Static and Dynamic Analysis of Multi-Storey Building with Floating Column & their Buckling Behaviour

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***Abstract*–Floating column is that type of column which is constructed without rigid foundation on a beam. Now a day, floating columns is a typical feature in the modern multi- storied buildings. The structural members fail due to buckling when they are subjected to heavy loads. Columns are the main elements in resisting lateral load moment and also play vital role in seismic performance of the building. In this study seismic performance of multistoried building with and without floating column and buckling analysis of column has been carried out. To analyze five and ten stories structure models were created considering zone IV parameters. Static and dynamic analysis of all models wascarried outby STADD- PRO software. The structural response for parameters like floor displacement, base shear, shear force, bending moment, elastic critical load corresponding to member strength for the columns were also studied.**

Keywords: Floating Column, Earthquake, Buckling.

I. Introduction

Earthquake proves to be most disastrous for Civil Engineering infrastructure, if not considered properly during design. There are number of factors or conditions which make the structure unstable and lead to failure of structure. The structure fails, when the stress in the building due to some external forces reached the yield or ultimate strength of the member, exceed a specific maximum deflection. Buckling is a broad term which describes the mechanical behavior and generally defined as the deformation which occurs due to increase in the small magnitude of load, causing the change in member shape. The elastic buckling of the member is generally analyzing by long slender compression member. With the advancement in research, it is observed that discontinuitiesare crucial in the load transfer mechanism. Due to discontinuities, in the path of load transfer at different floor level, the earthquake effects are different for each floor level in the buildings which leads to poor performance of the building.

The Floating Column: Now a days with change in design technology around the world, complex structures are being constructed efficiently giving due consideration to seismic phenomenon. The floating column in building works as large function space for storage purpose.In some cases, floating column may be provided economic structure. Floating column in multi-storied residential building has been studied by various researchers (2,34,6,8 and 10).

Avinash P. et al (9) investigated the seismic performance of the building with and without the floating column in terms of various parameters such as displacement, storey drift, maximum column forces time period of vibration etc. with various location of floating column and compare it with normal building. In this the building are modeled by using the finite element software ETABS. They conclude that floating columns are not suitable in high seismic zone.Gaurav K. et al (7) studied the dynamic structural behavior of simple configuration multi storey building with floating column. The analysis was done by using the ETABS software. Dynamic action is caused by the both wind and earthquake so with different level of forces along the height of the building. Pramod G. et al (5)analyzed the multi-stored steel structure building in zone 'II' and find the behavior of soft-storey at different floor level of building under the seismic load action. Sameer et al (1) analyzed the floating column in multistoried building. They developed FEM codes for the 2D multi storey frames with and without floating column under different earthquake excitation having different frequency content keeping the PGA and time duration factor constant. The study concluded that with increase in ground floor column the maximum displacement, inter storey drift values are reduced and base shear and overturning moment vary with the change in column dimension.

Different types of software's are available for modeling and validations. In the present study, STADD-PRO was usedforanalyzingthe buckling behavior of floating column in RCC framed structure. STADD-PRO was also used for comparing analysisof Multi-storiedstructure with and without floating column.Various parameters

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such as displacement, storey drift, and maximum column forces time period of vibration were also studied.

II. Research Methoology

STADD-Pro software was used for the seismic analysis of RCC framed structure for different arrangement of columns. In present work two structural models were studied (five storey and ten storey) with and without floating column. Table 1.1 shows the distribution of different type of models according to the position of floating columns and Table 1.2 represent the various parameters which were used for dynamic analysis of models.

Table 1.1: Arrangements of Floating Column

Model	Type of model
MOD0500	05 Storey without floating column.
MOD0502	05 Storey + floating 2nd floor.
MOD1000	10 Storey without floating column.
MOD1002	10 Storey + floating 2nd floor
MOD1005	10 Storey + floating 5th floor.

Table 1.2: Parameter Used for Dynamic Analysis

Name of parameter	Value	Unit
Number of storey	5 & 10	Nos.
Storey height	3.5	M
Foundation depth	2.85	M
Floor finish	1	KN/m^3
Column R1 (outside columns)	0.40 X 0.45	M
Column R4 (inside columns)	0.35 X 0.45	M
Beam R2 (outside beams)	0.30 X 0.30	M
Beam R3 (inside beams)	0.30 X 0.35	M
Importance factor	1	-
Seismic zone	IV	-
Zone factor	.24	-
Response reduction factor	5	-
Damping ratio	.05	%
Type of structure	01	-
Soil type	Medium	

III. Results and Discussion

Five and ten storey building was analyzed by STADD -Pro for various combination of load.

