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To Study Comparative Analysis and Design of Flat and Waffle Slab System in Multistory Building under Seismic Condition

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Abstract: ***There has been associate increasing demand for construction of tall buildings thanks to associate ever-increasing urbanization and increase in population. The modelling of such earthquake and wind masses has to be done, therefore on valuate the behavior of the structure with a transparent perspective of the injury that's expected. to research the structure for numerous earthquake and wind intensities and so perform checks for numerous criteria at every level has become a vital apply for the last few decades. The principle objective of this project is to research flat blocks and grid slab victimization ETABS, to urge the optimum style. the look involves load calculations and analyzing the full structure by ETABS. the look strategies utilized in ETABS analysis square measure Limit State style orthodox to Indian customary Code of apply. ETABS options have state-of the-art computer program, mental image tools, powerful analysis and style engines with advanced finite component and dynamic analysis capabilities.***

Keywords: Analysis And Design of Flat and Grid Slab system, ETAB, grid slab with drop, flat slab with drop, seismic condition.

I. INTRODUCTION

There has been Associate in Nursing increasing demand for construction of tall buildings due to Associate in Nursing ever-increasing urbanization and increase in population. Earthquake and wind load is that the curse of such tall structures. as a results of the earthquake forces unit of measurement risky in nature, we tend to tend to would really like to correct engineering tools for analyzing structures below the action of these forces. Thus, a careful modelling of such earthquake and wind tons got to be done, so on appraise the behavior of the structure with a clear perspective of the injury that is expected. to analyze the structure for varied earthquake and wind intensities so perform checks for varied criteria at each level has become a extremely important follow for the last style of decades. Earthquake causes|completely completely entirely completely different|completely different}|completely different}|completely different}|completely different} shaking intensities at different locations then the injury induced in buildings at these locations is besides different. Thus, it is necessary to construct a structure that's earthquake resistant at a selected level of intensity of shaking and assimilate the impact of earthquake.[1]

Even though same magnitudes of earthquakes unit of measurement occurring because of its varied intensity, it results into dissimilar damaging effects in several regions. Hence, it is necessary to look at unstable behavior of multi storied RC framed building for varied unstable intensities in terms of varied responses like lateral displacements, story drift and base shear. that the unstable behavior of buildings having similar layout got to be below all entirely utterly completely different intensities of wind and earthquake. For determination of unstable responses, it is a necessity to hold out unstable analysis of the structure victimization all entirely utterly completely different accessible ways in which. , it is necessary to look at unstable behavior of multi storied RC framed building for varied unstable intensities in terms of varied responses like lateral displacements, story drift and base shear.[6]

The principle objective of this project is to analyze flat blocks and grid block victimization ETABS, to urge the optimum vogue. the design involves load calculations and analyzing the complete structure by ETABS. the design ways in which employed in ETABS analysis unit of measurement Limit State vogue orthodox to Indian customary Code of follow. ETABS selections have state-of the-art interface, illustration tools, powerful analysis and magnificence engines with advanced finite part and dynamic analysis capabilities. From model generation, analysis and magnificence to illustration and result verification, ETABS is that the professional's different. ETABS decisions a extremely interactive computer code that allows the users to draw the frame and input the load values and dimensions. Then in step with the specified criteria assigned it analyses the structure and styles the members with reinforcement details for RCC frames.

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This project presents the "comparative study of flat and grid variety of block for multi storied building below unstable condition". This work includes the analysis of flat block and grid block. the aim of this study is to grasp the characteristics, the manoeuvre of study, then the design of flat block and grid block; and to seem out out that block system with positive parameters is superior to utterly completely different. A block is besides a flat a strive of dimensional two-dimensional structural part having thickness very little compared to its utterly completely different a strive of dimensions. It provides a operative flat surface or a covering shelter in buildings. It primarily transfers the load by bending in one or a strive of directions. concrete slabs unit of measurement em ployed in floors, roofs and walls of buildings and since the decks of bridges. rock bottom system of a structure can take many forms like insitu solid block, ribbed block or pre-cast units. Slabs may even be supported on monolithic concrete beam, steel beams, walls or directly over the columns. Concrete block behave primarily as flexural members then the design is analogous thereto of beams. The advantage of grid over different types of floors is that the flat roof or floor is obtained. By victimization commonplace con crete construction and by increasing vary of beams, the depth of beam is shortened. Thus, larger clearance is obtained. The structure is monolithic in nature and these forms of floors have any stiffness. the maintenance value of these floors is to boot negligibl e than that of steel-girders and pre-stressed concrete. one in each of the constraints of Grid floors is that the event value that's preventative. The Aims and main objectives of this project is to vogue a flat and grid block system in multi-storied building below unstable condition and to match the ETAB results of flat and grid block system in multi-storied building below unstable condition with the help of IS 1893: 2002 and IS 875

