"PUSHOVER ANALYSIS OF REINFORCED CONCRETE BUILDING WITH FLOATING COLUMNS"

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Abstract: Civil engineering structures such as building must have sufficient safety margin under dynamic loading like earthquake. The dynamic performance of a RCC building can be determined accurately that requires appropriate modelling considering foundation-soil, building-foundation and soil interactions. Building-foundation-soil interactions are complex phenomena requiring advanced mathematical and numerical modelling. The soil-structure interaction plays an important role particularly when subjected to seismic excitation, due to the potentially disastrous consequences of a seismic event. In the present work effectiveness of modelling in software for determination of seismic behavior of the mediumrise building over raft considering soil flexibility interaction is studied. Modal analysis of building system is carried out in software. For theanalysis, three dimensional multiple bays regular RC building model for eight storeys is considered and the soil beneath the structure is modelled as equivalent soil springs connected to the raft foundation. The response spectrum analysis of the soil-structure model was carried out using the general software STAAD.Pro. In both the cases (fixed base and flexible base) of modelling the structure, the earthquake records have been scaled according to the Indian Standard 1893-2002 for each type of soil (i.e. I, II & III) and applied to the ordinary moment resisting frame with seismic zone III, zone IV and zone V.

Index Terms – **Productivity, Lean construction, Cost comparison, Work breakdown structure.**

I. Introduction

It's also named as seismic analysis. A column is a primary vertical member of a frame system. It starts from a foundation level and runs up to the top, transferring the load to the foundation and ultimately to the ground below. Whereas floating columns are also vertical members, similar to normal RC columns, but these columns rest on a girder (which is a horizontal member) and does not have a foundation. A floating column acts as point load on agirder, which ultimately transfers the load to the supports below.

In present-day multi-storey buildings constructed in urban India, for the purpose of residential or commercial usage have an open ground storey as an unavoidable feature. This type of adoption is primarily for the purpose of accommodation of parking, where the ground storey is kept free without any interruptions or construction so that the vehicular moment is not interrupted. In case of commercial buildings, lower stories are reserved for reception lobbies, banquet hall, showrooms, conference rooms etc. Hence for the purpose of providing large uninterrupted space required for undisturbed human and vehicular moment, floating column system is adopted.

Floating column system may also be adopted with the aim of enhancing architectural beauty of the building, and sometimes to overcome the drawback of space restrictions. However, provision of floating column predominantly affects load resisting system, especially lateral load resting system.
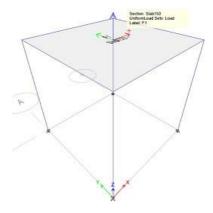
II. METHODOLOGY

The methodology for the determination of lateral forces suggested in IS 1893 (Part 1):2002 includes linear analysis methods which includes

➤ Equivalent static method

➤ Response spectrum method

In the present study, apart from these two methods Non-linear static analysis (Pushover analysis) is also adopted for better results.
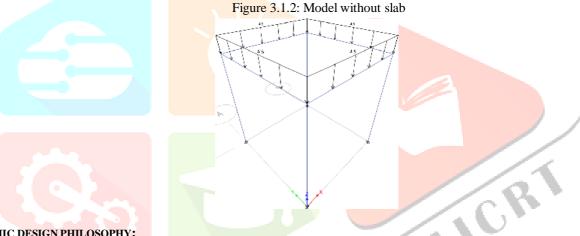
Case 1: Models with slabs

In this case, total three models are considered, one regular building and two buildings with the provision of floating columns. During modelling the inbuilt slab stacks available in ETABS 2013 are used so as to include the self-weight of slab and other inherent properties ofthe slab which ultimately participate in the analysis of the structure.

Figure 3.1.1: Model with slab

Case 2: Models without slabs

In this case, also three models are used as mentioned above but during modelling instead of using slab stacks, the self-weight of slabs and floor loads are proportionally divided and directly applied as the uniformly distributed load on beams.

Figure 3.1.2: Model without slab

1.0 SEISMIC DESIGN PHILOSOPHY:

Seismic design philosophy as per IS 1893 (Part1): 2002 can be summarized as follows.

