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Analysis and Design of Multistorey Building

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Abstract: The primary focus of this research is to analyze and design a multi-storey building (3D-dimensional reinforce concrete frame), the designing of building begins with making the plan of specific building which include the position of rooms, kitchen, toilet etc. the design should be such that it is up to mark of customer requirements and comport nowadays vastu shastra is also kept in mind while designing.

The second step is to design the reinforced concrete part which includes designing of slabs, columns, beams, staircase and footing these designing's were done manually and all the calculations were done according ACT code and the outcomes were compared using STAAD PRO.

I design an office building which is made of reinforced concrete frames and the building has three floors with 12 offices on each floor which sum up to 36 offices and the maximum area of a floor is (21.9*40.9) m^2.

To complete the architectural design, I AutoCAD program and for analyzing and designing the structure of building I used software known as STAAD Pro v8iSSS.and after both the designing I got the results as the map of a building which is architectural and structural safe.

For designing the structural plan and architectural design one requires high imagination power as well as theoretical knowledge and also keen knowledge of science of structural engineering and should know the recent design codes, laws and before designing he should have adequate experience and mind set to reach conclusion. STAAD PRO is a very user friendly software it is and easy to understand and operate. We can input the material properties, load value, dimensions and we can also draw the frame within the software and after taking all the data it analyze the whole structure and design the member with reinforced detail for concrete frame and all the designs are done under specified criteria. These criteria are implemented to keep careful balance between economy and safety.

I. INTRODUCTION

The population of world is increasing drastically and to fulfill the requirement of shelter the numbers of multistory are also growing worldwide. In developing countries, the multistory buildings consists of prismatic sections which are pretty good at resisting applied load and prismatic structure do not transfer deformation from one part to another. The main function of structure is to take load at a point (mainly service load) and transfer to the other point with safety. Designing of a structure is also needed for safe, serviceable, feasible and aesthetically pleasing fulfillment of a structure.

Most of the structures are built of reinforced concrete like tanks, tunnels, viaducts, retaining walls, buildings and bridges and many more.

In India concrete is most used structure material and not only in India but many other developing country use concrete as construction material because of its availability. Without a second thought concrete is most important building material it plays a role in every structure majorly or minor and concrete has a virtue of versatility that means concrete can be easily molded in different structure according to need and it is very durable and fire resistance if correct construction procedure are followed. The multistory building is combined of many element such as beams, slabs, column and footings. We must analyze these elements if we want to analyze a multistory building.

A. Reinforced Concrete

Concrete only can't be used for tension as concrete is very weak at tension so in mid 19th century the concept of reinforcement come in light to make concrete workable in tension. In reinforced concrete steel bars are inserted at casting stage with desirable magnitude that provides them resistance to tensile stress. In the starting of 20th century the production of good quality of concrete that have very high strength and the TMT steel with high bonding strength begins to manufacture which gave a hike to use reinforced concrete structure instead of woods and lime. This begins a new era in structural engineering.

B. Structural Elements

The following elements are consisted in each and every structure:-

1) *Slabs:* loads are carried out by these horizontal plates.
2) *Beams:* The loads of slabs are carried out by beams.
3) *Columns:* Columns are mainly used to carry axial loads but also sometimes they are used to carry momentum in case of exterior beams.
4) *Walls:* walls are the vertical plates which are used to resist vertical, lateral or in-plane loads.
5) *Bases And Foundations:* this element is used to distribute all the load on the soil which is transferred to it by walls and columns the distribution of load helps in reducing the stresses applied to the soil.

C. Design Philosophy

These are some very important requirements which should be completed while designing a reinforced concrete structure.

1) The strength of designed structure should always be greater than the ultimate flexural strength, shear strength, compressive strength and tension developed in structure and also more than their combined strength.
2) The designed structure should have high serviceability which means that the cracks width and the deflections of the structure should always be under the acceptable limits.
3) The designed structure should be highly durable and it should have resistance to acid, frost, fire and should be corrosion free.
4) The designed structure should be highly stable against overturning and should not vibrate under the given loads and should resist sliding and overturning.

