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Comparison of the Performance of Structures with a Special Lateral Bearing System of a Special Reinforced Concrete Frame with Special Shear Wall based on the Third Edition and the Draft of the Version No.4 of the Iranian Earthquake Code

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ABSTRACT

In this article the performance of structures with lateral bearing system of special reinforced concrete frame with special shear wall based on the third edition and draft of the fourth edition of the Iranian Earthquake Regulations has been studied. For this purpose, three structures of 10, 15 and 20 three-dimensional floors under linear dynamic dynamics analysis was performed, in which the 15-story structure is irregular. The structure is then analyzed with both of the above-mentioned regulations and then designed according to the ninth section of the National Building Regulations; Frame A of the three-dimensional structures is then subjected to push-up analysis. In the third version, taller structures, i.e. 15 and 20-storey structures, perform better than the fourth edition 2800, but this fact is the opposite for the shorter structure, i.e. 10-storeys, i.e. the 10-storey structure designed based on 2800 fourth edition has better performance than the same structure. But it is designed with the third edition. It should be noted that the structures are examined in the area away from the fault.

Keywords:

Special moment frames, shear walls, especially, shift, the earthquake, structural performance.

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1. Introduction

Basic design structures is based on Regulations 2800 the third edition. 2-Concrete building has a dual system of bending frame and shear wall with special ductility on both sides of the structure. 3-The structure designed in accordance with the 2800th edition of the third edition is controlled by the criteria set the forth 2800 edition. 4-All designed and controlled structures are named with the acronym A-VC so that: A is the number of floors, V is the regulation version with V3 for the third edition of the regulation and V4 for the fourth edition of the regulation of 2800 and C is the lateral load type. Is that for a uniform lateral load of C1, the lateral load of the triangle is C2 and the lateral load of the first mode is C3. After designing the structure in ETABS software, the following items are controlled and the amount of their change is determined: a- How to distribute seismic force in the floors b- Obtaining the base shear c- Controlling 25% of the lateral force that must be independently borne by the bending frame. d- Displacement control e- Oversight control and vertical force caused by seismic force and Stability index f-Nonlinear static analysis of frame A of the structure by ETABS software [1-8].

2. Limitations of Present Research

The limitations and assumptions made for the work limits in this research are: a- In this research, only the considered failure mode is related to bending. b- Foundation deformations and nonlinear shear deformations of plastic joints and the effects of reinforcement slip in the members have been avoided. c- The deformation of the connection area has been avoided and the connections have been considered as rigid. d- The effect of interactions has been neglected; e- Only the interaction of the same axial force is included in the anchor-curvature relationship of the columns. For this purpose, the axial force of the column during the analysis is assumed to be constant. f- In this research, all connections, regardless of the rules of the regulations for the formability class of the frame, observe the conditions of confinement according to the regulations of the Aba [6].

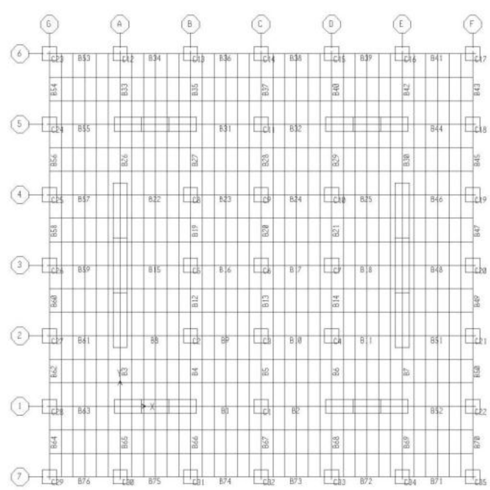


Figure 1. Type plan of three-dimensional structures designed by the linear method of 20-story structures

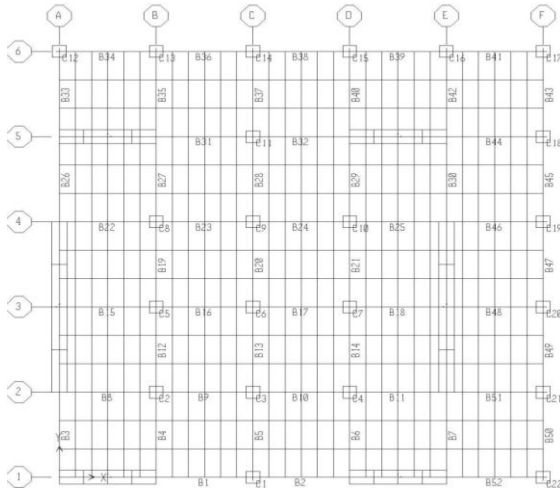


Figure 2. Type plan of three-dimensional structures designed by the linear method of 15-story structures.

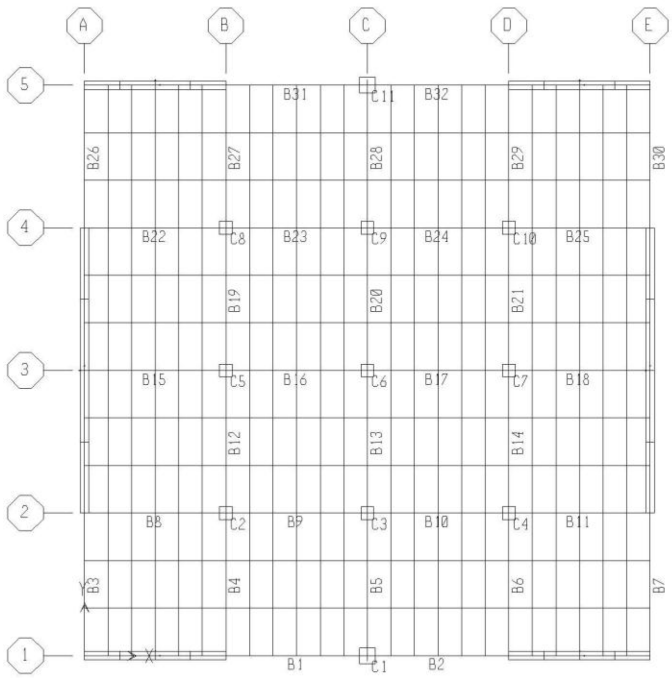


Figure 3. Type-plan of three-dimensional structures designed by the linear method of 10-story structure

3. Static Nonlinear Analysis of Frames

Nonlinear static analysis of frame A of a three-dimensional structure designed with linear spectral dynamic analysis; In all these structures, the length of the frame openings is 5 meters, the height of the floors is 3 meters and the wall thickness of the 10, 15 and 20-storey structures is 30, 80 and 100 centimeters, respectively. Frame A is separated from all six concrete structures designed by linear spectral dynamic analysis method and the required rebar values in both regulations are shown in Figure 4 to 9. It should be noted that the cross section of all beams and columns in both regulations is considered the same and only the amount of rebar steel of the beams is considered variable. All the beams used in section A are in a 10-story structure of 40 x 40 cm, the columns around the frame are actually the end of a five-meter shear wall. All the beams used in section A in a 15-storey structure are 65 x 65 cm and its columns are 70 x 70 cm. All the beams used in section A in a 20-storey structure are 90 x 90 cm and its columns are 100 x 100. In all structures, the columns around the frame of the shear wall with a span of 5 meters in length and the frame under study are frame A of the three-dimensional structure analyzed by linear spectral analysis [3].

