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Comparison between the seismic variation of conventional RC slab and flat slab with a drop for G+15 storey building in different zones using etabs software

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ABSTRACT

Every year thousands of buildings are damaged and collapsed and thousands of people become homeless due to the natural calamity Earthquake, which occurs with intensities not less than 3 on the seismic scale. In the present era, the low rise to high rise buildings is constructed due to limited space. Once, this earthquake occurs, its effects these structures most. Huge property loss and human loss occur. In order, to control this some precautions and codes for seismic-resistant building construction are assigned by various countries. In India, IS 1893-2002 provides the rules and precautions for various types of building construction that is seismic resistant. Buildings such as Conventional RC Frame structures are common in practice .but due to highly advanced technologies, beamless slab called Flat slab is in use these days. T Hough flat slab possess many advantages over conventional buildings when dealing with seismicity, the flat slab is far less potentially strong to resist for seismic conditions. In the present work the comparison of Conventional building and Flat slab with Drop in different zones, using ETABS software. Therefore, the characteristics of a seismic behavior of Flat slab and Conventional RC frame building measures for guiding the concept and design of these structures and for improving the performance of buildings during seismic loading. In Present work, a good amount of information regarding parameters such as Storey Displacement, Storey Shear, Overturning Moment, and Storey Drift for Flat Slab and Conventional Slab is provided and its variation of these parameters in different zones is also detailed.

Keywords: *Overturning moment, storey displacement, storey drift, Storey shear*

1. INTRODUCTION

Urban areas due to the scarcity of space vertical construction have developed such as low-rise, medium –rise and high rise buildings. These types of buildings utilize frame structures as Conventional RC frame structure and Flat slab frame structure. Conventional RC frame structure possesses Conventional slab used for the construction that accomplishes a system where a slab is supported by beam and beam supported by column. This may be called as Beam –Slab Load Transfer method, a technique that is common practice all over the world. The other form of frame structure called Flat Slab, where slab directly rests on the column. This is also called as Beamless Slab as there would be no beams in this frame structure. In multistory shopping malls, offices, warehouses, public community halls the esthetic view is improved by using Flat Slab in place of the conventional slab. The usage of Flat slab for residential buildings is also in practice provided span not more than 6m. Both conventional and flat slab frame systems are subjected to vertical as well as lateral loads. Lateral loads have an effect on buildings such as the height of the building increases, the effect of lateral load increases. The effect of Lateral loads is much stronger than vertical loads. These Lateral loads include Wind loads and Seismic loads. The Lateral forces tend to sway the building frame. As such building frame tends to act as a cantilever. Many seismic prone areas, the buildings are prone to collapse if construction is not abode by proper measures. All these studies make to study the effect of earthquake loads as important. A different earthquake occurs with different intensities, magnitudes at different places. It is quite essential, to study various seismic aspects such as story displacement, base shear etc. Seismic Analysis is, therefore, necessary to study the seismic response of building, the design of building without seismic analysis is not preferred especially in earthquake-prone zones.

2. CONVENTIONAL SLAB

Slab supported on walls or beams is called Conventional Slab. Conventional slabs are generally rectangular in shape, but they also occur any irregular shape such as triangular, circular, trapezoidal etc. Loads transferred by flexural, shear and torsion to slabs. The conventional slab can be one-dimensional slab or two-dimensional slab. If the length of the slab is quite larger than the width of slab then it is said to be a one-dimensional slab. L/B >2 for one dimensional slab. If the L/B<2 then it is called two-dimensional slab.

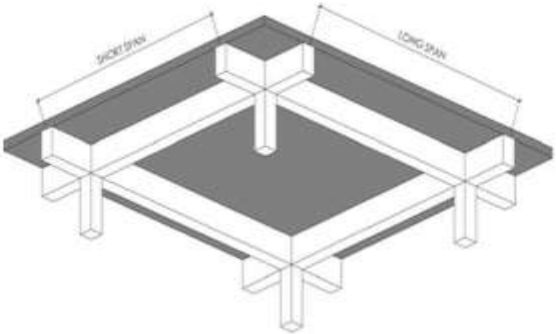

Fig. 1: Conventional slab

3. FLAT SLAB

In general frame, the system consists of columns, beams, and slab. But there is a way of undertaking a construction without beams, the frame system consists s of slab and columns only. This type of slab is called Flat Slab. The flat slab is reinforced by re-bars, thus forming RC slab with or without a drop, generally retained by columns and slab.