A. *Dead and Live Loads*

The following table (1.3) shows the comparison of dead load and live load of different models. Results indicates for residential building of 5 storey Dead load decreased by 9 % when floating column is provided at second storey where as in ten storey building decrease in dead load is 22% and 13 % respectively when floating column is provided at 2nd and fifth floor.

Table 1.3: Dead and Live Loads

Type of Model	Dead Load (DL) (KN)	Live Load (LL) (KN)
MOD0500	35913.65	8859.20
MOD0502	32664.61	8859.20
MOD1000	54428.85	17134.16
MOD1002	42584.78	8859.20
MOD1005	47475.54	17134.16

B. *Base Shear Force*

The table (1.4) represents the comparison of base shear force is calculated using the seismic zone, soil material, and building code lateral force equations, it indicates base shear decrease when floating columns are provided in the models MOD0502 and MOD1005.

Table 1.4: Base Shear Force

Model		MOD 0500	MOD 0502	MOD 1000	MOD 1002	MOD 1005
Base Shear Force (V) (KN)	X	1722.41	1569.05	1352.51	19383.47	1299.60
	Z	1722.41	1569.05	1352.51	19383.47	1299.60

C. *Storey Drift & Maximum Average Displacement*

The fig. 1.1 and 1.2 shows the comparison of average displacement and storey drift x and z between models MOD0500 and MOD0502 by using the observation reading from table 1.5 and 1.6.and The fig. 1.3, and 1.4 shows the comparison of average displacement and storey drift x and z between models M0D01000, M0D01002 and M0D01005 by using the observation reading from table 1.7, 1.8 and 1.9.

Table 1.5: Storey Drift & Maximum Average Displacement of model M0D0500

SR. NO.	STOREY HEIGHT (M)	MAX. AV. DISPLACEMENT (CM)		MAX. DRIFT (CM)	
		X	Z	X	Z
1.	0.00	0.4816	0.4486	0.3203	0.2999
2.	3.50	0.08513	0.9930	0.3856	0.3646
3.	7.00	0.8599	0.6685	0.0047	0.0041
4.	10.50	0.0785	1.0058	0.0047	0.0041
5.	14.00	1.0922	1.0123	0.0047	0.0041
6.	17.50	1.1022	1.0197	0.0047	0.0041

Table 1.6: Storey Drift & Maximum Average Displacement of model **M0D05002**

SR. NO.	STOREY HEIGHT (M)	AV. DISPLACEMENT (CM)		MAX. DRIFT (CM)	
		X	Z	X	Z
1.	0.00	0.5284	0.4253	0.3533	0.2617
2.	3.50	1.3484	1.1677	0.5502	0.4561
3.	7.00	1.8522	1.5386	0.3407	0.2748
4.	10.50	1.8428	1.5471	0.0055	0.0060
5.	14.00	1.8588	1.5880	0.0055	0.0060
6.	17.50	1.8620	1.5641	0.0055	0.0060

