A Thesis on

P-DELTA ANALYSIS OF FLAT SLAB AND R.C. FRAMED BUILDINGS

Submitted for partial fulfillment of award of

MASTER OF TECHNOLOGY

IN

Structural Engineering

By

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Under The Supervision of

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DECLARATION

I **Kanchan Gupta** declare that thesis **"P-Delta analysis of flat slab and R.C framed buildings"** submitted by me in the partial fulfillment of the requirements for the award of the degree of Master of Technology (Structural Engineering) of Integral University, Lucknow. The thesis is record of my own work carried under the supervision and guidance of **Md Tasleem, Assistant Professor, Department of Civil Engineering, Integral University, Lucknow.**

Further I declare that this is not previously formed the basis of the award of any degree, diploma, associate-ship or other similar degrees or diplomas, and has not been submitted anywhere else.

Date:

Place: Lucknow

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CERTIFICATE

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*Certified that the thesis entitled **"P-Delta analysis of flat slab and R.C framed buildings"** is being submitted by **Ms. Kanchan Gupta** (Roll No: 1801431007) in partial fulfillment of requirement for the award of degree of Master of Technology in Structural Engineering of Integral University, Lucknow, is a record of candidate's own work carried out by her under my supervision and guidance.*

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree or diploma.

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The satisfaction and euphoria on the successful completion of any task would incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crowned my effort with success. Though the work here presented is without any doubt fully my own, the support I got from many people was nevertheless necessary. These people have earned a special place within my mind and heart. I am grateful to the Department of Civil Engineering, **Integral University Lucknow.** for giving me the opportunity to execute this research work, which is an integral part of curriculum in **Integral University Lucknow.**

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I am indebted to Almighty God for the constant support.

DATE: KANCHAN GUPTA
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ABSTRACT

Common practice of design and construction is to support the slab by beam and beam is supported by column. This type of construction is called beam column construction. But in flat slab design we are constructed without beam i.e. the beam reduces the available net clear ceiling height of building. Two-way slab directly rests on column known as flat plates, in flat slab building formwork is simple as compare to normal slab (that means slab rest on beam column frame building) and reinforcement layout are also simple and storey height decreases. In flat slab building check second order effect (second order effect known as P-Delta effect). Current international design codes impose limits on the P-Delta ratio, which appear to have been set to ensure a minimum reloading stiffness during cyclic response and with due consideration for the likely ductility demands imposed on structures. Whilst the current code limits may be reasonable for normal height structures, it is argued that the code limits should be reconsidered for tall buildings owing to limited displacements that real earthquake ground motions impose on such buildings. In the present work The second order effect is the additional action in the structure due to the structural deformation by virtue of the applied loads which is also known as P-Delta effect. The P-Delta is a non-linear effect that occurs in every structure where elements are subjected to axial load. In slender columns or high rise structures, P-Delta effect becomes more significant. In the design of high rise buildings with vertical irregularity, it is very much important to examine whether the second order P-Delta effects are significant. This project consists of 6 building models with 10, 20, and 30 storey height of building for conventional slab modal and 10, 20, and 30 storey height of building for flat slab modal and analysed with and without P-Delta. In this model, zone V are taken as seismic zone and compared the effects of storey drift, storey displacement and overturning moment of each individual model with and without the effects of P-Delta.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Flat slabs system of construction is one in which the beams used in the conventional methods of constructions are done away with. The slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. To support heavy loads the thickness of slab near the support with the column is increased and these are called drops, or columns are generally provided with enlarged heads called column heads or capitals. Absence of beam gives a plain ceiling, thus giving better architectural appearance and also less vulnerability in case of fire than in usual cases where beams are used.

In general normal frame construction utilizes columns, slabs & Beams. However it may be possible to undertake construction without providing beams, in such a case the frame system would consist of slab and column without beams. These types of Slabs are called flat slab, since their behavior resembles the bending of flat plates. A reinforced concrete slab supported directly by concrete columns without the use of beams.

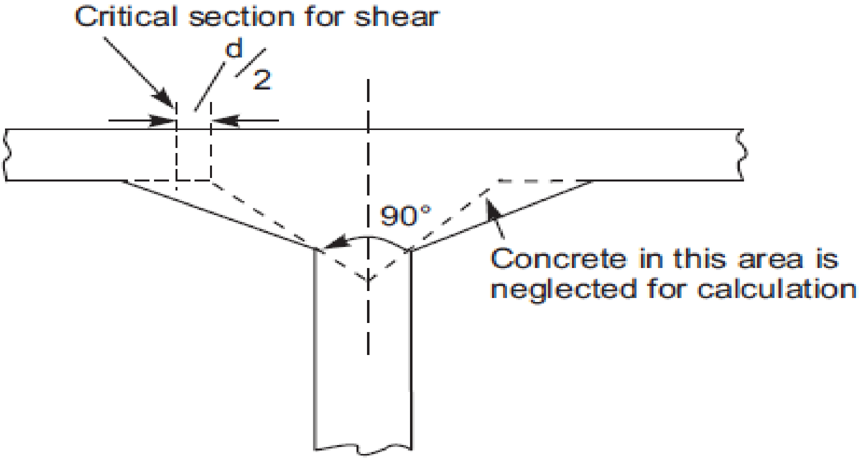
1.2 TYPES OF FLAT SLAB

Flat slabs can be classified as per the slab column junction. There are four types of flat slabs are

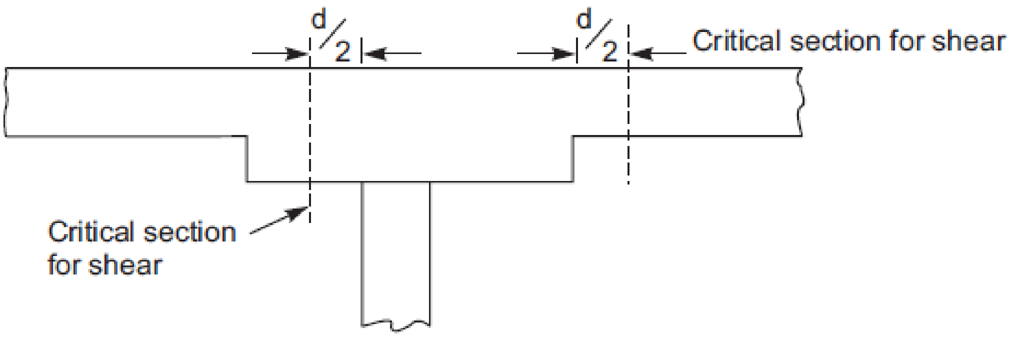
Commonly used in buildings. They are as follows

- Slab without drop and column with column head
- Slab with drop and column without column head.
- Slab without drop and column with column head.
- Slab without drop and column head.

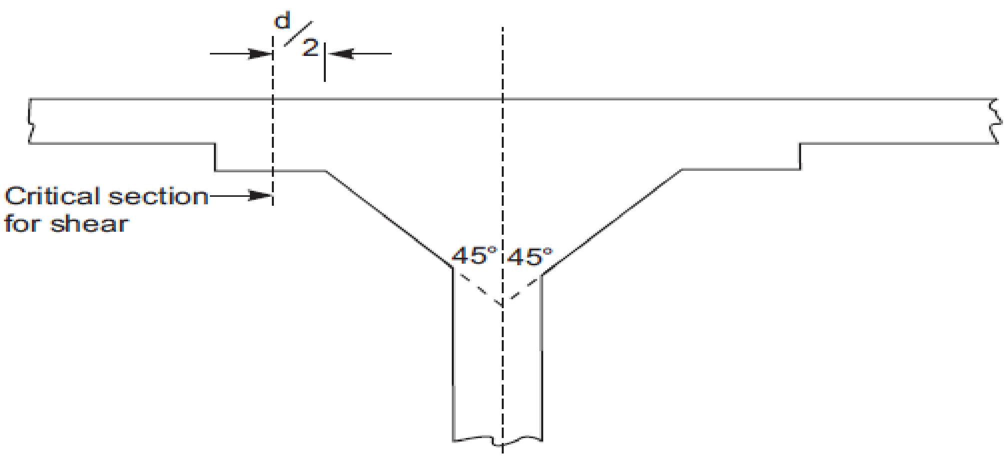
The Various Flat Slabs Are Shown In Fig-1.1.



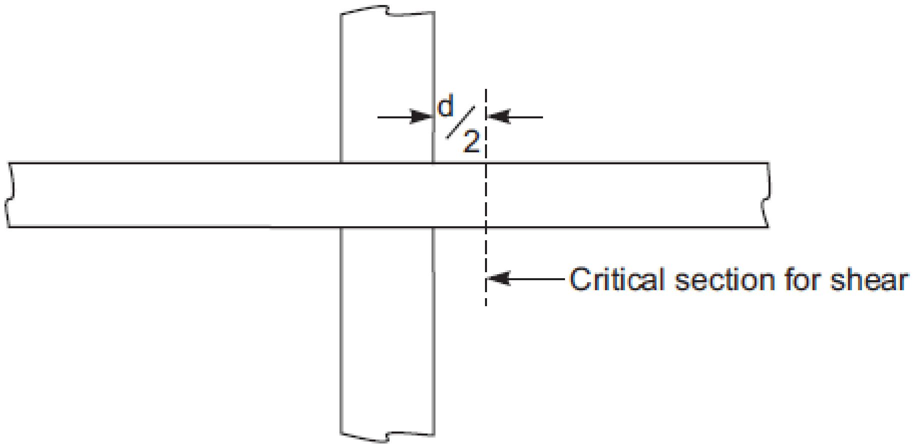
(A) Slab without Drop and Column with Column Head



(B) Slab with Drop and Column without Column Head



(C) Slab without Drop and Column With Column Head



(D) Slab without Drop Column Head

FIG 1.1: Slab with Various Drop Panels [36]

1.3 DIFFERENT COMPONENTS OF FLAT SLAB BUILDING

The main portion of interest in the flat slab building is the slab column junction. To ensure the safety drop panels and column heads are provided. The drop panel and column heads enhance the punching shear strength and increase the moment carrying capacity of the slab.

1.3.1 Uses of Column Heads

- Shear strength of flat slab is increased by using column heads.
- Column heads reduce the clear or effective span, and therefore, reduce the moment in the flat slab floor.

1.3.2 Uses of Drop Panels

- Drop panels increase the shear strength of flat slab floor.
- Drop panels increase flat slab's negative moment capacity.
- Drop panels reduce deflection by stiffening the flat slabs.

1.4 ADVANTAGES OF FLAT SLAB

- The layout of the building part like room, kitchen, are more flexible.

- The building height of flat slab building is more as compare to conventional building due to. Low story height.
- Time in construction of flat slab building is less.
- Fitting of electrical and mechanical devises are very easy.
- Welded mesh can use in flat slab building to increase the speed of construction

1.4.1 Flexibility in Room Layout

- Partition walls can be placed anywhere.
- Offers a variety of room layout to the owner.
- False ceilings can be omitted.

1.4.2 Prefabricated Welded Mesh

- Prefabricated Standard sizes
- Minimize installation time

1.5 BEHAVIOR OF FLAT SLAB BUILDING DURING EARTHQUAKE

The performance of flat slab building under seismic loading is poor as compare to frame structure due to lack of frame action which leads to excessive lateral deformation. In flat slab building the most vulnerable part is slab column joint. Extensive research has been done to find out the behavior of flat 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. Punching failure of flat slab can occur as a result of transfer of shearing force and unbalanced moment between slab and column.

The behavior and design of flat slab plat structure for gravity loads are well established. Transfer of lateral displacement induces moment at slab column connection which is of complex three dimensional behaviors. Due to the flexibility of flat plate building, they must be combined with a stiffer lateral force resisting system in high seismic regions. When flat slab is used in combination with braced frames, shear wall for lateral load resistance, the column in building can be designed for only 25% of the design seismic force.

1.6 TYPES OF ANALYSIS

1.6.1 Dynamic Analysis

- Dynamic linear analysis.
- Dynamic nonlinear analysis.

1.6.2 Static Analysis

- Static linear analysis.
- Static nonlinear analysis.

1.7 DYNAMIC ANALYSIS

Dynamic analysis is an analysis of the structure subjected to dynamic loads. Loads such as wind load earthquake load, traffic, blasts, comes under dynamic loading. Inertia forces are developed in a structure when the dynamic loading is subjected to it. Response of a structure can be analyzed by dynamic analysis if load varies rapidly with respect to time.

1.7.1 P-DELTA ANALYSIS

Generally, when building structures are subject to major earthquakes, large displacements and strains are made. The rise in internal1 forces and displacements due to the effects of vertical loads of second order acting on a laterally displaced system is commonly referred to as P-Delta. The P-Delta is generally acknowledged Effects can help reduce buildings ' seismic efficiency.

Currently, engineers usually use linear elastic static (first order) analysis to evaluate model axial forces and bending moments resulting from structural loads. The study of the first order assumes a small deflection behavior; the resulting axial forces and bending moments do not take into account the additional effect due to the lateral deformation of the structure under a given load. Second order analysis incorporates two factors in order to find a solution:-Large displacement theory; the resulting forces and moments take full account of the effects due to the deformed shape of both the structure and the system.

Stress stiffening the effect of component axial loads on structural stiffness, tensile loads, and compressive forces softening the element. As the building becomes more slender and less resistant to distortion, it is essential to consider the second order and to be more detailed, the P-Delta effect occurs. As a result, Codes of Practice refer engineers more and more to the use of the second order test to make P-Delta and pressure stiffen Effects shall be taken into account as necessary in the project. This is as true in the design of concrete and wood as it is in the development of steelworks.

The use of the geometric rigidity matrix is a general methodology to include secondary effects in the static and dynamic study of all types of structures. For sample, in building investigation, the lateral drive of the mass of the story to a deformed position is produced generates second-order overturning moments.

Numerous approaches find the problematic to be one of geometric non-linearity and suggest iterative solutions that can be mathematically inefficient. Therefore, these iterative methods are not suitable for vibrant analysis where the P-Delta effect allows the length of vibration to be extended.

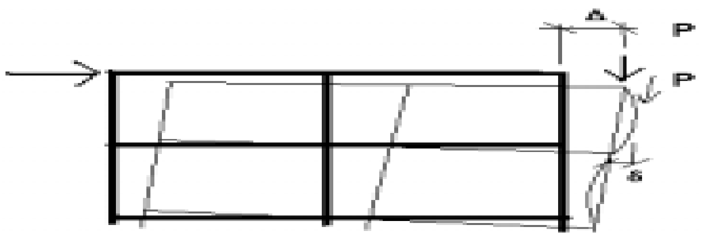


Fig.1.2: Illustrates the P-Delta effect in the framed structure [6]

P-DELTA EFFECTS ON BUILDINGS

When the seismic lateral loading acts on the building, causing it to deflect, the gravitational loading on the lateral deformed structure can increase the lateral displacement of the building. The second order effect of vertical loads acting on a laterally displaced system is referred to as the P-Noise effect, where P is the maximum vertical load, and A is the lateral displacement relative to the surface. Figure 3.2 demonstrates the P-noise effect on the SDOF device. The P-Noise effect refers to the weight of the structure. P, going through the displacement, A, creating a moment at the base of the PA-equal structure. The maximum moment at the base of the structure, M, is given,

$$M= HL+P\Delta$$

Where, H= the equivalent lateral force at the top of the structure

L = the height to the centre of mass,

P = the gravity load,

Δ= the lateral relative displacement.

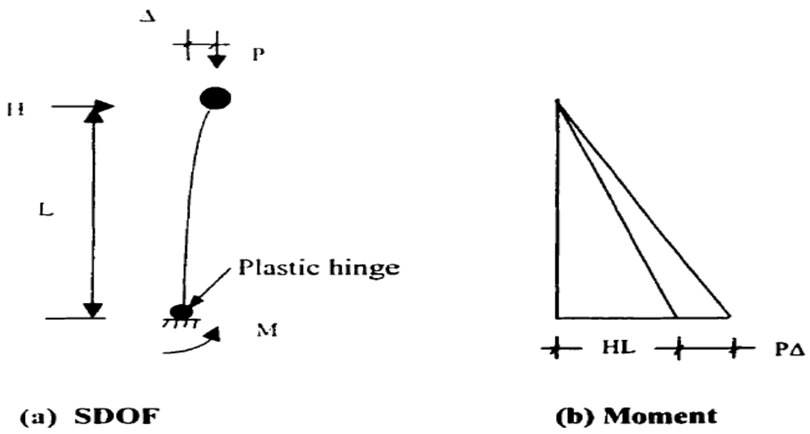


Fig. 1.3: P-Delta Effect on a SDOF System [6]

As the displacements increase, the P-Delta second at the base of the structure increases. This P-Delta moment can also significantly have an impact on the response of a structure, occasionally causing an expand in the maximum displacement. In low-rise structures, P-Delta outcomes are often small ample to be neglected. However. In taller buildings, the P-Delta results turn out to be greater massive due to the fact the structures tend to be slender and the lateral! Defections might also be plenty larger. In an excessive case of a very flexible shape with large gravity loading, the gravity loading acts on such a massive deformed structure so that P-Delta outcomes underneath seismic excitations arc severe enough to provoke collapse. Thus, it is necessary to investigate whether or not the second-order outcomes are enormous and have to be taken into account in design.

1.7.2 RESPONSE SPECTRUM ANALYSIS

It is a linear but dynamic analysis in which peak response of a structure subjected to earthquake loading is analyzed or in other word response spectrum analysis (RSA) is a linear-dynamic statistical analysis way which measures the contribution from each natural mode of vibration to indicate the expected maximum seismic response of a necessary elastic structure.

1.7.3 TIME HISTORY ANALYSIS

Is step wise analysis of the dynamic response of a RC structure to a particular loading that may changes with changes of time And the time history analysis is used to determine the seismic response of a building under dynamic loading of representative earthquake is a nonlinear dynamic analysis which is used to analyze structure when the response is nonlinear. From the Time history analysis we can know the dynamic response of structure for a specific loading that may changes with time.

1.7.4 BASE SHEAR

The amount of maximum lateral force because of seismic ground motion at the soffit or base of the structure is base shear, its horizontal movement of base of the structures, it depends on following factors:

- Condition of soil on the site
- Closeness to potential sources of seismic activity like geological faults.
- Probability of significant seismic ground motion due to earthquakes.
- Total weight of Building.
- Period of the vibration.

1.7.5 STOREY DRIFT

The word "Drift" can be defined as the lateral displacement of the structure, Storey drift is the slower and small movement of one level of a multilevel building relative to the level below. Inner storey drift is the difference between the floor and roof displacements of any given story as the building sways during the earthquake, marked by the story height, more is the storey drift will cause more damages to the structures, its value should not be beyond the limit 0.004h, where (h) is height of the building.

1.8 STATIC ANALYSIS

A static structural analysis determines the stresses, displacements, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects, static analysis is are those analysis which are on rest. I have did only seismic analysis for grid and flat slab, further work will be done latter.

1.9 PROBLEM BACKGROUND

The construction of multi-level structures has increases worldwide in these years, as we know with increase in the height of the building possibility of damages are more, to overcome this problem we can use flat slab to decrease the height of each floor of multi storey building, having the same number of floor but less height than normal slabs , including this advantage of flat slab there is architectural, aesthetic and more other advantages of flat slab over normal slab.

1.10 OBJECTIVE OF STUDY

The main objectives of the proposed research study are summarized as follows:

- To perform P-Delta analysis on conventional R.C. building & flat slab R.C. Building using ETABS software.
- To study the effect of earthquake loading on conventional R.C. building & flat slab R.C. Building using ETABS software.
- Study the result of displacement on conventional R.C. building & flat slab building by considering P-Delta effect and without P-Delta Effect.
- Study the result of drift on conventional R.C. building & flat slab building by considering P- delta effect and without P-Delta Effect.
- To decide the minimum height of building for which it is necessary to include, P-Delta effect in analysis.

CHAPTER-2

LITERATURE REVIEW

2.1 GENERAL

Common practice of design and construction is to support the slab by beam and beam by column. This may be called as beam-column construction. The beam reduces the available net clear floor height. In flat slab building flexibility of building should be increases. Seismic response of flat slab building has been a subject of discussion since many decades. A lot of research work has taken place in this addressing all relevant issues pertaining to the modeling, analysis and construction of flat slab structures. Literature survey for seismic safety, pushover analysis and time history analysis of flat slab building has also been covered.

2.2 REVIEW OF RESEARCH DONE IN PAST

Wajdi J. Baniya et.al (2020) "Behaviour of Composite pre-flat Slabs in resisting punching shear forces" For all composite pre-flat slab referring to numerical and experimental results, the relative deflection index was calculated by failure load over the deflection for each experimental and numerical specimen. The numerical maximum deflection was 19% higher over the experimental. Bent bar Vertical shear reinforcement indicated higher resistance of punching shear compared of those have closed stirrups. Epoxy bonding materials increases the slab resistance to vertical deflection.

