



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 3, March 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423



9940 572 462



6381 907 438



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Innovations in Flat Slab Systems: A Comprehensive Analysis for Structural Performance Enhancement

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ABSTRACT: Nowadays every designing organization is using this Software but there is a question mark to which software we must go for designing. The various organizations which have developed these designing tools promote their Software by showing all the positive points. In addition to this they are trying to fill all the loop holes which they found in their products but it will never happen that another developing company will put the points in light what the negative points are there in existing products. They keep on improving to deliver their best. In this project work I will present the difference for future users to which tool you must go through to acquire your needs. I am not saying that some products are not ok at all. I have designed a residential building with proper loading which is being designed on both ETABS. Manual calculations make it crystal clear the difference between the Software.

This research paper delves into the optimization of flat slab systems, with a focus on improving structural performance. The study incorporates an in-depth literature review, a detailed methodology for analysis, presentation of results and discussion, and concludes with insights into the future scope of enhancing flat slab designs. The goal is to contribute to the ongoing discourse on the efficiency and sustainability of flat slab structures.

KEYWORDS: Flat slab, structural performance, innovation, high-performance concrete, reinforcement techniques, post-tensioning, sustainability.

I. INTRODUCTION

1.1 Introduction

An RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer, in such a structure takes place from the slabs to the beams, from the beams to the columns and then to the lower columns and finally to the foundation which in turn transfers it to the soil. The floor area of a R.C.C framed structure building is 10 to 12 percent more than that of a load bearing walled building. Monolithic construction is possible with R.C.C framed structures and they can resist vibrations, earthquakes and shocks more effectively than load bearing walled buildings. Reinforced concrete is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength and ductility. The reinforcement is usually embedded passively in the concrete before the concrete sets.

The reinforcement needs to have the following properties at least for the strong and durable construction:

- High toleration of tensile strain.
- Good bond to the concrete, irrespective of pH, moisture, and similar factor.
- Thermal compatibility, not causing unacceptable stresses in response to changing temperatures.

Design needs to have good hand on numerical problem, to counter different challenges while getting twisted in a design. After complete knowledge of analysis and design one can design any structure but it is not possible for a single person to go through all fields. It is necessary to get a full knowledge in a particular field. Building analysis and design needs complete knowledge of IS Codes and numerical analysis. One must be well versed about loading which are considered in a building. Building can be of various types and can be residential, commercial, industrial and institutional. So, while performing a design we need to go through different design codes. Some of the codes are given below with their description of loading.



- IS- 875 (Part 1) - Design Code for Dead Loads.
- IS- 875 (Part 2) - Design Code for Live Loads.
- IS- 875 (Part 3) – Wind Load Design Code.
- IS- 1893 - Earthquake Design Code.

In addition to above codes we have other codes too to take proper loading and to follow the steps as per standard code recommendation. Engineers which are dealing with Analysis and Design of Structures are known as Structural Design Engineers. They are professional in design both by manual process and by software means. But there is a question that which method we must choose while designing nowadays. It is not as easy as it looks to design a problem it needs mathematical calculation and practice in that field. With this specialization one must have good hand on numerical calculation and must have good experience as well.

1.2 Objective

- 1- Modeling and analysis of G+14 R.C. framed structure by the use of ETABS and to detail the process using various design code algorithms for concrete member selection.
- 2- To assign a suitable cross section this will resist load as well as fulfill some design requirements such as economy and serviceability
- 3- Comparison of results obtained in terms of story drift, displacement, base shear, stresses and deflection in the portion of building with flat slab and the portion of building with grid slab and finally verifying the results.

