

Behavioral Study of Precast Concrete Structure with Fixity at Different Levels - Part II

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4. Two Successive Story's Released (Zone-II)

Story Displacement

Observations for Two Successive Story's Released Structure in Zone-II

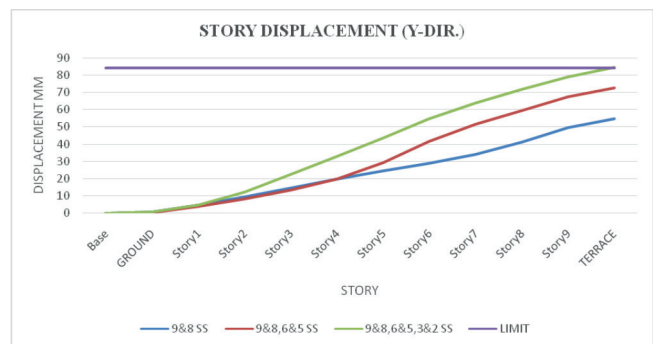
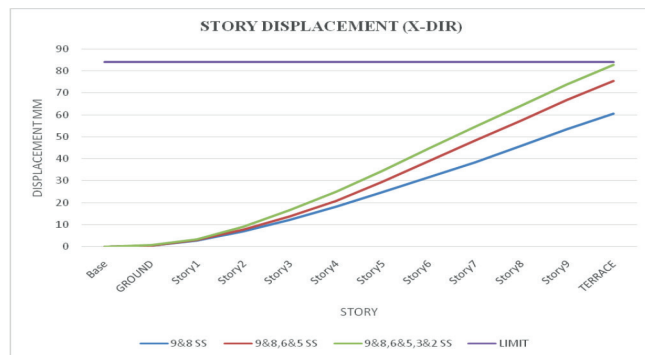
- Story displacement: -The structure is stable, deflections are within the limits (i.e. $H/500$) in both the directions. Column sizes are required to be increased to $1.2M \times 1.2M$ corresponding to 6th and 5th floor release, to control the displacements. When the 3rd and 2nd story releases are given, the column size needs to be further increased to $1.5M \times 1.5M$ to control the displacements.
- Story drift: - Inter-story drifts are within the Allowable limits of $0.004 \times$ floor height in both the directions.
- Column reinforcement: -When story releases are given to 9th and 8th floors, column reinforcements are observed as 1.20%. Corresponding to 6th and 5th floor release, when column size was increased to $1.2M \times 1.2M$, reinforcement in the columns are observed as 1.15%. Corresponding to 3rd and 2nd story releases, the column sizes were increased to $1.5M \times 1.5M$. the reinforcement in the columns are nearly nominal (0.80%)
- Modal Mass Participation: - The structure is getting the first mode in x-direction with the corresponding release at 9th and 8th floor. Thereafter, with releases to structure at 6th and 5th, 3rd and 2nd floor, the structure is getting the 1st mode in the y-direction instead of in x-direction. The mass participation values are happening between 67% to 73%. The torsion is occurring only in the 3rd mode.

STORY 9&8 IS SS (C-1.0mX1.0m)					
STORY	DISP. IN X DIR.	DISP. IN Y DIR.	DISP. LIMIT (H/500)	CONDITION OF FIXITY (R/SS)	REMARKS
TERRACE	60.45	54.861	84	R	Displacements are within the limits. Column size adopted is 1.0m*1.0m. For additional successive floor releases, column section size is required to be increased.
Story9	53.474	49.669	84	SS	
Story8	45.816	41.149	84	SS	
Story7	38.417	33.996	84	R	
Story6	31.444	29.214	84	R	
Story5	24.674	24.571	84	R	
Story4	18.227	19.718	84	R	
Story3	12.285	14.687	84	R	
Story2	7.105	9.601	84	R	
Story1	2.993	4.693	84	R	
Ground	0.636	0.724	84	R	
Base	0	0	84	R	
STORY 9&8, 6&5, 3&2 IS SS (C-1.5mX1.5m)					
TERRACE	82.823	83.59	84	R	
Story9	73.953	79.132	84	SS	
Story8	64.3	71.878	84	SS	
Story7	54.575	63.942	84	R	
Story6	44.671	54.626	84	SS	