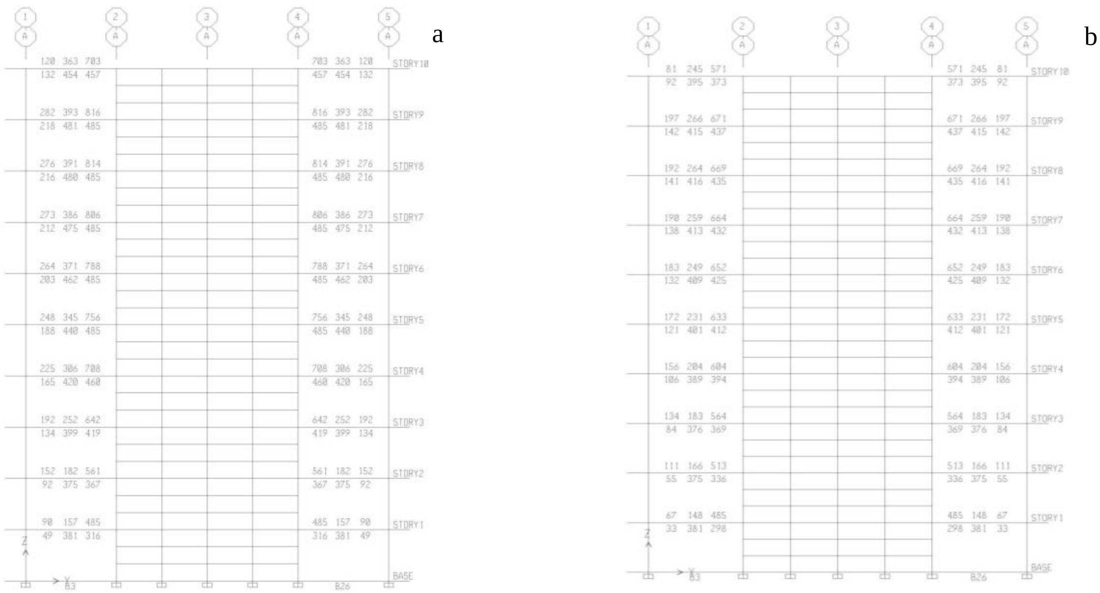


Figure 4. (a) Cross-section of beams from 10-V3 in mm, (b) Cross-section of beams from 10-V4 in mm

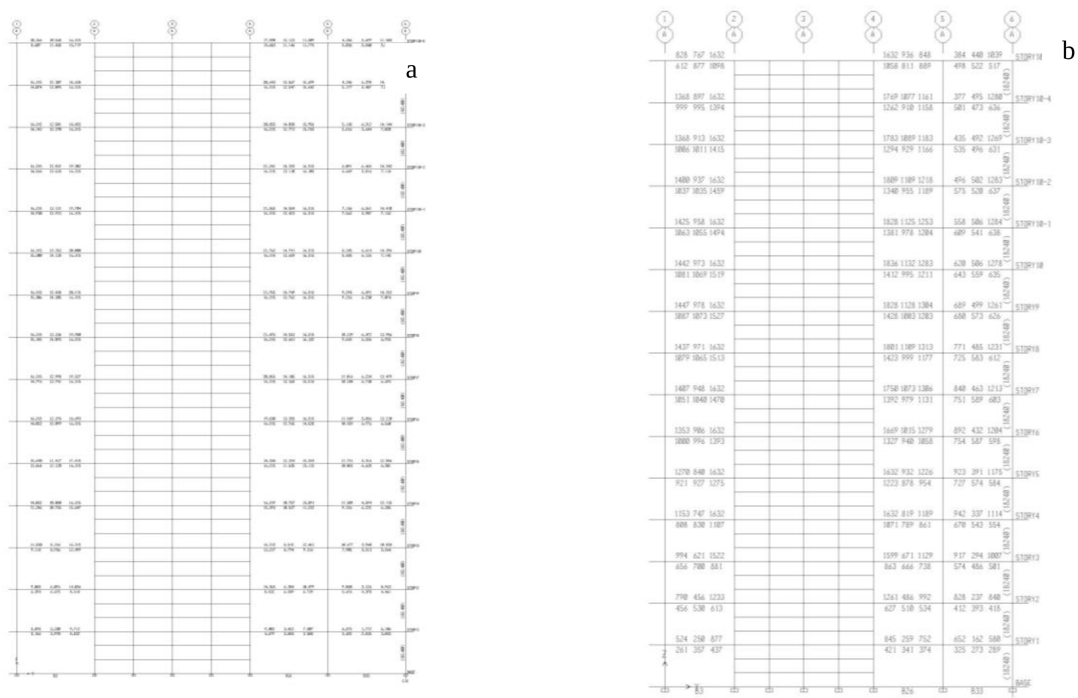


Figure 5. (a) Cross-section of beams from 15-V4 in mm, (b) Cross-section of rebar of beams from 15-15 V3 in mm.

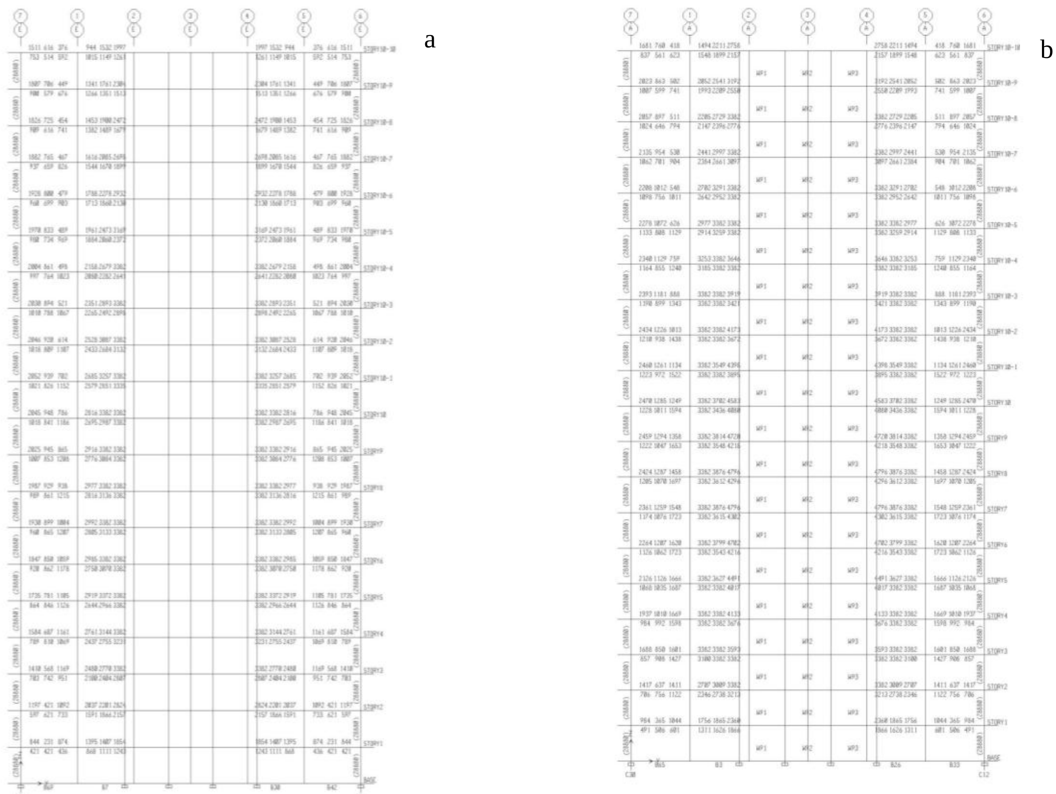


Figure 6. (a) Cross-section of rebar of beams from 20-V3 in mm, (b) Cross-section of rebar 20-V4 beams in mm.

Because ETABS software is not able to calculate the anchorage and flow time for concrete sections, these values are introduced to the CSI Calm software using linear cross-section rebar outputs, and the output it re-enters the definition of ETABS joints. Static nonlinear analysis is performed by assigning plastic joints to each of the frame nodes and introducing the target displacement and gravity force of each frame. Definitions of member specifications mentioned as follows:

Table 1. My and θy values assigned to type sections to define 20-story frame's plastic joints.