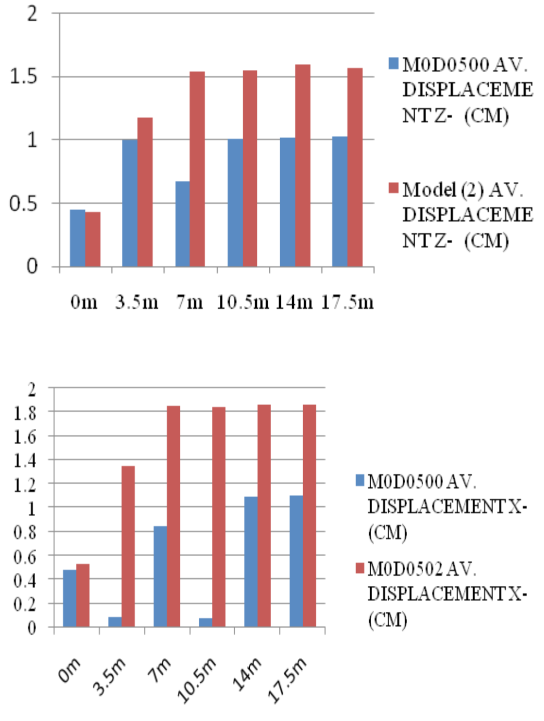

Fig. 1.1: Comparison of Av. Displacement – X and Z between M0D0500 & M0D0502

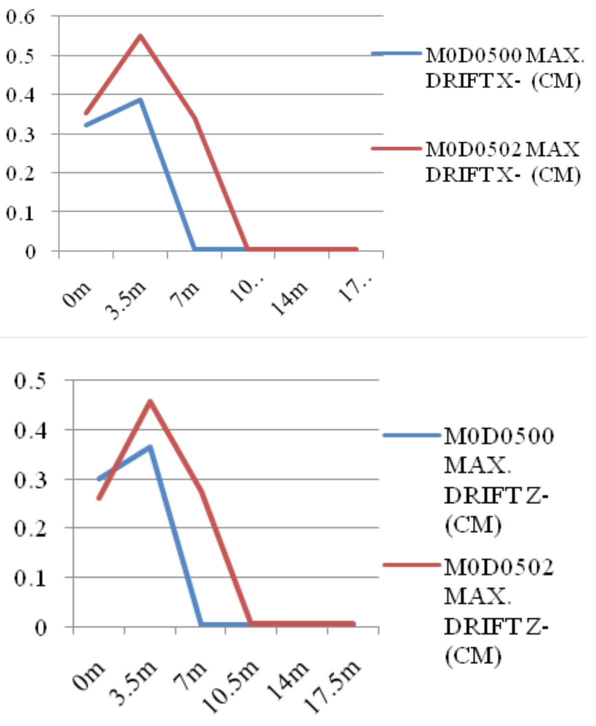

Fig. 1.2: Comparison of Storey Drift - X and Z between M0D0500 & M0D0502

It may be shown that the average displacement X & Z in M0D0500 is more than the average displacement X & Z in M0D0502, so that the floating column are increase the average displacement.

The fig. shows that the storey drift in X and Z are more at the 1st floor level and after it may be constant in both the models. If the storey height is increase the drift will be decrease.

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Table 1.7: Storey Drift & Maximum Average Displacement of Model M0D01000

SR. NO.	STOREY HEIGHT (M)	MAX. AV. DISPLACEMENT (CM)		MAX. DRIFT (CM)	
		X	Z	X	Z
1.	0.00	0.6291	0.4286	0.04192	0.0143
2.	3.50	1.3690	0.9456	0.4912	0.3986
3.	7.00	1.3899	0.9567	0.0091	0.0078
4.	10.50	1.4098	0.9677	0.0091	0.0078
5.	14.00	1.4302	0.9787	0.0091	0.0078
6.	17.50	1.4506	0.9897	0.0091	0.0078
7.	21.00	1.4710	1.0007	0.0091	0.0078
8.	24.50	1.4914	1.0177	0.0091	0.0078
9.	28.00	1.5118	1.0227	0.0091	0.0078
10.	31.50	1.5322	1.0337	0.0091	0.0078
11.	35.00	1.5526	1.0386	0.0091	0.0078

Table 1.8: Storey Drift & Maximum Average Displacement of Model M0D01002

SR. NO.	STOREY HEIGHT (M)	MAX. AV. DISPLACEMENT (CM)		MAX. DRIFT (CM)	
		X	Z	X	Z
1.	0.00	0.6562	0.5178	0.4388	0.3235
2.	3.50	1.6816	1.3953	0.6878	0.5706
3.	7.00	2.3300	1.9583	0.4380	0.3571
4.	10.50	2.3443	1.9794	0.0138	0.0149
5.	14.00	2.3585	2.0005	0.0138	0.0149
6.	17.50	2.3728	2.0216	0.0138	0.0149
7.	21.00	2.3870	2.0121	0.0138	0.0149
8.	24.50	2.4013	2.0638	0.0138	0.0149
9.	28.00	2.4156	2.0848	0.0138	0.0149
10.	31.50	2.4298	2.1059	0.0138	0.0149
11.	35.00	2.4441	2.1270	0.0138	0.0149

