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A Review on Dynamic Analysis and Design of R.C.C Solids Storage Structure

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Abstract— Aim of research paper is to compare and briefly describe about the advantage and limitations of solid storage structure by using Staad Pro Structural software. Solid storage structures are considered as special structures as its design is based on the properties of materials stored. The pressure exerted by the stored material on the side of a bin varies with the processes and arrangements of filling and emptying operations. Due to this variation, it is extremely difficult to analyze the pressure exerted on the walls of the bins. In our research work, we are designing the RCC solid storage structure located in all seismic zones with the help of structural software Staad Pro. The design concept include, all dimensions of structural component based on trial and error method, using Equivalent lateral force method in term of Comparison of different models of concrete solid storage structure for earthquake such as nodal displacement, stress and vertical or horizontal pressure on walls etc. for volume of 180 m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) and I.S 456 – 2000 codes, Based on these designs, that dimension of solid storage structures shows least amount of concrete and steel. Main objective of our research work is to compare of different models of concrete solid storage structure for earthquake in terms of nodal displacement, stress and vertical or horizontal pressure on walls etc.
Keywords— Staad-Pro, Baseshare, Displacement, Absolute wall stress, Bending moment, IS1893:2016 etc.

I. INTRODUCTION

The word "solid storage structure" or "Silo" includes equally deep bins and shallow bins; the latter are on occasion called bunkers. Wherever the term "solid storage structure" is used in the Design requirement, it should be interpreted as meaning a solid storage structure, bin, or bunker of any proportion, shallow or deep. Solid storage structures and bunkers are remarkable structures, and countless engineers are unknown with computation of their design loads and with other design and detail requirements. It is important that the design and the preparation of project drawings and project specifications for solid storage structures and bunkers be done under the supervision of an engineer with specialized knowledge and experience in design of such structures. If possible, the properties of the stored materials to be used in the design should be obtained from tests of the actual materials to be stored or from records of tests of similar materials previously stored. Solid storage structure failures alerted design engineers to the danger of designing solid storage structures for only static pressures due to stored material at rest. Those failures have inspired wide- spread research into the variations of pressures and flow of materials. The research thus far has established beyond doubt that pressures during withdrawal may be significantly higher or significantly lower than those present when the material is at rest. The excess (above static pressure) is called "overpressure" and the shortfall is called "under pressure." One of the causes of overpressure is the switch from active to passive conditions which occurs during material withdrawal Under pressures may occur at a flow channel in contact with the wall and overpressures may occur away from the flow channel at the same level. Under pressures concurrent with overpressures cause circumferential bending in the wall. Impact due to filling may cause total pressure to exceed the static. While overpressures and under pressures are generally important in deeper solid storage structures, impact is usually critical only for shallow ones (bunkers) in which large volumes are dumped suddenly. Solid storage structure th a substantial capacity in the cement industry may cause large eccentricities during discharge due to their individual bottom aeration sections. A large eccentricity is classed as when a discharge flow channel is more than half the radius of a solid storage structure from the solid storage structure mid-point. From different investigations, it is known that horizontal pressures in a flow channel are smaller than in the bulk material outside the flow channel. This results in a reduction in horizontal pressures in the zone in which the flow channel contacts the wall, compared to the horizontal pressure on the remaining wall circumference that corresponds with the fill pressures.[2] In the transformation from flow zone to static zone, horizontal pressures even higher than the fill pressure occurs due to the load balance. The result was an alternating pressure distribution when discharging large capacity solid storage structure, which could lead to critical wall loads in certain cases. Solid storage structure with bottom aeration was generally viewed as 'slender' solid storage structures.