- Structures must possess at least a minimum strength to withstand a minor earthquake(<DBE) which occur frequently, without damage.

- The structure must resist moderate earthquakes (DBE) without significant structuraldamage, though some non-structural damage may occur.

- Aim that structure withstands a major earthquake (MCE) without collapse thoughmuch severe structural damages may occur.

1.1 MODELLING AND ANALYSIS

4.1 EXPERIMENTAL PROGRAM

General description:

For the present study, ETABS-2013 software is used for modelling analysis and design of RC building for gravity and earthquake loading. Since this software is easy to use, able to consider various complex aspects like material nonlinearity, geometric nonlinearity, P-Δ effects and much more and yet enables to perform linear as well as non-linear analysis more precisely it is considered for the present study.

4.2 BUILDING MODELLING:

A G+5 RCC Ordinary Moment Resisting Frame having four bays of 3m in X and Y- direction with the open ground storey of 3.6m height and remaining storeys of 3.2m height with brick infill walls of 230mm and parapet wall of 150mm thick, 1m height is considered for the present study. The building is assumed to be of the general type with importance factor=1, located in zone II with medium soil type and damping ratio of 5%.

Total six different models are considered with and without provision of floating columns where columns are floated from the first slab. Out of six models, three models include slab modelling and remaining three are without slab modelling. In these models,

beams and columns are modelled as three-dimensional concrete frame elements with rigid beam-column joints and user-defined hinge properties are assigned to beam and column elements. Slabs are modelled as rigid diaphragms. The plan and elevation for eight different models are shown below.

4.3　Material property:

Basic material properties considered (as per IS 456:2000) for present buildingmodels are listed below in the table

Material properties	Values
Characteristic strength of concrete, Fc	25Mpa
Yield stress of steel, Fy	415Mpa
Modulus of elasticity of concrete, Ec	25000Mpa
Modulus of elasticity of steel, Es	200000Mpa

Table 4.2.1: Material properties

4.4　LOADS AND LOAD COMBINATIONS:

Dead loads:

- Once the material properties are defined and element sections are defined and modelled correctly, the software will automatically take the self-weight for the analysis.
- Since we are not modelling infill walls, wall load has to be calculated as wall load=wall thickness*wall height*density of wall material
Wall load=0.230m*(3.2m-0.45m)*22KN/cum=13.92KN/m
- Parapet wall load= 0.15m*1m*22KN/cum=3.3KN/m
- Floor finish is considered as 1KN/sqm

Live loads:

- Considered as 3KN/sqm

Load combinations:

Method of analysis	Load combination
Gravity analysis	1.5(DL+LL)
Equivalent static analysis	1.2(DL+LL+EQ)
	1.5(DL+EQ)
	0.9DL+1.5EQ
Response spectrum analysis	1.2(DL+LL+SPEC)
	1.5(DL+SPEC)
	0.9DL+1.5SPEC

Table 4.2.2: Load combinations

4.2　MODEL DESCRIPTION:

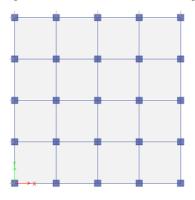**Model A1:** G+5 building frame without floating columns and with slab modelling.
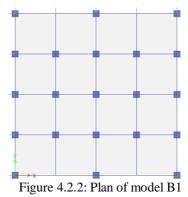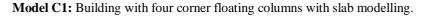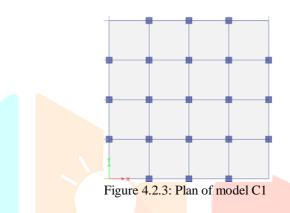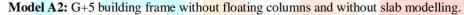

Figure 4.2.1: Plan of model A1

Model B1: Building with four alternative floating columns on the outer side with slabmodelling. The columns are floated from first-floor level.

Figure 4.2.2: Plan of model B1

Model C1: Building with four corner floating columns with slab modelling.

Figure 4.2.3: Plan of model C1

Model A2: G+5 building frame without floating columns and without slab modelling.
Model B2: Building with four alternative floating columns on the outer side without slabmodelling. The columns are floated from first-floor level.