Josef Hegger et.al (2020) "Contribution of concrete and shear reinforcement to the punching shear resistance of flat slab" The use of post-installed shear reinforcement increases the punching strength as it raises the failure criterion; moreover, it also enhances the ductility. The efficacy of the strengthening is lower when performed on loaded slabs; nevertheless, this problem can be overcome using headed bolts and applying pre-stress in shear reinforcement. Flexural strengthening is performed by gluing FRP or casting BRCO on the top of slabs. The first affects only the load-rotation curve, while the latter affects both the failure criterion and the load-rotation curve.

Ala torabian et.al (2019) "Behaviour of Thin lightly reinforced flat slabs under concentric loading" The current research aim to study the behaviour of thin reinforced concrete (RC) slabs under concentrated loads as well as to investigate the application of critical shear crack theory (CSCT) to such slabs. He check punching shear according to ACI 318 and EURO code 2 and find the punching failure through shear reinforcement.

Atif Zakaria et.al (2019) "To study comparison of seismic performance of RCC building with ribbed slab and grid slab" They considered models in this study was OMRF frame with shear walls in addition to adopting 4, 6, 8 numbers of the storey by using ETABS software for analyzing and design, the followed analysis methods was Equivalent static method, response spectrum, and time history. The criteria for assessment are storey drift, base shear, time period, storey shear and axial force in columns. They concluded that, the appropriate selection of the slab system plays an important role in the structure stability against the both of lateral and gravity forces, In OMRF building shear wall takes the immense percentage of the base shear and the storey shear. Approximately above 95% from the load would be withstood by shear walls, when the total height of the structure increases the base shear, displacement, Storey shear and drift increases simultaneously.

Ahmad sada dheeb et.al (2019) "Deterministic Wind load dynamic analysis of high rise steel buildings including P-Delta Effects"Objective of this work determine the deterministic wind load dynamic analysis of high rise steel building including P-Delta effects. Results show that the effects of P-Delta on the dynamic response of tall buildings with 20 storey heights or more must be added dynamic analysis.

M .deephti et.al (2019) "Behaviour of P-Delta Effect in High- Rise Buildings with and Without Shear Wall" The work deals with behaviour of P-Delta effect in high rise buildings with and without shear wall. Displacements of conventional building models without P-Delta is less when compare to building with P-Delta and storey drift also max. in case of P-Delta effects. And shear wall placed at centre of frame shown more effectiveness when comparing with shear wall placed at corner and without shear wall of the structure.

Marcos Honorato Oliveira et.al (2019) "Tests on the Punching resistance of flat slabs with unbalanced moments"The work examines the experimental tests on the punching resistance of flat slabs with unbalanced moment. He did eight tests on slab column connection with concentric and eccentric loading and found that slab without shear reinforcement, the transference of unbalanced moments significantly affected the cracking pattern and failure occur in unbalanced moments.

A Naga Sai et.al (2018) "Seismic and Wind effect on High Rise Structure using ETABS"The work deals with seismic and wind effects on high rise structure using ETABS. Found the displacement value in Zone II, Zone III, Zone IV, Zone V and concluded that reinforcement percentage increase as we consider seismic and P-Delta effects. When we considered shear wall then wind effects, seismic effects, and P-Delta effects on the structure reduced.

Dr. A.K. Jain et.al (2018) "found that comparative study of flat slab with perimeter beams & conventional slab structures under seismic conditions" In this study, ETABS software is used for the analysis of different structures in Indian seismic zones III, IV and Having 10, 12 and 15 storeys. The models taken in this study have Rectangular and L shape configurations. The conclusion of this study was if we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed maximum reaction increases by an amount of 20% and 25% respectively in both Conventional and Flat Slab structures having Perimeter Beams. When we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed maximum storey displacement increases approximately by an amount of 24% and 30% respectively along X and Y direction in both Conventional and Flat Slab structures having Perimeter Beams.

Justin Russell et.al (2018) "Nonlinear behaviour of reinforced concrete flat slabs after column loss event"He work on the study on investigate the non linear behaviour of RC flat slab structures. After a sudden column loss event, he concluded on reaction force and deflection and concrete cracking in the slab.

Massimo Lapi et.al (2018) "found that the main strengthening techniques against punching shear were presented and discussed" Shear strengthening, flexural strengthening, enlargement of the support and post-tensioning systems are available techniques to improve the punching and flexural capacities of existing reinforced concrete flat slabs. The authors applied the Critical Shear Cracks Theory (CSCT) to each strengthening technique to evaluate its efficacy against punching failure. The punching failure predictions provided by the CSCT.

Priya M P et.al (2018) "Experimental Study on the behaviour of Flat Slab under different support condition"He studied the experimental study on the behaviour of flat slab under different support conditions. Poor side supported slab column connection improve the punching shear resistance of the slab and increase the stiffness of the slab and improve concrete ductility and integrity of vicinity of slab column connections.

Raunaq Singh Suri et.al (2018) "study that, ETABS software is used for the analysis of different structures in Indian seismic zones III, IV and V having 10, 12 and 15 storeys", the models taken in this study have Rectangular and L shape configurations. They Concluded that It shows that if we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed value increases by an amount of 20% and 25% respectively in both Conventional and Flat Slab structures having Perimeter Beams. It shows that when we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed value increases approximately by an amount of 24% and 30% respectively along X and Y direction in both Conventional and Flat Slab structures having Perimeter Beams.

Tejas Jain et.al (2018) "P-Delta Analysis of RCC framed High rise building equipped with shear wall and Damper: An overview of experimental and numerical study"Researched on the recent development made on study the experimental analytical research for shear wall and damper study. He concluded shear wall and damper are effective in reducing the lateral and gravity forces in the building. Location of shear wall and damper affect the torsional effect of building. The opening of shear wall will cause extra tension around opening and will have to provide extra reinforcement around openings and see location and height to width ratio of opening in shear wall affect the displacement of the building.

Balaji Kumar et.al (2017) "To study the performance of flat slab and conventional slab structure subjected to various loads and conditions", behaviour of both structure for the parameters like storey shear, storey displacement drift ratio, axial forces.
The main objective of the analysis is to study the different forces acting on a building. The analysis is carried out in ETABS software. Results of conventional reinforced concrete. Structure i.e. Slab, beam and column and flat slab reinforced concrete. Structure for different heights.

Remigijus Salna et.al (2017) "Calculation of Punching shear strength of steel fiber reinforced concrete flat slabs" Work on calculating the punching shear strength of steel fiber reinforced concrete flat slab. He checks the punching shear in conventional slabs and flat slabs and found result in both case.

Thimmayapally Dileep Kumar et.al (2017) "Analysis and design of regular and irregular flat slab for multi storied building under two seismic zones using ETABS and safe".Flat-slab building structures possesses major advantages over traditional slab-beam-column Structures because of the free design of space, shorter construction time, architectural –functional and economical aspects. Because of the absence of deep beams and shear walls, flat-slab structural system is significantly more flexible for lateral loads then traditional RC frame system and that make the system more vulnerable under seismic events. The purely flat-slab RC structural system is considerably more flexible for horizontal loads than the traditional RC frame structures which contributes to the increase of its vulnerability to seismic effects. The critical moment in design of these systems is the slab-column connection, i.e., the penetration force in the slab at the connection, which should retain its bearing capacity even at maximal displacements.

Anghan Jaimis et.al (2016) This paper specify the comparative study of slab in this paper two type of slab is used , they are flat or conventional slab. During earthquake heavy damage occurs in building. So, this paper helps us to understand the behaviour of flat slab or conventional slab in seismic zones. This paper also helps us to understand the time period of the building. In comparison of the conventional R.C. building to flat slab building, the time period is more for conventional building than flat slab building because of monolithic construction. In flat slab building base shear only increases. But in case of conventional slab base shear decreases after 6 floors.

Hamed salem et.al (2016) "Progressive Collapse assessment of Mid-Rise Reinforced Concrete Flat Slab Structures"Objective of the work based on progressive collapse assessment of mid rise reinforced concrete flat slab structures using applied element method (AEM). Numerical result showed that the edge shear wall loss is the most critical case of support loss, where the structure underwent a partial collapse due to its removal at G+7 and G+9 floors.

Kavish Patwari et.al (2016) "studied on Comparative Study of Flat Slab Building with and Without Shear Wall to see earthquake Performance of G+10 building using response spectrum method by ETABS", They concluded that The values of storey drift for all the stories are found to be within the permissible limit i.e. not more than 0.004 times to storey height according to IS 1893 (Part 1): 2016 For Structure with shear wall along periphery have story displacement is minimum. It is 29.13 % and10.06 % less for Structure with shear wall along periphery than Structure with L type shear wall and Structure with non parallel shear wall along periphery respectively.

K Jaya Prakash et.al (2016) "found that flat slab has more advantage than the conventional slab it provide more structural stability to the building and give the aesthetic view to the building" For designing purpose of flat slab we can use post tensioning as well as conventional reinforce concrete. The cost of post tensioning for designing flat slab is higher than the reinforce concrete design. Design of conventional reinforced concrete. flat plate/slab in India, utilizing Indian codes, has many shortcomings, which have to be addressed and revised soon S. N. Utane, H. B. Dahake Volume 5, Issue 2, March (2016) when we compare a industrial structure constructed by using waffle system and flat slab system in a square and rectangular layout the displacement is more in case flat slab than the waffle system. As we increase the height of structure, displacement is also increases. Storey shear of the industrial structure is also more in flat slab system than waffle system.

Mohit Jain et.al (2016) “In this paper flat slab system is compare with wide beam system. In this paper we consider the modal of 4 story building” , And analyzed under gravity and seismic load we conclude that deformation in the building are less in case of flat slab system compare to wide beam system. When we perform linear static analysis under gravity load this is due to when we used flat slab the weight of stricture is reduced. From the seismic analysis it is observed that lateral deformation of comparatively larger magnitude has been observed in case of flat slab. This is due to decrease in lateral stiffness.

Rajini .et.al (2016) “in their paper analyzed about comparative study of the behaviour of flat slab and conventional slab structures of 20 stories in diverse cases” Conventional RC slab and flat slab structure, flat slab structure with column drop, conventional structure and flat slab structure with shear wall at diverse locations were analyzed by taking into consideration two typical zones of zone III and zone V, through dynamic response spectrum analysis by using ETABS software. Comparing the results of all models in condition of time period and frequency, lateral displacements, story shear and story drifts by plotting graphs. Flat slab structure with arrangement of column drop and shear wall is performed extremely fine under seismic loads to decrease the displacements and drifts with enhancement in stiffness of building. This paper summarized a review of the study, for conventional R.C.

Sakseshwari et.al (2016) “studied on Comparative study on conventional beam slab and flat slab under various seismic zones and soil conditions by using ETABS” They concluded that, the base shear is maximum at plinth level. The base shear will increase drastically as the height increases. Base shear of conventional beam slab building is less than the flat slab building; the base shear is maximum in a soft soil compared to the rock soil. This shows that mass participation factor is high in flat slab compared to the conventional beam slab building. Displacement increases as the height increases for all the structure. Displacement of flat slab building is more than conventional beam slab building.

Vinod Goud et.al (2016) “this paper concern on the Analysis and Design of Flat Slab with and without Shear Wall of Multi-Storied Building Frames” By this paper we conclude that value of storey drift does not exceed permissible limit i.e. 0.004 times the storey height. In case of flat slab with shear wall the thickness of the building changes with the storey height. And the surface shear and bending stress increases in 10 to20 storey building and decreases in 20 to30 storey building. And the von mis stresses at top and bottom increases in both the case with and without shear wall.

Amrut manvi et.al (2015) "Cost Comparison between conventional and flat slab structures"Main work of this project is cost comparison between conventional and flat slab structures and found that flat slab is not economical than conventional slabs.

Hamed S.Askar et.al (2015) "Usage of Prestressed vertical bolts for retrofitting flat slabs damaged due to punching shear"Work on usage of prestressed vertical bolts for retrofitting flat slab damaged due to punching shear repaired specimen recorded higher punching failure load value relative to their reference slabs indicating that the suggested system of repairing punching damaged slab is an effective system and could be used in practice.

Prof. Naveen Kumar et.al (2015) "Comparative study of flat slabs and conventional RC slabs in high seismic zone" The present study covers the behaviour of multi-storey buildings having conventional RC frame building, flat slabs and to study the effect of height of the building on the performance of these types of buildings under seismic forces. It gives good source information on the parameters storey drift, lateral displacement, natural time period and seismic base shear.

Rajiv M S et.al (2015) "In their paper analyzed about work to compare the behavior of multistory buildings having flat slabs with drops to that of having two way slabs (conventional slab)" ,The consequence of part shear walls on the performance of different types of buildings [(G+7) and (G+14)] under seismic forces are considered. Equivalent static force method, Response spectrum method and Time history analysis were considered for diverse types of models and relative results were drawn. The natural mode (time) period increases as the height of building increases, irrespective of type of building conventional slab (bare), flat slab (bare) and flat slab with shear wall. On the other hand, the time period is more for conventional slab and flat slab with bare frame compared with that of flat slab with shear wall for dissimilar models due to stiffness participation factor being less in bare frame for both storeys. This presents a summary of the project work, for conventional R.C.C building, flat slab building and flat slab building with shear wall at diverse locations for different types of building [(G+7) and (G+14)] in the seismic region.

Swathi Rani K.S et.al (2015) "Study on effective bracing systems for high rise steel structures"The objective of this study is to use the bracings in different patterns in models and he concluded that displacement criteria bracings are good to reduce the displacement.

Navyashree K et.al (2014) "In the present work six number of conventional RC frame and Flat Slab buildings of G+3, G+8, and G+12 storey building models are considered", The performance of flat slab and the vulnerability of purely frame and purely flat slab models under different load conditions were studied and for the analysis, seismic zone IV is considered. The analysis is done with using E-Tabs software. The effect of seismic load has been studied for the two types of building with different height. On the basis of the results following conclusions have been drawn. The moment is maximum at plinth, first and second level. After second level moments decreases and increases at the top storey. The column behaviour changes as height of the building increases.

Dr. S. K. Dubey et.al (2014) "found that interaction of asymmetry of building on the P-Delta effects in elastic and inelastic ranges of behavior is evaluated" , Contributions of lateral load resisting system, number of stories, degree of asymmetry, and sensitivity to ground motion characteristics are assessed. Four buildings with 7, 14, 20 and 30 story are designed based on typical design procedures, and then their elastic and inelastic static and dynamic behavior, with and without considering P-Delta effects, are investigated. Each building is considered for 0%, 10%, 20% and 30% eccentricity levels.

Sumit Pawah et.al (2014) "focuses to compare behaviour of flat slab with old traditional two way slab along with effect of shear walls on their performance". The parametric studies comprise of maximum lateral displacement, storey drift and axial forces generated in the column. For these case studies they have created models for two way slabs with shear wall and flat slab with shear wall, for each plan size of 16X24 m and 15X25 m, analyzed with Staad Pro. 2006 for seismic zones III, IV and V with varying height 21m, 27 m, 33 m and 39 m. This investigation also tells us about seismic behaviour of heavy slab without end restrained. For stabilization of variable parameter shear wall are provided at corner from bottom to top for calculation. Results comprises of study of 36 models, for each plan size, 18 models are analyzed for varying seismic zone.

Mohd Rizwan et.al (2014) "This paper concern with Different aspect of flat slab building over a conventional building", in this paper we consider the three storey building with flat or conventional slab. by performing static analysis on the 3 storey building by using Indian is 456 and euro code we conclude that Indian code suggest more reinforcement and stiffness as compare to euro code. by performing response spectrum analysis we get that building with flat slab is more flexible as compare to building with conventional slab.

Kiran et.al (2013) "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.

R.S.More et.al (2013) "Investigated on effect of different types of flat slab Subjected to dynamic loading, by using ETABS, of G+8 building". In this study relation between the number of stories, zone and soil condition were developed. They concluded that Drift of top storey of flat plate slab is about 18 % more than that of top storey of grid slab, and for flat slab it is about 8% more than that of grid slab. Drifts of flat slabs and grid slabs are approximately equal up to storey 4. Storey number 7 experiences maximum value of drift.

Dr. Uttamasha Gupta, et.al (2012) "Seismic Behaviour of Buildings Having Flat Slabs with Drops" The main object of this paper is to compare the behaviour of multi-storey buildings having flat slabs with drops with that having two way slabs with beams and to study the effect of part shear wall on the performance of these types of buildings under seismic forces. Present work provides a good source of information on the parameters lateral displacement and storey drift**.**

Prof. K S Sable et.al (2012) " Comparative Study of Seismic Behaviour of Multi-storey Flat slab and Conventional Reinforced Concrete Framed Structures" Tall commercial buildings are primarily 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 anyone of them, then a redistribution of forces takes place. Therefore it is necessary to analyze seismic behaviour of building for different heights to see what changes are going to occur if the height of conventional building and flat slab building changes.

Fayazuddin Ahmed et.al (2012) "studied analysis of Flat Plate Multi storied Frames with and Without Shear Walls under Wind Loads". It is seen that the column moments for flat plate floor system building with Shear walls has decreased by 69.17 % & 58.2 % when compared with flat floor system, conventional beam supported slab system. The Shear walls with flat plates contribute towards reducing the column axial force even in the middle frame region also. In the case of other building frames there is similar reduction in column axial force when wind is acting. The flat plate floor system can be further strengthened against the lateral loads by providing Shear walls also. The drift becomes minimum, so that there is 65.77% reduction in the drift in this case.

2.3 CONCLUSION AND RESEARCH GAP OF LITERATURE REVIEW

From the above literature review it is found that studies have been carried out for Response spectra analysis is also performed to determine the response of the flat slab and conventional buildings. Indian and Euro codes have been employed to compute the response of the two buildings. Although the flat slab building is more flexible, still show large base shear due to thicker floor slab. Seismic performance of a conventional building is superior better than a flat slab building. Due to the architectural purpose flat slab building becomes more popular. Many experimental and analytical works has been done by many researchers in the area of the pushover analysis of the structural members. The concept of pushover analysis is rapidly growing nowadays. It is found that Standard pushover analysis and response spectrum method are more popular for seismic evaluation but a very small work has been carried on modal pushover analysis method.

Further above literature review some work has been done on P-Delta effect on flat slab building

CHAPTER-3

METHODOLOGY

3.1 METHODOLOGY

In designing and analyzing the performance of flat slab buildings and conventional building, it is especially important that an effective modeling technique be involved because of the complexity of the real structural behavior and the difficulties of full scale measurement. In both the cases, foundations slightly vary. During the whole process of analysis and design structural member dimensions will seems to vary being of difference in load transfer mechanism. The analysis has been done both for gravity load and lateral load.

3.2 BASIC ASSUMPTION

In the analysis of all kind of structure, a number of assumptions should be made in order to reduce the size of the actual problem. in this part, the assumption used in the modelling studies are presented.

These assumption are divided into three categories

- Material behavior
- Element behavior
- Structural behavior

3.3 MATERIAL BEHAVIOR

The behavior of the material in this study is assumed to be linear elastic. Linear elasticity is the most common material model for analyzing structural system and is based on the following assumption.

1. The material is homogenous and continuous.
2. The stain increases in linear portion as stress increases.
3. As stress decreases, the strain decreases in the same linear portion.
4. The strain induced at right angles to an applied strain is linearly proportional to the applied strain, which is called poisson ratio effect. In addition, the effects of

cracking, creep, shrinkage and temperature on the material are not taken into consideration.

3.4 ELEMENT BEHAVIOR

Using ETABS software structural element are used in the analyses. The three dimensional frame elements are used for modeling the beams, slab column of the structural system. It is assume to have six degree of freedom at each end.

3.5 STRUCTURAL BEHAVIOR

The flat slab building system analyzed in this study is considered to be rigid frame structure. In such a system, all structural element of the system are assumed to have rigid moment resistance connection at the both ends. Another assumption about the structural system is the linear elastic structural system behavior, in which the deformation is proportional to the loads. In supervision, if a linear elastic structure is subjected to a no of simultaneously applied loads, the overall response can be determine by assuming the response of the structure to the loads applied at one time.

3.6 APPLIED LOADS

The loads that are applied on the model so as for the model verification are determined according to the IS 875:1987 code.

3.6.1 Dead Load

The dead load applied on the modal is determined by the ETABS program itself based on the material properties .The finish loads are taken as 1 kN/m^2. Those loads are considered as 'super dead' loads in the ETABS software since the program separates them with structural dead loads (column, beam, slab etc.)

