Analysis and Design of Flat slab with various shapes

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***Abstract*-Flat slabs are now a days becoming more popular and they are economical as compared to beam-column connections. RC frame buildings are commonly used for the construction. The use of flat slab building provides many advantages over RC frame building in terms of architectural tractability, use of the space, easier formwork under earthquake loads. In the present work flat slab building of G+8 storey building models are considered. The design of flat slab building with direct design method and also we have discussed the results obtained by performing Non-linear pushover analysis on flat slab building of various shapes and different types also by using software ETAB2015. To improve performance of building,it is necessary to analysis the seismic behaviour of building, provision of flat slab with drop and without drop on the performance of these two types of buildings. As per IS 456:2000 codes provisions present work gives the information on the parameters max strip moments, base shear, max storey displacement and storey drift.**

***Key words:* - Design of flat slab building with various shapes and also with drop and without drop, Max strip moments, Base shear, Max storey Displacements and Storey drift.**

1. INTRODUCTION

Flat slab are preferred by both architects and clients because of their artistic and economic rewards. This form of reinforced concrete construction gives more rewards over framed structure, they also gives some disfavour because ofpunching failure and larger deformation. Many researchers proposed that slab should be designed to resist only gravity loads when used in high seismic zones and lateral loads should be carried by lateral resisting system. The load transferred path changes due to the excision of beams. But, the safety of buildings is to be checked. But from the past history it can be concluded that the flat slab is very susceptible to criticism for earthquakes. The floor system resists the GL (DL and LL) acting on it and transmits this to the vertical frames of buildings. In this process, the floor system is subjected to flexure and transverse shear, whereas the vertical frame elements are subjected to axial compression, frequently coupled with flexure and shear. The floor also used as a horizontal diaphragms connecting together. Under the action of lateral loads, the floor diaphragms distribute the lateral load to the different vertical frames and shear walls.

2. FLAT SLAB

The general frame construction uses columns, slabs and beams it may be possible to attempt construction without providing beams, this frame consist of slab and column without beams or a RC structure slab supported directly by columns without the use of beams. This type of slabs are called as flat slabs. The flat slab is having with various shapes (rectangular/square). The design of flat slabs is regularise by the punching shear strength at failure. Flat slab system is very simple to construct and it requires the minimum building height for a number of stories. As compared to the flat plate the flat slab is suitable for higher loads and longer spans, because of more capacity in resisting shear and hogging moments near the supports. The slab thickness varies from 125mm to 300mm for spans of 4 to 9 m. Thecast-in-situ reinforced concrete construction have following four types of floor system: -

1) Wall supported slab system
2) Beam supported slab system
3) Two way ribbed (waffle) slab system
4) Flat slab system

Component parts of flat slab are [a] Panel [b] Drop [c] Column head [d] Column strip [e] Middle strip.

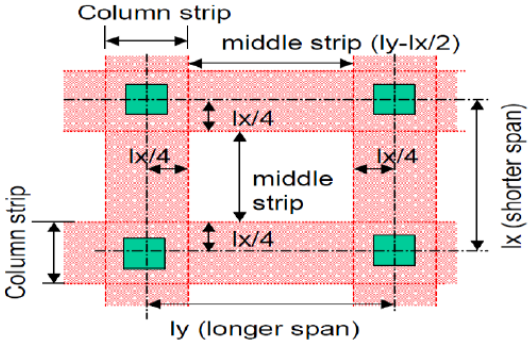


Fig:-1 Components of flat slab

Column Strip: -Strip is defined as in flat slab system some part of the slab along the column lines, it is act as flexible wide beams. The column strip is defined as the strip of slab acting as a beam along the centre line joining the columns. It has a width of (0.25 X Ly) but not greater than (0.25 X Lx) on each side of centre line. Lx and Ly are the shorter span and longer span.

Middle strip: - The middle strip is defined as the middle portion of slab between column strips. A slab suspended across flexible column strip is considered as the portion of the slab between the middle strips.

Drop Panels: - Mainly for the purpose of reducing shear stress around the column supports drops are provided, also helps in reducing the steel requirements for the negative moments at the column supports. The code says that drops should be rectangular in plan, and having length in each direction not less than one third of the panel length in that direction. The length measured for exterior panels, perpendicular to the discontinuous edge from the column centreline taken as one half of the width of drop for the interior panel. There are four types of flat slabs generally used in buildings. They are as follows

A) Slab without drop and without column head.
B) Slab with drop and without column head.
C) Slab without drop and with column head.
D) Slab with drop and with column head.