Model C2: Building with four corner floating columns without slab modelling.

4.3   MODELING PROCEDURE IN ETABS 2013:

- Start ETABS 2013, select "New Model" and complete initial settings.

- Specify the number of grid lines and grid spacing in X, Y and Z directions. Substitutethe storey data as per requirement.

- Go to "Define" then "Material property" to add new material.

- Go to "Define" then "Section property" to add new sections like beams, columns,slabs etc.

- Go to "Load pattern" to define loads which include dead load, live load, othersuperimposed loads.

- Now beams and slabs are drawn in the X-Y plane, and columns are drawn in X-Z, andY-Z plane.

- "Load cases" are defined and the loads are assigned using "Assign" on the menu bar.

- Once the model is ready to go "Analyse" and "Check model".

- Go to "Analyse'" and perform analysis using "Run analysis".

- To know analysis results "Display", "Show tables" for the required type of results.

4.4   PROCEDURE FOR PUSHOVER ANALYSIS IN ETABS :

- A three-dimensional model is created, loads are defined and assigned.

- "Define" hinges for frame sections and assign (It may be Auto hinges or user-definedhinges).
- Perform Static linear analysis and design.

- Now "Define" Non-linear load cases and perform Static Pushover analysis to obtainperformance point.

RESULTS AND DISCUSSIONS

Results are obtained for all six models by carrying out different types of analysis in ETABS 2013. From Static analysis which includes Equivalent static analysis and Response spectrum analysis, we obtained base shear, natural time period, lateral displacement, storey drifts etc. From the non-linear static analysis that is pushover analysis safety ratio, global stiffness and performance points are obtained.

BASE SHEAR

Base shear can be defined as the maximum lateral force that acts at the base of the structure due to seismic activity. It is a function of mass, stiffness, height, and fundamental time period. The base shear obtained from Response spectrum method (VB) is equalized to the base shear obtained from the Equivalent static method (ṼB) by using a scale factor as per clause 7.8.2 of IS1893(part I): 2002. Base shear values obtained from different methods are tabulated below.

Table 5.1.1: Base shear of buildings with 1.5(DL+EL) load combination considering with and without slab

LOAD CASE /MODEL	A1	B1	C1	A2	B2	C2
1.5(DL+EQ)	1704.2673	1701.322	1702.02	1704.513	1701.568	1702.266
1.5(DL+SPEC)	945.726	921.4587	892.0993	889.9625	851.8822	834.7331
Scale factor	1.802073	1.846335	1.907882	1.915264	1.997421	2.039294

Table 5.1.2: Base shear of buildings considering with and without slab

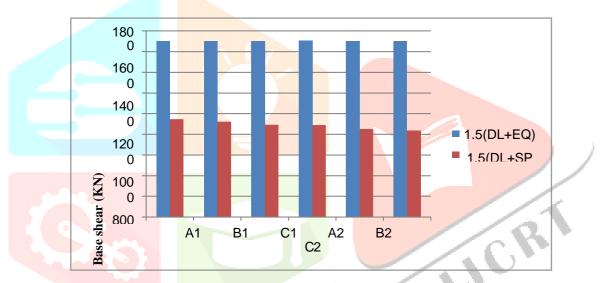| LOAD CASE /MODEL	A1	B1	C1	A2	B2	C2
EQ	1136.1782	1134.215	1134.68	1136.342	1134.378	1134.844
SPEC Max	630.484	614.3058	594.7328	593.3083	567.9215	556.4887
PUSH	4251.6522	3334.1	3329.4	2212.01	2122.36	2100.72

Figure 5.1.1: Base shear of buildings with 1.5(DL+EL) load combination considering with and without slab
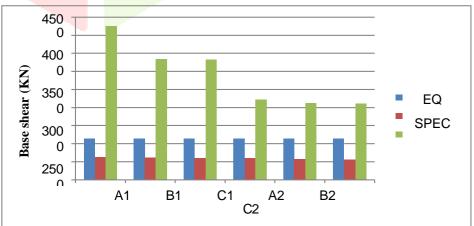