II. LITERATURE SURVEY

Lalit Balhar et.al (2019): carried out the research on multi-storied RC slab buildings having flat slabs & conventional RC slabs with and without shear walls. All modeling is done in STAAD PRO software. For the analysis he was considering buildings of stories G+10. Building is subjected to gravity and dynamic loads and seismic zone V is selected. Analysis is done by time history analysis, response spectrum analysis, and equivalent static analysis. From the analysis it has been observed that the lateral displacement is increasing from bottom level to top level and storey drift is minimum at bottom level and is increasing up to the middle stories and after that it will decreases up to top level of building for all types of models [1]

Indrani V et. al (2018): It studies the Dynamic Analysis of Multistory RCC Building Frame with Grid Slab and Flat Slab. It is revealed from the study that base shear of grid slab building is more than the base shear of flat slab in building in both directions. Drift in grid slab building and flat slab building is within limit in both X and Y-directions. Axial force in intermediate columns of grid slab building is less as compared to flat slab building. Building drift in flat slab building is more as compared to grid slab building in each story and in both X and Y-directions. Axial force in end columns of flat slab building is less as compared to grid slab building [2]

Ashwini Waghule et.al (2018): Reviewed on bubble deck slab and concluded that the usage is reduced by replacing the concrete by recycled plastic and reduces production of cement. This will help in reduction of global CO₂ emissions. Hence this technology is environmentally green and sustainable. Reducing material consumption made it possible to make the construction time faster and reduces the overall cost of construction. By using this technology dead weight of slab is reduced up to 18%. Foundation sizes become smaller due to the reduced dead weight. The Bubble Deck configuration gives much improved shear capacity, flexural capacity and stiffness when the same amount of reinforcement and the concrete is used as in the solid slab. Waste plastic material is utilized in construction as it gives same strength or load carrying capacity as that of conventional slab. This type of slab is advantageously utilized for longer spans halls such as auditorium and theatre halls. [3]

Mohd Aasim Ahmed et.al (2018) Analyzed that the Quantity of Concrete required for grid slab is more than conventional slab followed by flat slab for shorter spans. The Quantity of Steel required for grid slab is more than conventional slab followed by flat slab for shorter spans. As Span increases the Quantity of steel required for a slab system increases. The Maximum Joint Displacement (lateral sway) was found to be more for grid slab system followed by conventional slab system and least for flat slab system. The Maximum Joint Displacement (downward deflection) was found to be more for flat slab system followed by grid slab system and least for conventional slab system. The Maximum Storey Drift was found to be least for flat slab followed by conventional slab and more for grid slab system. The Maximum Column forces was found to be more for grid slab followed by conventional slab and least for flat slab

system. The Maximum Column Moments was found to be more for grid slab followed by conventional slab and least for flat slab system.[4]

S.V Mahamuni et.al (2018) has done the analysis of the various methods by which grid floor system can be analyzed. He has done the analysis of grid slab manually by using Plate theory, Rankine-Grashoff method, and Stiffness method. Used various approaches for analyzing the grid slab system. For carrying out study, ratio of hall dimensions (L/B) from 1 to 1.5, halls having constant width 10.00m are considered. After applying the theoretical formulas, he observed that by using stiffness method, bending moment in x direction is increasing linearly by increasing L/B ratio. By using Rankine-Grashoff method it will give the lowest values of bending moment in x direction, which the lowest value among all the methods that is used in the analysis.[5]

Sumit Sharma et.al (2018) observed that thickness of the building having flat slab with shear wall changes with the storey height. Flat slab provides more flexibility to the building as compare to conventional slab. Flat slab also provides more stability and aesthetic view to the building. In case of industrial structures constructed in a square and rectangular layout the displacement is more in case of flat slab as compare to waffle system and displacement is increases with the increases in the height of the building.[6]

R.S.More et.al (2015) has done analytical study of different types of flat slab subjected to dynamic loading. Drift of flat plate is maximum than grid floor slab and flat slab. Grid slab has less drift compared to others. He gives the result that all slabs deflect within the limit when strata is of type one i.e. rock, or hard soil. There is definite correlation between increase in shear force and storey drift with change in soil condition for particular type of slab. [7]

