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A PERFORMANCE STUDY OF HIGH RAISE BUILDING WITH FLAT SLAB SYSTEM UNDER LATERAL LOADS

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***ABSTRACT - Flat** slab structural systems have a large applicability due to their functional and economic advantages. As such, a good number of commercial and office buildings around many Indian metro cities, in India, have been observed to adopt flat-slab system. Initially, the reinforced concrete flat slabs had drops, and columns with capitals, and were considered to be the structures of choice for warehouse construction and heavy loads because shear was not a problem. But, till date the analysis of flat-slab systems has been a problem due to its complex load transfer mechanism and failure patterns. Flat plate slabs exhibit higher stress at the column connection and are most likely to fail due to punching shear rather than flexural failure. Thus, the vulnerability to punching shear failure has caused structural engineers to rethink the design of slab-column connections in new flat-plate frames constructed in areas of high seismicity. The present analytical study investigates the influence of some of the parameters governing the behavior of connections under punching shear which are concrete strength, column aspect ratio, slab thickness, gravity loading. Firstly, modelling of the whole building is carried out using the computer program SAP 2000 V [20].*

Key Words: Flat-slab, displacement, storey drift, base shear

1. INTRODUCTION

The increase in population and shortage of land in urban areas, leads to development of tall buildings and forcing urban area to grow in vertical instead horizontally. Such buildings are subject to lateral loads such as wind and seismic loads play a dominant role due to their height and terrain characteristics and show greater sensitivity.

Fazlur Rahman Khan[11] was a Bangladeshi-American structural engineer and architect, who initiated important structural systems for skyscrapers considered the "father of tubular designs" for high-rises, Khan was also a pioneer in computer-aided design (CAD). Khan has been called the "Einstein of structural engineering" and the "Greatest Structural Engineer of the 20th Century" for his innovative use of structural systems that remain fundamental to modern skyscraper design and construction

The narrow tall building is usually considered as the beam cantilevering from earth. The critical loads to which these buildings usually subjected are seismic and wind loads which are not linearly uniform with respect to time and height. Due to these loads building is subjected to both shear and moment.

1.1 Flat plate/slab system

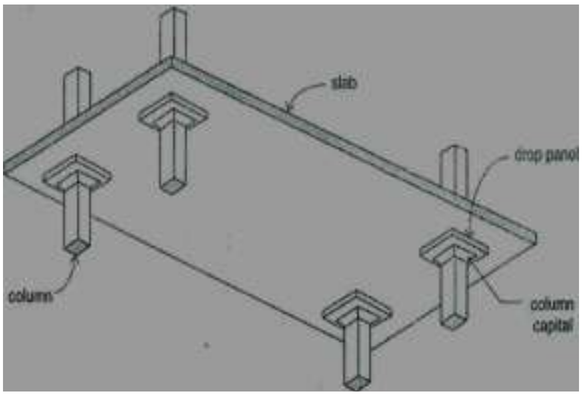

Fig 1.1 flat slab with drop panel and column capital

RC slabs with long spans extended over several bays and only supported by columns, without beams known as flat slab. Flat slab system is very simple to construct and is efficient in that it requires the minimum building height for a given number of stories. Such structure contains large bending moment and vertical forces occur in a zone of supports. This gives a very efficient structure which minimizes material usages and decreases the economic span range when compared to reinforced concrete. Post-tensioning improves the structural behaviour of flat slab structure considerably.

This is more acceptable concept to many designers. It is adopted in some office buildings. The flat slabs are plates that are stiffened near the column supports by means of „ drop panels" and/or „column capitals" (which are generally concealed under „drop ceilings"). Compared to the flat plate system, the flat slab system is suitable for higher loads and larger spans, because of enhanced capacity in resisting shear and hogging moments near the supports. The slab thickness varies from 125 mm to 300 mm for spans of 4 to 9m. Among the various floor systems, the flat slab system is the one with the highest dead load per unit area.