Figure 5.1.2: Base shear of buildings in X-direction considering with and without slab

- Base shear obtained from the Equivalent static method (ESM) are almost 1.8 to 2.03 times higher than that of base shear from Response spectrum method (RSM).
- Base shear from Pushover analysis is almost 1.85 to 3.74 times higher than that of base shear obtained from the Equivalent static method and 3.77 to 6.74 times higher than the values from Response spectrum method.
- Even though base shear from Equivalent static method does not vary much from one model to another, but there is a variation in Response spectrum method values. Base shear obtained from Pushover analysis varies drastically from one model to another. Base shear of buildings without floating columns are on an average(18.75%) higher than that of buildings with floating columns.
- Base shear of buildings with slab has 70% higher values than that of buildings without slabs.

5.1 FUNDAMENTAL NATURAL PERIOD:

The fundamental natural period (Ta) is an inherent property of building, which can be defined as the time taken for one complete cycle of oscillation. From the literature review, we observed that presence of floating column significantly affects fundamental natural period, which is a function of mass, stiffness and damping characteristics. Fundamental natural period obtained from Seismic code IS 1893(Part 1)2000 and from the analysis are compared in the table below.

Table 5.2.1: Fundamental natural period from codal and analytical method

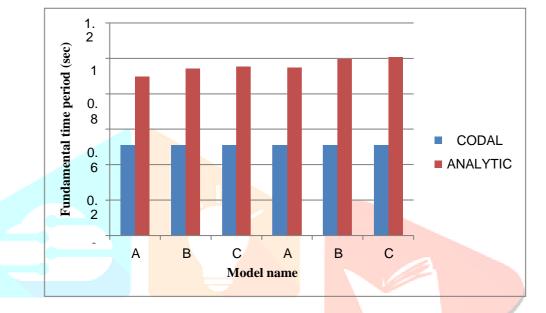| TIME PERIOD /MODEL	A1	B1	C1	A2	B2	C2
CODAL	0.51	0.51	0.51	0.51	0.51	0.51
ANALYTICAL	0.898	0.943	0.953	0.947	0.994	1.008

Figure 5.2.1: The Fundamental natural period from codal and analytical method.

- The analytical time period is higher than codal time period.

- Building models with floating columns give longer time periods than building models without floating columns.

- Models with slabs give shorter time periods than models without slabs.

5.2 LATERAL DISPLACEMENT:

Lateral displacement can be defined as the maximum horizontal displacement of the structure when subjected to lateral loads like wind loads or earthquake loads. Lateral displacement will be minimum at the ground level and maximum at the roof level of the topmost storey. Lateral displacements caused due to seismic loads by using Equivalent static method (ESM) and response spectrum method (RSM) are tabulated below.

Table 5.3.1: Lateral displacement for a building by ESM with 1.5(DL+EL) combination

STOREY/MODEL	A1	B1	C1	A2	B2	C2
Storey7	33.9	35.8	38.4	38.8	41.1	43.4
Storey6	31.7	33.6	35.6	36.3	38.6	40.3
Storey5	27.7	29.5	31	31.5	33.7	35
Storey4	22.1	24	24.8	25	27	27.8
Storey3	15.6	17.5	17.7	17.5	20.3	19.9
Storey2	8.8	10.6	10.3	9.5	13.3	11.9
Storey1	1.1	1.4	1.3	1.1	1.8	1.5
Base	0	0	0	0	0	0

Table 5.3.2: Lateral displacement for a building by RSM with 1.5(DL+EL) combination

STOREY/MODEL	A1	B1	C1	A2	B2	C2
Storey7	15.8	16.3	16.9	17	17.4	17.9
Storey6	15.1	15.6	15.9	16.2	16.6	16.8
Storey5	13.5	14.1	14.2	14.5	15	15.1
Storey4	11.2	11.9	11.8	12	12.4	12.4
Storey3	8.2	9	8.8	8.7	9.7	9.1
Storey2	4.8	5.6	5.3	4.9	6.5	5.7
Storey1	0.6	0.8	0.7	0.6	0.9	0.7
Base	0	0	0	0	0	0

Figure 5.3.1: Lateral displacement for a building by ESM with 1.5(DL+EL) combination

Figure 5.3.2: Lateral displacement for a building by RSM with 1.5(DL+EL) combination

- Lateral displacement is equal in both X and Y direction as the building has symmetrical geometry.