Ch. Rajkumar et.al (2017) analyzed a multistoried building and observed that the results are more conservative in Static analysis when compared with the dynamic analysis results in an uneconomical structure. Overall stiffness of the building increases therefore the sway problem in the structure reduces. As building is not regular the behavior in x and y directions are not similar for earthquake load the story drift values in x and y direction is higher than the wind load. For spectrum loads the storey shear is maximum in the top storey location. For top stories location the twisting moment increases from top to bottom stories. The story shear and twist increases from top to bottom storey for the bottom storey location and will be maximum for bottom storey. For force in z direction the support reaction values are maximum. [8]

Anitha.K et.al (2017) has done the analysis of grid slab and observed the influence of various parameters on the economical spacing of the transverse beams in grid floor. The bending moment, the shear force and the mid span deflection developed in grid floor beams have been predicted by conventional and numerical methods and the results are compared. Area of steel required in the slab at a critical section for column is determined and also for the middle strips. Span to depth ratio 16 to 60 considered. The spacing of 0.5m to 2.0 m is used for transverse beams. The model is made by ANSYS 12.0 software. For the optimum performance of grid floors range of the magnitude of the various parameters to be considered in this paper.[9]

Avinash Patel et.al (2017) studied the behavior of flat slab, grid slab and conventional slab separately. A comparative study was done to know which slab system is best. For this he performed the dynamic analysis of multi-storey building having flat slab, grid slab and conventional slab separately. In all the systems, the storey drift is within the permissible limits according to the IS: 1893 (Part 1). Cost of grid slab system is more than the other slab systems. Storey drift in Flat Slabs are least than the other slab systems. The quantity of concrete and steel in case of Grid Slab system is huge when compared to Conventional Slabs or Flat Slabs. Flat Slabs resist the lateral loading most effectively than grid slab or conventional slab. [10]

III. RESEARCH METHODOLOGY

3.1 STRUCTURAL DESIGNING

Structural engineers have proper technical knowledge for structural detailing and their analysis. So, they are more experienced to design structures. The structural designing procedures carried out by the structural engineers include calculating the loads and the stresses acting on the building, analysis results for the applied loading, design of sections of structures to sustain the loads, so that the structure designed will withstand the loads predicted safely. The structural engineers are also involved in the selection of materials best suited for the structure.

3.2 WORKING TIME AND LOCATION OF A STRUCTURAL ENGINEER

When looking into the working time and the place spent by the structural engineers, most of the highly involved structural engineers will be working in office as well as on the construction sites.

They can work by splitting the time between both the contexts. The locations of work vary based on the working environments. Rural or metropolitan areas have different working schedules and environment.

The structural engineers may have to work for long hours sometimes similar to site engineers, which mainly depend on the size of the project and the size of the organization. If the structure of the organization is well defined and large, it will have sufficient members for the design team, planning team, execution team with a group of professionals, skilled as well as semi-skilled employees and workers. This will reduce some burden on the structural engineer.

3.3 DESCRIPTION OF MODEL TYPE

The model consists of RCC frame with concrete as a base material. This project mainly consists of Grid Slab and Flat slab in building at each level. Flat slab is being used at front portion of building to make beamless area for aesthetic purpose whereas inner side of building is having grid slab to resist loads easily and to increase rigidity of the structure. This consideration of both flat slab and grid slab helps us to minimize use of closely spaced columns. The various parameters taken for analysis and design process are mentioned below:

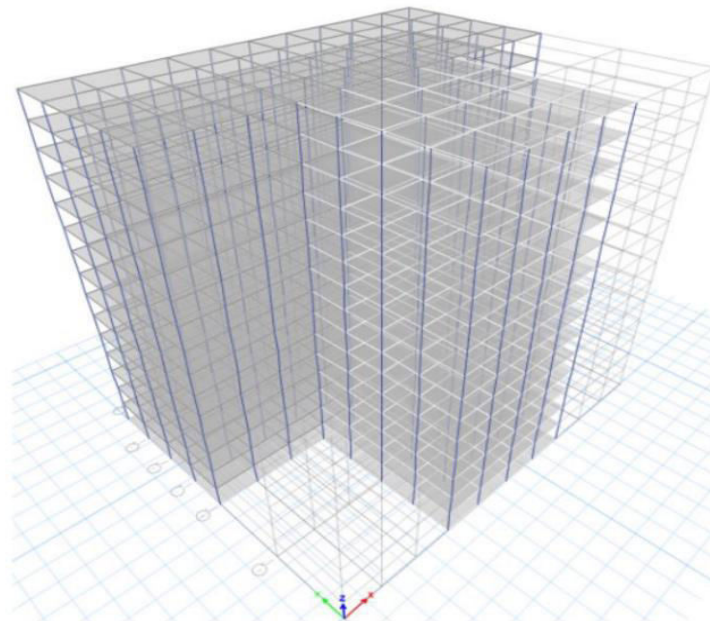


Fig 1.1: Isometric view of structure.

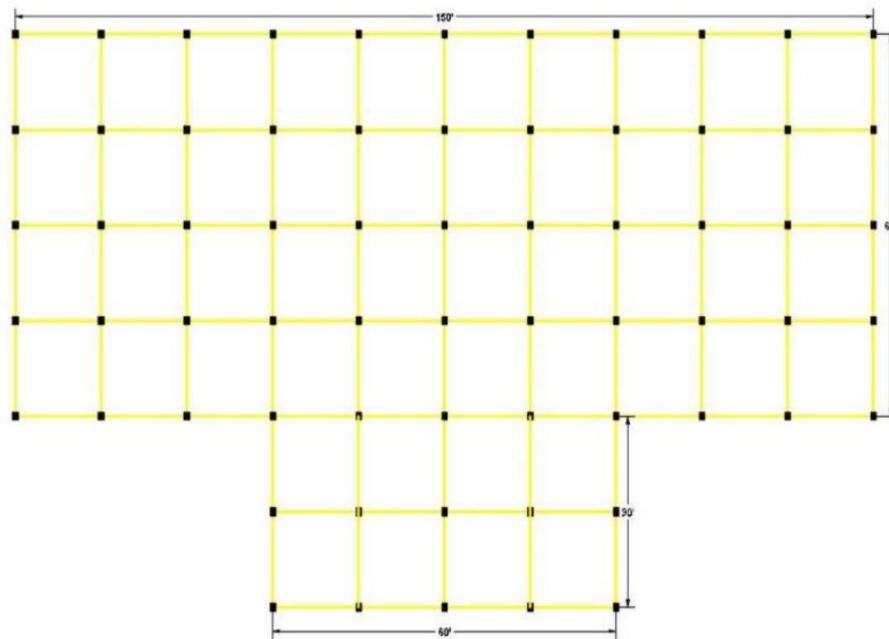


Fig 1.2: AutoCAD file showing PLAN of Structure.

IV. RESULT AND DISSCUSSION

4.1 Loads

This chapter provides loading information as applied to the model.

4.1.1 Load Patterns

Table 1.1 Load Pattern

Name	Type	Self-weight multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
Masonry	Superimposed dead	0	
Ex	Seismic	0	IS 1893-2002
Ey	Seismic	0	IS 1893-2003