1.2 The advantages of flat slab are

1. Faster construction

2. Reduced services and cladding cost

3. Flexibility for the occupier

4. Slab thickness

5. Flexibility in room layout

6. Saving in building height

7. Shorter construction time

8. Ease of installation of m&e services

1.3 Major problems in flat slab

1. Slab column connection does not possess the rigidity of the beam column joint.

2. Shear concentration around column is very high due to the possibility of the column punching through the slab.

3. Deflections tend to be very large due to lesser depth of slab.

2. LITERATURE REVIEW

A. Eebrik [3] discussed about Flat-slab RC buildings exhibit several advantages over conventional moment resisting frames. However the structural effectiveness of flat-slab construction is hindered by its alleged inferior performance under earthquake loading. This is a possible reason for the observation that no fragility analysis has been undertaken for this widely-used structural system. This study focuses on the derivation of fragility curves using medium-rise flat-slab buildings with masonry infill walls. The developed curves were compared with those in the literature, derived for moment-resisting RC frames. This study also concluded that earthquake losses for flat-slab structures are in the same range as for moment-resisting frames for low limit states, and considerably different at high damage levels.

M.A. Eebrik [4] focuses on the study of earthquake records compatible with the design spectrum selected to represent the variability in ground motion. Inelastic response-history analysis was used to analyse the random sample of structures subjected to the suite of records scaled in terms of displacement spectral ordinates, whilst monitoring four performance limit states. The fragility curves developed from this study were compared with the fragility curves derived for moment-resisting RC frames. The study concluded that earthquake losses for flat-slab structures are in the same range as for moment-resisting frames.

U.Gupta et.al [6] studies about flat slab building structures which are more significantly flexible than traditional concrete frame/wall or frame structures, thus becoming more vulnerable to seismic loading. Therefore, the characteristics of the seismic behavior of flat slab buildings suggest that additional measures for guiding the conception and design of these structures in seismic regions are needed. To improve the performance of building having flat slabs under seismic loading, provision of part shear walls is proposed in the present work. The object of the this work is to compare the behavior of multi-storey buildings having flat slabs with drops to the two way slabs with beams and to study the effect of part shear walls on the performance of these two types of buildings underseismic forces. This work provides a good source of information on the parameters lateral displacement and storey drift.

S. Patil et.al [8] study about optimum design of reinforced concrete flat slab with drop panel according to the Indian code (IS 456-2000) is presented. The objective function is the total cost of the structure including the cost of slab and columns. The cost of each structural element covers that of material and labour for reinforcement, concrete and formwork. The structure is model and analyzed using the direct design method. The optimization process is done for different grade of concrete and steel. The comparative results for different grade of concrete and steel is presented in tabulated form. Optimization for reinforced concrete flat slab buildings is illustrated and the results of the optimum and conventional design procedures are compared. The model is analyzed and design by using MATLAB software. Optimization is formulated is in nonlinear programming problem (NLPP) by using sequential unconstrained minimization technique (SUMT).

K.S.Sable et.al [9] focuses on tall commercial buildings are primarily a response to the demand by business activities to be as close to each other, and to the city centre as possible, thereby putting intense pressure on the available land space. Structures with a large degree of indeterminacy is superior to one with less indeterminacy, because of more members are monolithically connected to each other and if yielding takes place in any one of them, then a redistribution of forces takes place. Therefore it is necessary to analyze seismic behavior of building for different heights to see what changes are going to occur if the height of conventional building and flat slab building change

3. OBJECTIVES:

3.1 Aim and Objectives of the Present Study are

1. The main aim of the research program is to analysis the building with Flat slab structural system to that of the bare frame subjected to Non-linear reponce spectrum method

2. To study the effect of flat slab structural system placement along width and height of building

3. To study the effect of relative displacement and storey drift on the behaviour of Flat slab structural system

4. To study the comparison between building in different zones and soil condition using response spectrum method time history method.

