IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

ANALYSIS OF FLAT SLAB STRUCTURE WITH OR WITHOUT LATERAL FORCE RESISTING SYSTEM.

Rishabh Mishra[1], Rajiv Banarjee[2],

[1]Post Graduate Student, Department of Civil Engineering, Integral University, Lucknow

[2]Assistant Professor, Department of Civil Engineering, Integral University, Lucknow.

Abstract: The flat slab system has become increasingly prevalent in modern building construction due to its ability to satisfy economic and architectural demands by reducing floor heights. Compared to conventional moment resisting frames, reinforced concrete buildings utilizing flat slabs exhibit numerous advantages. Despite the fact that flat slab construction offers several advantages over conventional moment resisting frames, its ability to withstand seismic loading is limited, thus reducing its overall structural effectiveness. Despite numerous studies conducted by various authors in recent years, the behaviour of flat slab structures under lateral-displacements remains poorly understood. Nevertheless, flat slabs continue to be popular even in areas prone to earthquakes.

This present study involves the analysis and comparison of a 12-story flat slab reinforced concrete structure with vertical and mass irregularities subjected to lateral loads according to IS codes. The primary objective of this work is to analyze and compare irregular flat slab reinforced concrete structures with and without lateral force resisting systems, such as shear walls and bracing systems. Etabs software is utilized to conduct the structural analysis. For structures with vertical irregularities, dynamic analysis is carried out in accordance with IS 1893:2002 (part 1), and various parameters, including base shear, time period, storey drift, storey displacement, and storey stiffness, are compared for these structures.

***Index Terms* - Flat Slab, Seismic loading, Irregular building, Shear Wall, Bracing, Etabs.**

I. INTRODUCTION

In many countries, flat slab RC structures are widely adopted in residential and commercial construction due to their cost-effectiveness and construction efficiency. These structures offer a range of benefits, including lower storey height, improved lighting and ventilation, easier arrangement of pipes and wires beneath the slabs, increased open spaces, architectural flexibility, and simplified formwork, all of which help to shorten the construction period. While flat slabs were primarily developed to resist gravity loads, extensive research has been conducted on their resistance capacity for lateral loads. The floor slabs exhibit larger flexural deformation around columns when subjected to lateral loads, leading to the division of the floor slab into column and middle strips during analysis and design of flat slab structures.

Despite the extensive research conducted in recent years by numerous authors, the behavior of flat slab structures under lateral displacements remains poorly understood. Under seismic loading, the behavior of flat slab structures becomes even more complex. One issue observed is the potential for large transverse displacements due to the absence of deep beams, resulting in low transverse stiffness. This can cause excessive deformations that damage non-structural members, even when subjected to low or moderate intensity earthquakes.

This paper examines the behavior of high-rise buildings with flat slab reinforced concrete (RC) structures by analyzing four types of models simulated in ETABS. The models are subjected to linear static analysis and response spectrum analysis, and a comprehensive comparison is made among all the models. The study discusses the results obtained and various parameters associated with them.

Based on the findings, it is recommended that in areas with high seismic hazard, flat slab construction should be employed solely as the vertical load-carrying system in structures that are supported by frames or shear walls responsible for the lateral capacity of the structure.

II. OBJECTIVE OF THIS REVIEW

In this paper, flat slab reinforced concrete highrise models are analysed for earthquake resistance and lateral force resisting systems in form of bracing and shear wall .The main objectives of this paper are as follows:

- To analyse the irregular highrise flat slab buildings supported by Bracing system under seismic load with the help of Etabs by performing both linear static and response spectrum analysis.
- To compare the structural parameters such as Time period and Eccentricity of different models using Response spectrum method.
- To compare the Engineering demand parameters such as Max Displacement, Max story drift, Story shear, base shear distribution for different models.

III. LITERATURE REVIEW

- ***Latha M.S and Pratibha K*** : A study was conducted to analyze the behavior of multi-storied structures with conventional slabs and grid slabs. Since the buildings in question are irregular structures, the behavior of the structure varies. In regular structures, the maximum deflection of the slab is observed in the conventional slab system. On the other hand, irregular structures with grid slabs exhibit the highest deflection. Specifically, in symmetric structures, the deflection of the conventional slab is approximately 9.3% higher than that of the grid slab. In symmetrically planned irregular structures, the deflection of the conventional slab is about 6.1% higher compared to the grid slab. It is noteworthy that the story stiffness is highest in the conventional slab system and lowest in the grid slab system, regardless of whether the structure is regular or irregular.

