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DYNAMIC ANALYSIS OF 3D RC BARE FRAME WITH PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION

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Abstract - *Prefabricated Prefinished Volumetric Construction (PPVC) is a construction method whereby free-standing 3D modules are completed with internal finishes, fixtures and fittings in an off-site fabrication facility, before it is delivered and installed on-site. The whole idea is to significantly speed up construction in this traditionally manpower-intensive industry.*
In this dissertation work, a 3D RC bare frame structure having conventional beam column system and prefabricated prefinished volumetric construction system are compared with G+10, G+20 and G+30 stories by performing FE analysis involving modal, equivalent static, response spectrum analysis. The results of time period, base shear, storey displacements, storey drifts are obtained. All the results are tabulated, discussed and conclusions are drawn.

Key Words: ***Modal analysis, Equivalent static analysis, Response spectrum analysis, Flexible loop connectors***

1.INTRODUCTION

Prefabricated prefinished volumetric construction (PPVC) is an innovative and cleaner approach that has restructured the production of the construction industry. It can improve the workflow continuity, increase the efficiency in the use of resources, minimize construction wastes, and reduce the number of on-site contractors as well as construction durations. While the benefits of PPVC have been widely recognized over the past two decades, the constraints on using PPVC remains unexplored.

2. OBJECTIVES

1. 3D RC frame with regular frame system and PPVC system are considered for seismic loading.
2. PPVC connections are designed for seismic loading.
3. FE Analysis of the structure is done by Modal, Equivalent Static and Response Spectra Analysis methods for both plan and vertical irregularities.

3. METHODOLOGY

1. Detailed literature review is carried out on the Prefabricated Prefinished Volumetric Construction and Plan & Vertical irregularity.
2. The study is based on the analysis of structural models representing multi-storey buildings with regular frame system and PPVC system are presented and discussed in detail.
3. Basically, six types of models G+10, G+20 and G+30 with regular frame system and PPVC system. For all seismic zones are considered, for each such building model is considered with critical soil types.

4. PROBLEM FORMULATION AND ANALYSIS

A detailed summary of the various parameters defining the Prefabricated Prefinished Volumetric construction (PPVC) and Regular frame system (RFS) with plan and vertical irregularities in each model is also presented.

The methodology involved in computing some of these parameters is explained and important feature of the current provisions relating to earthquake resisting design of reinforced concrete lateral forces resisting system are presented.

5. PRESENT STUDY

The present study adopts structural 3D models with different types of plan irregularity & vertical irregularity. The seismic responses of these Prefabricated Prefinished Volumetric construction building models have been compared with that of the Regular frame system building model. The base plan size has been kept as 30m x 30m.

6. PROJECT DISCRIPTION

Table1: Structural configuration

Description	Data
Type of structure	Special moment resisting RC frame
Grade of Concrete (f_{ck})	M30
Grade of Reinforcing Steel (f_{yr})	Fe 500
Number of storeys	G+10, G+20, G+30

Storey to storey Height	3.0m
Bottom storey Height	3.0m
Span Length	5m
Column Size used for PPVC system.	2 no's of 300x600(10floors), 2 no's of 400X800mm(20 & 30floors)
Column Size used for RF system	600x600(10floors) 800X800mm(20 & 30floors)
Beam Size used	400x600(All floors),
Thickness of Slab	150mm
Live Load	3kN/m^2
Floor Finish Load	1.5kN/m^2
Seismic Zone	V
Seismic Zone Factor (Z)	0.36
Importance Factor (I)	1.0
Response Reduction Factor (R)	5.0
Damping Ratio	0.05
Soil Type	Soft soil
Load Combination	1.5 (DL+LL) 1.2 (DL+LL$\pm$ EQ) 1.5 (DL$\pm$ EQ) 0.9DL $\pm$ 1.5EQ

Table2: Building Nomenclature

Nomenclature	Description
R10	Regular frame system of 10 floors
R20	Regular frame system of 20 floors
R30	Regular frame system of 30 floors
P10	Prefabricated prefinished volumetric construction system of 10 floors
P20	Prefabricated prefinished volumetric construction system of 20 floors
P30	Prefabricated prefinished volumetric construction system of 30 floors
RPI10	Regular frame system of 10 floors with plan irregularity
RPI20	Regular frame system of 20 floors with plan irregularity
RPI30	Regular frame system of 30 floors with plan irregularity
PPI10	Prefabricated prefinished volumetric construction system of 10 floors with plan irregularity
PPI20	Prefabricated prefinished volumetric construction system of 20 floors with plan irregularity
PPI30	Prefabricated prefinished volumetric construction system of 30 floors with plan irregularity
RVI10	Regular frame system of 10 floors with vertical irregularity
RVI20	Regular frame system of 20 floors with vertical irregularity
RVI30	Regular frame system of 30 floors with vertical irregularity
PVI10	Prefabricated prefinished volumetric construction system of 10 floors with vertical irregularity
PVI20	Prefabricated prefinished volumetric construction system of 20 floors with vertical irregularity
PVI30	Prefabricated prefinished volumetric construction system of 30 floors with vertical irregularity

Plan of Bare Frame Structure model created in software as shown in figure 1 & 2 below.

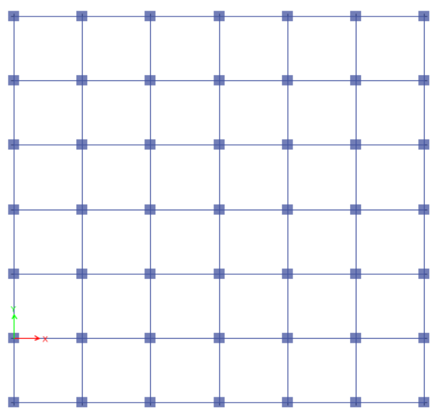


Fig 1: Plan of RFS for G+10, G+20, G+30 Storey.