5. To investigate the contribution Flat slab to displacement and storey drift of the buildings.

6. To quantify the structural behaviour due to presence of Flat slab.

7. Draw the seismic parameters such as displacement, story drift, base shear in terms of graphs.

4. Methodology of study

1. The present work is done keeping in view finding the displacement, base shear, Earth quake analysis and Response spectrum for rigid frame at different heights of building, 10 and 20 storey using SAP 2000 V.20.

2. To suggest the best structural system with critical sectional, material properties at specified height to resist lateral loads.

3. To evaluate these above mentioned using Equivalent static analysis (ESA) and Response spectrum analysis (RS) for different load combination as per IS: 1893:2002.

4. Assign loads as per relevant IS codes

5. Analysis – ESA and RS as per IS1893:2002.[17]

6. Design – make sure all sections are passed and rebar percentage of column are below the permissible limit which is specified as per IS 456:2000 (Column – 0.8% to 4%).[14]

7. In case, rebar percentage is exceeding 4% the sectional property is increased and vice-versa.

8. There by selecting the optimum sectional and material property as above.

9. For selected sectional and material property the rigid frame system is modelled and analysed and the top storey displacement is checked for critical combination as per IS1893:2002.

10. From literature review, it is noticed that permissible top storey displacement is H/500, H – total height of the building, [5] if the rigid frame system is exceeds the permissible limit then a necessity of new structural system like core and outrigger is adopted.

11. Flat slab system depends on the position of Flat slab , so optimum location of Flat slab for different height of building is studied for different seismic zone and soil types.

5. MODELLING AND ANALYSIS

5.1 Model Description

For the study purpose a 20 story building model has been considered, the modling is presented in Fig 5.1 & 5.2

1. Number of stories = G+19
2. C/C dist between columns in X- dir = 6m
3. C/C dist between columns in Y- dir = 6m
4. Foundation level to ground level = 3.5m
5. Floor to floor height = 3.5m
6. Live load on all floors = 2 kN/m^2
7. Roof Live load = 1.5 kN/m^2
8. Floor Finishes = 3 kN/m^2
9. Material =M40 and Fe500
10. Depth of slab = 350 mm
11. Depth of the slab drop =500 mm

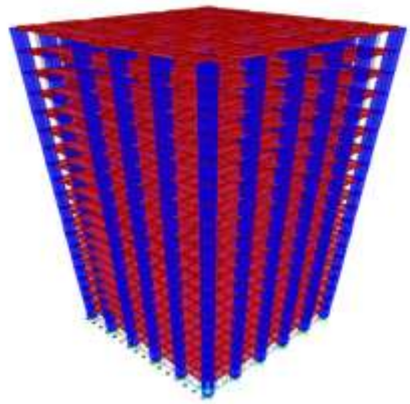

Fig 5.1 3D elevation view of 20 storey Flat slab buiding

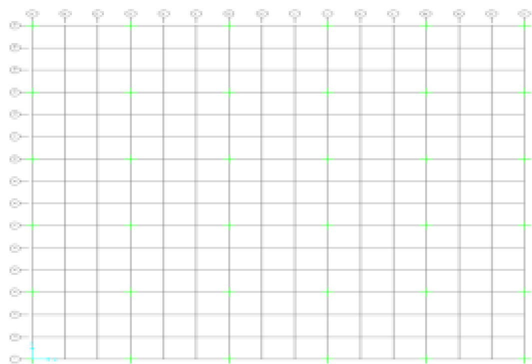

Fig 5.2 Plan considered for the project work in SAP 2000

6. RESULTS AND DISCUSSION

It deals with results and discussion of Flat slab structural system

Discussions are made based on following parameters storey displacement, storey drift, base shear

The floor level versus displacement graph is been plotted for both models in X and Y direction.

6.1 STOREY DISPLACEMENT AND STOREY DRIFT

Zone III and soil III

It is the important factor, when the structure is affected by seismic forces .it mainly depends on the height of the structure and tall structures are more flexible for lateral loads.

