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COMPARATIVE STUDY OF PERFORMANCE BASED BEHAVIOUR OF MOMENT RESISTING FRAMES WITH STRUCTURAL SHEAR WALLS, CONCENTRIC BRACED FRAMES & BUCKLE RESISTING BRACED FRAMES

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Buckle Resisting Braced Frames (BRBF)
American Society for Civil Engineers (ASCE)

ABSTRACT

Performance evaluation and design of civil facilities against earthquakes is a challenge to engineers because of the large uncertainty in the seismic demand and capacity of structures. The purpose of the study is to perform comparative analytical investigation of performance-based behavior between Moment Resisting Frames with Structural shear Walls, Concentric Braced Frames & Buckle Resisting Braced Frames of a concrete structure by using ETABS-2017 software. The comparative analytical evaluation of the study will be based on the parameters such as displacement, inter-story drift, pushover curve and life expectancy level. The purpose of the study is to obtain a structural system which is more efficient, reliable and strong in its nature and strength.

1. INTRODUCTION

A static non-linear analysis i.e. pushover analysis, is performed in the analytical investigation. The investigation is performed by developing three different models in ETABS-2017 software. First model consists of building with ductile reinforced concrete structural walls. Second model consist of building with special braced frames having concentric braces, these concentric braces are modeled as X-braces. Third model consist of buckle resisting braced frames, these braces are modeled as single inclined braces. Since the Indian Standard Codes do not address the BRBF

system and also the performance-based analysis of the structure, we will be proceeding with the procedure prescribed in ASCE 41-13. Evaluation of the performance needs to be described in terms of reliability of the structural system against various limit states over a given period of time. In view of the large uncertainties in both demand and capacity, the performance of the structural systems can be described meaningfully only when these uncertainties are taken into consideration explicitly.

2. METODOLOGY

- Modeling the separate models for SSW, CBF and BRBF of a concrete building with their respective analytical system.
- Introducing a static nonlinear case to investigate a performance-based behavior in the above defined system.
- Analyzing the models and evaluating the study.

3. MODELLING AND ANALYSIS

The structure consists of G+10+T floors, the usage of the structure is for the residential use with 48meters height. In the first model structural shear walls are modelled, in the second model steel box section is used for the bracing and in the third model star seismic buckle resisting braced frames properties were imported in the model and these were assigned to the bracing members for the analysis of concrete structure. Although all the three models are similar in its properties and parameters in model but they differ by using the SSW, CBF & BRBF system.

Table 4.1: Analysis data

Plan Size	25m X 25m (5x5 m Bay)
No. Of Story's	12
Story Height	4m
Wall Thickness	250mm
Column Size	550x550mm
Beam Size	250x450mm
Thickness of Slab	125mm
Bracing Size	Steel 200x14
Grade of column	M30
Grade of beam	M30
Grade of bracing	Fe 350
Grade of shear wall	M 40
BRBF bracing size	Star Seismic 10.0

Table 4.2: Load considered

Live load	2.00 kN/m2
Floor finish	1.25 kN/m2
Wall Load	7.90 kN/m

Table 4.3: Analysis parameters

Time period	SSW - Bare frame CBF - Bare frame BRBF - Bare frame
Response Reduction Factor	MRF - 4, CBF - 4.5 BRBF – 4.5
Importance Factor	1
Soil type	II (medium)
Seismic zone	IV
Zone Factor	0.24

Figure 4.1: MRF with SSB plan

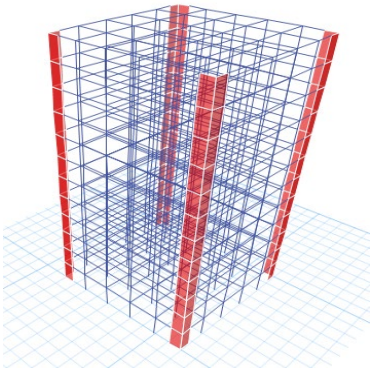

Figure 4.2: MRF with SSB 3D view

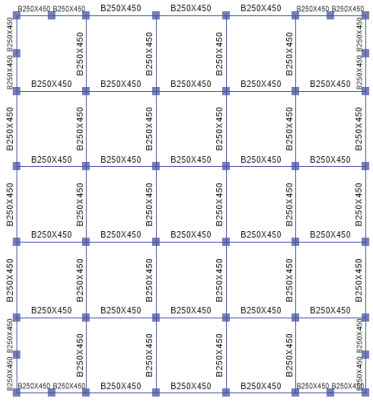

Figure 4.3: MRF with CBF plan

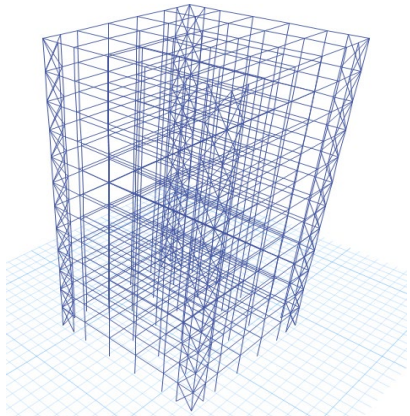

Figure 4.4: MRF with CBF 3D view

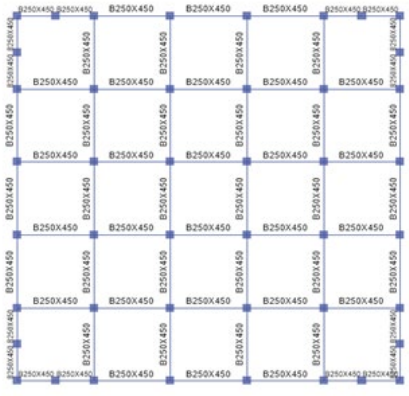

Figure 4.5: MRF with BRBF plan

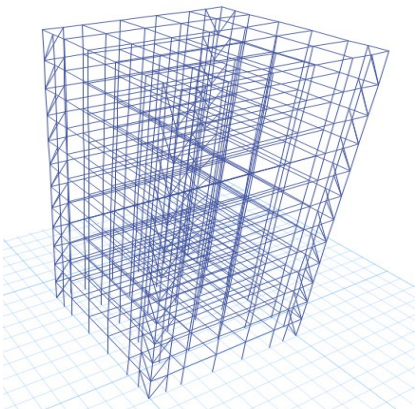

Figure 4.6: MRF with BRBF 3D view

4. RESULT AND CONCLUSION

The evaluation of the analysis based on the parameters such as target displacement, inter-story drift, pushover curve and life expectancy level are as follows with a comparison of the results and discussion.

