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Study of Behaviour of RC Silo for Lateral Loads Using Sap

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Abstract-- A silo is a structure for storing bulk materials. Silos are used in agriculture to store grains these are more commonly used to store coal, cement, carbon black, woodchips, food products and sawdust. However a detailed study to understand the structural behaviour of the silo under seismic loading is essential for appropriate design and their better performance. The main objective of this study is to understand the displacement of the silo along x direction by varying column heights. Linear dynamic analysis is done using software package SAP2000 as per IS 1893(Part I):2002. For the assessment of the silos for bulk density and angle of internal friction of various stored materials the IS 4995 (Part I) 1974 is preferred. Poorly designed silos have buckled and even collapsed due to earthquakes. The sectional dimension of the beam and column should be strong to hold the total mass of the silo. In this research work three models are considered with the different heights of the column keeping the H/D ratio of the cylinder constant and the analysis is carried out.

***Keywords**: silo, displacement, response spectrum, equivalent static method.*

I. INTRODUCTION

This Silo is a bulk storage structure is also known as deep bin. It is usually constructed of steel or concrete used for storage of chemicals, grains and mining operations. In the developing countries like India, villages and farms have insufficient storage of grain which leads into wastage of grains in large quantity at post-harvest stage. Therefore in order to store the large quantity of grains economically an alternative is required. The small precast concrete blocks which is of high strength shell with corrugated grooves along each edge that lock the blocks together and it is of high incompressibility, therefore the silo is held together by concrete/steel hoops surrounding the tower and the staves are compressed in to a tight ring. The upright stacks are held jointly by intermeshing of staves at ends by a small distance around each layer of the perimeter and the hoops are tightened the stave edges across directly. The material inside the silo creates more static pressure, thus the pressure pressing outer the staves increases to the bottom of the silo, so that the hoops should be spaced broad apart close to the top and to prevent opening the hoops are closely spaced progressively. Axisymmetric loading is due to stored materials and gravity is the conventional method of analysis of silo. A silo is a superior structure it is subjected to terrific lateral loads due to earthquake and wind. The effect of lateral loads in the design procedure cannot incorporate in the conventional methods effectively. Hoop and Meridional forces were developed. Calculation of variety stress resultants at significant location may not always be acceptable by conventional method. Moreover the traditional approach analysis cannot expect several types of moments at all.

II. LITERATURE REVIEW

H.A. Janssen (1895) carried out his first experiment with the corn and stated the saturation pressure with height in a granular system. Later, Janssen derived the corresponding barometric formula for granular material from the main assumption that weight carried by the walls. He assumed that the ratio of horizontal strain against the wall to the mean vertical strain within the stored stable (the lateral pressure ratio K) is invariant with depth inside the silo

Janssen's equation for horizontal pressure is:

$P= \gamma R/ \mu' [1-e^{-\mu' kh/R}]$

Luigi Di Matteo[3] et.al (2009) were carried out several experimental investigations with a rectangular silo. By emptying the two silos the main focus on the stress states, the extraction screws and the relationships between the walls normal stresses, the torques and the flow profiles required for the extraction screws. The wall normal stresses are lower in moving zones than in stationary zones.

Mahesh Z. Mali[4] et.al (2015) carried out research to check the behaviour of silos in wind load and earthquake condition. A typical silo model checked for both static and dynamic analysis. Both the manual and software analysis is done for the static condition. Both the results are same for analysis and design. Wind load and Earthquake combination referring to relevant IS codes such as IS 456, IS 1893, IS 875. It is concluded from the analysis that stresses on silo are more in the wind load and earthquake load compare to stresses due to static load. In order to resist the stresses during high wind and earthquake, Silo should design for additional wind forces and earthquake.

III. OBJECTIVES OF THE PRESENT WORK

A. Analysis of Silo for different column heights using Equivalent static method and Response-spectrum method.
B. Analysis of Silo for different Load combinations in X direction using Equivalent static method and Response-spectrum method.
C. Comparison of displacement for various column heights for different load combinations.