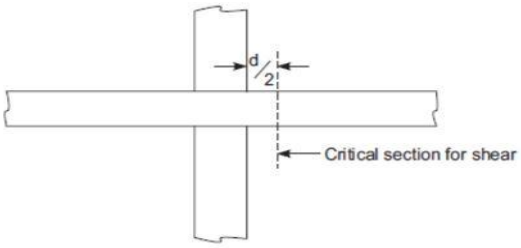


Fig: 2 Slab without drop and column head

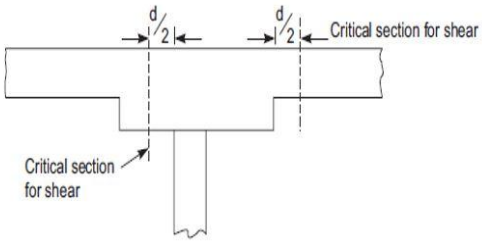


Fig: 3 Slab with drop and without column head

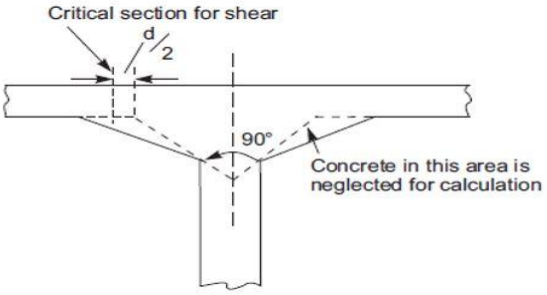


Fig: 4 Slab without drop and with column head

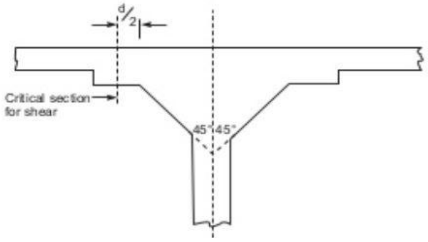


Fig: 5 Slab with drop and column head

3. STRUCTURAL SYSTEM DEVELOPMENT

3.1 Physical Data:-

Analysis of flat slab (G+7) office building with various shapes (i.e. Rectangular & Square). Sizes of flat slab are 6.8 mx6.4 m and 6.4 mx6.4 m providing with drop panel and without drop panel. Live load=3 KN/m^2 and floor finishing load=1 KN/m^2. Use M20 concrete and Fe415 steel. Flat slab is designed by using direct design method. The properties of column size, drop panel size, slab thickness taken as per the design given as per IS code. The modelling of the structure has been done by using the structural software ETABS as per the design.

3.1.1 Design Parameters: -

The following parameters are same for all models-

Grade of concrete=20 N/mm2, Grade of steel=500N/mm2, Density of concrete = 25 KN/m2, Modulus of elasticity of concrete=5000$\sqrt{Fck}$, Floor to floor height=4 m, Wall thickness=150 mm, Shear wall thickness =150 mm, Live load=3 KN/m2, Floor finish load =1 KN/m2, B230x450 mm.

Flat slab with drop: - C800x800 mm, S300 mm, D400 mm, Dead load = 7.5 KN/m2.

Flat slab without drop: - C1000x1000 mm, S400 mm, Dead load = 10 KN/m2.

