Structural behaviour of RC Building by using & without using Floating Columns.

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***Abstract*- In the modern era of construction, floating columns are an unavoidable feature of buildings. However, in seismic prone areas, they are highly vulnerable. This study highlights the response of RC buildings due to discontinuity in load path and evaluates the risk of floating columns for a G+4 RCC building project. The proposed analysis method is based on IS 1893 Part 1: 2016, and it focuses on the effect of earthquake forces on various building models for various parameters, including storey shear, storey displacement, storey drift, and bending moment and shear force in transfer girder. The analysis results in the building, such as base shear Modal Participating Mass Ratios, Torsional Irregularity ,storey displacement, storey drift, and fundamental time period, are measured for review. The present work deals with the mitigation of intended risk of floating columns by providing a structural system/configuration such as pre-stressed girder, shear wall, and bracing system. Finally, conclusions are made on the percentage reduction in building response by comparing models having floating columns with structurally configured models.**

***Index Terms*: RCC**, Floating **Columns, Seismic forces, Bending Moment, Modal Participating Mass Ratios, Torsional Irregularity**

I. INTRODUCTION

1.1 *General*

In Current time for better space utilization and providing the facilities for the requirements of open space , such as Architectural requirement, Construction of Soft storey requirement, Parking & entrance, party/assembly hall, swimming pool, reception lobbies, auditorium, swimming pool, etc. the open first story is a common feature in commercial and residential buildings. During the earthquake, the behavior of a building depends upon its geometrical shape, size, and how the earthquake force is carried to the ground. Usually in every building load is transferred from horizontal members (beam and column) to vertical members

(Walls & Columns) and then to the foundation. A structure having a floating column can be classified as vertically irregular as it causes the irregular distribution of mass, strength, and stiffness along with the building height. The absence of any column at any level of structure changes the load transfer path and a load of this floating column is transferred through the horizontal beam below it, known as transfer girder. This paper explains the behavior of multi-story floating column building and comparison between floating as well as without floating column structure and values of various parameters like story drift, storydisplacement, etc. based on seismic load.

1.2 *Floating Column*

A column is a vertical compression member which starts from foundation level and continues up to top level which transfers the load to the ground. The term floating column is also a vertical component which at its lower-level rests on a beam which is a horizontal member. Structures with columns that suspend or float on beams at a middle level and do not go all the way to the footing, have breaks in the load transfer path. The beams in turn transfer the load to other columns under it. In such columns the loads were measured as a point load. Floating column does not have any structural continuity because they are built over the beam. There are many projects in which floating columns are already accepted, particularly above the ground floor, so that more open space is available on the ground floor.

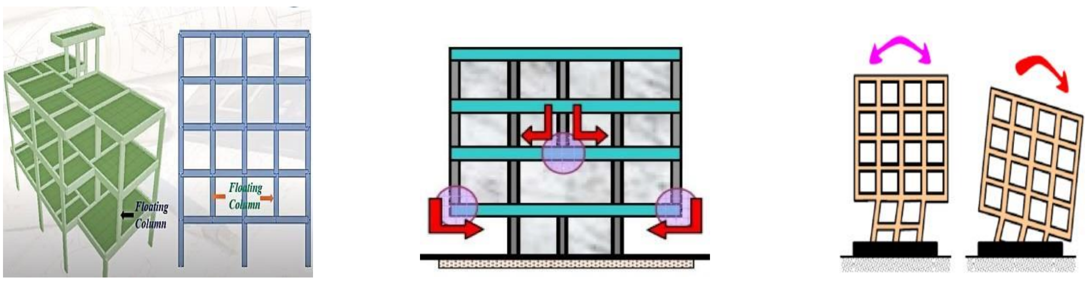


Figure. A) Model of floating column building, B) Load transfer Path, C) force- displacement

II. Objective of the study

- To study the responses of structure with and without location floating column
- To study the responses like storey displacement, storey drift, storey shear, etc.
- To provide an alternative solution to overcome the problem of floating columns.

III. Scope of the study

- In this study, the main aim is to do evaluation of the risk involve in RC building having floating columns than the regularbuilding.
- The finding of the risk study will help us to design of Structural system/configuration such that, it will mitigate theintended risk of floating columns to achieve adequate safety under gravity & seismic actions.

IV. Problem Statement

- How the floating columns gives response to the seismic forces and also to study the critical members of the structure havingfloating columns.
- In accordance with IS-1893-2016 (part-1), to study the performance levels and performance points of the building.
- To study about risk factors with floating columns.

V. Advantages

- A floating column is primarily used to meet the architectural requirements of a building.
- Floating columns are noticeable when there is a large span hall with rooms on the upper floor like a hotel or auditorium onthe lower floor.
- Floating columns are useful in the construction of soft floors.
- The project layout at each site may be different.
- The rooms can be divided and some area can be raised without raising the whole area.

VI. METHODOLOGY

1. General

- Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis isa recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.
- A thorough literature review to understand the seismic evaluation of building structures and application of Equivalent Staticanalysis and Response Spectrum analysis.
- Seismic behavior with various concentric and eccentric bracings, geometrical and structural details.
- Modelling with various concentric bracing by using computer software Staad pro.
- Carry out Equivalent Static Analysis and Response Spectrum Analysis on the models and arrive at a conclusion.

2. Methods Of Analyzing

- Effects of design earthquake loads applied on structures can be considered in two ways, namely:

A] Equivalent Static Method

- As per this method, first, the design base shear shall be computed for the building as a whole. Then, this shall be distributedto the various floor levels at the corresponding centres of mass. And, finally, this design seismic force at each floor level shall be distributed to individual lateral load resisting elements through structural analysis considering the floor diaphragm action. This method shall be applicable for regular buildings with height less than 15 min Seismic Zone II.

B] Dynamic Analysis Method

- Linear dynamic analysis shall be performed to obtain the design lateral force (design seismic base shear, and its distribution to different levels along the height of the building, and to various lateral load resisting elements) for all buildings, other thanregular buildings lower than 15 m in Seismic Zone II.

Design base shear (VB): It is the horizontal lateral force in the considered direction of earthquake shaking that the structureshall be designed for.

- The analytical model for dynamic analysis of buildings with unusual configuration should be such that it adequatelyrepresents irregularities present in the building configuration.
- Dynamic analysis may be performed by either the Time History Method or the Response Spectrum Method.