3.6.2 Live Load

Live load shall be computed as per IS: 875 (Part 2): 1987. Live load is the load that accounts for the intended use or occupancy. The value of live load shall be taken as 3 kN/m^2. In conventional slab and 3 kN/m^2 in flat slab including wall load in flat slab will be the same for floor from top to bottom.

3.6.3 Earthquake Load

As earthquake load case is also considered in the ETABS analysis. The earthquake load case is defined using ETABS program's joint weight and response spectrum in accordance to IS 1893 (Part 1): 2016.

3.7 CODAL PROVISION

In design and analysis of the models the codes which has been used in experimental work can be listed below: -

1. IS 1893 (Part 1): 2016: - This is a general provision building code for earthquake design of the structure. Altogether it has five Parts , Part 2 is for liquid retaining tanks, Part 3 bridges, Part 4 industrial structures including stacks and part 5 for dams and embankments.
2. IS 875 (Part 1): 1987: - This code is a code of practice for design loads (other than earthquake) for buildings and structures. This is only for dead load on the structures with includes unit weight of building materials and stored materials.
3. IS 875 (Parts 2): 1987: - This code is also for design loads other than earthquake loads. This includes only live load acting on the structure.
4. IS 456:2000: - This code is used for the general design of RC building structures.

3.8 METHODOLOGY FLOW CHART

RIVIEW OF THE EXISTING LITERATURES BY DIFFERENT RESEARCHES

↓

TAKING G+10, G+20, G+ 30 STOREYS CONVENTIONAL & R C STRUCTURE AND FLAT SLAB R C STRUCTURE WITH EQUAL AREA PLAN.

↓

MODELLING OF THE STRUCTURES ARE IN ETABS

↓

LOAD SUCH AS SEISMIC IN X DIRECTION AND Y DIRECTION, WIND LOAD, DEAD LOAD, LIVE LOAD ARE ASSIGNED TO THE STRUCTURES FOR ZONE V

↓

VARIOUS SPECIFICATIONS ARE PROVIDED AS PER REQUIREMENT AND THE DYNAMIC ANALYSIS (P-DELTAANALYSIS) OF BUILDINGS IS PERFORMED.

↓

VARIOUS RESULTANT PARAMETERS SUCH AS ,% OF STEEL ,MAX SHEAR FORCE ,MAX DISPLACEMENT ,SUPPORT REACTIONS , MAX DRIFT, BASE SHEAR ,OVERTURNING MOMENT ARE THEN STUDIED AND COMPARED FOR THREE MODELLED BUILDINGS IN ZONE V.

CHAPTER-4

RESULT AND DISCUSSION

4.1 GENERAL

The aim of the present work is to evaluate the seismic response of the structure subjected to bi-axial excitation with the help of ETABS 2015. The layout of the plan is symmetric in both X and Y direction with re-entrant corner having bay length of 6m in x direction and 6m in y direction. The models considered are reinforced concrete ordinary moment resisting frame of ten, twenty and thirty with same column sizes, modified columns sizes based on stiffness or strength assignments, with base isolators and with shear walls. All these buildings have been analysed by non- linear dynamic analysis [P-Delta analysis]. Horizontal loads produce double curvature of beams and columns on one side of centre of gravity of column with axial compression on the other side will also cause deformation and horizontal movement. Due to this effect there is deflection at top of tall building known drift. A wind – drift limit is H/500 of height of building for each story while the story drift in any story due to minimum specified design lateral force with partial load factor of 1.0 shall not exceed 0.004 times the storey height. The procedure for calculation of total drift is to find out the deflection of each floor starting from 0 floors due to double curvature of the columns and the beams and sum up these horizontal drifts. Next come the Determination of fundamental natural period for calculation of horizontal thrust which governs the lateral forces in a building. These are different for different media, for Reinforced concrete frame, it is $0.075h^{0.75}$ but for steel frame, it is $0.085h^{0.85}$ but this formula can be applied when there is no infill panel. For other building including moment resisting frame building with infill wall, this is $T_a=0.09h/d^{0.5}$ where h = Height of building in meter and d = Dimension of the width at plinth level in meter in the direction of horizontal force.

Behavior of lateral load (wind or seismic) is erratic in the sense that it may come in any direction and therefore analysis shall be done accordingly. In tall building it is desirable to have shear wall which reduces the chance of much deformation (Not to the extent of collapse of the structure). A residential or commercial structure with a height to minimum dimension ratio of more than five, and those having natural frequency the first mode less than 1.0Hz need to be examined for dynamic effect of wind or seismic.

Besides lateral weight under gravity can also be reduced to a great by using newer material like fiber glass window panel or light weight infill walls etc .further, reduction of imposed load. The typical storey height is 3m for all models the plan configurations consists of,

MODELS FOR FIVE, TEN AND FIFTEEN STORIED BUILDING

Model 1 – R.C framed Building (G+10) is symmetric in both X & Y directions, all column sizes are same. (Basic model with column sizes 600 X600 at storey 5 and 500*500 above storey 5 and beam size 350*300, provided shear wall (150mm thick) at the edge corner).

Model 2 – Flat slab Building (G+10) is symmetric in both X & Y directions, all column sizes are same. (Basic model with column sizes 600 X600 at storey 5 and 500*500 above storey 5 no beam considered in flat slab building, provided shear wall (150mm thick) at the edge corner).

Model 3 - R.C framed Building (G+20) is symmetric in both X & Y directions, all column sizes are same. (Basic model with column sizes 750 X750 at storey 12 and 600*600 above storey 12 and beam size 350*300 , provided shear wall (150mm thick) at the edge corner).

Model 4 – Flat slab Building (G+20) is symmetric in both X & Y directions, all column sizes are same. (Basic model with column sizes 750 X750 at storey 12 and 600*600 above storey 12, provided shear wall (150mm thick) at the edge corner).

Model 5 - R.C framed Building (G+30) is symmetric in both X & Y directions, all column sizes are same. (Basic model with column sizes 900X900 and beam size 350*300, provided shear wall (150mm thick) at the edge corner).

Model 6 – Flat slab Building (G+30) is symmetric in both X & Y directions, all column sizes are same. (Basic model with column sizes 900X900, provided shear wall (150mm thick) at the edge corner.

4.2 PROBLEM LAYOUT

It is proposed to design and analysis of G+10, G+20, G+30 storied building by finite element method and compare their design results. The nature of the building is of commercial building. The building is located in seismic zone V on a site with soft soil. The proposed plan is attached in below table 4.1.

Details of dimension’s & properties are given in table. Model has been analysed and design by use of ETABS software. Initially column & beam dimensions were taken same for conventional slab structure & for flat slab structure, but result was not good i.e. structure pass for conventional slab at same time structure with flat slab get failed with similar dimensions of beam & column, which shows that we have to provide greater dimension of column in flat slab for similar span as in conventional slab structure.

TABLE 4.1 ASSUMED PRELIMINARY DATA REQUIRED FOR THE ANALYSIS

Description	Conventional slab	Flat slab
Plan size	30*30m	30*30m
Building heights	36.2m,66.2m,96.2m	36.2m,66.2m,96.2m
Number of storey's above ground level	G+10,G+20,G+30	G+10,G+20,G+30
Type of structure	Conventional slab	Flat slab
Size of beam	350*300mm	No beam
Size of column in mm	500*500,600*600,750*750,900*900	500*500,600*600,750*750,900*900
Earthquake zone	V	V
Zone factor	0.36	0.36
Types of soil	Soft	Soft
Thickness of slab	125mm	210mm and drop thickness105mm
Response RF	5.0	5.0
Imposed load	$3kN/m^2$	$3kN/m^2$
Floor finish	$1kN/m^2$	$1kN/m^2$
Density of masonry wall	$20kN/m^2$	$20kN/m^2$
Grade of concrete	M25	M25

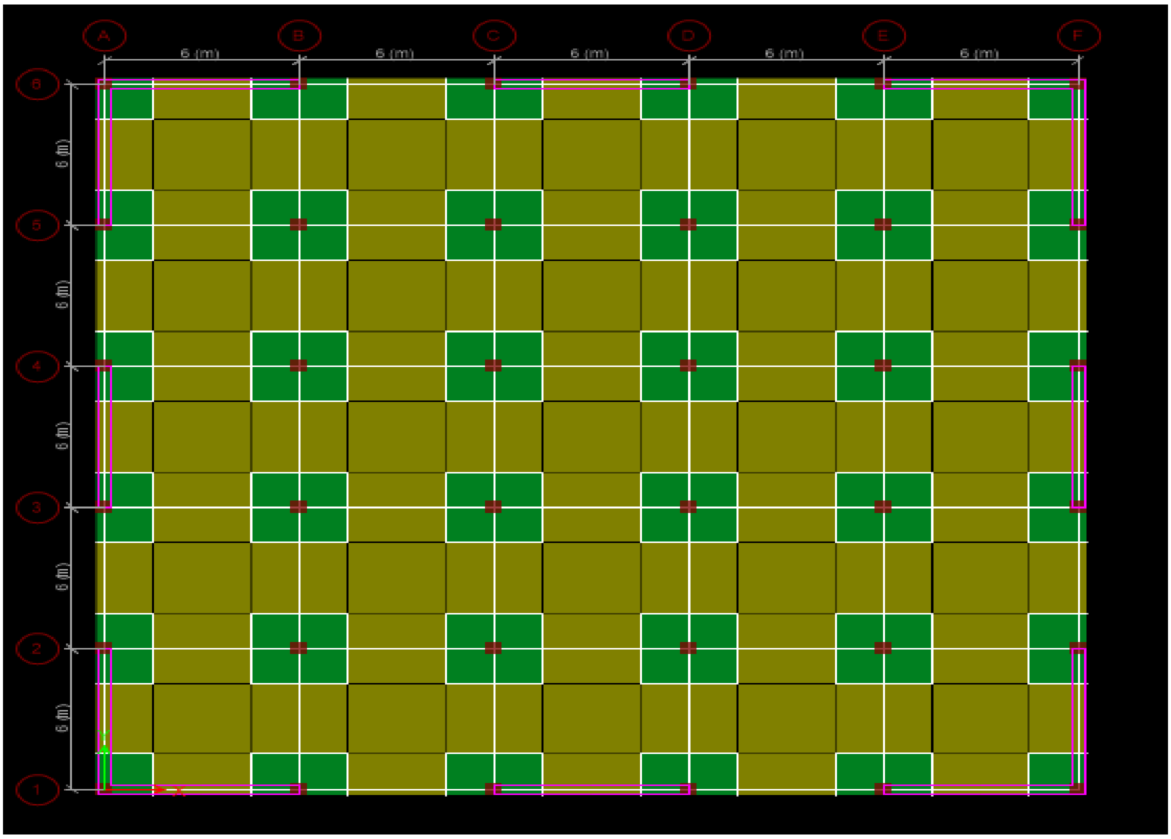


FIG. 4.1: Plan View of Flat Slab Buildings

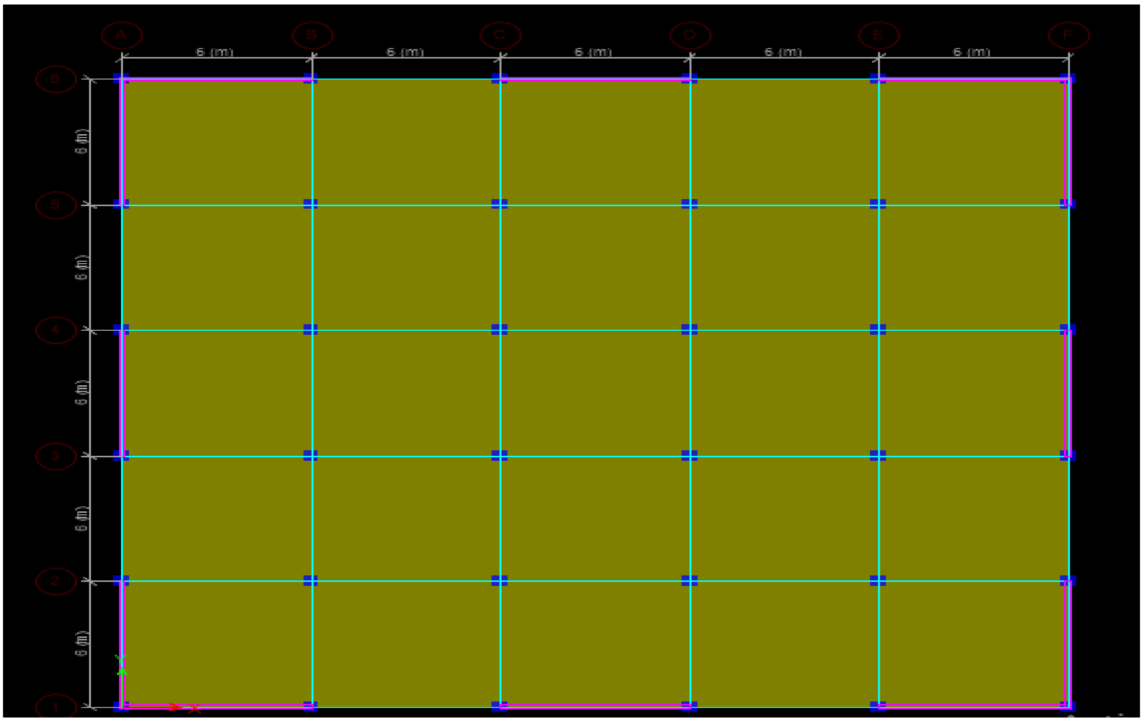


FIG. 4.2: Plan View of R.C Framed Buildings

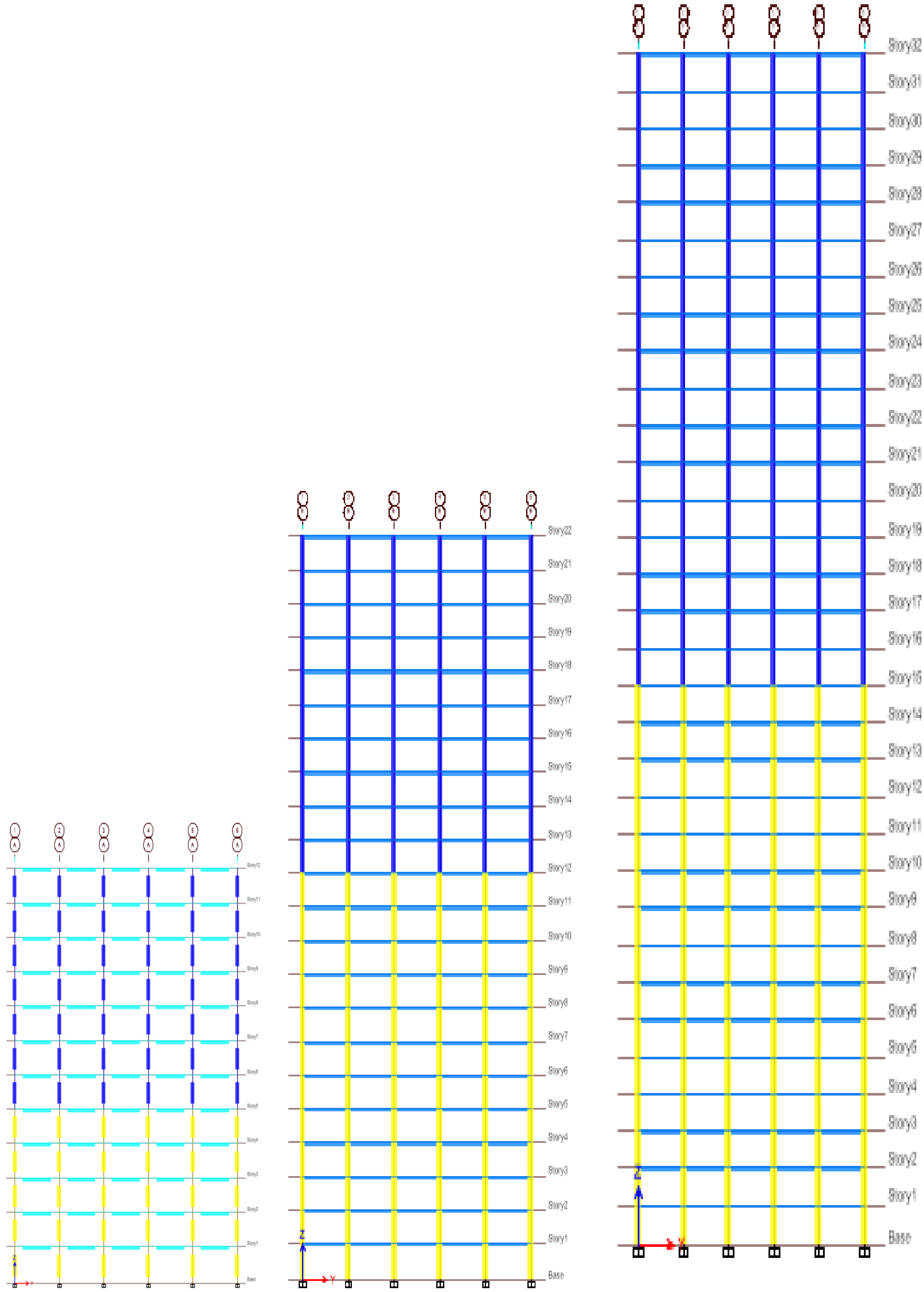


FIG. 4.3: Elevation View of Model (G+10, G+20, G+30)

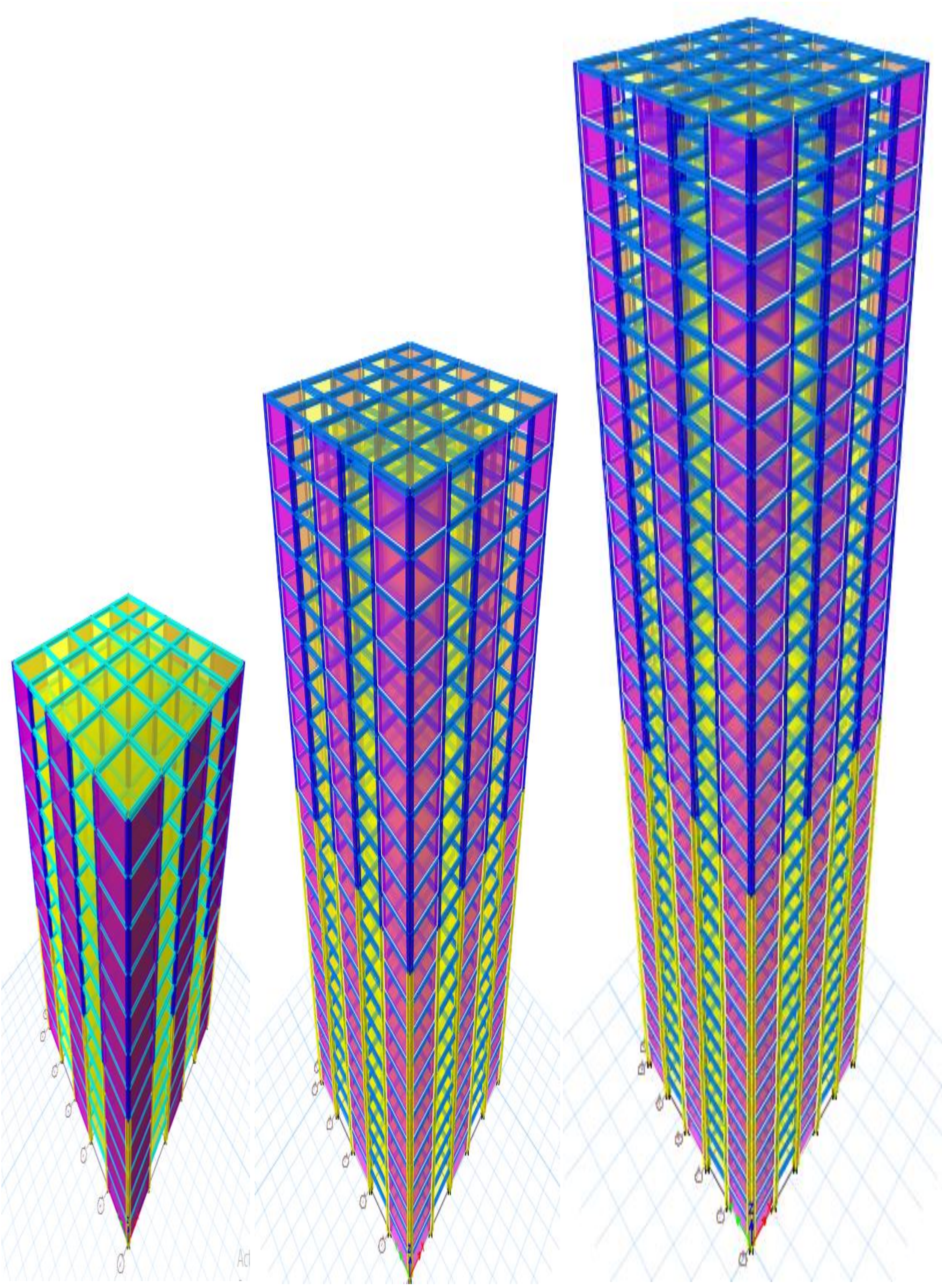


FIG. 4.4: Isometric Views of R.C .Framed Building
(G+10, G+20, G+30)