Name of cross-section	Cross-section of upper rebar$^{(cm)}$	Cross-section of under rebar$^{(cm)}$	$\theta_y^{(rad)}$	$M_y^{(ton/m)}$	rebar
Beam90*90	48	43	0.0055	150	ϕ20
Beam90*90	42	37	0.00608	129	ϕ20
Beam90*90	36	34	0.00623	119.36	ϕ20
Beam90*90	30	25	0.00816	88.32	ϕ20
Beam90*90	24	19	0.00871	64.77	ϕ20
Beam90*90	21	10	0.01231	40.7	ϕ20
Beam90*90	16	9	0.0124	40.4	ϕ20
Beam90*90	10	6	0.01514	29.67	ϕ22
Column100*100	-	-	0.00477	480	76*ϕ22
Shearwall100*90.9	16ϕ22 upper and under	16ϕ22 right and left	0.00447	343.24	ϕ22
Shearwall100*83.3	16ϕ22 upper and under	16ϕ22 right and left	0.00504	384.36	ϕ22

Table 2. My and θy values assigned to type sections to define 15-story frame's plastic joints.

Name of cross-section	Cross-section of upper rebar$^{(cm)}$	Cross-section of under rebar$^{(cm)}$	$\theta_y^{(rad)}$	$M_y^{(ton/m)}$	rebar
Beam65*65	21	16	0.0135	45.22	ϕ16
Beam65*65	17.59	16	0.00889	36.74	ϕ16
Beam65*65	16.5	14	0.00991	32.45	ϕ16
Beam65*65	12	12	0.01081	27.56	ϕ16
Beam65*65	15	9	0.01231	23.88	ϕ16
Beam65*65	10	5	0.01386	19.05	ϕ16
Column70*70	-	-	0.00662	208	48*ϕ22
Shearwall80*90.9	12ϕ22 upper and under	14ϕ22 right and left	0.00529	276	ϕ22
Shearwall80*83.3	12ϕ22 upper and under	14ϕ22 right and left	0.00652	204.05	ϕ22

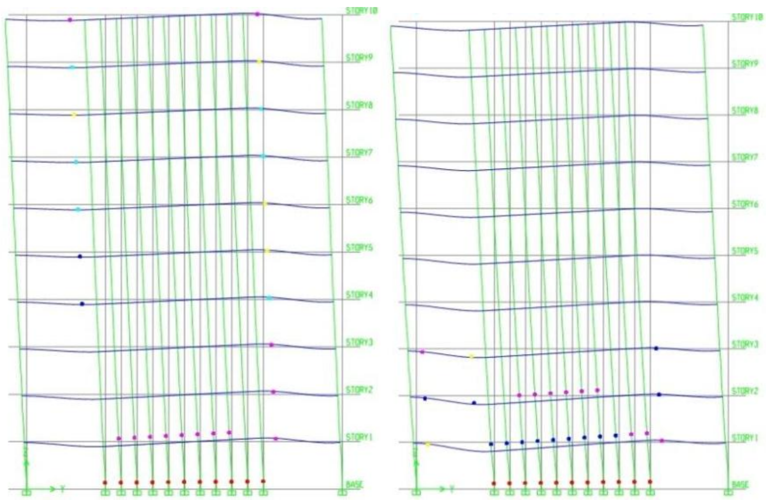
Table 3. My and θy values assigned to type sections to define 10-story frame's plastic joints.

Name of cross-section	Cross-section of upper rebar$^{(cm)}$	Cross-section of under rebar$^{(cm)}$	$\theta_y^{(rad)}$	$M_y^{(ton/m)}$	rebar
Beam40*40	3ϕ12	3ϕ16	0.0145	7.27	ϕ16, ϕ12
Beam40*40	4ϕ16	4ϕ12	0.0219	6.64	ϕ16, ϕ12
Beam40*40	2ϕ16	2ϕ16	0.022	3	ϕ16, ϕ12
Shearwall30*90.9	4ϕ22 upper and under	14ϕ22 right and left	0.0051	155	ϕ22
Shearwall30*83.3	4ϕ22 upper and under	14ϕ22 right and left	0.0084	68	ϕ22

In this study assign plastic joints to the members of the frames, based on the probability of joint formation at specific points of the members. In beams, two bending joints in five and ninety-five percent of the beam length and in columns, two interactive joints (P-M3) [4] were considered at the beginning and end of the column length; Then the hypothetical frames are introduced.

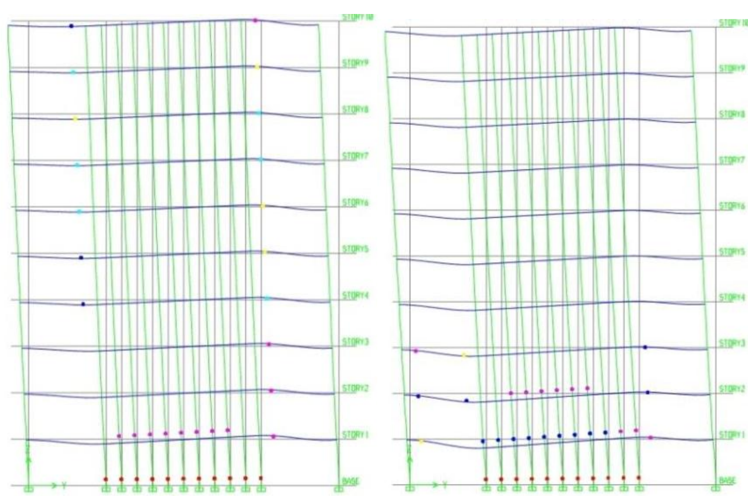
4. Plastic Joints Created in Structure

It should be noted that the most critical load combination is given in each frame. Displacement is low for two reasons: 1. Due to the type of loading that is applied uniformly. 2. Because these frames are separated from the three-dimensional structure and maybe no longer have sufficient support in some nodes that were supported in the three-dimensional structure. As the height of the structure increases, the openings of the frame also increase because at high altitudes, the displacement of the bending frame is less than the shear wall.



(a) (b)

Figure 7. Plastic joints formed in the structure (a) 10- V3-C1 (b) 10- V4-C1



(a) (b)

Figure 8. Plastic joints formed in the structure (a) 10-V3-C2 (b) 10-V4-C2.

