Analytical Investigation of RCC Building with Different Type of Slabs using Time History Method

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Abstract - **In the present work, (G+4) RCC Building assumed to be situated in seismic zone V, are analyzed by using time history analysis, using ETABS Software. Determination of seismic load effect on the structural system is important in all types of buildings. 3 different type of slabs namely conventional slab, flat slab without drop panel and waffle slab without drop panel are compared in RCC building inorder to analyze their seismic performance by using time history method in ETABS Software. Dynamic responses of building under actual earthquakes, EL-CENTRO 1949 have been investigated. From analysis results, the parameters like storey displacement, storey drift, storey stiffness are determined for comparative study.**

Keywords - Time history analysis, storey displacement, drift, stiffness, RC building, conventional slab, flat slab, waffle slab.

I. INTRODUCTION

Structural analysis is concerned with finding out the behavior of a physical structure when subjected to force. RC buildings are subjected to several types of forces during their lifetime such as people, furniture, wind, snow, rain etc. or some other kind of excitation such as earthquake, blast etc. In Laila Elhifnawy (2017) study, he investigated the inelastic behavioral characteristics of three RC buildings having 6-, 10- and 20-stories under near-source multi- component earthquake excitations [1]. In Zaid Mohammad (2017) study, he revealed that the framed structures constructed on hill slopes show different structural behaviour than that on the plain ground [2]. In El-Sokkary (2009), he investigated the performance of two RC frames with or without masonry infill when rehabilitated and subjected to three types of ground motion records [3]. In Bahador Bagheri (2012) study, he compared static and dynamic analysis of multi-storey irregular building [4]. In Mahmood Hosseinia (2017), he studied the Seismic Design Evaluation of Reinforced Concrete Buildings for Near-Source Earthquakes by Using Nonlinear Time History Analyses The distinction is made between the dynamic and static analysis on the basis of acceleration of applied action in comparison to the structure's natural frequency. Conventional slabs are the slabs which are supported with beams and columns. The load is transmitted from slab to the beams and then to the column below it and to the foundation. Flat slabs are supported directly by concrete columns or caps and there is no need of beams. They are supported on columns itself and hence loads are directly transferred to columns. The flat slab is easy to construct and requires less formwork. It is less resistant to earthquake as it is less flexible than slab beam system. Waffle slabs without drop panel can be used both as floor and ceiling. Waffle slabs are also known as two way ribbed flat slab and have 2D reinforcement on the outside of material. Purpose of providing waffle slab is to reduce the depth of foundation. They can also hold a greater amount of load as compared to that of flat slabs. It is economical and have constructional benefits than flat slab. These slabs are used for office buildings, theatre halls, show rooms, auditorium etc. The main objective of this paper is to choose which slab performs better in dynamic analysis. In the present study, RCC building (G+4) is analyzed using static and dynamic codal provision and to compare the 3 different types of slabs namely conventional slab, flat slab without drop panel and waffle slab without waffle slab using time history method in ETABS software.

Fig 1: Conventional Slab

Fig 2: Flat Slab

Fig 3: Waffle Slab

II. METHOD OF ANALYSIS

A. Time history analysis

Time History method is step by step analysis of the dynamic response of the structure at each time increment when its base is subjected to ground motion time history record. To perform such an analysis a representative earthquake time history is essential for a structure being evaluated. It is used to determine the seismic response of a structure under dynamic loading of considered earthquake.

III. STRUCTURAL DETAILS

In the present study, three models are generated by using ETABS software. All the models are analyzed in seismic zone V in a G+4 multistorey RC building by using time history method.

MODEL 1 - CONVENTIONAL SLAB MODEL

2 - FLAT SLAB WITHOUT DROP MODEL 3 -

WAFFLE SLAB WITHOUT DROP

The building is assumed to be situated in zone V. Grade of concrete used is M25 and grade of steel is Fe500. Beam size is taken as 230X400mm and column size is taken as 400X400mm.External wall thickness is taken as 230mm. Internal wall thickness is taken as 115mm. Density of plastered masonry wall is assumed as 20 KN/m^3. Live load is 3 KN/m^2. Floor finish load is 0.5 KN/m^2. Structural data is as follows:

Table 1: Building datas

1	Building type	Commercial
2	Plan dimensions	42m X 24m
3	No. of stories	5
4	Floor to floor height	3.2
5	Total height of building	17.5m
6	Slab thickness for conventional slab	150mm
7	Slab thickness for flat slab	180mm
8	Slab thickness for waffle slab	100mm

The plan view and the 3 dimensional view of the models have been shown as follows:

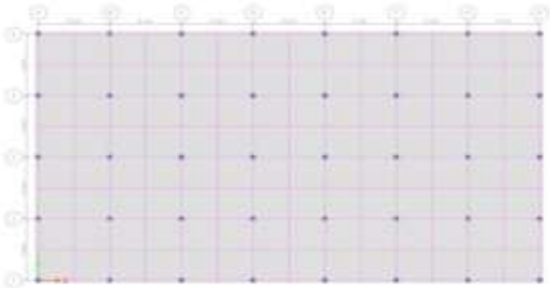

Fig 4: Plan view of Waffle Slab

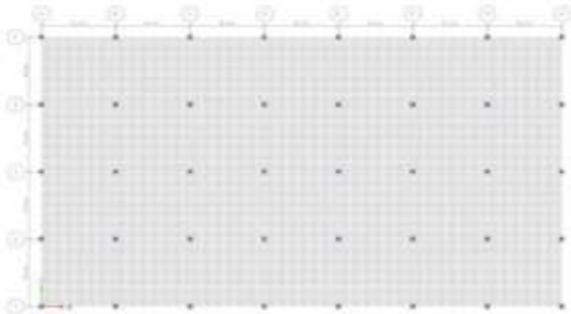

Fig 5: Plan view of Waffle Slab

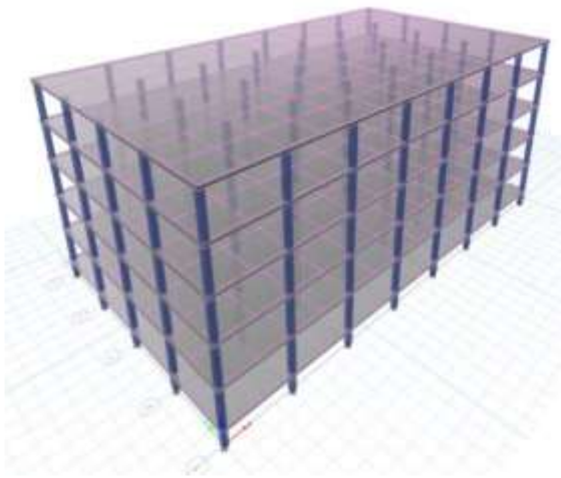

Fig 6: Plan view of Waffle Slab

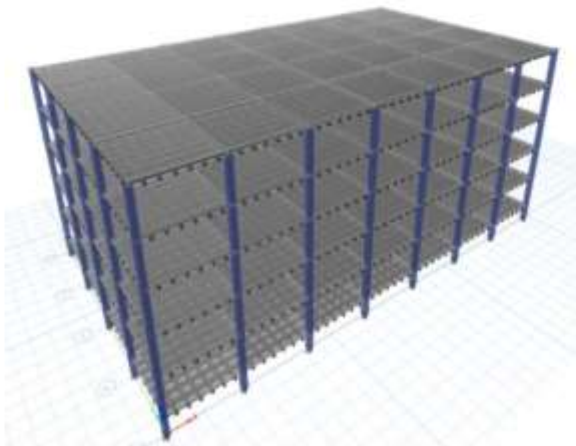

Fig 7: Plan view of Waffle Slab

IV. RESULT AND DISCUSSION

A. ***Storey displacement***

Chart: 1 *Storey displacement*

Story displacement is the displacement of the storey with respect to ground. According to IS 1893:2002 clause 7.11; maximum allowable deflection is calculated as h/250, where h is the height of the storey from the ground level. The variations of story displacement of each storey has been shown above.

B. Storey drift

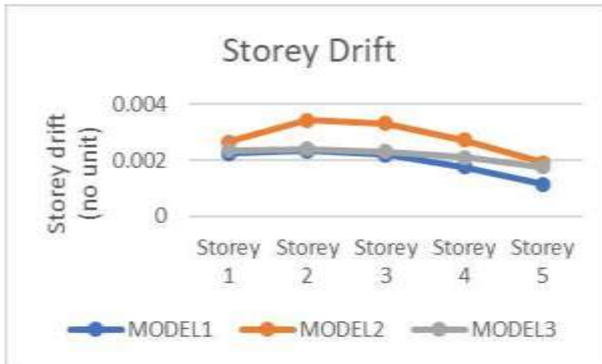

Chart:2 *Storey drift*

Story drift is an important criteria in earthquake engineering and it is defined as ratio of displacement of two consecutive floor to height of that floor. It represents the performance of structure as per IS 1893:2002 part 1, clause 7.11.1; story drift should be less than 0.004 times the height of the story under consideration.

C. Storey stiffness

Chart: 3 *Storey stiffness*

Story stiffness is the ratio of story shear to story drift. Indian code 1893:2002 recommends that for a building to be considered regular, lateral stiffness in any story should not be less than 70 percent of that in the story above it or less than 80 percent of the average lateral stiffness of three storeys above it.

V. CONCLUSION

The present research represents the study of conventional slab, flat slab without drop, waffle slab without drop in a G+4 storey commercial building. Overall analysis shows that the conventional slab performance when subjected to seismic excitation is better as compared to waffle and flat slab. The execution is easier in waffle slab in comparison

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to flat slab. Though the formwork required is more for waffle slab, it can be re-used many times for construction. Effect of different type of slab on the parameters taken into account and their comparison is made and we conclude the following results:

- Conventional slab show better performance during earthquake excitation as compared to the flat slab without drop and the waffle slab without drop. The stiffness is maximum in case of conventional slab. As the flat slabs are used without drop and shear wall they show minimum stiffness when compared to waffle slab.

- The story drift is maximum in case of flat slab without drop and it is exceeding the specified value according to Indian standard code i.e., 12mm; the maximum drift of waffle slab compared to conventional slab at story 5 is 20-25% greater.

- The story displacement increases when storey height increase. Maximum displacement is in flat slab case when compared to the conventional and waffle slab because of the lack of frame action which leads to excessive lateral deformation. The displacement of waffle slab when compared to conventional in approximately 23% greater.

- To increase the performance of flat slab structure with horizontal loads, particularly in seismic areas, flat slab is strengthened by providing reinforced concrete shear walls.

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