Story5	34.569	43.602	84	SS	
Story4	25.171	33.103	84	R	
Story3	16.625	22.779	84	SS	
Story2	9.103	12.416	84	SS	
Story1	3.522	4.672	84	R	
Ground	0.69	0.597	84	R	
Base	0	0	84	R	

R-Rigid SS- Simply Supported

Table 4: Story Displacement in x and y-direction



COLUMN REINFORCEMENT

COL. NO	STORY 9&8 IS SS (C-1M*1M)	STORY	STORY 9&8, 6&5 IS SS (C-1.2M*1.2M)	STORY	STORY 9&8, 6&5, 3&2 IS SS (C-1.5M*1.5M)	STORY
C1, C4	1.49%	Ninth	1.32%	Ninth	0.80%	All Story
C2, C3	1.12%	Ninth	1.07%	Ninth	0.80%	All Story
C5, C12	0.85%	Eighth	0.88%	Eighth	0.80%	All Story
C6, C11	0.80%	All Story	0.81%	Eighth	0.80%	All Story
C7, C8, C9, C10	0.84%	Eighth	0.84%	Eighth	0.80%	All Story
C13, C20	0.87%	Eighth	0.88%	Fifth	0.80%	All Story
C14, C19	0.97%	Ninth	0.95%	Ninth	0.80%	All Story
C15, C16, C17, C18	0.90%	Ninth	0.90%	Ninth	0.80%	All Story
C21, C28	0.89%	Eighth	0.89%	Fifth	0.80%	All Story
C22, C27	0.85%	Eighth	0.85%	Fifth	0.80%	All Story
C23, C24, C25, C26	0.84%	Eighth	0.84%	Fifth	0.80%	All Story

SS- Simply Supported C1-Column number 1

C29 TO C56 are like the above configuration, correspondingly.

Table 5: Column Longitudinal Reinforcement

MODAL MASS PARTICIPATION

CASE	STORY 9&8 SS			STORY 9&8, 6&5 SS			STORY 9&8, 6&5, 3&2 SS		
MODE	1	2	3	1	2	3	1	2	3
Ux	0.6846	0	0	0	0.6749	0	0	0.7289	0
Uy	0	0.752	0	0.6647	0	0	0.6769	0	0
Rz	0	0	0.6958	0	0	0.6713	0	0	0.6903

Table6: Modal Mass Participation

5 Alternate Story Released (ZONE-III)

The results of analysis for alternate story released structure in zone -III are presented in the following tables.

Observations for Alternate Story's Released Structure in Zone-III

- Story displacement: - The structure is stable, and deflections are within the limits (i.e. $H/500$) in both the directions.
- Story drift: -Inter-story drifts are within the Allowable limits of $0.004 \times$ floor height in both the directions.
- Column reinforcement: - Column reinforcements are nearly

nominal for the story releases corresponding to 9th and 7th floors. Thereafter, its demand is increasing when the 5th and 3rd floor releases are given. In addition to 9th and 7th floor, when 5th and 3rd floors are also released, the increased deflections (still within Allowable limits) and the reinforcement percentages are observed in the columns.

