

A Review paper on seismic response of various slab systems with and without lateral load resisting systems

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Abstract

With the ongoing modern trends of the construction industry, slab systems like flat slab and post tensioned slabs are widely used in the construction. Flat and post tensioned slab are widely favored by architects and clients for aesthetic reasons. They also do possess a huge advantage structurally over conventional slab arrangement such as Less depth of the slab is required, increasing the floor-to-floor height, longer spans are possible, no beam projections, reduced self-weight of the building and many more. But it comes with its own disadvantages as well such as Brittle punching (shear) failure. Which requires additional reinforcement along the connections of column and slab. Which increases the longitudinal steel required. Slab – column connections are the first point of yielding in higher seismic zones with buildings without lateral load resisting system (LLRS). In higher seismic zones the slabs can resist only the gravity loads and can't resist the lateral dynamic loading and hence may require additional lateral load resisting system (LLRS) to resist lateral loads such as seismic and wind loads. Thus it becomes essential to study the seismic behavior of conventional slab, flat slab and post tensioned slab systems in high rise RCC structure with and without various LLRS (lateral load resisting system). This study is aimed to study various literatures related to effects of lateral loads on flat and post tensioned slab system and different LLRS (lateral load resisting system) to make the structure more resistant and economical against such lateral loads considering parameters like story displacement, base shear, stiffness of the connections and time period.

Keywords: conventional slab, flat slab, post tensioned slabs, RCC high rise structure, LLRS (lateral load resisting system)

1. Introduction

In RCC structures, flat and post-tensioned slab systems provides various advantages over conventional slab system. They are architecturally more flexible and aesthetically more pleasing. But when conventional slab system is replaced by a flat and post tensioned system, the loads are most of the time directly transmitted on the columns through slab-column connections. This affects the lateral resistance of the building. Two major lateral loads acting on high rise RCC structure are seismic and Wind. There are 2 general methods to analyze these loads which are static and dynamic analysis. In order

to resist this loads, LLRS (lateral load resisting system) is introduced in the structure in various forms such as RCC bracing system, steel bracing system, shear walls, etc.

1.1 Slab System

The three most commonly used slab system are conventional, flat and post tensioned slab system. In conventional the loads are transferred from slabs to beam and then to the vertical element column or shear walls. In flat and post tensioned slab most of the time, the loads from the slab are directly transferred on to the columns or shear walls

through slab-column connection. Thus making this connection vulnerable to punching shear. This makes the connection less stiff laterally and hence requires additional lateral load resisting system.

1.2 LLRS (Lateral Load Resisting System.)

To resist various lateral forces acting on a high rise RCC structure it is very important to strengthen the structure with lateral load resisting system. It is very an important decision to select the right type of LLRS for the structure. Every high rise structure is unique and hence the effectiveness of LLRS keeps on varying. There are many factors to consider while choosing a LLRS like architectural preference, construction cost, ease of execution, structural performance, etc. [12]

2. Literature Review

Omar Ahmad et al (2023) analyzed various slabs for different effective span lengths of 4m, 6m and 8m and above. Various types of slabs like post tensioned, conventional, flat slab and HB (hollow block) were analyzed and compared based on parameter like economical and quantity of concrete, steel, blocks, formwork and tendons required. SAFE software was used for the analysis of this slabs and to find out the various material quantity required. ACI code was used for the analysis of these slabs. The assumptions made in the analysis was live load (LL) and super imposed dead load (SIDL) both were taken as 3.5 kn/m². The load combination considered were $U1 = DL + LL$ and $U2 = 1.2DL + 1.6LL$. As per the ACI code the deflection of the span was restricted to $Span/240$. The quantity of concrete, steel, blocks, formwork and tendons were calculated and compared. Also, the economical aspect of this slabs were compared for different span length – 4m, 6m, and 8m and above. It was found that for the concrete quantity, HB slab required the least concrete for a span of 4m and 6m. For span of 8m and above post tensioned slab required the least concrete. In terms of steel, post tensioned slab required the least steel for span lengths of 4m, 6m and 8m and above. From economical aspect, the most economical slab was flat slab for 4m span, post tensioned slab for 6m and 8m and above [1]. Shahid Ul Islam and Shakeel A. Waseem (2020) compared different types of RCC