1) Time History Method:-

- Time history method shall be based on an appropriate ground motion (preferably compatible with the design acceleration spectrum in the desired range of natural periods) and shall be performed using accepted principles of earthquake structuraldynamics.

2) Response Spectrum Method:-

- Response spectrum method may be performed for any building using the design acceleration spectrum, or by a site-specific design acceleration spectrum.

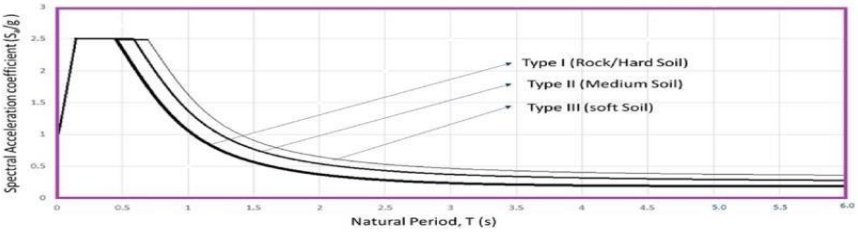


Fig. Spectra for Response Spectrum Method

- All mentioned data for RCC buildings is analyze as per Indian code which are IS: 456-2000 and IS: 875-1987. The seismicload and response spectrum analysis of different models are carried out using STAAD-Pro Connect edition and ETABS.
- The load combinations considered in seismic analysis are done as per Indian code which is IS:1893-2002Moment resisting frame (MRF)
  RCC Building with X bracing system (XBF)RCC Building with V bracing system (VBF)

3. Loads to be considered in analysis & design.

- Dead loads.
- Live loads.
- Seismic loads.
- Breeze loads.
- Wall load
- Floor finish
- Res X & Res Y

VII. MODELLING

1. MODAL DESCRIPTION

Design data and seismic parameters considered for analysis of different geometry of frame structure is listed in the table. Table no. VII.1. Structure Details

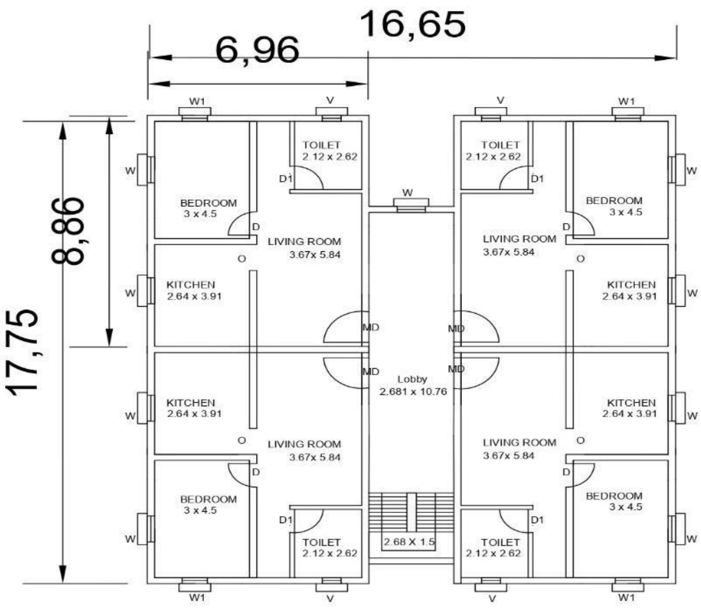
Sr.no.	**Particulars**	**Dimensions/size/values**
1.	Model	G+4
2.	Building Height	15M
3.	Storey Height	3M
4.	Size of Columns	230 X 400mm
5.	Size of Adjacent Columns	300 X 1000mm
6.	Size of Beam	280 X 300mm
7.	Size of Beam for 1st slab for fc str.	500 X 900mm
8.	Live load on floors	3.5 KN/M2
9.	Floor finishing load	2.5 KN/M2
10.	Wall thickness	230MM
11.	Thickness of slab	150 MM
12.	Grade of concrete	M25
13.	Grade of steel	FE 500
14.	Zone	III (MUMBAI)

2. SEISMIC PARAMETERS

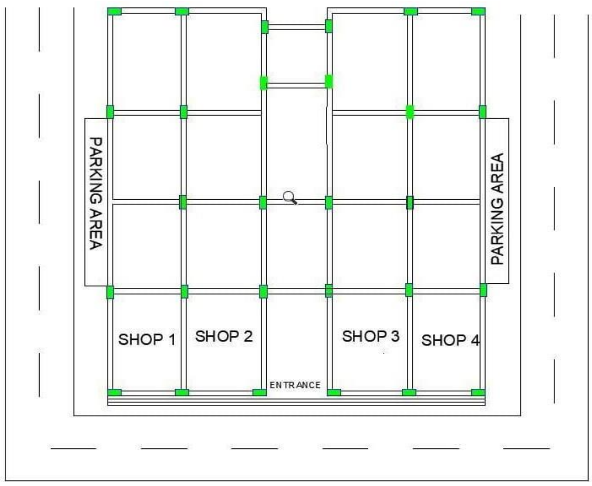
The different Seismic Parameters for the model analysis are taken from the IS 1893 (Part1)-2016 which is as followsTable VII.2 Seismic Parameters

Sr.no.	Particulars	Values	Clause NO.
1.	Soil type (Rocky & Hard soil)	I	IS 1893:2016 cl 6.4.2.1
2.	Importance factor	1.2	IS 1893:2016 cl 7.2.3 Table 8
3.	Seismic zone	III	IS 1893:2016 cl 6.4.2 Table 3
4.	Zone Factor	0.16	IS 1893:2016 cl 6.4.2 Table 3
5.	Damping Ratio	5%	IS 1893:2016 cl 7.2.4
6.	Response Reduction Factor	4	IS 1893:2016 cl 7.2.6 Table 9