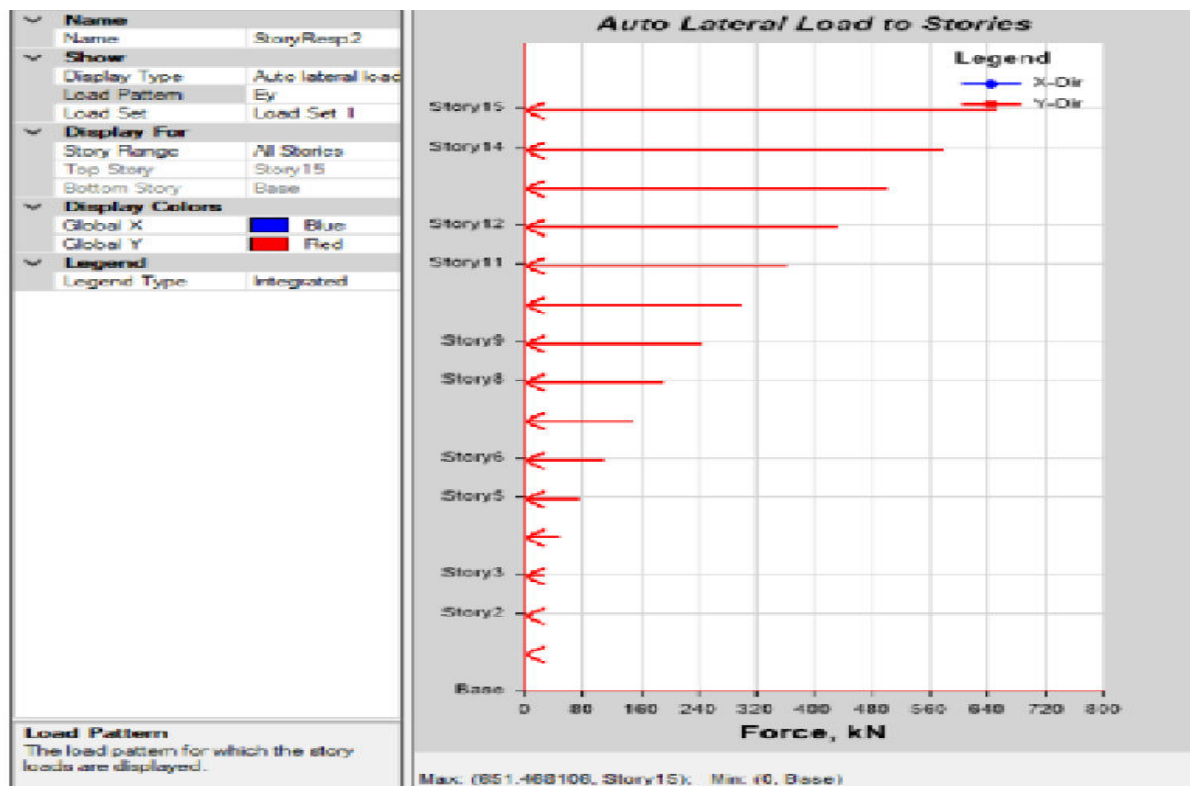


Fig 1.3: Earthquake loading along-X

The lateral loads considered for this structure is shown by two graphs above. Intensity of earthquake depends on the zone in which building is located. The consideration of earthquake zone for this building is zone III and location for the construction site, India. Earthquake loading is the main cause of building failure in earthquake prone areas. So, to make building earthquake resistant we consider earthquake loading while analyzing structure. Dynamic analysis is the main consideration if building is of 5 or more than 5 stories.

