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EFFECT OF SHAPE IRREGULARITY ON FLAT SLAB INDUSTRIAL BUILDING UNDER LATERAL LOADING

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Abstract - The rapid growth of the urban population needs to construct big prestigious buildings for companies and industrial purpose. The construction of multi-storey buildings and large span structures is becoming a necessary part of our living style. Construction of large span structure using flat slab system is simple to construct and also efficiently provides maximum clear height. The present objective of this work is to compare the various parameters like base shear, story displacement and story drift acting on flat slab system. With that behavior of expansion joint which is provided between existing building and industrial structure in earthquake prone region is also checked. Analysis of the large industrial structures constructed using 10m and 7m panels of flat slab for square shape and rectangular shape layout is carried out with the help of Stab software in reference with IS 456-2000 code.

Keywords-Flat slab, forces, base shear, story displacement.

I. INTRODUCTION

A flat slab is a one-way or two-way system with increasing the thickness of slab at the columns top called 'drop panels'. Drop panels act as T-beams over the supports. They increase the shear capacity and the stiffness of the floor system under vertical loads, thus increasing the economical span range. This form of construction has become popular in recent years because of the large spans of about 10 m for reinforced slabs and about 12 m for prestressed slabs. Reinforced flat slabs may need to be sensibly pre-cambered (not overdone) to control deflection.

A reinforced concrete flat slab, also called as beamless slab, is a slab supported directly by columns without beams. A part of the slab bounded on each of the four sides by centerline of column is called panel. The flat slab is often thickened closed to supporting columns to provide adequate strength in shear and to reduce the amount of negative reinforcement in the Support regions. Waffle slab construction consists of rows of concrete joists at right angles to each other with solid heads at the column (needed for shear requirements) or with solid wide beam sections on the column centerline s for uniform depth construction. Waffle slab construction allows a considerable reduction in dead load as compare to conventional flat slab construction since the slab thickness can be minimized due to the short span between the joists.

In some cases, the section of column at top, as it meets the floor slab or a drop panel, is enlarged so as to increase primarily the perimeter of the critical section. Due to which shear capacity of flat slab increases which also resists two-way shear and also reduces negative bending moment at the support. Slab of constant thickness which do not have drop panels or column capitals are referred as flat plates. The strength of the flat plate structure is often limited due to punching shear action around columns, and consequently they are used for light loads and relatively small spans.

