

Comparison of Seismic Performance of RC Flat Slab with and without Drop Panel for Steel Bracing

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Abstract

One of the lateral load opposing frameworks in multi-storey structures is Steel brace frame. The resistance of the structure which enhances against horizontal forces by expanding its stiffness and stability is Steel bracing system in RC multi-storey building is conservative, simple to set up, involve less space and give obliged quality and inflexibility. Flat slab reinforced buildings have exhibit many dominances over conventional type of beam column building. However, the effectiveness of structure in flat slab construction is inferior in performance under earthquake loading. Flat slab requires the simple formwork which usually result in an economical construction. In present study, a G+9 storey building is analysed for seismic zone IV as per IS 1893: 2002 using ETABS software. Flat slab is used by providing drop panels and peripheral beam. For all models parameters are kept constant. The effect of the distribution of the steel bracing along with the flat slab RC frame on the seismic performance of the building is studied. The performance of the building is evaluated in terms of storey displacement, storey shear, story drifts and slab stresses. The percentage reduction in lateral displacement along X direction is tabulated. By providing drop panels the slab stress is reduced on structure compared to RC bare frame. Hence it is concluded that the use of steel bracing with flat slab in construction resists the lateral forces for many vulnerable conditions.

Keywords: Seismic Performance, Response Spectrum ANALYSIS, Steel Bracing, Flat SLAB, Drop PANEL

I. INTRODUCTION

Earthquake is one of the most destructive natural calamities. It is termed as abrupt and transient motion of the earth's crust, which originates below the surface of earth naturally. Earthquakes are caused due to the movement of the tectonic plates which are interconnected to each other, both in direction and magnitude, leads to an accumulation of strain, both at the plate boundaries and inside the plates.

At the plate or at the faults boundaries due to slips most earthquakes are produced. There are many records which show that the results which destroys many properties and loss of human lives which finally affects the national economy due to occurrence of earthquakes.

The land for housing demand is increasing due to increased population periodically. The only option is multi-storey buildings to fulfil the need of the land for housing and development of commercial offices.

The multi-storey buildings are highly susceptible to additional lateral loads due to earthquake and wind hence this type of development requires safety. As their action to lateral loads increases, the elevation of building increases. The necessity of the introduction of special measures to decrease the deformations in which multi-storey RC buildings undergoes excessive deformation.

A. Steel Brace and Flat Slab

For multi storey reinforced concrete these are the frequently used for hotels, hospitals, apartment houses and dormitories. In Flat slab the drawback is their lateral load resistance hence special features like steel brace can be provided for High rise constructions.

- Flat slab can also be used by providing drop panels. Usually column patterns are on a rectangular grid and peripheral beam can be added. In flat slab structures the supporting columns loads are directly considered. Flat slab requires the simple formwork which usually result in an economical construction.
- One of the lateral load opposing frameworks in multi-storey structures is Steel brace frame. The resistance of the structure which enhances against horizontal forces by expanding its stiffness and stability is Steel bracing system.

For example, by interchanging the horizontal loads the steel bracings hold the structure stable from wind or quake from the opposite side and ground loads. Steel bracing members in RC multi-storey building is conservative, simple to set up, involve less space and give obliged quality and inflexibility. X, K, inverted V, and Diagonal and knee bracings are distinct types of bracing systems.

B. Need for Present Study

- From the first high rise buildings constructed in the old century until the modern days, the structure has played a major role in the overall design.
- The structural engineers focus to increase the height and slenderness which brought a change from static gravity loads to horizontal dynamic loads generated by wind and earthquakes.
- There was necessary to develop the different kind of structural system, in that by incorporating steel braces and flat slab in the structures is one such method came into existence.
- Several previous studies show that the use of bracing in a building is highly efficient and economical method to resist lateral forces.
- The use of flat slab in construction of building has many advantages but it is not suitable for supporting brittle (masonry) portions.
- Use of drop panels reduces deflection by stiffening the flat slab from which slab stresses get reduced.
- To overcome some of the disadvantages of above point both bracing systems and flat slabs (with and without drop) has been combined in our present study.

