(2016), "Seismic Analysis Of Rcc Building With & Without Floating Columns", *International Journal of Advanced Technology in Engineering and Science,Vol No 4,Issue No 3*
4. IS : 875 (Part 1) – 1987 Code of practice for design loads (other than earthquake) for buildings and structures
5. IS : 875 (Part 2) – 1987 Code of practice for design loads (other than earthquake) for buildings and structures
6. Sarita Singla, Ashfi Rahman (2015), "Effect of Floating Columns on Seismic Response of Multi-Storeyed RC Framed Buildings*" International Journal of Engineering Research & Technology, Vol. 4 Issue 06*
7. Preethi , Sudha PH , Maganur D S (2017), "Study The Behaviour Of Seismic Evaluation Of Multistoried Building With Floating Columns*" International Journal of Scientific Engineering and Applied Science, Volume-3, Issue-9*
8. Altaf Husain, Kailash Narayan(2018), "Seismic Response of Multistory Building with Floating and Setback Columns", *International Journal of Engineering Research in Mechanical and Civil Engineering, Vol 3, Issue 5*
9. ETABS 2016 *Package*
10. IS 1893(Part 1):2002 Criteria for Earthquake Resistant design of structures: General provisions and buildings
11. S.B. Waykule, Dr. C.P. Pise ,C.M. Deshmukh, Y.P. Pawar, S.S. Kadam, D. D. Mohite, S.V. Lale(2016), "Study of behaviour of floating column for seismic analysis of multistorey building" *International Journal of Civil Engineering and Technology, Volume 7, Issue 6, pp. 676–685.*
12. www.nptel.ac.in

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