IV. METHOD OF ANALYSIS

To study the lateral performance of the RCC circular silo two various types of structural analysis is done. They are

A. Equivalent static method

This technique is a smooth method to alternative the effect of dynamic loading of a predicted earthquake by using a static pressure disbursed tangentially on a structure for design functions. The earthquake load is considered in both the directions i.e. X and Y.

B. Response spectrum method

For analysing and the performance of structures response spectrum is one of the useful tools especially in earthquakes, since numerous systems behave as single degree of freedom systems. Thus the natural frequency of the structure is found and from the ground response spectrum the appropriate frequency value of the peak response of the building is noted.

V. PROBLEM FORMULATION

A. Data

Diameter of Silo=6m
Depth of cylindrical portion=20m
Depth of hopper bottom = 2.5m
Diameter of the opening in hopper bottom = 1m
Density of Wheat=8.5kN/m^3 (**As per IS: 4995:1974**)
Coefficient of friction between wall and material=0.444
The ratio of horizontal to vertical pressure intensity = 0.40
Angle of repose = 28 degrees

1) Circular silo with column height of 5m.
2) Circular silo with column height of 7.5m.
3) Circular silo with column height of 10m.

B. Sectional properties of Silo (assumed)

Table 1 Sectional Properties

NO	MEMBER	SECTION
1	BEAM	300 X 300 mm
2	COLUMN	300 X 600 mm
3	SHELL	200 mm

VI. LOADS CONSIDERED FOR ANALYSIS OF STRUCTURE

Once the modelling is completed the next step is loading. The loading consists of various types of loads and the pressure due to the stored wheat on the walls of the silo with the appropriate direction of the load

The various loads considered for the analysis are as follows:

Horizontal pressure on cylindrical walls = 26.02 kN/m2.

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Vertical pressure on cylindrical portion = Pv = (Ph / n) = 26.02/0.4 = 65.05 kN/m^2.
On hopper bottom = surcharge load at hopper bottom = 242.96 kN