C. Objective of the Study

- To compare the behavior of Framed RC structure with flat slab structure with drop panel and flat slab structure without drop panel.
- To study the performance level of flat slab structure when added with the steel bracing using linear dynamic analysis (response spectra method).
- To understand the behavior of FSWP (Flat Slab with Perimeter beam) with drop panel and with different bracings systems.
- To study the behavior different bracing systems (i.e. X, V, Diagonal and inverted V bracings)
- To obtain the most effective bracing which resist the lateral loads among all the bracings considered.
- To study the results of lateral displacement, shear storey, storey drift and slab stresses of a flat slab structure assigned with steel bracing.
- To identify the most vulnerable building among the models considered for seismic action.

II. MATERIALS AND METHODS

A. Building Description

In our study four different types of bracing has been chosen i.e. X, V, inverted V and diagonal in the structure. The plan, floor to floor height, column size, peripheral beam, flat slab thickness, floor finish loads, wall loads, live loads and Response-spectra data remains same for all the models. The models consist of G+9 stories in which column spacing of 5m is considered along both X and Y directions. For all models the column of size 900x900mm, peripheral beam of 500x500mm and steel bracing (ISMB 450) is kept constant. The Response Spectrum analysis is made for all the buildings using ETABS software.

Table – 1

The data is taken for the analysis is as follows:

Layout of plan	4bays x 4bays
Spacing of each bay	5m
Support condition	Fixed
Height of each storey	3m
Grade of concrete	40 Mpa
Grade of reinforced steel	Fe 500
Structural steel considered	ISMB 450
Thickness of main wall	200mm
Column size	900mmx900mm
Peripheral Beam size	500mmx500mm
Flat slab thickness	125 mm
Floor finish load	1 kN/m ²
Live load	3 kN/m ²
Seismic Zone	IV (Z=0.24)
Soil type	II
Importance factor	1
Response reduction factor	3
Damping ratio	5%

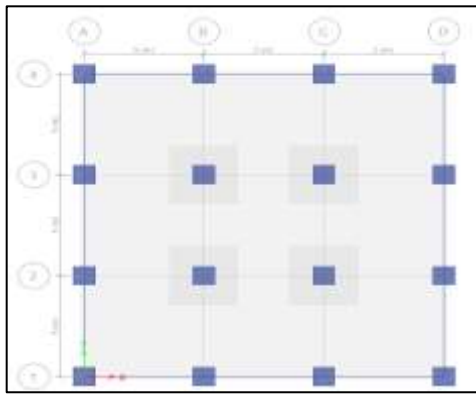


Fig. 1: Flat slab with drop



Fig. 2: Flat slab without drop



Fig. 3: 3D Model of Flat structure with peripheral beam and drop panel.

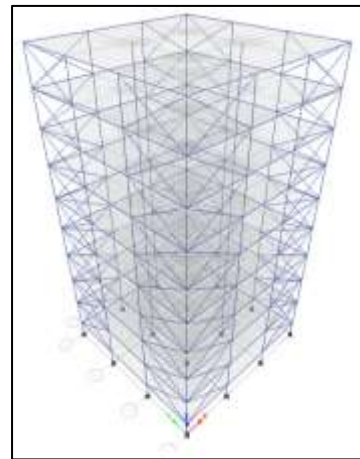


Fig. 4: Arrangement of bracing system.

III. RESULTS AND DISCUSSION

The present work took place to compare the dynamic response of buildings with bracings. Totally 15 models/structures are taken for dynamic analysis which includes Response Spectrum method. Code used is IS-1893 (part-I):2002 for Response Spectrum method from which storey shear, storey drift, slab stresses and storey displacement results for seismic zone-IV are obtained.