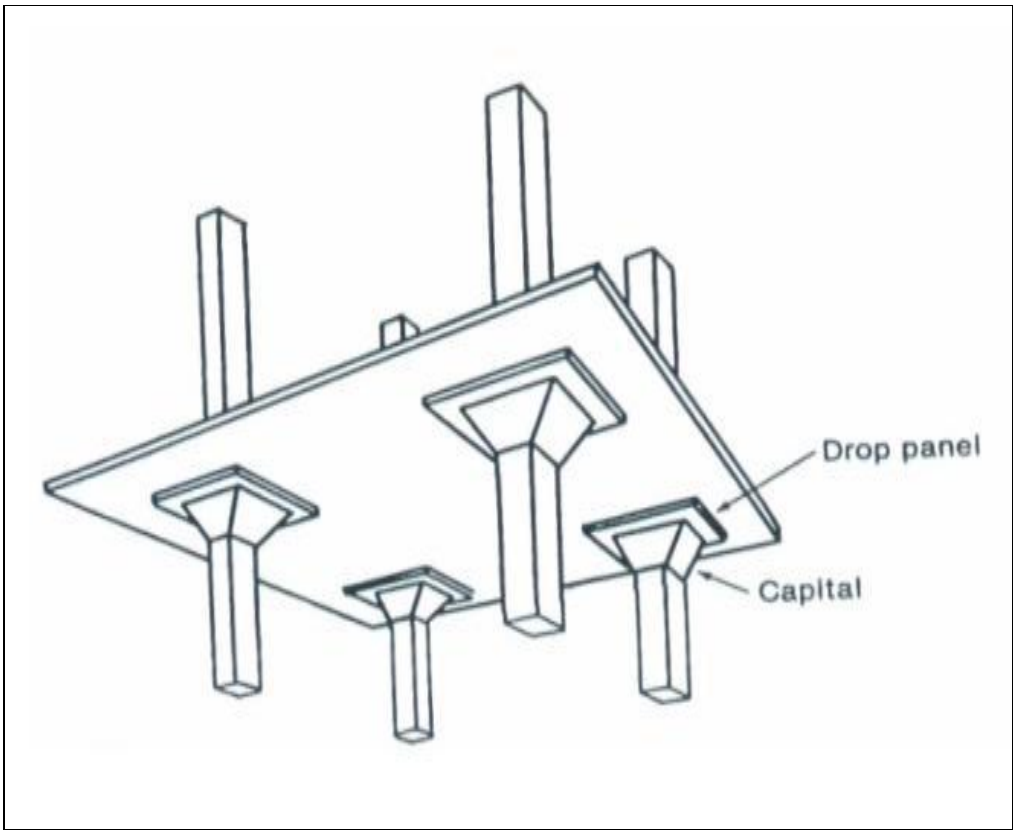


Fig 1: Flat slab with drop & column head structure

II. METHODS OF ANALYSIS

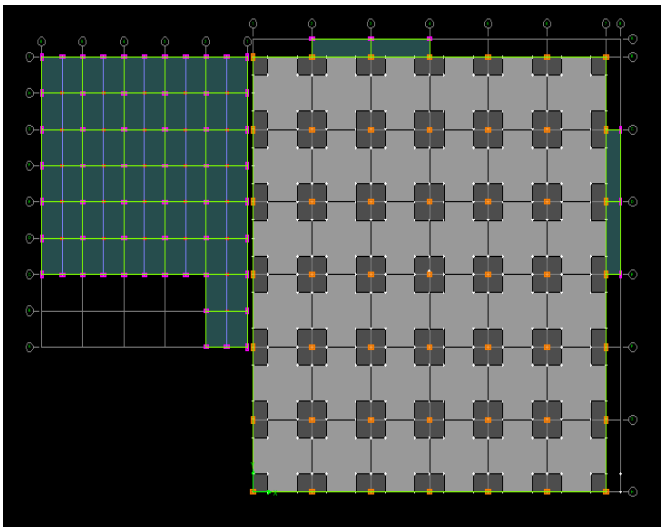
There are various methods of analysis of industrial structures such as;

1) Response Spectrum Analysis
2) Non-Linear Static Analysis
3) Linear Dynamic Analysis
4) Non-Linear Dynamic Analysis

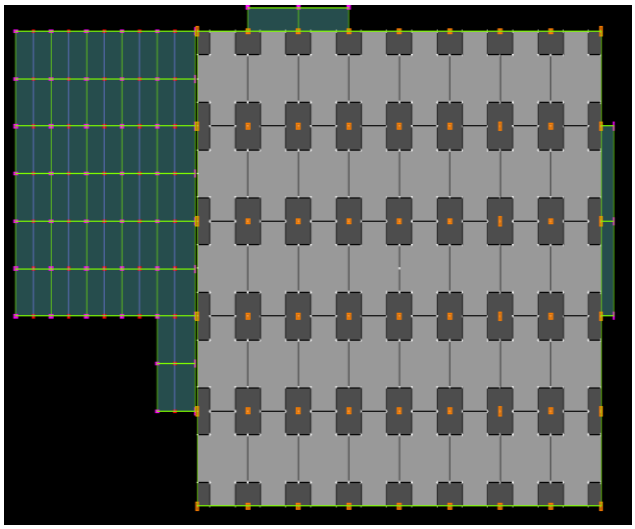
Thus in this research work response spectrum analysis is carried out for analysis using Etabs software version *9.7.3*. The analysis is carried out on four models with various configurations having square panels and rectangular panels. E combinations of these panels are as given below.

I. Model-1 = Flat slab with 10m panel size having square layout.
II. Model-2 = Flat slab with 10m panel size having rectangular layout.
III. Model-3 = Flat slab with 7m panel size having square layout.
IV. Model-4 = Flat slab with 7m panel size having rectangular layout.