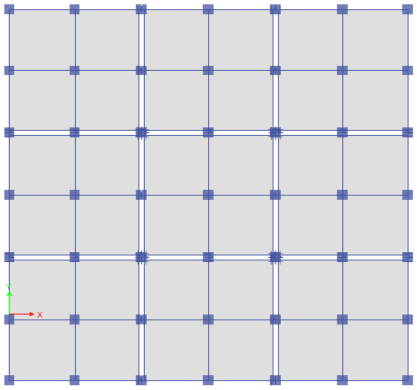


Fig 2: Plan of PPVC for G+10, G+20, G+30 Storey.

3D view of Bare Frame structure model created in software as shown in figure 3 below.

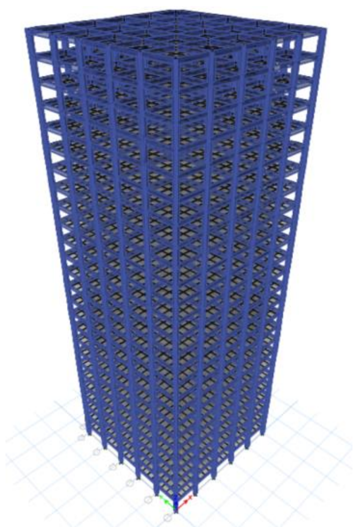
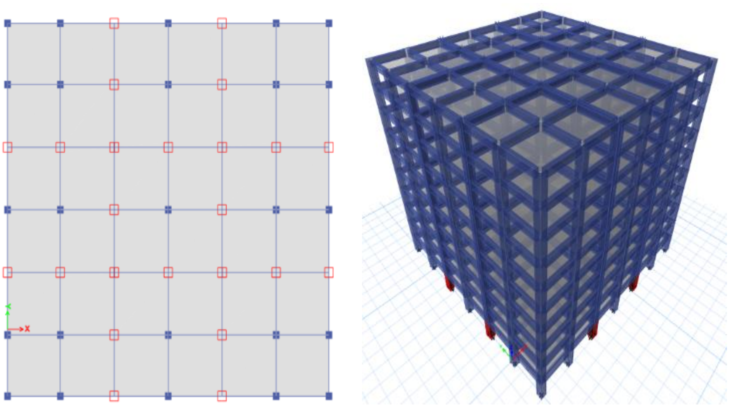


Fig 3: 3D view of G+10,G+20 and G+30 model

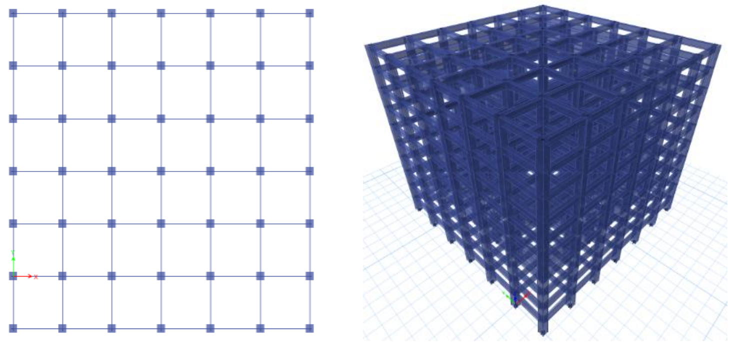
a) Building model with PPVC System

Plan, 3D View of bare frame reinforced concrete structure G+10(P10), G+20(P20) and G+30(P30) with PPVC System created in software as shown below.



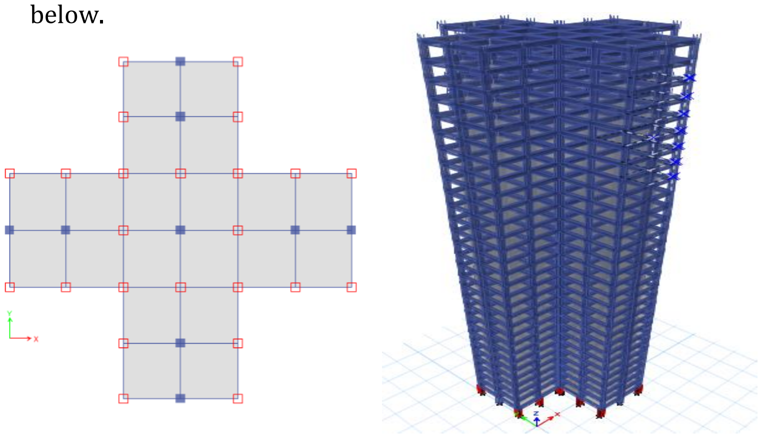
b) Building model with RFS System

Plan,3D View of bare frame reinforced concrete structure G+10(R10), G+20(R20) and G+30(30) with RFS System created in software as shown below.



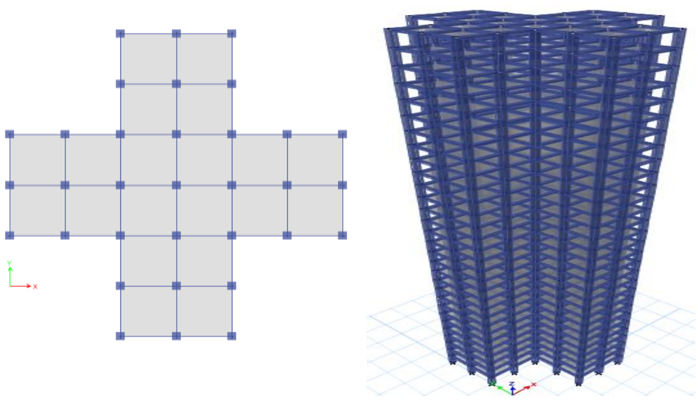
c) Building model with PPVC System with Plan Irregularity

Plan, 3D View of bare frame reinforced concrete structure G+10(PPI10), G+20(PPI20) and G+30(PPI30) with PPVC System with Plan Irregularity created in software as shown below.



