# Effect of Floating Column on Dynamic Response of Multi-Storeyed RC Framed Buildings

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***Abstract****- In recent times, buildings with floating column are required to have free space due to the aesthetic and other functional requirements in urban India. This study deals with analyzing the effects of floating column location in multi-storey building under the earthquake excitation. Different cases of the building are studied by varying the location of floating columns floor wise and within the floor. The structural response of the building models with respect to Base shear, Storey Shear, Storey drift and Storey displacement is investigated. The analysis is carried out using software STAAD Pro V8i software. The Response Spectrum seismic analysis is carried out for G+5storey RC framed building comprising with floating at different storey levels and without floating column has been discussed. Structures were assumed to be situated in earthquake Zone III and Zone V on a medium soil (type II). The response of building such as storey drift, storey displacement and storey shear has been to evaluate and the results are to be obtained using STADD.Pro V8i software.*

***Keywords***- Floating columns, Storey Shear, Storey Drift, STAAD Pro V8i, Response Spectrum Seismic analysis.

## I. INTRODUCTION

Nowadays multi-storey buildings constructed for the purpose of residential, commercial, industrial etc., with an open ground storey is becoming a common feature. For the purpose of parking all, usually the ground storey is kept free without any constructions, except the columns which transfer the building weight to the ground. 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 behaviour 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 Bhuj earthquake. Buildings with 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.

WHAT IS FLOATING COLUMN?

Floating column is also a vertical member, The Columns Float or move in above stories such that to provide more open space is known as Floating columns. Floating columns are implemented, specially above the base floor, so that added open space is accessible for assembly hall or parking purpose. Floating columns are usually adopted above the ground storey level. So that maximum space is made available in the ground floor which is essentially required in apartments, mall or other commercial buildings where parking is a major problem. The floating column act as a point load on the beam and this beam transfers the load to the columns below it. But such column cannot be implemented easily to construct practically since the true columns below the termination level are not constructed with care and hence finally cause to failure. The floating column is used for the purpose of architectural view and site situations. Since balconies are not counted in floor space index (FSI), buildings have balconies overhanging in the upper stories beyond the column foot print areas at the ground storey, overhangs up to 1.2 m to 1.5 m in plan are usually provided on each side of the building. In such cases, floating columns are provided along the overhanging perimeter of the building. Most of the time, architect demands for the aesthetic view of the building, in such cases also many of the columns are terminated at certain floors and floating columns are introduced. But Provision of floating columns resting at the tip of overhanging beams increases the vulnerability of the lateral load resisting system due to vertical discontinuity. This type of construction does not create any problem under vertical loading conditions. But during an earthquake a clear load path is not available for transferring the lateral forces to the foundation. Lateral forces accumulated at the upper floor during the earthquake have to be transmitted by the projected cantilever beams. Overturning forces thus developed overwhelm the columns of the ground floor. Under this situation the columns begin to deform and buckle, resulting in total collapse. This is because of primary deficiency in the strength of ground floor columns, projecting cantilever beams and ductile detailing of beam column joint. In case of floating column, shear is induced to overturning forces to another resting element of the low level. This imposition of overturning forces overwhelms the columns of lower level through connecting elements. Therefore the most critical region of damage is the connecting element (link between discontinuous columns to lower level column) and lower level columns. Therefore, the primary concern in load path irregularity is the strength of lower level columns and strength of the connecting beams that support the load of discontinuous frame. Floating column provided in a structural system is highly undesirable especially in higher zones like III, IV & V.