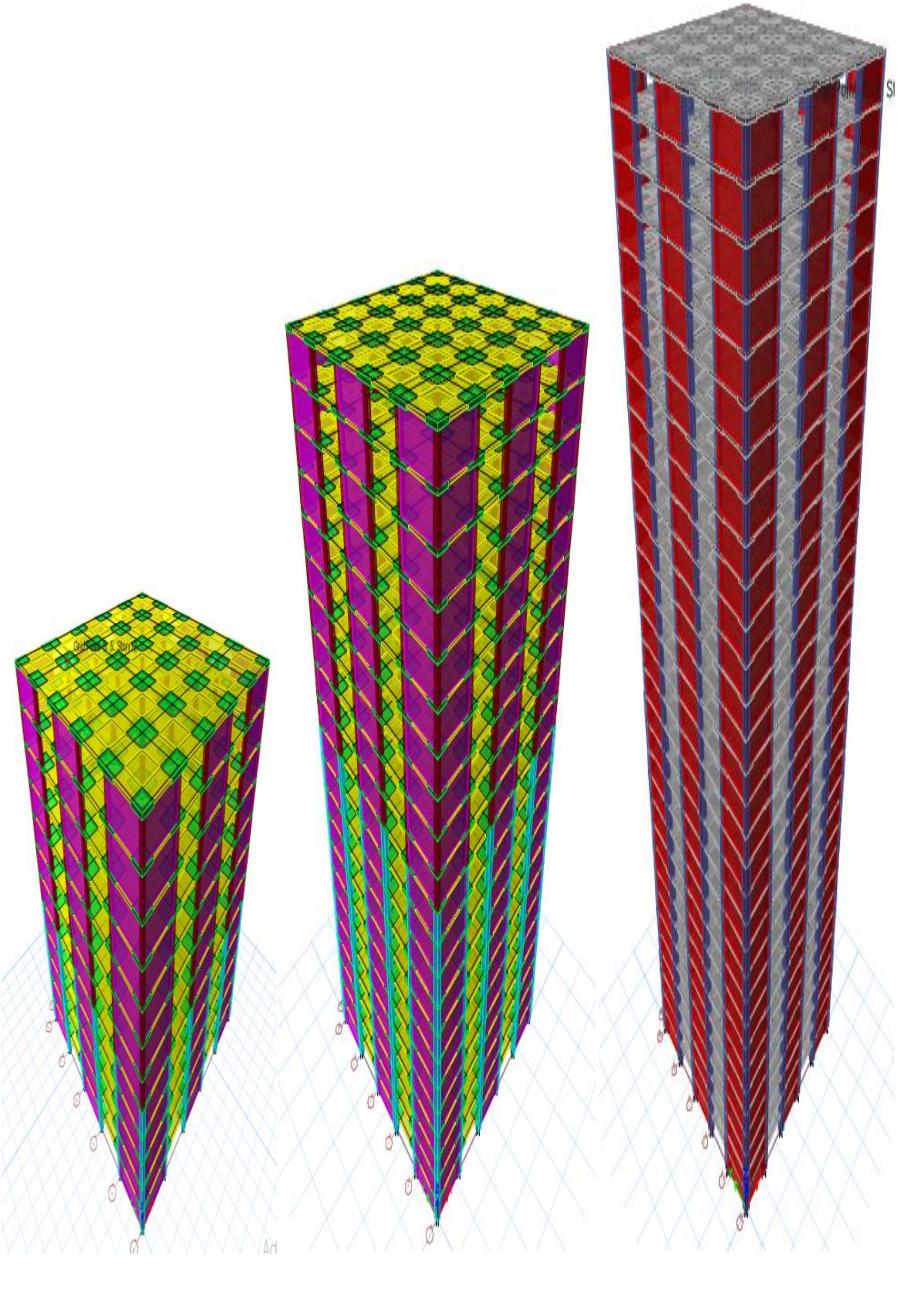


FIG. 4.5: Isometric Views of Flat Slab Buildings

(G+10, G+20, G+30)

4.3 ANALYSIS METHODS

Analysis methods are broadly classified as linear static, linear dynamic, nonlinear static and nonlinear dynamic methods. In these the first two methods are suitable when the structural loads are small and no point, the load will reach to collapse load and are differs in obtaining the level of forces and their distribution along the height of the structure. Whereas the non- linear static and non-linear dynamic analysis are the improved methods over linear approach. During earthquake loads the structural loading will reach to collapse load and the material stresses will be above yield stresses. So in that case material nonlinearity and geometrical nonlinearity should be incorporated into the analysis to get better results. These methods also provide information on the strength, deformation and ductility of the structures as well as distribution of demands. These methods also provide information on the strength, deformation and ductility of the structures as well as distribution of demands.

4.4 EQUIVALENT STATIC METHOD

Equivalent static method of analysis is a linear static procedure, in which the response of building is assumed as linearly elastic manner. The analysis is carried out as per IS 1893 (Part 1):2016.

Design Seismic Base Shear

The design base shear is depends on the lump mass of structure and acceleration coefficient. Base shear is total lateral force at a base of the structure and distributed along the member to calculate the serviceability and behavior.

$V_b = A_h * W$

A_h = Design horizontal seismic coefficient.

W = Seismic weight of the building.

Seismic Weight of Building

The seismic weight of each floor is its full dead load plus appropriate amount of imposed load as specified. The mass source from which e can compute the seismic weight is (DL+0.25LL) up to 3 KN/m2 and (DL+0.5LL) for above 3KN/m2 While computing the seismic weight of each floor, the weight of columns and walls in any story shall be equally distributed to the floors above and below the story. The seismic weight of the whole building is the sum of the seismic weights of all the floors. Any weight supported in between the story shall be distributed to the floors above and below in inverse proportion to its distance from the floors.

Fundamental Natural Time Period

The fundamental natural time period (Ta) calculates from the expression

$Ta = 0.075h^{0.75}$ for RC frame building

$Ta = 0.085h^{0.75}$ for steel frame building

If there is brick filling, then the fundamental natural period of vibration, may be taken as

$Ta = 0.09h / \sqrt{d}$

Distribution of Design Force

The design Base Shear, V_b computed above shall be distributed along the height of the building as per the following expression.

$Qi = V_b*Wi*hi^2 / \sum Wj*hj^2$

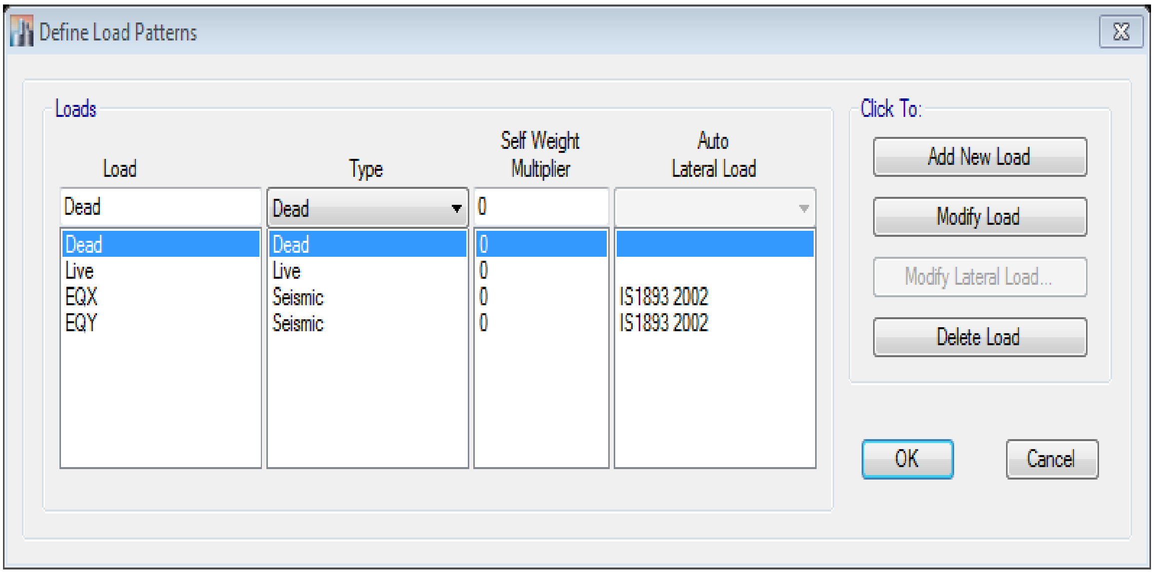


FIG. 4.6 the Equivalent Static Gravity & Lateral Load

In above Fig4.6 define a load pattern is the spatial distribution of a specific set of force, displacement, and other effects which act on a structure. Any combination of joint and elements may be subjected to loading and kinematic conditions. Each load pattern is assigned a design type (dead, wind, earth quake, etc.) which classified the load and initiates the associated computational process. Users may define an unlimited number of load patterns. Load patterns to generate analysis results.

A load case define how load patterns are applied (statically or dynamically), how the structure responds (linearly or nonlinearly), and how analysis is performed (through modal analysis, direct integration, etc) for each analysis to be performed, a load case is defined.

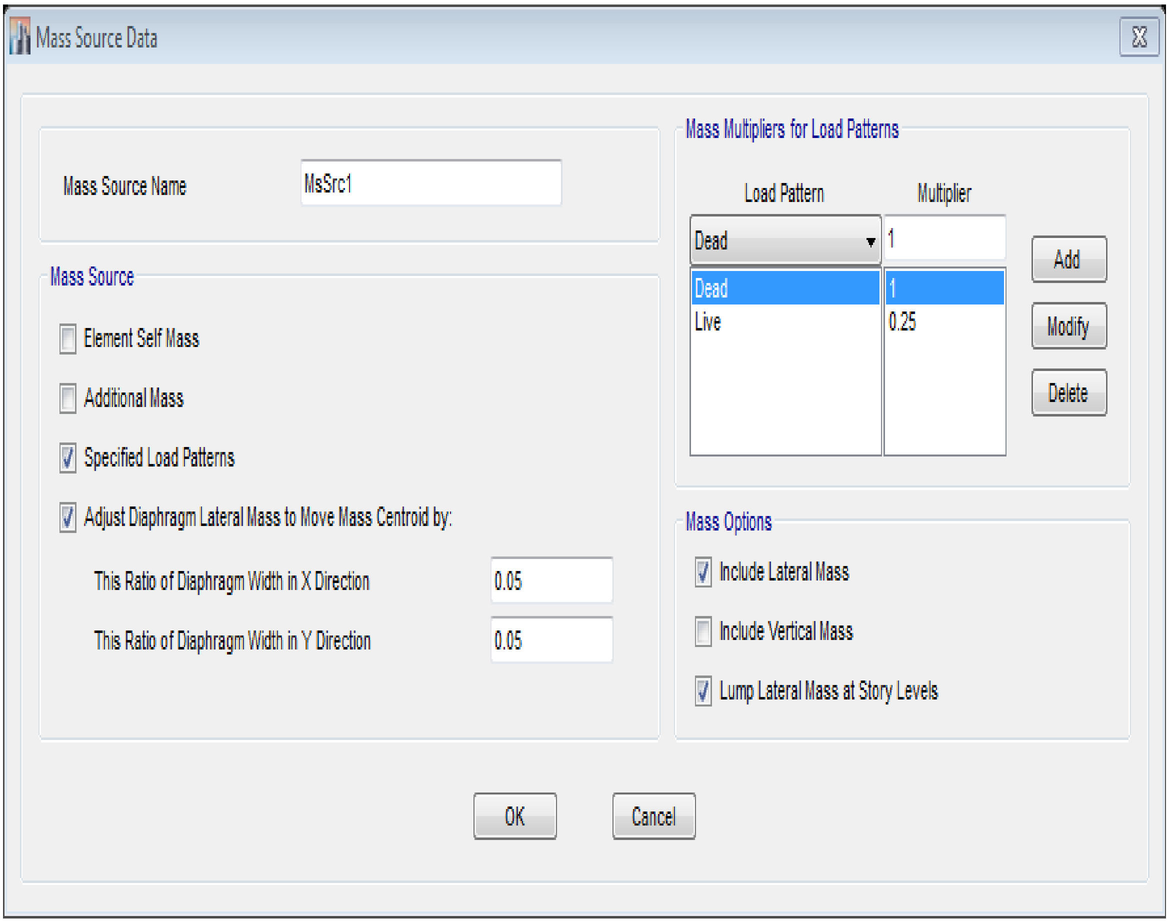


FIG.4.7 Illustrate the Use of Seismic Weight as Mass Source And the Mass Lumped At Each Storey Level

In above figure 4.7 define a mass source data as the name indicates it's the mass of the structure i.e. self weight as well as additional mass due to surface loads line loads ,usually DL+LL. It's required to calculate base shear of the structure. In ETABS need to define it whenever u perform a seismic analysis. ETABS has 3 options to define mass source

1. Element mass source: defines mass using mass per unit volume of materials defined. And also considers additional loads like LL and SDL
2. Additional Mass: it includes loads like cladding etc.
3. Specified Mass: when u selects this option only selected load patters are considered for calculations of mass of structure. It's the best way to define and IS 1893 (Part 1):2016 specifies to consider 100% dead load along with 25% live load when your live load doesn't exceed 3kN/m2,when Live load Exceeds 3 then mass source will be 100% DL+ 50%LL.

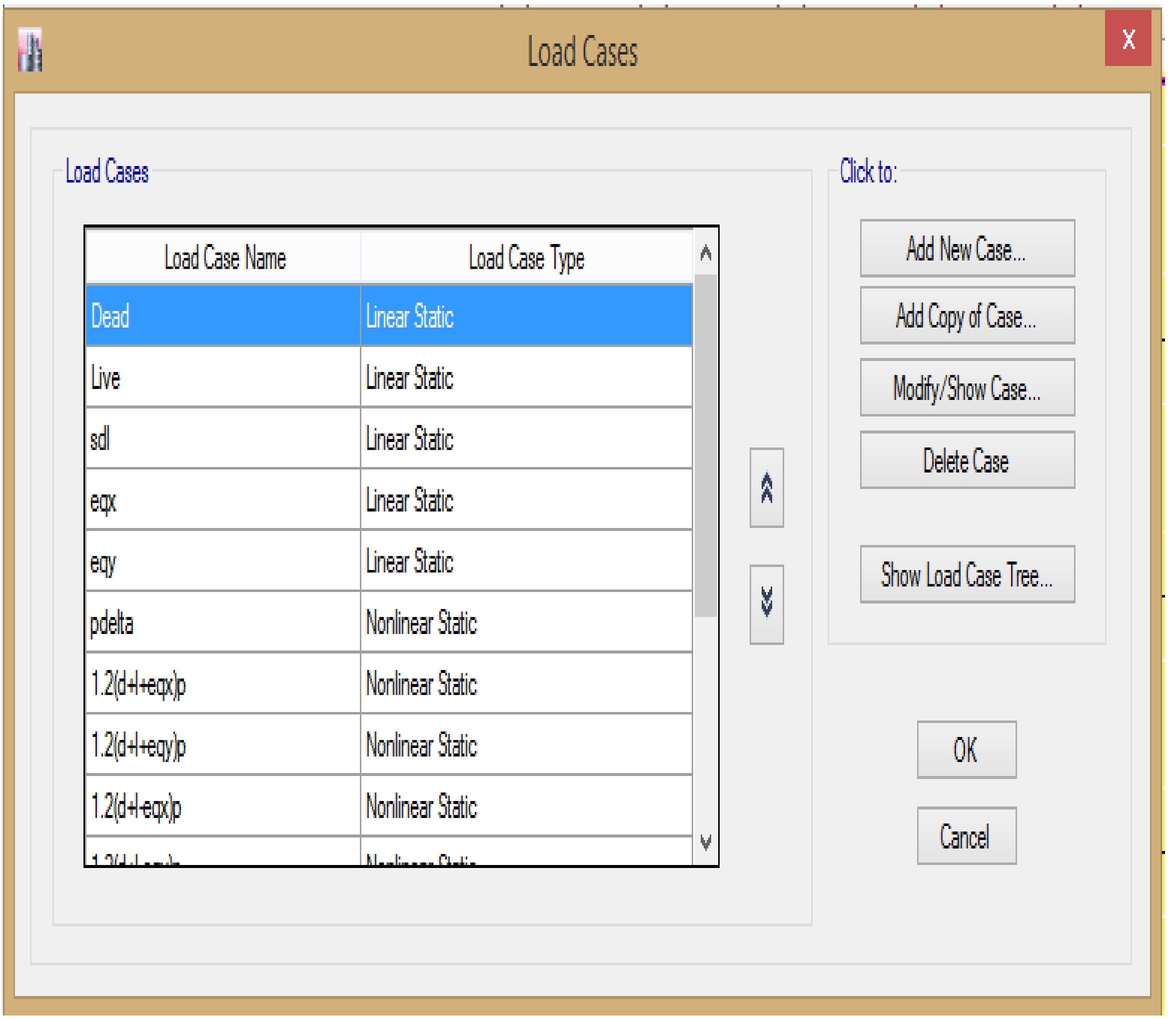


FIG 4.8 P- Delta Non Linear Analysis to Run

In above figure 4.8 load cases defines how load patterns are applied (statically or dynamically), how the structure responds (linearly or nonlinearly), and how analysis is performed (through modal analysis, direct integration, etc.). For each analysis to be performed, a load case is defined. Each load case may apply a single load pattern or a combination of load patterns. An unlimited number of load cases may be defined, and then any set of load cases may be selected for analysis. Once analysis has run, load-case results may be selectively deleted or compiled for output reports. In my research work I m considering dead load, live load, super dead load, earthquake in x-direction and earthquake in y-direction in linear static and P-Delta and load combination taken according to Indian standard code IS:1893 (Part 1) : 2016 in nonlinear static load case type for analysis the second order effects of buildings .

4.5 RESULTS AND DISCUSSION

4.5.1 Displacement

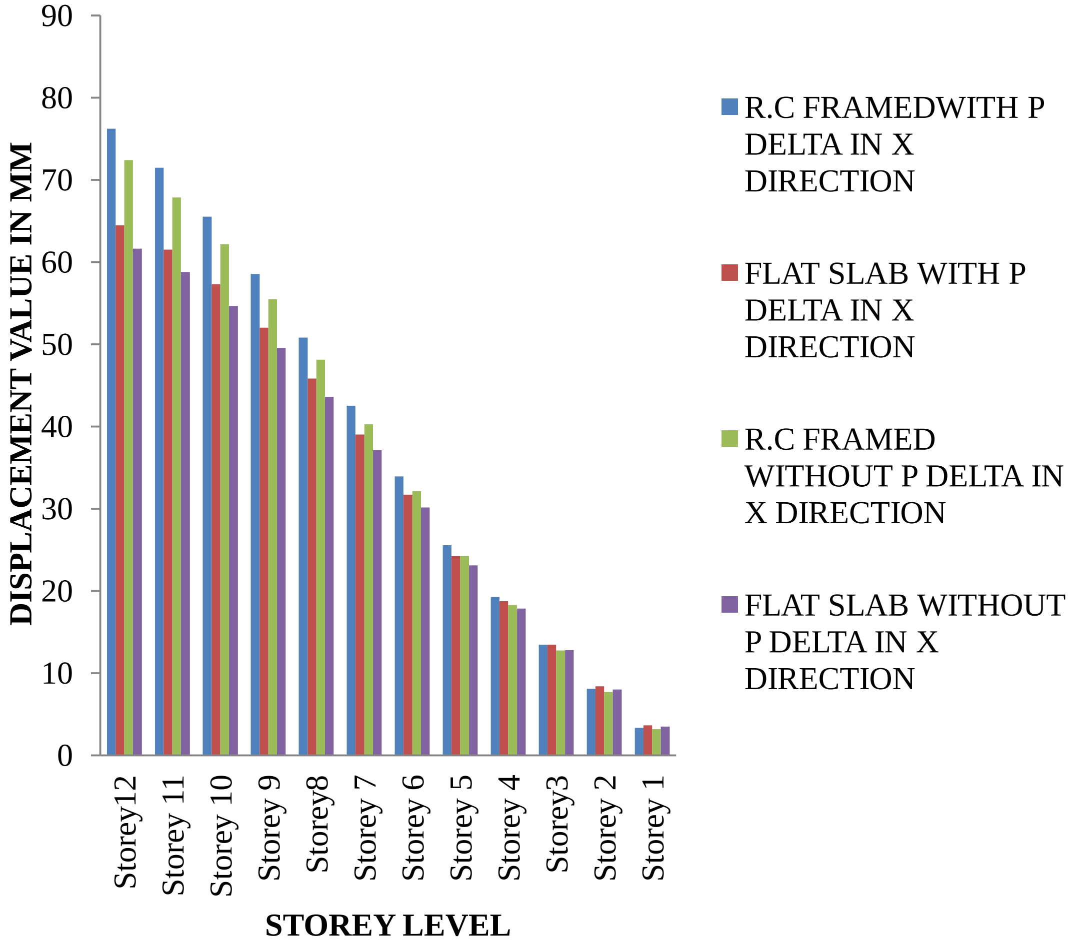
Storey displacement is an important criterion when structures are subjected to lateral loads like earthquake and wind load. Height of structure and slenderness of structure are important factors for determining storey displacement because structure are more vulnerable as height of building increases by becoming more flexible to lateral loads. The displacement is maximum at top and minimum at base of structure. According to IS1893 (Part 1):2016 maximum allowable deflection is calculated as h/250, where h is height of storey from the ground level. The displacement of all models has been compared for flat slab and r c framed building analysis. All displacement of all models are tabulated in form of graph for different stories for both x and y direction.