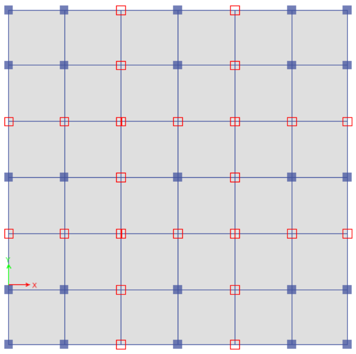
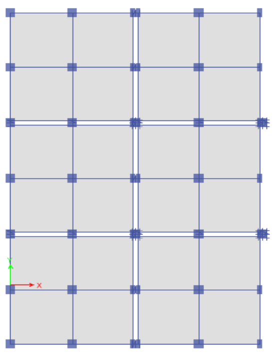
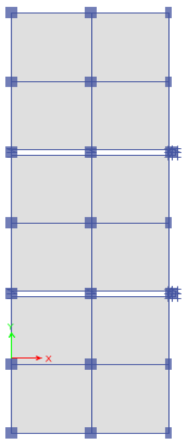
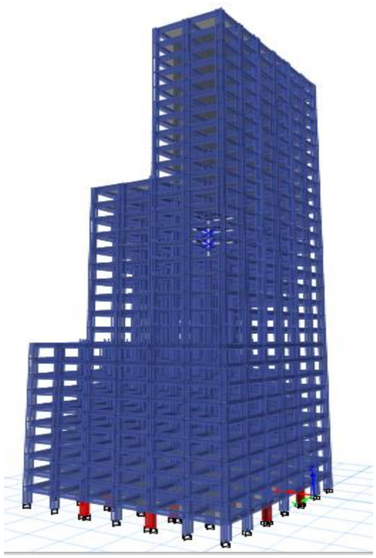
d) Building model with RFS System with Plan Irregularity

Plan, 3D View of bare frame reinforced concrete structure G+10(RPI10), G+20(RPI20) and G+30(RPI30) with RF System with Plan Irregularity created in software as shown in below.



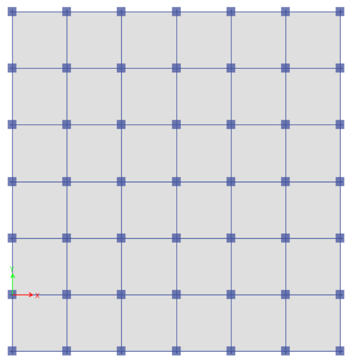
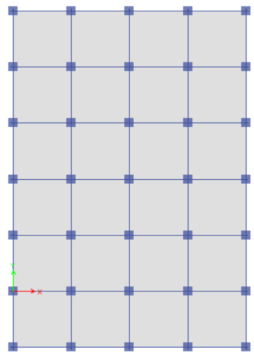
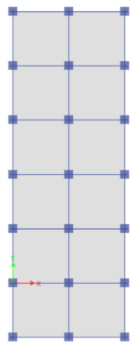
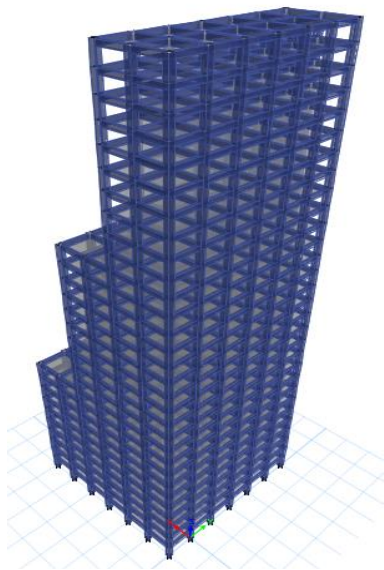
e) Building model with PPVC System with Vertical Irregularity

Plan, 3D View of bare frame reinforced concrete structure G+10(PVI10), G+20 PVI20), and G+30 (PVI30), with PPVC System with Vertical irregularity is created in software as shown below.

f) Building model with RFS System with Vertical Irregularity

Plan, 3D View of bare frame concrete structure G+10 (RVI10),G+20(RVI20) and G+30 (RVI30) with RFS System with Vertical irregularity is created in software as shown below.

7. DESIGN OF LINK PROPERTIES

Vertical Modules Connection

- The vertical modules connection is crucial for the structural behaviour specially for high rise buildings.
- Vertical joints are to be designed for eccentricity or imperfection in accordance with the Building Code Requirement.

Horizontal Modules Connection

- The horizontal modules connection forming the floor diaphragm, are contribute to the overall building stiffness.
- The peripheral ties and internal ties shall be provided as per the Building Code Requirement

PPVC LINK CONNECTIONS

<u>Structural Analysis for Link Connector (ETABS 3D Analysis Software)</u>

- To analyze the connection forces induced in flexible loop connector.

- To See building behavior and to check provision of tie requirements.
- Flexible loop connectors are modelled as nonlinear link with tension only.
- Design Capacity of link connector under tension = 18kN
- Design Capacity of link connector under shear = 27kN

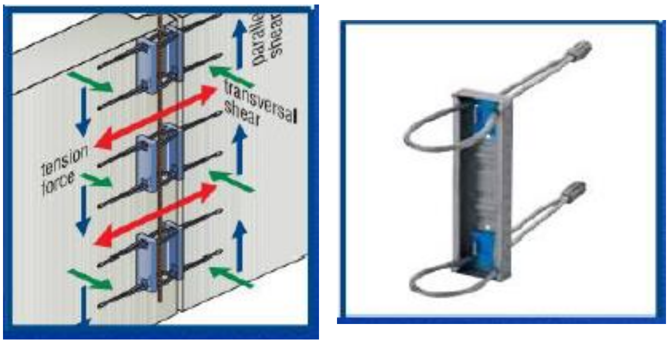


Fig 4: Link Properties and Capacity

Table 3: Design resistance of flexible loop connector

Design resistance of flexible loop connector for PPVC project			
wall/column thickness	Out of plane shear(kN/BOX)	In plane shear(kN/BOX)	Direct tensile forces(kN/BOX)
>200 mm	6	27	18

8. FEM ANALYSIS

Step by step procedure for all methods of analysis is performed in this project work is explained. Figs 5 shows plan, elevation and 3D view of regular frame structural model from ETABS.