3. Architecture Plan/Layout

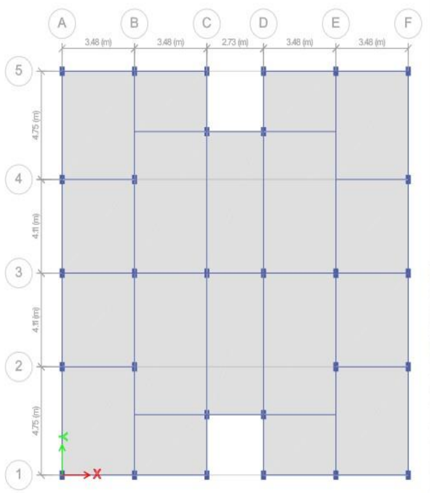


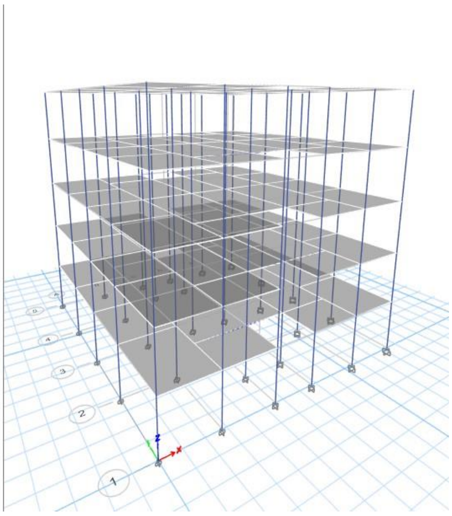
TYPICAL FLOOR PLAN



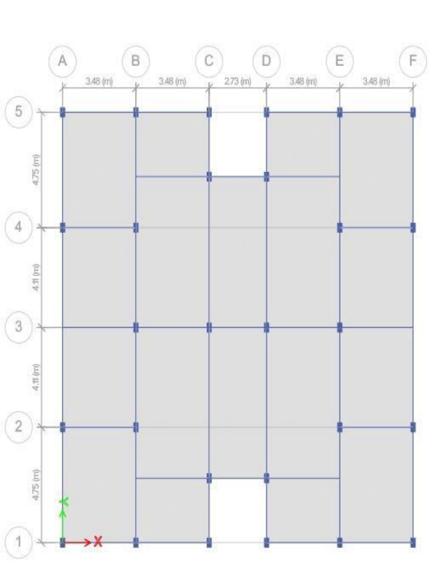
Ground floor plan

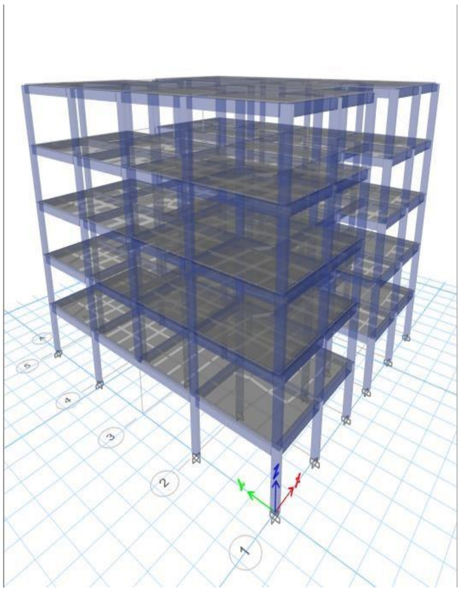
Regular Building plan and 3D view





Building having floating column plan with 3D view





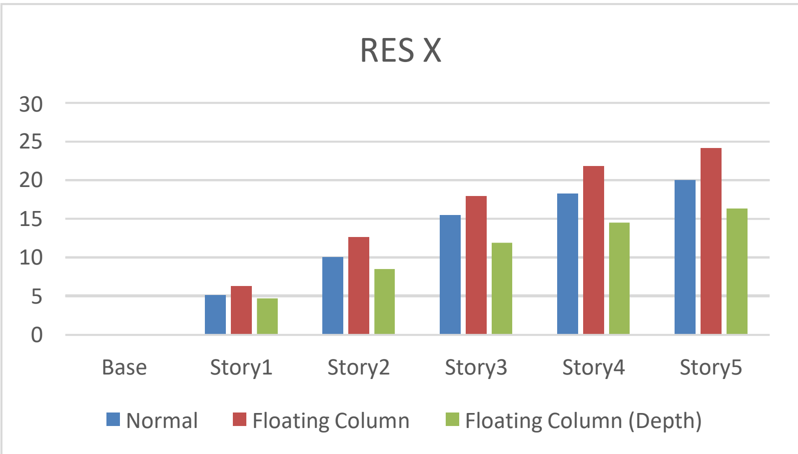
VIII. RESULTS AND DISCUSSION

Model No. 1: Regular Residential Building

Model No. 2: Residential Building having Floating columns

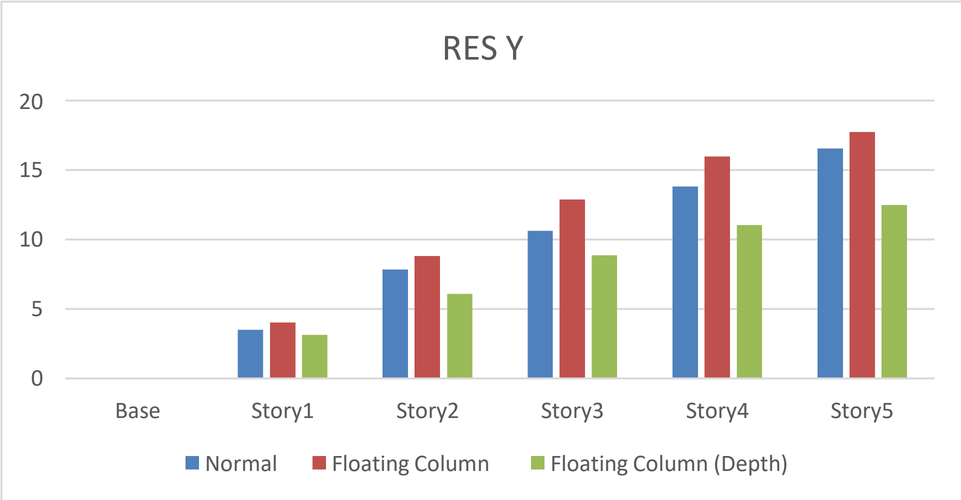
Model No. 3: Residential Building having floating columns with grade of concrete M40Maximum Storey displacement in X direction: (RES-X)

Storey	Elevation (m)	Location	Model 1	Model 2	Model 3
Base	0	Top	0	0	0
Storey1	3	Top	5.12	6.318	4.71
Storey2	6	Top	10.05	12.677	8.514
Storey3	9	Top	15.46	17.936	11.909
Storey4	12	Top	18.23	21.857	14.519
Storey5	15	Top	20.03	24.141	16.29