- ***Robert Koppitz, Anbil Kenel, and Thomas Keller :*** The need to address the conversion of existing buildings, establish standards, and overcome deficiencies in the detailing of strengthening methods for existing concrete Flat Slabs against punching shear is becoming increasingly apparent. In order to address this, over 40 models for new slabs were classified and evaluated to determine their suitability for strengthening existing structures. It is important to note that existing slabs may already have some damage, which can be indicated by additional slab rotation. To ensure a cautious approach until sufficient knowledge is acquired, the contribution of inadequately anchored rebars must be reduced by considering the effective anchorage length when calculating the bending strength of the slab, as opposed to the full anchorage length. Furthermore, it is crucial to conduct further research to accurately model the effects of non-uniform local stress fields.

- ***Stanislav Aidrov, Francisco Mena, and Albert de la Fuente :*** This paper presents an analysis of the structural response of a full-scale column-supported SFRC (Steel Fiber Reinforced Concrete) flat slab. The study focuses on evaluating the structural integrity, cracking behavior, and deflections of the slab. Unlike previous experiences that mainly used point loading, this study applies five different phases of uniformly distributed loads (UDL).By increasing the load from the characteristic load combination (q_k = 9.8 kN/m²) to 16.0 kN/m² (14% higher than the design load combination, q_{sd} = 14.0 kN/m²), deflections increased by 31mm (L/250) without any signs of failure. This demonstrates the moment distribution capacity and ductility of the system. The performance in terms of cracking and deflections remained acceptable even when the structural system was subjected to loads (q = 8.7 kN/m²) that were 13% higher than the quasi-permanent load combination (q_k = 7.7 kN/m²) typically used for residential buildings. Results obtained from an inductive test on drilled cores confirmed that 76.8% of the cores were favorably oriented along the in-plane axis of the slab. These findings contribute to understanding and validating the performance of the SFRC flat slab system.

- ***M. Altug Erberik and Amr S. Elnashai :*** The objective of the mentioned study conducted by M. Altug Erberik and Amr S. Elnashai, is to develop fragility curves specifically tailored for flat slab structural systems. The study acknowledges the lack of previous fragility analysis for this particular construction type. To achieve this objective, a mid-rise flat slab building is designed and modeled, incorporating the typical characteristics of flat slab construction.

  Through preliminary evaluations, the researchers observe that the modeled structure demonstrates increased flexibility compared to conventional frames, primarily due to the absence of deep beams or shear walls commonly found in other construction types. The intention behind developing fragility curves is to employ them in seismic loss assessment, particularly in regions where flat slab structures are prevalent.

These curves aim to capture the distinctive response characteristics of flat slab buildings.The study emphasizes that using vulnerability curves developed for moment resisting frames to assess seismic damage in flat slab buildings is not a conservative approach. Therefore, the researchers aim to fill this gap by creating fragility curves specifically tailored to flat slab structures. This research aims to provide valuable insights and tools for assessing the seismic vulnerability and potential damage of flat slab buildings.

- ***M. G. Sahab, A. F. Ashour, V. V. Toropov*** : This paper presents a cost optimization approach for reinforced concrete flat slab buildings using a multi-level optimization procedure. The procedure encompasses determining the optimal layout, cross-sectional dimensions, and reinforcement of various reinforced concrete elements, including columns. To illustrate the design optimization process, three rainforest concrete flat slab buildings with different structural characteristics and numbers of stories were analyzed. The study reveals the following conclusions:

  1. Increasing the number of stories in rainforest concrete flat slab buildings results in greater cost savings through design optimization. This is because the higher the number of structural elements, the greater the potential for achieving cost reductions.

  2. Optimizing the column layout in flat slab buildings can lead to significant savings in the total structural cost of the building.

  3. The cost of floors represents a substantial portion of the total structural cost of Stanford concrete flat slab buildings.

  By implementing the proposed design optimization approach, significant cost savings can be achieved in the construction of reinforced concrete flat slab buildings.

- ***David Z. Yankelevsky, Yuri S Karinski, Alex Brodsky, Vladimir R Feldgun*** : This paper addresses the failure of slab-column connections in which a slab falls downwards and impacts a slab located one floor level below, resulting in dynamic punching shear of the lower slab. It identifies this scenario as critical, as the impacted flat slab is unable to withstand the impact and fails rapidly.

  The study focuses on investigating potential enhancements for flat slabs by incorporating added drop panels. These drop panels are casted with the slab, forming a thicker concrete zone around the column. This configuration improves the shear resistance of the impacted slab, particularly in the near column zone where the highest shear stresses are developed. Additionally, the drop panel restricts the contact zone between the impacting slabs. The localized impact and the thickened slab contribute positively to enhancing dynamic punching shear resistance.