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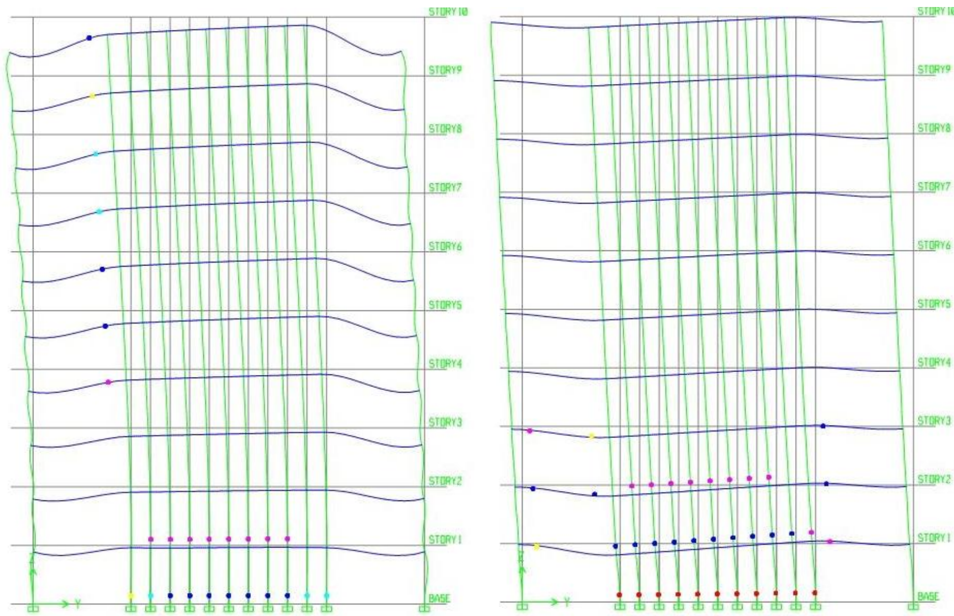
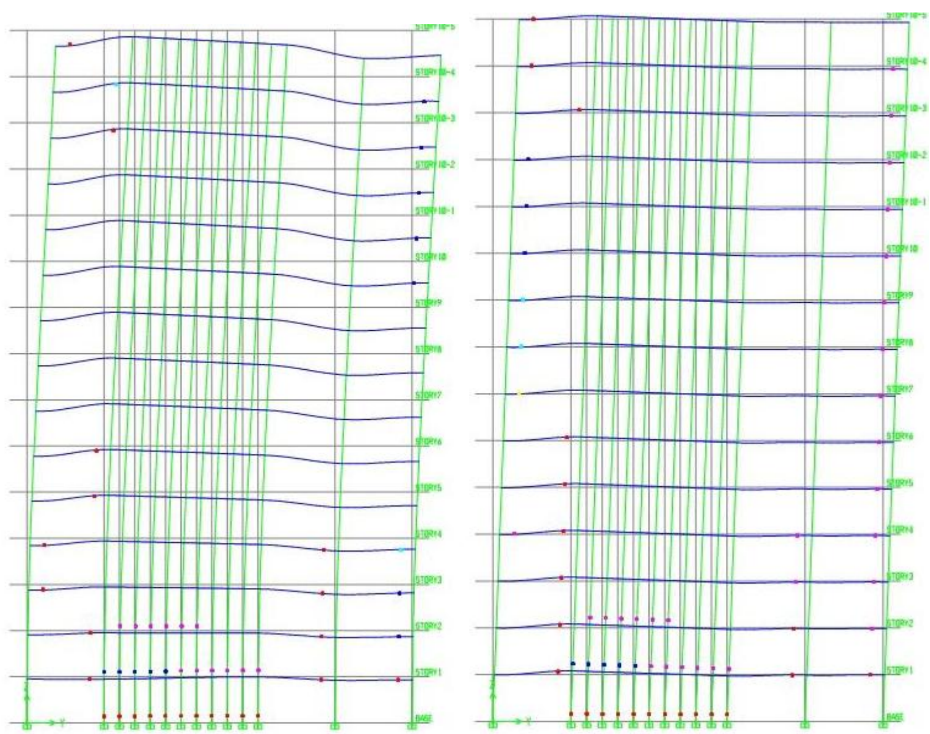


(a) (b)

Figure 9. Plastic joints formed in the structure (a) 10- V3-C3 (b) 10- V4-C3.



(a) (b)

Figure 10. Plastic joints formed in the structure (a) 15- V3-C1 (b) 15- V4-C1.

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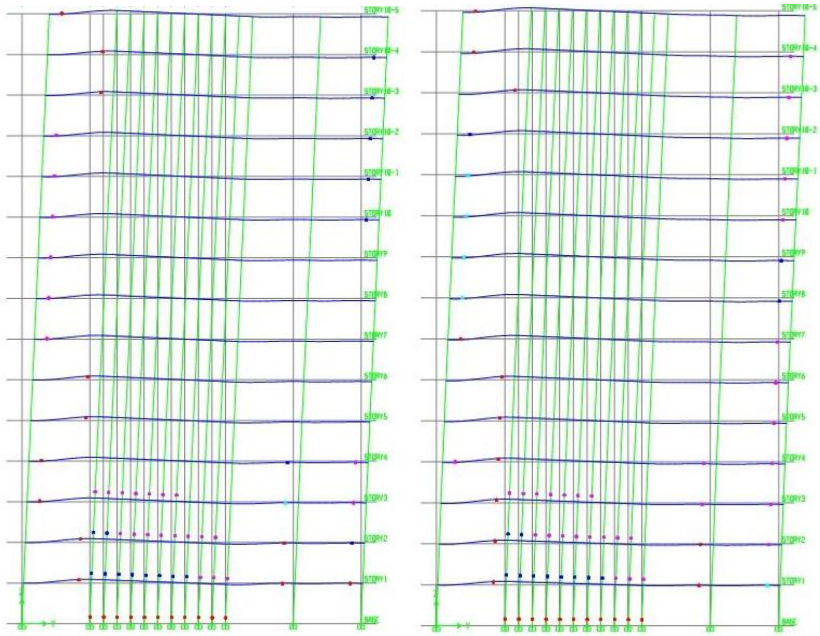
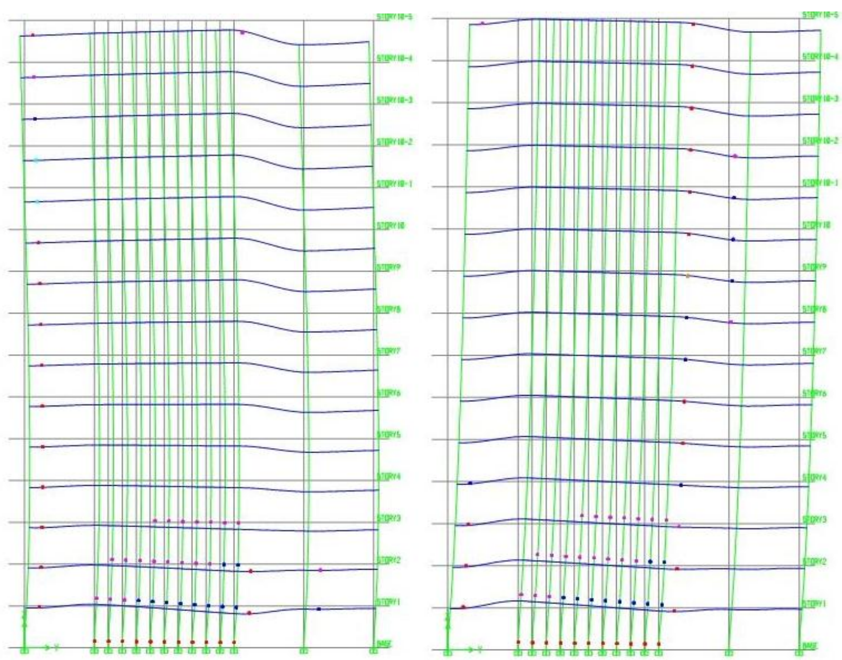


(a) (b)

Figure 11. Plastic joints formed in the structure (a) 15- V3 -C2 (b) 15- V4-C2.



(a) (b)

Figure 12. Plastic joints formed in the structure (a) 15- V3-C3 (b) 15- V4-C3.