- Lateral displacement by the Equivalent static method is on an average 2.2 times higher than that of lateral displacement obtained from Response spectrum method.

- Lateral displacements of building with floating columns are 7.6% higher than that of buildings without floating columns.
- In all six cases, lateral displacement is minimum at the base and maximum at terrace level.
- Lateral displacements of building without slab are 11.5% higher than that of building with the slab.
- Lateral displacements are higher for buildings with corner floating columns than that of edge floating columns.
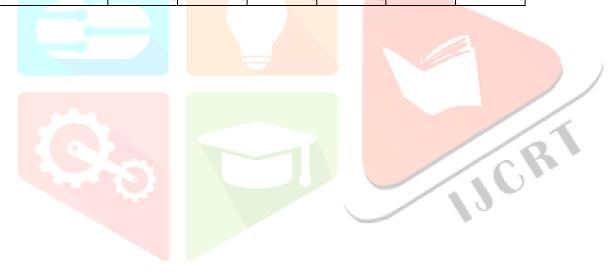
5.3 STOREY DRIFT:

Storey drift can be defined as the Lateral displacement of one level of building compared to that of lateral displacement of the subsequent storey level below. Storey drifts for all sis models obtained by using Equivalent static method and response spectrum method are as shown in the tables below. As per clause 7.11.1 of IS1893 (part I): 2002 the storey drift in any storey due to the maximum specified design lateral force, with a partial load factor of

1.0 shall not exceed 0.004 times the storey height. Hence for 3.6m storey height, maximum storey drift is 14.4mm and that for 3.2m storey height it is 12.8mm.

Table 5.4.1: Storey drifts of a building by ESM

STOREY/MODEL	A1	B1	C1	A2	B2	C2
Storey7	0.000449	0.000448	0.000573	0.000517	0.000053	0.000733
Storey6	0.000851	0.000085	0.000973	0.000988	0.001014	0.001115
Storey5	0.001162	0.001161	0.001286	0.001358	0.001408	0.001502
Storey4	0.001344	0.001343	0.00147	0.00157	0.001656	0.001738
Storey3	0.001431	0.001445	0.001556	0.001659	0.001789	0.001845
Storey2	0.001430	0.001717	0.001672	0.00156	0.002132	0.001905
Storey1	0.000469	0.000626	0.000575	0.000484	0.000791	0.000649
Base	0	0	0	0	0	0

Table 5.4.2 Storey drifts of a building by RSM

STOREY/MODEL	A1	B1	C1	A2	B2	C2
Storey7	0.000168	0.00016	0.000211	0.000185	0.000169	0.00026
Storey6	0.000339	0.000323	0.000372	0.000373	0.000353	0.000405
Storey5	0.000499	0.000478	0.000523	0.000553	0.000541	0.000576
Storey4	0.000627	0.000604	0.000643	0.000693	0.000701	0.000715
Storey3	0.000727	0.000711	0.000735	0.000799	0.000828	0.000823
Storey2	0.000776	0.000911	0.000854	0.000806	0.001043	0.000908
Storey1	0.000258	0.000337	0.000299	0.000254	0.000392	0.000316
Base	0	0	0	0	0	0

Figure 5.4.1: Storey drifts of a building by ESM

Figure 5.4.2: Storey drifts of a building by RSM

- As the building has symmetrical geometry storey drifts are equal in both X and Y direction
- In all six cases, storey drifts are minimum at the base and maximum at the soft storey level.
- Storey drifts of building with floating columns are 25.2% (By ESM) and 7.6% (By RSM) higher than that of buildings without floating columns.
- The storey drifts determined by the Equivalent static method are on an average 2.2 times higher than that of storey drifts obtained from Response spectrum method.
- Storey drifts of building without slab are 18% (By ESM) and 10.8% (By RSM) higher than that of building with the slab.