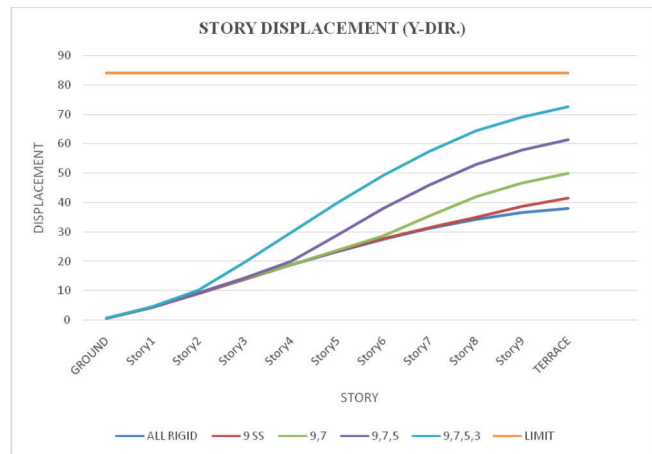
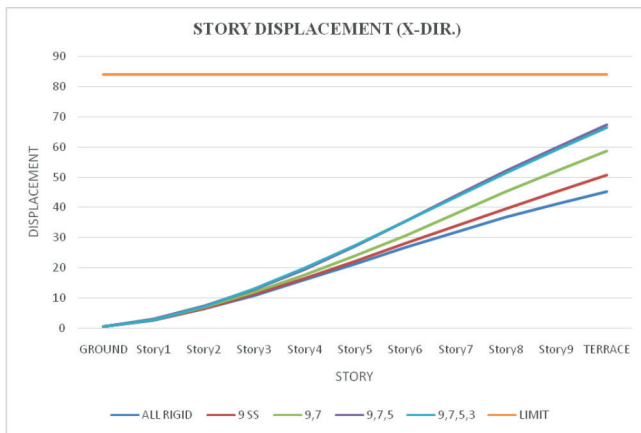
- Modal Mass Participation: -The structure is getting the first mode in x-direction with the corresponding release of 9th and 7th floor. After the release of 5th and 3rd floor the first mode is shifting into the y-direction instead of in x-direction. The mass participation values are happening between 68% to 73%. The torsion is occurring only in the 3rd mode.

STORY DISPLACEMENT

ALL STORY RIGID B-600X1000 C-1000X1000 SW-350 MM THK					
STORY	DISP. IN X DIR.	DISP. IN Y DIR.	DISP. LIMIT (H/500)	CONDITION OF FIXITY (R/SS)	REMARKS
Terrace	45.304	38.038	84	R	Displacements are within the limits
Story9	41.241	36.639	84	R	
Story8	36.76	34.38	84	R	
Story7	31.903	31.317	84	R	
Story6	26.734	27.599	84	R	
Story5	21.387	23.384	84	R	
Story4	16.05	18.819	84	R	
Story3	10.961	14.04	84	R	
Story2	6.414	9.188	84	R	
Story1	2.733	4.495	84	R	
Ground	0.589	0.694	84	R	
Base	0	0	84	R	
STORY 9,7,5,3 IS (4 SW 450MM THK)					
Terrace	66.488	72.624	84	R	Displacements are within the limits. Thickness of shear wall is increased to 450mm to resist lateral forces and to keep displacements within the limits for zone-III area, compared to 350 mm thick in zone-II area.
Story9	59.142	69.143	84	SS	
Story8	51.432	64.335	84	R	
Story7	43.49	57.376	84	SS	
Story6	35.449	49.315	84	R	
Story5	27.517	39.872	84	SS	
Story4	19.94	29.911	84	R	
Story3	13.077	19.754	84	SS	
Story2	7.21	10.293	84	R	
Story1	2.941	4.643	84	R	
Ground	0.596	0.695	84	R	
Base	0	0	84	R	

R-Rigid SS- Simply Supported

Table 7: Story Displacement in x and y-direction



COLUMN REINFORCEMENT

Longitudinal R/F In Column (C-1000Mm*1000Mm)										
COL. No	ALL STO- RY FIXED	STORY	STORY 9 SS	STORY	STORY 9,7 SS	STORY	STORY 9,7,5 SS	STORY	STORY 9,7,5,3 SS	STORY
C1, C4	0.89%	Ninth	1.10%	Ninth	1.44%	Ninth	1.62%	Ninth	1.65%	Ninth
C2, C3	0.82%	Ninth	0.87%	Ninth	1.03%	Ninth	1.27%	Ninth	1.24%	Ninth
C5, C12	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.88%	Fifth	0.90%	Third
C6, C11	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.81%	Third
C7, C8, C9, C10	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.83%	Fifth	0.83%	Third
C13, C20	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.88%	Fifth	0.89%	Third
C14, C19	0.80%	All Story	0.84%	Ninth	0.90%	Ninth	1.15%	Ninth	1.13%	Ninth
C15, C16, C17, C18	0.80%	All Story	0.82%	Ninth	0.88%	Ninth	1.05%	Ninth	1.02%	Ninth
C21, C28	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.90%	Fifth	0.93%	Third
C22, C27	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.84%	Fifth	0.83%	Third
C23, C24, C25, C26	0.80%	All Story	0.80%	All Story	0.80%	All Story	0.83%	Fifth	0.82%	Third

