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Seismic Performance of RC Structure with & without Shear Wall Using Flat Slab with Huge Openings Subjected to Diaphragm Discontinuity - A Literature Review

[1]Lucky Raghuvanshi, [2]Dr. J N Vyas

[1]PG Student, [2]Professor
[1,2]Department of Civil Engineering
[1,2]Mahakal Institute of Technology and Management, Ujjain, India

ABSTRACT—

A horizontal structural module called a diaphragm transfers seismic loads to the structure's vertical module. Discontinuities in the diaphragm are used for visual appeal and other purposes, but these openings in the diaphragm root stresses at discontinuities at joints with the building modules. When subjected to seismic loads, buildings with diaphragm discontinuity characteristically uphold damage. However, the structure's receptiveness to damage can be reduced by strategically positioning this diaphragm discontinuity with the introduction of shear wall in the system from which the strength and serviceability can be improved. Additionally, their existence can significantly change how the diaphragm functions. In this study, the effects of variables like the position of the diaphragm discontinuity with the different positions of shear wall are also investigated. The objective of this study is to review, how a diaphragm discontinuity will affect a flat slab multi-story building with and without shear wall at different locations.

Keywords: Diaphragm Discontinuity, Flat Slab System, Shear Wall, Response Spectrum Analysis, Story Displacement, Story Drift, Base Shear, ETABS.

1. Introduction -

The modern trend is towards taller and slender structures and there has been a considerable increase in the construction of tall buildings both residential and commercial. In the building type of structures, the primary purpose of all kinds of structural systems is to transfer gravity loads effectively. Lateral loads like wind loads, earthquake loads and blast forces are attaining importance and every designer is facing with the problems of providing stability and adequate strength against lateral loads. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

Residential, commercial, and contemporary trend buildings have all become significantly taller. The two most appealing and widely used systems today are the shear wall and flat slab systems. Flat slabs are RC slabs with vast spans that are spread over numerous bays and merely supported by columns, without beams. It is fairly easy to design a flat slab system, and it is effective in that it just calls for the bare minimum building height for a specified number of stories. A zone of supports experiences vertical forces, and the structure in question has a significant bending moment. In comparison to reinforced concrete, this results in a very efficient structure that uses less material and has a shorter economic lifespan. The structural behavior of steel is enhanced by post tensioning. The structural behavior of flat slab structures is significantly improved by post tensioning. Many designers find this concept to be more acceptable. In some office buildings, it is used. The flat slabs are plates that have drop panels or column capitals to reinforce them close to the column supports (which are generally concealed under drop ceilings). Because of its improved ability to withstand shear and hogging moments close to the supports, it is appropriate for higher loads and longer spans. For spans of 4 to 9 meters, the slab thickness ranges from 125 mm to 300 mm. The flat slab system has the largest dead load per unit area when compared to the other floor types.

Without the aid of beams, solid concrete slabs of uniform depths called flat plates are transfer loads directly to the supporting columns. Today, the most commonly used slab systems used for multi-storied buildings are Flat Slabs. Their lack of resistance to lateral loads is the main disadvantage of Flat slab. Hence, in high rise constructions special features like shear walls to be provided. Shear wall can be defined as structural elements, which provide strength, stability and stiffness lateral loads deriving strength. To reduce ill-effects of twist of buildings, shear walls must be located symmetrically in plan.

2. Concept of Flat Slab & Lateral Load Resisting System –

In common practice of design and construction is the slabs supported by the beams and beams supported by the columns. This type of construction is called beam-slab construction in which due to the beam depth, the available net clear ceiling height reduces. Mostly beams are avoided in warehouses, offices and public halls, slabs are directly supported by columns. This type of design & construction is aesthetically better. These slabs which don’t have

beams & are directly supported by columns are called Flat slabs. To overcome the negative bending moments near the column of flat slab column capital and drop panels are used to support. This type of system has been adopted in many buildings which are constructed recently because of the advantage of reduced floor heights, cost effective and aesthetically better. Floor slab supported on beams or walls are called as conventional slab. In this type, slab thickness is less for supporting this slab, depth of beam will be large & loads are transferred by the slab to beams then to columns or shear walls.