Fig. 5: Storey Displacement v/s type of bracing (drop panel)

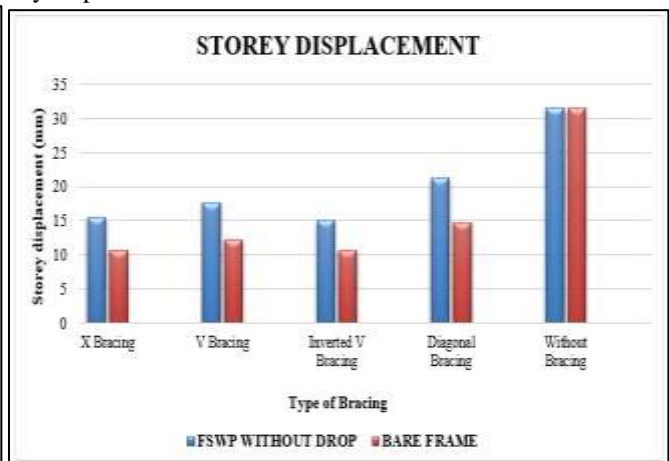


Fig. 6: Storey Displacement v/s type of bracing (without drop panel)

The Fig 5,6 shows the variation of maximum storey displacement v/s type of bracing along X direction and the comparison of Flat slab with perimeter beam (FSWP) with and without drop panel and RC bare frame. As seen above the lateral displacement is minimum for inverted V and X bracings. It is observed that without bracing and flat slab without drop panel structure has more displacement value. The percentage reduction of displacement is as shown below:

Table – 2
Percentage reduction of displacement (mm) of X bracing with drop panel.

No. of stories	Seismic Loads		% Reduction
	Without bracing	X Bracing (with drop panel)	
7 th storey	22.83	7.56	66.86
8 th storey	26.19	8.84	66.23
9 th storey	29.04	10.02	65.59
10 th storey	31.48	11.08	64.78

Table – 3
Percentage reduction of displacement (mm) of X bracing without drop panel.

No. of stories	Seismic Loads		% Reduction
	Without bracing	X Bracing (without drop panel)	
7 th storey	31.93	10.59	66.85
8 th storey	36.52	12.37	66.12
9 th storey	40.38	14.04	65.32
10 th storey	31.48	15.47	50.84

Table – 4
Percentage reduction of displacement (mm) of Inverted V bracing with drop panel.

No. of stories	Seismic Loads		% Reduction
	Without bracing	Inverted V Bracing (with drop panel)	
7 th storey	22.83	7.45	67.36
8 th storey	26.19	8.67	66.91
9 th storey	29.04	9.77	66.35
10 th storey	31.48	10.75	65.85

Table – 5
Percentage reduction of displacement (mm) of Inverted V bracing without drop panel.

No. of stories	Seismic Loads		% Reduction
	Without bracing	Inverted V Bracing (without drop panel)	
7 th storey	31.93	10.42	67.36
8 th storey	36.52	12.12	66.81
9 th storey	31.48	13.66	66.17
10 th storey	31.48	15.02	52.28

– The Table 2,3,4,5 shows the percentage reduction of storey displacement in the structure which indicates that for X and Inverted V bracing structure there is lesser reduction when compared with bare frame structure.

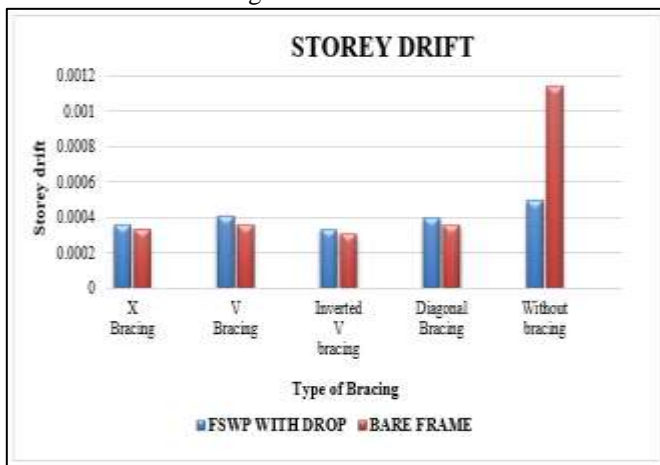


Fig 7: Storey Drift v/s type of bracing (drop panel)