Components of the flat slab are as following,

- Column head
- Drop

3.1. Column heads

Generally, in Flat Slab, the columns are supported with the head of wide enlargement called column head or capitals. Column head resists against the negative moment that is transferred to column from a slab-column junction.

3.2. Drop

The thickened part of the slab above columns the heavy loads on the column is called Drop. It provides resistance to Punching shear which is predominant at the junction of column and slab.

Flat slab buildings are significantly more flexible than the conventional RC frame buildings during earthquakes. The Flat slab thus satisfies Architectural demand by some highlighting features such as better illumination, simple formwork and maximum vision with the optimum use of available space hence leading to an admired concept in the field of Structural Engineering.

3.3. Types of flat slabs

a) A flat slab having drop panel
b) A flat slab having column head
c) A flat slab having drop panel and column head
d) Flat slab without having drop panel and column head

In the present project, case a) Flat slab having drop is considered.

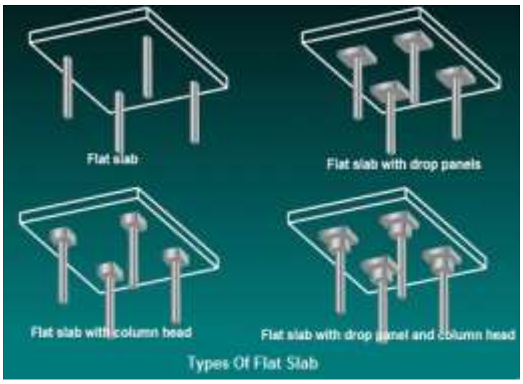

Fig. 2: Various types of flat slabs

3.4 Advantages of flat slabs over conventional slabs

3.4.1. Flexibility in the layout of the room

Flat Slabs satisfying architectural demand eases architect work and simplifies it to the maximum by the provision to introduce partition walls were ever needed, allowing to adopt the type of layout of the room as per owner's requirement. There is a benefit that ceiling height is omitted and finish soffit with the skim coating.

3.4.2. Decreases the height of the building

Since false ceiling height is omitted, the height of the building is lowered, thus the storey height is decreased than storey height of the conventional building. This decrease in storey height further reduces building weight on slabs due to cladding and less no .of partitions. Thus total load on foundation gets reduced to approximately 10% in building height of vertical members is decreased.

3.4.3. Shorter construction time

In Flat slab, usage of big table formwork shortens the time taken for construction.

3.4.4. Use of prefabricated welded mesh

Prefabricated welded mesh minimizes the installation time and therefore its usage in Flat slabs makes Flat slab more quickly constructed than conventional RCC slab. Further, these meshes are available in standard size thus providing better quality control of flat slab than Conventional RC slab.

3.4.5. Less no.of workers –less construction cost

The construction of Flat slab includes standardized structural members and prefabricated sections in design thus reducing the number of site workers and increasing quality and quantity of work at the site. This eases the construction and achieves the higher buildable score.

4. LITERATURE REVIEW

4.1. S. D. Bothara et.al studies discuss the comparative study of the earthquake on flat slab & Grid floor system. Grid slab consisting of beam spaced at regular intervals in perpendicular directions, monolithic with slab, whereas Flat slab does not consist of beams. A comparative study gives how flat slab is more feasible than Grid slab.

4.2. A. B. Climate study is focused on the behavior of corner slab-column connections with structural steel I- or channel-shaped sections (shear heads) as shear punching reinforcement using dynamic table taking results of the effective width of the flat slab. The result consists of the Flat slab with 1/2 scale test model supported on four box-type steel columns the results focuses on that flat slabs subjected to several seismic simulations of increasing intensity. The test results proved that effective width varies directly proportional to the intensity of the seismic simulation. There is a limitation, which strain reversal takes place due to adherence between reinforcing steel and concrete during an earthquake. Variation in stain and strain reversals finally resulted in a difference in values of effective width from that in the literature thus attributing to the stiffness of steel structure in the flat slab in earthquake-prone areas.

4.3. M. A. Eebrik has focused on the comparison of Flat-slab RC buildings conventional RC slab building seismic conditions. The study showed that the structural effectiveness of flat-slab construction is hindered during earthquakes. This results showed fragility analysis could not be undertaken under seismic conditions though Flat slab is used the structural system. This study focuses slabs on the derivation of fragility curves and comparison made with those in literature for a moment –resisting curves that conclude that flat slab shows similarity to that in literature for small-medium height buildings and varies as height increases.