VII. THREE DIFFERENT MODEL

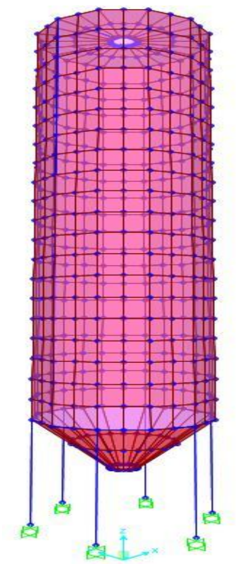
Fig. 1 5m column model

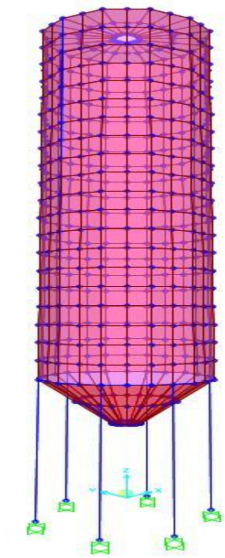
Fig. 2 7.5m column model

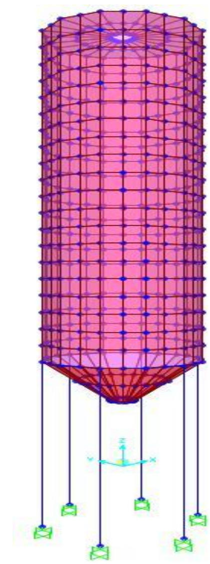
Fig. 3 10m column model

VIII. RESULTS

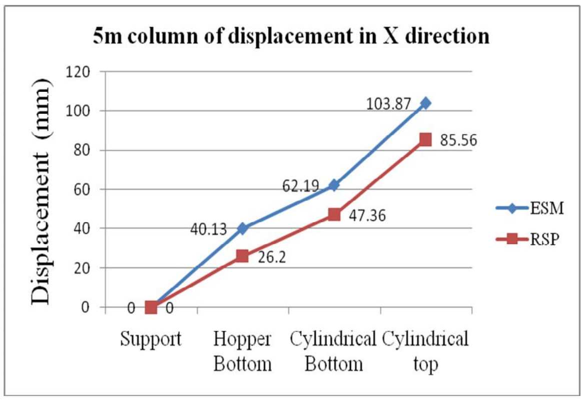

Fig. 4 Displacements (mm) of 5m column model for seismic analysis combination 1.2of DL+LL+EQX & 1.2of DL+LL+RSPX

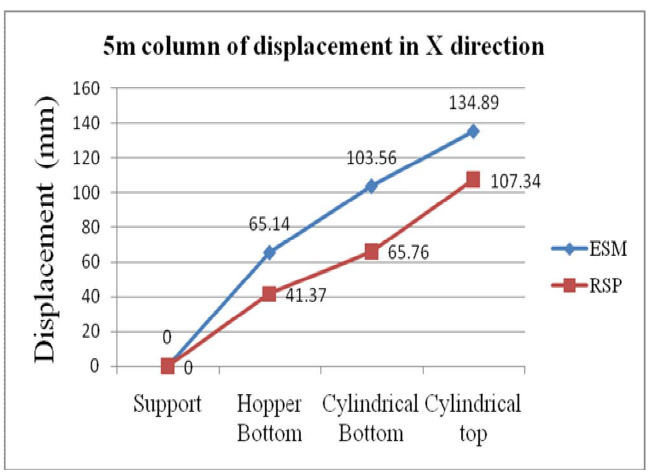

Fig. 5 Displacements (mm) of 5m column model for seismic analysis combination 1.5(DL+EQX) & 1.5(DL+RSPX)

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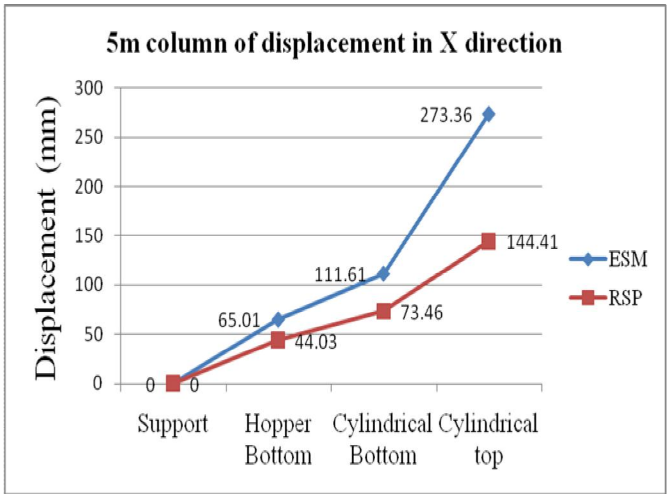

Fig. 6 Displacements (mm) of 5m column model for seismic analysis combination of (0.9DL+1.5EQX) & (0.9DL+1.5RSPX)

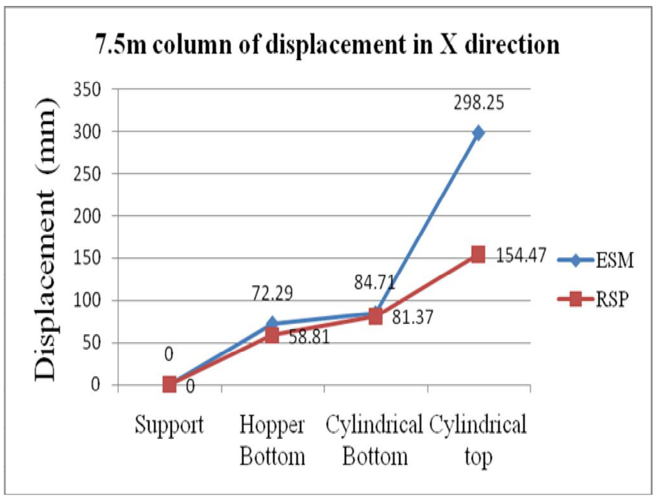

Fig. 7 Displacements (mm) of 7.5m column model for seismic analysis combination 1.2of DL+LL+EQX & 1.2of DL+LL+RSPX