4.1. TARGET DISPLACEMENT

The target displacement is evaluated from different analysis carried out on moment resisting frame with SSW, CBF & BRBF. The peak target displacement at top level is enlisted in table no. 5.1.1. From figure no. 5.1.1, it is evaluated that moment resisting frame with SSW have maximum target displacement between CBF & BRBF and target displacement between CBF & BRBF analysis has come out to be same.

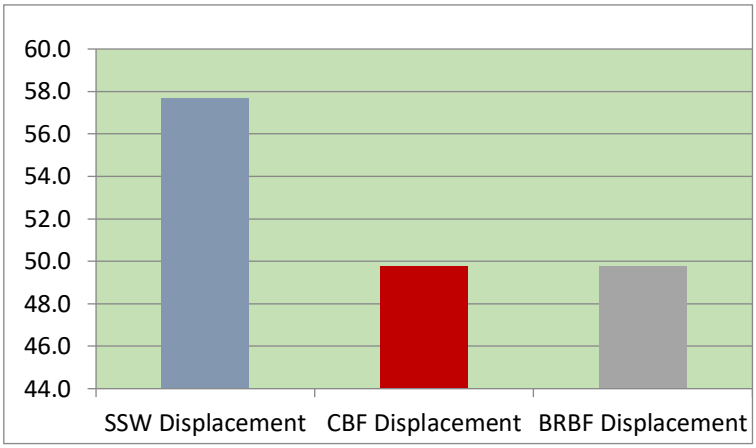

Figure 5.1.1: Top level story displacement

Table 5.1.1: Peak target displacement

SSW Displacement	57.7 mm
CBF Displacement	49.8 mm
BRBF Displacement	49.8 mm

4.2. STORY DRIFT

The story drift is evaluated from different analysis carried out on moment resisting frame with SSW, CBF & BRBF. The results are evaluated story wise which are enlisted in in table 5.2.1. From figure 5.2.1, it is evaluated that moment resisting frame with SSW have maximum story drift as compared with CBF & BRBF and from ground floor level to 6 floor level story drift exist more in CBF than BRBF system and above it goes inverse.

Table 5.2.1: Story drift

STORY NO.	SSW Story Drifts	CBF Story Drifts	BRBF Story Drifts
T	0.92	0.78	0.68
10	1.03	0.91	0.85
9	1.17	1.02	0.99
8	1.31	1.12	1.10
7	1.43	1.19	1.19
6	1.52	1.24	1.25
5	1.55	1.25	1.28
4	1.53	1.22	1.27
3	1.44	1.15	1.22
2	1.24	1.02	1.12

STORY NO.	SSW Story Drifts	CBF Story Drifts	BRBF Story Drifts
1	0.91	0.82	0.96
G	0.37	0.44	0.53

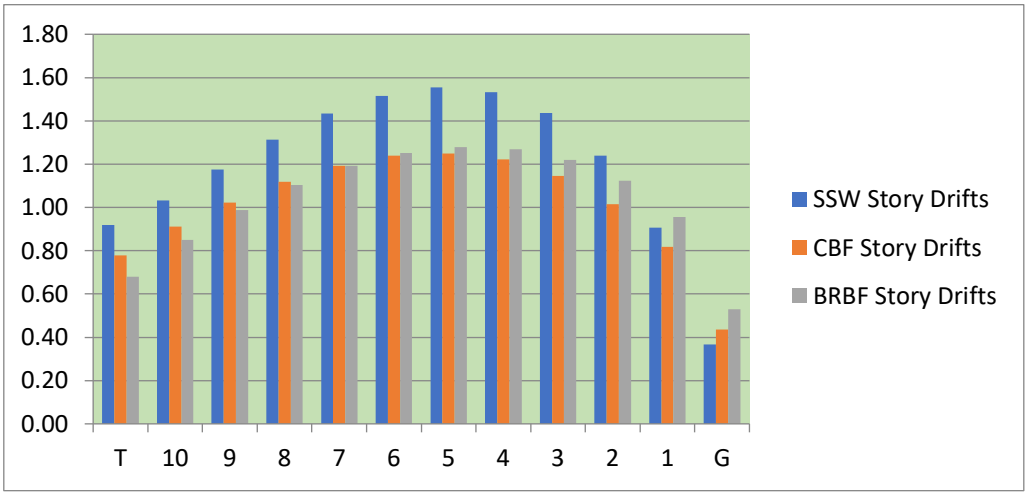

Figure 5.2.1: Comparison of story drift

4.3. HINGES FORMED IN THE LIFE EXPECTANCY LEVEL

A plot is drawn to know about the hinges formed in the life expectancy level in various steps defined in the analysis. From figure 5.3.1 to 5.3.6, it is evaluated that maximum number of hinges lies in the immediate occupancy level in all the three systems. As number of steps increased in the analysis states of hinges starts changing to the higher states. Moment resisting frame with SSW have maximum number of hinges in life safety level than CBF & BRBF system. Maximum number of hinges beyond the collapse prevention level is formed in the BRBF system and least number of hinges beyond the collapse prevention level is formed in the SSW system.