While a conventional slab is supported by beams on two parallel or opposite side & bending in the direction perpendicular to supports are called as one way slab. Slabs supported on four sides carrying loads and bending in two perpendicular directions such slabs are known as two-way slab.

The design of reinforced concrete (RC) multi-storeyed structure for seismic cases, determination of lateral load-resisting system is an important matter. The choosing of lateral load resisting system for special building is clearly a design decision of fundamental importance, yet there is no system that is best for all buildings. Some of the factors to be consider while selecting a seismic force resisting system include architectural, construction cost, performance, design budget & non-structural coordination. Configuration of the lateral load resisting system within the building should satisfy the following condition of good design, concerning such problems torsion, structural irregularities, redundancy & the combination of systems. The most regularly used structural system are as follows moment resisting frames, shear wall system, braced system, tube in tube systems with interior columns & bundled tubes.

SHEAR WALLS are the walls provided in a structure that withstand horizontal forces such as those caused by wind or earthquakes. SHEAR WALLS are structural walls that are provided parallel to the direction of horizontal force and are exposed to bending moments and shear (in-plane) forces.

Types of shear wall -

Core type shear wall

C shaped shear wall

L shaped shear wall at corners

Parallel shear wall along the outskirts

Non-Parallel shear wall along the outskirts

+ Shaped shear wall at center

E Shaped shear wall

Shear Wall Position -

At corners of building

At centre (core) of structure

At periphery of building

3. Literature Review –

A brief review of previous studies on the comparative analysis of the Conventional and Flat slabs structure. This literature review also includes previous studies on comparative analysis of flat slab structure with and without shear wall. This literature review is on recent contribution related to Comparative Analysis of Flat slabs & Conventional RC slabs with and without shear wall and past efforts most closely related to aspects of present work.

Vikunj k. Tilva, Prof. B.A. Vyas (2011)] **"Comparative study of seismic behaviour of Flat slab and Conventional RC framed structure" International Journal of Engineering Research and Technology (IJERT) Vol.6, Issue 4, April- 2011** in their paper presented that to aim a comparison between flat slab panel with drop and without drop in four storey lateral load resisting model. A four storey structure is subjected to gravity load + lateral load using ETABS software and each storey was exported to SAFE software for analyzing punching effect due to lateral loads. On the beginning of permissible punching shear criterion on accordance with IS 456, economical thickness of flat slab with drop and without drop are preferred the results showed that since economic point of view slab with drop provision is preferable. Also punching shear stress is abridged by adopting drop at slab-column connection.

Dr. Uttamasha Gupta, Shruti Ratnaparkhe, Padma Gome (2012) Analysis and design of flat slab with and without shear wall of multi-storied building frames" International organization of scientific Research Journal of Engineering (IOSRJEN) Vol.6, Issue 9, Sep- 2012 - in their paper presented work to compare the behaviour of multi-storey buildings having flat slabs with drops with that of having two way slabs with beams and to analyze the cause of part shear walls on the performance of these two types of models under seismic forces. Present work provides a good source of information on the parameters lateral displacement, seismic base shear, storey shear and storey drift. Despite the cases taken drift values follow a parabolic path along storey height with maximum value lying somewhere near the middle storey. Use of flat slabs with shear wall will increase in drift values in similar plans as compared to conventional slabs with shear wall. Still all drift values are within permissible limits even without shear walls .In zone V use of flat slabs with shear wall in comparison to conventional slab arrangements alters the maximum lateral displacement values, however, these all are

well within permissible limits, even without shear walls. Similarly, storey shear for flat slabs with shear wall as compared to conventional slab system with shear wall has is increased to a great extent.

Sharad P. Desai, Swapnil B. Cholekar (2013) "Use of Flat slabs in multi story commercial building situated in high seismic zone" International Journal of Research in Engineering and Technology (IJRET) Vol.3, Issue 8, Aug-2013 - in their paper presented that the Dynamic response of Flat slab with drop and without drop and Conventional RC Framed Structures, for different height with and without masonry infill wall. Dynamic analysis for diverse types of building is done by using Response Spectrum method for earthquake zone III as per I S code. The consequence of Flat slab with drop and Flat slab without drop taking into consideration with and without masonry infill wall is evaluated. It was found a major alteration in the seismic parameters such as Fundamental Natural Period, Design Base Shear, Displacement and Axial Force of the structure.