A designer should design the structure economically and aesthetically. The designed structure should have 3S strength, stability and serviceability.

D. Design Bases

The strength of structure member should be large enough to resist all the loads and forces that act on that member during all the life span of the structure and the strength of that structure should be high enough that the structure never goes under failure or distress. The concrete volume and the reinforcement should be designed such that the member strength should be capable to resist the loads and forces which occur suddenly or unexpectedly these overloads should include in service loads. The designing of these sudden overloads is called strength design. A reinforced structure at the stage or close to failure reaches than both concrete and steel are in their nonlinear elastic range. From this we can conclude that the concrete used in structure member reaches its maximum strength at a stage that is far beyond its initial elastic range in which stress is almost proportional to strain. Similarly, the steel used in construction members have failure point beyond yield region. Consequently, on the bases of inelastic behavior of material the nominal strength of a member must be calculated. If a structural member is designed under the strength method than also the member should perform brilliant under nominal service loading. For instance, bar diversions should be restricted to adequate qualities, and the number and width of flexural breaks at administration loads should be controlled. Functionality limit conditions are a significant piece of the complete plan, despite the fact that consideration is centered at first around strength.

E. Multi-Storey Buildings

The term tall is always relative you cannot say something tall unless you any relevant in the same way tallness of a building is related by the height or number of floors present in the building. But, the definition of tall building is different for structural engineers for engineers a tall building or multistory building is that building which got affected by lateral forces (wind or earthquake) or both of them so much that they play an important role in their structural design.

People were always fond of tall structures from the starting of the mankind let’s take an example of one of the seven wonders of the world the Egyptian pyramids these pyramids were built as a symbol of pride of their nation and also as defense wall and more fascinating thing is that they were constructed in 2600 B.C with just using raw power. In the late nineteenth century the construction of tall buildings increased rapidly but this time it is not only to show power status but also to check the population residence consumption of land. In the developing countries the peoples are migrating towards the cities and this started the urbanization which this migration was due to start of industrialization thus we can say that industry leads to urbanization. Industrialization gives the job and food but the land was not enough to handle the migrants which leads to chaos and this result in rapid increase in the prices of land.

F. Concrete Frame Structures

The use of concrete frame structures are very common now a day and common would be less, we can say almost each and every building requires the concrete structures. Concrete frame structures can be defined as the frames which are made of reinforced concrete. The concrete frame which is used horizontally to transfer the load is known as beam and the frame which is used the bear the load of whole building is known as column and the floor of building is known as slab. The most important part of a building is its column as if any of the other member of a building get destroyed than the building could withstand it but if the column get damaged the whole building could collapse. The concrete used in a structure is the RCC here RCC means reinforced concrete. Concrete is reinforced to increase its tensile strength and reinforcement could be done by steel, fiber, wool or any other material.

G. Reinforced Concrete (RCC)

RCC can be explained as putting together of two materials with different properties together for e.g., concrete which is weak at tensile and is less ductile with the material which is high in tensile strength and ductility. The reinforcement is provided only when high tensile strength is required. In reinforcement process we embedded steel bars is wet concrete. Concrete is generally weak at the tensile strength so we provide reinforcement at particular region which might results in cracking and failure. Steel is not the only reinforcement material in the technological era we use many materials for reinforcing like, polymers, fiber, and composite material with conjunction. We can enhance the behavior of the designed structure under the live load by permanently stressing he concrete.
The most common method of permanently stressing a concrete are pre-tensioning the concrete and post-tensioning the concrete.
A construction which have high ductility and durability and strength should have following properties in their reinforcement:

1) The reinforcement should resist high tensile strength and should have high strength
2) The reinforcement should have great bond with concrete
3) The reinforcement should be durable to high temperature and should adjust in concrete environment.