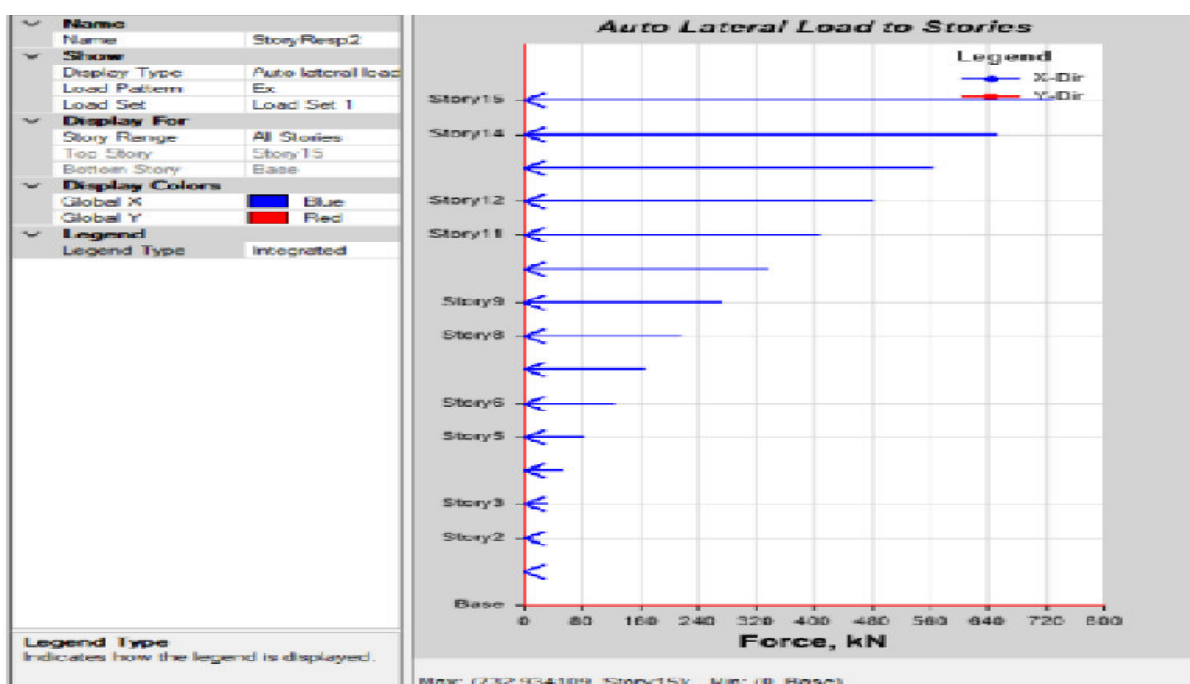


Fig 1.4: Earthquake loading along-Y

4.2 Storey drifts:

The resultant drift in two adjacent storey define storey drift. Below graph makes it clear to know the condition of the building for storey drift due to external loading

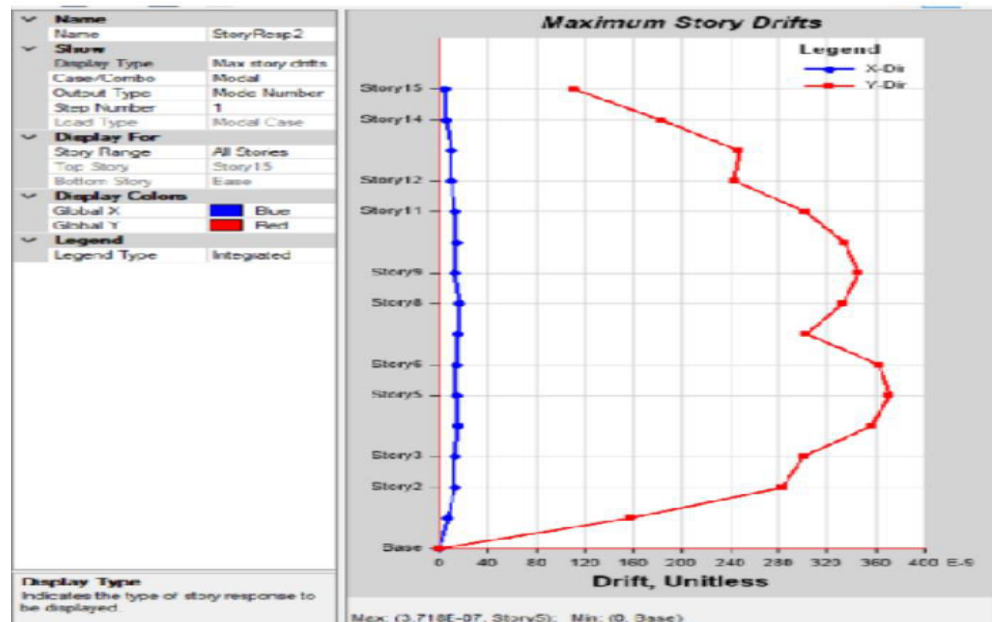


Fig 1.5: Maximum Storey Drift

4.3 Storey Stiffness

This is the reaction of storey towards force being exerted on it. Storey stiffness defines the amount of force that will lead to failure along and the resistance of storey to counter act that critical load. The values of story stiffness are tabulated below.