TABLE 4.2 Displacement in X-X Direction for R.C Framed and Flat Slab with P-Delta and without P-Delta Effect In Case Of G+10 (in mm)

Storey Level	Displacement In X-Direction With P-Delta		Displacement In X-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey12	76.211	64.501	72.414	61.651
Storey 11	71.482	61.56	67.876	58.796
Storey 10	65.525	57.323	62.16	54.683
Storey 9	58.569	52.026	55.502	49.561
Storey8	50.829	45.862	48.123	43.632
Storey 7	42.538	39.03	40.256	37.098

Storey 6	33.917	31.718	32.117	30.147
Storey 5	25.566	24.259	24.248	23.084
Storey 4	19.262	18.768	18.277	17.851
Storey3	13.443	13.467	12.763	12.803
Storey 2	8.087	8.395	7.691	7.985
Storey 1	3.313	3.662	3.166	3.493

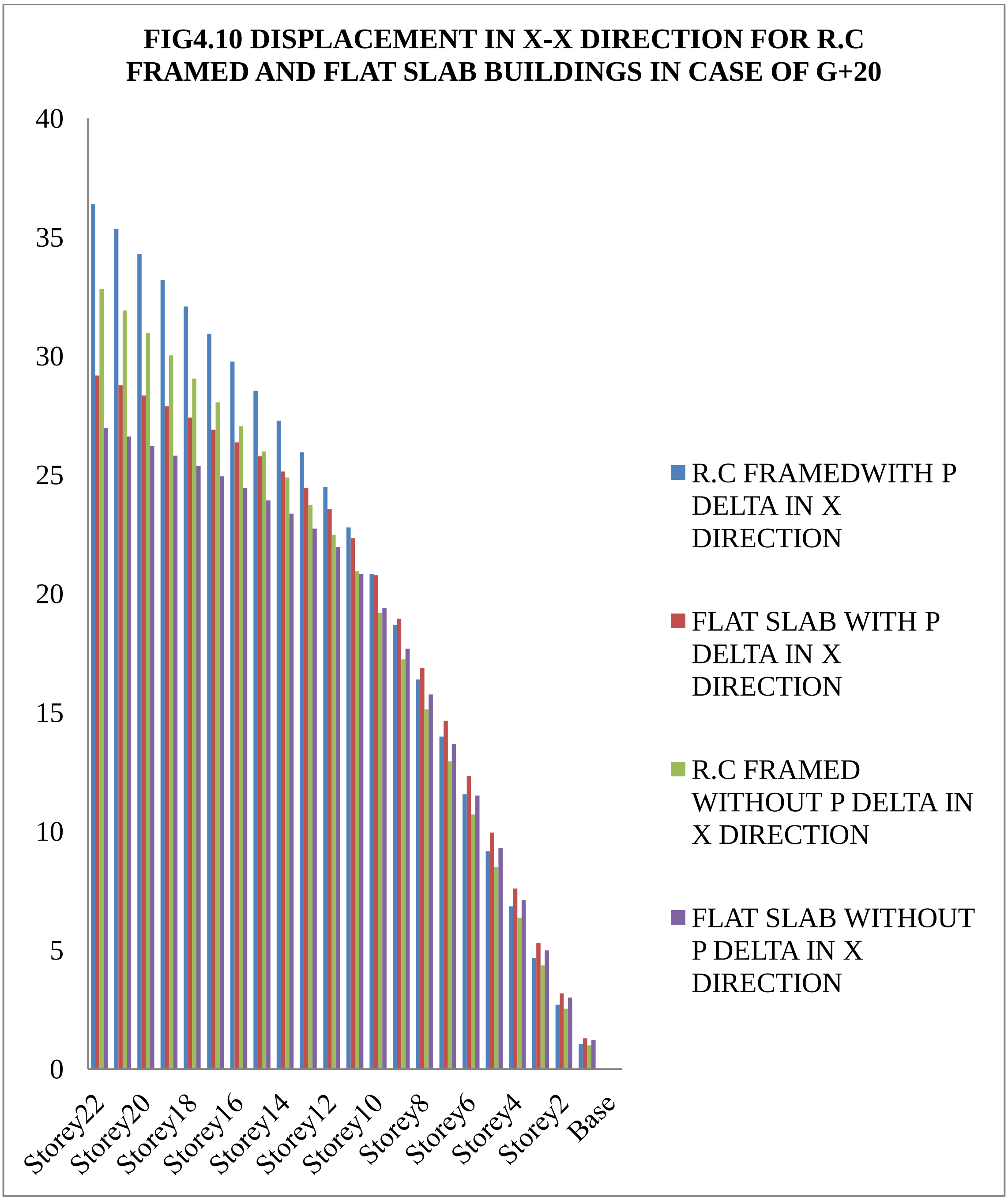
FIG4.9 DISPLACEMENT IN X-X DIRECTION FOR R.C FRAMED AND FLAT SLAB IN CASE OF G+10



For displacement with P-Delta and without P-Delta in x-direction ,when it was compared with R C framed building and flat slab building in case of P-Delta effects it was observed that maximum displacement was 16.64% for R.C. framed building. Where as in case of without P-Delta analysis displacement was found maximum by 16.05% when compared with R C framed building with flat slab building.

TABLE 4.3 Displacement in X-X Direction for R.C Framed and Flat Slab with P- Delta and without P-Delta Effect In Case of G+20 (in mm)

Storey Level	Displacement In X-Direction With P-Delta		Displacement In X-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey22	36.382	29.18	32.832	26.985
Storey21	35.351	28.772	31.922	26.614
Storey20	34.28	28.335	30.979	26.218
Storey19	33.191	27.882	30.025	25.81
Storey18	32.079	27.407	29.053	25.383
Storey17	30.937	26.904	28.059	24.933
Storey16	29.76	26.364	27.037	24.451
Storey15	28.542	25.779	25.982	23.931
Storey14	27.276	25.14	24.885	23.363
Storey13	25.952	24.434	23.741	22.736
Storey12	24.496	23.559	22.472	21.956
Storey11	22.788	22.333	20.945	20.83
Storey10	20.841	20.779	19.186	19.389
Storey9	18.69	18.942	17.23	17.68
Storey8	16.389	16.879	15.129	15.758
Storey7	13.993	14.651	12.937	13.682
Storey6	11.562	12.318	10.708	11.508
Storey5	9.157	9.942	8.498	9.296
Storey4	6.839	7.586	6.364	7.102
Storey3	4.667	5.31	4.36	4.982
Storey2	2.709	3.182	2.544	2.997
Storey1	1.043	1.285	0.988	1.219

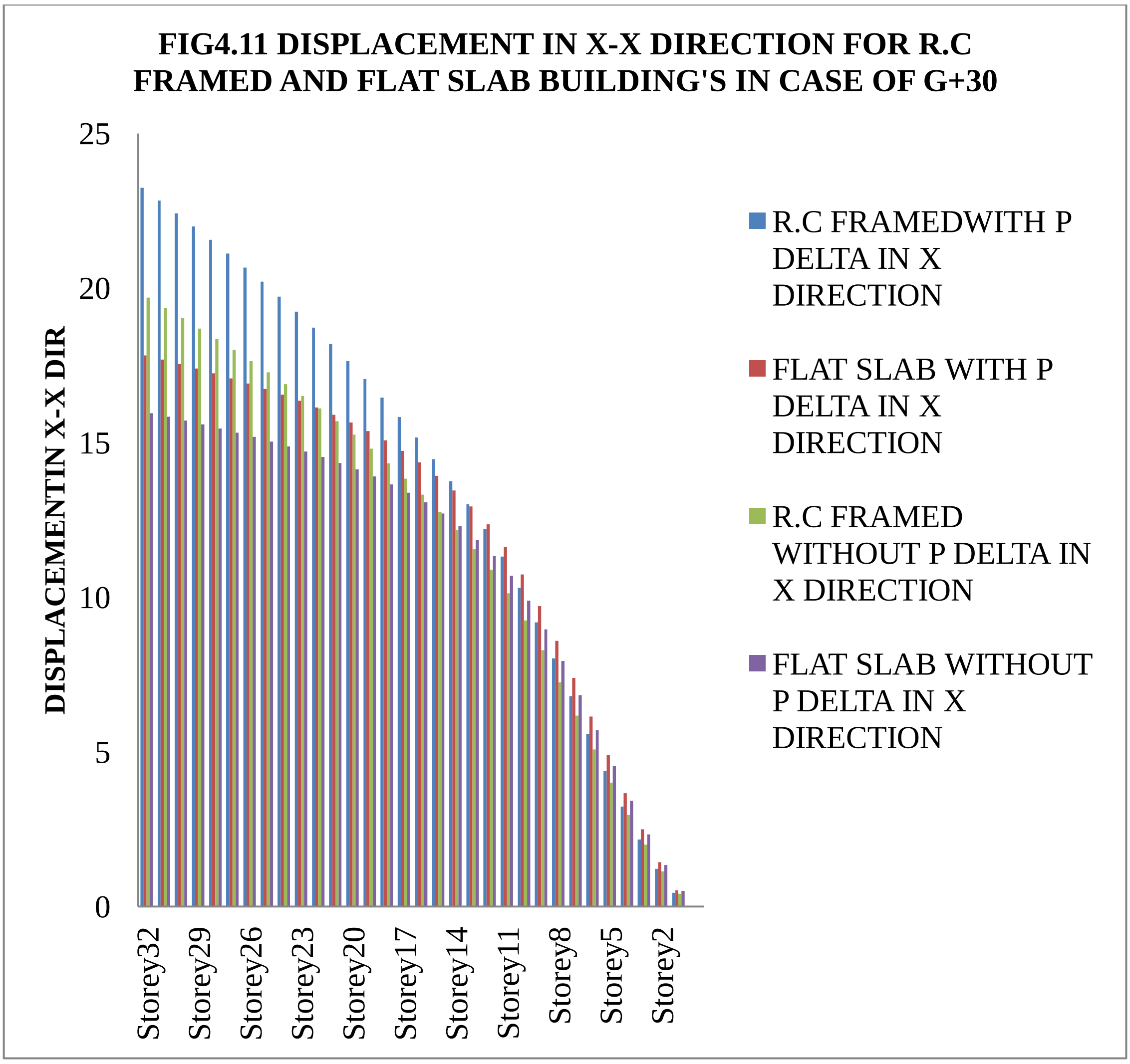


For displacement with P-Delta and without P-Delta in x-direction , conclusion was that for storey 1 displacement was minimum for both cases (R.C framed and flat slab) and for storey 22 displacement was maximum for both cases (R.C framed and flat slab) buildings . When it was compared with R C framed building and flat slab building in case of P-Delta effects it was observed that maximum displacement was 21.97%. Where as in case of without P-Delta analysis displacement was found maximum by 19.54% when compared with R C framed building with flat slab building.

TABLE 4.4 Displacement in X-X Direction for R.C Framed and Flat Slab With P -Delta and Without P-Delta Effect In Case of G+30 (in mm)

Storey level	X-Dir Without P- Delta For R C Framed	X-Dir With P-Delta For R C Framed	X-Dir Without P-Delta For Flat Slab	X-Dir With P-Delta For Flat Slab
Storey32	42.207	136.856	48.457	139.45
Storey31	41.994	136.289	47.854	139.334
Storey30	41.781	135.706	47.785	138.425
Storey29	41.567	135.1	47.685	138.025
Storey28	41.351	134.461	47.582	137.485
Storey27	41.133	133.778	47.421	136.487
Storry26	40.911	133.04	46.425	135.487
Storey25	40.685	132.231	46.215	134.465
Storey24	40.452	131.335	46.112	133.452
Storey23	40.21	130.329	46.012	133.124
Storey22	39.955	129.187	44.125	132.487
Storey21	39.681	127.877	43.0147	132.241
Storey20	39.383	126.358	43.085	132.475
Storey19	39.05	124.581	42.451	132.014
Storey18	38.669	122.49	41.245	130.245
Storey17	38.223	120.015	41.147	130.147
Storey16	37.685	117.076	40.225	126.241
Storey15	37.023	113.58	40.014	125.142
Storey14	36.187	109.419	39.147	125.012
Storey13	35.114	104.471	37.452	124.247
Storey12	33.715	98.602	36.145	112.247
Storey11	31.884	91.682	35.487	102.245
Storey10	29.579	83.676	33.245	98.251
Storey9	26.816	74.652	32.254	85.241
Storey8	23.653	64.773	30.568	72.124
Storey7	20.178	54.287	26.254	60.245

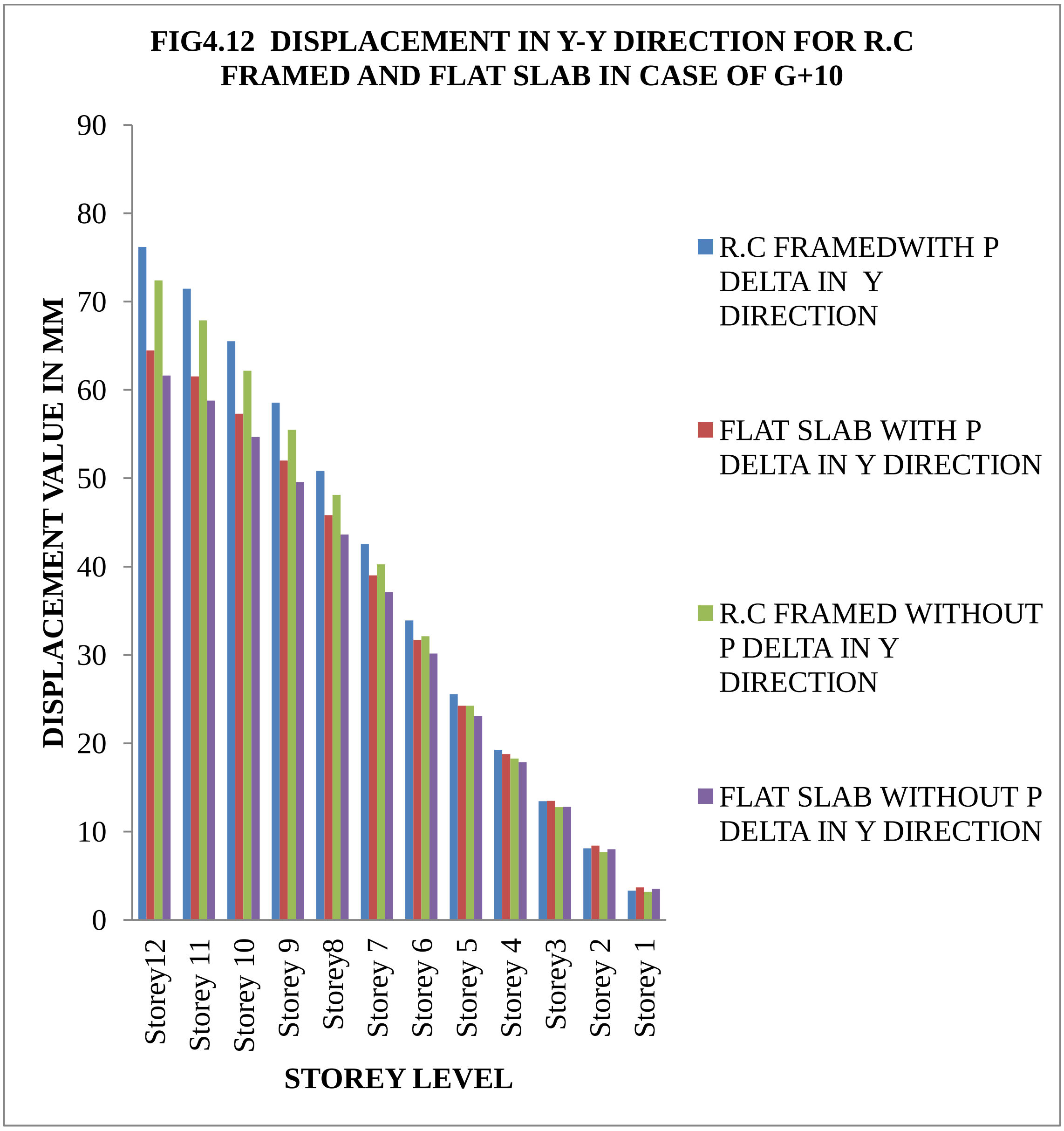
Storey6	16.503	43.524	20.145	54.124
Storey5	12.763	32.891	16.784	39.245
Storey4	9.117	22.86	12.458	30.254
Storey3	5.756	13.967	8.785	20.245
Storey2	2.911	6.788	5.345	11.254
Storey1	0.87	1.931	3.254	5.245
Base	0	0	0	0



For displacement with P-Delta and without P-Delta in x-direction , conclusion was that for storey 1 displacement was minimum for both cases (R.C framed and flat slab) and for storey 32 displacement was maximum for both cases (R.C framed and flat slab) building. For storey 32 displacement was maximum for both cases (R.C framed and flat slab) building. When it was compared with R C framed building and flat slab building in case of P-Delta effects it was observed that maximum displacement was 1.87%. Where as in case of without P-Delta analysis displacement was found maximum by 13.78% when compared with R C framed building with flat slab building. When storey height increases (more than 66.2 m) then displacement value increase in case of P-Delta effects. When I was considered R.C. Framed buildings in case of P-Delta and without P-Delta then it observed that in case of P-Delta analysis displacement was maximum approx 105.716% and it is observed that approx 96.849% displacement was maximum when compared with P-Delta effects in flat slab buildings.