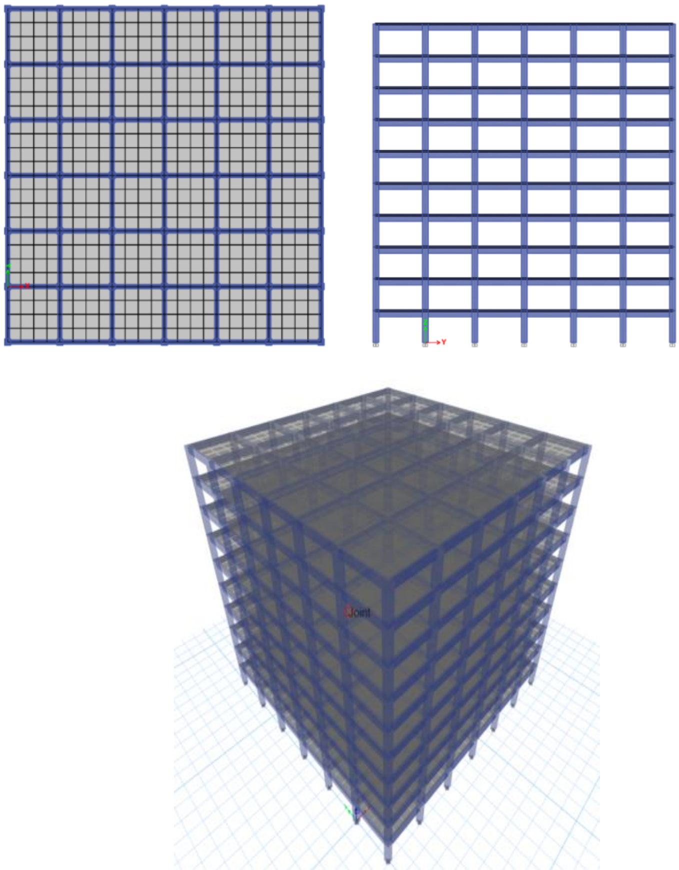


Fig 5: Plan, Elevation and 3D View of Regular structural model

CROSS SECTIONAL PROPERTIES AND MATERIAL CONSTANTS:

The cross-sectional properties of members of infilled frame considered for the study are as follows.

Compressive strength of concrete	30MPa
Characteristic strength of Reinforcing Steel	500MPa
Modulus of elasticity of concrete	27386.13MPa
Modulus of elasticity of steel	2.0×10^8 kN/m^2
Density of concrete	25.0 kN/m^3
Density of steel	78.5 kN/m^3
Poisson's Ratio for concrete	0.2
Poisson's Ratio for steel	0.3

LOADS:

Three types of loads are as follows:

1. Dead load
2. Live load
3. Earthquake load (in X-direction and Y-direction)

LINEAR DYNAMIC ANALYSIS:

Seismic Coefficients:

Seismic Zone Factor: Z = 0.36

Soil type: Medium soil (Type – II)

Importance Factor: I = 1 (Special Moment Resisting Frame)

Response Reduction Factor: R = 5

Time period (T) : Program calculated.

9. RESULTS AND DISCUSSIONS

MODAL ANALYSIS

The fundamental time period for all models is obtained from the modal analysis, which calculates the time period on the basis of mass and stiffness of the structure. IS 1893 (Part I): 2016 gives the empirical formula for calculating the natural time period without masonry infill. i.e,

$T_a = 0.075h^{0.75}$

Where h is the total height of the building.

For G+10; $T_a = 0.075 \times 30^{0.75} = 0.96$ sec

For G+20; $T_a = 0.075 \times 60^{0.75} = 1.62$ sec

For G+30; $T_a = 0.075 \times 90^{0.75} = 2.19$ sec

Fundamental time period calculated by modal analysis results are tabulated in Table 6.1 and the graph showing time period versus models are shown in Fig 6.1

Table 4: Time period (s)

BUILDING MODELS	Time period (Sec)	Time period from IS CODE(s)
R10	1.305	0.96
P10	1.34	
RPI10	1.277	
PPI10	1.338	
RVI10	1.227	
PVI10	1.358	
R20	3.419	1.62
P20	3.05	
RPI20	3.414	
PPI20	3.054	
RVI20	3.095	
PVI20	2.942	
R30	5.309	2.19
P30	5.26	
RPI30	5.337	
PPI30	5.264	
RVI30	5.281	
PVI30	5.015	

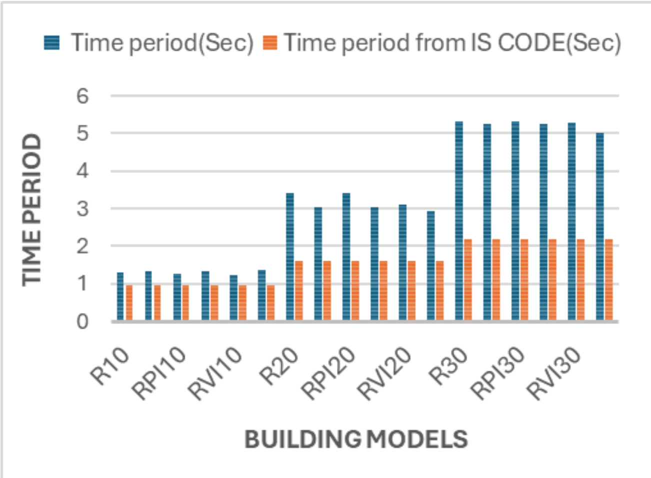


Fig 6 Time period

From Table 4 and Fig 6 the following observations are made.