Table 1.9: Storey Drift & Maximum Average Displacement of model M0D01005

SR. NO.	STOREY HEIGHT (M)	MAX.AV. DISPLACEMENT (CM)		MAX. DRIFT (CM)	
		X	Z	X	Z
1.	0.00	0.5412	0.3986	0.3586	0.2658
2.	3.50	1.5159	1.2120	0.6394	0.5369
3.	7.00	2.5865	2.0790	0.6976	0.5722
4.	10.50	3.623	2.8984	0.6758	0.5346
5.	14.00	4.4617	3.5975	0.5576	0.4263
6.	17.50	4.9592	3.9377	0.2771	0.2017
7.	21.00	4.9577	3.9354	0.0322	0.0244
8.	24.50	5.1040	3.9964	0.0184	0.0180
9.	28.00	5.0704	4.0573	0.0184	0.0180
10.	31.50	5.0208	4.0110	0.0184	0.0180
11.	35.00	5.0656	4.0584	0.0184	0.0180

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It may be assign the average displacement (X) &(Z) in the M0D1005 is more than the average displacement X & Z in M0D1000 & M0D1002, so that the floating column which are used at 5th increase the average displacement.

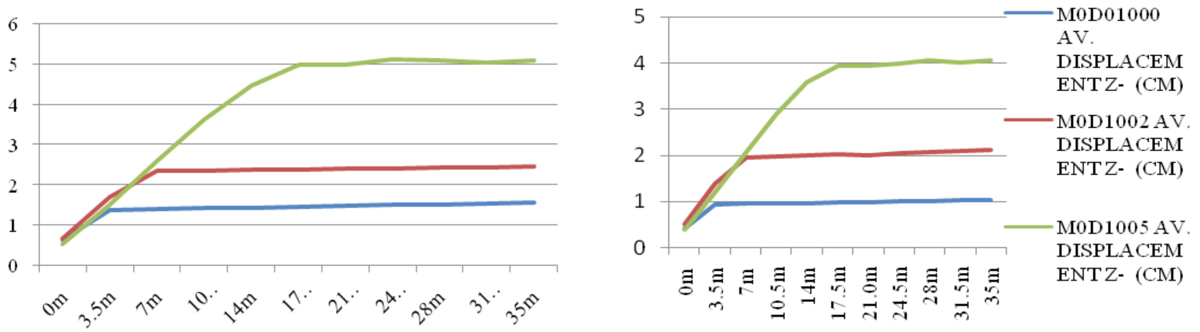

Fig. 1.3: Comparison of Av. Displacement - X and Z between M0D1000 & M0D1002 & M0D1005

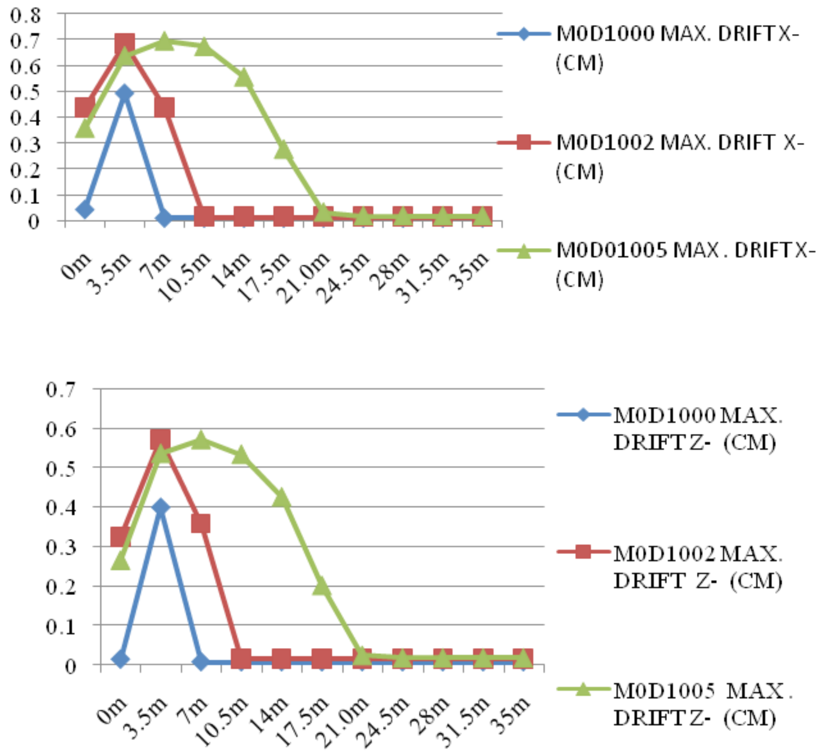

Fig. 1.4: Comparison of Storey Drift - X and Z between M0D1000 & M0D1002 & M0D1005

It may be shown that the storey drift X & Z in M0D1005 is more than the storey drift X & Z in M0D1000 & M0D1002, so that the floating column which are used at 5th increase the average displacement.