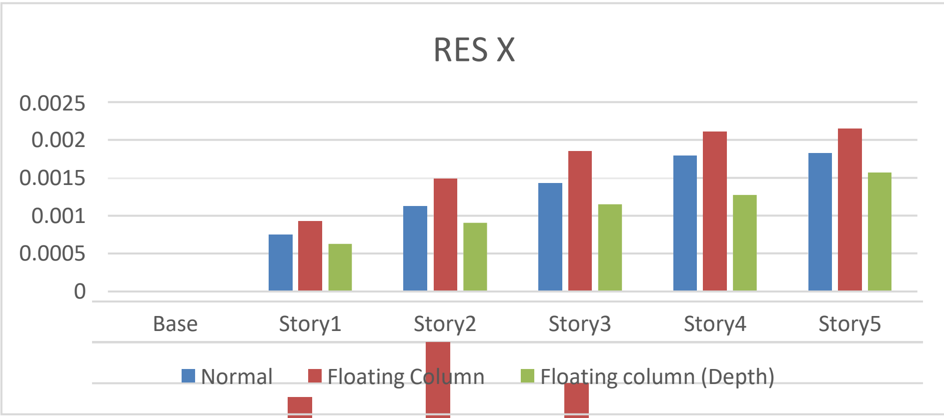
Maximum Storey displacement in Y direction: (RES-Y)

Storey	Elevation (m)	Location	Model 1	Model 2	Model 3
Base	0	Top	0	0	0
Storey1	3	Top	3.5	3.999	3.126
Storey2	6	Top	7.8	8.782	6.092
Storey3	9	Top	10..61	12.884	8.869
Storey4	12	Top	13.81	15.937	11.033
Storey5	15	Top	16.52	17.712	12.493



Maximum Storey Drift in X direction: (RES-X)

Storey	Elevation (m)	Location	Model 1	Model 2	Model 3
Base	0	Top	0	0	0
Storey1	3	Top	0.000752	0.000928	0.000628
Storey2	6	Top	0.001124	0.001486	0.000906
Storey3	9	Top	0.001425	0.001854	0.001151
Storey4	12	Top	0.00179	0.002106	0.001273
Storey5	15	Top	0.001826	0.002146	0.001571



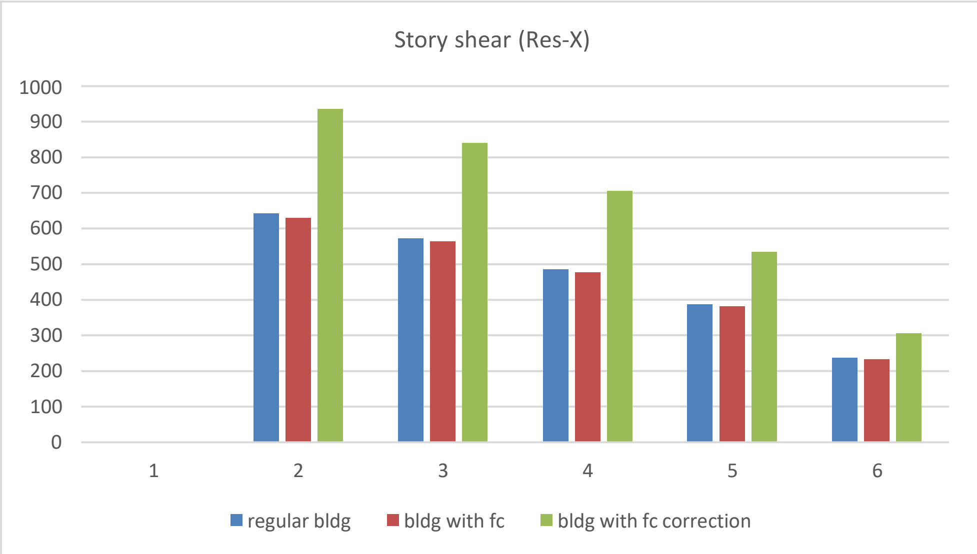
Maximum Storey Drift in Y direction: (RES-Y)

Storey	Elevation (m)	Location	Model 1	Model 2	Model 3
Base	0	Top	0	0	0
Storey1	3	Top	0.000825	0.001333	0.000506
Storey2	6	Top	0.00112	0.001601	0.000738
Storey3	9	Top	0.00115	0.0014	0.000935
Storey4	12	Top	0.001015	0.001081	0.000991
Storey5	15	Top	0.000526	0.000657	0.001042


RES Y
0.0018
0.0016
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
Base
Story1
Story2
Floating Column
Story3
Story4
Story5
Normal
Floating Column (Depth)

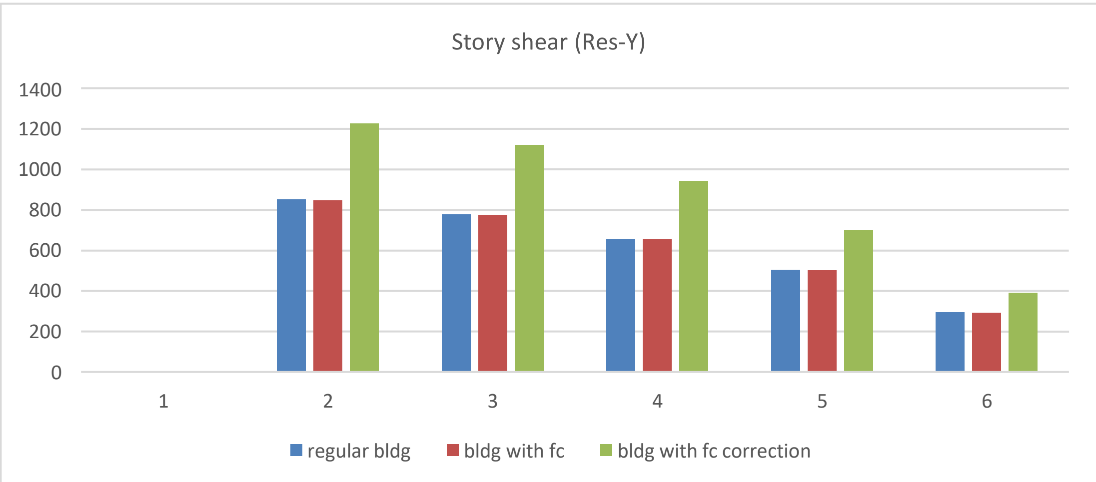
Storey Shear (Res-X)