1. As per IS 1893:2016 there is no consideration of irregularity in the code. Time period will vary only with the height of structures for all the models.

2. As the height increases, time period increases as the weight of the structure increases.

3. The codal time period does not match with the modal analysis results highlighting the deficiency of the code. Time period obtained from dynamic analysis for PPVC & RFS method are more compared to codal method for all the load cases.

6.2 RESPONSE SPECTRUM ANALYSIS

Response spectrum analysis of structure is carried out for the seismic zone V, as per IS 1893-2016, using the response spectrum generated. Base shear, Displacement, Inter-storey drift are obtained for all the models are discussed in this section.

6.2.1 Scale Factor

Scale factor is defined as the ratio of static base shear to dynamic base shear, the ratio this obtained is used in further part of dynamic analysis and shown in Table 5 and the graph showing corrected base shear versus models are shown in Fig 7.

$$\text{Scale factor} = \frac{\text{static base shear}}{\text{dynamic base shear}}$$

$$\text{Scale factor (RF)} = \frac{5547}{5847} = 0.94$$

DESIGNED BUILDING FLOORS	STATIC BASE SHEAR	DYNAMIC BASE SHEAR	SCALE FACTOR
	EQX/EQY	RSPX/RSPY	X/Y
R10	5547	2900	1.9
P10	5718	2830	2.0
RPI10	3334	1735	1.9
PPI10	3517	1670	2.1
RVI10	5209	2621	2.0
PVI10	5130	2452	2.1
R20	2187	2400	0.9
P20	2622	2702	1.0
RPI20	1304	1435	0.9
PPI20	1554	1557	1.0
RVI20	2438	2198	1.1
PVI20	2840	2436	1.2
R30	1868	2933	0.6
P30	1930	2938	0.7
RPI30	1114	1745	0.6
PPI30	1187	1690	0.7
RVI30	1863	1900	1.0
PVI30	1932	2134	0.9

Table 5 Scale Factor

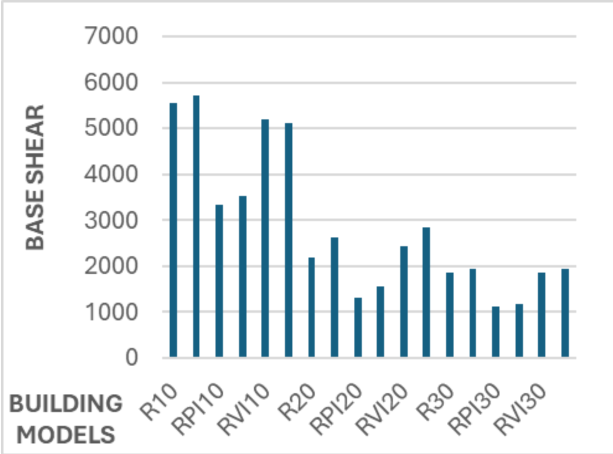


Figure 7 Corrected dynamic Base shear (kN)

6.2.2 Corrected Dynamic Base Shear (kN)

Table 6 Corrected Dynamic Base Shear (EQ Loads)

DESIGNED BUILDING FLOORS	CORRECTED BASE SHEAR
	RSPX/RSPY
R10	5547
P10	5718
RPI10	3334
PPI10	3517
RVI10	5209
PVI10	5130
R20	2187
P20	2622
RPI20	1304
PPI20	1554
RVI20	2438
PVI20	2840
R30	1868
P30	1930
RPI30	1114
PPI30	1187
RVI30	1863
PVI30	1932

From Table 5 & 6 and Fig 6 the following observations are made.

1) As the height of the building increases there is a decrease in the base shear due to the increase in time period.

2) As there is a decrease in the considered Plan area, Base shear of RFS and PPVC System with plan irregularity is less compared with other buildings irrespective of number of floors due to lesser weight.

3) PPVC models have higher base shear for all floors more due to the stiffness offered by dual columns.

6.2.3 Storey Displacement

The results of G+10, G+20 & G+30 buildings are shown in table 7, 8 & 9 respectively. The plot of displacement versus storey for RFS and PPVC with plan and vertical irregularity models are shown in Fig 8, 9 & 10 respectively.

Table 7 Storey Displacement (mm) of G+10 with Plan & Vertical irregularity

DESIGNED BUILDING FLOORS	R10	P10	RPI10	PPI10	RVI10	PVI10
10	21.0	25.2	20.7	25.0	20.4	27.0
9	20.4	23.5	19.9	23.3	19.5	24.9
8	19.2	21.5	18.8	21.3	18.1	22.6
7	17.7	19.2	17.3	19.0	16.1	19.7
6	15.7	16.7	15.3	16.5	13.8	16.5
5	13.4	13.9	13.0	13.7	11.4	13.3
4	10.8	10.8	10.4	10.6	9.3	10.0
3	7.9	7.4	7.6	7.2	6.9	6.6
2	4.8	3.9	4.5	3.7	4.2	3.3
1	1.8	0.8	1.7	0.7	1.6	0.6
0	0.0	0.0	0.0	0.0	0.0	0.0