TABLE 4.5 Displacement in Y-Y Direction for R.C Framed and Flat Slab with P- Delta and without P-Delta Effect In Case of G+10 (in mm)

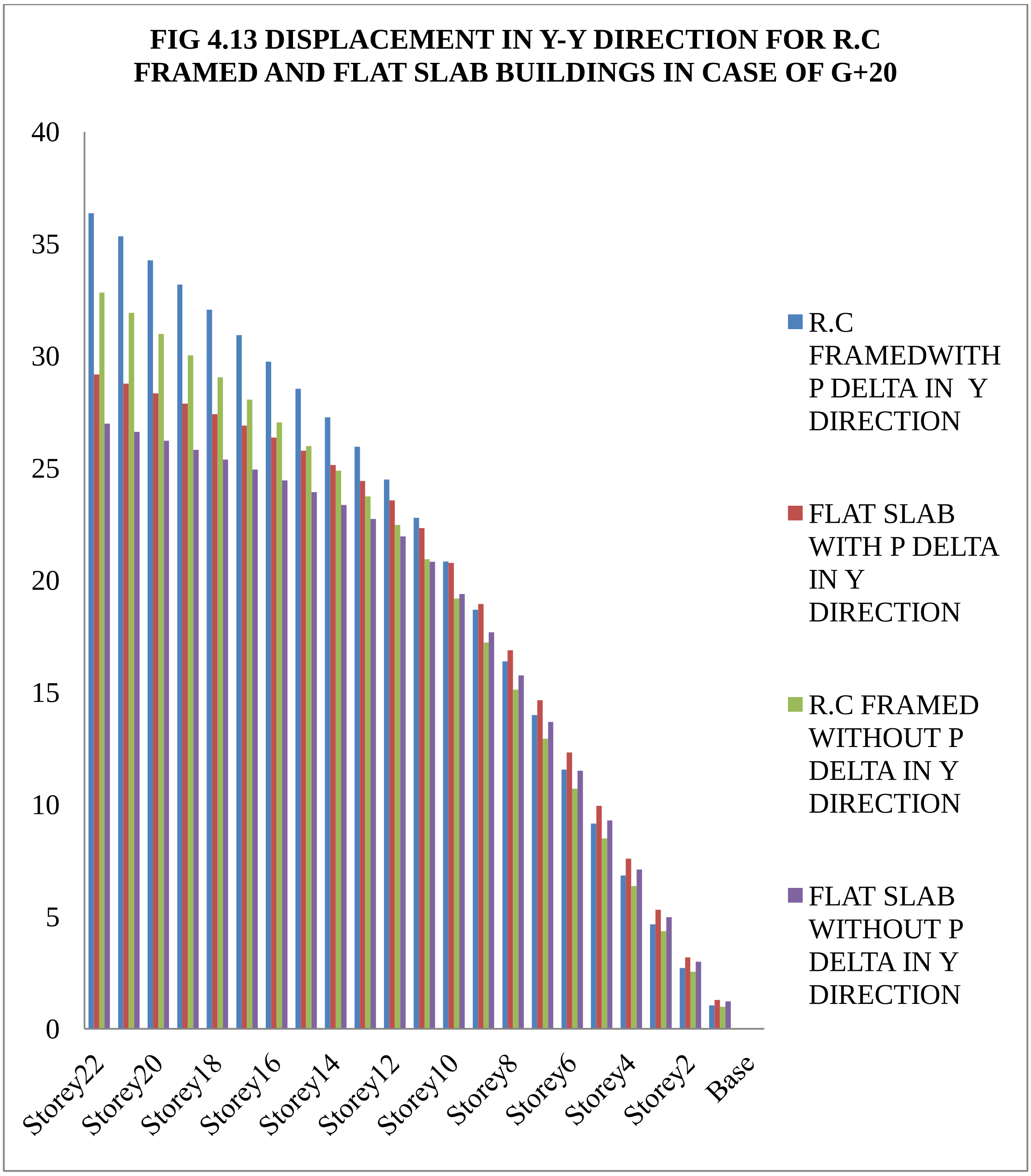
Storey Level	**Displacement In Y-Direction With P-Delta**		**Displacement In Y-Direction Without P-Delta**	
	R.C Framed	**Flat Slab**	**R.C Framed**	**Flat Slab**
Storey12	76.206	64.473	72.414	61.651
Storey 11	71.478	61.533	67.876	58.796
Storey 10	65.522	57.297	62.16	54.683
Storey 9	58.566	52.003	55.502	49.561
Storey8	50.827	45.842	48.123	43.632
Storey 7	42.537	39.013	40.256	37.098
Storey 6	33.916	31.705	32.117	30.147
Storey 5	25.565	24.248	24.248	23.084
Storey 4	19.262	18.76	18.277	17.851
Storey3	13.443	13.461	12.763	12.803
Storey 2	8.087	8.391	7.691	7.985
Storey 1	3.313	3.661	3.166	3.493



For displacement with P-Delta and without P-Delta in Y-direction, conclusion was that for storey 1 displacement was minimum for both cases (R.C framed and flat slab) and for storey 12 displacement was maximum for both cases (R.C framed and flat slab) building It was compared with R C framed building and flat slab building in case of P-Delta effects it was observed that maximum displacement was 16.6805%. Where as in case of without P-Delta analysis displacement was found maximum by 16.056% when compared with R C framed building with flat slab building.

TABLE 4.6 (Displacement in Y-Y Direction for R.C Framed and Flat Slab with P- Delta and without P-Delta Effect In Case of G+20 (in mm)

Storey Level	Displacement In Y-Direction With P-Delta		Displacement In Y-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey22	36.368	29.18	32.832	26.985
Storey21	35.338	28.772	31.922	26.614
Storey20	34.269	28.335	30.979	26.218
Storey19	33.181	27.882	30.025	25.81
Storey18	32.07	27.407	29.053	25.383
Storey17	30.93	26.904	28.059	24.933
Storey16	29.755	26.364	27.037	24.451
Storey15	28.538	25.779	25.982	23.931
Storey14	27.272	25.14	24.885	23.363
Storey13	25.95	24.434	23.741	22.736
Storey12	24.495	23.559	22.472	21.956
Storey11	22.787	22.333	20.945	20.83
Storey10	20.84	20.779	19.186	19.389
Storey9	18.69	18.942	17.23	17.68
Storey8	16.388	16.879	15.129	15.758
Storey7	13.993	14.651	12.937	13.682
Storey6	11.562	12.318	10.708	11.508
Storey5	9.157	9.942	8.498	9.296
Storey4	6.839	7.586	6.364	7.102
Storey3	4.667	5.31	4.36	4.982
Storey2	2.709	3.182	2.544	2.997
Storey1	1.043	1.285	0.988	1.219

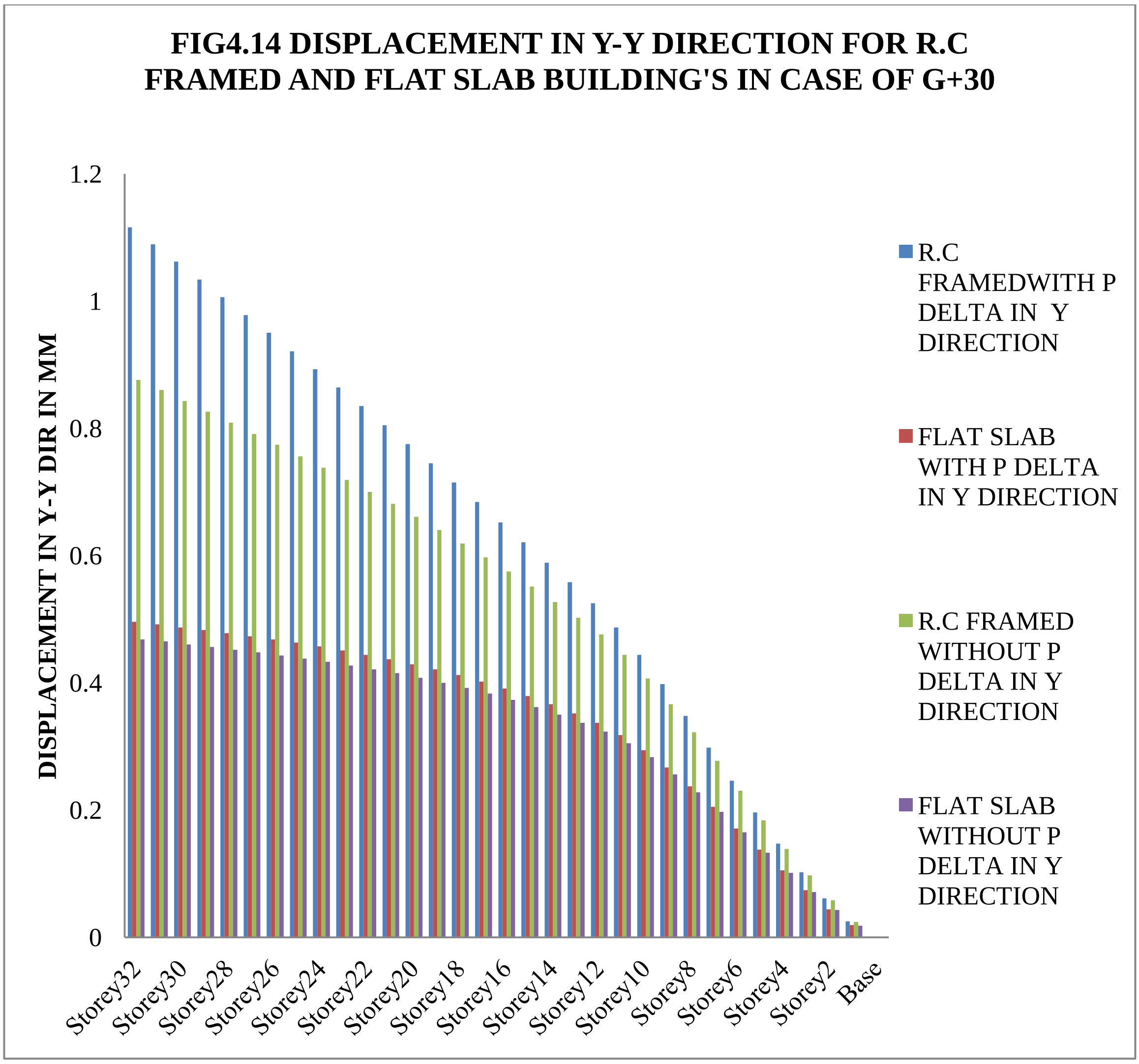


For displacement with P-Delta in Y-direction, conclusion was that for storey 1 displacement was minimum for both cases (R.C framed and flat slab) and for storey 22 displacement was maximum for both cases (R.C framed and flat slab) building . It was compared with R C framed building and flat slab building in case of P-Delta effects it was observed that maximum displacement was 21.932%. Where as in case of without P-Delta analysis displacement was found maximum by 19.54% when compared with R C framed building with flat slab building.

TABLE 4.7 (Displacement in Y-Y Direction for R.C Framed and Flat Slab with P- Delta and without P-Delta Effect In Case of G+30 (in mm)

Storey level	Y-Dir Without P-Delta For R C Framed	Y-Dir With P-Delta For R C Framed	Y-Dir Without P-Delta For Flat Slab	Y-Dir With P-Delta For Flat Slab
Storey32	40.7	132.142	45.874	138.245
Storey31	40.55	131.761	45.675	137.785
Storey30	40.4	131.368	45.354	137.542
Storey29	40.249	130.954	45.245	136.245
Storey28	40.096	130.511	45.125	136.124
Storey27	39.941	130.029	44.754	139.078
Storry26	39.782	129.496	44.662	137.245
Storey25	39.619	128.897	44.552	136.124
Storey24	39.448	128.216	44.321	136.087
Storey23	39.268	127.431	44.214	135.754
Storey22	39.074	126.514	44.142	134.254
Storey21	38.861	125.433	42.124	132.241
Storey20	38.623	124.146	41.895	130.245
Storey19	38.349	122.604	41.557	128.451
Storey18	38.027	120.749	41.225	125.425
Storey17	37.638	118.508	40.654	124.125
Storey16	37.157	115.799	40.254	121.875
Storey15	36.549	112.526	40.078	118.124
Storey14	35.766	108.578	38.145	115.243
Storey13	34.744	103.83	38.0147	108.425
Storey12	33.393	98.142	37.245	102.125
Storey11	31.609	91.382	35.247	98.452
Storey10	29.348	83.511	34.784	90.784
Storey9	26.626	74.595	32.745	80.451
Storey8	23.501	64.794	26.451	77.245
Storey7	20.059	54.358	22.178	62.245
Storey6	16.414	43.619	18.981	48.365

Storey5	12.701	32.986	15.754	36.245
Storey4	9.077	22.941	12.451	26.354
Storey3	5.733	14.022	7.412	20.128
Storey2	2.9	6.817	4.125	11.274
Storey1	0.867	1.939	2.125	5.241
Base	0	0	0	0



For displacement with P-Delta and without P-Delta in Y-direction , conclusion was that for storey 1 displacement was minimum for both cases (R.C framed and flat slab) and for storey 32 displacement was maximum for both cases (R.C framed and flat slab) building When It was considered for R.C. Framed buildings in case of P-Delta and without P-Delta then it observed that in case of P-Delta analysis displacement was maximum approx 105.81% and it is observed that approx 100.33% displacement was maximum when compared with P-Delta effects in flat slab buildings.

TABLE 4.8 Maximum Displacement in X-X Direction for R.C Framed and Flat Slab with and without P-Delta Effect In Case of G+10, G+20, G+30 (in mm)

Storey Height	X-Dir Without P -Delta For R C Framed	X-Dir With P -Delta For R C Framed	X-Dir Without P-Delta For Flat Slab	X-Dir With P -Delta For Flat Slab
	mm	mm	mm	mm
G+10	68.909	81.379	72.44	84.379
G+20	41.047	77.729	45.487	83.745
G+30	42.207	136.856	48.457	139.45

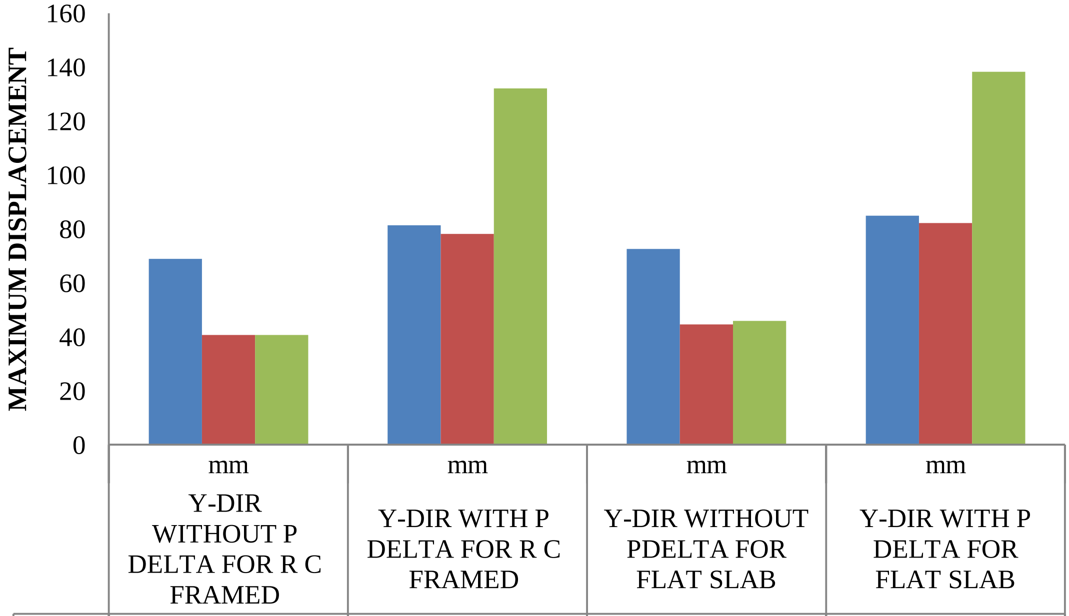
FIG 4.15 MAX. DISPLACEMENT IN X-X DIRECTION FOR G+10,G+20,G+30

For displacement with P-Delta and without P-Delta in X-direction, In case of P-Delta effects maximum displacement occurs in R.C. framed building as well as with flat slab for G+30 when compared with G+10, G+20 storey buildings.

TABLE 4.9 Maximum Displacement in Y-Y Direction for R.C Framed and Flat Slab with and without P-Delta Effect In Case of G+10, G+20, G+30 (in mm)

Storey Height	Y-Dir Without P-Delta For R C Framed	Y-Dir With P-Delta For R C Framed	Y-Dir Without P-Delta For Flat Slab	Y-Dir With P-Delta For Flat Slab
	mm	mm	mm	mm
G+9	68.93	81.425	72.546	84.875
G+19	40.658	78.214	44.587	82.255
G+29	40.7	132.142	45.874	138.245

FIG 4.16 MAX .DISPLACEMENT IN Y-Y DIRECTION FOR G+10,G+20,G+30



	mm Y-DIR WITHOUT P DELTA FOR R C FRAMED	mm Y-DIR WITH P DELTA FOR R C FRAMED	mm Y-DIR WITHOUT PDELTA FOR FLAT SLAB	mm Y-DIR WITH P DELTA FOR FLAT SLAB
G+10	68.93	81.425	72.546	84.875
G+20	40.658	78.214	44.587	82.255
G+30	40.7	132.142	45.874	138.245

For displacement with P-Delta and without P-Delta in Y-direction, conclusion was that maximum. Displacement occurs for G+10 storey, as compared with G+20 & G+30. Same Condition Occurred for analysis without P-Delta effect.

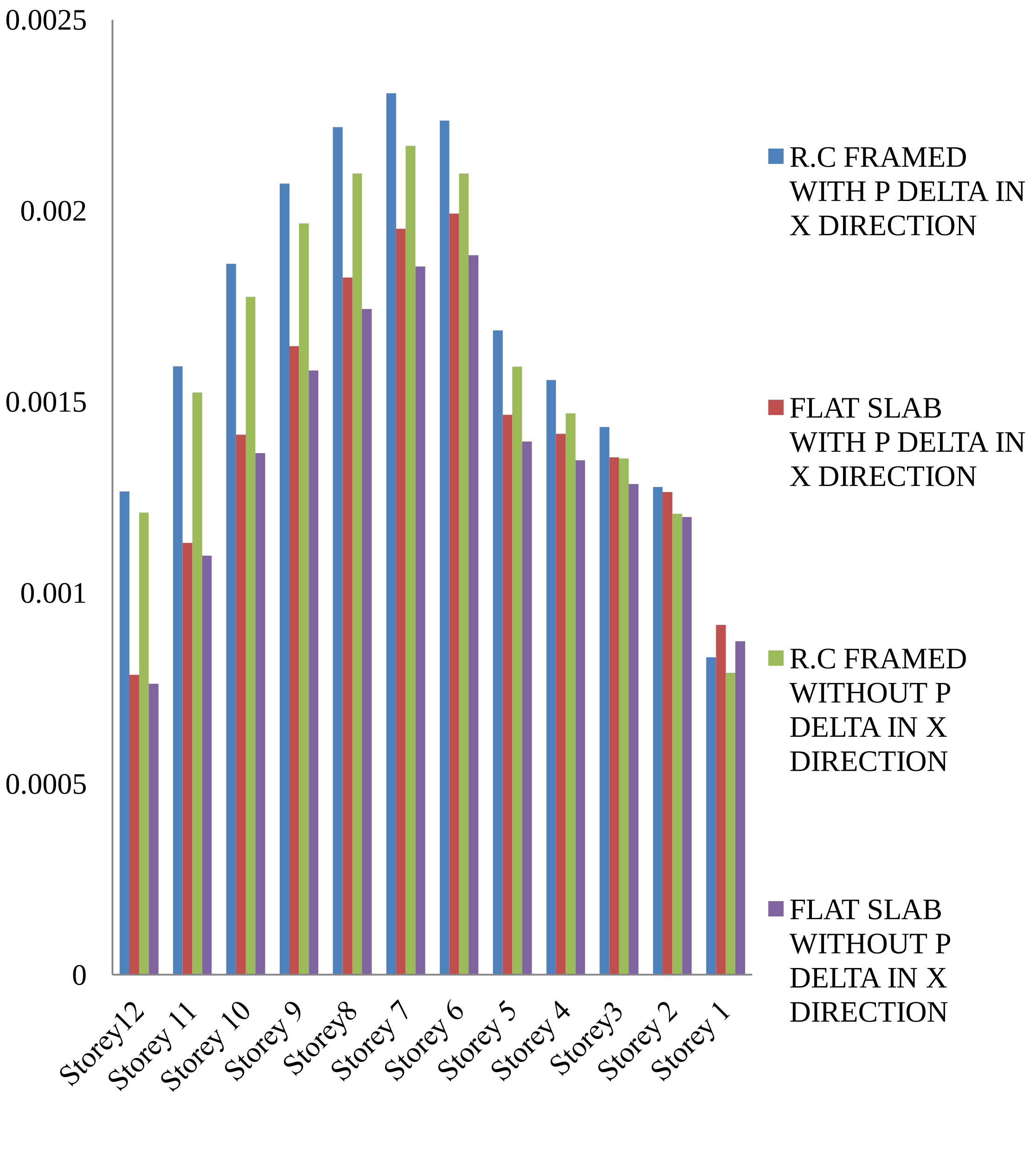
4.6 STOREY DRIFT

storey drift can be defined as the lateral displacement of one level relative to the level above are below it: As per clause no. 7.11.1 of IS 1893 (Part-1): 2016, the storey drift in any storey due to specified design lateral force with partial load factor of 1.0, shall not exceed 0.004 times the storey height. Below Tables gives the value of storey drift in x and y direction.