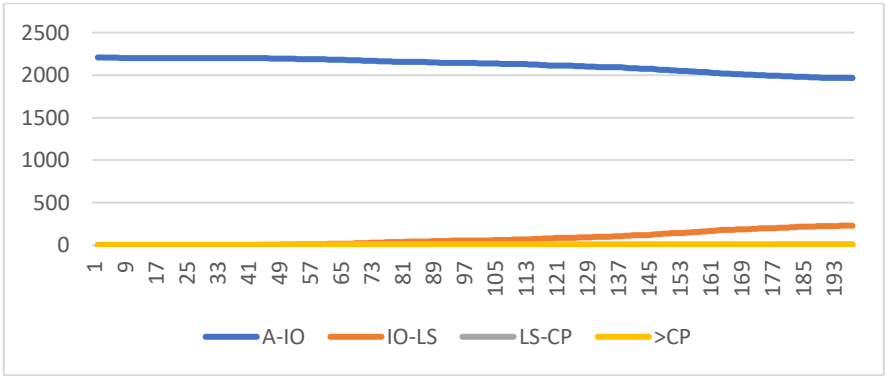

Figure 5.3.1: Hinges formed in life expectancy level SSW system X direction

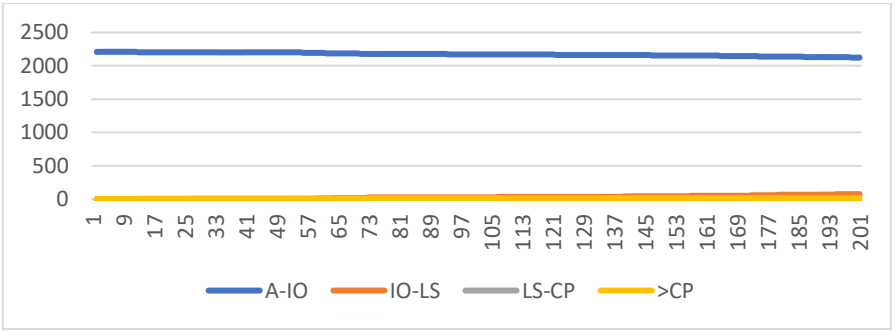

Figure 5.3.2: Hinges formed in life expectancy level SSW system Y direction

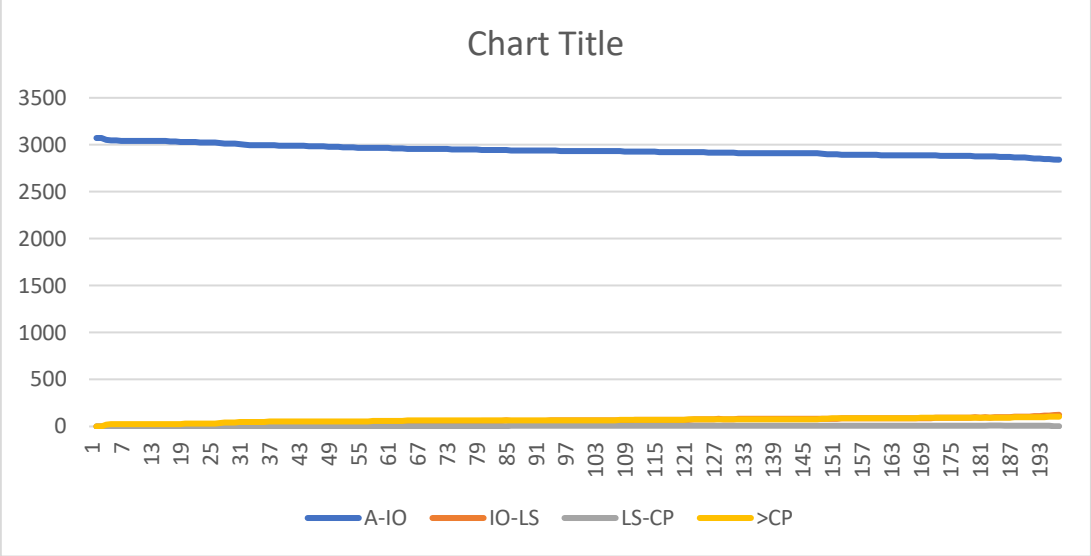

Figure 5.3.3: Hinges formed in life expectancy level CBF system X direction

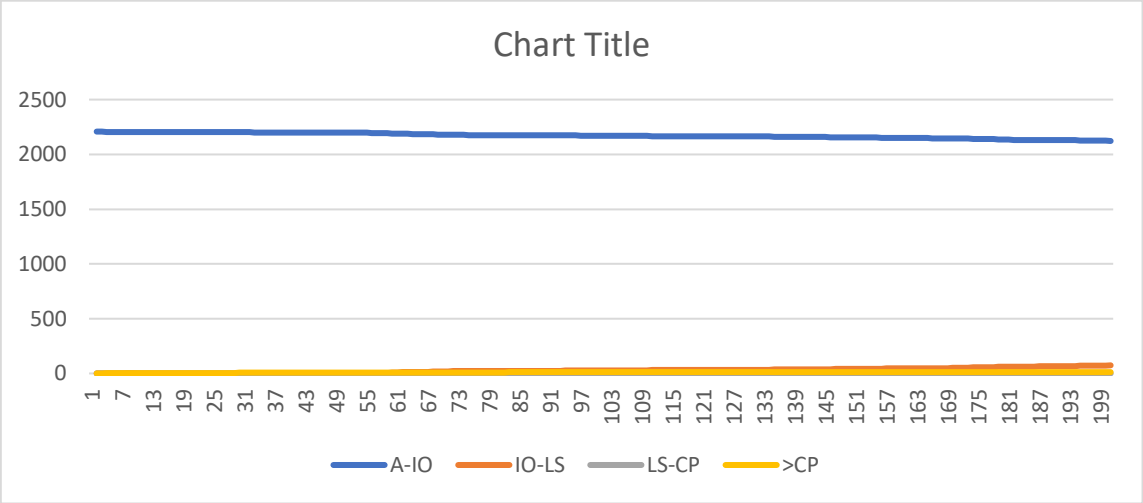

Figure 5.3.4: Hinges formed in life expectancy level CBF system Y direction

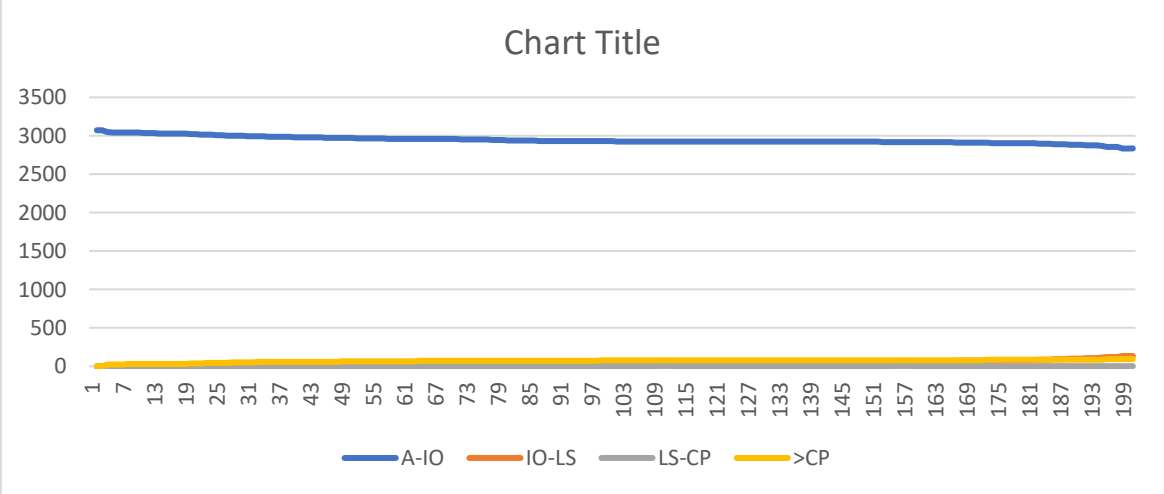

Figure 5.3.5: Hinges formed in life expectancy level BRBF system X direction

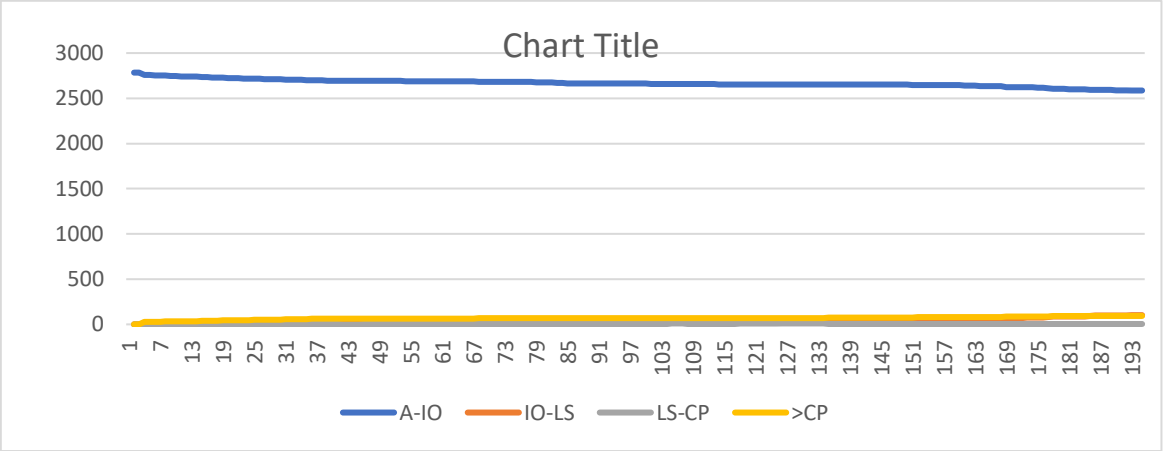

Figure 5.3.6: Hinges formed in life expectancy level BRBF system Y direction

4.4. HINGES

Figure 5.4.1 to 5.4.6, shows the view of the structure in 3-dimensional form. From the figures we can see the hinges formed in the different element of the structure. Green hinges represent the hinges lies in the life safety level and red hinges represents the hinges lies beyond the collapse prevention level. From the analysis it can be evaluated that maximum number of hinges lies beyond the collapse prevention level is formed in the BRBF system and least number of hinges lies beyond the collapse prevention level is formed in the SSW system.