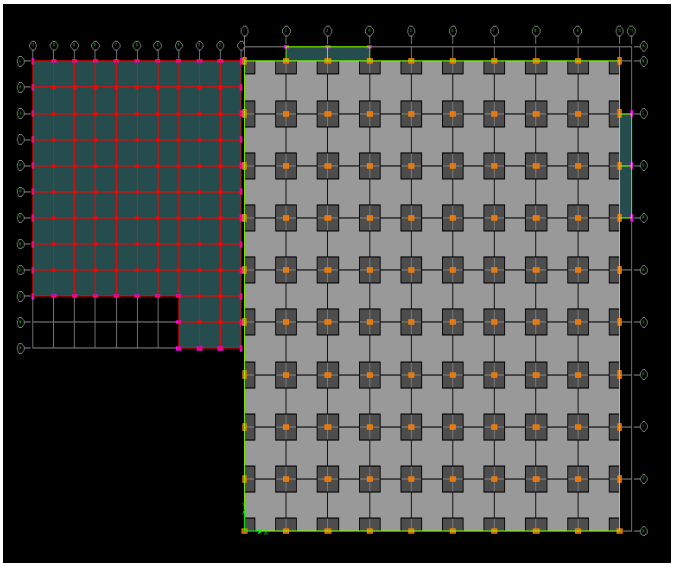
The structural configuration of these models is as shown in Fig. 2 below. Extensive research has been carried out to find out the behavior of slab-column connection. The failure mode depends upon the type and extent of loading. Punching shear strength of slab-column connection is of importance which very much depends on the gravity shear ratio. The mechanism of transfer of moments from slab to column is very complex when subjected to lateral loading and unbalance moments. These unbalanced moments produce additional shear and torsion at the connections and then get transferred into the column which results in excessive cracking of slab leading to further reduction in the stiffness of the slab.



(a) Model-1: Flat slab with 10m panel size having square layout.

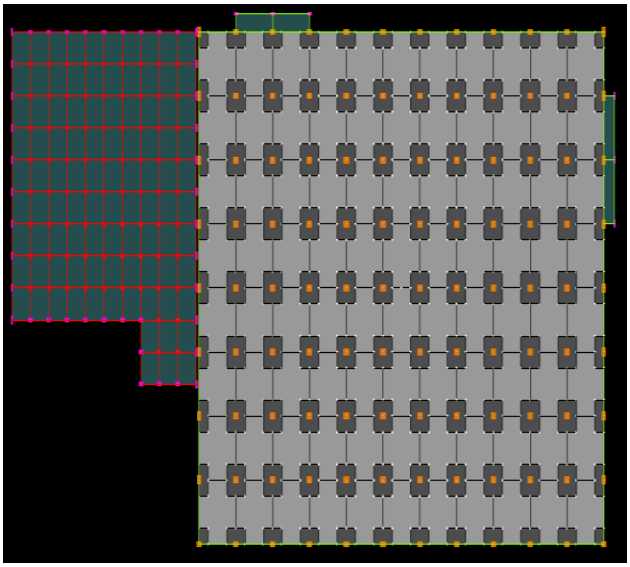


(b) Model-2: Flat slab with 10m panel size having rectangular layout.



(c) Model-3: Flat slab with 7m panel size having having

Square layout



(d) Model-4: Flat slab with 10m panel size

Rectangular layout

Fig. 2: Models used for analysis

A. Salient Features of the Building

The structural configuration of the building is as given in Table 1 below

1. Type of the structure is Industrial structure.
2. Seismic zone is taken as IV as per IS 1893(Part I):2002
3. Numbers of storeys are G+3.
5. Total height of the building above ground level is 24m
6. Each floor is 8m high.

Table 1: Details of Building

Parameters	**Panel size 10m**	**Panel size 7m**
Plan dimension	62.5m X 62.5m	64.5m X 64.5m
Floor to floor height	8m	8m
No of stories	3	3
Total height of building	24m	24m
Flat slab thickness	300mm	300mm
Drop thickness	375mm	375mm
Grade of steel	Fe 500	Fe 500
Grade of concrete	M30	M30
Column size	600X1000mm	
	350X750mm	
	300X450mm	
	300X300mm	
	300X600mm	

III. LOAD COMBINATIONS

In the limit state design of reinforced and prestressed Concrete structures, the following load combinations shall be accounted. In this analysis all the combinations of load has been used and the results obtained for worst combination is selected.