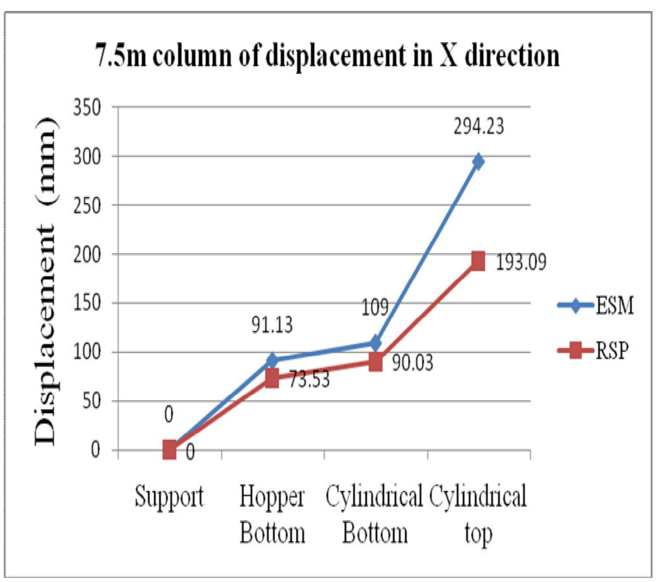

Fig. 8 Displacements (mm) of 7.5m column model for seismic analysis combination 1.5(DL+EQX) & 1.5(DL+RSPX)

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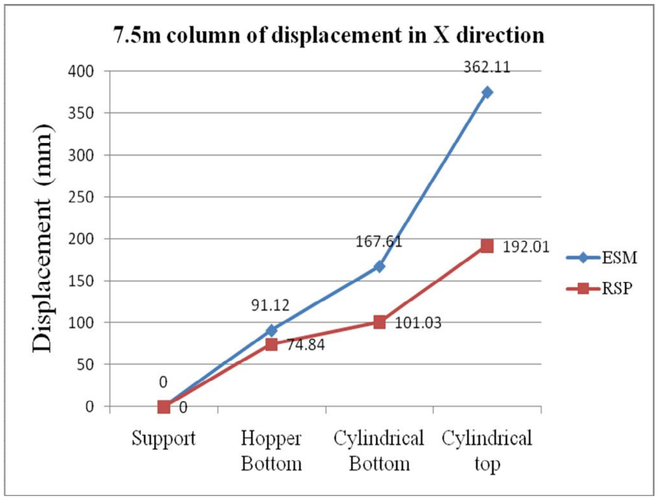

Fig. 9 Displacements (mm) of 7.5m column model for seismic analysis combination of (0.9DL+1.5EQX) & (0.9DL+1.5RSPX)

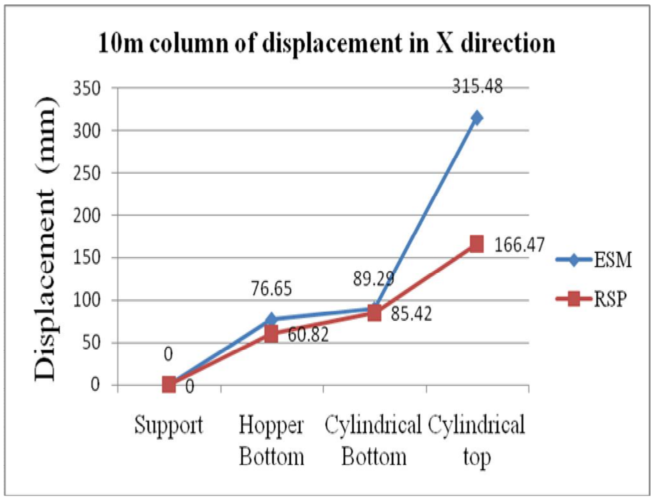

Fig. 10 Displacements (mm) of 10m column model for seismic analysis combination 1.2of DL+LL+EQX & 1.2of DL+LL+RSPX