- Storey drifts are higher for buildings with corner floating columns than that of edge floating columns.

5.4 STOREY STIFFNESS:

Since Response spectrum method gives more reliable values of storey stiffness compared to the Equivalent static method, hence these values are tabulated below.

Table 5.5.1: Storey stiffness

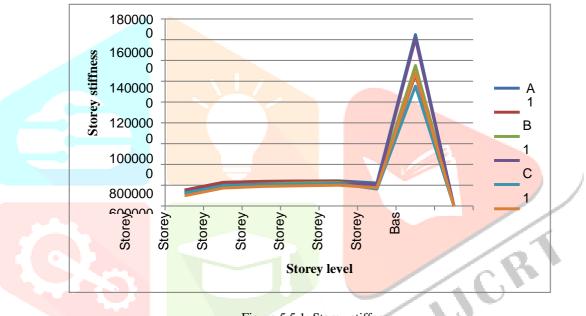| STOREY/MODEL	A1	B1	C1	A2	B2	C2
Storey7	158020.4	155947.2	120041.6	134136.2	129555.7	101970.5
Storey6	231040.9	230021.7	199777.6	202661.3	199353.0	175284.3
Storey5	240268.5	239684.1	216266.2	210859.3	209135.3	189713.7
Storey4	244125.5	243618.5	223509.7	213638.2	213649.2	195667.5
Storey3	246402.9	243355.2	228637.9	217160.6	217223.0	203108.4
Storey2	225655.7	188077.4	193670.2	210504.1	167296.4	177324.0
Storey1	1650570	1266896	1353478	1610344	1156134	1284597
Base	0	0	0	0	0	0

Figure 5.5.1: Storey stiffness

- Storey stiffness is minimum at the base level and maximum at the soft storey level where columns are floated.
- Storey stiffness for buildings with slab has 9.2% higher values than storey stiffness of buildings without a slab.
- Storey stiffness of building without floating columns has 26.4% higher values than buildings with floating columns.

5.5 PERFORMANCE EVALUATION OF THE BUILDING:

Pushover analysis is carried out on all six models by adopting user defined hinges. The target displacement is set to 4% of total height of the building. The results at the performance point are as tabulated below.

Table 5.6.1: Results at Performance point in X and Y direction of model A1

LOAD CASE	PUSHX	PUSHY
Shear force (KN)	3547.2	3374.3
Displacement (mm)	124.9	116.8
Spectral acceleration	0.225	0.214
Spectral displacement (mm)	103.7	96.4
Time period (sec)	1.356	1.345
Ductility ratio	2.592	2.355
Damping ratio	0.129	0.113
Modification factor	1.005	0.902

Figure 5.6.1: Performance point in X and Y direction obtained by Pushover analysis for model A1.

Table 5.6.2: Results at Performance point in X and Y direction of model B1

LOAD CASE	PUSHX	PUSHY
Shear force (KN)	3334.1	3264
Displacement (mm)	134.6	133.2
Spectral acceleration	0.205	0.203
Spectral displacement (mm)	112.7	110.3
Time period (sec)	1.484	1.48
Ductility ratio	2.911	2.742
Damping ratio	0.152	0.141
Modification factor	1.055	1.01

Table 5.6.3: Results at Performance point in X and Y direction of model C1

LOAD CASE	PUSHX	PUSHY
Shear force (KN)	3329.4	3099.4
Displacement (mm)	129.8	119.7
Spectral acceleration	0.208	0.192
Spectral displacement (mm)	106.4	98.8
Time period (sec)	1.431	1.438
Ductility ratio	2.441	2.232
Damping ratio	0.119	0.104
Modification factor	0.953	0.846

Table 5.6.4: Results at Performance point in X and Y direction of model A2

LOAD CASE	PUSHX	PUSHY
Shear force (KN)	2090.8	2089.2
Displacement (mm)	150.5	144.5
Spectral acceleration	0.139	0.139
Spectral displacement (mm)	123.8	118.5
Time period (sec)	1.883	1.844
Ductility ratio	4.658	4.579
Damping ratio	0.199	0.202
Modification factor	1.02	0.996