SS- Simply Supported C1-Column number 1

C29 TO C56 are like the above configuration, correspondingly

Table 8: Column Longitudinal Reinforcement

MODAL MASS PARTICIPATION

CASE	ALL STORY RIGID			STORY 9 SS			STORY 9,7 SS			STORY 9,7,5 SS			STORY 9,7,5,3 SS		
MODE	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Ux	0.71	0	0	0.70	0	0	0.68	0	0	0	0.72	0	0	0.73	0
Uy	0	0.80	0	0	0.79	0	0	0.758	0	0.67	0	0	0.67	0	0
Rz	0	0	0.73	0	0	0.71	0	0	0.69	0	0	0.68	0	0	0.68

Table 9: Modal Mass Participation

6. Twosuccessive Story's Released (Zone-III)

STORY DISPLACEMENT

STORY 9&8 IS SS (4 SW 350 MM THK)					
STORY	DISP. IN X DIR.	DISP. IN Y DIR.	DISP. LIMIT (H/500)	CONDITION OF FIXITY (R/SS)	REMARKS
Terrace	58.032	52.666	84	R	Displacements are well within the limits
Story9	51.335	47.683	84	SS	
Story8	43.983	39.503	84	SS	
Story7	36.881	32.636	84	R	
Story6	30.186	28.046	84	R	
Story5	23.687	23.588	84	R	
Story4	17.498	18.929	84	R	
Story3	11.794	14.1	84	R	
Story2	6.821	9.217	84	R	
Story1	2.873	4.505	84	R	
Ground	0.611	0.695	84	R	
Base	0	0	84	R	
STORY 9&8, 6&5, 3&2 IS SS (4 SW 450 MM THK)					
Terrace	79.51	81.207	84	R	Displacements are within the limits. column size is increased from 1.0m*1.0m. to 1.5m*1.5m. to keep displacement in limits.
Story9	70.995	75.967	84	SS	
Story8	61.728	69.003	84	SS	
Story7	52.392	61.384	84	R	
Story6	42.884	52.441	84	SS	
Story5	33.186	41.858	84	SS	
Story4	24.164	31.779	84	R	
Story3	15.96	21.868	84	SS	
Story2	10.23	11.919	84	SS	
Story1	3.381	4.485	84	R	
Ground	0.662	0.573	84	R	
Base	0	0	84	R	

R-Rigid SS- Simply Supported

Table 10: Story Displacement in x and y-direction

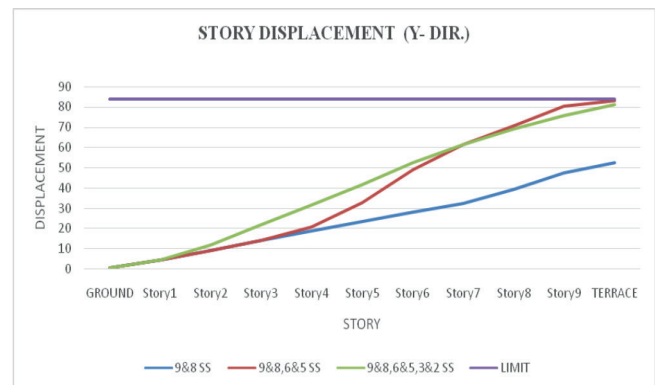
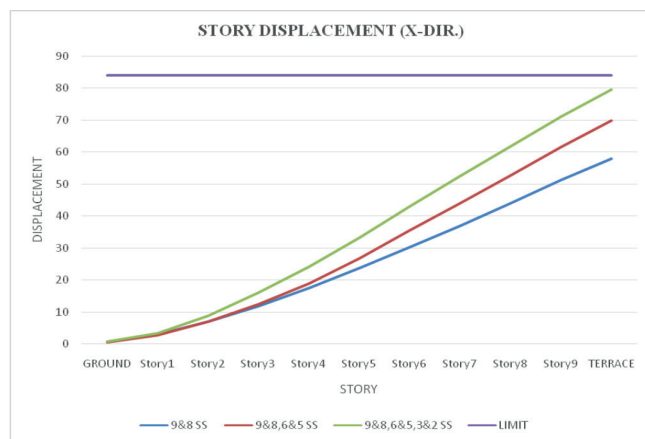