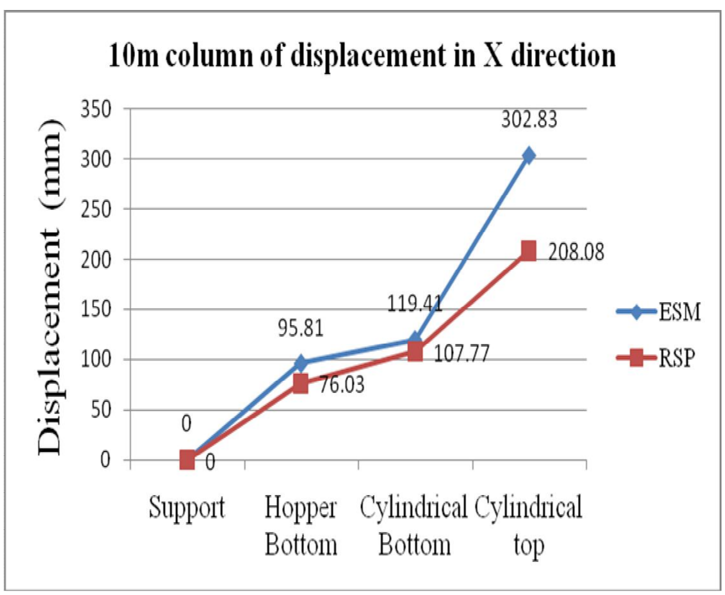

Fig. 11 Displacements (mm) of 10m column model for seismic analysis combination 1.5(DL+EQX) & 1.5(DL+RSPX)

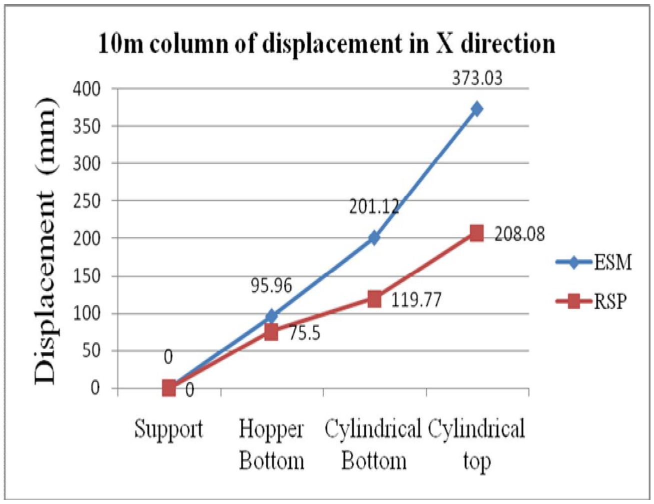

Fig. 12 Displacements (mm) of 10m column model for seismic analysis combination (0.9DL+1.5EQX) & (0.9DL+1.5RSPX)

IX. CONCLUSIONS

The Silo is analysed for various heights of column under the action of load combination. The cylindrical portion of all the 3 models kept constant. Equivalent static and response spectrum analysis were carried out for each model located in medium soil for the seismic zone factor of 0.36.

Results are summarized as follows:

A. The maximum displacement observed was at the cylindrical top of 373.03mm.

B. The maximum displacement is a result of slender column, where the height was more compare to the other sectional dimension.

C. Due to the increased height of the silo the displacement will be more at the top portion of the structure these is because of the fact that the increased mass attract more seismic energy.