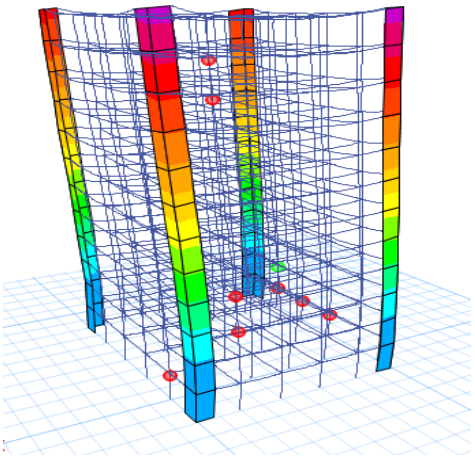

Figure 5.4.1: Hinges 3D SSW X direction

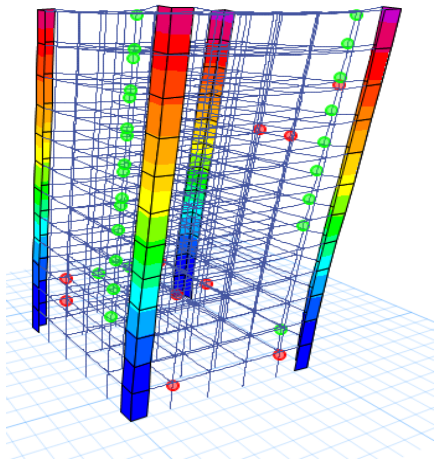

Figure 5.4.2: Hinges 3D SSWY direction

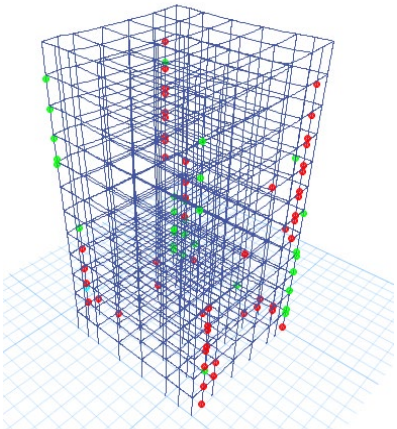

Figure 5.4.3: Hinges 3D CBF X direction

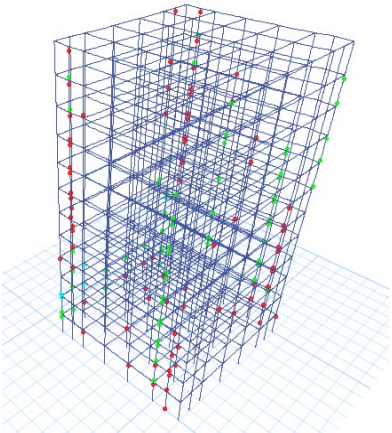

Figure 5.4.4: Hinges 3D CBF Y direction

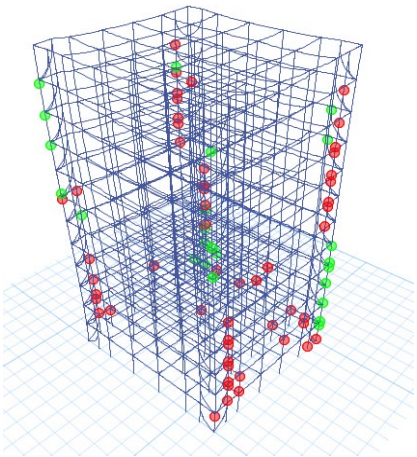

Figure 5.4.5: Hinges 3D BRBF X direction

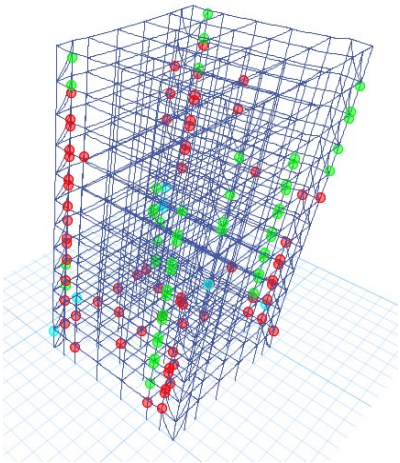

Figure 5.4.6: Hinges 3D BRBF direction

4.5. BASE SHEAR VS MONITORED DISPLACEMENT

Figure 5.5.1 to 5.5.6, represent the curve between the base shear and monitored displacement. The smoothness of the curve shows the accuracy of modelling and analysis. In SSW system the curve seems to be heading constantly upward with the increasing in the base shear & displacement values till its reached the collapse point though in this system the collapse point didn't formed. In CBF system the curve is also observed to be smooth but at the later stages the downward kink is observed in the curve that downward kink is the collapse point in the analysis. In BRBF system the curve is also observed to be smooth and we also have a collapse point in the analysis.