D. Comparison of Maximum Node Displacement, Support Reaction and Maximum Beam End Forces of each Model in X, Y & Z direction

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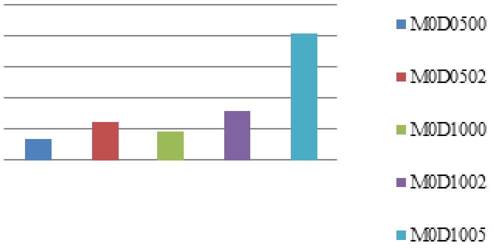

Fig. 1.5: Maximum Node Displacement in x-direction mm

The above Fig.(1.5) assign the displacement in x-direction in case of non- floating column (model 1 &model 3) is less than the floating column (M0D0502 & M0D1002), and also if the floating are started from the 5th floor (M0D1005) displacement will be more than the column are started from 2nd floor level (M0D1002).

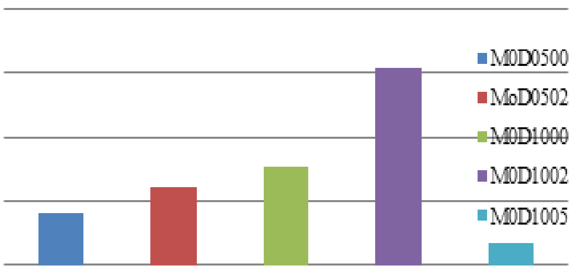

Fig. 1.6: Maximum Node Displacement in y-direction mm

The above Fig.(1.6) shows that the maximum node displacement y-direction in case of non-floating column (M0D0500) is less than the floating column (M0D0502), but in case of 10 storey maximum node displacement in case of non-floating column (M0D1000) and floating (M0D1002) more than the model 5, which are started from the 5th floor (M0D1005).

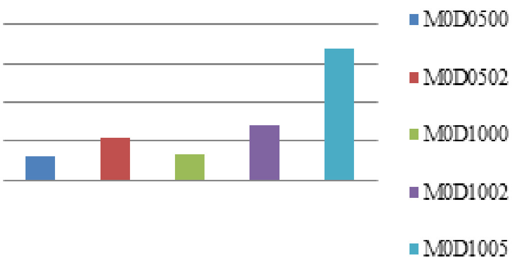

Fig. 1.7: Maximum Node Displacement in z-direction mm

The above Fig. shows that the displacement in z-direction in case of non-floating column (MOD0500& M0D1000) is less than the floating column (M0D1002 & M0D1002), also more in floating column are started from the 5th floor (M0D1005).

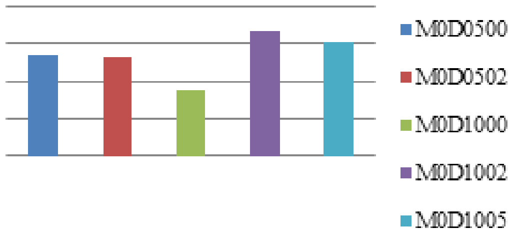

Fig. 1.8: Maximum Support Reaction in x- direction KN

The above Fig. shows that the maximum support reaction in x-direction in case of non-floating column (M0D0500 & M0D0502) is less than the floating column (M0D0502, M0D1002 & M0D1005).

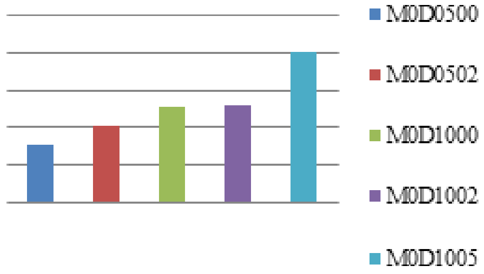

Fig. 1.9: Maximum Supports Reaction in y-direction KN

The Fig. (1.9) shows that the maximum supports reaction in y-direction in case of non-floating column (M0D0500) is less than the floating column (M0D1000). If the storey height is increase it will be same.