bracings for high rise reinforced concrete structure. The aim of the study was to compare the different types of RCC bracing based on parameters like base shear and story displacement. In this study a high rise G+10 storey RCC structure was modelled using STADD PRO V8i software. Different types of RCC bracing system used in the analysis were RCC diagonal, chevron and cross bracings. 4 different structural configuration were used for modelling which were moment resisting frame for model 1, MRF stiffened with concentric RCC X-bracing system for model 2, MRF stiffened with RCC diagonal bracing system for model 3, MRF stiffened with RCC chevron bracing system for model 4. From this study it was found out that for a RCC high rise building the most important design parameters are lateral strength and stiffness. To enhance this parameters various types of bracing system are to be implemented. [11] MRF structure had high storey displacement then MRF with RCC X-bracing arrangement. The model 2 – MRF with RCC X-braces was the safest and showed the least story displacement. The primary strength of the structure was also increased due to RCC bracing system [2]. Shital Borkar et al (2021) analyzed different types of slab structures such as conventional slab structure, flat slabs structure, and flat slabs structure with drop panel for different seismic zones In India. The analysis was carried out on etabs software. A G+5 storey RCC structure with regular plan configuration was modelled on etabs and static equivalent method was used for seismic analysis. Comparison between conventional and flat slab structures was made on various parameters like base shear, story drift and torsional moment imposed on the slab on top and bottom. From the analysis it was found out that the story drift was maximum in the flat slab structure as compared to conventional structure for regular plan configuration in all seismic zones of India. Story shear was found to be more in flat slab structure as compared to flat slab with the drop panel. In higher seismic zones it is essential to use flat slab structure with drop panels [3]. Syed Ishaq et al (2022) analyzed a G+7 storey RCC structure

with and without shear walls. An L-shaped plan was selected and all the general loadings were assigned to the structure. The analysis was done for seismic zone 2 with type of soil as medium. The ground floor was assigned as a soft storey for analysis purpose. It is observed that the model 2 with shear walls and GF as a soft storey performed better than model 1 without shear walls and GF as soft storey. The story drift, displacement as well as bending moment and shear acting on columns and beams were considerably less in model with shear wall in zone 2. By the inclusion of shear walls in an irregular plan configuration, the effects of irregularities such as soft storey drift, bending moment, shear forces were countered and reduced. The location of [9] the shear walls also played an important role in the effectiveness of the shear wall and economical aspect of the overall construction [4]. Arjun Poudel et al (2020) modelled 3 different RCC moment resisting frames of 7, 12, and 18 storeys. The software used for the analysis was finite element software SAP2000. Static and dynamic loadings was assigned as per all relevant IS codes. 5 types of steel bracing system were used to resist the seismic forces and check the efficiency of the frames. K, V, inverted V, X and diagonal steel braces were analysed using response spectrum analysis method which is dynamic seismic analysis. Inverted V and X bracing system showed better seismic performance as compared to other steel braces. V, K and diagonal bracing showed similar seismic resistance. The time period of the RCC frame structure was the most reduced by X bracing system and other steel braces showed similar performance. Among the steel braces, K and diagonal bracing system failed to achieve the target story drift ratio required for high rise RCC structures [5]. Apurb Kumar Jain et al (2021) compared the the two wind analysis methods which are static and dynamic wind analysis methods. Peak wind approach (static analysis) and Gust factor analysis (dynamic analysis) were used by keeping on increasing the height of the RCC framed structure. [10] As the height increased the intensity of the lateral force increased as well in both static and dynamic approach. When the aspect ratio is changed, there is a sudden increased in the

moment in dynamic approach. The gust factor is maximum in square plan configuration and decreases after increase in height of the building very slightly. It is very important to perform both static and dynamic wind analysis in high rise RCC structure above 18 storeys [6]. Jnanesh Reddy R et.al (2017) compared the post tensioned flat slabs and RCC slabs using softwares like RAPT and ETABS to find out the system will be more cost effective. The analysis was carried out by using load balancing method and equivalent frame method. After conducting estimates for both slabs from the design from the software it was found out that the post tensioned flat slab system was most cost effective. Although it requires slightly more steel as compared to RCC flat slab system. [7]. Abhinav V et.al (2016) conducted an analysis of G+11 RCC structure with shear walls at different location of the structure. The analysis was done on the stadd pro software. It was found out that the building performed better against the seismic force when the shear wall was placed along the periphery of the building [8].

Conclusion

Flat and post tensioned slab both provides significant economic advantage over conventional slab. For shorter spans of 4-6 m flat slab are preferred whereas for spans above 6 m post tensioned slabs are preferred. The slab column connections are vulnerable to punching shear are reduced lateral stiffness and hence additional LLRS (lateral load resisting system) may be required to counter seismic and wind loads. Also, flat slab with drop panel performs better in comparison to flat slabs without drop panels. To counter act the seismic and wind loads various LLRS can be used. The 2 most common types are RCC and steel. The steel brace system has a considerable advantage over RCC bracing. Whereas the geometric consideration of the steel and RCC braces depends significantly on the plan configuration of the RCC structure, slenderness ratio, and positioning of the shear walls and bracing system. For high rise structures or structures of great importance it is very necessary

to perform dynamic analysis like gust factor analysis and response spectrum analysis for the lateral loads acting on the structures.

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