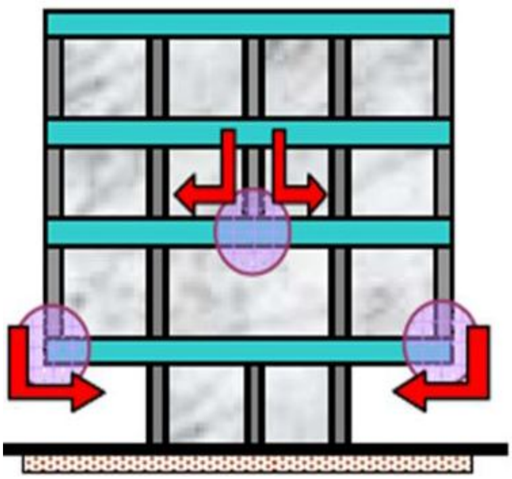


Fig 1 Building with floating columns

## II. OBJECTIVES

The primary objectives of the study are as under –

1. To model the building with and without floating columns using software STAAD PRO V8i for analysis and design purpose.
2. To carry out Static and Dynamic analyses for different cases by varying the location of floating columns floor wise and within the floor for both the Seismic Zone III and Seismic Zone V.
3. To study the structural response of the building models with respect to following aspects –
   - Base shear.
   - Storey Shear.
   - Storey drift.
   - Storey displacement.

## III. METHODOLOGY

A 32m X 16m multi-storeyed building (G+5), with Special Moment Resisting Frame was selected for study. The building had a one brick thick exterior wall along the periphery and all the interior walls are half brick thick. It was considered to be located in Zone III and in Zone V on medium (Type II) soil. The loads and member sizes are summarized in Table I. In this study first a normal building (NB) without any floating columns on Zone III and Zone V is modelled whose floor plan and elevation are shown in figure 2. Then, four types of models, namely MODEL 1, MODEL 2, MODEL 3 and MODEL 4 are modelled. MODEL 1 and MODEL 2 are assumed to be in Zone III on medium (Type II) soil. MODEL 3 and MODEL 4 are assumed to be in Zone V on medium (Type II) soil. In MODEL 1 and MODEL 3, the floating columns are located at ground floor and and again divided in to two types of models namely MODEL 1A, MODEL 1B and MODEL 3A, MODEL 3B,where in MODEL 1A and in MODEL 3A all the exterior columns are floating columns and in model 1B and in MODEL 3B all the interior columns are floating columns. Similarly, in MODEL 2 and MODEL 4, all the floating columns are at first floor and again subdivided in to two models namely MODEL 2A, MODEL 2B and MODEL 4A, MODEL 4B. In MODEL 2A and MODEL 4A, all the exterior columns are floating columns at first floor and in Model 2B and MODEL 4B all the interior columns are floating columns at first floor.

Table 1
PROBLEM STATEMENT

| Sr No | Parameters | G+5 Building |
|---|---|---|
| 1 | Height of building | 18 m |
| 2 | Floor height | 3m |
| 3 | Seismic Zone | Zone III, Zone V |
| 4 | Zone Factor (*Z*) | 0.16, 0.36 |

| | | |
|---|---|---|
| 5 | Importance Factor (*I*) | 1.0 |
| 6 | Response Reduction Factor (*R*) | 5.0 |
| 7 | Soil Type | Medium |
| 8 | Size of beams | 300mm X 450mm |
| 9 | Size of columns | 450mm X 450mm |
| 10 | Spacing of columns | 4m |
| 11 | Thickness of slab | 125mm |
| 12 | Damping | 0.05 |
| 13 | Live Load On floors except roof | 3 kN/m$^2$ |
| 14 | Live load on roof | 1.5 kN/m$^2$ |
| 15 | Floor Finish | 1.5 kN/m$^2$ |
| 16 | Load due to partition | 2kN/m$^2$ |
| 17 | Grade of concrete | M30 |
| 18 | Grade of steel | Fe415 |

## IV. MODEL OVERVIEW

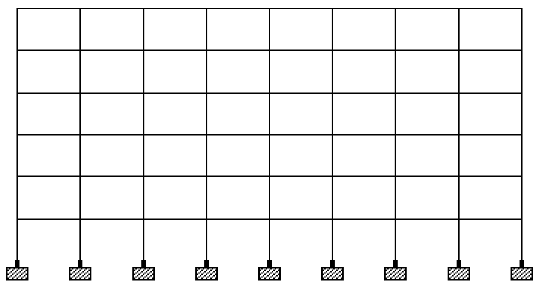


Figure 2 : G+5 Building without any floating column( Front Elevation) on Zone III and Zone V