Table 5.6.5: Results at Performance point in X and Y direction of model B2

LOAD CASE	PUSHX	PUSHY
Shear force (KN)	2006	1960
Displacement (mm)	151.4	146.6
Spectral acceleration	0.131	0.129
Spectral displacement (mm)	125.2	120.8
Time period (sec)	1.959	1.94
Ductility ratio	4.166	4.211
Damping ratio	0.196	0.198
Modification factor	0.98	0.956

Table 5.6.6: Results at Performance point in X and Y direction of model C2

LOAD CASE	PUSHX	PUSHY
Shear force (KN)	1972.8	1961.7
Displacement (mm)	150.6	155.2
Spectral acceleration	0.129	0.129
Spectral displacement (mm)	122.8	126.4
Time period (sec)	1.951	1.987
Ductility ratio	3.73	3.784
Damping ratio	0.189	0.192
Modification factor	0.948	0.963

- Base shear at performance point also depends on stiffness value hence is maximum for building with the slab-without floating column, and is minimum for building without slab-with floating column. Base shear is almost 68% higher for buildings with slabs than compared to buildings without slabs. Building without floating columns has 6% higher base shears than building with floating columns.

- As stiffness decreases, displacement value increases, hence displacements at performance point are 16.2% higher for buildings without slabs and are 2.8% higher for building with floating columns.

- Spectral acceleration is almost 60% higher for buildings with slabs and is 8.1% higher for buildings without floating columns.

- The fundamental time period is 35.6% higher for buildings without a slab, and 5.3% higher for buildings with floating column.

- Damping ratios are 46% higher for buildings without slabs than compared to buildings with slabs. Damping ratios are almost equal for buildings with and without floating columns.

5.6 SAFETY RATIO:

Safety ratio or safety factor can be defined as the ratio of base shear obtained at performance point by using Pushover analysis to that of base shear obtained from the Equivalent static method. The safety ratios for all six models are tabulated below. The concept of safe structure can be percept by safety ratios. If the safety ratio is equal to one then the structure is "Just safe". If the safety ratio is less than one then the structure is "Unsafe" and if the safety ratio is more than one then the structure is "More safe".

Table 5.7.1: Safety ratios for all six models by using Equivalent static and Pushover analysis in X-direction

Model	Base shear at performance point (KN)	Base force at EQX	Safety ratio
A1	3547.2	1136.1782	3.122045
B1	3334.1	1134.2145	2.939567
C1	3329.4	1134.6801	2.934219
A2	2090.8	1136.3420	1.839939
B2	2006.0	1134.3783	1.768370
C2	1972.8	1134.8439	1.738389

Table 5.7.2: Safety ratios for all six models by using Equivalent static and Pushover analysis in Y-direction

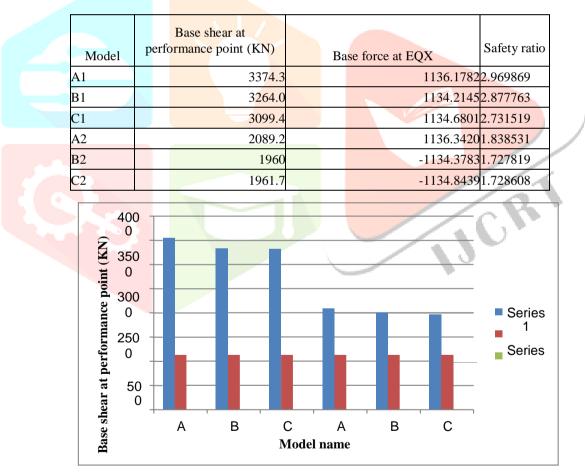| Model	Base shear at performance point (KN)	Base force at EQX	Safety ratio
A1	3374.3	1136.1782	2.969869
B1	3264.0	1134.2145	2.877763
C1	3099.4	1134.6801	2.731519
A2	2089.2	1136.3420	1.838531
B2	1960	-1134.3783	1.727819
C2	1961.7	-1134.8439	1.728608