4.4. M. A. Eebrik study focuses on compatibility between various seismic zones for flat slab RC frame structure using inelastic response history method and design ground movement method. The fragility curves obtained for the flat slab in different seismic zones are compared to that with moment resisting curves. The results a similarity between Flat slab fragility curves obtained in observation and in literature.

4.5. M. A. Eebrik detailed about the comparative study of loss estimation analysis between Flat slab RC frame structure and Conventional RC frame structure, results showed a difference and variation of behavior and response patterns of between above frame systems. The fragility information of flat-slab structures was presented using software HAZUS. The program includes many existing structural types, except flat-slab structures. Since, fragilities already available in software HAZUS by the implementation of this software, the difference in response to earthquake scenario by Flat slabs from that of other structural frames would be established.

4.6. U. Gupta et.al study focuses on flexibility of Flat slabs when compared to traditional RC wall structures, and design of these Flat slab building in seismic regions. The study presents usage of shear walls as resistant to flexibility under seismic conditions for Flat slabs as well as traditional RC wall structures.

5. BUILDING DETAILS

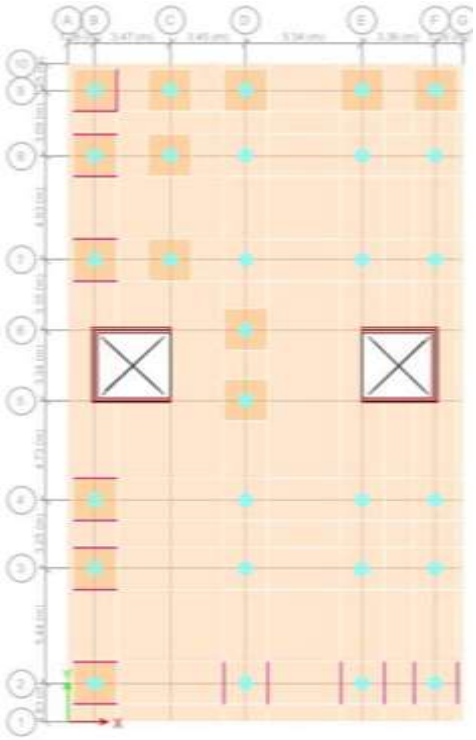

Fig. 3: Plan View of a flat slab

Table 1: Building Model Detailing

Design Data Of Building	Dimensions
Plan Dimensions	18.14 m x 31.21m
No. Stories	16(G+15)
No. Of Grids In X-Direction	6Grids
No. Of Grids In Y-Direction	9 Grids
Thickness Of Slab	165mm
Typical Storey Height	3m
Base Storey height	3.5m
Grade Of Concrete	M20
Grade Of Steel	Hysdfe415
Circular Column Diameter	600mm
Wall Size	230 Mm
Column Strip Size	0.7x0.7m
Middle Strip Size	1.55x1.55m
Thickness Of Drop	200 Mm
Drop Dim	2mx2m
Column Size	230x400 Mm
Beam Size	230x500 Mm

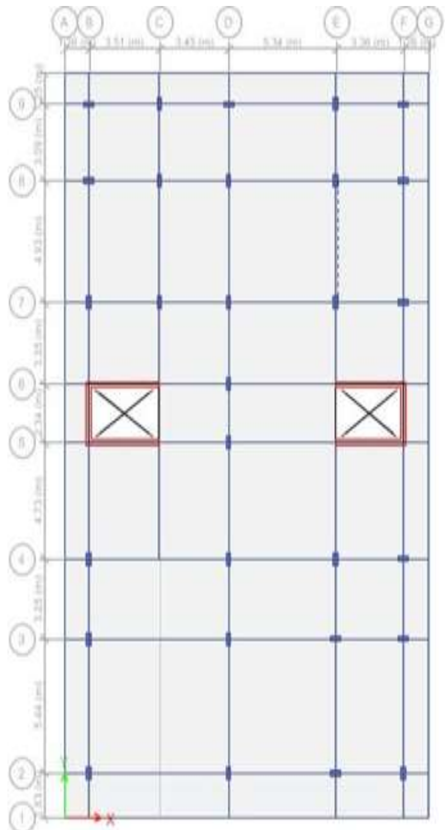

Fig. 4: Plan view of a conventional slab

6. ETABS

ETABS is a structural analysis software.ETABS expands as "Extended Three Dimensional Analysis of Buildings Software", especially to carry out the response of building structures in seismic prone areas. As traditional book system of analysis could not be applied to tall building structures, software developed in computers has solved this problem too a long way. Moreover, in present competitive and fast developing world, computers became mandatory as each and every manual work gets simplified using computers that includes designing of buildings.