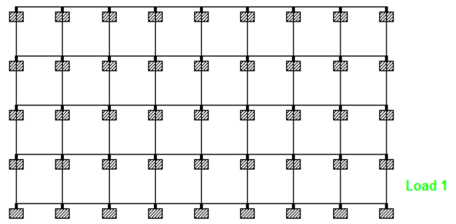



Figure 3 : G+5 Building without any floating column(Plan) on Zone III and Zone V

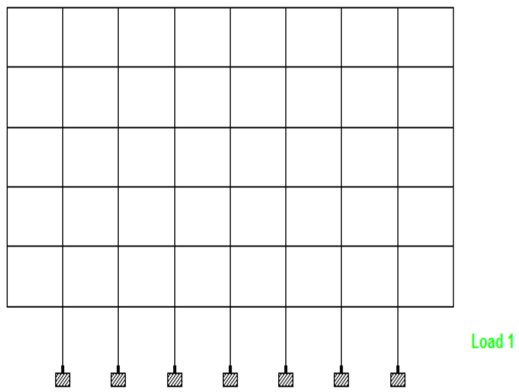



Figure 4 : G+5 Building with exterior floating column at ground floor (Front Elevation) on Zone III and Zone V

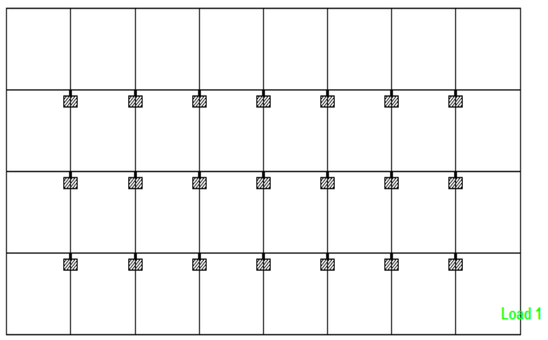



Figure 5: G+5 Building with exterior floating column at ground floor (Plan) on Zone III and Zone V

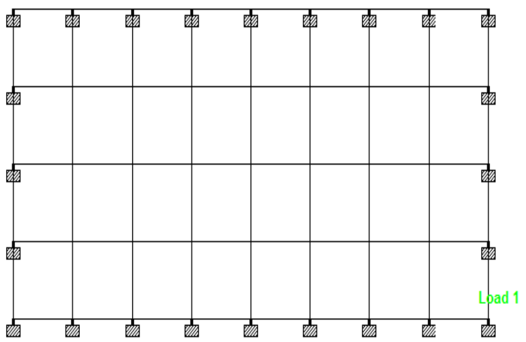



Figure 6: G+5 Building with interior floating column at ground floor (Plan) on Zone III and Zone V

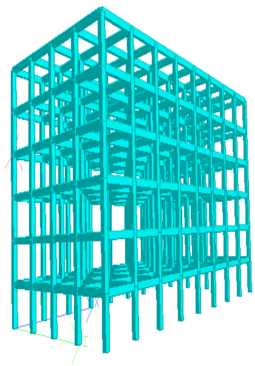


Figure 7: G+5 Building with interior floating column at ground floor (Isometric View) on Zone III and Zone V

MODEL 1B, MODEL 3B

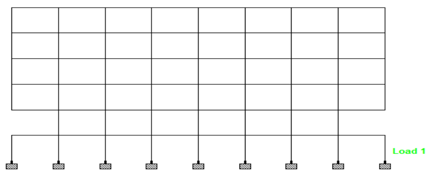



Figure 8: G+5 Building with exterior floating column at first floor (Front elevation) on Zone III and Zone V

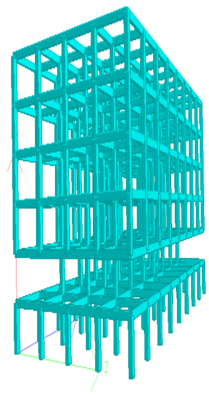


Figure 9: G+5 Building with exterior floating column at first floor (Isometric View) on Zone III and Zone V