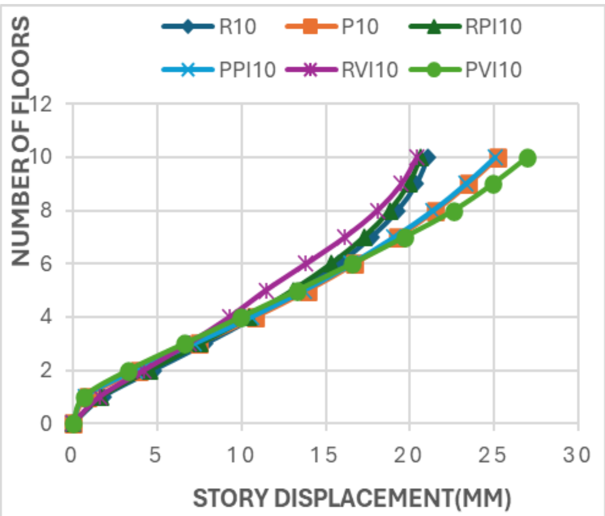


Figure 8 Storey Displacement for G+10 Building

Table 8 Storey Displacement (mm) of G+20 with Plan & Vertical irregularity

DESIGNED BUILDING FLOORS	R20	P20	RPI20	PPI20	RVI20	PVI20
20	55.8	58.0	56.0	57.8	60.9	72.5
19	54.9	55.0	55.0	54.8	52.6	68.4
18	53.8	52.3	53.9	52.1	51.1	64.4
17	52.5	49.6	52.5	49.5	49.3	60.4
16	50.8	47.0	50.8	46.9	47.2	56.2
15	48.9	44.4	48.8	44.2	44.7	51.8
14	46.7	41.8	46.5	41.6	42.0	47.3
13	44.2	39.3	44.0	39.1	39.0	42.7
12	41.5	36.6	41.2	36.4	35.9	37.9
11	38.5	33.7	38.2	33.6	32.7	33.5
10	35.3	30.8	35.0	30.6	29.7	29.4
9	31.9	27.8	31.5	27.6	26.8	25.5
8	28.2	24.6	27.9	24.4	23.9	22.0
7	24.4	21.4	24.0	21.2	20.8	18.6
6	20.4	18.1	20.0	17.9	17.6	15.4
5	16.3	14.6	15.9	14.4	14.2	12.6
4	12.1	11.1	11.8	10.9	10.6	9.6
3	8.0	7.4	7.8	7.2	7.1	6.4
2	4.3	3.8	4.1	3.6	3.8	3.1
1	1.3	0.8	1.2	0.7	1.2	0.6
0	0.0	0.0	0.0	0.0	0.0	0.0

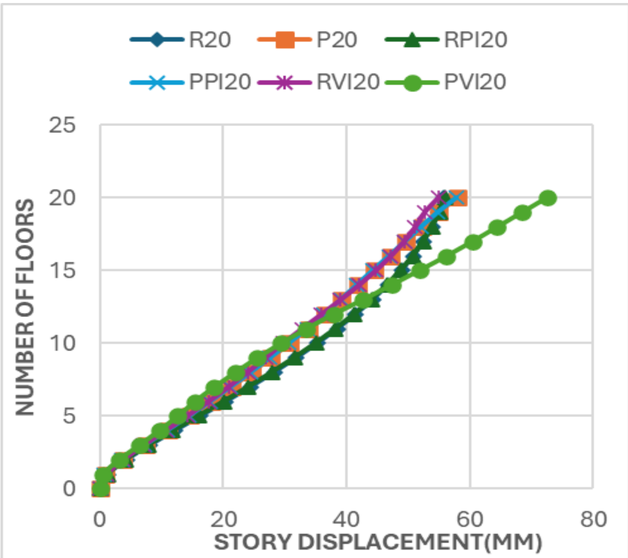


Figure 9 Storey Displacement for G+10 Building

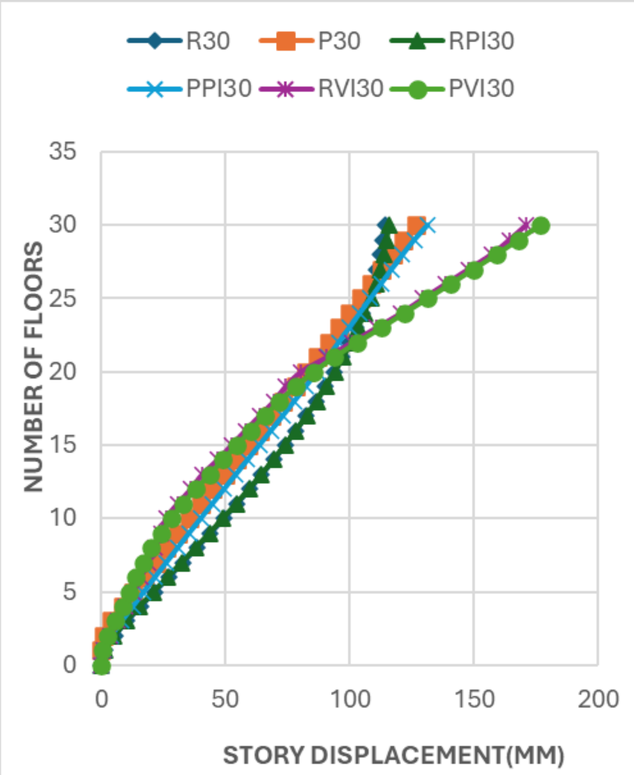


Figure 10 Storey Displacement for G+30 Building

DESIGNED BUILDING FLOORS	R30	P30	RPI30	PPI30	RVI30	PVI30
30	114.0	131.7	116.0	131.2	170.8	176.6
29	113.1	126.4	114.9	125.9	164.1	167.8
28	112.0	121.6	113.6	121.2	156.9	159.0
27	110.6	117.2	112.1	116.8	147.7	149.9
26	109.0	112.9	110.4	112.5	138.6	140.6
25	107.1	108.6	108.3	108.2	129.4	131.2
24	104.9	104.3	106.0	103.9	120.7	121.9
23	102.5	100.1	103.4	99.7	110.7	112.6
22	99.7	95.8	100.6	95.4	100.9	102.9
21	96.7	91.5	97.5	91.1	90.8	93.8
20	93.5	87.1	94.1	86.7	80.4	85.4
19	90.0	82.5	90.5	82.2	74.2	78.2
18	86.3	77.9	86.7	77.6	69.6	71.7
17	82.3	73.3	82.6	72.9	63.7	65.6
16	78.2	68.6	78.4	68.2	58.0	60.0
15	73.8	63.9	73.9	63.5	52.5	54.5
14	69.3	59.1	69.2	58.8	46.8	48.9
13	64.5	54.4	64.4	54.1	40.6	43.6
12	59.6	49.6	59.4	49.3	36.1	38.1
11	54.5	44.9	54.2	44.6	30.6	32.6
10	49.2	40.2	48.9	39.9	26.1	28.1
9	43.9	35.5	43.5	35.3	24.3	23.9
8	38.4	30.9	37.9	30.7	21.6	20.1
7	32.7	26.3	32.3	26.1	18.8	16.8
6	27.1	21.8	26.6	21.6	15.8	14.0
5	21.4	17.3	20.9	17.1	12.7	11.3
4	15.7	12.8	15.3	12.6	9.6	8.5
3	10.3	8.4	10.0	8.2	6.4	5.5
2	5.4	4.1	5.2	3.9	3.4	2.6
1	1.6	0.8	1.6	0.7	1.1	0.3
0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9 Storey Displacement (mm) of G+30 with Plan & Vertical irregularity