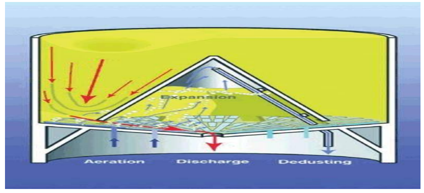

Fig1 Solid storage structure with central cone for the cement industry

Above Fig1. shows the solid storage structure with central cone for the cement industry Where all the dust which is generate in solid storage structure is discharge with the help of dusting pipe and discharge gape is also mean as hopper which is us to provide discharging all the row material The largest solid storage structures in the cement industry are built with diameters up to 30 meter; typical solid storage structures for storage of 20000 tons cement are, for example, 20 m in diameter and 60 m high. Although there is different design variations by the leading supplier, large capacity solid storage structures with diameters above 12 m are mainly executed as central cone versions. The central cone has a material displacement function, which allows the material in the solid storage structure to come into motion during discharge. All solid storage structures with a central cone (Figure 1) was designed as quasi flat bottom solid storage structures, whereby the solid storage structure bottom forms a ring space. This are divided into individual aeration sections that are slightly declined towards the outlet by approximately 10°. The solid storage structure bottom is equipped with so-called fluid slides that have an air-permeable fabric on the upper side. The aeration air is blown under the fabric in order to fluidize the bulk material on the fabric. The amount of coverage of the solid storage structure bottom with fluid slides varies between 35 and 50% depending on system and requirements. In order to make problem-free discharge of material, air amounts and aeration pressure must be adjusted to each other. The air amounts increase roughly linearly from a minimum air amount with the required discharge throughputs. As a rule, blowers with 500 mbar pressure are sufficient for aeration. The solid storage structure bottom was aerated section by section, so that all sections are aerated in a complete cycle. It is insignificant whether two or more sections are connected for aeration. Correspondingly, only the parts of the bulk materials above the actively aerate solid storage structure section was in motion, and a flow channel forms increasing upwards, which can include almost the entire cross section, depending on discharge amount, solid storage structure height and aeration time. Within the flow channel there is a convergent material flow. The gradient of flow is illustrated in the figure by the increasing width of the blue and white material elements. As only the bulk material above the aerated section was in motion, no mass flow will occur in the solid storage structure. With mass flow the entire material in the solid storage structure would be in motion uniformly. Due to the cyclic aeration of the ring zone, one section after another, the discharge process in the solid storage structure must be strongly eccentric. There are different types of cement solid storage structure such as the low-level mobile solid storage structure and the static upright cement solid storage structure, which are used to hold and discharge cement and other powder materials such as PFA (Pulverized Fuel Ash). The low-level solid storage structure is fully mobile with capacities from 100 to 750 tons. This is simple to transport and are easy to set up on site. These mobile solid storage structures generally come equipped with an electronic weighing system with digital display and printer. This allow any quantity of cement or powder discharge from the solid storage structure to control and also provides an accurate indication of what remains inside the solid storage structure. The static upright solid storage structure have capacities from 200 to 800 tons. This is considered as a low-maintenance option for the storage of cement or other powders. Cement solid storage structure can be used in conjunction with bin-fed batching plants. Cement can be stored in different types of Solid storage structures like Horizontal Solid storage structures, Concrete Solid storage structures, and Steel Panel Solid storage structures etc. depends upon the requirement of the end user. While Mobile Solid storage structure come in a relatively small storage capacity of approximately 90MT of Cement, Concrete Solid storage structure can be store practically thousands of MT of Cement. A majority of Solid storage structure that store more than 5000 Cements are constructed from Concrete. A good compromise between cost, construction time and ease of operation is Steel Panel Solid storage structures. These solid storage structures can manufacture in a factory, and then erect at site using small panels that are bolted together to form a Solid storage structure that is watertight because of a sandwiched layer of special rubber seals.

II. LITERATURE REVIEW

Literature Review for Paper [1] shows a Fly ash storing in solid storage structure and check stresses, bending moment and design of solid storage structure in this paper. Also, done a comparison between manual load calculation for three solid storage structures and calculating results of stresses and bending moment in STAAD Pro software After both load calculation and find the stresses, bending moment of three of solid storage structures comparing and design best solid storage structure. In this paper, author comparing the three types of solid storage structure such as square, rectangular & circular. On these solid storage

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structure what effects (shear stresses, bending moment) takes places after applied load such as ash loading, seismic load & wind load with the help of STAAD-PRO software.