II. FLAT SLAB

The flat slab is usually thickened closed to supporting columns to supply adequate strength in shear and to scale back the amount of negative reinforcement within the support regions. The thickened portion the projection below the slab is understood as drop or drop panel.

A. Design of Flat Slab

The flat slabs designing methods are as following: The empirical method The sub-frame method The yield line method Finite – element analysis For smaller frames, empirical methods are used but sub-frame method is employed just in case of more irregular frames. The foremost cost effective and homogenous installation of reinforcements is typically achieved by applying the yield line method. A radical visualization in terms of complete examination of separate cracking and deflection is required since this procedure utilizes only collapse mechanism. Deflections and cracked width also can be calculated using Finite- element analysis.

III. GRID SLAB

These slabs are wont to cover an oversized column free area and thus are good selection for public assembly halls. It gives pleasing appearance. The upkeep cost of those floors could also be a smaller amount. By investigating various parameters the price effective solution are often found for the grid slabs that proper method of study got to be used. [6] There are various approaches available for analyzing the grid slab system. They're generally employed for architectural reasons for giant rooms like auditoriums, vestibules, theater halls, show rooms of outlets where column free space is usually the foremost requirements. The oblong or square void formed within the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept an equivalent. The absolute best surface of a grid section could even be a smooth surface, almost kind of a typical building surface, they're commonly provided within the structures like theaters, tradition corridors, shopping centers where section free space is usually the principle necessity.

IV. METHODS OF ANALYSIS

The analysis is typically performed on the thought of external action, the behavior of structure or structural materials, and thus the sort of structural model selected. supported the type of external action and behavior of structure, the analysis are often further classified as given below.

A. Equivalent Static Analysis

For straightforward regular structures, analysis by equivalent linear static analysis method is sufficient. this is often often permitted in most codes of practice for normal, low- to medium-rise buildings. This procedure doesn't require dynamic analysis, however, it account for the dynamics of building in an approximate manner. The static method is that the only one; it requires less computational efforts and is based on formula given within the code of practice. First, the planning base shear is computed for the entire building, and it's then distributed along the peak of the building.

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V. METHODOLOGY

A. General

The building considered in the present report is G+12 Conventional Frame structure, complete analysis is carried out for dead load, live load & seismic load using ETABS software. All combinations are Considered as per IS 1893:2002.

B. Method of Analysis

In this study method of analysis is done by using Dynamic analysis method (only response spectrum method) for seismic loads acting on the structure.

1) Seismic analysis is the calculation of the building response of structure to earthquake and is a relevant part of structural design where earthquakes are prevalent.
2) The seismic analysis of a structure involves evaluation of the earthquake forces acting at various levels of the structure during an earthquake and the effectiveness of such forces on the behavior of the overall structure.
3) In the process of structural analysis system the analysis is carried out to predict its behaviors by using mathematical equation and physical laws.
4) Under various load effects, the main objective of structural analysis is to determine internal forces, stresses and deformation of structures.

C. Dynamic Analysis

It should be performed to get the design seismic force and its allotment to different levels along the height of the building and to different lateral load resisting elements. Though in both methods, the planning base shear (Vb) should be compared with a base shear (vb) calculated employing a basic period Ta. When (Vb) is a smaller amount than (vb) all the response quantities shall be multiplied by Vb /vb.

The values of damping for a building may be taken as 2 and 5 percent of the critical, for the purpose of dynamic analysis of steel and reinforced concrete buildings, respectively.