From the table 7,8 & 9 and fig 8,9 & 10 the following observations are made.

1. As the height of the building increases there is an increase in the storey displacement.

2. Due to vertical irregularity, displacement has increased due to reduction in weight of structure.
3. Due to plan irregularity, displacement varies due to reduction in the stiffness of structure

6.2.3 Storey Drift

The plot of storey drift vs. storey height for PPVC and RFS models are shown in Fig 11,12 & 13 respectively. Table 10, 11 & 12 show the maximum drift for models in zone V.

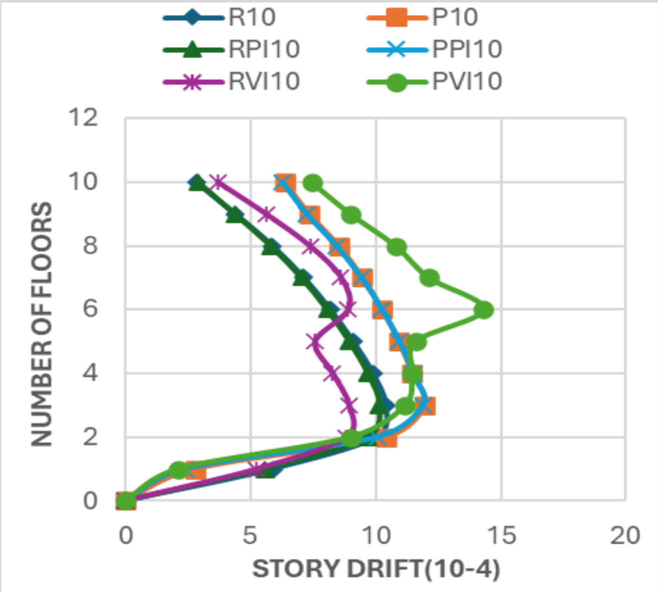


Figure 11 Storey Drift for G+10 Building

Table 10 Storey Drift (10^{-4}) of G+10 with Plan & Vertical irregularity.

DESIGNED BUILDING FLOORS	R10	P10	RPI10	PPI10	RVI10	PVI10
10	2.8	6.4	2.9	6.3	3.7	7.4
9	4.4	7.3	4.4	7.3	5.6	9.0
8	5.9	8.5	5.8	8.4	7.4	10.8
7	7.1	9.5	7.0	9.4	8.6	12.1
6	8.2	10.3	8.1	10.3	8.9	14.3
5	9.1	10.9	8.9	11.0	7.6	11.6
4	9.9	11.5	9.7	11.5	8.3	11.5
3	10.4	11.9	10.2	11.9	8.9	11.2
2	10.0	10.4	9.7	10.1	8.8	9.0
1	5.9	2.8	5.6	2.4	5.3	2.1
0	0.0	0.0	0.0	0.0	0.0	0.0

Table 11 Storey Drift (10^{-4}) of G+20 with Plan & Vertical irregularity.

DESIGNED BUILDING FLOORS	R20	P20	RPI20	PPI20	RVI20	PVI20
20	4.4	10.6	4.7	10.6	5.9	14.1
19	5.3	10.0	5.6	10.0	7.0	14.4
18	6.4	10.0	6.6	10.0	8.2	15.4
17	7.4	10.2	7.5	10.2	9.4	16.2
16	8.3	10.4	8.4	10.4	10.4	17.0
15	9.0	10.7	9.2	10.7	11.2	17.5
14	9.8	10.9	9.9	10.9	11.9	18.0
13	10.5	11.1	10.6	11.1	12.4	19.2
12	11.2	11.3	11.3	11.3	12.4	20.1
11	11.8	11.5	11.9	11.4	11.9	21.5
10	12.4	11.6	12.5	11.6	10.7	14.4
9	12.9	11.7	13.0	11.7	10.7	13.2
8	13.4	11.7	13.4	11.7	11.0	12.3
7	13.8	11.7	13.8	11.8	11.4	11.6
6	14.0	11.8	14.0	11.8	11.8	11.2
5	14.1	12.1	14.0	12.1	12.0	10.9
4	13.8	12.3	13.5	12.3	11.9	10.8
3	12.6	12.3	12.3	12.2	11.1	10.9
2	9.9	10.1	9.6	9.9	8.8	8.8
1	4.4	2.6	4.2	2.3	3.9	1.9
0	0.0	0.0	0.0	0.0	0.0	0.0