Figure9: Story Displacement in x and y-direction

COLUMN REINFORCEMENT

COL. NO	STORY 9&8 IS SS (C-1M*1M)	STORY	STORY 9&8, 6&5 IS SS(C-1M*1M)	STORY	STORY 9&8, 6&5, 3&2 IS SS(C-1.5M*1.5M)	STORY
C1, C4	1.43%	Ninth	1.75%	Ninth	0.84%	Ninth
C2, C3	1.04%	Ninth	1.39%	Ninth	0.82%	Ninth
C5, C12	0.83%	Eighth	1.57%	Fifth	0.80%	All Story
C6, C11	0.80%	All Story	1.36%	Fifth	0.80%	All Story
C7, C8, C9, C10	0.82%	Ninth	1.52%	Fifth	0.80%	All Story
C13, C20	0.85%	Eighth	1.60%	Fifth	0.80%	All Story
C14, C19	0.90%	Ninth	1.43%	Fifth	0.80%	All Story
C15, C16, C17, C18	0.89%	Ninth	1.40%	Fifth	0.80%	All Story
C21, C28	0.87%	Eighth	1.66%	Fifth	0.80%	All Story
C22, C27	0.83%	Ninth	1.53%	Fifth	0.80%	All Story
C23, C24, C25, C26	0.82%	Ninth	1.50%	Fifth	0.80%	All Story

SS- Simply Supported C1-Column number 1

C29 TO C56 are similar to above configuration, correspondingly

Table 11: Column Longitudinal Reinforcement

MODAL MASS PARTICIPATION

CASE	STORY 9&8 SS			STORY 9&8, 6&5 SS			STORY 9&8, 6&5, 3&2 SS		
MODE	1	2	3	1	2	3	1	2	3
Ux	0.684	0	0	0	0.658	0	0	0.7289	0
Uy	0	0.752	0	0.661	0	0	0.676	0	0
Rz	0	0	0.695	0	0	0.665	0	0	0.6903

Table 12: Modal Mass Participation

Observations for Two Successive Story's Released Structure in Zone-III

- Story displacement: -Column sizes are required to be increased to 1.5M*1.5M corresponding to 3rd and 2nd story release, such that deflections are within the limits.
- Story drift: - Inter-story drifts are within the Allowable limits of 0.004x floor height in both the directions.
- Column reinforcement: -When story releases are given to 9th and 8th, 6th and 5th floors, column reinforcements are nearly 1.0% and 1.60% respectively. Thereafter, the column sizes are also required to be increased to 1.5M*1.5M corresponding to 3rd and 2nd story release for controlling increased deflection. Reinforcement in the columns are nearly nominal (0.80%)
- Modal Mass Participation: -The structure is getting the first mode in x-direction with the corresponding release at 9th and 8th floor. Thereafter, with releases to structure at 6th and 5th, 3rd and 2nd floor, the first mode is shifting to the y-direction instead of in x-direction. The mass participation values are happening between 67% to 73%. The torsion is occurring only in the 3rd mode.

The plan above shows the structure is requiring extra shear walls for structural stability purpose in Zone IV, when alternate floors releases are given to the structure. The releases can be given for the 9th and 7th floors without the necessity of the extra shear walls. For successive story releases also, the extra shear walls are required and thus it is not cost effective for releases to be given in zone-IV area.

Similarly, it is observed that the structure in zone-V area, releases to the structure are not preferable as it demands more number of shear walls for structural stability purpose.