- 1.5 DL + 1.5 LL
- 1.5 DL+1.5 EQX
- 1.5 DL - 1.5 EQX
- 1.5 DL+1.5 EQY
- 1.5 DL - 1.5 EQY
- 1.2 DL + 1.2 LL+1.2EQX
- 1.2 DL + 1.2 LL - 1.2EQX
- 1.2 DL + 1.2 LL+1.2EQY
- 1.2 DL + 1.2 LL - 1.2EQY
- 0.9DL + 1.5EQX
- 0.9DL - 1.5EQX
- 0.9DL + 1.5EQY
- 0.9DL - 1.5EQY
- 1.5 DL + 1.5 RSPX
- 1.5 DL+1.5 RSPY
- 1.2 DL + 1.2 LL+1.2RSPX
- 1.2 DL + 1.2 LL+1.2RSPY
- 0.9DL + 1.5RSPX
- 0.9DL + 1.5RSPY

IV. DYNAMIC ANALYSIS

Response spectrum method is the linear dynamic analysis method. In this method the peak responses of a structure during an earthquake is obtained directly from the earthquake responses. The maximum response is plotted against the undamped natural period and for various damping values, and can be expressed in terms of maximum relative velocity or maximum relative displacement.

Response spectrum method is used for the analysis. Importance factor and response reduction factor are considered as 1 and 3 respectively. Eigen Vector analyses are used for analysis. Rigid diaphragm action is considered for analysis.

V. RESULTS AND DISCUSSON

5.1 COMPARISION OF STORY DISPLACEMENT

Comparison of story displacement between industrial structure constructed using 10m and 7m flat slab panel having square and rectangular layout is as shown below;