Steps to be considered in tabs

6.1. Plan

PLAN of the building is drawn in AUTOCAD and imported to ETABS. Grid System is followed to reproduce plan in ETABS.

6.2. Defining of material

Table 2: The materials required for reinforced concrete building are given details.

Type Of Material	Concrete
Code Standard	IS 456-2002
Mix Of Concrete	M20
Reinforcement Type	Rebar
Grade Of Reinforcement	FE -415 HYSD BARS

6.3. Defining of loads

Table 3: Defining of various types of loads as per code

Definition of load	Load type	Coefficient factor	Code standard followed
Dead Load	Dead	1	IS 875-1987 Part 1
Live Load	Live	0	IS 875-1987 Part II
Wind Load	Wind	0	IS 875-1987 Part V
Seismic Load	Seismic	0	IS 1893-2002

6.4. Defining of load combinations

1.2(DL+LL+EQX)
1.2(DL+LL+EQY)
1.2(DL+LL+EQX+EC)
1.2(DL+LL+EQY+EC)
1.2(DL+LL+EQX+WL)
1.2(DL+LL+EQY+WL)
1.5(DL+LL)

DL=Dead load, LL=Live Load, EQX=Earthquake Load in X-axis, EQY=Earthquake Load in Y-axis, EC=Eccentricity

6.5. Steps were taken in modeling a building plan

a) New > Open New Model
b) Define > Define Materials Required
c) Draw > Draw the Structural Members –Columns, Beams.
d) Define > Load Patterns
e) Define > Load Combinations
f) Select > Slab Sections > Slab 125
g) Assign > Shell Loads >DL>LL > EQX> EQY
h) Analysis > Check Loads For Warnings
i) Analysis > Set Loads To Run
j) Display > Display Deformed Shapes
k) Display> Storey Plots
l) Design > Concrete Frame Design

7. SEISMIC ZONES IN INDIA

In INDIA there are majorly 4 zones as per IS 1893-2002

a) ZONE II
b) ZONE III
c) ZONE IV
d) ZONE V

Places that come under various zones in India (as per is 1893-2002):

7.1. ZONE V

Entire Northeastern India, some parts of Jammu and Kashmir, Some parts around the Himalayan region that includes Himachal Pradesh and Uttaranchal, Western side of India including Gujarat till Ran of Kutch, Northern Bihar and Union Territory of India such as Andaman and Nicobar Islands are the places under ZONE V that experience very severe seismic vibrations when compared to remaining zones in India.

7.2. ZONE IV

Zone IV includes Northern India From Jammu and Kashmir to Maharashtra and some regions that spread from west-eastern side of India namely northern part of Uttar Pradesh ,National Capital Territory –Delhi ,Bihar ,West Bengal ,Sikkim and some parts of Maharashtra near western coast of Rajasthan that are the places subjected to severe seismic conditions next to zone V in India.

7.3. ZONE III

ZONE III covers almost middle part of India extending to four corners below and above Vindhya Mountain region Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa and also zone II spreads to Southern India such as Andhra Pradesh, Tamil Nadu, Karnataka, Kerala where seismicity is milder than those places in zones V and IV but not least . It comes under moderate seismic prone areas.

7.4. ZONE II

ZONE II covers remaining parts of the country where seismic vibrations are mildest and least of all four zones in India. Therefore, since earthquake effects are moderate in zones III and IV we are considering in the present project about the earthquake effects in zones III and IV only. In zone V earthquake occurrence is most, but there more than 10(G+9) stories are not constructed. Hence in present project ZONES, II III AND IV are only taken into consideration in present topic.

8. TYPES OF SEISMIC ANALYSIS

IS 1893-2002Code based procedure for seismic analysis.

a. Equivalent Linear Static Analysis
b. Response Spectrum Analysis
c. Time History Analysis

In the present study, we consider the equivalent linear static analysis

8.1. Equivalent Linear Static Analysis

This method is also called as Seismic Coefficient Method. Design dealt with seismicity, loads must be considered dynamic in nature. However, seismic analysis by the equivalent linear static method is simple and sufficient for a low rise to medium rise buildings. Many codes provide this method. It deals with calculation of base shear and its distribution on each storey , applying the formulae taken from the codebook. In Equivalent linear static analysis method, there will be no consideration of lateral torsion modes, but the only first mode in each direction is considered. This method, is much for a low rise to moderate rise buildings, whereas for tall buildings (height of 75m and above) where torsion modes of second and higher modes are required this method is quiet, not suitable.