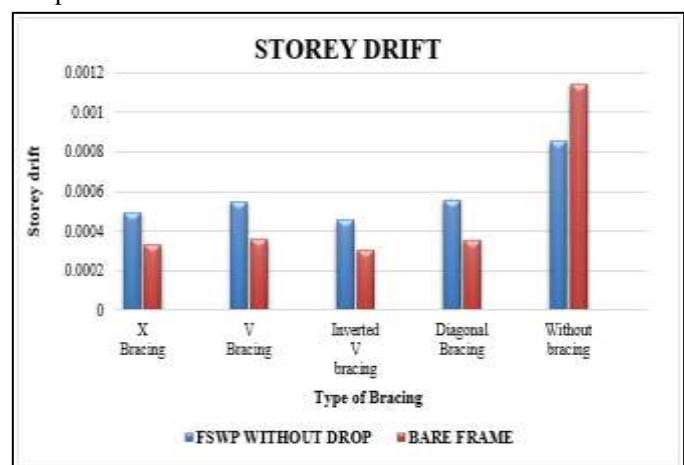


Fig 8: Storey Drift v/s type of bracing (without drop panel)

The Fig 7,8 shows the variation of maximum storey drift v/s type of bracing along X direction and the comparison of Flat slab with perimeter beam (FSWP) with and without drop panel and RC bare frame .As seen above the drift is minimum for inverted V and X bracings. It is observed that without bracing and flat slab without drop panel structure has more drift value.

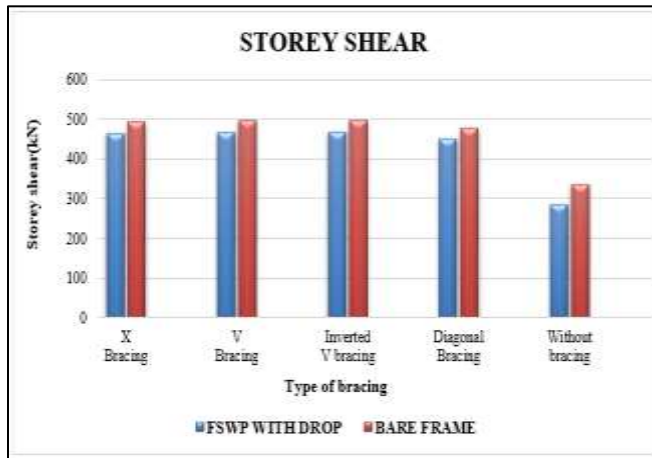


Fig. 9: Base Shear v/s type of bracing (drop panel)

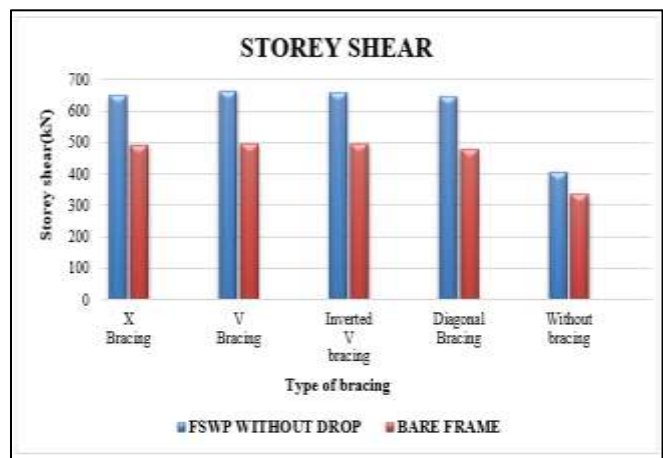


Fig. 10: Base Shear v/s type of bracing (without drop panel)

The Fig 9,10 shows the variation of maximum storey shear v/s type of bracing along X direction and the comparison of Flat slab with perimeter beam (FSWP) with and without drop panel and RC bare frame. As seen above the base shear is maximum for V and inverted V bracing. It is observed that without bracing and flat slab without drop panel structure has less base shear value.