H. Beam -and-Column Construction:

The construction of Beams and column in a building is also known as "skeleton construction". Beams and columns support all the loads of structure which includes, slabs, walls and partitions etc. In construction of beams and columns the beams and girders get support from the columns from both the direction on each and every floor. Using the skeleton system, we can construct very tall buildings. The column used in this skeleton system are hot-rolled I-sections or concrete encased steel columns. If the capacity of the given section is less than the loading requirements than the use of type of beam depends on the loading and limitations on overall depth and span. For the smaller spans the most economic beams are the beams with composite metal deck floors and beams with precast floors but for larger spans, plate-girders or plated- beams are used.

I. One-way or two-way reinforced concrete slabs:

One-way and two-way RCC slabs are adopted for heavy loads as these slabs are very heavy. These floors are not just heavy but also take more time to construct than rest of new light weight floor system. If the longitudinal span is double or more than double the short span than we use the One-way slabs. The direction in which loads get transferred from slab to the beams is the direction of short span in one-way slab.
Hence, we provide the main reinforcing bars in this direction and the distribution steel temperature and shrinkage is given along the longer span.
If the aspect ratio is “2” of the slabs that support all the four edges which are longitudinal span and transverse span than the two-way concrete slab is used. The main reinforcement runs in both directions.
Dead loads can be said as all the load that is due to the permanent construction of the structure. The dead load includes all the permanent loads such as false floors, false ceiling, and weight of other permanent constructions. To calculate the dead load, we need to know the dimensions and their respective unit weights. The plain concrete or the concrete which is made up of sand and aggregates have same unit weight which is $24KN/m^3$.
In the construction of RCC slabs, the slabs are usually flat, broad and flat useful surface and RCC slabs are usually horizontal with top and bottom surfaces parallel. It may be supported by reinforced concrete beams, by masonry or reinforced concrete walls, by structural steel members, directly by columns, or continuously by the ground.
Substantial pieces at times be conveyed straight by sections without the utilization of bars or girders, such chunks are portrayed as level plates and are normally utilized where ranges are not enormous and loads not especially weighty.

Flat plates can be built in less time and with least work costs. In numerous urban communities the most extreme stature of structures is limited, and afterward the meager level plate allows the development of the greatest number of stories in a given tallness.
Flat plates are provided for the flexibility in the layout of columns, partitions and small openings, etc.
Another benefit of level plate chunks that ought not be over glanced in imperviousness to fire. Also, the chunks are ordered to single direction piece or two-way section as per the strategy for move of minutes in the two ways relies upon the proportion of long range/limited ability to focus On the off chance that the proportion is more than or equivalent to two, load move overwhelmingly by bowing the short way and the board goes about as single direction chunk. And if the ratio is less than two, then the load is transferred by bending in both orthogonal directions, and the panel is two-way slab.
We have several methods to design the slabs like direct design method, method three, etc.