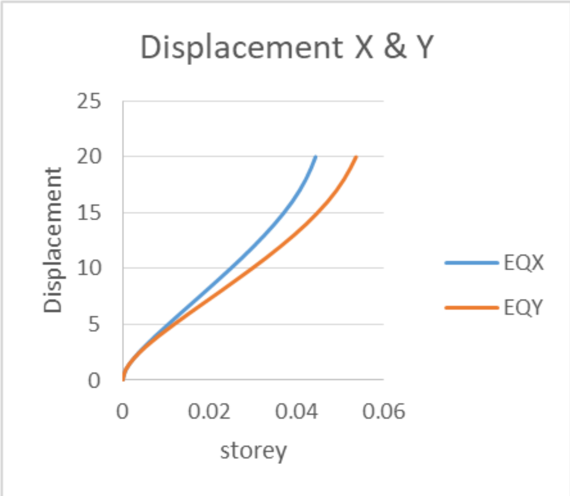

Fig 6.1: Displacement in X and Y

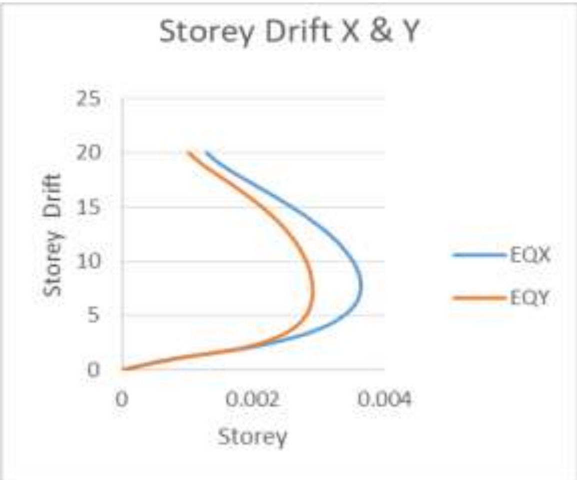

Fig 6.2: Storey drift in X and Y

Zone V and soil III

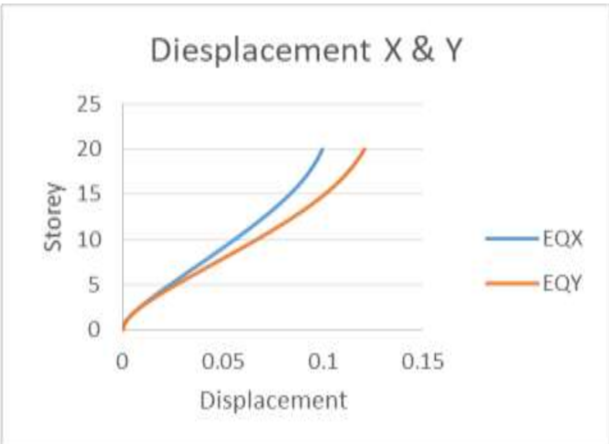

Fig 6.3 Displacement in X and Y

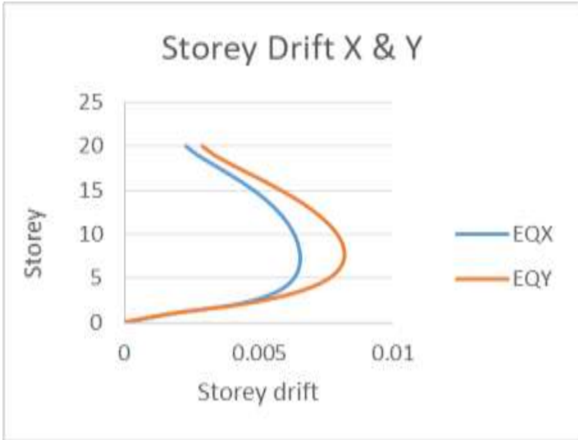

Fig 6.4: Storey drift in X and Y

6.2 Comparison of displacement along X and Y direction

Fig 6.5: Displacement in X of all zones

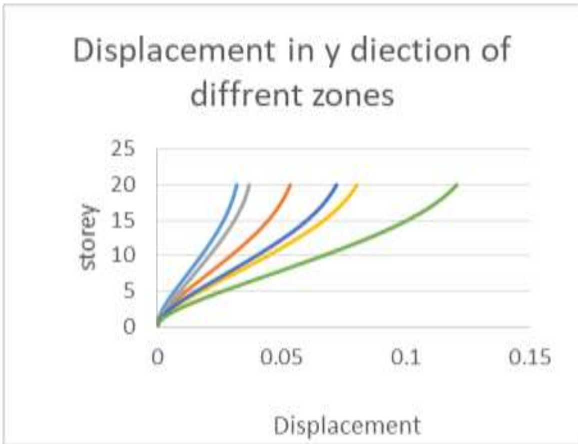

Fig 6.6: Displacement in Y of all zones

Comparison of storey drift along X and Y direction

Fig 6.7: Storey drift in X of all zones

Fig 6.8: Storey drift in X of all zones

6.3 Maximum Base shear along X and Y direction

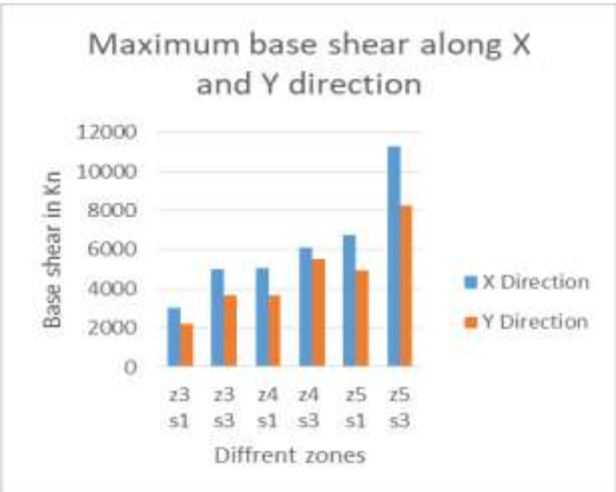

Fig 6.9: Base shear in X and Y direction

1] There is increase in the storey displacement of 17% from zone III & soil III to zone VI & soil III and 22% increase in the storey displacement from zone V & soil III in Y direction.

2] There is increase in the storey drift of 17% from zone III & soil III to zone VI & soil III and 10% increase in the storey drift from zone V & soil III in Y direction.

3] There is increase in the storey displacement of 28% from zone III & soil III to zone VI & soil III and 40% increase in the storey displacement from zone V & soil III in Y direction.

4] There is increase in the storey drift of 18% from zone III & soil III to zone VI & soil III and 27% increase in the storey drift from zone V & soil III in Y direction

5] There is increase in the base shear of 11.10% from zone III & soil III to zone VI & soil III and 51.55% increase in the base shear from zone V & soil III in X direction

6] There is increase in the base shear of 18.24% from zone III & soil III to zone VI & soil III and 27.62% increase in the base shear from zone V & soil III in Y direction

7. CONCLUSIONS

In this study the focus is made on the study of seismic effect on RC building. The performance of building is studied in terms of response spectrum, base shear, lateral displacements, storey drifts of (G+19) storey building models. Analysis is carried by equivalent static and response spectrum mehod.

We can conclude from analysis ad result obtained from present study.

1. From the analysis results it is suggested that the structural systems with respect to that material and sectional properties for 20 storey under seismic zones III, VI , V.

2. As the height of the building increase then a necessity of new structural system arise other than rigid frame system.

3. It is observed that material (concrete M40 and rebar Fe 500) and sectional property (1200 x 1200 mm) have significant effect on displacement, storey drift and base shear of the structure.

4. It is unsuitable to provide rigid frame OMRF structural system above 15 m height under seismic zone III and soil type III, [18] clause 1.1.1 (d) in Flat slab .

5. Building above 15 m height under seismic zone III, IV and V and soil type I, III additional structural system is preferred with rigid frame system.

6. Flat slab system is best suitable up-to 20 storey building, 60 m under seismic zone V and soil type III with considerable sectional property of column for residential building.

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