  When two slabs impact each other and drop panels are present, both slabs experience severe damage without immediate failure if the drop panel sizes are shorter than approximately 35% to 45% of the slabs' span. The sensitivity of the connection damage, in terms of displacement magnitude, is somewhat more moderate for smaller drop panel sizes compared to moderate size increases beyond the optimal point, which result in significantly larger damage. If the drop panel size exceeds half of the span size, the impacted slab connection experiences complete failure, followed by downward motion of the impacted slab.The findings highlight the potential benefits of incorporating drop panels to improve the performance of slab-column connections in situations involving dynamic punching shear.

- ***Sahand Rafee, Abdollah Hosseini, Mohammad Sadgeh Marefat*** : This study proposes specific details for the connections of post-tensioned flat slabs to steel columns. These details involve the use of top and bottom steel plates welded to the steel column, reinforced by vertical stiffeners, and connected to the slab using high-strength bolts. To evaluate the performance of these proposed connection details, a half-scale specimen is subjected to reversed-cyclic loading with increasing amplitudes. The test results reveal the following observations:

  - The connection remains within the elastic range until a drift of 1% is reached. It exhibits a stable nonlinear response up to a drift of 3.5%. Moreover, it demonstrates the ability to tolerate relatively large lateral displacements up to a drift of 6% without losing its gravity bearing capacity. The response of the connection is idealized using a bilinear curve (elastic-perfectly plastic), with the nominal yield drift ratio estimated to be approximately 2%.
  - The test results highlight the influence of several factors on the seismic behavior of the proposed connection. These factors include the prestressing level, the magnitude of the gravity shear force, and the dimensions of the horizontal steel plates.

  Overall, the study concludes that the proposed connection details exhibit favorable performance characteristics, demonstrating their suitability for post-tensioned flat slabs connected to steel columns. The findings emphasize the importance of considering prestressing level, gravity shear force magnitude, and plate dimensions in designing the connection for desired seismic behavior.

- ***Dr. K Naresh :*** The displacement of industrial and commercial structures constructed using a flat slab system is generally greater than those constructed using a conventional slab system.
  The summary highlights the following key points:

  1. Displacement: Industrial and commercial structures constructed using flat slab systems generally exhibit greater displacement compared to those constructed using conventional slab systems. However, the combination of a flat slab with a shear wall can improve the resistance to displacement.
  2. Height and Displacement: As the height of the structure increases, the displacement tends to increase as well.
  3. Story Shear: Flat slab buildings have lower shear forces in the Y-direction compared to conventional slab buildings.
  4. Maximum Story Shear: The maximum story shear occurs at the base level and decreases as the height of the structure increases.
  5. Base Shear: Flat slab buildings have lower base shear in both the X and Y directions compared to conventional slab buildings.
  6. Story Drift: Conventional slab buildings experience higher story drift, which refers to the lateral displacement between consecutive floors, compared to flat slab buildings. Flat slab buildings with shear walls exhibit significantly lower story drift.
  7. Story Stiffness: Conventional slab buildings generally have higher story stiffness compared to flat slab buildings. As the number of stories increases, the stiffness of conventional slabs also increases.

  These observations highlight the differences in displacement, shear forces, and stiffness between flat slab and conventional slab buildings. It emphasizes the potential advantages of using flat slab systems with shear walls in terms of reducing displacement and improving structural performance.

IV. CONCLUSION

- In conclusion, the lateral force resisting system in flat slab structures plays a crucial role in ensuring the stability and structural integrity of buildings.
- When combined with appropriate lateral force resisting elements such as shear walls, flat slab systems demonstrate enhanced resistance to displacement compared to conventional slab systems. The presence of shear walls in flat slab structures improves their ability to withstand lateral forces and reduces overall displacement.
- In flat slab buildings, the story shear is generally lower than that in conventional slab buildings, particularly in the Y-direction. This indicates that flat slab structures are more effective in distributing and resisting lateral forces.
- The base shear, representing the total lateral force at the base level of the building, is lower in flat slab structures than in conventional slab structures, both in the X and Y directions. This suggests that flat slab buildings have a greater capacity to resist lateral forces at the foundation level.
- Furthermore, flat slab structures with shear walls exhibit significantly lower story drift compared to conventional slab structures. This indicates that they experience reduced lateral displacement between consecutive floors, enhancing overall stability and minimizing potential damage.
- Overall, the lateral force resisting system in flat slab structures, especially when combined with shear walls, offers improved displacement resistance, lower story shear, lower base shear, reduced story drift, and adequate stiffness. These factors contribute to the overall structural robustness and safety of flat slab buildings against lateral forces.