J. Beams

A beam is an underlying component that is fit for withstanding load basically by opposing bowing. The twisting power actuated into the material of the bar because of the outside loads, own weight, length and outer responses to these heaps is known as a bowing second.
Beams generally convey large vertical gravitational powers however can likewise be utilized to convey level burdens (i.e., stacks because of a quake or wind). The heaps conveyed by a pillar are moved to sections, dividers, or supports, which then, at that point move the power to nearby primary pressure individuals. In light edge development the joists lay on the pillar.
Beams are portrayed by their profile (the state of their cross-segment), their length, and their material. In contemporary development, radiates are ordinarily made of steel, supported cement, or wood. Quite possibly the most well-known sorts of steel bar is the I-pillar or wide-rib bar (otherwise called a "all-inclusive shaft" or, for stouter segments, a "general segment"). This is normally utilized in steel-outline structures and extensions. Other normal shaft profiles are the C-channel, the empty primary segment pillar, the line, and the point.
Structural member of reinforced concrete set on a level plane to convey loads over openings. Since both twisting and shear in such pillars instigate tractable anxieties, steel supporting massively expands shaft strength. Normally, radiates are planned under the presumption that pliable anxieties have broken the substantial and the steel supporting is conveying all the strain. See likewise anxiety segments can be separately or doubly built up (segments with just tractable support or segments with both pliable and compressive support). Practically speaking most bars are planned with just ductile support (separately built up). Notwithstanding, in specific circumstances it very well may be important to configuration radiates with both ductile and pressure support (doubly reinforced).
For instance, when pillar cross area is restricted on account of design or different contemplations, it might happen that the substantial can't foster the pressure power needed to oppose the given bowing second. Sometimes if a pillar is planned with just tractable support, the part may get over built up, which is neither alluring nor adequate by most codes of training, in these circumstances the segment should likewise be planned as doubly built up. There are circumstances in which compressive support is utilized for reasons other than strength.
We can reduce the long term deflection of beams by including some compression reinforcement.
Likewise, sometimes, steel will be set in the pressure zone for least second stacking or as stirrup-support bars ceaseless all through the shaft range. It is normal attractive to represent the presence of such support in flexural plan. By and by T, L, and U segments infrequently need pressure steel for strength reason, and frequently if this steel is available it is overlooked in plan. In any case, the Beam Strength applet is fit for assessing the strength of T, L, U segment with both tractable and pressure steel.
The program plays out the plan of a non-prestressed T or reversed T cement footer when exposed to a mix of bowing, twist and shear stacking, in view of the most recent ACI twist plan measures and the Ultimate Strength Design Method.
According to ACI, the commitment of cement to torsional strength (Tc) is ignored. Hence, Vc is unaffected by the presence of twist. Plan for twist depends on a meager walled tube, space support similarity. The connection of twisting with shear and twist in a cement footer is represented by adding the twist longitudinal steel to that needed by flexure.

K. Columns

Columns can be explained as the members which carry load in compression. The bending moment is carried by column about one or both axes of the cross-section, and the bending action may produce tensile forces over apart of cross-section. The columns can be said as compression members, as the main work of columns are to transfer compression force to the ground.

The three types of RCC compression member are:

1) Members that are reinforced with longitudinal bars and lateral ties.
2) Members that are reinforced with longitudinal bars and continuous spiral.
3) Composite compression members reinforced longitudinally with structural steel shapes, pipe, or tubing, with or without additional longitudinal bars, and various types of lateral reinforcement.

The ACI-code gives the limits of the space of longitudinal support, for no composite pressure individuals will be at the very least 0.01 Ag or more than 0.08 Ag. Least number of longitudinal bars in pressure individuals will be 4 for bars inside rectangular or round ties, 3 for bars inside three-sided ties, and 6 for bars encased by twisting. The slenderness ratio have great effective in describe the type of columns (short or long) where, when ($KL/r \leq Cc$) then the column defined as short column, otherwise the column defined as long column, Where:

$Cc=\sqrt{2\pi\epsilon/fy}$

But the effect of slenderness neglected in the following cases:

a) In sway frame when $KL/r<22$
b) In non-sway frame when $KL/r \leq 34\text{-}12\ M1/M2$.

L. Foundation

A foundation is a lower portion of building structure that transfers its gravity loads to the earth. Foundation can be broken into two classifications: shallow foundation and profound foundation. A tall structure should have a solid foundation on the off chance that it is to represent quite a while. To make an foundation, we typically dive a channel in the ground, burrowing further and more profound until we come to dirt, which is more strong than the dirt that is utilized to develop plants and yields. At the point when the channel is sufficiently profound, we fill it with any solid, hard material we can discover. Sometime we empty concrete into the trench, which we strengthen much more by initial placing long thin round bits of steel into the trench. At the point when the substantial dries, the steel behaves like the bones in our body to integrate the foundation. We call this supported cement. When the foundation has been pressed down firmly, or dried hard, we can start to construct the superstructure.