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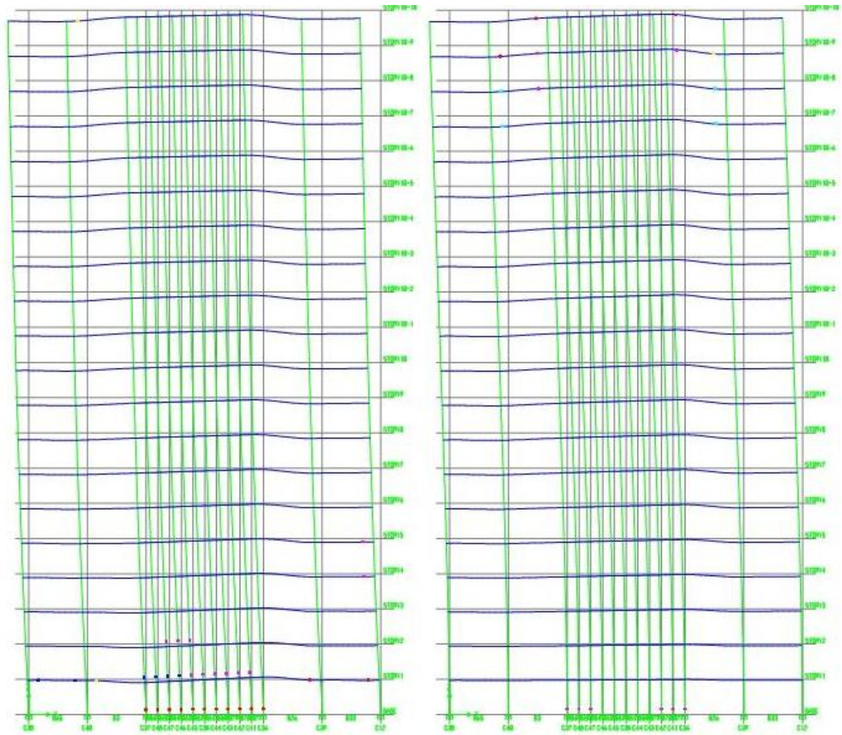
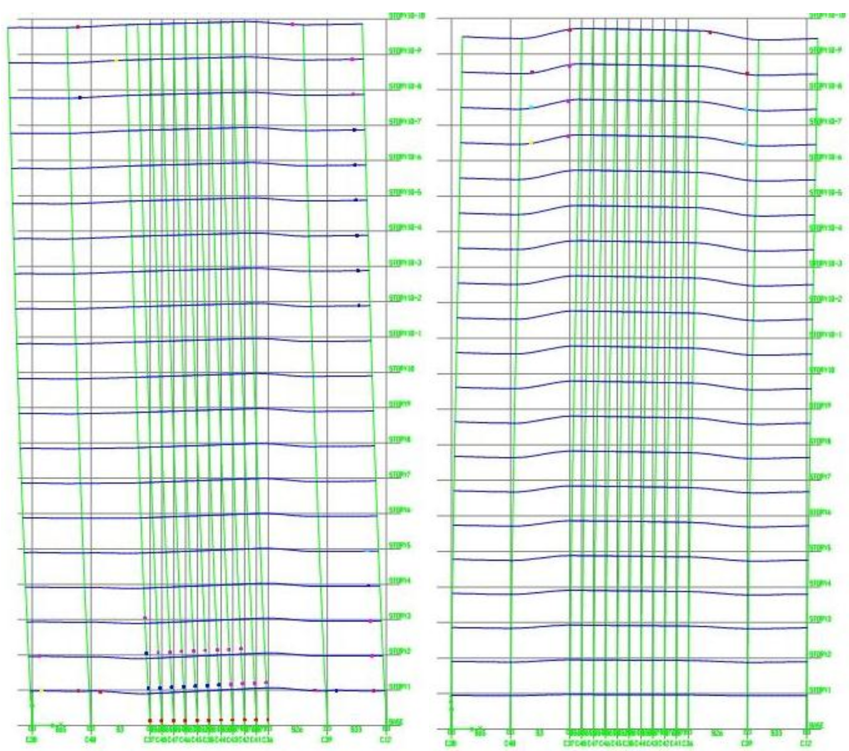


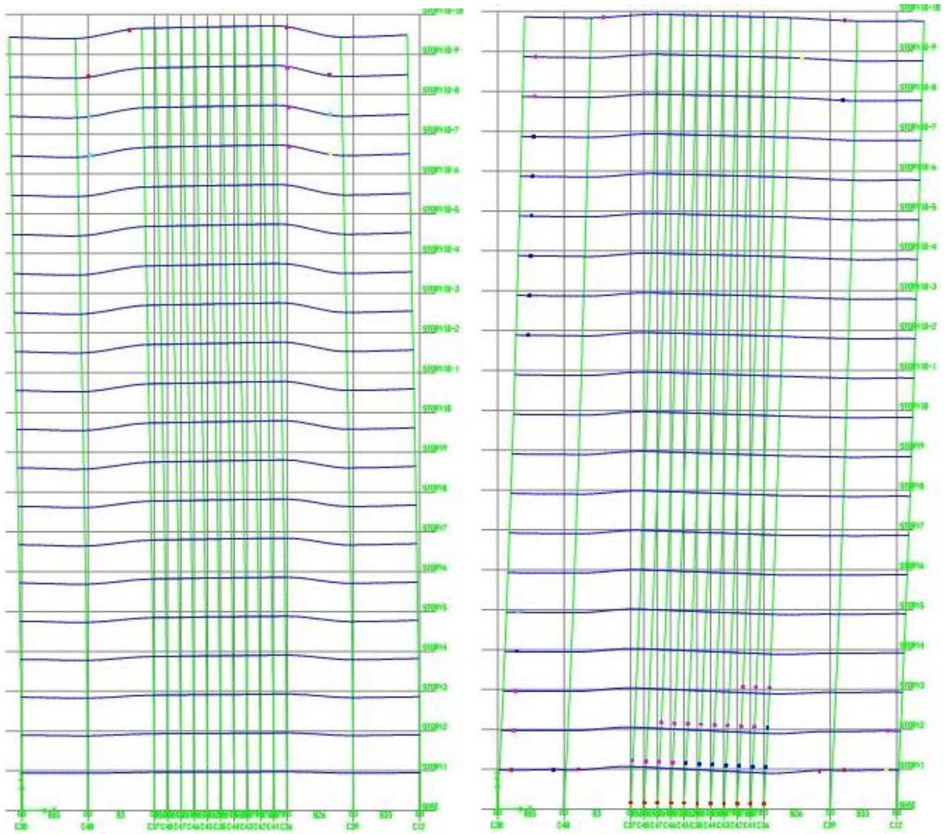
(a) (b)

Figure 13. Plastic joints formed in the structure (a) 20- V3-C1 (b) 20- V4-C1.



(a) (b)

Figure 14. Plastic joints formed in the structure (a) 20- V3-C2 (b) 20-V4-C2.



(a) (b)

Figure 15. Plastic joints formed in the structure (a) 20- V3-C3 (b) 20- V4-C3.

Table 4. Number of joints formed Structures 10-V3-C1 and 10-V4-C1.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	**Change target location (cm)**	**Frame type**
11	**0**	**4**	**0**	**6**	**2**	**13**	**264**	**1.1**	**10 floor version 3**
11	**0**	**2**	**0**	**0**	**13**	**10**	**264**	**1.46**	**10 floors Version 4**

Table 5. Joints formed in structures 10-V3-C2 and 10-V4-C2.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	**Target displacement (cm)**	**Frame type**
11	**0**	**4**	**0**	**6**	**3**	**12**	**264**	**1.1**	**10 Floor version 3**
11	**0**	**1**	**0**	**0**	**13**	**10**	**264**	**1.46**	**10 Floor version 4**

Table 6. Joints formed in the structure 10-V3-C3 and 10 -V4-C3.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	**Change target location (cm)**	**Frame type**
0	**0**	**2**	**0**	**5**	**10**	**9**	**274**	**1.08**	**10 floor version 3**
11	**0**	**2**	**0**	**0**	**14**	**11**	**262**	**1.48**	**10 floors version 4**

Table 7. Joints formed in the structure 15-V3-C1 and 15-V4-C1.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	**Relocation of target (cm)**	**Frame type**
24	**0**	**0**	**0**	**2**	**12**	**12**	**460**	**5.42**	**15 floors version 3**
23	**0**	**1**	**0**	**2**	**8**	**28**	**448**	**5.17**	**15 floors version 4**

Table 8. Joints formed in the structure 15-V3-C2 and 15-V4-C2.