In these analyses, the different results of stress and bending moment during comparison of three types of solid storage structures in staad pro software, It is concluded that, the change of in manual calculation of load circular solid storage structure is very easy. Value of these loading is very less. Applied the loading in staad pro v8i is very easy in the circular solid storage structure comparative other solid storage structures and load combination also very easy. Stress and bending moment value very low of circular solid storage structure and near same value of rectangular and square solid storage structure. But in literature surveys, more storage capacity in rectangular solid storage structure and square solid storage structure. The power tool for computerized structural engineering STAAD Pro is the most popular structural engineering. Analysis & multi material design prepare 3D finite model of solid storage structure in STAAD.

The aim of paper [2] is to compare and briefly describe about the superiority and limitations of four codes. This paper looks over the superiority and limitations of the four codes namely Bureau of Indian Standard (BIS), American Concrete Institute (ACI), German Standard (DIN) and British Standards Institution (BSI). For the sake of complete, logical and relevant analysis, this study has been divided into two parts. In the first part, each code was thoroughly studied and the basic concepts behind each code were explained. The second part presents the comparison and discussion of similarities and dissimilarities of each code and the analysis of the parameters involved in the design of the solid storage structure. The insight of loads exerted by the stored materials and external forces to the solid storage structure is significant for designing the safe solid storage structure. A slight modifications in the parameters, namely the effect of the thermal variation and the properties of stored materials, if taken into account in the analysis of solid storage structure, the discrepancies associated with various codes can be further reduced.

Paper [3] describes a brief descriptions of each of codes, their limitations, and common design conditions that are not covered are identified. Users of solid storage structure codes will find this information invaluable, as will code writers who will benefit by being given direction as to how to improve their codes to make them more useful. External equipment such as electric or pneumatic vibrators, vibrating bin discharger (bin activator), localized aeration devices, and air cannons impart significant forces to a solid storage structure structure that must be taken into account. They can also affect the stored bulk solid in such a way that its properties change, resulting in different solid storage structure loads. AS 3774-1996 provides some limited guidance on this phenomenon, but it does not cover loads acting on external equipment itself by the stored bulk solid. The other three solid storage structure design codes do not cover these at all Feeders and gates are also critical to a safe and properly functioning solid storage structure. AS 3774-1996 provides guidance regarding loads imposed on them, but the other three codes do not. Knowledge of the loads applied to the walls and internals (if any) of a solid storage structure is extremely important. Such loads must not be ignored if a stable, safe solid storage structure is to be designed. Much progress has been made in the last 50 years in providing solid storage structure load guidance to design and structural engineers. EN 1991-4:2006 is a significant advance over all previous codes, but even it does not cover many common load cases.

For load cases not covered by the codes, the design/structural engineer is left with two choices: Be extremely conservative in estimating applied loads. This approach can be quite expensive and yet still may not be conservative enough to prevent the solid storage structure from failing and Rely on design engineers who have significant experience in calculating solid storage structure loads.

In Paper [4] study the most economical configuration of solid storage structures to store a given volume of a material, twenty eight samples of solid storage structures have been designed by changing the ratio of height to diameter for storing a given material, namely, bituminous coal. In this investigation, for volume of 125m3, the diameter to height ratio is varied and has been designed and finally, the most economical size is found out. This method is carried out for volume of 125m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) “Criteria for Design of Reinforced Concrete Bins for The Storage of Granular and Powdery Materials” and I.S 456 – 2000 codes Based on these designs, those dimensions of solid storage structures which will lead to least amount of concrete, steel and total cost to store a given amount of material have been found out. These findings will be useful for the designers of solid storage structures. H/D ratio and Total cost in INR are taken in x and y axis respectively. The most economical solid storage structure has been found to the dimension of height: 8.35m. And diameter: 4.2m. The total cost required for economical solid storage structure is Rs. 116682.48 and for uneconomical one is Rs. 163763.56. It is found that the requirement of cost for construction of solid storage structure is directly proportional to height and inversely proportional to that of diameter.