M. Staircases

Staircases can be defined as the member which helps to move from one floor to another in a structure. Staircases are provided at a definite interval for the comfort and safety of the person and the landings should be horizontal.

1) *Rise:* It is the vertical distance between two consecutive treads.
2) *Flight:* It is the number of steps given between two landings.
3) *Landing:* It is a horizontal slab provided between two flights.
4) *Waist:* It is the least thickness that can be provided of a stair slab.
5) *Winder:* They are the radiating or angular tapering steps.
6) *Soffit:* It is the bottom surface of a stair slab.
7) *Nosing:* It is the intersection of the tread and the riser.
8) *Headroom:* It is the vertical distance from a line connecting the nosing's of all treads and the soffit above.

N. Types of Stairs

For the designing purpose, stairs can be classified into two types; transversely supported and longitudinally supported.

1) *Transversely supported (transverse to the direction of movement):*

The following are included in transversely supported stairs:

a) Simply supported steps supported by two walls or beams or a combination of both.
b) Steps cantilevering from a wall or a beam.
c) Stairs cantilevering from a central spine beam.

2) *Longitudinally supported (in the direction of movement):*

In these types of stairs, the staircases are supported from top and bottom of a flight and is unsupported at the sides. Longitudinally supported stairs may be supported in any of these manners:

a) Stairs supported by beams or walls at the outer edges of the landings.
b) The end of flight of stair is supported by the internal beams or the outside edge of landing is supported by the beams or walls.
c) The landings of stairs are supported by beams or walls which are in the longitudinal direction.

d) Combination of (a) or (b), and (c).
e) In open-well types where the Stairs are present with quarter landings.
- *Effective Span: The effective span can be explained as the horizontal distance between centerlines of supporting elements.*

3) *Loading*
1) Dead Load
The dead load, is mainly calculated on horizontal plan, that includes:
§ Steps own weight.
§ For calculation of flight load, for getting the load in horizontal projection we divide the load by cosα where α is the angle of slope of the flight.

2) Live Load
Live load is always presented on horizontal projection.
a) Design for Flexure and Shear: The slabs of stairs are always designed for maximum shear and flexure. The main reinforcement is always provided in the longitudinal direction, while the shrinkage reinforcement is provided in the transverse direction. The opening joints in reinforcement requires special attention.

II. CONCLUSION

In the present study building of two storey is designed and explored with its (Slabs, Beams, Columns and Footings and staircase) using software like (Auto CAD, MD solid, Excel, and Staad Pro). Mainly two types of loads are designed in this study which are: dead load and live load. Dead load includes concrete and brick work is designed using the unit load of the resources while the live load is designed using the codes. The architectural and structural designing of a building is very necessary because the safety of a building is dependent on these designs. The other aspects for a safer building are: quality of the structural analysis, design and reinforcement detailing of the building frame to achieve stability of elements and their ductile performance. The quality of construction should be great and the walls should be stable and stable partition are some requirements for a building to be safe.
- The advantages of using computer program is, It is faster to analysis the structural element and reduce time consuming.
- In this project we design and analyze the Multi storey building using the equations to design and analyze and solve. So that the time for solving the equation of design in project reduces. This is done by using a computer software programs, which takes the inputs of design and carried out the calculations easily and quickly so that we saved time and ensure that the design was correct.

A. *Comparing The Hand Calculations And The Program Calculations, We Conclude That*
1) The hand calculations take much more time than the programs as they are very fast at calculating results program can calculate within a minute.
2) The degree of agreement of the results with the program is good.
3) The only scope of wrong result is if we enter inputs wrong.
4) The hand calculations are much more difficult than program.

III. RECOMENDATIONS

1) Design and analysis of different type of Multi storey building (concrete and steel).
2) Design and analysis of multi storey building with other codes not just ACI codes.
3) Design and analysis of multi storey building with different type like, Agricultural, Commercial, Residential, Educational, Government, Industrial, Military, Parking structures and storage, Religious, Transport, Infrastructure and PowerStation/plants.