D. Response Spectrum Analysis

Response spectrum is the useful tools of earthquake engineering. The height response of the building is often estimated by reading the worth from the bottom response spectrum for the appropriate frequency if you'll determine the natural frequency of the structure.

A response spectrum may be a plot of the utmost response amplitude (displacement, velocity or acceleration) versus period of time of the many linear single degree of freedom oscillators to a give component of ground motion. The resulting plot are often wont to select the response of any linear SDOF oscillator, given its natural frequency of oscillation. Response spectroscopy (RSA) is an elastic method of study and lies in between equivalent force method of study and nonlinear analysis methods in terms of complexity.

RSA is predicated on the structural dynamics theory and may be derived from the essential principles (e.g. Equation of motion). Damping of the structures is inherently taken under consideration by employing a design (or response) spectrum with a predefined damping level. The maximum response of every mode is a particular solution. The sole approximation utilized in RSA is that the combination of modal responses.

RCC Frames with G+12 have been considered in the study. Fundamental period of vibration of the frame with fixed support using modal formula in IS 1893(Part I):2002 and model analysis has been evaluated. In order to understand the resistance effect of earthquake and stability of structure has been modeled as response spectrum method by using Etabs.

Response spectra method of analysis of the models are performed using Etabs Effects flat slab and grid slab on different parameters are studied i.e. storey drift, displacement, Shear force and Bending moment.

E. Structural Modeling

General 13 storied buildings are modeled using flat slabs & grid slabs respectively. These buildings were given rectangular geometry. These are then analyzed using response spectrum method for earthquake zone II of India. The details of the modeled building are listed below. Modal damping of 5% is considered with SMRF and Importance Factor (I) =1. The isometric 3D view and elevation of the building model is shown as below.

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F. Structure Data: Site Properties

1) Details of building:: G+12
2) Dimension:: 30m x 36m
3) Length in X- direction:: 30m
4) Length in Z- direction:: 36m
5) Total height of Building:: 43.4m
6) Soil Type:: Hard
7) Spacing:: 6m
8) Base storey height:: 5m
9) Floor height ::3.2 m

a) Seismic Properties

i) Seismic zone:: II
ii) Zone factor:: 0.16
iii) Importance factor:: 1
iv) Response Reduction factor R:: 5

b) Material Properties:

i) Grade of concrete :: M40
ii) Grade of Steel :: Fe500

c) Loading on structure:

i) Dead load :: self-weight of structure +1kN/m2
ii) Live load:: 4kN/m2
iii) Wind load :: Not considered
iv) Seismic load:: Seismic Zone II

d) Optimized Sizes of members

e) Flat slab Design parameters

i) Column:: 700mm x 700mm
ii) Flat Slab thickness:: 250mm
iii) Drop:: 1.5m
iv) Drop thickness:: 350mm

f) Grid slab Design parameters

G. Models to be considered for study are:

1) Column:: 700mm x 700mm
2) Beam:: 400mm x 500mm
3) Slab thickness:: 250mm
4) Grid Size :: 1m
5) Model 1- Flat Slab with Drop by the effect of Diaphragm for zone II.
6) Model 2- Grid Slab by the effect of Diaphragm II.

Above types of slab are analyzed for seismic zone by response Spectrum Method.

H. Load combinations as per IS 1893:2016 (part 1)

By using IS 1893:2016 the analysis of following load combinations specified. The basic load combinations given by the code as per clause 6.3.4.1 are as follows:

1) 1.5 (D.L. + L.L.)
2) (D.L. + L.L. ± EQ x)
3) 1.2 (D.L. + L.L. ± EQ y)
4) 1.5 (D.L. ± EQ x)
5) 1.5 (D.L. ± EQ y)
6) 0.9 (D.L.) ± 1.5 (EQ x)

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7) 1 (D.L. + L.L. ± EQ x)
8) 1 (D.L. + L.L. ± EQ y)
9) 1 (D.L. ± EQ x)
10) 1 (D.L. ± EQ y)