In [5] paper Manual design of circular solid storage structure for various material and also done .net programming for different material storing in solid storage structure & check pressure and design of reinforcement and also done a comparison between manual design and.net programming. In both designs, influence of different parameters discussed. The same result of stress and area of steel has been found during comparison of manual design and .net (VB) programming. When increasing height and diameter ratio decreases thickness of wall [6]. It is concluded that, ease to various results of various material storing in solid storage structure in Design of .net (VB) programming.

The paper [7] shows an industrial solid storage structure analyzed and designed according to the Indian standards (IS 4995) and also by referring Euro code (EN 1998 -4: 1999 & EN 1991-4: 2006) and ACI code (ACI 313). In this study, a 450 cum capacity flat bottom solid storage structure design & analysis. Concrete flat bottom circular solid storage structures are often deployed to store material in various industries like cement plants, power plants, oil and gas industry etc. Solid storage structures are special structures subjected to many different unconventional loading conditions, which result in unusual failure modes. Failure of a solid storage structure can be devastating as it can result in loss of the container, contamination of the material it contains, loss of material, cleanup, replacement costs, environmental damage, and possible injury or loss of life. The best design of solid storage structure has helped in safe structure.

Paper [8] describes four and a half decades and resulted from all and introduced the first integrated method for characterizing powders for flow, and using this information to design a solid storage structures and bunkers that would discharge without hang-up. Sadly, many users and designers of solid storage structures and bunkers still do not benefit from this, so a lot of process vessels in industry still suffer from rat-holing, arching and bridging. Objections of cost, time and questionable accuracy were levelled at the original hopper design method, in spite of the breakthrough it represented. However, over the last 40 years these problems have been overcome with the introduction of faster, easier to use and more sensitive powder flow ability measurement techniques, and a lot of experience of what measurements matter with which materials and in what operational scenarios. Solid storage structure and bunker failure can occur due to many reasons, following these1) Due to design, 2) Fabrication and erection error, 3) Improper usage,4) Improper maintenance. Now this design project will pull together various lessons learned from many years of solid storage structures and bunkers design projects, and show a practical approach to deciding) Flow pattern is required (mass flow or core flow), b) Measurements need to be made of the powder properties, c) Design models should be used, based on the material being handled and the operational requirements of any given case.

In paper [9] Thin shell structures have given considerably attention for the at least six decades especially during the war time because of their importance in aircraft and missile applications. Shells of various shapes were investigated such as elliptical hemispherical, conical and cylindrical shells. These structures are mostly failing by bucking under external pressure. Cylindrical steel solid storage structures are tall slender structures used for storing materials like cement, grains, fly ash, carbon black, coal saw dust etc. They are special structures subjected to many different unconventional loading conditions, ranging from few tones to hundreds to thousands of tones which results in unusual failure modes.[3] Failure of a solid storage structure can be devastating as it results in loss of the containers, contamination of material it contains, loss of materials environmental damages, and possible injuries and loss of life. Solid storage structures are subjected to normal pressure and axial compressive loads along with the self-weight. They also carry lateral loads due to wind and seismic forces [10].

III. AIM AND OBJECTIVE OF PROJECT

Aims and objectives present an outstanding agenda for the container for support in a research allowance application. The principle objectives of research project can be shortening as follows:

A. A clear and broad learning of recent available international paper on solids storage structure (silos).
B. To perform the Analysis of solids storage structure (silo) using Equivalent lateral force method and to study the performance of structure located in all seismic regions.
C. Design of different models of RCC silo in STAAD pro for different seismic zones by using IS-4995:1974(Part-I,Part-II).
D. Comparison of different models of RCC silo for earthquake as per IS 1893:2016 in terms of nodal displacement, stress and vertical or horizontal pressure on walls etc.
E. To compare the results obtained to assess their potentiality and suitability in understanding the true behavior of such a structure.
F. Presentation of the result in tabular appearance to simply be familiar with the analysis of structure.