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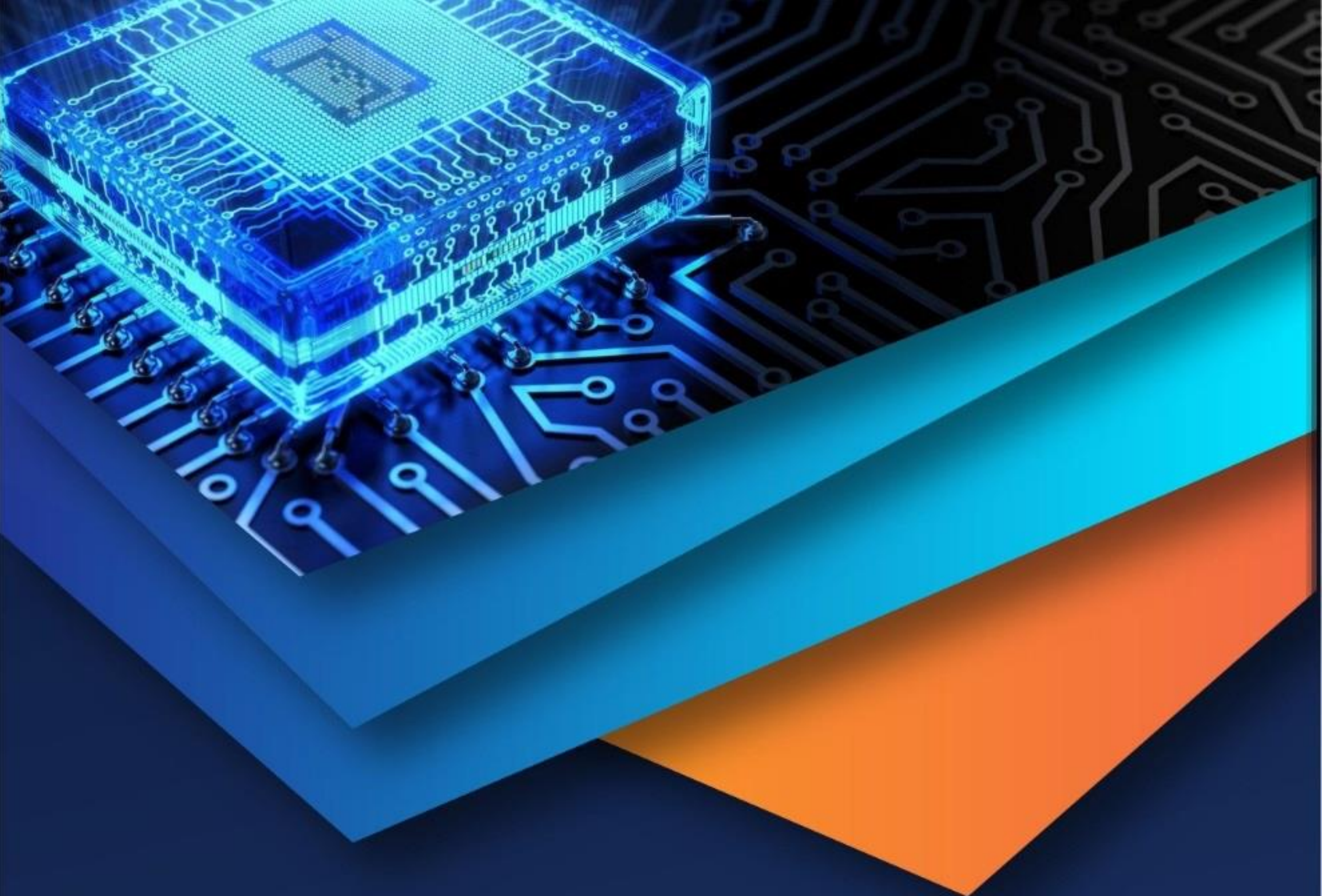

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