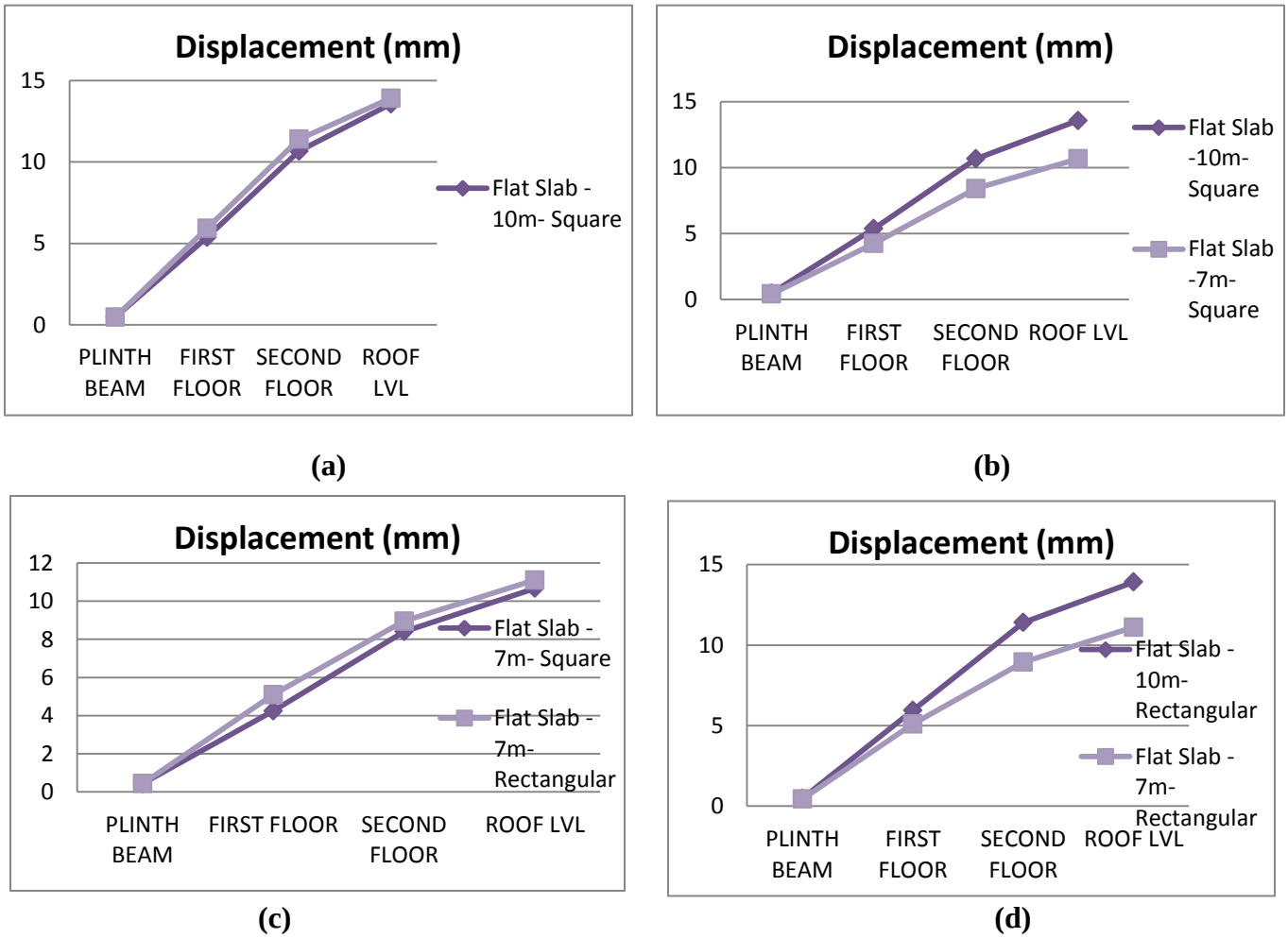


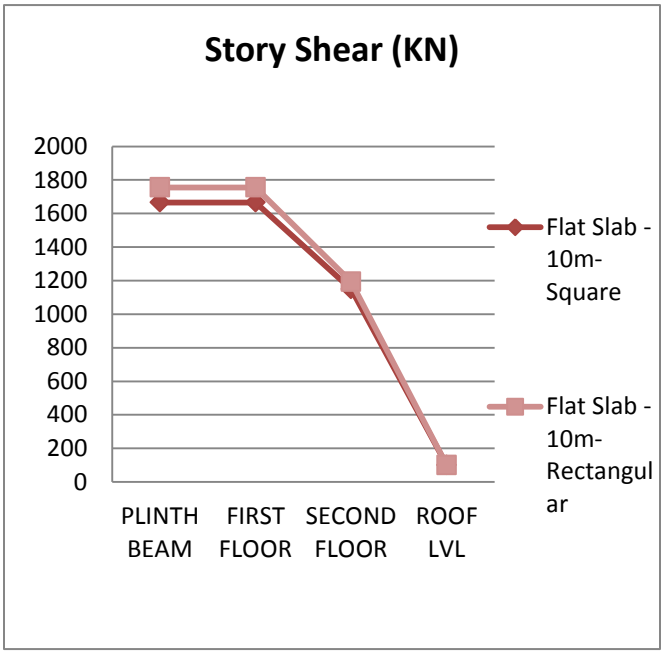
Fig 3: Load-Displacement Curve for Square and Rectangular Building

5.2 COMPARISION OF BASE SHEAR

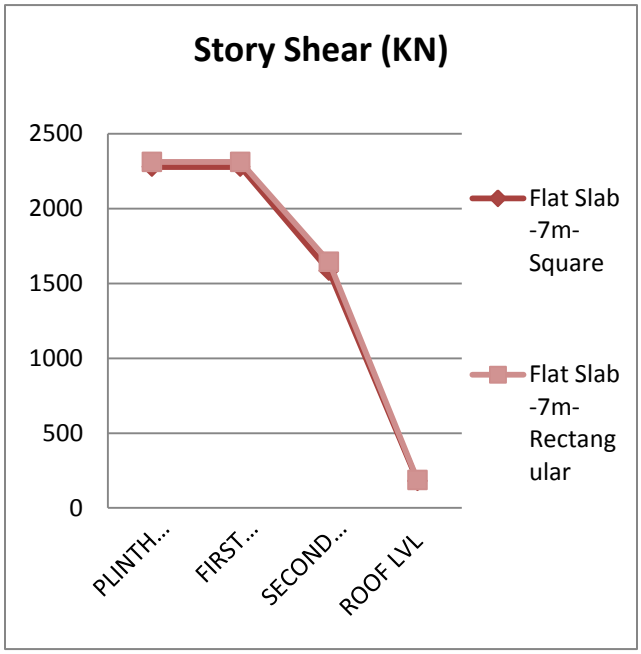
Comparison of base shear between industrial structure constructed using 10m and 7m flat slab panel having square and rectangular layout is as shown below. The total base shear is determined by the following expression;