TABLE 4.10 Drift in X-X Direction for R.C Framed and Flat Slab with P-Delta and without P-Delta Effect In Case of G+10 (in mm)

Storey Level	Drift In X-Direction With P-Delta		Drift In X-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey12	0.001265	0.000785	0.00121	0.000762
Storey 11	0.001593	0.001131	0.001524	0.001097
Storey 10	0.001861	0.001414	0.001775	0.001366
Storey 9	0.002071	0.001646	0.001967	0.001582
Storey8	0.002219	0.001825	0.002098	0.001743
Storey 7	0.002308	0.001953	0.00217	0.001854
Storey 6	0.002236	0.001993	0.002098	0.001884
Storey 5	0.001687	0.001466	0.001592	0.001396
Storey 4	0.001557	0.001416	0.00147	0.001347
Storey3	0.001434	0.001355	0.001352	0.001285
Storey 2	0.001277	0.001264	0.001207	0.001198
Storey 1	0.000831	0.000916	0.000791	0.000873

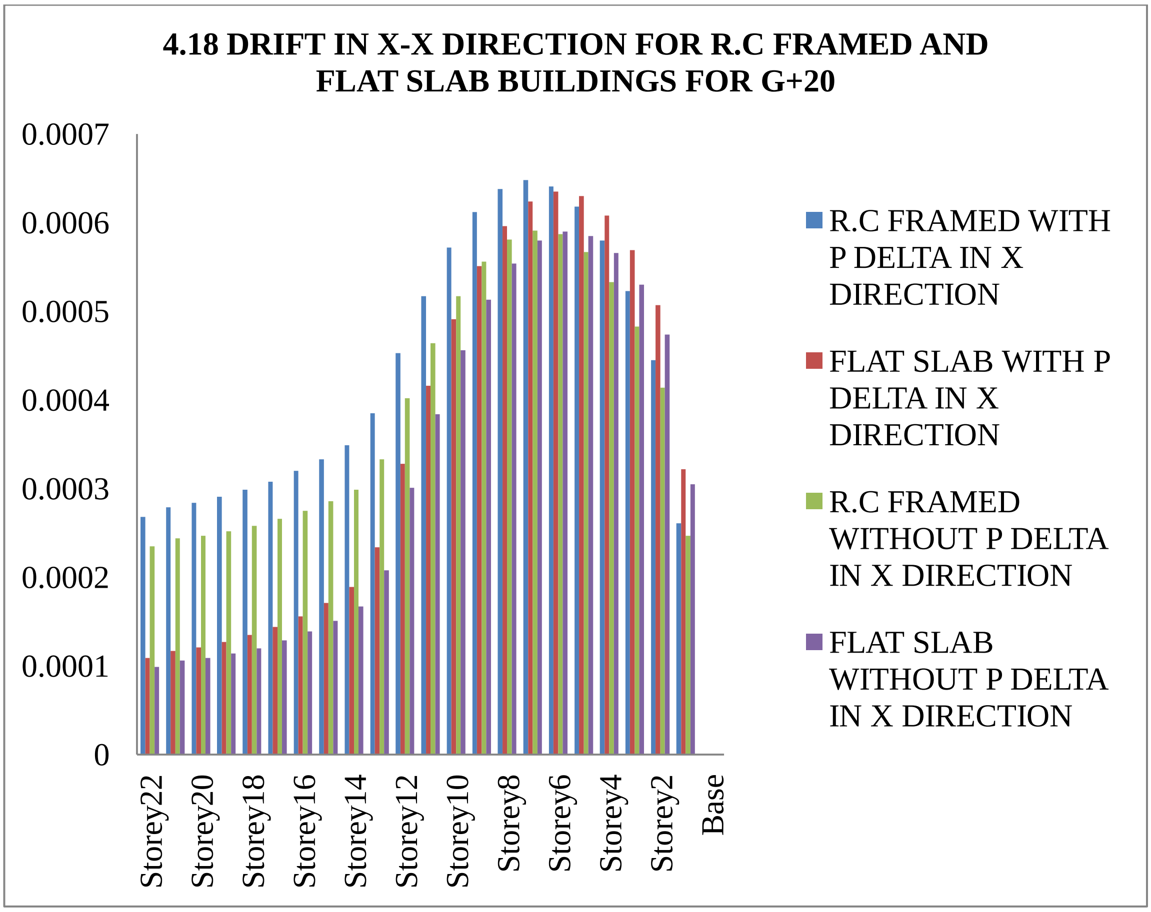
FIG 4.17 DRIFT IN X-X DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS FOR G+10



For storey drift with P-Delta and without P-Delta in X-direction, maximum storey drift occurs at storey 7 of the buildings in both cases (R.C.framed and flat slab). For storey drift with P-Delta in X-direction, maximum storey drift occurs at storey 7 of the buildings in both cases (R.C.framed and flat slab).

TABLE 4.11 Drift in X-X Direction for R.C Framed and Flat Slab with P-Delta and without P-Delta Effect In Case of G+20 (in mm)

Storey Level	Drift In X-Direction With P-Delta		Drift In X-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey22	0.000268	0.000109	0.000235	0.000099
Storey21	0.000279	0.000117	0.000244	0.000106
Storey20	0.000284	0.000121	0.000247	0.000109
Storey19	0.000291	0.000127	0.000252	0.000114
Storey18	0.000299	0.000135	0.000258	0.00012
Storey17	0.000308	0.000144	0.000266	0.000129
Storey16	0.00032	0.000156	0.000275	0.000139
Storey15	0.000333	0.000171	0.000286	0.000151
Storey14	0.000349	0.000189	0.000299	0.000167
Storey13	0.000385	0.000234	0.000333	0.000208
Storey12	0.000453	0.000328	0.000402	0.000301
Storey11	0.000517	0.000416	0.000464	0.000384
Storey10	0.000572	0.000491	0.000517	0.000456
Storey9	0.000612	0.000551	0.000556	0.000513
Storey8	0.000638	0.000596	0.000581	0.000554
Storey7	0.000648	0.000624	0.000591	0.00058
Storey6	0.000641	0.000635	0.000587	0.00059
Storey5	0.000618	0.00063	0.000567	0.000585
Storey4	0.00058	0.000608	0.000533	0.000566
Storey3	0.000523	0.000569	0.000483	0.00053
Storey2	0.000445	0.000507	0.000414	0.000474
Storey1	0.000261	0.000322	0.000247	0.000305
Base	0	0	0	0

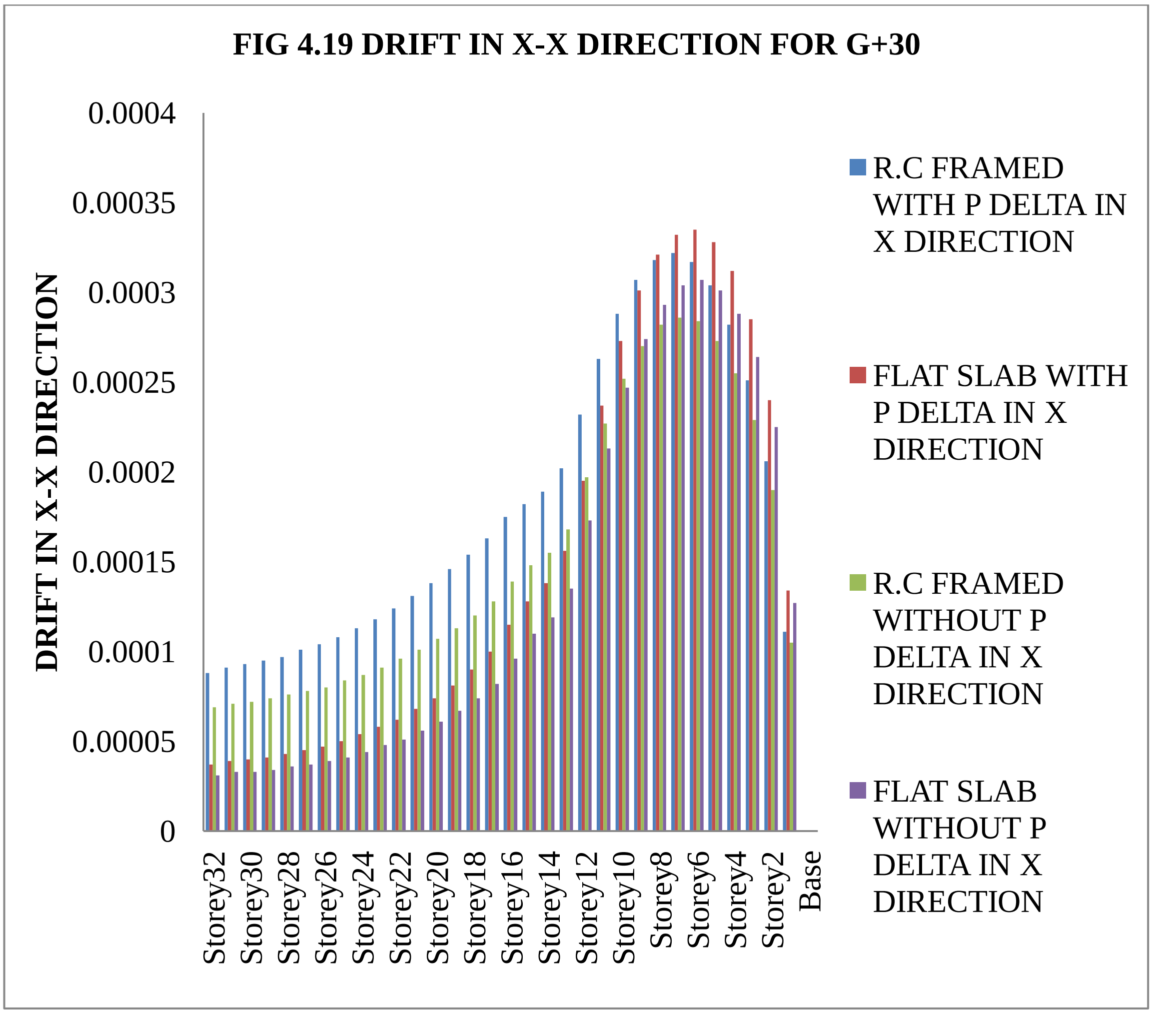


For storey drift with P-Delta in X-direction, maximum storey drift value occurs at storey 7 of the buildings in both cases (R.C.framed and flat slab). And minimum drift value occurs at storey 22.

TABLE 4.12 Drift in X-X Direction for R.C Framed and Flat Slab with P-Delta and without P-Delta Effect In Case of G+30 (in mm)

Storey Level	Drift In X-Direction With P-Delta		Drift In X-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey32	0.000088	0.000037	0.000069	0.000031
Storey31	0.000091	0.000039	0.000071	0.000033
Storey30	0.000093	0.00004	0.000072	0.000033
Storey29	0.000095	0.000041	0.000074	0.000034
Storey28	0.000097	0.000043	0.000076	0.000036

Storey27	0.000101	0.000045	0.000078	0.000037
Storey26	0.000104	0.000047	0.00008	0.000039
Storey25	0.000108	0.00005	0.000084	0.000041
Storey24	0.000113	0.000054	0.000087	0.000044
Storey23	0.000118	0.000058	0.000091	0.000048
Storey22	0.000124	0.000062	0.000096	0.000051
Storey21	0.000131	0.000068	0.000101	0.000056
Storey20	0.000138	0.000074	0.000107	0.000061
Storey19	0.000146	0.000081	0.000113	0.000067
Storey18	0.000154	0.00009	0.00012	0.000074
Storey17	0.000163	0.0001	0.000128	0.000082
Storey16	0.000175	0.000115	0.000139	0.000096
Storey15	0.000182	0.000128	0.000148	0.00011
Storey14	0.000189	0.000138	0.000155	0.000119
Storey13	0.000202	0.000156	0.000168	0.000135
Storey12	0.000232	0.000195	0.000197	0.000173
Storey11	0.000263	0.000237	0.000227	0.000213
Storey10	0.000288	0.000273	0.000252	0.000247
Storey9	0.000307	0.000301	0.00027	0.000274
Storey8	0.000318	0.000321	0.000282	0.000293
Storey7	0.000322	0.000332	0.000286	0.000304
Storey6	0.000317	0.000335	0.000284	0.000307
Storey5	0.000304	0.000328	0.000273	0.000301
Storey4	0.000282	0.000312	0.000255	0.000288
Storey3	0.000251	0.000285	0.000229	0.000264
Storey2	0.000206	0.00024	0.00019	0.000225
Storey1	0.000111	0.000134	0.000105	0.000127
Base	0	0	0	0

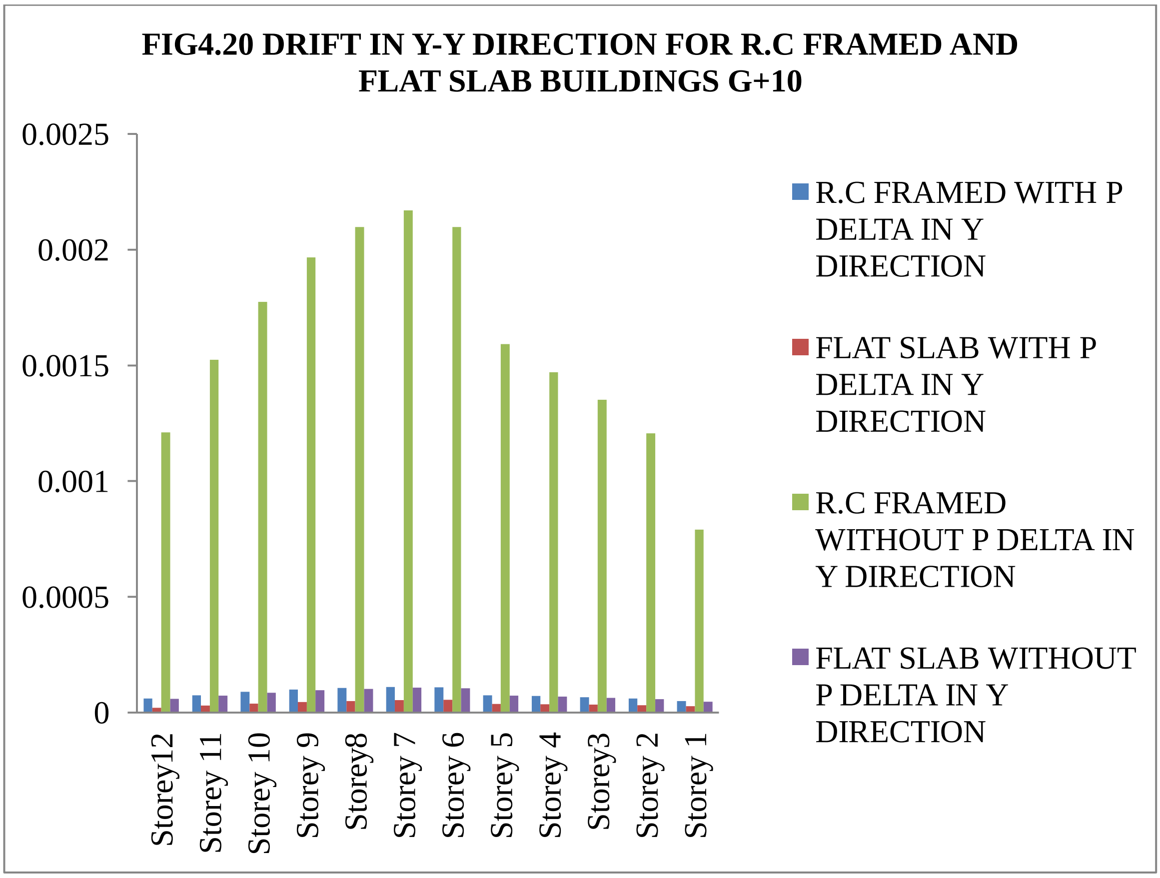


For storey drift with P-Delta in X-direction, maximum storey drift value occurs at storey 7 of the buildings in both cases (R.C.framed and flat slab). And minimum drift value occurs at storey 32.

TABLE 4.13 Drift in Y-Y Direction for R.C Framed and Flat Slab with P-Delta and without P-Delta Effect In Case of G+10 (in mm)

Storey Level	Drift In Y-Direction With P-Delta		Drift In Y-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey12	0.000061	0.00002	0.00121	0.000059
Storey 11	0.000075	0.00003	0.001524	0.000073
Storey 10	0.000089	0.000038	0.001775	0.000086
Storey 9	0.000099	0.000045	0.001967	0.000096

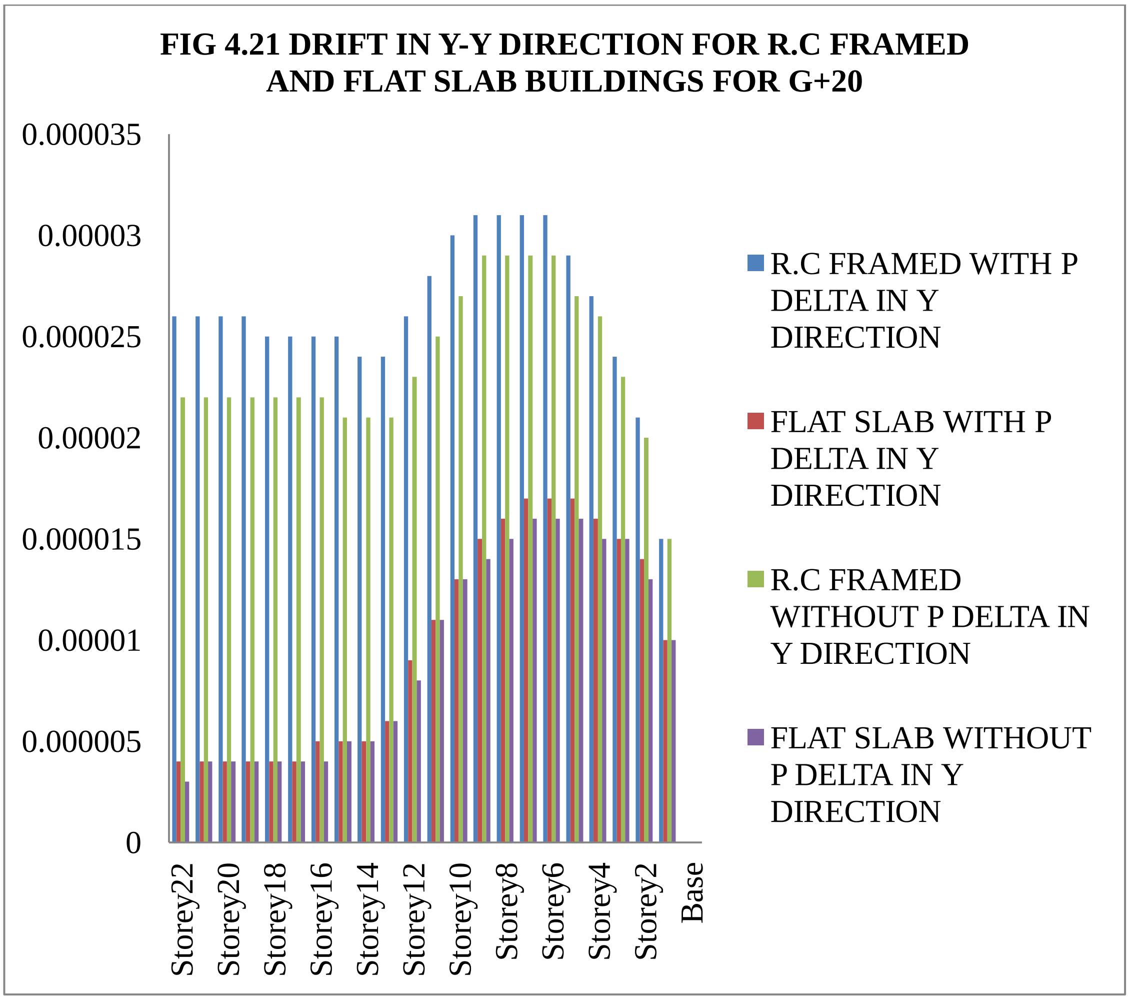
Storey8	0.000106	0.00005	0.002098	0.000102
Storey 7	0.000111	0.000054	0.00217	0.000107
Storey 6	0.000109	0.000055	0.002098	0.000105
Storey 5	0.000075	0.000037	0.001592	0.000073
Storey 4	0.000071	0.000036	0.00147	0.000069
Storey3	0.000066	0.000034	0.001352	0.000064
Storey 2	0.00006	0.000032	0.001207	0.000058
Storey 1	0.000049	0.000027	0.000791	0.000047



For storey drift with P-Delta in Y-direction, maximum storey drift occurs at storey 7 for R.C framed building.