8.1.1. Design base shear as per equivalent linear static analysis

As per code IS **1893:2002**

Design base shear in principal direction shall be designed by the following expression;

The expression for Design Base Shear: VB= AH X W (1)

AH= Design horizontal acceleration spectrum value obtained using fundamental natural period T, considered in direction of vibration, W= Seismic weight of the building as per code IS 1893-2002.

As per clause 6.4.2 of IS 1893-2002:

$$Ah=Z/2 \times I/R \times Sa/g \quad (2)$$

Z=Zone Factor and given as z=0.1, 0.16, 0.24. 0.36 for zone II, zone III, zone IV, and zone V respectively.

I=Importance Factor which depends upon the purpose of Structure that is built depends such as a residential building or commercial complex. Its value is taken from the table -6 of IS 1893-2002

R=Response Reduction Factor, that is affected by the type of resistance material used for retaining of building against seismicity. It's value obtained from the table -7 of IS 1893—2002

Sa/G=Average Response Acceleration Coefficient Which Is Obtained From Graph.

Table 4: Various zones division as per seismic intensity variation

Seismic severity	Low	Moderate	Severe	Very severe
ZONES RELATED	ZONE II	ZONE III IS 1893-2002	ZONE IV	ZONE V

Table 5: Seismic zone factors and values considered as per code

Equivalent linear static analysis terms	Values taken from code is 1893-2002
Zone factor	0.1-Zone Ii,0.16 –Zone Iii,0.24 – Zone 1v
Importance factor	1
Response reduction factor	4-zoneII,III,IV
SOIL TYPE	I, II, III

9. RESULTS AND GRAPHS

9.1 Storey displacement

Story displacement is also called Lateral Displacement or Sway of the building. It is defined as Displacement taken in the Lateral direction of building due to seismic load and wind load that acts in Lateral direction on the building. Sway is directly proportional to height and slenderness of structure that is storey displacement increases as the height of building increases. Storey displacement is least at base and highest at the top storey as the height of structure increases. From the above fig., it is said that storey displacement of the flat slab with the drop gradually increases with height but less than that of the storey displacement of the conventional slab (two-way slab) building. Storey displacement of the flat slab is more than conventional slab by0.33 percent.

Storey Displacement of flat Sslab and conventional slab for 1.2(DL+LL+EQX) In X-Direction. In Zone II, Zone III And Zone IV For Soil Type I (In mm) is given as figure 5, 6 and 7.

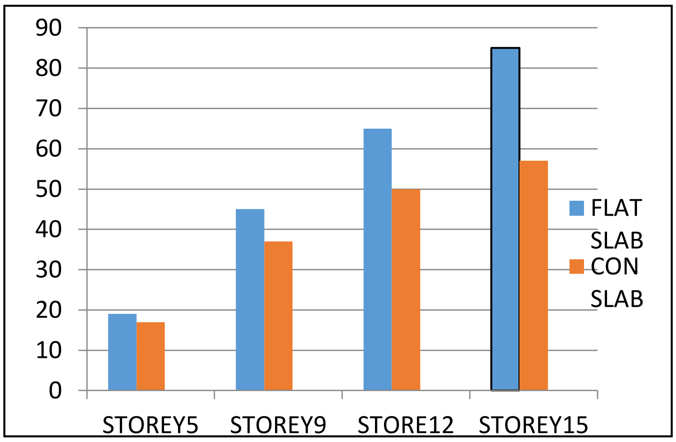

Fig. 5: Storey Displacement Graphs Between Flat Slab And Conventional Slab In ZONE III

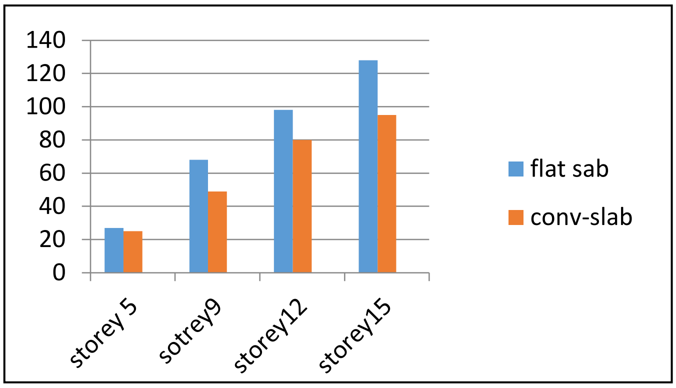

Fig. 6: Storey Displacement Graphs Between Flat Slab And Conventional Slab In ZONE IV