MODEL 2A, MODEL 4A

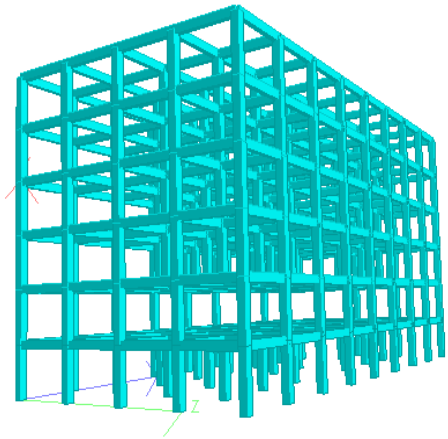


Figure 9: G+5 Building with interior floating column at first floor (Isometric View) on Zone III and Zone V

MODEL 2B, MODEL 4B

## V. METHODS OF ANALYSIS

Seismic analysis is an important tool in earthquake engineering which is used to investigate the response of buildings in a simpler manner due to seismic forces. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

The earthquake analysis methods used in the study are –

I. Equivalent Static Analysis
II. Response Spectrum Analysis

I. Equivalent Static Analysis - This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. The response is read from a design response spectrum, given the natural frequency of the building.

II. Response Spectrum Analysis- This method permits the multiple modes of response of a building to be taken into account. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effects on the building are observed.

## VI. ANALYSIS OF RESULTS

In the present study, the effect of varying the location of floating columns floor wise and within the floor of multi storeyed RC building on various structural response quantities of the building using static analysis and dynamic analysis is studied. The results are compared in tabular form and graphically for the analysis of the building without floating columns and with floating columns at different storey levels in both seismic zone III and in seismic zone V.

TABLE 1: COMPARISON OF BASE SHEAR

| SrNo | Model No | Base shear in kN (X – direction) |
|---|---|---|
| 1 | Reference Model1 | 1077.27 |
| | Reference Model2 | 2451.87 |
| 2 | 1A | 1046.76 |
| | 3A | 2424.43 |
| 3 | 1B | 1070.04 |
| | 3B | 2413.73 |
| 4 | 2A | 1050.65 |
| | 4A | 2419.67 |
| 5 | 2B | 1055.71 |
| | 4B | 2402.64 |

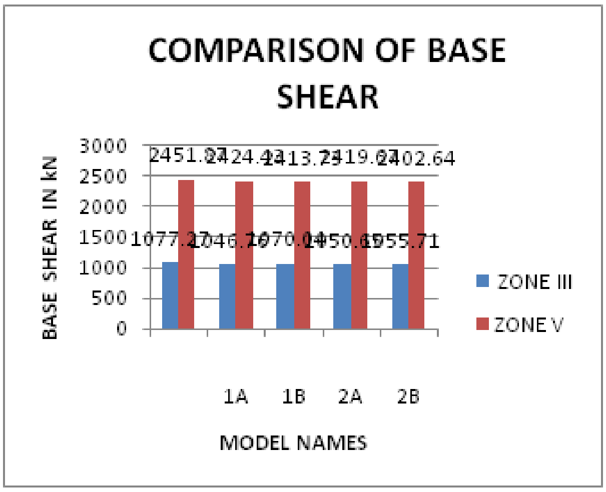



TABLE 2: COMPARISON OF STOREY SHEAR in kN (in X- direction)

ZONE III :-

| Storey level | Reference Model 1 | MODEL 1A | MODEL 1B | MODEL 2A | MODEL 2B |
|---|---|---|---|---|---|
| 1 | 1077.27 | 1046.76 | 1070.04 | 1050.65 | 1055.7 |
| 2 | 1029.03 | 975.54 | 991.13 | 1020.26 | 1024.2 |
| 3 | 909.20 | 845.81 | 847.81 | 888.68 | 873.86 |
| 4 | 722.63 | 666.07 | 658.56 | 699.23 | 674.95 |
| 5 | 482.36 | 444.75 | 432.91 | 466.26 | 442.00 |
| 6 | 205.63 | 191.68 | 182.81 | 200.57 | 186.21 |