TABLE 4.14 Drift in Y-Y Direction for R.C Framed and Flat Slab with P-Delta and Without P-Delta Effect G+20 (in mm)

Storey Level	Drift In Y-Direction With P-Delta		Drift In Y-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey22	0.000026	0.000004	0.000022	0.000003
Storey21	0.000026	0.000004	0.000022	0.000004
Storey20	0.000026	0.000004	0.000022	0.000004
Storey19	0.000026	0.000004	0.000022	0.000004
Storey18	0.000025	0.000004	0.000022	0.000004
Storey17	0.000025	0.000004	0.000022	0.000004
Storey16	0.000025	0.000005	0.000022	0.000004
Storey15	0.000025	0.000005	0.000021	0.000005
Storey14	0.000024	0.000005	0.000021	0.000005
Storey13	0.000024	0.000006	0.000021	0.000006
Storey12	0.000026	0.000009	0.000023	0.000008
Storey11	0.000028	0.000011	0.000025	0.000011
Storey10	0.00003	0.000013	0.000027	0.000013
Storey9	0.000031	0.000015	0.000029	0.000014
Storey8	0.000031	0.000016	0.000029	0.000015
Storey7	0.000031	0.000017	0.000029	0.000016
Storey6	0.000031	0.000017	0.000029	0.000016
Storey5	0.000029	0.000017	0.000027	0.000016
Storey4	0.000027	0.000016	0.000026	0.000015
Storey3	0.000024	0.000015	0.000023	0.000015
Storey2	0.000021	0.000014	0.00002	0.000013
Storey1	0.000015	0.00001	0.000015	0.00001
Base	0	0	0	0

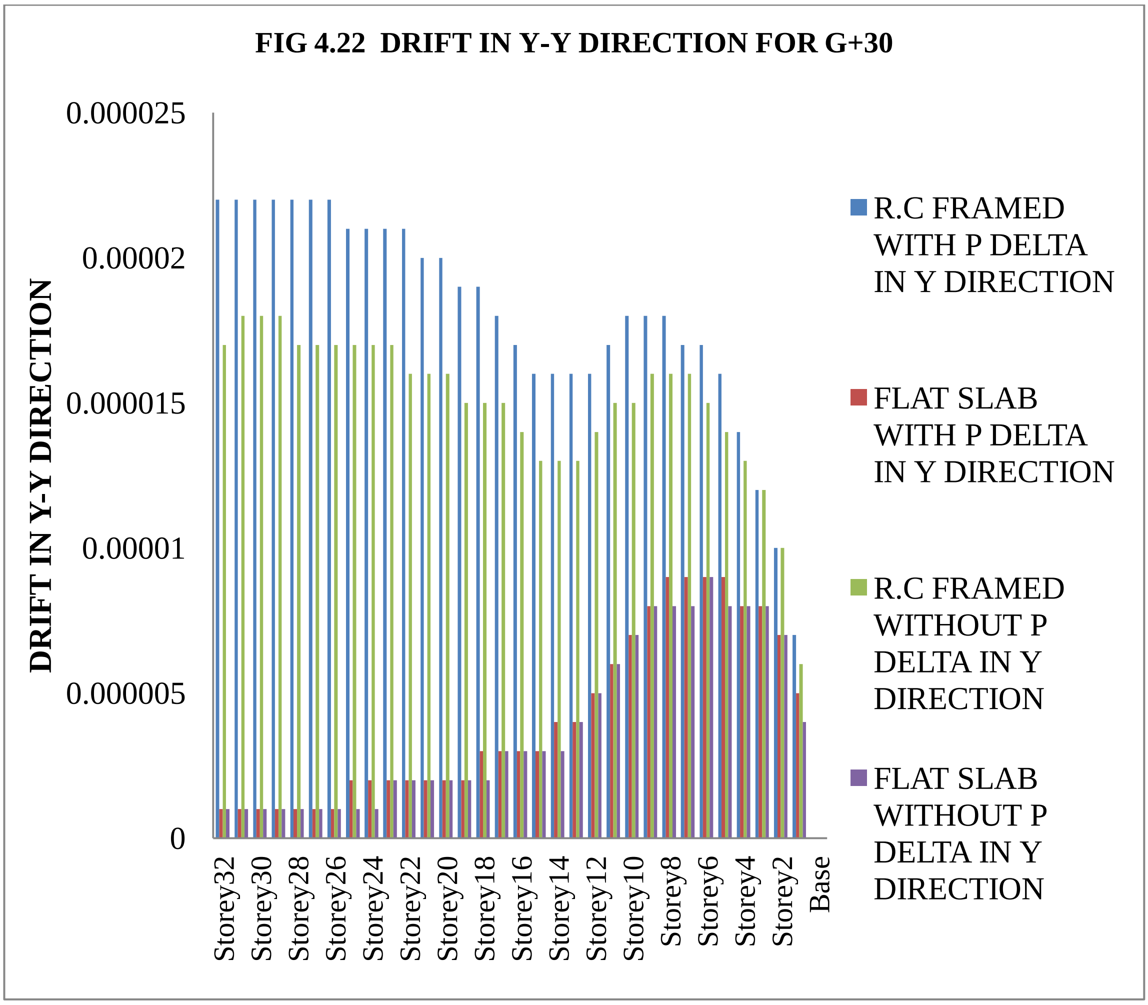


For storey drift with P-Delta in Y-direction, maximum storey drift occurs at storey 6, 7, 8, and 9 in both cases (R.C.framed and flat slab). And minimum drift occurs at storey 1 in case of G+20 storey.

TABLE 4.15 Drift in Y-Y Direction for R.C Framed and Flat Slab with P-Delta and without P-Delta Effect G+30 (in mm)

Storey Level	Drift In Y-Direction With P-Delta		Drift In Y-Direction Without P-Delta	
	R.C Framed	Flat Slab	R.C Framed	Flat Slab
Storey31	0.000022	0.000001	0.000018	0.000001
Storey30	0.000022	0.000001	0.000018	0.000001
Storey29	0.000022	0.000001	0.000018	0.000001

Storey28	0.000022	0.000001	0.000017	0.000001
Storey27	0.000022	0.000001	0.000017	0.000001
Storey26	0.000022	0.000001	0.000017	0.000001
Storey25	0.000021	0.000002	0.000017	0.000001
Storey24	0.000021	0.000002	0.000017	0.000001
Storey23	0.000021	0.000002	0.000017	0.000002
Storey22	0.000021	0.000002	0.000016	0.000002
Storey21	0.00002	0.000002	0.000016	0.000002
Storey20	0.00002	0.000002	0.000016	0.000002
Storey19	0.000019	0.000002	0.000015	0.000002
Storey18	0.000019	0.000003	0.000015	0.000002
Storey17	0.000018	0.000003	0.000015	0.000003
Storey16	0.000017	0.000003	0.000014	0.000003
Storey15	0.000016	0.000003	0.000013	0.000003
Storey14	0.000016	0.000004	0.000013	0.000003
Storey13	0.000016	0.000004	0.000013	0.000004
Storey12	0.000016	0.000005	0.000014	0.000005
Storey11	0.000017	0.000006	0.000015	0.000006
Storey10	0.000018	0.000007	0.000015	0.000007
Storey9	0.000018	0.000008	0.000016	0.000008
Storey8	0.000018	0.000009	0.000016	0.000008
Storey7	0.000017	0.000009	0.000016	0.000008
Storey6	0.000017	0.000009	0.000015	0.000009
Storey5	0.000016	0.000009	0.000014	0.000008
Storey4	0.000014	0.000008	0.000013	0.000008
Storey3	0.000012	0.000008	0.000012	0.000008
Storey2	0.00001	0.000007	0.00001	0.000007
Storey1	0.000007	0.000005	0.000006	0.000004
Base	0	0	0	0

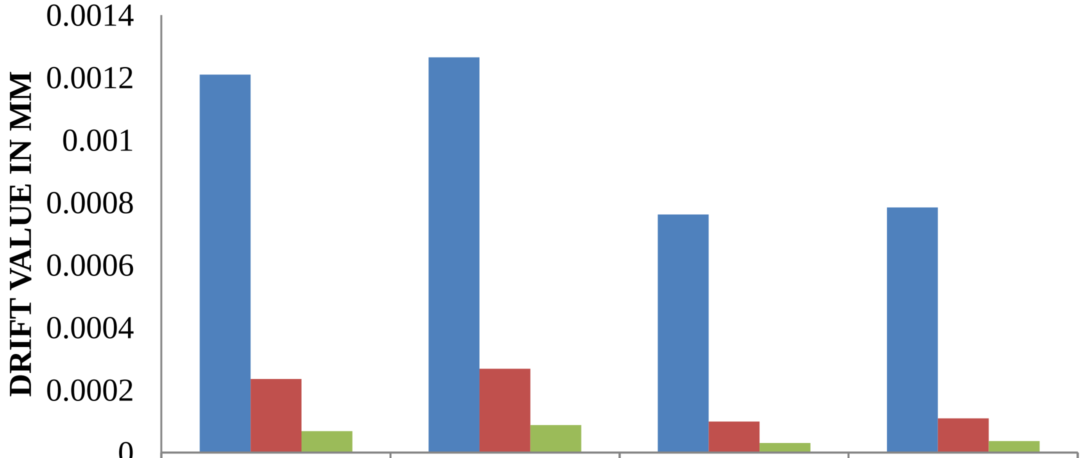


For storey drift with P-Delta in Y-direction, maximum storey drift value occurs at top storey of the buildings.

TABLE 4.16 Maximum Drift in X-X Direction for R.C Framed and Flat Slab With P-Delta and Without P-Delta Effect In Case Of G+10, G+20, G+30 (in mm)

Storey Height	X-Dir Without P -Delta For R C Framed	X-Dir With P -Delta For R C Framed	X-Dir Without P-Delta For Flat Slab	X-Dir With P -Delta For Flat Slab
G+10	0.00121	0.00127	0.00076	0.00079
G+20	0.00024	0.00027	9.9E-05	0.00011
G+30	0.000069	0.000088	0.000031	0.000037

FIG 4.23 MAX DRIFT IN X-X DIRECTIONFOR G+10,G+20,G+30



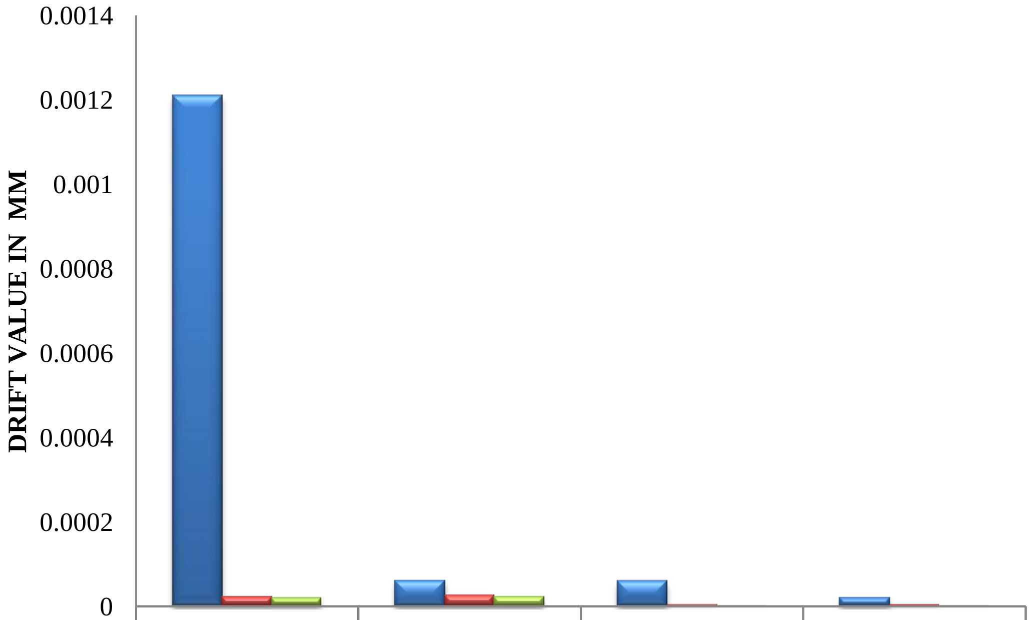
	mm X-Dir Without P - Delta For R C Framed	mm X-Dir With P - Delta For R C Framed	mm X-Dir Without P-delta For Flat Slab	mm X-Dir With P - Delta For Flat Slab
G+10	0.00121	0.001265	0.000762	0.000785
G+20	0.000235	0.000268	9.9E-05	0.000109
G+30	6.9E-05	8.8E-05	3.1E-05	3.7E-05

Storey drift with P-Delta and without P-Delta in X-direction, conclusion was-For G+ 10 storey's drift was maximum in R.C framed For without P-Delta maximum displacement occurs in R.C. framed and flat slab building for G+10 Storey buildings when compared with G+20, G+30 storey buildings.

TABLE 4.17 Maximum Drift in Y-Y Direction for R.C Framed and Flat Slab With P-Delta and Without P-Delta Effect In Case of G+10, G+20, G+30(in mm)

Storey Height	Y-Dir With P - Delta For R C Framed	Y-Dir Without P -Delta For R C Framed	Y-Dir Without P-Delta For Flat Slab	Y-Dir With P -Delta For Flat Slab
G+10	0.00121	6.1E-05	5.9E-05	0.00002
G+20	2.2E-05	2.6E-05	3E-06	4E-06
G+30	0.000018	0.000022	0.000001	0.000001

FIG .4.24.MAX DRIFT IN Y-Y DIRECTIONFOR G+10,G+20,G+30



	mm Y-Dir With P -Delta For R C Framed	mm Y-Dir Without P -Delta For R C Framed	mm Y-Dir With P-delta For Flat Slab	mm Y-Dir Without P -Delta For Flat Slab
G+10	0.00121	6.1E-05	5.9E-05	0.00002
G+20	2.2E-05	2.6E-05	3E-06	4E-06
G+30	1.8E-05	2.2E-05	0.000001	0.000001

Storey drift with P-Delta and without P-Delta in Y-direction, conclusion was-For G+ 10 storey‘s drift was maximum in R.C framed For without P-Delta maximum displacement occurs in R.C. framed and flat slab building for G+10 Storey buildings when compared with G+20, G+30 storey buildings.

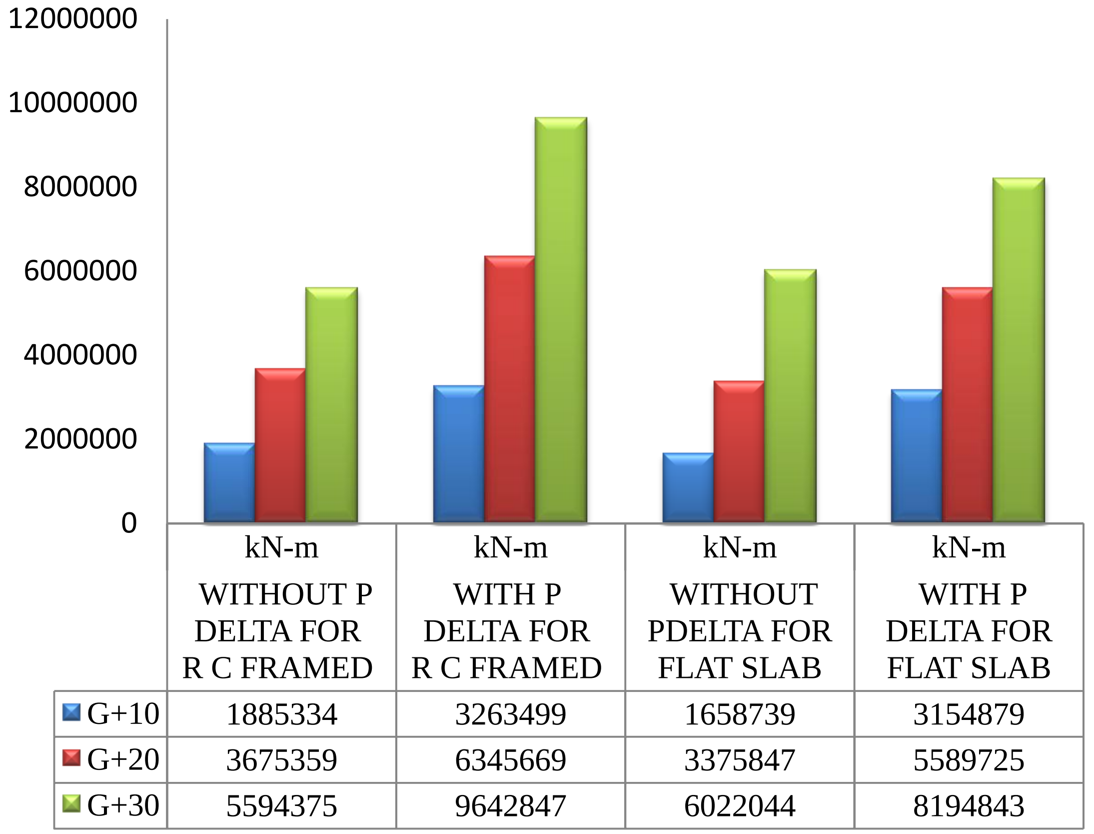
4.7 OVERTURNING MOMENT

For the Seismic loading in X direction, the maximum bending is found about Y axis, and vice-versa. Being an important parameter torsional moment is calculated about Z axis because models are in X-Y plane. The value of maximum bending moment increased when type of analysis changes from linear to P-Delta. The value of maximum torsional moment decreased for the same. The percentage variation of maximum bending moment increases with the storey height.

TABLE 4.18 Maximum Overturning moments for R.C Framed and Flat Slab Buildings in Case of G+10, G+20, G+30 (in kN-m)

Storey Height	Without P-Delta For R C Framed	With P-Delta For R C Framed	Without P-Delta For Flat Slab	With P-Delta For Flat Slab
	kN-m	kN-m	kN-m	kN-m
G+10	1885334	3263499	1658739	3154879
G+20	3675359	6345669	3375847	5589725
G+30	5594375	9642847	6022044	8194843

FIG.4.25 OVERTURNING MOMENT FOR G+10,G+20 & G+30 IN kN-m



Overturning moment with P-Delta and without P-Delta , conclusion was that For G+ 30 storey building overturning moment was maximum in both cases R.C framed and flat slab buildings in case of P-Delta effect when compared with G+10, G+20 storey buildings.

CHAPTER-5
CONCLUSIONS

5.1 CONCLUSION

This chapter presents the main conclusion of P-Delta analysis and it's important for building analysis. In last century there was observation that many buildings constructed near seismic zone get failure due to less knowledge of modern engineering.

Conclusion observed is as follows:

Increases in number of storey directly affect the P-Delta. It has been also observed that results of analysis without and with P-Delta effect are important for a building. For high rise building in seismic zone P-Delta analysis is mandatory, because buckling will occur at top storey due to secondary moment.

P-Delta effect calculation is important because when the earthquake occurs, the structural behaviour becomes very important and run out to its first order behavior and go to directly to second order, therefore it needs to analysis the structure by one of the nonlinear analysis method such as P-Delta effect.

As number of storey increases P-Delta effects becomes more important, P-Delta analysis and linear static analysis are carried out for 10, 20 and 30 storey RC framed structure and flat slab structure using ETABS. On the basis of results obtained, following conclusions are drawn.

We can say that ten story building the analysis results with and without P-Delta effect were very close to each other and it was not necessary to observe or take in account the P-Delta effect, but for above ten story building many properties such as displacement, overturning moment and story drift has been changed and it can be concluded that P-Delta effect is a disturbance effect for tall building and it is necessary to include in calculations to rescue the tall building from sudden collapse.

The displacements of conventional building models (without P-Delta) is less when compare to building with p- delta and the displacements of flat slab building models (without P-Delta) is less when compare to flat slab building with p- delta. And also analyze that displacements of conventional building models is maximum when compare to flat slab building models in case of without P-Delta analysis. And the displacements of conventional building models is maximum when compare to flat slab building models in case of P-Delta analysis.

The storey drift of conventional building models (without P-Delta) is less when compare to building with P-Delta. And the storey drift of flat slab building models (without P-Delta) is less when compare to flat slab building with P-Delta. And also the storey drift of conventional building models is maximum when compare to flat slab building models in case of without P-Delta effects. And the storey drift of conventional building models is maximum when compare to flat slab building models in case of P-Delta effects.

5.2 SCOPE FOR FUTURE WORK

Future of designing a building is limitless, an indomitable venture. One can after using various commercial software which have one or more advantages for using in irregular or regular building, can find an optimum solution in terms of safety and economy. The buildings studied in this section are 10, 20 & 30-storey Reinforced concrete Moment Resisting Space Frames Designed for Gravity and Seismic Loads Using Linear Analysis. Further work and studies on the P-Delta effect on high-rise buildings is highly recommended to eliminate the risk of failures of high-rise buildings. Below are some of the recommendations for further studies:

- In this work nonlinear behavior of building was studied by static P-Delta analysis method further study can be carried out by using nonlinear dynamic analysis.
- In this work the stiffness of structure is increased by the concept "The more uniform the internal force distribution, the stiffer the structure" further study can be carried out for the remaining concepts i.e. X bracing for achieving economical design.
- In further study can be carried out to know how the P-Delta effect changes by changing the stiffness of shear wall i.e. by increasing length and thickness.
- In further study can be carried out the cost effectiveness of flat slab over a conventional building.
- In further study can be carried out the non-linear pushover analysis to detect the failure pattern.

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