MODEL 1 6.8 X 6.4 m panel with drop line plan: -

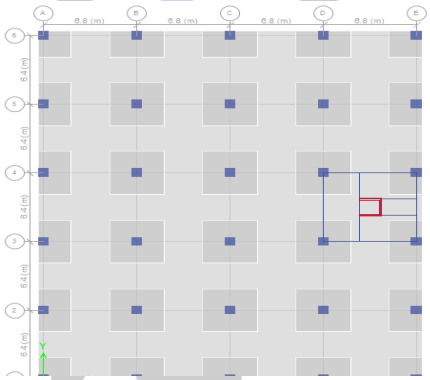


Fig 6

MODEL 2 6.8 x 6.4 m panel without drop line plan: -

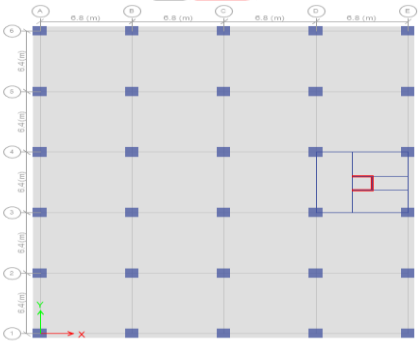


Fig 7

MODEL 3 6.4 x 6.4 m panel with drop line plan: -

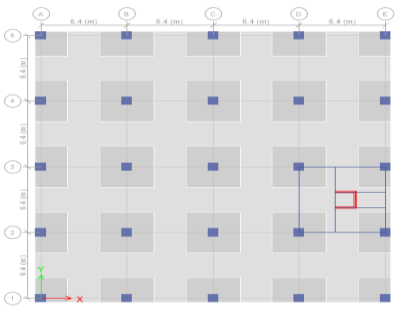


Fig 8

MODEL 4 6.4 x 6.4 m panel without drop line plan: -

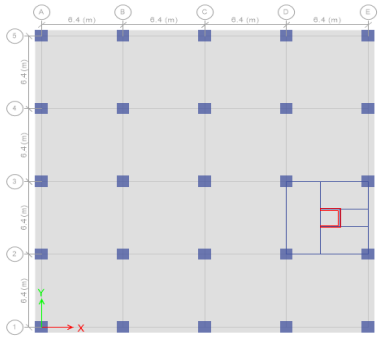


Fig 9

3.2 Static Analysis: -

By considering the Self-weight and live load on the structure Static analysis is done. The linear analysis is performed to get static results.

3.2.1 Pushover Methodology: -

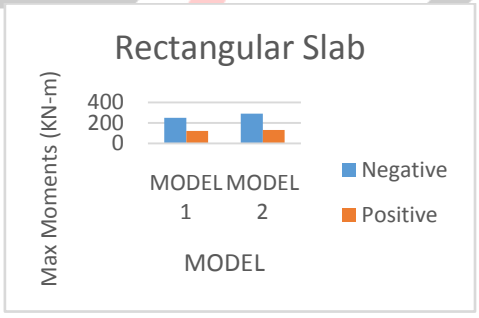
A pushover analysis is performed by increasing pattern of lateral loads, representing the inertial forces which is experienced by the structure when subjected to ground shaking. The various structural elements may yield successively under incrementally increasing loads. The structure experiences a loss in stiffness at each event successively. Using a pushover analysis, a characteristics non-linear force displacement relationship can be determined. A generalized force-displacement curve of a non-degrading frame element (or hinge properties) is carried out.

3.3 Earthquake Analysis: -

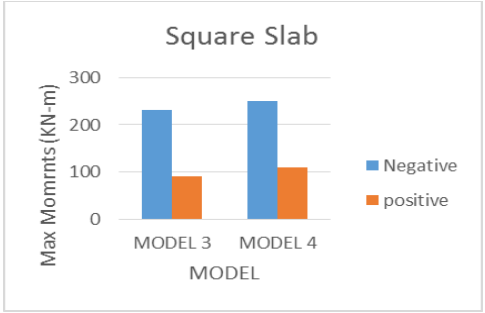
3.3.1 Seismic Co-efficient Methodology: -

It is easy to calculate the elastic stiffness of the building in the first stage of the design. It is also used to know the non-linear response from the elastic stiffness. Storey drift of RC structure caused by strong ground shaking is an important factor in earthquake resistance design. It is used to calculate the storey displacement, storey shear, storey drift verses storey height or no of storey curves. It gives the curve for maximum storey displacement verses no of stories for combination of loads & maximum storey drift verses no of stories for Drift-X.

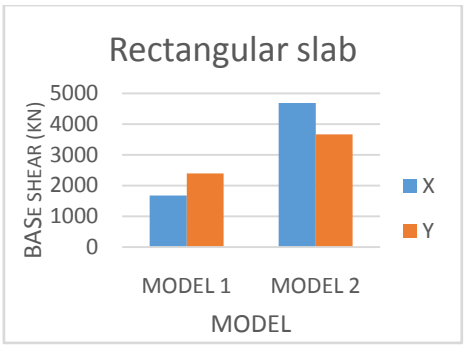
4 RESULTS



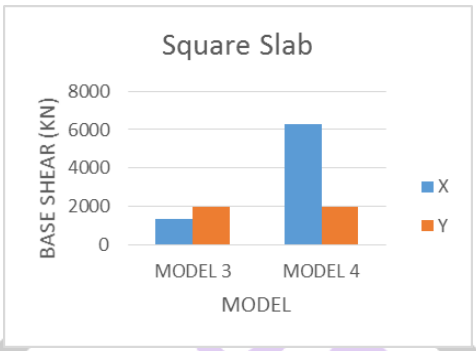
Max strip moments vs model graph for Rectangular slab