Storey	Elevation (m)	Location	Model 1	Model 2	Model 3
Base	0	Top	0	0	0
Storey1	3	Top	642.2018	630.2358	935.2226
Storey2	6	Top	571.9917	563.1974	841.279
Storey3	9	Top	485.3612	477.5609	706.4643
Storey4	12	Top	386.8769	380.8008	534.4977
Storey5	15	Top	236.907	232.7171	306.4209



Story Shear (Res-Y)

Storey	Elevation (m)	Location	Model 1	Model 2	Model 3
Base	0	Top	0	0	0
Storey1	3	Top	850.695	846.7943	1226.347
Storey2	6	Top	777.0116	775.5426	1119.283
Storey3	9	Top	658.1079	656.0339	942.7059
Storey4	12	Top	503.4773	500.9407	701.8479
Storey5	15	Top	294.6864	291.8726	391.7208



Bending moment & shear force distribution:

MODEL NO. 1: Bending moment at X and Y direction (Res-x) & (Res-y) of Regular Building

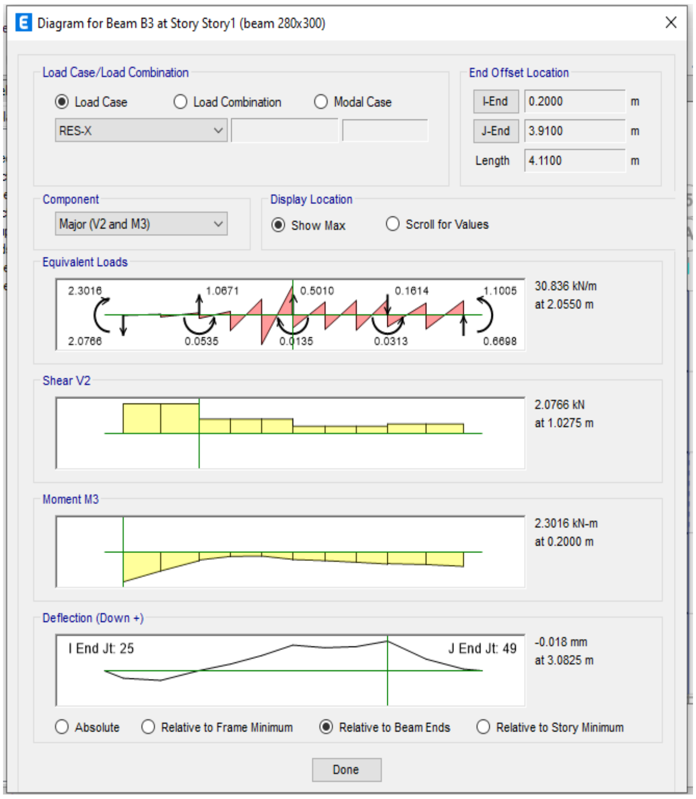


Fig.1. BM at X direction (Res-X)

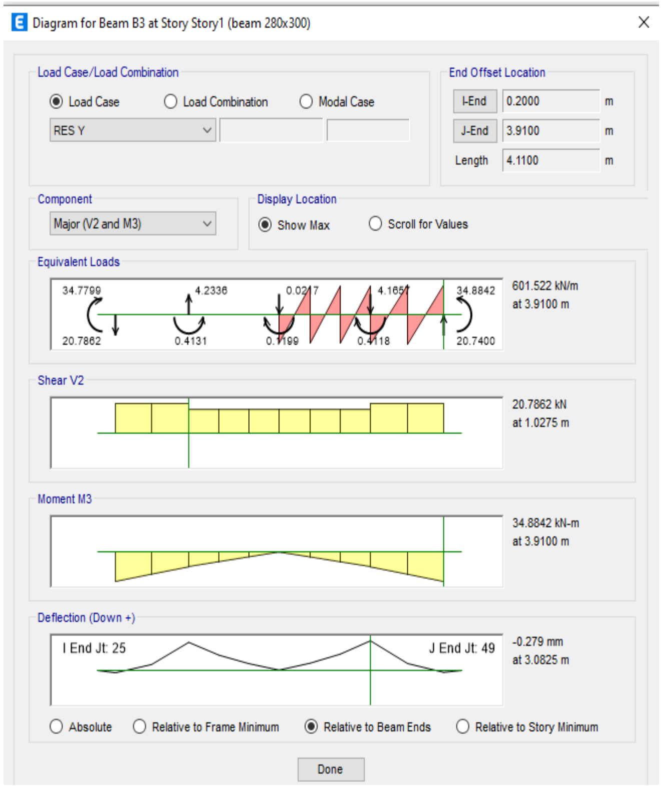


Fig.2. BM at Y direction (Res-Y)

MODEL NO. 2: Bending moment at X and Y direction (Res-x) & (Res-y) of Regular Building

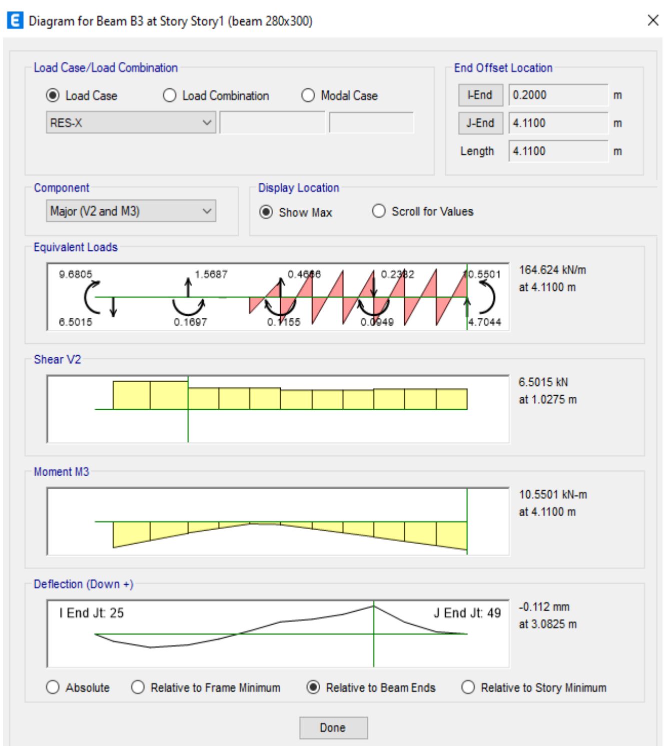


Fig.3. BM at X direction (Res-X)