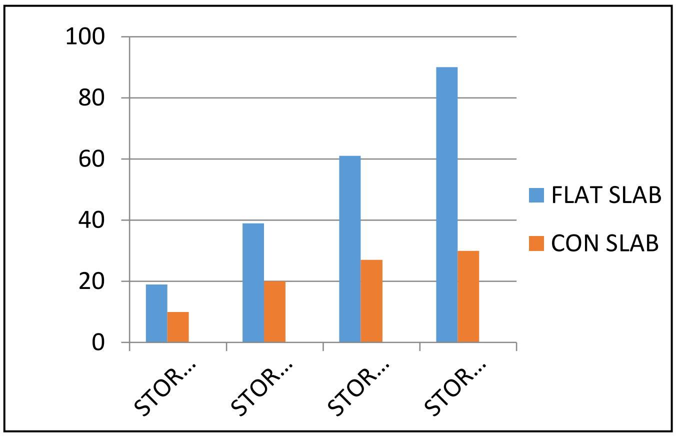

Fig. 7: Storey Displacement Graph Between Flat Slab And ConventionalSLAB In ZONEII

9.2. Storey shear and base shear

A sum total of reactive forces obtained due to the action of seismic forces on building act at column base of building in the direction opposite to that in which they act (sum of the lateral load = base shear). As considered it does not only act on base, indeed it acts on every story and varies with height and masses over every story and this reactive force is called as Storey Shear. Here, from above graphs clearly represents that Flat slab exhibit more value of the variation of storey shear than Conventional slab as storey shear flat slab is more at the base and decreases continuously towards top storey 15.Storey shear of the flat slab is 25.3 percent more than the conventional slab.

Storey shear for flat slab and conventional slab for load combination For 1.2(DL+LL+EQX) In Zones Iii and Zone IV of Soil Type I. In X-Direction (In Newton) is given as follows.

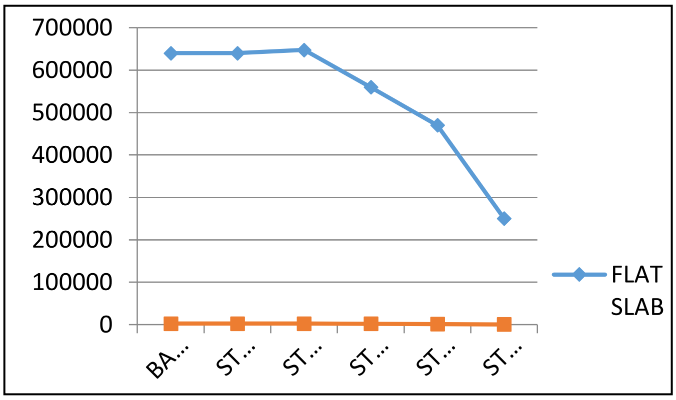

Fig. 8: Storey shear graph between the flat slab and conventional slab in ZONEII

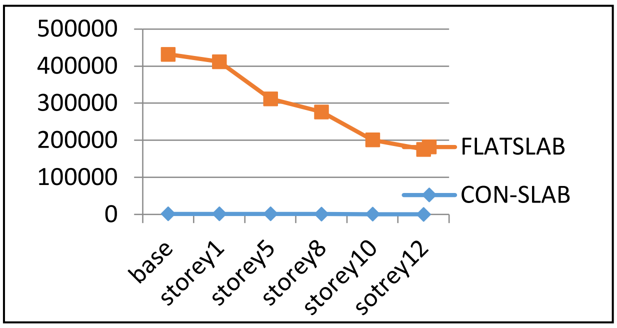

Fig. 9: Storey shear graph between the flat slab and conventional slab in ZONE III

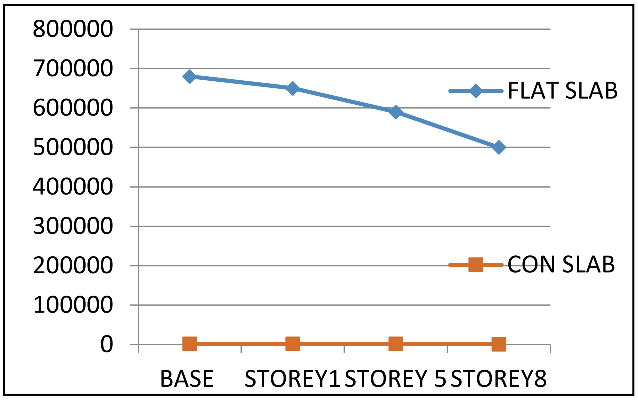

Fig. 10: Storey shear graph between the flat slab and conventional slab in ZONE IV

9.3 Overturning moment

Overturning moment varies inversely of the square of the height of the building. The overturning moment is highest at the base and decreases with increase in height of the building.