I. IS 1893 2002 Auto Seismic Load Calculation:

Direction and Eccentricity
Direction = Multiple
Eccentricity Ratio = 5% for all diaphragms

1) Structural Period

Period Calculation Method = Program Calculated
Factors and Coefficients
Response Reduction Factor, R[IS Table 7] ::R=5
Importance Factor, I [IS Table 6] :: I=1
Site Type [IS Table 1] = II Seismic Response

Spectral Aeleration Coefficient, $\frac{S_a}{g} = 0.34$

Seismic Coefficient, Ah= $\frac{ZI\frac{S_a}{g}}{2R}$

VI. ANALYSIS OF RESULTS

A. General

A G+12 storied RCC building in zone II is modeled using Etabs software and the results are computed. Different models were prepared based on different configuration, for Flat Slab and Grid Slab.
Model 1- Frame Structure with Flat Slab. Model 2- Frame Structure with Grid Slab.
Above types of Slab are analyzed for zone II by conventional fixed base, Limit State Design Method. Different models are prepared for analysis. These models are analyzed and designed by using the specifications of Indian Standard codes IS 1893:2002 IS and IS 456: 2000. The response spectrum method had been used to find the design lateral forces along the storey in X and Z direction of the building.

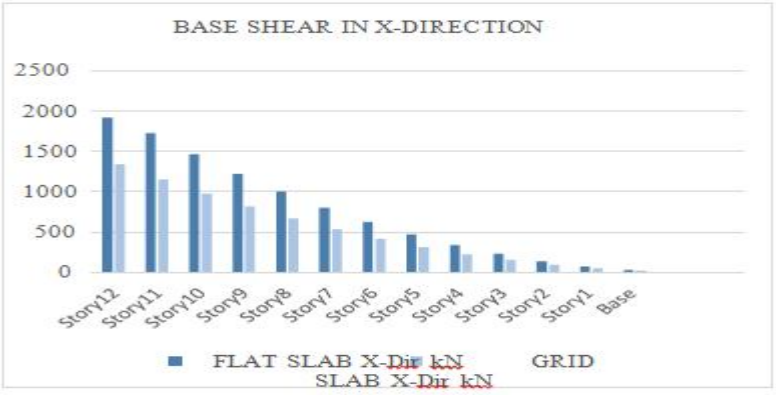

Fig. 1 Graph of Base shear (kN) in X direction for Flat Slab and Grid Slab

Fig 1 shows the graph of maximum base shear comparison of Flat Slab and Grid Slab in X direction for RCC Frame by conventional fixed base, Response Spectrum Method. It shows that base shear values is maximum for Flat Slab and also base shear is minimum for Grid Slab. But the base shear value for base for flat slab structure and grid slab structure is zero. As the elevation level increases the base shear value is increases. As per graph grid slab having the slightly minimum base shear as compare to flat slab.

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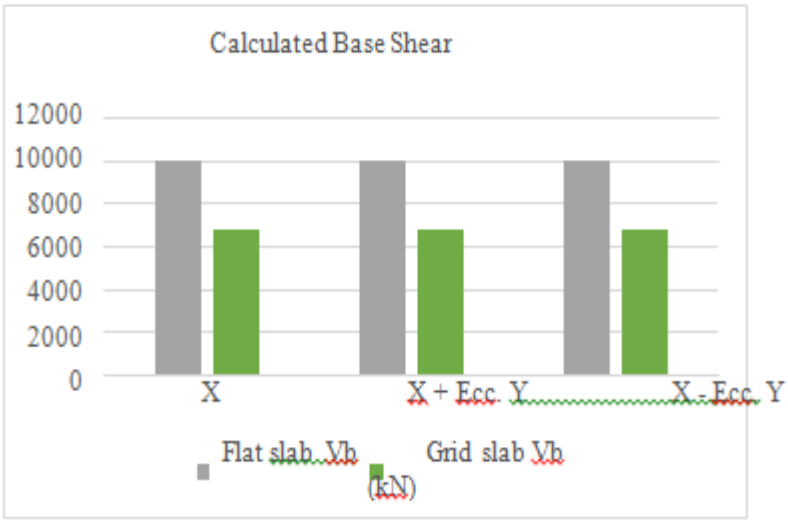

Fig. 2 Graph Calculated shear (kN) in X direction for RCC Frame with Flat Slab and Grid Slab

Fig 2 shows the graph of maximum base shear comparison of Flat Slab and Grid Slab in X direction for RCC Frame by conventional fixed base, Response Spectrum Method. It shows that. Calculated base shear values is maximum for Flat Slab and Also base shear is minimum for Grid Slab.