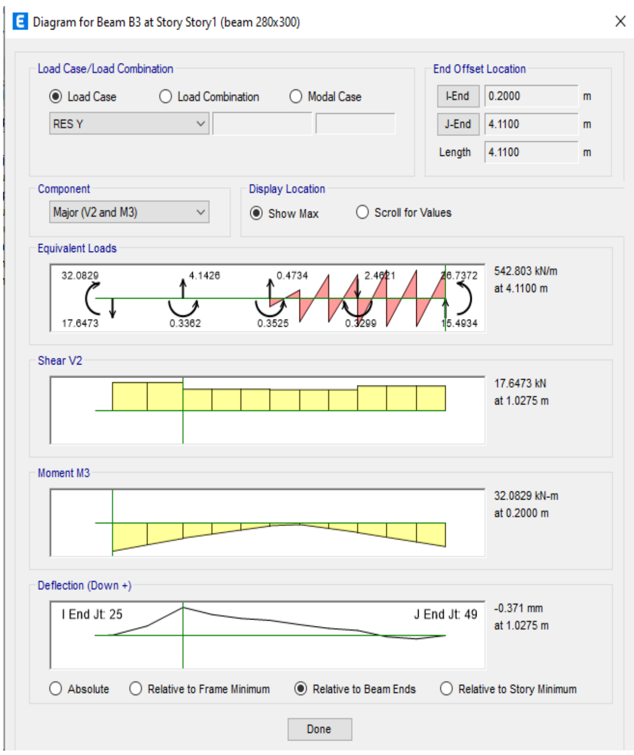


Fig.4. BM at Y direction (Res-Y)

MODEL NO. 3: Bending moment at X and Y direction (Res-x) & (Res-y) of Regular Building

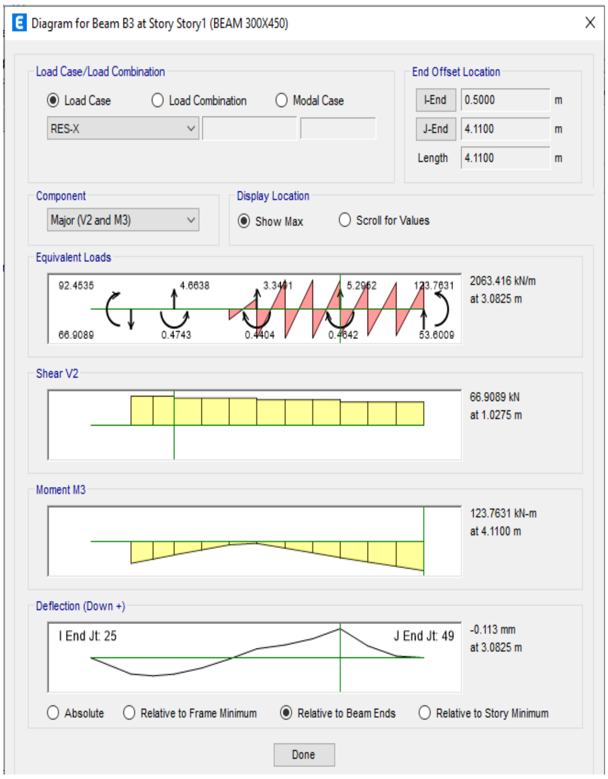


Fig.5. BM at X direction (Res-X)

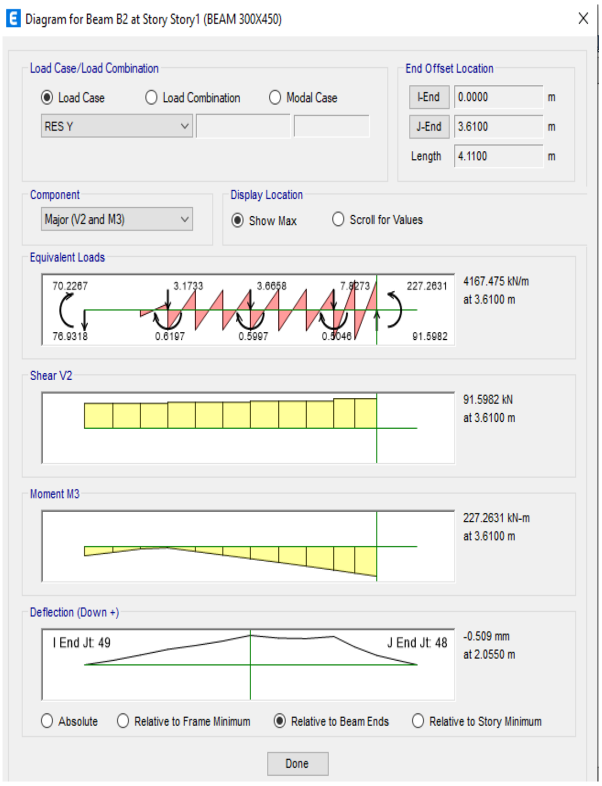


Fig.6. BM at Y direction (Res-Y)

Modal Participating Mass Ratios

As per Indian standard, clause no. 7.7.5.2 , IS 1893(Part 1): 2016, the number of modes Nm tobe used in the analysis forearthquake shaking along a consider direction should be such that the sum total of modal mass of these modal mass consider is at least 90% of total seismic mass.

Model No. 1: Regular Building

Mode	Period sec	UX	UY	RZ	SumUX	SumUY	SumRZ
1	1.498	0.8605	1.36E-05	0.0008	0.8605	1.36E-05	0.0008
2	1.14	0.0008	0.0506	0.7976	0.8613	0.0506	0.7983
3	1.064	9.37E-06	0.7902	0.0513	0.8613	0.8408	0.8497
4	0.502	0.0954	2.14E-06	0.0001	0.9567	0.8408	0.8498
5	0.375	0.0001	0.0044	0.094	0.9568	0.8451	0.9437
6	0.346	8.45E-07	0.0989	0.0041	0.9568	0.944	0.9478
7	0.306	0.0297	0	2.95E-05	0.9865	0.944	0.9478
8	0.229	0.0108	0	1.01E-06	0.9974	0.944	0.9478
9	0.221	3.15E-06	0.0009	0.0334	0.9974	0.9448	0.9812
10	0.2	0	0.0352	0.0008	0.9974	0.9801	0.982
11	0.194	0.0026	0	1.17E-06	1	0.9801	0.982
12	0.17	0	0.0001	2.71E-05	1	0.9801	0.982
Summation	Of	12	modes		99.89%	98.01%	98.2%

1. Mode No.01 has Maximum Mass Participation in Translational X-direction with 86.05% andTime Period of 1.498 Sec.
2. Mode No.02 has Maximum Mass Participation in Translational Z-direction with 79.83% andTime Period of 1.14 Sec.
3. Mode No.03 has Maximum Mass participation in Rotational Y-direction with 84.08% andTime Period of 1.064 Sec.
4. Maximum Mass Participation for Summation of 12 Modes is 99.89% in Translational X-direction.