ZONE V :-

| Storey Level | REFERENCE MODEL 2 | MODEL 3A | MODEL 3B | MODEL 4A | MODEL 4B |
|---|---|---|---|---|---|
| 1 | 2451.87 | 2424.43 | 2413.73 | 2419.67 | 2402.64 |
| 2 | 2342.07 | 2259.47 | 2215.04 | 2349.69 | 2330.97 |
| 3 | 2069.34 | 1959.01 | 1894.72 | 2046.65 | 1988.79 |
| 4 | 1644.71 | 1542.71 | 1471.78 | 1610.36 | 1536.08 |
| 5 | 1097.86 | 1030.1 | 967.49 | 1073.81 | 1005.94 |
| 6 | 468.01 | 443.96 | 408.56 | 461.92 | 423.8 |

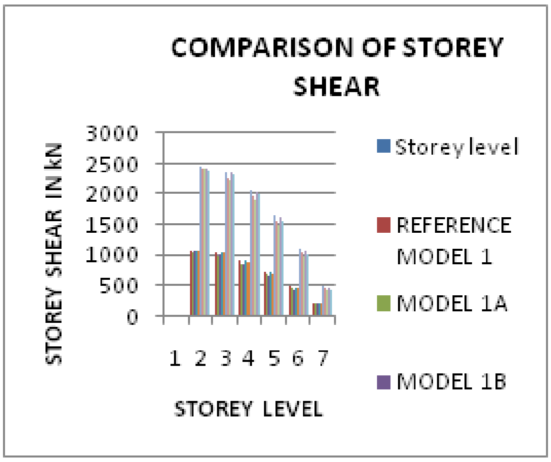



TABLE 3: COMPARISON OF STOREY DRIFT in cm (in X-direction)

ZONE III :-

| Storey level | REFERENCE MODEL 1 | MODEL 1A | MODEL 1B | MODEL 2A | MODEL 2B |
|---|---|---|---|---|---|
| 1 | 0.1505 | 0.4711 | 0.3466 | 0.1674 | 0.1563 |
| 2 | 0.2236 | 0.2852 | 0.2212 | 0.6621 | 0.5144 |
| 3 | 0.2085 | 0.2654 | 0.1937 | 0.2670 | 0.2110 |
| 4 | 0.1679 | 0.2246 | 0.1524 | 0.2270 | 0.1602 |
| 5 | 0.1142 | 0.1735 | 0.1020 | 0.1737 | 0.1070 |
| 6 | 0.0579 | 0.1219 | 0.0514 | 0.1197 | 0.0539 |

ZONE V :-

| Storey Level | REFERENCE MODEL 2 | MODEL 3A | MODEL 3B | MODEL 4A | MODEL 4B |
|---|---|---|---|---|---|
| 1 | 0.3387 | 1.0599 | 0.7799 | 0.3316 | 0.3517 |
| 2 | 0.5032 | 0.6416 | 0.4978 | 1.4897 | 1.1573 |
| 3 | 0.4691 | 0.5972 | 0.4358 | 0.6008 | 0.4747 |
| 4 | 0.3778 | 0.5053 | 0.3428 | 0.5108 | 0.3603 |
| 5 | 0.2570 | 0.3903 | 0.2296 | 0.3908 | 0.2409 |
| 6 | 0.1303 | 0.2742 | 0.1157 | 0.2693 | 0.1213 |