IV. REASEARCH METHODOLOGY

A. Step 1: Fix The Dimensions

To create a model for the analysis in software dimensions is necessary for the given requirements, Dimension of Silo being drawn based on the requirements.

B. Step 2: Load Calculations And Load Combinations

Load calculations are carried out based on various Indian Standards such as IS: 875(Part – 1)-1987 for Dead loads (Unit weight of Building materials and Stored materials), IS: 875(Part –2)-1987 for Imposed loads and IS: 1893(Part 1)-2002 for Seismic loads. Horizontal pressure acting on Silo wall at various depths and forces due to horizontal pressure are calculated based on IS:

4995(Part I)-1974. Temperature stresses and Hoop steel required to resist those stresses are calculated based on IS: 4995(Part II) - 1974. Loads mentioned above are considered to be Primary load cases.

C. Step 3: Analysis Using Staad Pro

The created model in the STAAD has to be analyzed after the assignment of properties of members. Load cases details and definition of loads should be defined carefully based on the calculation of loads and IS codes. Load cases details be in the order of Dead load, Live load, Ash load, & -z, Seismic +x & +z and other load combinations for the analysis.

D. Step 4: Design As Per Indian Standards

Design of R.C.C. solids storage structure (Silos) is based on the values obtains from analysis where IS: 456 -2000 and SP are be use for the design procedure and for various checks.

V. CONCLUSION

This paper has to study the behaviour of the RCC solid storage structure structure in different seismic zones, which means the study was carried to observe RCC solid storage structure structure under the influence of horizontal force i.e. earthquake force or seismic force. According to my literature review lot of authors have mentioned how difficult it is to design a thick rcc solid storage structure with a single country's building standard code. The design and analysis of rcc solid storage structure was done on ' Staad Pro ' software which is used widely for similar purpose.

- In the study this is observed that the structure placed on the greater seismic zone have shown greater horizontal displacement than the one's placed in lower seismic zones.
- The maximum nodal displacement in x direction was noted in model M4 displacing 1453.397mm; other models have shown relative decrease in the displacement as the zone was lowered.
- The least value of displacement was noted on the model M1 located in the seismic zone II showing 514.556mm displacement.
- Model 3 and 4 have shown about 1 m nodal displacement in X direction which is necessary in revision of structural dimension and grade of materials.
- The maximum force at the base was noted in model M4 725.073 KN the value of base force kept decreasing as the seismic zone is lowered hence giving least base moment in model M1 202.468 KN.
- The maximum moment at the base was noted in model M4 3715.78 KN-m; the value of base moment kept decreasing as the seismic zone is lowered hence giving least base moment in model M1 1035.723 KN-m.
- The maximum Shear Force in Beam was noted in model M4 6058.655 KN; the value of maximum Shear Force in Beam kept decreasing as the seismic zone is lowered hence giving least maximum Shear Force in model M1 4882.82 KN.
- The maximum Bending Moment in Beam was noted in model M4 3715.78 KN-M; the value of maximum Bending Moment in Beam kept decreasing as the seismic zone is lowered hence giving least maximum Bending Moment in model M1 1277.66 KN-M.
- The maximum Absolute Wall Stress was noted in model M4 20.942 N/MM2; the value of maximum Absolute Wall Stress kept decreasing as the seismic zone is lowered hence giving least maximum Absolute Wall Stress in model M1 5.817 N/MM2.
- In manual estimate of load in RCC solid storage structure is very easy. Value of these loading is very less and when applied the loading in staad pro v8i is very easy.

A. Future Scope

- H/D ratio of all types of solid storage structures needs to be studied this result can be used in IS: 9178 part II 2006. Comparison should be made under various type of eccentricity hopper bottom for various soil conditions.
- Comparison should be made for different H/D ratios.
- Solid storage structure structures can also be strengthened and upgraded using certain new materials and techniques including Post-Tensioning.
- The study may be carried out with an opening for the movement of vehicles (i.e. removing diagonal bracings either on one side or two sides for the first storey).
- The Study may be carried out with other materials carrying different flow pattern.
- Analysis study can be carried out for typically filled conditions where there is no pressure induced on the wall (i.e. only for material filled in hopper plus the repose material forming cone).