Rajiv M S, Guru Prasad T N, (2015) "Comparative study of Flat slabs and Conventional RC slabs in high seismic zone" International Research Journal of Engineering and Technology (IRJET) Vol.2, Issue 6, Sep2015 - in their paper analyzed about work to compare the behaviour of multi-storey buildings having flat slabs with drops to that of having two way slabs (conventional slab). The consequence of part shear walls on the performance of different types of buildings [(G+7) and (G+14)] under seismic forces are considered. Equivalent static force method, Response spectrum method and Time history analysis were considered for diverse types of models and relative results were drawn. The natural mode (time) period increases as the height of building increases, irrespective of type of building conventional slab (bare), flat slab (bare) and flat slab with shear wall. On the other hand, the time period is more for conventional slab and flat slab with bare frame compared with that of flat slab with shear wall for dissimilar models due to stiffness participation factor being less in bare frame for both storeys. This presents a summary of the project work, for conventional R.C.C building, flat slab building and flat slab building with shear wall at diverse locations for different types of building [(G+7) and (G+14)] in the seismic region.

Rajini .A .T, Dr. Manjunath N Hegde (2016) "Comparative study of on conventional beam slab and flat slab under various seismic zones and soil conditions" International Research Journal of Engineering and Technology (IRJET) Vol.3, Issue 7, July- 2016 - in their paper analyzed about comparative study of the behaviour of flat slab and conventional slab structures of 20 stories in diverse cases. Conventional RC slab and flat slab structure, flat slab structure with column drop, conventional structure and flat slab structure with shear wall at diverse locations were analyzed by taking into consideration two typical zones of zone III and zone V, through dynamic response spectrum analysis by using ETABS software. Comparing the results of all models in condition of time period and frequency, lateral displacements, story shear and story drifts by plotting graphs.. Flat slab structure with arrangement of column drop and shear wall is performed extremely fine under seismic loads to decrease the displacements and drifts with enhancement in stiffness of building.

Mitan Kathrotiya, Dr. Kaushal Parikh (2017) "Comparison between the Seismic variation of Conventional RC slab and Flat slab with a drop for G+15 storey building in different zones using Etabs software" International Journal of Advance Research , Ideas and Innovations in Technology (IJARIIT) Vol.4, Issue 3, 2017 - in paper summarizes the revised study of the performance of multi-storey building having conventional RC frame structure, flat Slabs and to study the consequence of the models under the seismic forces. The model was subjected to various loading condition in special Seismic Zone and for diverse Soil condition. The seismic performance of the flat Slab and the conventional RC building was analyzed using different software aid. Due to the seismic behaviour, the performance of the building was analyzed. This study includes a variety of info on the seismic parameters say storey drift, seismic base shear, and natural time period, Depending on the study they concluded that Lateral Displacement at middle storey level is more. The displacement of the flat slab structure decreases by stipulation of shear wall. Due to the increase in the number of floor the lateral Displacement increases. The natural time period increases as the numbers of floors increases. Depending on assessment from different case studies, the subsequent conclusions are being carried out, as time period is more for conventional building than flat slab structure due to huge construction.

Karthik Prashar & Jagdeep Singh Gahir [2018] "Review paper on Seismic Behavior of RC frame structure with different types of bracing system", International journal of engineering and techniques, Vol-4, Issue-2, March-April 2018 - studied with help of literature review papers on the seismic behavior of RC frame structure with different types of bracing system. After studying all the literature review, they conclude that steel bracing system is an efficient effective lateral load resisting system. Out of various arrangement of bracing X bracing system are more effective in increasing lateral load capacity of structure. Bracing system reduces the shear force and bending moment of the column.

Shahid Ul Islam & Shakeel A. Waseem [2020] "**Comparative study on seismic behaviour of different types of reinforced cement concrete- bracing system in high rise reinforced concrete structure", International symposium on fusion of science and technology, ISFT/2020/R/1194, Jan-2020 -** analyzed the behaviour of different types of RCC- bracing system in High (G+10) and also the comparative study of performance of RCC diagonal, chevron and cross- Bracing system in high rise commercial structure under seismic loading in addition to gravity loads was performed. The RCC X-bracing give the better results in higher stiffness and stability over other types of bracing.