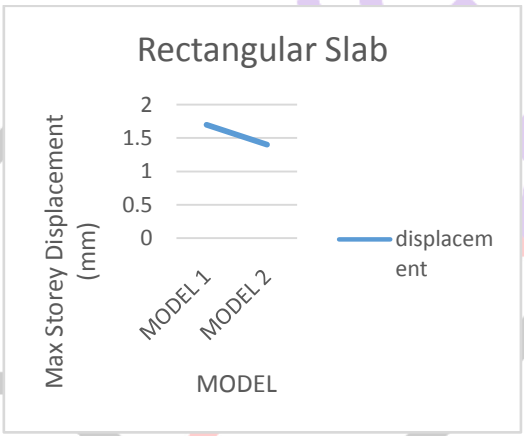
Max strip moments vs model graph for Square slab



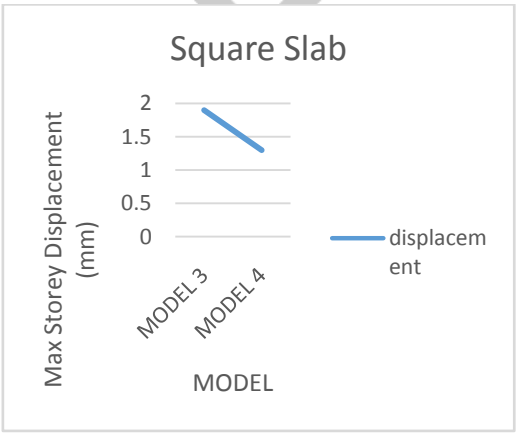
Base shear vs Model graphs for Rectangular slab



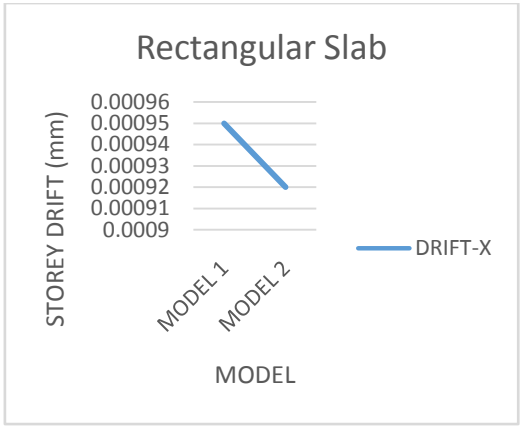
Base shear vs Model graphs for Square slab



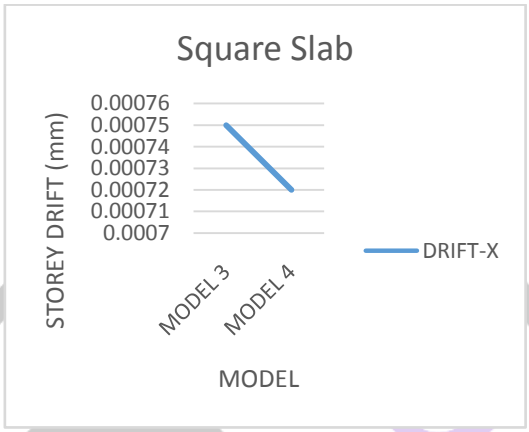
Max storey displacement vs model graph for Rectangular slab



Max storey displacement vs model graph for Square slab



Storey drift vs model graph for Rectangular slab



Storey drift vs model graph for Square slab

5 CONCLUSIONS

From the scope of present work following conclusions are drawn

- In flat slab building in both cases (manual design & software analysis) the results are satisfied for Punching Shear and Strip Moments criteria for all models.
- The Design Base Shear for zone-3 & soil type-3 is much higher in flat slab without drop as compared to flat slab with drop for all models.
- The Design Base Shear is much higher in square slab as compared to rectangular slab building.
- The Natural Period value are not having so much variation in both rectangular and square slab.
- For all models considered Storey Drift values follows a parabolic path along storey height with maximum value laying the 3rd storey for flat slab with drop building and 4th storey for flat slab without drop building.
- Storey drift values for rectangular and square slab not have much variation.
- For all cases considered Storey Displacement values follow a parabolic path along storey height with maximum value laying the 8th storey.
- Storey displacement in rectangular slab is higher as compared to that of square slab building.

Future scope for this topic

1. The project future works can be done with the analysis and design of flat slab with grid mesh model with different shapes of flat slab and analyse with Finite Element software.
2. The structure behaviour different Seismic zones and its behaviour of building having flat slabs with column head.
3. The structure earthquake analysis can be done with response spectrum method as well as time history analysis.
4. The structure can be analysed by another software also as like SAP2000.

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BIOGRAPHIES

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