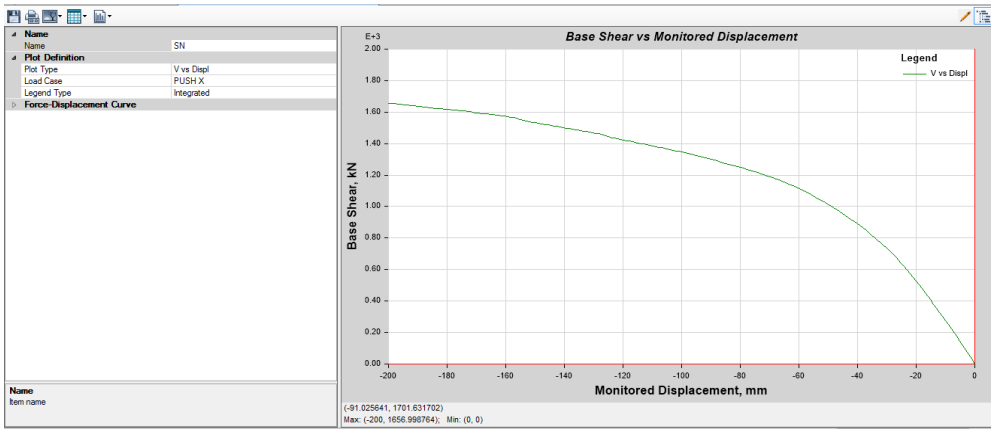

Figure 5.5.1: Base shear vs monitored displacement SSW system X direction

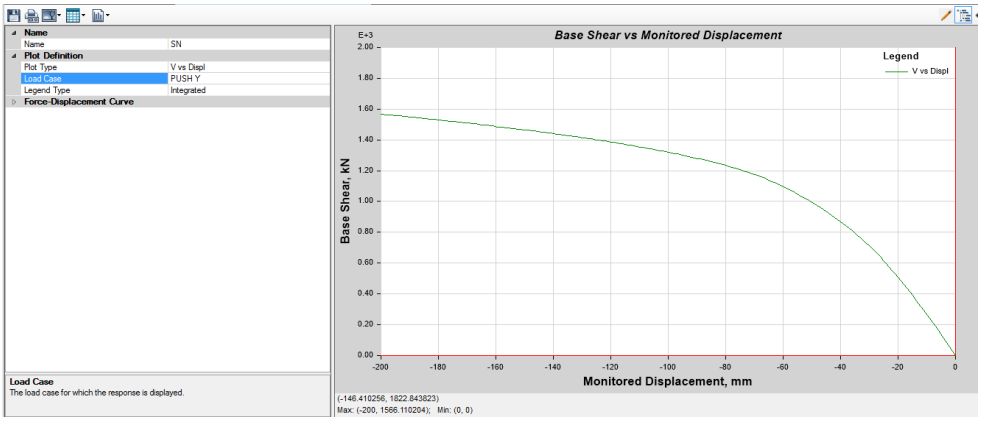

Figure 5.5.2: Base shear vs monitored displacement SSW system Y direction

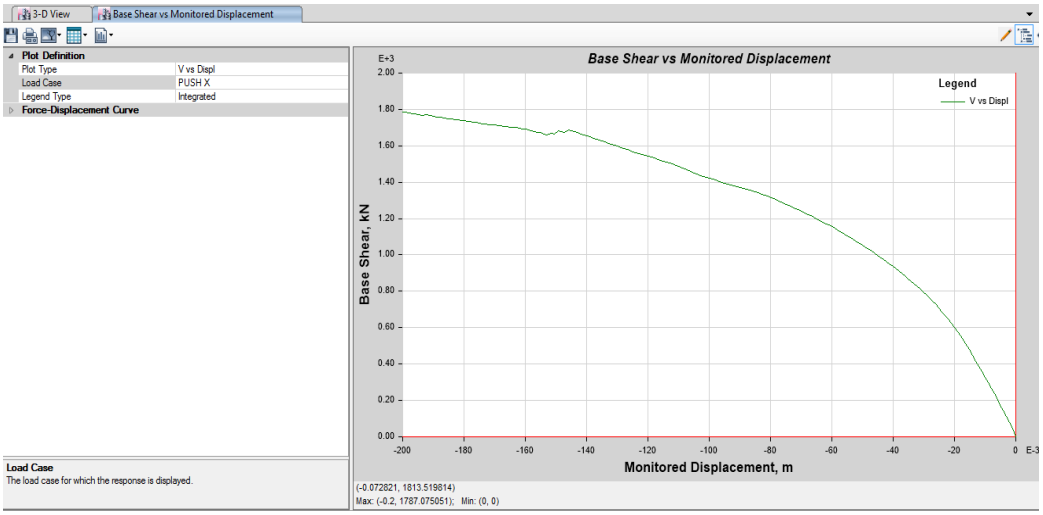

Figure 5.5.3: Base shear vs monitored displacement CBF system X direction

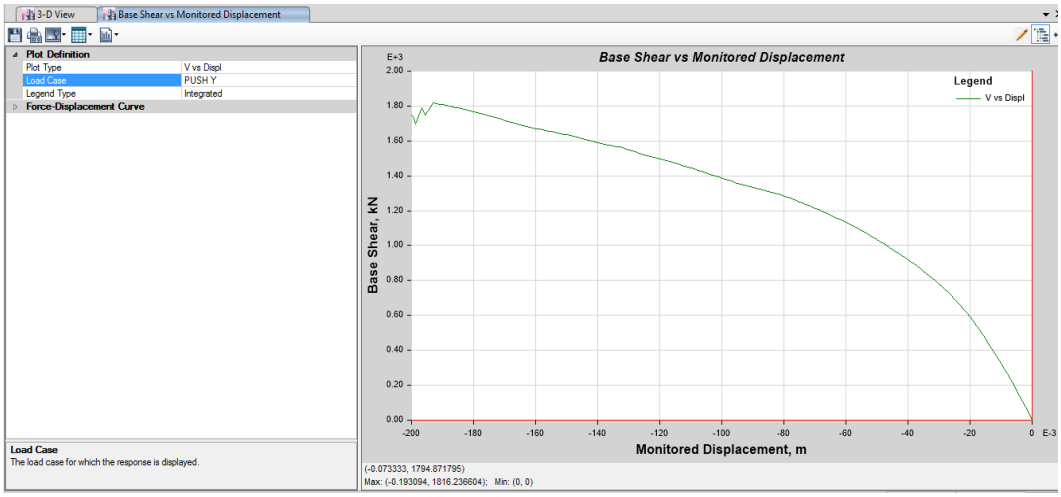

Figure 5.5.4: Base shear vs monitored displacement CBF system Y direction

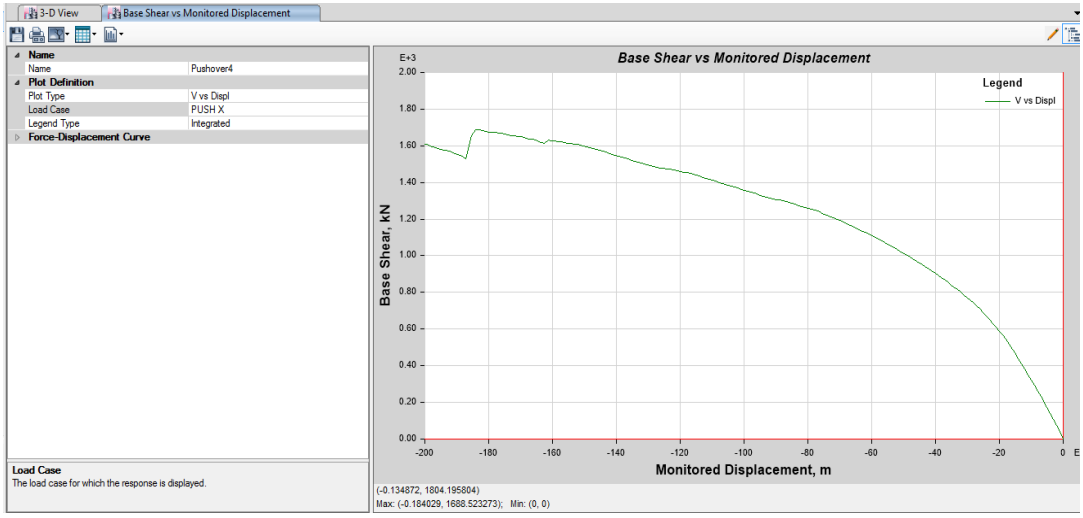

Figure 5.5.5: Base shear vs monitored displacement BRBF system X direction