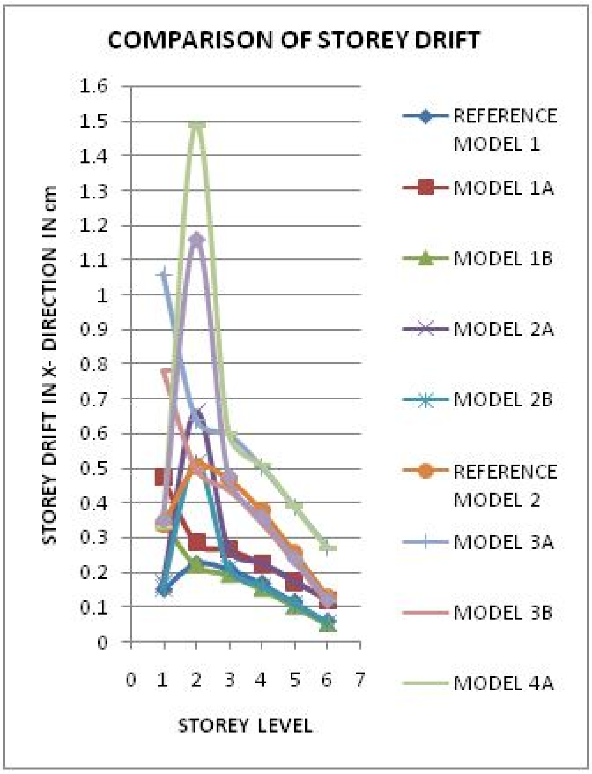


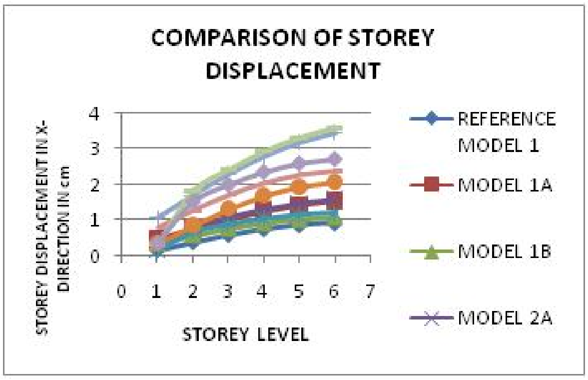

TABLE 4: COMPARISON OF STOREY DISPLACEMENT in cm (in X- direction)

ZONE III :-

| Storey level | REFERENCE MODEL 1 | MODEL 1A | MODEL 1B | MODEL 2A | MODEL 2B |
|---|---|---|---|---|---|
| 1 | 0.1505 | 0.4711 | 0.3466 | 0.1674 | 0.1563 |
| 2 | 0.3742 | 0.7562 | 0.5678 | 0.8095 | 0.6707 |
| 3 | 0.5827 | 1.0217 | 0.7615 | 1.0765 | 0.8817 |
| 4 | 0.7506 | 1.2462 | 0.9139 | 1.3035 | 1.0418 |
| 5 | 0.8648 | 1.4197 | 1.0159 | 1.4772 | 1.1489 |
| 6 | 0.9227 | 1.5416 | 1.0673 | 1.5969 | 1.2028 |

ZONE V :-

| Storey level | REFERENCE MODEL 2 | MODEL 3A | MODEL 3B | MODEL 4A | MODEL 4B |
|---|---|---|---|---|---|
| 1 | 0.3387 | 1.0599 | 0.7799 | 0.3316 | 0.3517 |
| 2 | 0.8419 | 1.7015 | 1.2776 | 1.8213 | 1.5091 |
| 3 | 1.3110 | 2.2987 | 1.7134 | 2.4221 | 1.9838 |
| 4 | 1.6888 | 2.8040 | 2.0562 | 2.9329 | 2.3441 |
| 5 | 1.9457 | 3.1943 | 2.2858 | 3.3237 | 2.5850 |
| 6 | 2.0760 | 3.4686 | 2.4015 | 3.5930 | 2.7062 |




## VII. CONCLUSION

- Storey displacement increases along the height of the building. All the model of displacement value is increased for the floating column building especially for corner floating column provided building.Storey displacement increases or decreases depend upon the storey mass.
- Storey drift is increases due to the presence of floating column. It reduces in the lower storey, this happened because of storey displacement reduction in lower floor than higher floor.
- Storey shear decreases along the storey height. It reduces than usual column due to the presence of floating column

in building. Because of the mass is less in floating column building than without floating column.

- Hence from the comparative analysis of all models, the floating columns in buildings are to be avoided especially corner floating columns is must avoided because its more vulnerable in seismic prone areas.

ADVANTAGES AND DISADVANTAGES:

Advantages :

1) By using floating columns large functional space can be provided which can be utilize for storage and parking.
2) In some situations floating columns may prove to be economical in some cases

Disadvantages :

1) Not suitable in high seismic zone since abrupt change in stiffness was observed
2) Required large size of girder beam to support floating column.
3) Floating columns leads to stiffness irregularities in building
4) Flow of load path increases by providing floating columns. The load from structural members shall be transfer to the foundation by the shortest possible path.

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