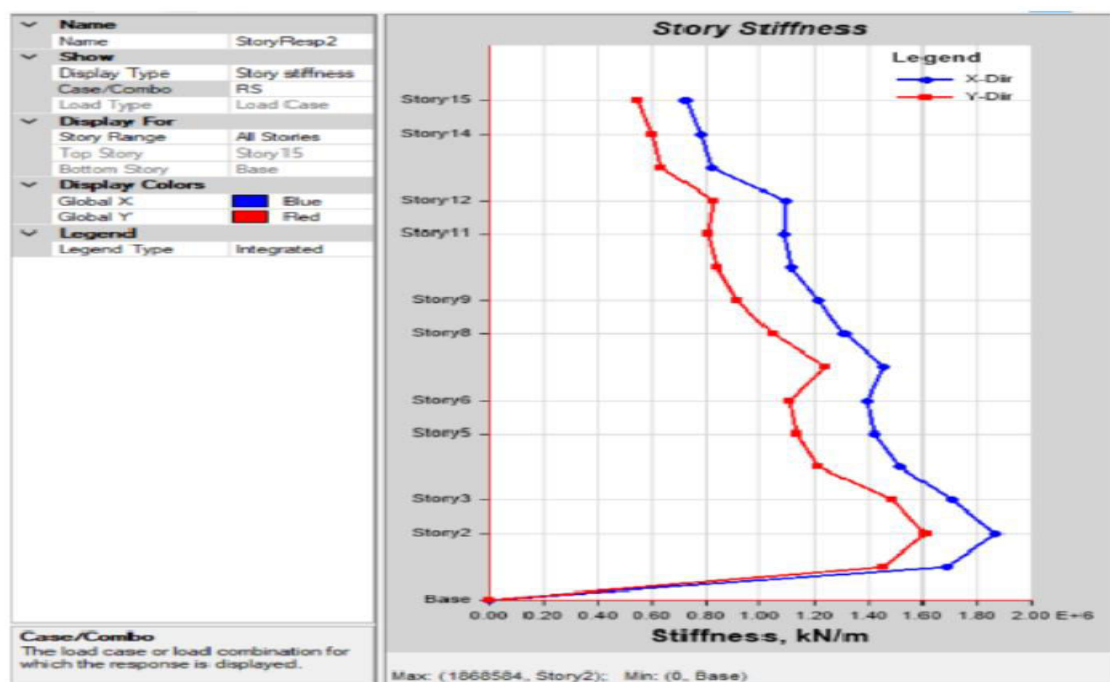


Fig 1.6: Storey Stiffness by Response Spectrum.

V. CONCLUSION

The research concludes by summarizing the key findings and their implications for the optimization of flat slab structures. It emphasizes the importance of adopting innovative approaches to overcome challenges and enhance the overall efficiency of these systems.

To know the inter-relation between grid slab and flat slab and their dependency on adjacent beams and to check the effect on reinforcement, section detailing. By going through some of the researches done previously I came to conclusion by this research that:

1. Flat slab makes it best for design purpose instead of grid slab if we take economic point of view.
2. Reinforcement provided for flat slabs is minimum as compared to grid slabs.
3. Grid slabs help to minimize provision of number of columns as they are rigid and can be used for longer spans. But flat slabs cannot resist that much amount of load as they are not supported by beams.
4. Stress is found to be maximum on flat slab as compared to grid slab. So, chances of cracks will be more in flat slabs.
5. As found in analysis result stress is minimum at column joints in both the cases but in case of flat slab drop panels are used to minimize stress on columns. Drop panels transfer loading uniformly from all sides.

VI. FUTURE-SCOPE

The paper concludes with insights into potential areas for future research, including advancements in sustainable materials, integration of emerging technologies, and further exploration of performance under dynamic loading conditions. Some researchers are still going there on types of slabs to be provided at different instances. This research will help other researchers to get idea and to put fore front its results and then elaborate it with other techniques. There might be some flaws in this research which can be fulfilled onwards by engineers going for higher studies.

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