VB=Ah **x** W

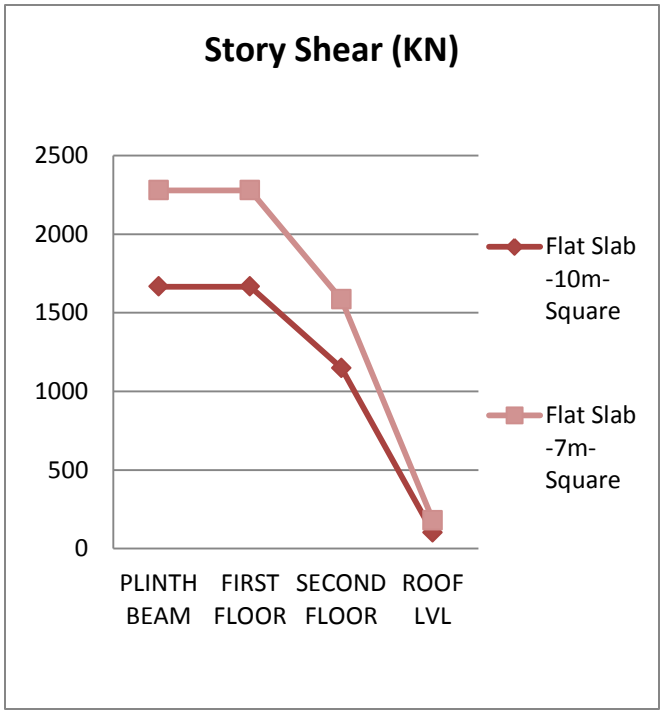
Where- Ah =Design horizontal acceleration spectrum
W= Seismic weight of the building



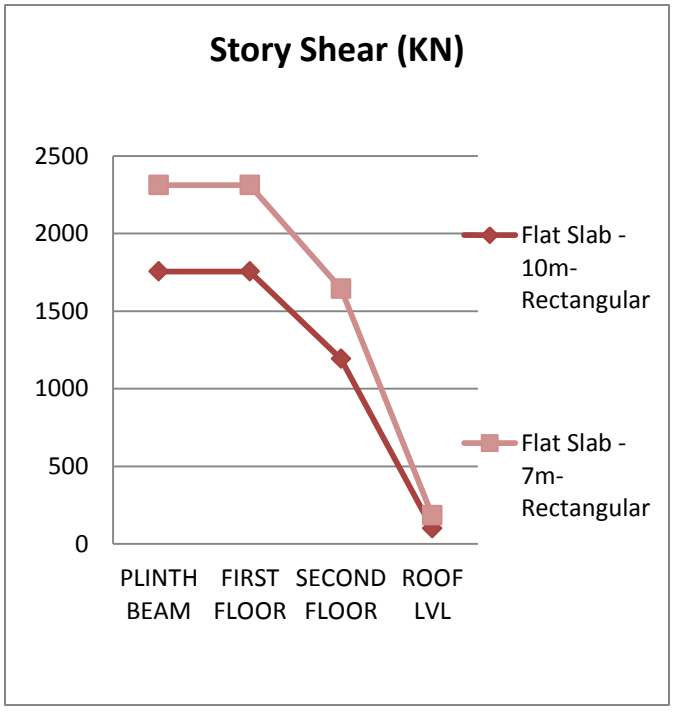
(a)



(b)



(b)



(d)

Fig. 4: Storey Shear for Square and Rectangular Buildings

5.3 COMPARISION OF STORY DRIFT

Storey drift is defined as difference between lateral displacements of one floor relative to the other floor. Total building drift is the absolute displacement of any point relative to the base. Comparison of story displacement between industrial structure constructed using 10m and 7m flat slab panel having square and rectangular layout is as shown below;