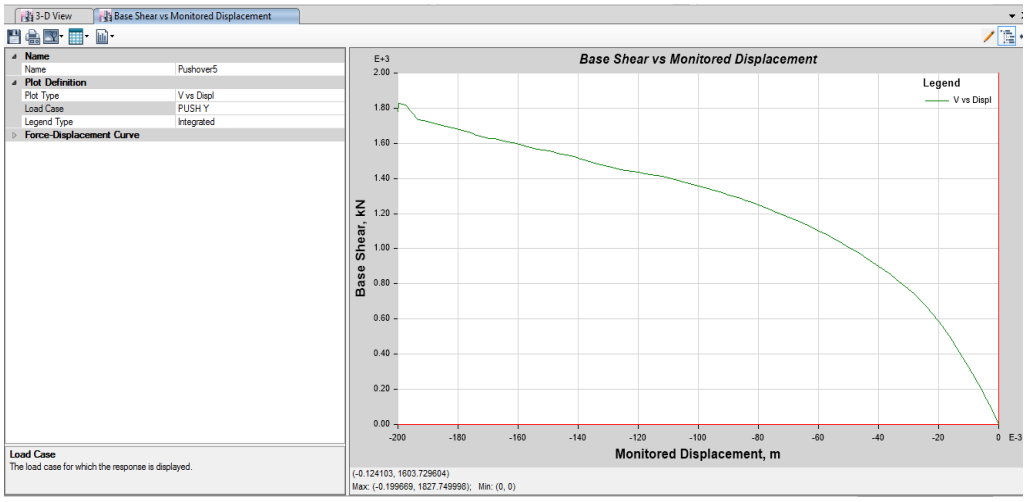

Figure 5.5.6: Base shear vs monitored displacement BRBF system Y direction

4.6. SPECTRAL ACCELERATION VS SPECTRAL DISPLACEMENT

Figure 5.6.1 to 5.6.6 represent the curve of single demand and capacity of the structure. The point where both the curve intersects that point is known as performance point. In SSW system the performance point is obtained at minimum base shear as compared to the CBF & BFBR system. In CBF system the performance point is obtained at maximum base shear as compared to the SSW & BFBR system.