Beyond E	DE	CD	CP- C	LS-CP	IO-LS	B-IO	AB	**Target relocation (cm)**	**Frame type**
23	**0**	**0**	**0**	**1**	**17**	**26**	**443**	**5.15**	**15 floor version 3**
23	**0**	**0**	**0**	**5**	**13**	**32**	**437**	**5.15**	**15 floor version 4**

Table 9. Joints forming Structures 15-V3-C3 and 15-V4-C3.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	**Relocation of target (cm)**	**Frame type**
24	**0**	**0**	**0**	**2**	**12**	**21**	**451**	**5.07**	**15 floor version 3**
24	**1**	**0**	**0**	**0**	**17**	**22**	**446**	**3.9**	**15 Floors Version 4**

Table 10. Joints formed in structures 20-V3-C1 and 20-V4-C1.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	Apple Target location (cm)	Frame type
13	**0**	**2**	**0**	**0**	**6**	**11**	**728**	**3.69**	**20 floors version 3**
3	**0**	**1**	**0**	**4**	**0**	**9**	**743**	**1.73**	**20 floors version 4**

Table 11. Joints formed in the structure 20-V3-C2 and 20- V4-C2.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	Move target (cm)	Frame type
16	**0**	**2**	**0**	**1**	**17**	**19**	**705**	**4.55**	**20 Floor version 3**
4	**0**	**1**	**0**	**3**	**0**	**3**	**749**	**1.59**	**20 Class 4 Version**

Table 12. Joints formed in the structure 20-V3-C3 and 20-V4-C3.

Beyond E	DE	CD	CP-C	LS-CP	IO-LS	B-IO	AB	Change the target location (cm)	Frame type
16	**0**	**2**	**0**	**1**	**17**	**21**	**703**	**4.56**	**20 floors version 3**
4	**0**	**1**	**0**	**3**	**0**	**3**	**749**	**1.59**	**20 floors version 4**

curve Frame thickness curve is obtained based on the total force absorption from the structure [5], which means that whenever the difficulty Significantly reduced so that the numerical calculations of the structure are not converged by the ETABS software, the software removes the load on the structure completely and recalculates the stiffness of each member and continues to cover the structure.

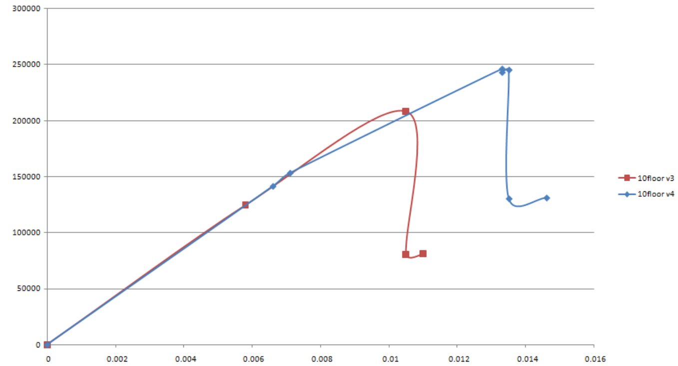


Figure 16. Capacity curve of 10-story frames, under uniform load pattern.

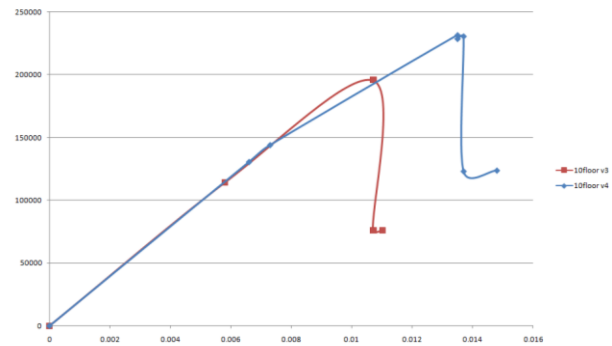


Figure 17. Capacity curve of 10-story frames, under triangular load pattern.

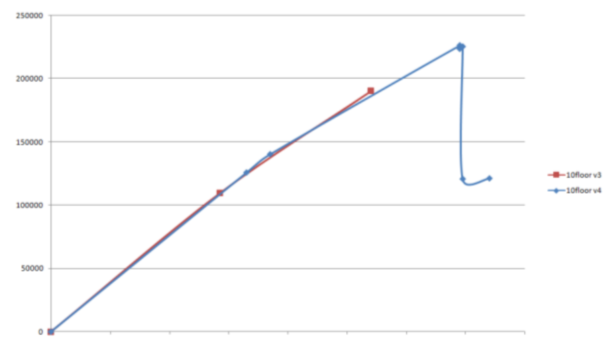


Figure 18. Capacity curve of 10-story frames, under load pattern of first mode.

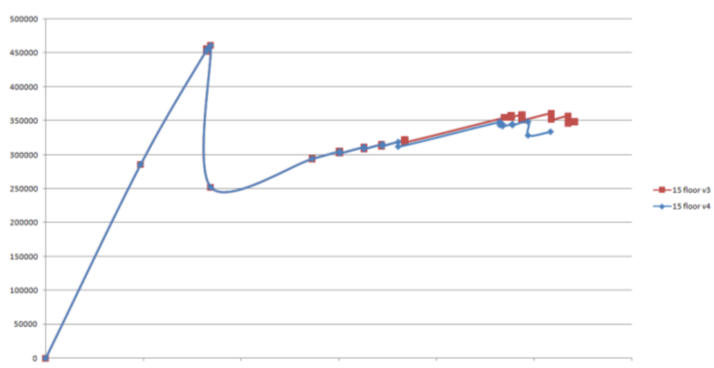


Figure 19. Capacity curve of frames 15 floors, under uniform load pattern.

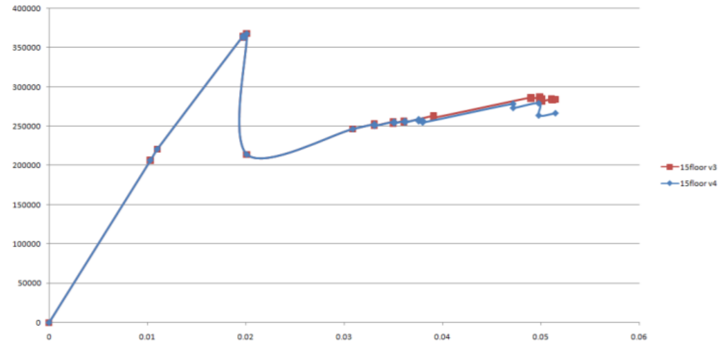


Figure 20. 15-story frame capacity curve, under triangular load pattern.

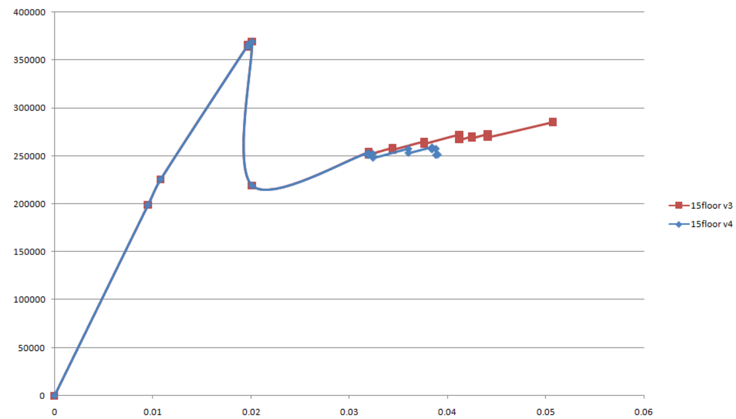


Figure 21. 15-story frame capacity curve, under first mode load pattern.