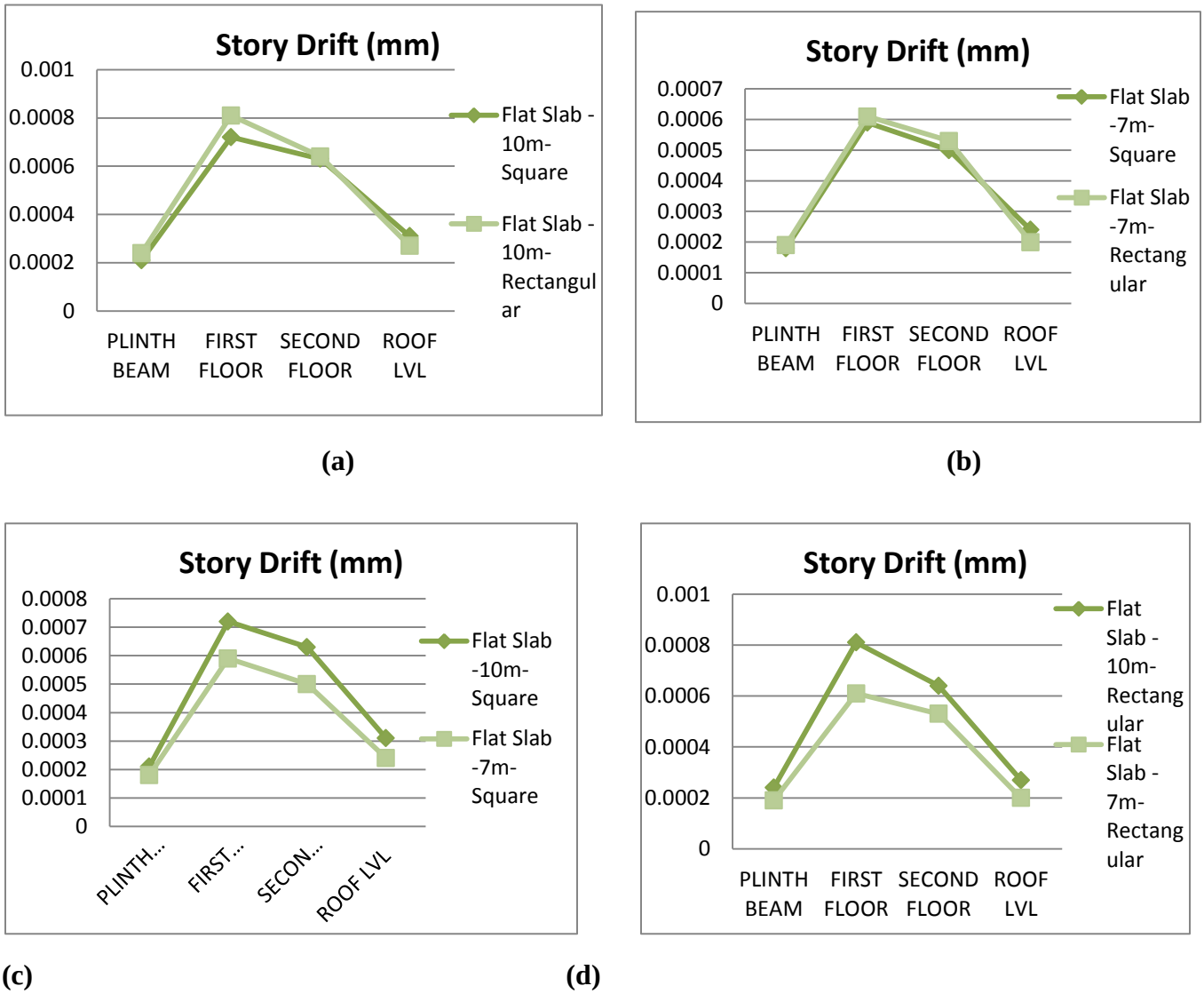


Fig. 5: Plot of Storey Drift for Square and Rectangular Buildings

VI. CONCLUSION

1) Displacement of rectangular shape layout flat slab industrial structure with 10m and 7m panel is more than the square shape layout flat slab industrial structure.
2) In both square and rectangular shape layout it is seen that displacement is more for structure constructed with 10m size panel than 7m size panel.
3) With the increase in height of structure displacement is also goes on increasing.
4) Story shear of rectangular shape layout flat slab industrial structure with 10m and 7m panel is more than the square shape layout flat slab industrial structure.

5) In both square and rectangular shape layout it is seen that story shear is more for structure constructed with 10m size panel than 7m size panel.
6) Story shear is maximum at base level and it decreases as height of structure increases.
7) It is seen that story drift is maximum at first floor i.e. at 8m from ground level.
8) Story drift of rectangular shape layout flat slab structure with 10m and 7m panel is more than the square shape layout flat slab structure.
9) In both square and rectangular shape layout it is seen that story drift is more for structure constructed with 10m size panel than 7m size panel.
10) Maximum story drift is 0.0009 mm and maximum displacement is 15 mm, hence all the structures have less displacement and story drift than 50 mm.

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