B. Shell Stresses

These are the shell elements considered in this study which is the internal stresses of the possible components of the structure. In that the components are as follows:

- S11: These are the direct stress (force per unit area) acting on the one negative and positive faces in the one axis direction.
- S22: These are the direct stress (force per unit area) acting on positive and two negative faces in the two axis direction.
- S12: These are the shearing stress (force per unit area) acting on the positive and one negative faces in the two axis direction and action on the positive and negative two faces in the one axis direction.

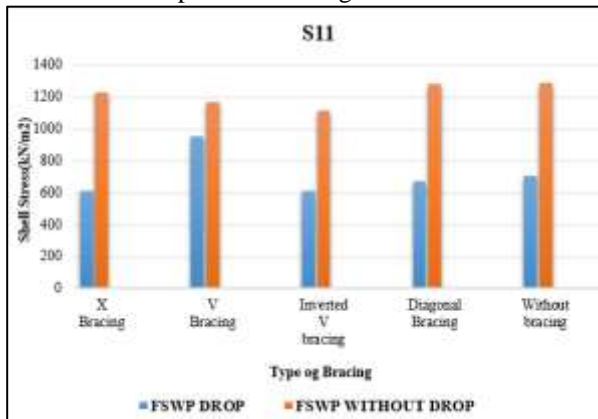


Fig. 11: Shell stresses v/s type of bracing for S11

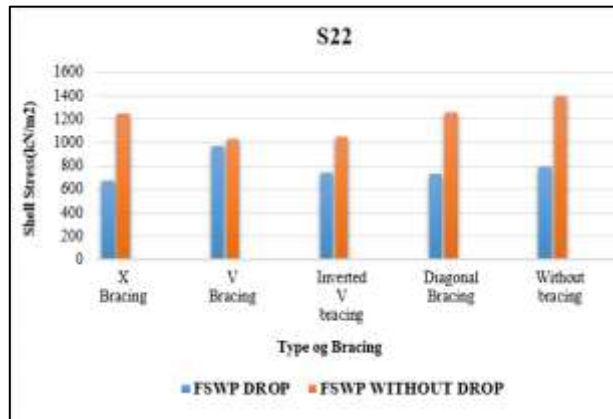


Fig. 12: Shell stresses v/s type of bracing for S22



Fig. 13: Shell stresses v/s type of bracing for S12

From the Fig 11,12,13 shows the variation of maximum slab stresses of S11, S22, S12 v/s type of bracing along X direction and the comparison of Flat slab with perimeter beam (FSWP) with drop panel. As seen above the flat slab structure without drop panel have more slab stress compared to slab with drop panel.

IV. CONCLUSION

It may be concluded that-

- Steel bracing system provides the economical and efficient measures for RC multi-storey structures in high seismic regions. Models indicate that arrangement of bracing made at the corners of the structures has considerable effect on seismic performance.
- Flat slab when assigned along with drop panel gives efficient results on seismic effect on the structure due to the absence of lateral load resisting system bracing.
- In this study, the inverted V and X braced frame shows minimum displacements and storey drift value when compared with V and diagonal braced frame, combined with flat slab along with drop panel.
- The percentage reduction of storey displacement in the structure is tabulated, indicates that for X and Inverted V bracing structure there is lesser reduction when compared with bare frame structure.
- Steel bracing increases the storey shear of the structure. This will be the estimate of maximum expected lateral force that a building can resist.
- Flat slabs with drop panels indicate reduction in slab stresses for S11, S12 and S22 when compared with RC bare frame.
- Hence it is concluded that the use of steel bracing with flat slab in construction resists the lateral forces for many vulnerable conditions.

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