- The study may be carried out with other types of solid storage structure with different specifications.

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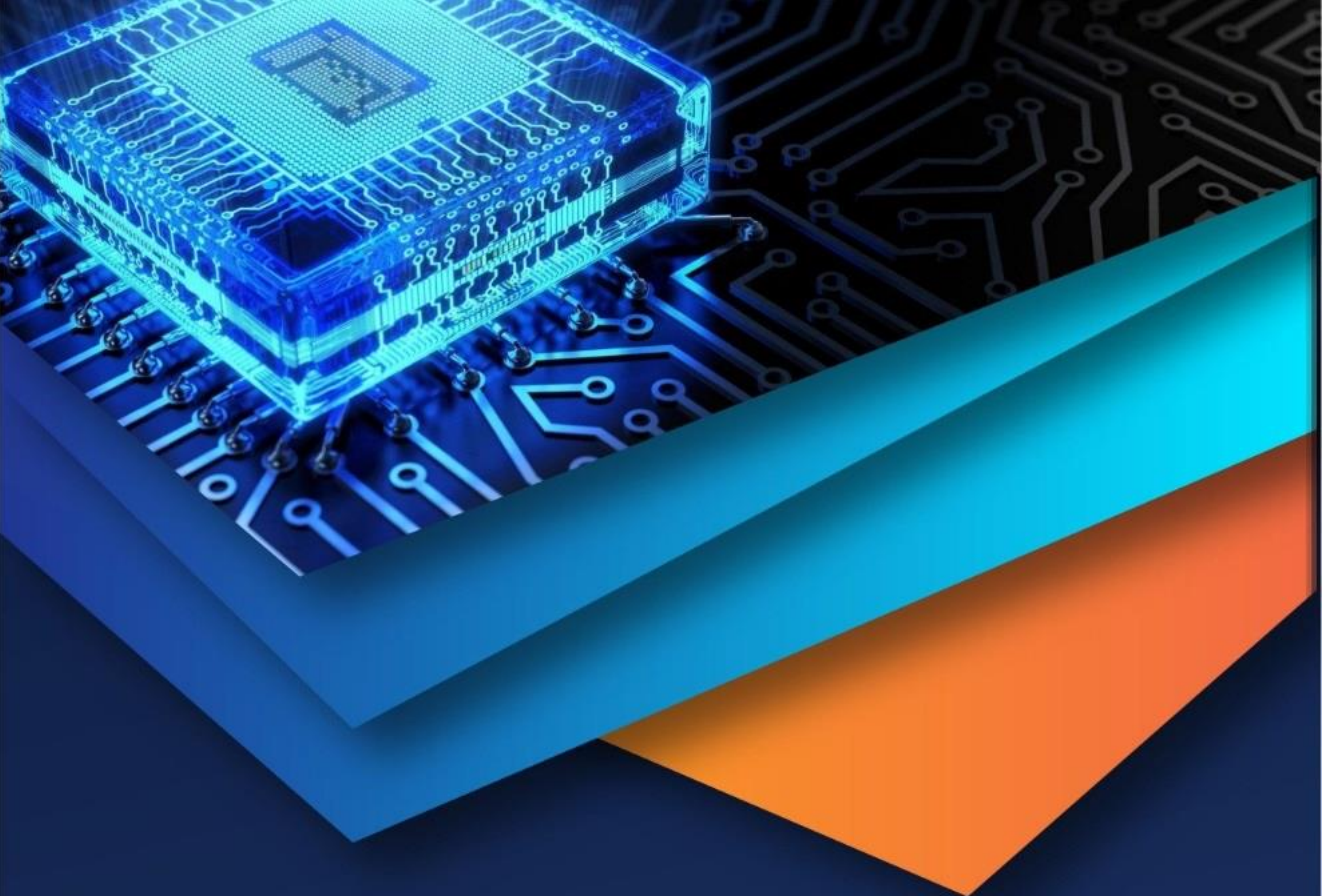

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