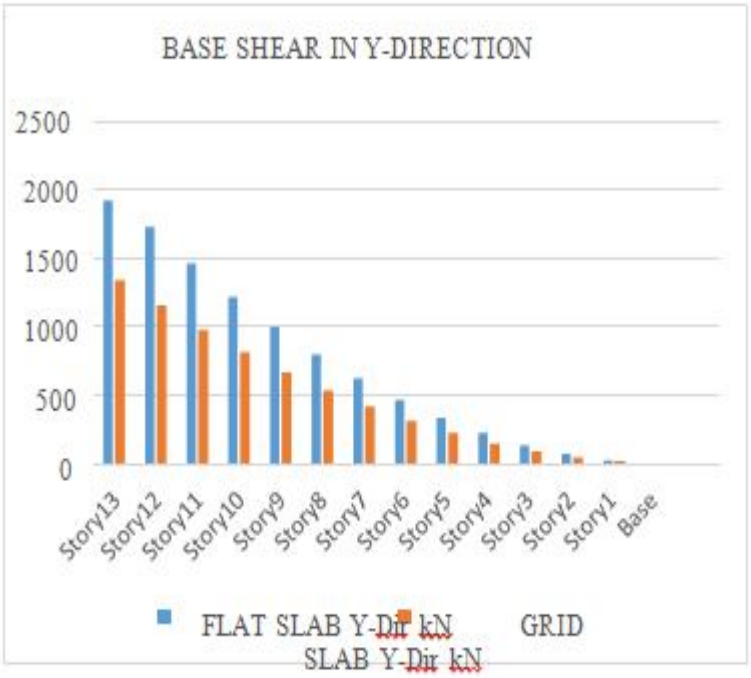

Fig.3 Graph of Base shear (kN) in Y direction for RCC Frame with Flat Slab and Grid Slab

Fig 3 shows the graph of maximum base shear comparison of Flat Slab and Grid Slab in Y direction for RCC Frame by conventional fixed base, Response Spectrum Method. It shows that base shear values is maximum for Flat Slab and also base shear is minimum for Grid Slab. But the base shear value for base for flat slab structure and grid slab structure is zero. As the elevation level increases the base shear value is increases. As per graph grid slab having the slight minimum base shear as compare to flat slab.

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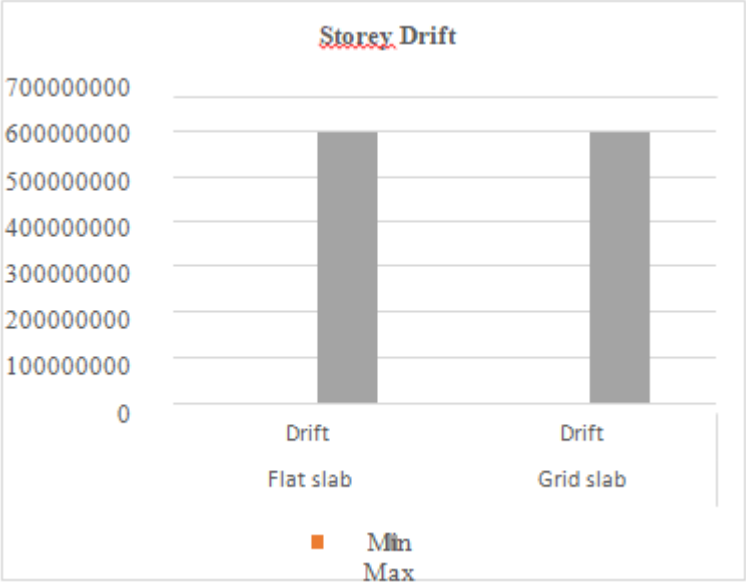

Fig. 4 Graph Max & Min storey drift for Flat Slab and Grid Slab

Fig 4 shows the graph of maximum and minimum storey drift comparison for each storey of Flat Slab and Grid Slab for RCC Frame by conventional fixed base, Response Spectrum Method. It shows that maximum storey drift values for grid slab and flat slab is same and also minimum storey drift values for flat slab and grid slab same for each storey.