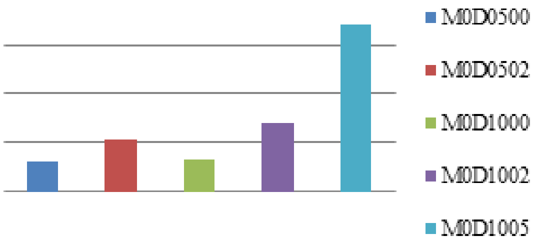

Fig. 1.10: Maximum Support Reaction in z- direction KN

The above Fig. (1.10) shows that the maximum support reaction in x-direction in case of non-floating column (M0D0500 & M0D1000) is less than the floating column (M0D0502, M0D1002 & M0D1005).The maximum support reaction in z-direction in case of non- floating column (M0D0500) is less than the floating column (M0D0502), but in case of 10 storey the support reaction in M0D01002 more than the M0D1005. If the floating started from the 5th floor (M0D1005) maximum support

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reaction in z-direction will be less than the column are started from 2nd floor level.

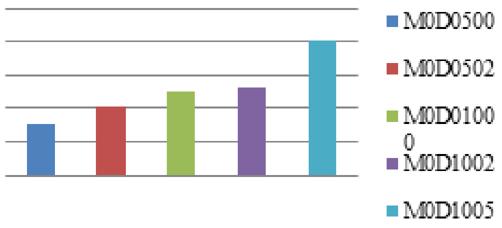
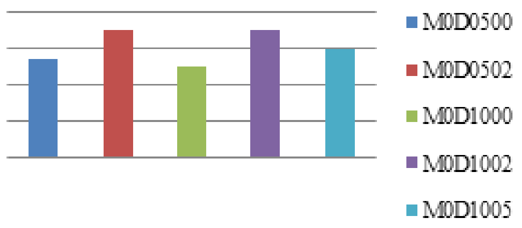


Fig. 1.11: Maximum End Forces in x- direction KN

The above Fig. (1.11) assign the maximum support reaction in x-direction in case of non-floating column (M0D0500 & M0D01000) is less than the floating column (M0D0502, M0D1002 & M0D1005).that the maximum end forces in x-direction in case of non-floating column (M0D0500 & M0D1000) is less than the floating column (M0D0502 & M0D1002), and also if the floating are started from the 5th floor (M0D1005) maximum end forces in x-direction more than the column are started from 2nd floor level.



.Fig. 1.12: Maximum End Forces in y- direction KN

The above Fig. 1.12 shows that the maximum end forces in y-direction in case of non-floating column (M0D0500) is more than the floating column (M0D0502), but in case of 10 storey maximum end forces in case of non-floating column (M0D1000) less than the M0D1005, but if the floating are started from the 5th floor (M0D1005) maximum end forces in z-direction also more than the column are started from 2nd floor level (M0D1002).

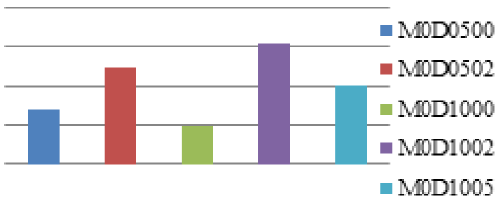


Fig. 1.13: Maximum End Forces in z- direction KN

The above Fig. 1.13 shows that the maximum end forces in z-direction in case of non-floating column (M0D0500) is more than the floating column (M0D0502), but in case of 10 storey maximum end forces in case of non-floating column (M0D1000) less than the M0D1005, but if the floating are started from the 5th floor (M0D1005) maximum end forces in z-direction also less than the column are started from 2nd floor level (M0D1002).

V. Conclusion

Noteworthy conclusions from the study are as under

1. The use of floating column in the framed structure decreased the dead load ranging from 9% to 22%.
2. In multistoried building with floors more than 5, drift decreases with increase in height of structure.
3. End forces also decreased if floating column are used at 5th floor in the high rise building.
4. Base shear force also decrease if floating columns are used in high rise buildings

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