Varun N & Bhavani Shankar [2021] "Pushover analysis of multi-storied building with flat slab with shear wall & core wall", International research journal of Engineering & technology (IRJET), Vol-8, Issue-08, Aug-2021 - analyzed the multistoried building with flat slab along with shear wall & core shear wall. This study is made to determine the behavior of flat slab building with shear wall and core shear wall. For this study total six model of G+9 storey has been considered in seismic zone-II and pushover analysis has been was performed with the help of SAP2000 software. From this analysis it is concluded that base shear is maximum in core shear wall model, displacement is minimum in core shear wall model when compared to shear wall model & bare frame model. Time period for bare framed building is more compared to shear wall and core shear wall.

Arbaz Ali khan & Vaijanath Halhalli[2021] "Design of RCC flat slab structure with drop and shear wall under earthquake loading using Etabs software", International research journal of Engineering & technology (IRJET), Vol-08, Issue-07, July 2021 - analyze and design the RCC flat slab structure with drop and shear wall under earthquake loading using Etabs software. The objective of this study is to investigate the behaviour of the flat

slab structure under lateral loads. G+14 storied building has been selected with four different model such as 1) Flat slab without drop 2) flat slab with drop 3) flat slab with shear wall 4) flat slab with drop & shear wall. Equivalent static method and response spectrum method is used for the structure. After studying all the model post-analysis result, they concluded that lateral displacement & storey drift of flat slab without drop & shear wall is maximum. Result obtained from response spectrum analysis is less as compared to equivalent static method.

Ms Naik Ashwini Shankarrao & Dr. P.B. Ullagaddi [2021] "Comparative assessment of flat slab with shear wall and bracing system for different building height", International research journal of Engineering & technology (IRJET), Volume-08, Issue-07, July-2021 studied the comparative assessment of flat slab with shear wall and bracing system for different building heights. For this project work 12 models of (G+8), (G+10) & (G+12) stories with shear wall and bracing system were used. From the assessment it was found that flat slab with shear wall is the best choice as compared to bracing system. Displaced & drift values of flat slab with shear wall is less as compared to bracing system. Storey stiffness and storey shear of flat slab with shear wall was better than flat slab with bracing system.

Shailendra singh & Dr. Niraj Soni [2021] " Comparative analysis of Different lateral load ressiting system in flat slab multistorey building", Science technology and development, Volume-10, Issue-12, December 2021 - had done the comparative analysis of different lateral load resisting system in flat slab multi-storey building. In this study they consider lateral load resisting such as outrigger braced system diagrid system & shear wall system. For this study, the conventional structural model having the central core of reinforced concrete and the model with outrigger at top, top & 0.75H, top & 0.5H and top where H is the height of the building are modelled for the G +20 storey building height. The main objective of the study is to determine the optimum location of the outrigger bracing system for high rise building. The result obtained from the post analysis that the top displacement and drift is minimum at the optimum location of the outrigger bracing system for high rise building is at top & mid height of the building. The outrigger system is stiffer than the conventional, diagrid and shear wall system.

4. Conclusion –

From the above studies carried out by researcher, following are the conclusion or summary of the literature review.

1) Spans 6-7 meter not much significant economy was achieved but above 7-meter span post-tensioned flat slab with drop panel leave conventional flat slab far below in economy.
2) Steel bracing system is an efficient effective lateral load resisting system. Steel bracing can also be used to retrofit the existing structure for maintaining stability.
3) From the various arrangements of bracing, the performance of the cross bracing or X- bracing are more effective in increasing lateral load capacity of structure.
4) On comparison of different parameters like lateral displacement, storey drift and base shear, Flat plate system with shear wall is at higher preference and better performance against lateral load when compared to bracing & bare frame.
5) Shear wall location at building core has good response compared to other location of shear wall.
6) Base shear is inversely proportional to the storey displacement, model with least storey displacement has the maximum base shear.
7) Flat slab building shows large storey displacement and storey drift values when compared to conventional slab building.
8) Flat Slab building or Conventional slab building with shear wall at peripherical corner is suitable as compared to peripherical center for the effect of wind load and earthquake load.
9) Result obtained from response spectrum analysis is less as compared to equivalent static method.
10) After reviewing all the parameters, flat slab building with shear wall is the best to safeguard against lateral loads.

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