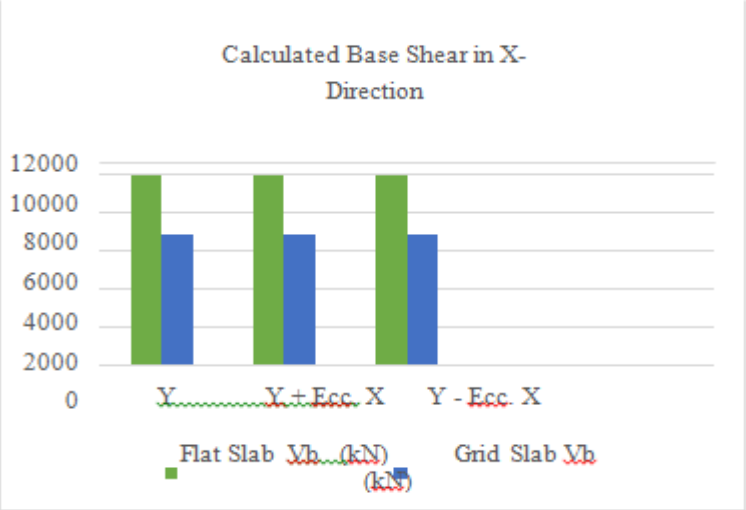

Fig. 5 Graph Calculated Base shear (kN) in Y direction for RCC Frame with Flat Slab and Grid Slab

Fig 5 shows the graph maximum base shear comparison of Flat Slab and Grid Slab in X direction for RCC Frame by conventional fixed base, Response Spectrum Method. It shows that. Calculated base shear values is maximum for Flat Slab and also base shear is minimum for Grid Slab.

Storey Drift		
Min &Max Drift	Min	Max
Flat slab	2951.111111	606066183
Grid slab	2951.116635	606066183

Fig. 6 Table Comparison of Maximum & Minimum Storey Drift of Flat Slab and Grid Slab

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The drift of one level of a multi-storey building relative to the level below is known as Storey drift. The difference between the floor displacements and roof of any given story as the building sways during the earthquake, and normalized by the story height is the inter story drift. Storey drift is same for flat slab and grid slab.

VII. CONCLUSION & SUGGESTED FURTHER WORK

A 13 storied RCC building in zone II is modeled using Etabs software and the results are computed. The configurations of all the models are discussed in previous chapter.

Model 1- Frame Structure with Flat Slab. Model 2- Frame Structure with Grid Slab.

Above types of Slab are analyzed for zone II by conventional fixed base, Limit State Design Method. These models are analyzed and designed as per the specifications of Indian Standard codes IS 1893:2016 IS and IS 456: 2000. The response spectrum method had been used to find the design lateral forces, drift, base shear, base reaction along the storey in X and Z direction of the building.

1) *Storey Shear:* It is the lateral force acting on a storey, due to the forces such as seismic force. It is calculated for each storey, changes from maximum at the bottom to minimum at the top of the building. As per analysis Storey shear is maximum for flat slab and minimum for grid slab.
2) *Shear Force:* As per the observation, shear force value is same for grid slab and flat slab in the direction X & Y. But for direction Z Shear Force value is Maximum for grid slab and minimum for flat slab. So basically shear force value is maximum for Grid slab. Shear force value is minimum for flat slab.
3) *Bending Moments:* As per the observation, bending moment value is greater for flat slab in the direction X. For direction Y bending Moment value is maximum for grid slab as well for direction Z bending Moment value is Maximum for flat slab. So overall bending Moment value is maximum for flat slab and bending Moment value is minimum for grid slab.
4) *Storey Displacement:* It is total displacement of the storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings. Storey displacement is same for all direction.
5) *Storey Drift:* Storey drift is the drift of one level of a multi-storey building relative to the level below. Drift of inter story is the difference between the floor displacements and roof of any given story as the building sways during the earthquake and normalized by the story height. Storey drift is same for grid slab and flat slab.