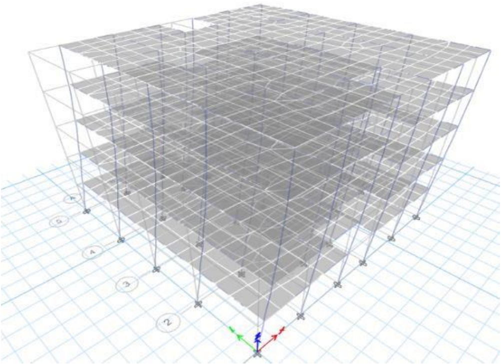


Figure no. MODE 1

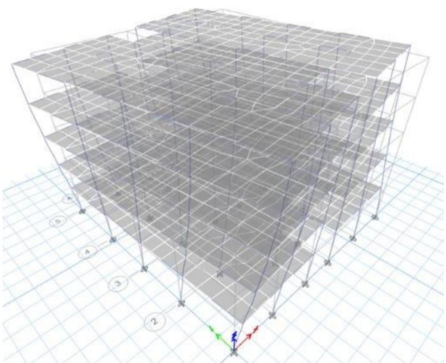


Figure no. MODE 2

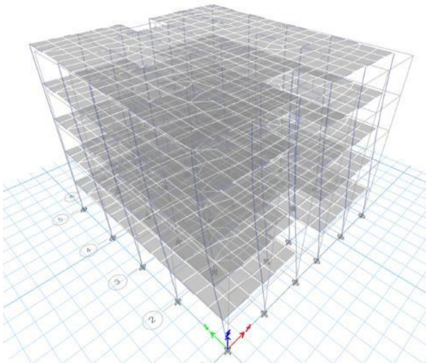


Figure no. MODE 3

Model No.2: Residential Building having floating columns

Mode	Period sec	UX	UY	RZ	Sum UX	Sum UY	Sum RZ
1	1.519	0.8663	5.59E-06	0.0006	0.8663	5.59E-06	0.0006
2	1.152	0.0006	0.0368	0.8232	0.8669	0.0368	0.8238
3	1.071	7.23E-06	0.8117	0.0379	0.8669	0.8485	0.8616
4	0.505	0.0934	1.25E-06	0.0001	0.9603	0.8485	0.8617
5	0.377	0.0001	0.0035	0.0898	0.9604	0.852	0.9515
6	0.347	0	0.0964	0.003	0.9604	0.9484	0.9546
7	0.305	0.0272	0	3.17E-05	0.9875	0.9484	0.9546
8	0.228	0.01	0	1.46E-06	0.9975	0.9484	0.9546
9	0.222	1.21E-06	0.0008	0.0294	0.9975	0.9492	0.984
10	0.2	0	0.0326	0.0006	0.9975	0.9818	0.9846
11	0.194	0.0025	0	1.22E-06	1	0.9818	0.9846
12	0.173	0	2.65E-05	5.93E-06	1	0.9818	0.9846
Summation	Of	12	modes		99.89%	98.18%	98.46%

1. Mode No.01 has Maximum Mass Participation in Translational X-direction with 86.63% andTime Period of 1.519 Sec.
2. Mode No.02 has Maximum Mass Participation in Translational Z-direction with 82.32% andTime Period of 1.152 Sec.
3. Mode No.03 has Maximum Mass participation in Rotational Y-direction with 81.17% andTime Period of 1.071 Sec.
4. Maximum Mass Participation for Summation of 12 Modes is 99.89% in Translational X-direction.

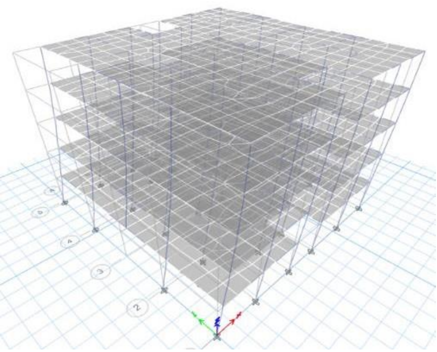
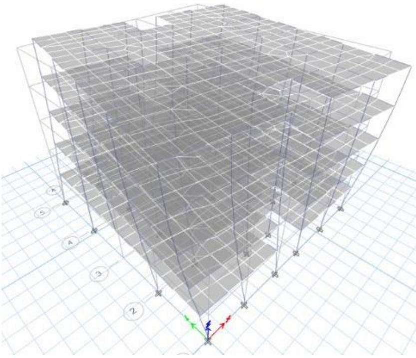
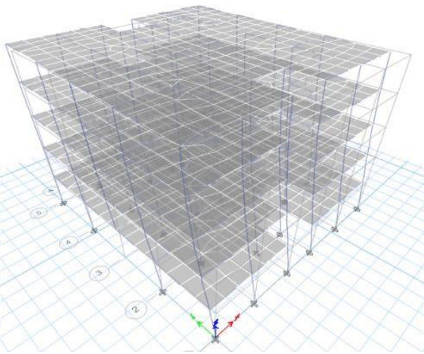




Figure no. MODE 1 **Figure no. MODE 2** **Figure no. MODE 3**

Model No.3: Residential Building having floating columns with grade of concrete M40