7. Summary of Observations

Based on the details presented above, the following observations are made:

- The structure is analyzed corresponding to seismic zones-II, III, IV and V. The structure analyzed is of 10 story high with bay size of 8m*8m and 7 bays in each direction.
- Precast hollow core slabs with structural topping will give the diaphragm action.
- As precast hollow core slabs are one-way slabs, all the in-

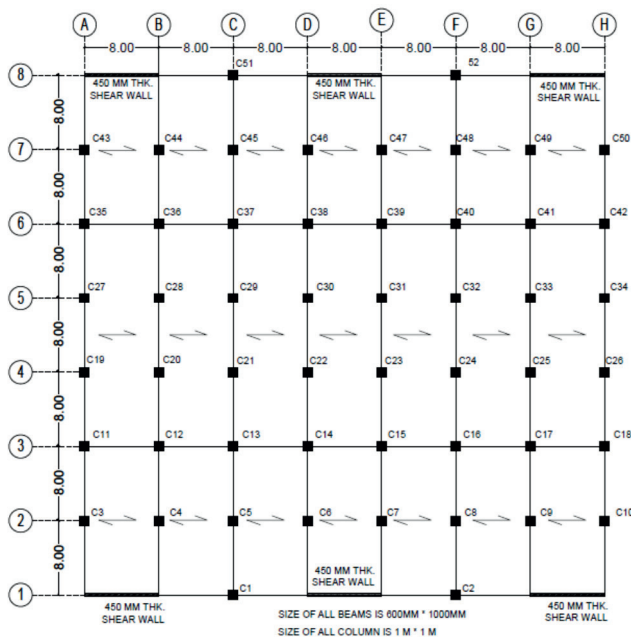


Figure 10: Plan of building in Zone-IV

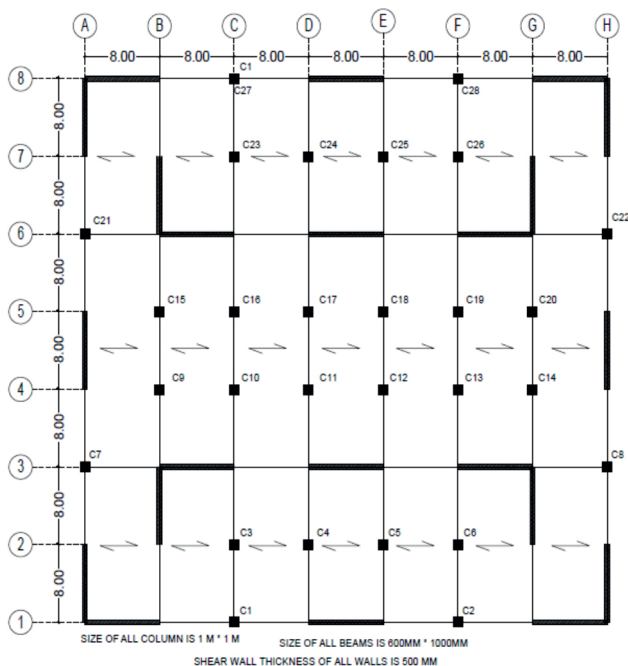


Figure 11: Plan of building in Zone-V

ternal frames are moment resistant frames connected by the floor slab perpendicular to it.

- In the Y-direction, all are moment resistant frames are in y-direction
- In the x- direction, two internal frames and two peripheral frames + shear walls are provided as Moment resistant frames to resist lateral forces initially for zone II and III

Zone-II and III

Alternate story release: - Alternate story release concept is recommended for zone II and III and is cost effective too.

Two successive story releases: -Successive story releases concept is also effective for zone II and III, even though, it demands increased column sizes of 1.5m* 1.5m compared to 1.0m*1.0m. However, few shear walls can be introduced in y- direction too, and there by retain the same column size will be further studied and reported

Zone-IV and V

Additional shear walls are required to be provided internally too for zone-IV and V areas and thus they are not cost effective and thereby, releases to the structure in Zone IV and V is not recommended

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