The overturning moment for flat slab and conventional slab in Zone II, Zone III and Zone IV for Soil Type I In X-Direction for Load Combination 1.2(DL+LL+EQX) In KN-M is given as follows:

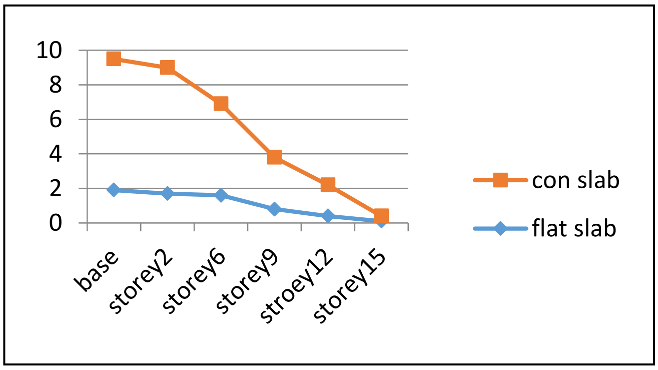

Fig. 11: Overturning moment graph between the flat slab and conventional slab in ZONE II

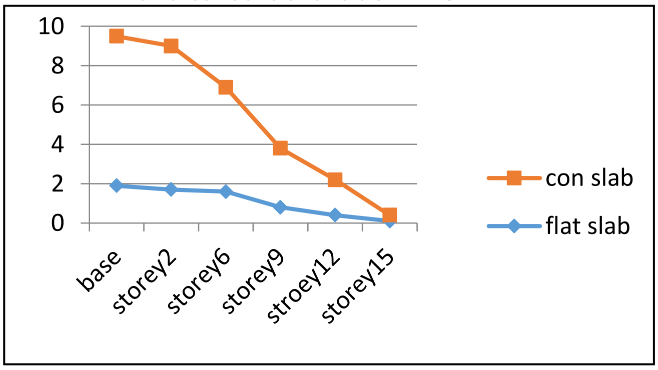

Fig. 12: Overturning moment graph between the flat slab and conventional slab in ZONE III

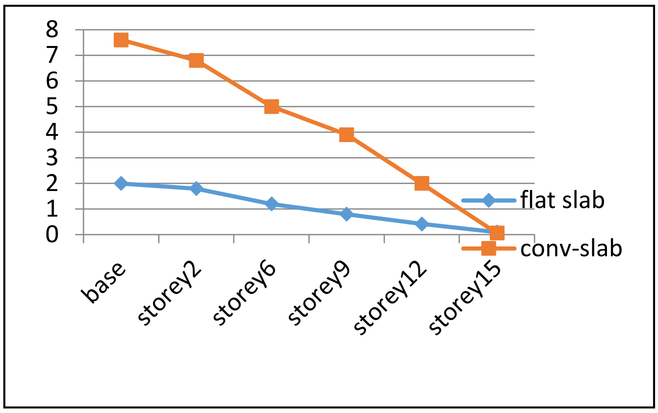

Fig. 13: Overturning moment graph between the flat slab and conventional slab in ZONE IV

9.4. STOREY DRIFT

Storey Drift is nothing but the ratio of displacement taken place between two consecutive floors to a height of that the building. It is also defined as the Lateral Displacement of a single storey that occurs in the multistory building. Story drift varies as parabolic path and assumes maximum at some storey in middle but not at the topmost storey.