Figure 5.7.1: Safety ratios by using ESM and Pushover analysis in X-direction
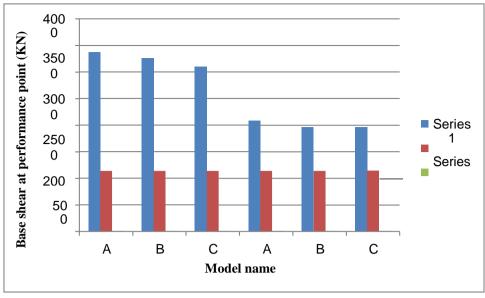
Figure 5.7.2: Safety ratios by using ESM and Pushover analysis in Y-direction

- Safety ratios for all six models have values higher than one. Hence all six models are considered as structurally safe. The models with slab, without flouting columns are more safe compared to other models.
- Safety ratios of the model without floating column are on an average 6% higher than that of buildings with floating columns.
- Safety ratios of models with slabs are almost 65% higher than that of buildings without slabs.

5.7 GLOBAL STIFFNESS:

Global stiffness is defined as the ratio of base shear to the displacement at performance point. Poor distribution of relative masses results in sharp changes in stiffness, strength and or ductility which are considered as structural weaknesses. The concept of stiffness helps in describing dynamic response of the building. The global stiffness of buildings are tabulated below.

Table 5.8.1: Global stiffness of building using Pushover analysis in X-direction

Model	Base shear at performance point (KN)	Performance displacement (mm)	Global stiffness
A1	3547.2	124.9	28.40032026
B1	3334.1	134.6	24.77043091
C1	3329.4	129.8	25.65023112
A2	2090.8	150.5	13.89235880
B2	2006.0	151.4	13.24966975
C2	1972.8	150.6	13.09960159

Table 5.8.2: Global stiffness of building using Pushover analysis in Y-direction

Model	Base shear at performance point (KN)	Performance displacement (mm)	Global stiffness
A1	3374.3	116.8	28.88955479
B1	3264.0	133.2	24.50450450
C1	3099.4	119.7	25.89306600
A2	2089.2	144.5	14.45813149
B2	1960.0	146.6	13.36971351
C2	1961.7	155.2	12.63981959

- Global stiffness is highest for a model with slab-without floating column and minimum for building without slab-with floating column.
- Global stiffness is almost twice for buildings with slabs when compared to buildings without slabs.
- When compared to buildings without floating columns, the buildings with floating columns have 11.8% higher global stiffness values.

Conclusions

6.1 GENERAL:

The conclusions for all six models are presented for linear and nonlinear analysis by using ETABS 2013. The prime importance is given to analyzing the effect of floating column and presence of slab in load distribution and overall response of the building. The conclusions on base shear, fundamental time period, lateral displacement, storey drift, storey stiffness are evaluated and presented using Equivalent static method and Response spectrum method. Finally, results of Pushover analysis are concluded by analyzing different parameters at performance point.

6.2 ABOUT PRESENT STUDY:

- As the provision of floating column decreases stiffness, base shear also decreases. Similarly as the stiffness of the building increase with the provision of slabs, base shear increases.
- From the linear analysis, the fundamental natural period obtained from analytical method does not tally with natural period obtained from codal empirical formula. Natural periods are longer for building models with floating columns and without slabs due to reduced stiffness and more flexibility.
- The buildings with floating columns and without slabs resulted in increased lateral displacement and storey drift compared to buildings without floating columns and with slabs, due to more flexibility.
- The performance level of all the buildings is found within the life safety range.

- Base shear at performance point maximum for building without slab with floating column whereas displacements maximum for building without slab with floating columns.
- For all six models, safety ratios are more than one, hence buildings are over safe. Regular buildings are safer compared to buildings with floating columns. Compared to without slab models with slab models are more safe.
- The global stiffness of floating column building is very less compared to regular buildings hence it is better to avoid floating columns in buildings located in earthquake-prone areas. With slab buildings, have higher global stiffness than without slab buildings.