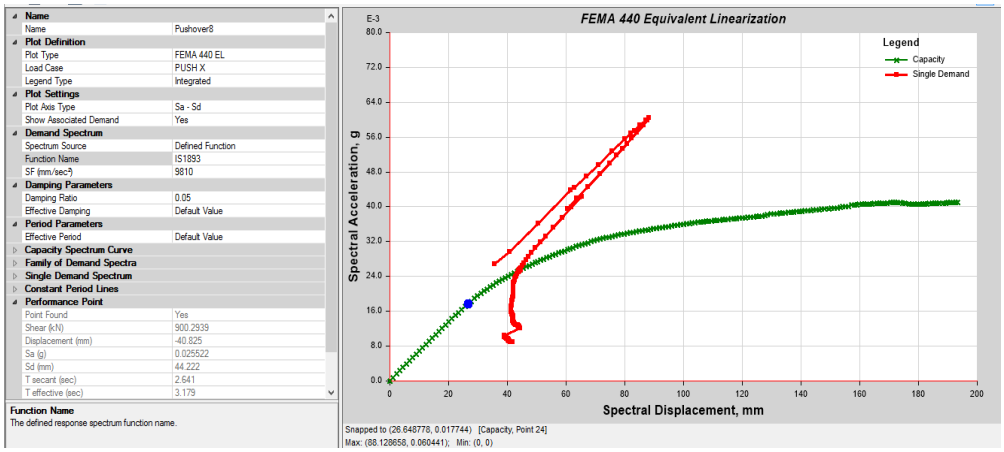

Figure 5.6.1: Spectral acceleration vs spectral displacement SSW system X direction

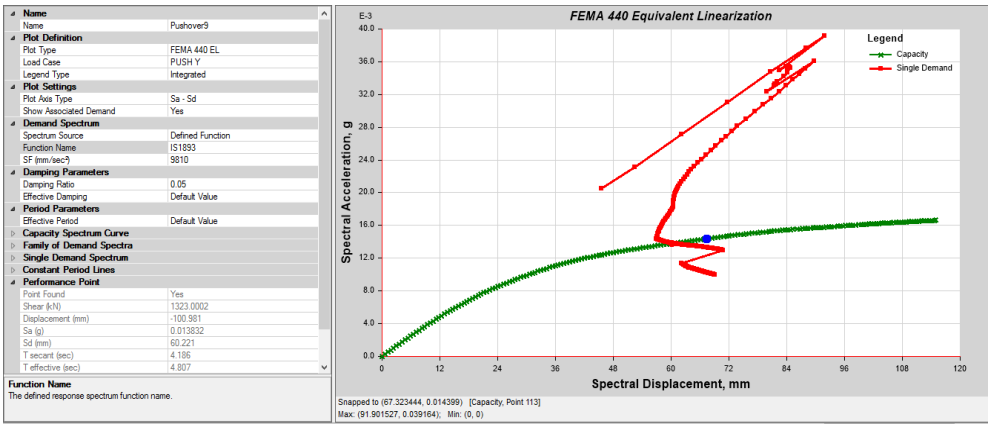

Figure 5.6.2: Spectral acceleration vs spectral displacement SSW system Y direction

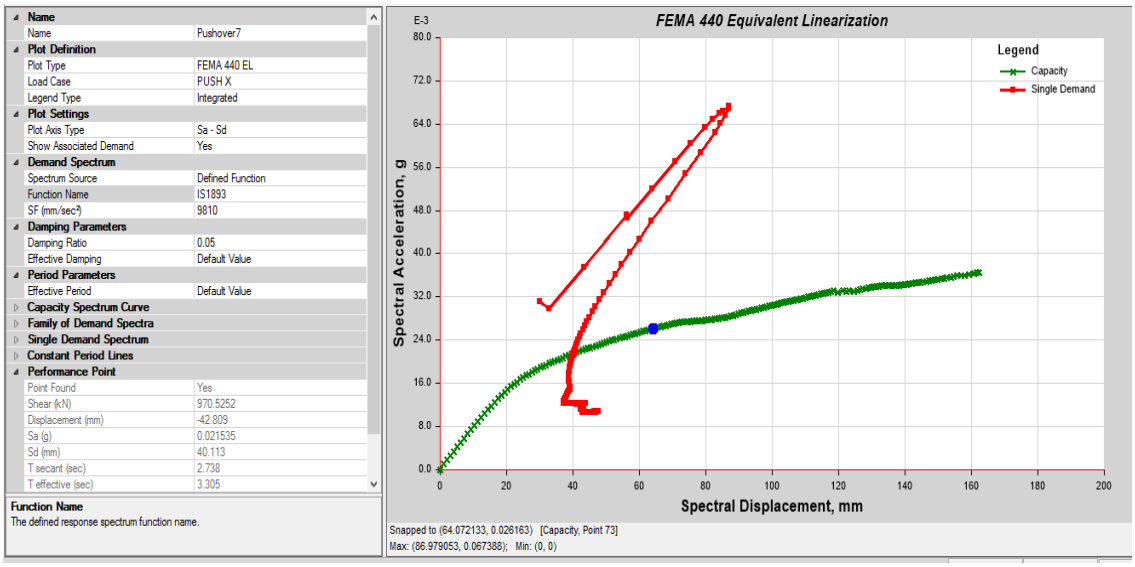

Figure 5.6.3: Spectral acceleration vs spectral displacement CBF system X direction