V. ACKNOWLEDGEMENT

I would like to express my gratitude to Mr. Rajiv Banarjee, Associate Professor of the Civil Engineering Department at Integral University, Lucknow. He served as my dissertation advisor and provided valuable guidance whenever needed throughout the entire process. I would also like to thank Mr. Syed Aqeel Ahmed, Head of the Civil Department at Integral University, Lucknow, for his assistance and provision of the lab resources required for conducting my research.
The author also wishes to acknowledge the support obtained from the faculty of civil department of Integral University, and also from my fellow mates H.M Khan and Alok Tiwari.

VI. REFERNCES

[1] IS: 1893(part 1)-2016.
[2] IS: 875(Part 3)-1987.
[3] M.G. Sahab, AF Ashour, and VV Toporov (2004), "Cost optimisation of reinforced concrete flat slab buildings", Elsevier publication, December 2004.
[4] Fasil Mohi ud din (2017), "Effectiveness of bracing in high rise structure under response spectrum analysis", International Journal of Engineering and Technical Research, vol. 7, no. 7, July 2017.
[5] R.P Apostolska., G.S. Necevska-Cvetanovska, J.P.Vetanovska and N. Mircic (2008), "Seismic performance of flat – slab building structural system" The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.
[6] Dr. G Hemalatha and Dr. P Muthupriya (2008), "Response spectrum analysis and design of case study building", International Journal of Civil Engineering and Technology (IJCIET), Volume 8, Page no.1227–1238.
[7] M.V. Sabeena & Meera Pradeep (2016)," Seismic Behaviour of flat slab building strengthened with perimeter beam, Shear wall and beam in Alternate storey", International Journal of Innovative Research in Science, Engineering and Technology) Vol. 5, Issue 8, Page no. 14617-14624.
[8] Sruthi K Chandra & M.V. Athira (2017) ,"Seismic analysis of flat slab building with shear wall ",International Journal of Engineering Research & Technology (IJERT) Vol. 5, Issue 8, Page no. 1-4.
[9] Sen S. and Singh Y. Seismic Performance of Flat Slab Buildings. Adv. in Struct. Eng. Springer New Delhi, 2 (2015) 897-907.
[10] Lakshmi K O (2014), "Effect of shear wall location in buildings subjected to seismic loads", ISOI Journal Engineering and Computer Science, Volume 01, December 2014.
[10] Latha MS, Pratibha K (2020), "Analysis and comparison of conventional slab and grid slab for symmetric and asymmetric structures", Materials today, Elsevier publication 2214-7853.
[11] Robert Koppitz, Albin Kenel, Thomas Keller, " Punching shear of RC flat slabs – Review of analytical models for new and strengthening of existing slabs" , Elsevier ltd, engstruct.2013.02.014.
[12] M. Altug Erberik, Amr S. Elnashai, "Fragility analysis of flat slab structures", Engineering structure 25 (2004) 937-948, j.engstruct.2004.02.012.
[13] Etabs reference guide by CADD CENTRE.
[14] Lakshmi K.O, Prof Jayshree ramanujan, Mrs Bindu sunil, Dr Taju Koltali, "Effect of shear wall location in buildings subjected to seismic loads", ISOI journal of Engineering and Computer Science, Vol 1,2017.
[15] Mr Rajiv Banarjee, J.B.Srivastava " Determination of optimum position of shear wall in an irregular building for zone III and IV", IJITEE, International journal of innovative technology and exploring engineering, Vol 9, issue 1, November 2019.
[16] Nitin Patel, Chetan Machhi, "Comparitive study of Tall RC building with outriggers and shear wall", JETIR, Vol 6, Issue 5, 2019.
[17] Pankaj Agarwal, Manish Shrikhande, "Seismic analysis of High rise building with Flat slab using Etabs", IRJET, Vol 07, Issue 09, 2020.
[18] Vivek Kumar, Dr Kailash Narayan, "Seismic behavior of flat slab building with steel bracing system using pushover analysis on Etabs-17", JETIR, Vol 6, 2019.
[19] Kavish Patwari, L.G. Kalurkar, "Comparitive study of Flat slab building with and without shear wall to earthquake performance", IJSDR, Vol 1, Issue 6, 2016.
[20] Punith B.R, Sharath H.P, " Analysis of regular and plan irregular flat slab structure with or without lateral force resisting system (LFRS)", IJERT, Vol 8, Issue 6,2019.