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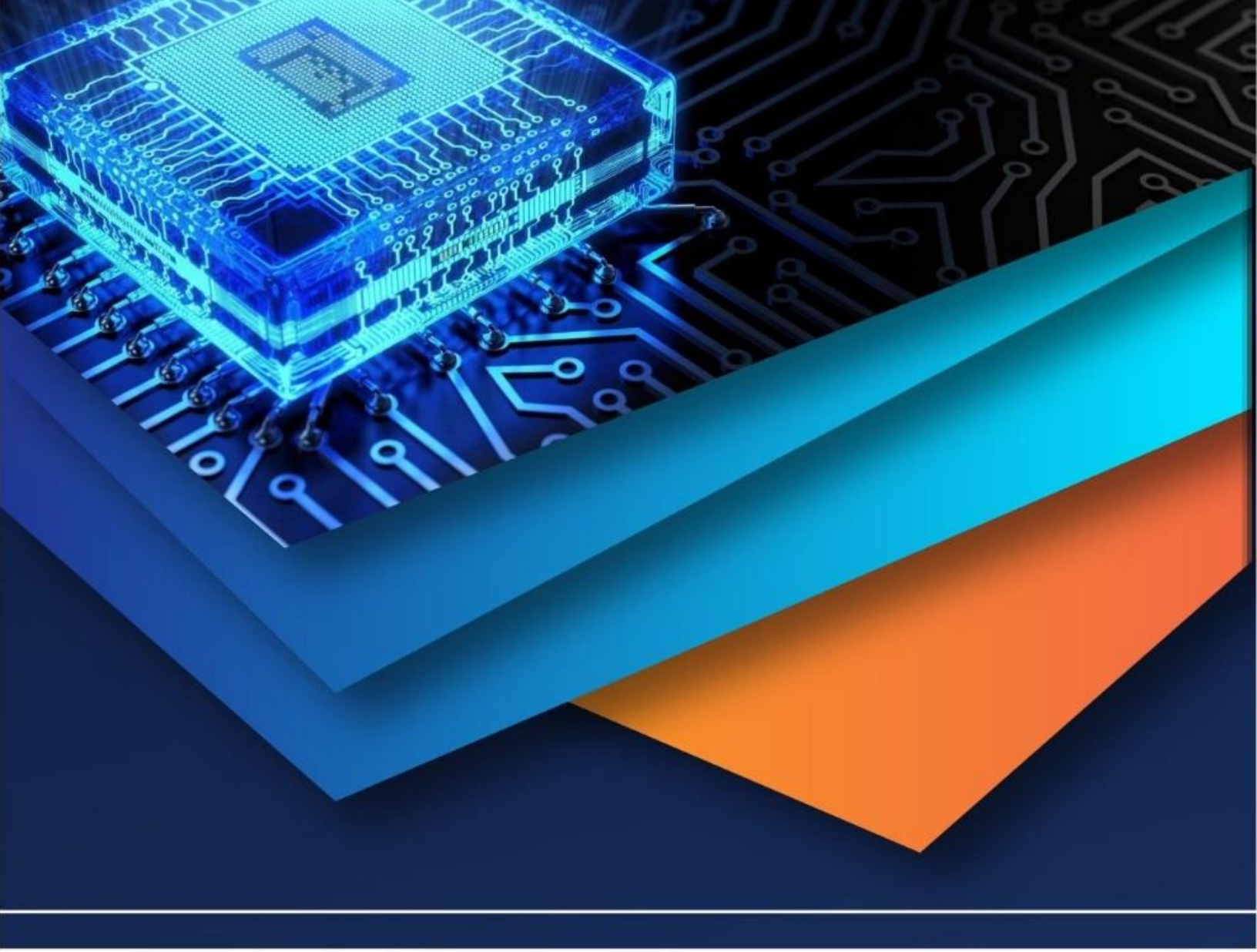

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