Mode	Period sec	UX	UY	RZ	SumUX	SumUY	SumRZ
1	1.033	0.8757	0	4.08E-05	0.8757	0	4.08E-05
2	0.811	3.21E-05	0.0045	0.8643	0.8757	0.0045	0.8643
3	0.774	0	0.8544	0.0043	0.8757	0.8588	0.8686
4	0.317	0.0945	0	0	0.9703	0.8588	0.8686
5	0.249	2.96E-06	0.0004	0.0968	0.9703	0.8592	0.9654
6	0.239	0	0.1031	0.0005	0.9703	0.9623	0.9659
7	0.167	0.0219	0	5.28E-07	0.9922	0.9623	0.9659
8	0.126	0	0.0001	0.0252	0.9922	0.9624	0.9911
9	0.123	0	0.0277	0.0001	0.9922	0.9901	0.9912
10	0.104	0.0065	0	0	0.9987	0.9901	0.9912
11	0.092	8.79E-07	0	6.85E-07	0.9987	0.9901	0.9912
12	0.092	5.69E-06	0	4.52E-06	0.9987	0.9901	0.9912
Summation	Of	12	modes		99.87%	99.01%	99.12%

1. Mode No.01 has Maximum Mass Participation in Translational X-direction with 87.57% andTime Period of 1.033 Sec.
2. Mode No.02 has Maximum Mass Participation in Translational Z-direction with 86.43% andTime Period of 0.811 Sec.
3. Mode No.03 has Maximum Mass participation in Rotational Y-direction with 85.44% andTime Period of 0.774 Sec.
4. Maximum Mass Participation for Summation of 12 Modes is 99.87% in Translational X-direction.

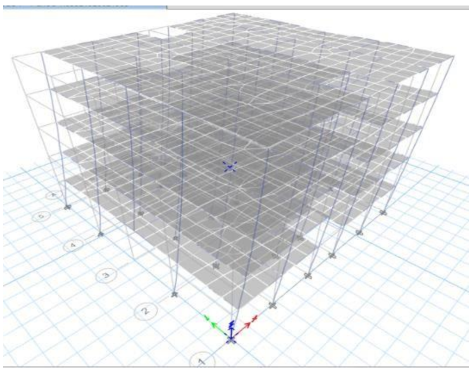
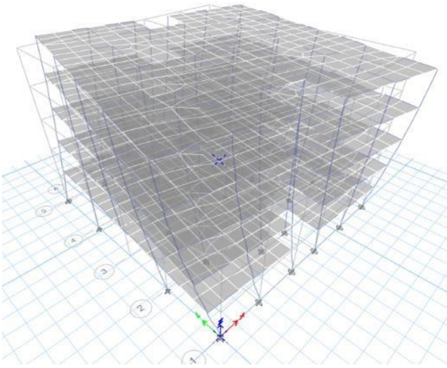
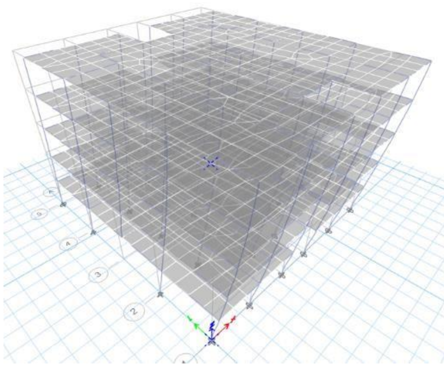




Figure no. MODE 1 **Figure no. MODE 2** **Figure no. MODE 3**

- **Check for Torsional Irregularity**

Torsional Irregularity for Conventional Building
Displacement of Conventional Building in X- Direction are as follows:Dmax = 24.2 mm
Dmin = 22.5 mm
Average Displacement (Davg) Davg = (24.2+22.5)/2
= 23.35 mm
Torsional Irregularity= Dmax/Davg
= 24.2/23.35
= 1.03<1.2

Displacement of Conventional Building in Y Direction are as follows:
Dmax = 18.3 mmDmin = 16.2 mm
Average Displacement (Davg) Davg = (18.3+16.2)/2
= 17.25 mm
Torsional Irregularity = Dmax/Davg
=18.3/17.25
= 1.06<1.2

Torsional Irregularity for Residential Building having floating columns
Displacement of Residential Building having floating columns in X-Direction are as follows:Dmax = 25.1mm
Dmin = 23.2 mm
Average Displacement (Davg) Davg = (25.1+23.2)/2
= 24.15 mm
Torsional Irregularity = Dmax/Davg
=25.1/24.15
= 1.03<1.2
Displacement of Residential Building having floating columns in Y-Direction are as follows:Dmax = 18.23 mm
Dmin = 16.21 mm
Average Displacement (Davg) Davg= (18.23 +16.21)/2
=17.22 mm
Torsional Irregularity = Dmax/Davg
=18.23/17.22
= 1.06<1.2

Torsional Irregularity for Residential Building having floating columns with grade of concrete M40 Displacement of Residential Building having floating columns with grade of concrete M40 in X- Direction are asfollows:
Dmax = 16.52 mmDmin = 16.21 mm
Average Displacement (Davg) Davg = (16.52 +16.21)/2
= 16.365 mm
Torsional Irregularity= Dmax/Davg
=16.52 /16.365
= 1.02<1.2
Displacement of Residential Building having floating columns with grade of concrete M40 in Y- Direction are asfollows:
Dmax = 12.52 mm Dmin = 12.203 mm
Average Displacement (Davg) Davg = (12.52+12.203)/2
= 12.3615 mm
Torsional Irregularity = Dmax/Davg
= 12.52/12.3615
= 1.012<1.2

IX. CONCLUSION

1. From analysis, it is found that when we provide FC, then there is discontinuity in load path, to transfer gravity & lateral loads tothe ground, in buildings with FC have longer load path instead of shorter load path as in regular case.
2. The Axial forces, Bending moments & shear force concentration are very high in beams & columns nearer to floating column junction, under dynamic loading vulnerable to local failure & cause to global failure of structure.
3. Bending moments and shear forces in transfer girder carrying floating column is drastically increasing about 4 to 5 times morethan the beam of regular structure. Due to concentrated loads, so heavy beams are need to design for huge actions, this will contradictory to strong column weakbeam theory of design.
4. Due to discontinuity in load path, longer load path is there to transfer superstructure load to foundation, hence the axial forces in FC structures are about 2 to 3 times more than the columns in regular structure. Some of columns is under axial tension forcein building having floating columns, failure of such columns leads to global failure of structure.
5. The Beams & columns are to be designed with greater sectional area to sustain with such hugeaxial compression & shear forces, floating column building required huge sections. Quantity of concrete & steel required is more, so this floating columnstructures

should build only wherever necessary.

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