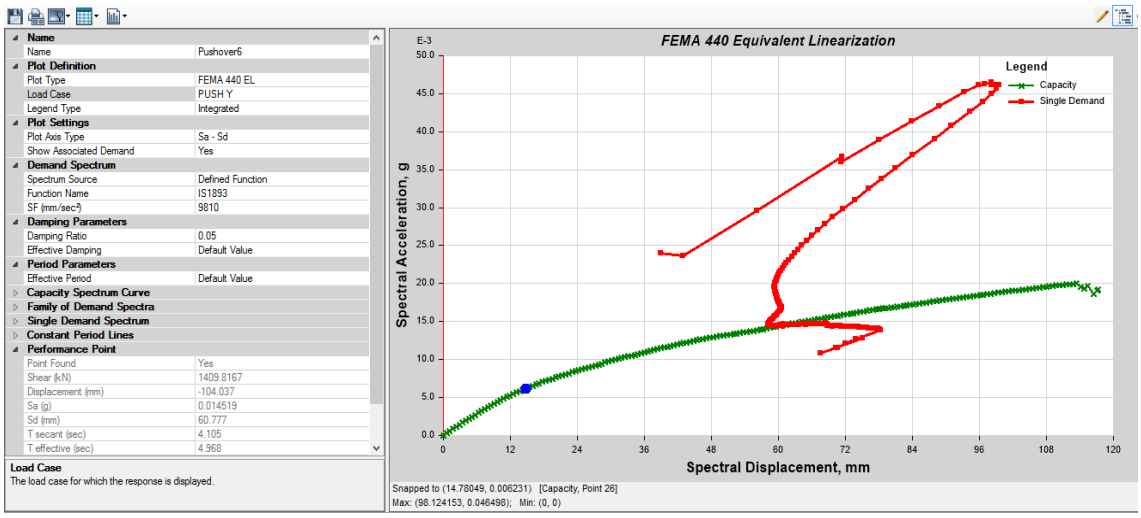

Figure 5.6.4: Spectral acceleration vs spectral displacement CBF system Y direction

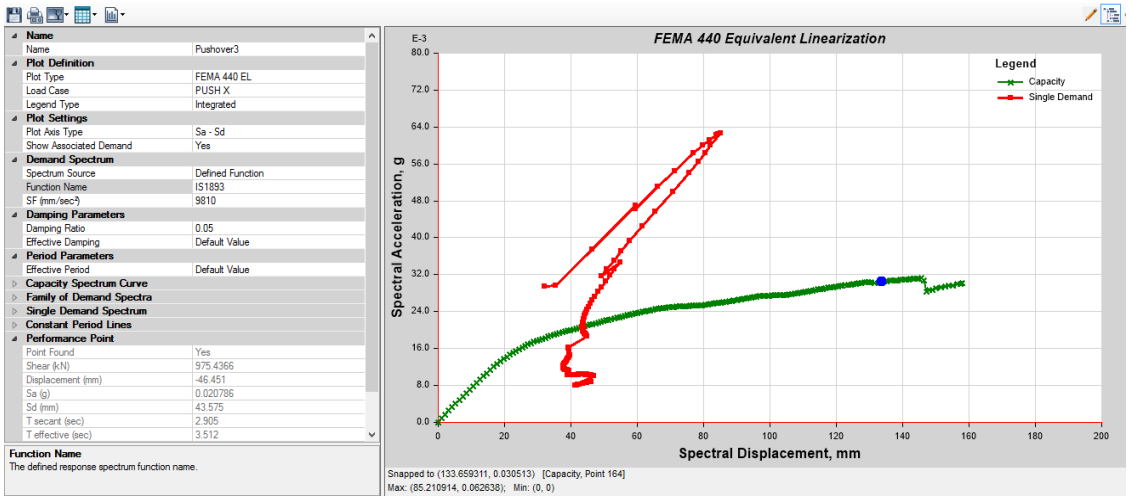

Figure 5.6.5: Spectral acceleration vs spectral displacement BRBF system X direction

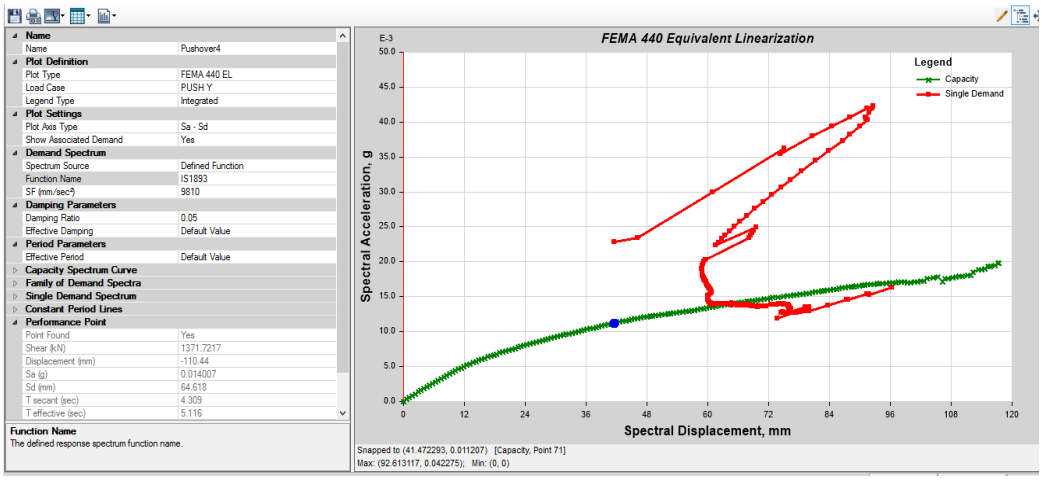

Figure 5.6.6: Spectral acceleration vs spectral displacement BRBF system Y direction

4.7. CONCLUSION

This paper proposes the study to obtain a structural system which is more efficient, reliable and strong in its nature and strength. For this purpose, the investigation is carried out for 3 different structural system i.e. moment resisting frame with SSW, CBF & BRBF. The sizes of the members and loads on the building are kept same in all the systems. The conclusion on the evaluated results for the parameters such as target displacement, inter story drift, pushover curve and life expectancy level.

The maximum target displacement and story drift is obtained in the SSW system as compared with CBF & BRBF system but the maximum number of hinges formed beyond the collapse prevention level is formed in BRBF system although we also encountered a collapse point in CBF & BRBF system.

From the investigation it can be concluded that moment resisting frame with SSW system is more efficient, reliable and strong in its nature and strength as compared with CBF & BRBF system.

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CONFLICT OF INTEREST

The author have declared that no competing interests exist.

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None.

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