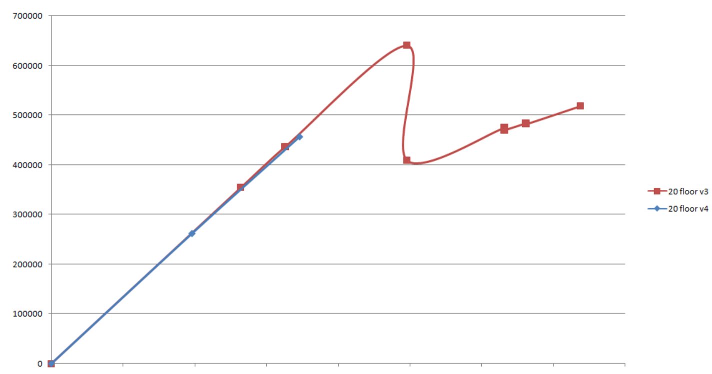


Figure 22. 20-story frame capacity curve, under uniform load pattern.

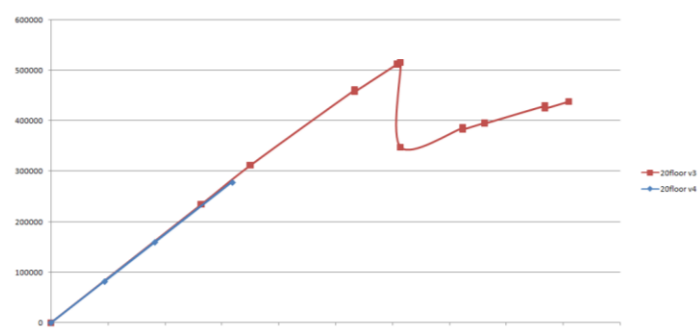


Figure 23. Capacity curve of 20-story frames, under the triangular load pattern.

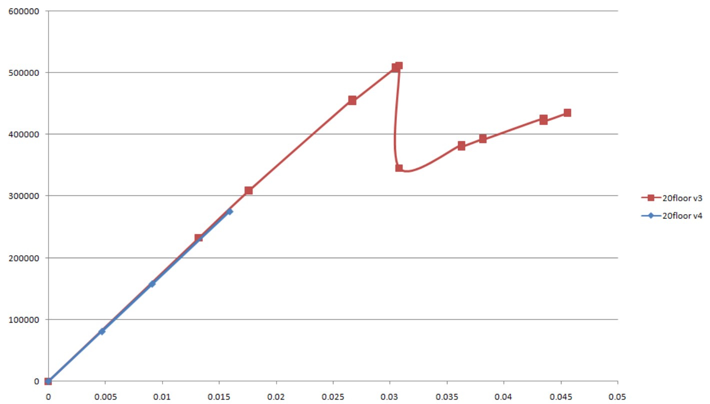


Figure 24. Capacity curve of 20-story frames, under the load mode of the first mode.

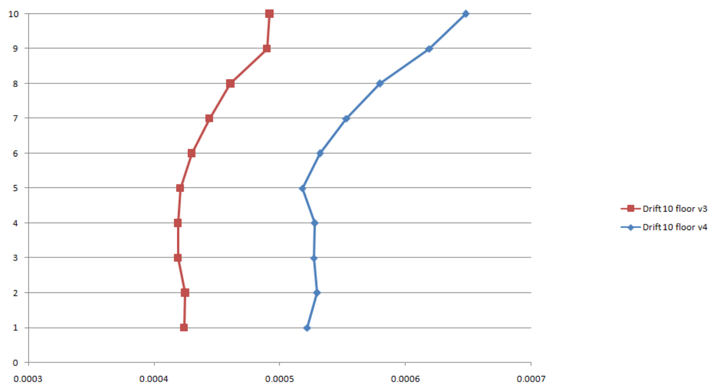


Figure 25. Relative displacement curve of 10-story frames under the uniform load pattern.

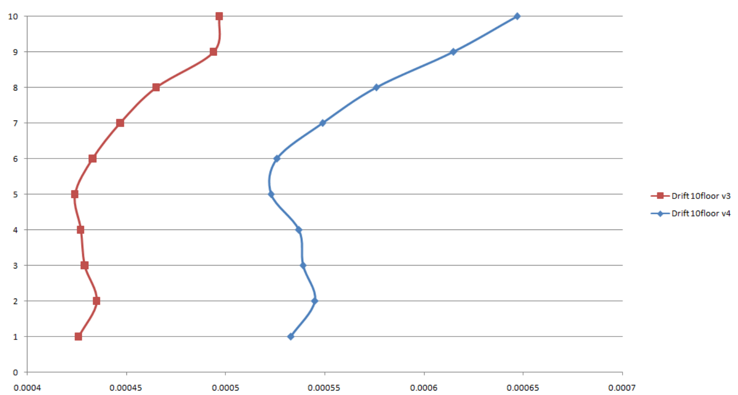


Figure 26. Relative displacement curve of 10-story frame floors under triangular load pattern.

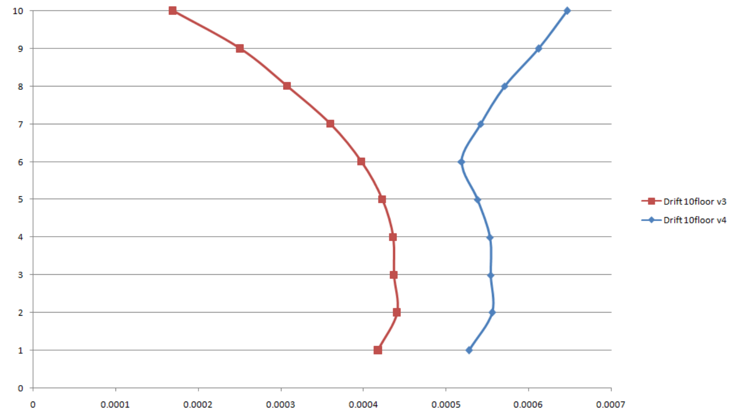


Figure 27. Relative displacement curve of 10-story frame floors under load pattern of first mode.

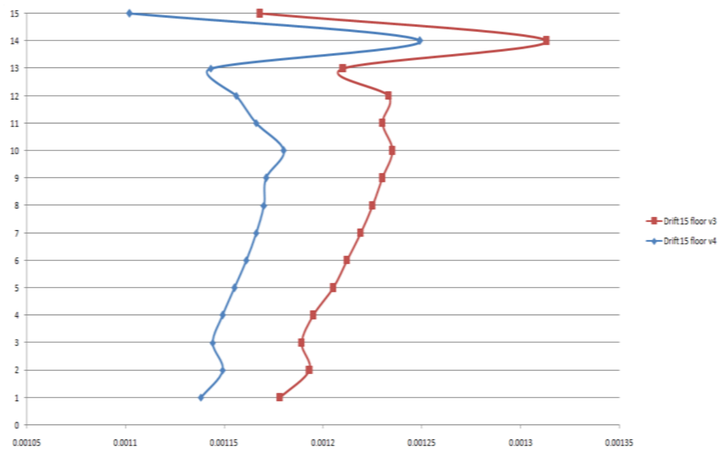


Figure 28. Relative displacement curve of 15-story frame floors under uniform load pattern.