D. The maximum displacement of the silo of all the models is well within the permissible limits as per the design code.

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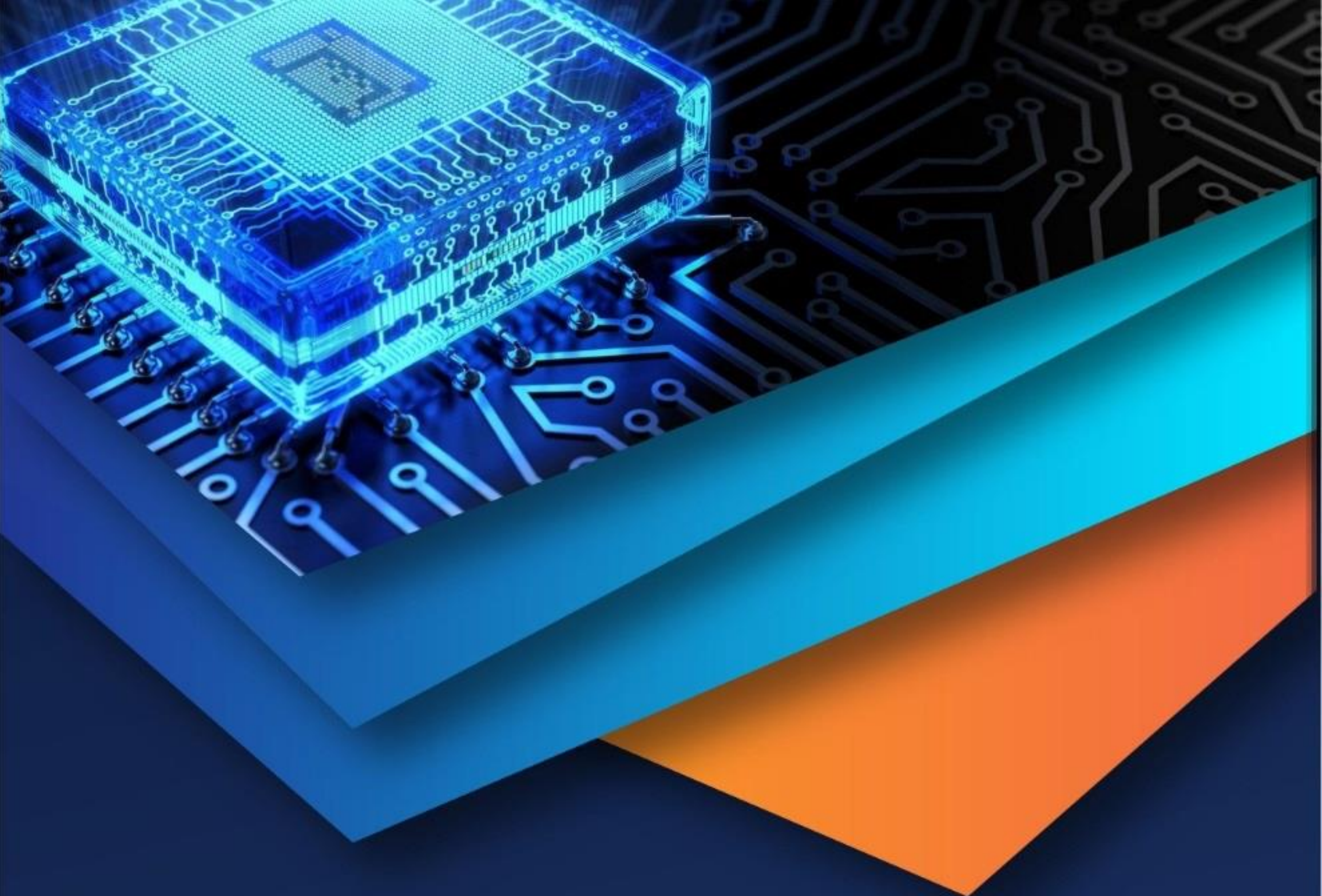

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