Storey drift for flat slab and conventional slab for Zone II, Zone III, and Zone IV for soil Type I for load combination 1.2(DL+LL+EQX) is given as follows:

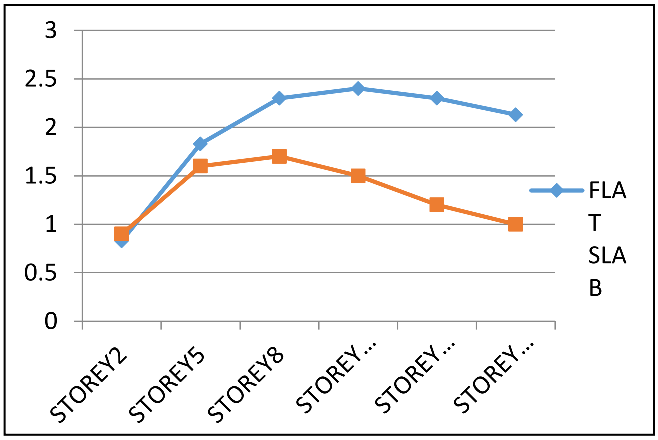

Fig.-14: Storey drift graph between the flat slab and conventional slab in ZONE III

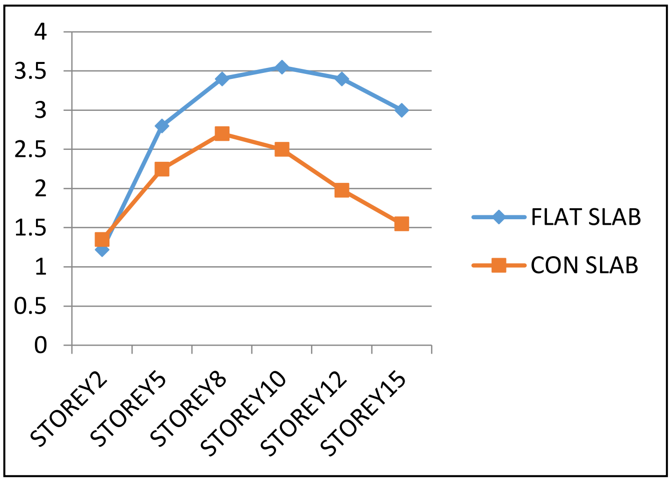

Fig.-15: storey drift graph between the flat slab and conventional slab in ZONE IV

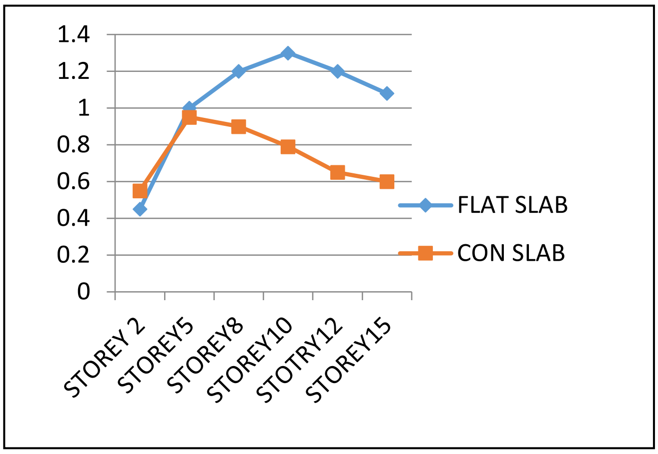

Fig. 16: Storey drift graph between the flat slab and conventional slab in ZONE II

10. CONCLUSION

The summary of the project is a comparison of the conventional building with flat slab building in seismic zones for soil type I.

From above Graphs it is concluded as below:

1. Storey displacement varies directly with a height of the building and increases with increasing height of the building. Flat slabs exhibit more values of storey displacement than that of Conventional RC slab. Storey Displacement values of the Flat slab are more than that of the Conventional slab by o.33 percent.
2. Storey shear varies inversely as the height of building .it's value decreases as the height of building increases and is highest at the base at least at top storey . From fig's it can be seen that storey shear of the flat slab is higher than that of conventional slab almost 25.3percent.
3. Overturning moment varies inversely as the square of height and is maximum at the base of the slab. Overturning moment of the Conventional slab is higher than the Flat slab. Overturning moment of the conventional slab is 0.26 percent more than the flat slab.
4. Storey Drift varies as a parabolic path with increases of stories. The storey drift of flat slab is more than that of the conventional slab by o.615 percent.
5. A flat slab having drop and column head provides a reduction of large shear force and negative bending moment and thereby reducing loss due to the seismic condition.

In general, Flat slabs are more flexible than Conventional slabs under seismic conditions and resistant to seismic conditions can be imparted by the provision of drop and column head or by imparting shear walls.

11. SCOPE OF THE WORK

1. Comparison of a flat slab having a drop with flat slab without drop can be done for different seismic zones
2. Comparison between pre-tensioned and post-tensioned for Flat slabs having Drop with Flat slab without drop can be done.
3. Comparison of cost of construction and estimation of cost and loss analysis of various types of structures can be done.

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