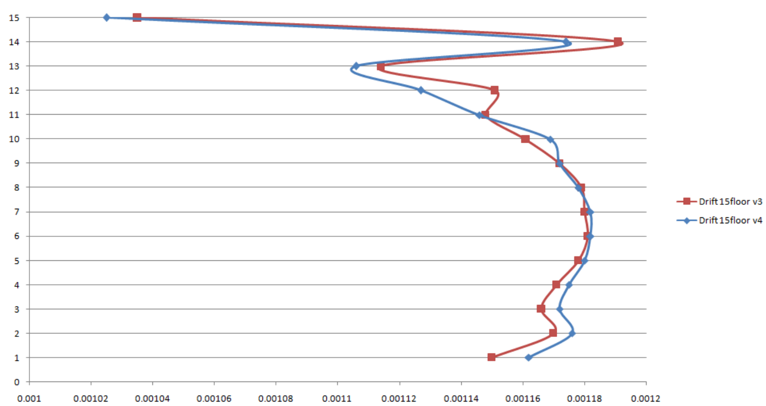


Figure 29. Displacement curve Relative 15-story frame floors under the triangular load pattern.

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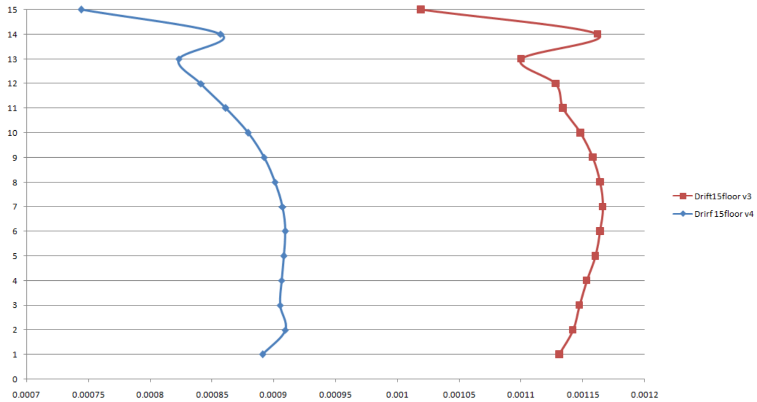

Figure 30. The relative displacement curve of the 15-story frame floors under the load-bearing pattern of the first mode floor.

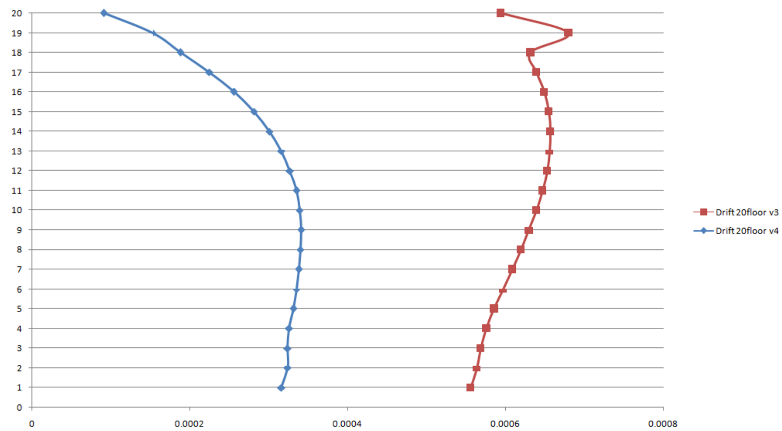

Figure 31. Relative displacement curve of the20-story frames under uniform load pattern.

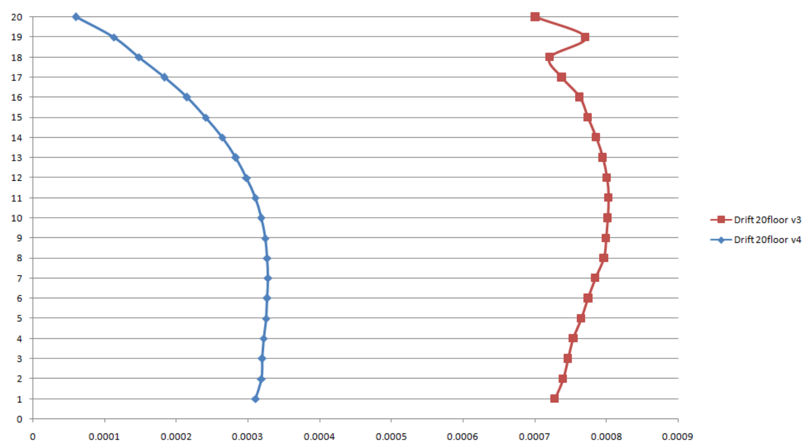

Figure 32. Relative displacement curve of floors 20-story frames under triangular load pattern.

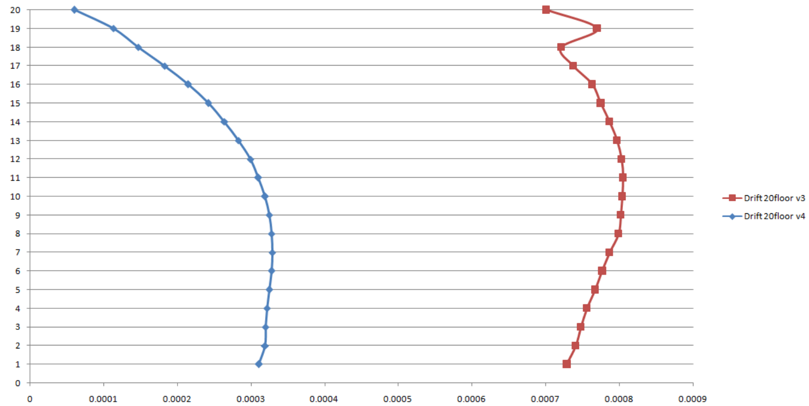

Figure 33. Relative displacement curve of floors 20-story frames under load-bearing pattern First mode.

5. Conclusions

1-10-story structure in new regulations It became critical to control the bending frame, meaning that the special bending frame of this structure does not withstand 25% of the lateral force of the earthquake and some of the lower columns do not respond, but it still had no problem controlling the relative displacement.

2-90% of the mass involved in the modes in both regulations, one came out, except for the 20-story structure, where the effective mode was reduced from the 9th mode to the 8th mode.

3- The base shear in the 10-storey structure was increasing, but in the 15- and 20-storey structures it decreased. The amount of base shear in the ten-story structure in the third and fourth editions in the direction of Horizontal is 270785.96 and 374796.69, respectively, and the absolute displacement of the roof is 32.6299 and 47.2745 mm, and the absolute displacement of the roof in the X direction is 63.1927 and 91,654 mm. The amount of base shear in the fifteen-story structure in the third and fourth editions in the direction of Horizontal is 1222099.15 and 1045549.24, respectively, and the absolute displacement of the roof is 6.8757 and 5.05427 cm, and the absolute displacement of the roof in the X direction is 9.8543 and 7.2378 cm. The amount of base shear in the twenty-story structure in the third and fourth editions in the direction of Horizontal are 2849671.79 and 2135972.29, respectively, and the absolute displacement of the roof is 62.5273 and 41.1319 mm, and the absolute displacement of the roof in the X direction is 69.8273 and 45.9684 mm.

4. The reflection coefficient in the new regulation for structures with period in the constant acceleration zone is much higher than structures with period in the constant velocity zone, but the rigid region of the two reflection spectra is almost identical.

5. The value of ρ for the 15-story structure in the studied frame, i.e. frame A in both editions 2800 is equal to 0.25%.

6- The value of ρ for the 10-story structure in the studied frame, i.e. frame A in both 2800 editions is equal to 0.25%, but in the first floor at the bottom of the shear wall is 0.52% and 0.39%

7. The value of ρ for the 20-story structure in the studied frame, i.e. frame A in both versions, is 2800 equal to 0.25%.

8- In general, in the constructions of the near area, the structures with less number of floors and designed with the fourth edition show better performance against the lateral force of the earthquake, but the opposite is true for high-rise structures.

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