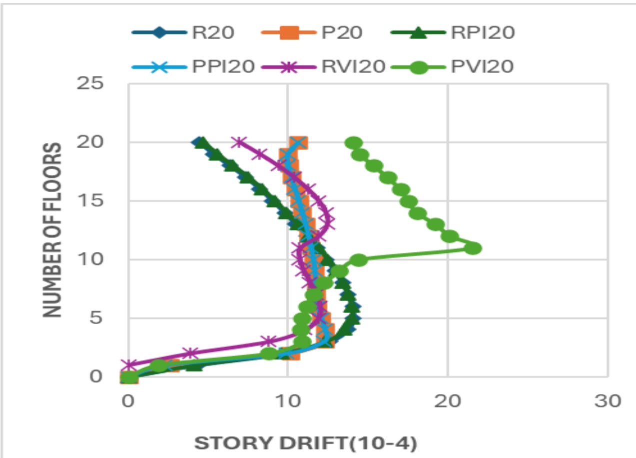


Figure 12 Storey Drift for G+20 Building

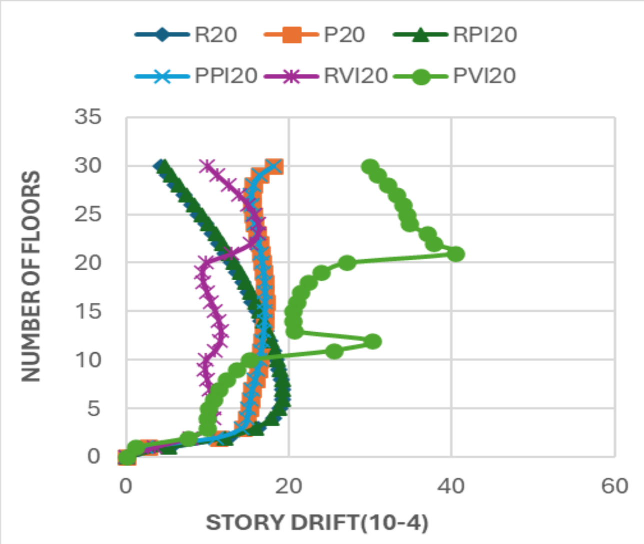


Figure 13 Storey Drift for G+30 Building

DESIGNED BUILDING FLOORS	R30	P30	RPI30	PPI30	RVI30	PVI30
30	4.3	18.1	4.8	18.1	10.0	29.9
29	5.1	16.4	5.5	16.3	11.2	30.9
28	6.1	15.7	6.5	15.6	12.6	32.1
27	7.1	15.4	7.5	15.4	13.8	33.3
26	8.0	15.4	8.4	15.4	14.9	34.0
25	8.9	15.6	9.3	15.6	15.7	34.4
24	9.8	15.8	10.2	15.8	16.2	34.8
23	10.6	16.1	11.0	16.0	16.2	36.9
22	11.4	16.3	11.8	16.3	15.3	37.8
21	12.2	16.6	12.6	16.5	13.0	40.4
20	12.9	16.8	13.3	16.7	9.9	27.0
19	13.6	16.9	14.0	16.9	9.3	24.0
18	14.3	17.0	14.7	17.0	9.5	22.3
17	14.9	17.1	15.3	17.1	9.9	21.5
16	15.5	17.1	15.9	17.1	10.4	20.9
15	16.1	17.1	16.4	17.0	10.9	20.4
14	16.6	17.0	16.9	17.0	11.4	20.4
13	17.1	16.9	17.4	16.9	11.6	20.6
12	17.6	16.8	17.9	16.8	11.6	30.2
11	18.1	16.6	18.3	16.6	10.9	25.5
10	18.5	16.4	18.6	16.4	9.8	15.1
9	18.8	16.2	18.9	16.1	9.7	13.6
8	19.1	15.9	19.2	15.8	9.9	12.4
7	19.2	15.5	19.3	15.5	10.2	11.4
6	19.2	15.3	19.2	15.2	10.6	10.7
5	18.9	15.1	18.8	15.0	10.8	10.1
4	18.1	14.9	17.8	14.9	10.7	10.0
3	16.3	14.3	15.9	14.2	9.9	9.9
2	12.6	11.3	12.2	11.1	7.9	7.7
1	5.5	2.7	5.2	2.4	3.5	1.2
0	0.0	0.0	0.0	0.0	0.0	0.0

Table 12 Storey Drift (10^{-4}) of G+30 with Plan & Vertical irregularity.

From table table 10, 11 & 12 and fig 11,12 & 13 following observations are made:

1. Due to the sudden decrease in the area at 5th floor there is a increase in the story drift.
2. The presence of vertical irregularities at the 10th, 20th, and 30th floors resulted in a significant rise in storey drift due to reduced structural stiffness.
3. Storey drift of all models is within the permissible limits i.e 0.004 times the storey height as per IS 1893-2016.

10. CONCLUSIONS

1. The design of PPVC Link Connections is done using softwares.
2. The Torsional irregularity, Re-entrant corner irregularity and soft storey check is done and observed results are SAFE as per IS Code.
3. As per IS 1893:2016 there is no consideration of irregularity in the code. Time period will vary only with the height of structures for all the models.
4. As the height increases, time period increases as the weight of the structure increases.
5. The codal time period does not match with the modal analysis results highlighting the deficiency of the code. Time period obtained from dynamic analysis for PPVC & RFS method are more compared to codal method for all the load cases.
6. As the height of the building increases there is decrease in the base shear due to the increase in time period.
7. As there is a decrease in the considered Plan area, Base shear of RFS and PPVC System with plan irregularity is less compared with other building irrespective of number of floors due to lesser weight.
8. PPVC models have higher base shear for all floors more due to the stiffness offered by dual columns.
9. As the height of the building increases there is an increase in the storey displacement.

10. Due to vertical irregularity, displacement has increased due to reduction in weight of structure.
11. Due to plan irregularity, displacement varies due to reduction in the stiffness of structure.
12. Due to the sudden decrease in the area at 5th floor there is a increase in the story drift.
13. The presence of vertical irregularities at the 10th, 20th, and 30th floors results in a significant rise in storey drift due to reduced structural stiffness.
14. Storey drift of all models are within the permissible limits i.e 0.004 times the storey height as per IS 1893-2016.
15. By Looking into my analysis results, PPVC can improve productivity by up to 40% in terms of manpower and time savings, depending on the complexity of the projects.

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