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Comparative Analysis of Precast Construction and Conventional Construction of Small-scale Concrete Building in Terms of Cost

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Abstract: ***Building a house is one of the basic needs of humans. To build a house with high durability and low cost, engineer A.N.S. Kulasinghe introduced the pre-cast concrete technology in late 1940's. According to past studies, National Engineering Research and Development (NERD) Centre precast items are used in housing and other constructions and those details were collected by literature review. Objective of this study is updating the cost effectiveness of pre-cast concrete construction of a small-scale building.***

Data were collected from the NERD Centre and few pre-stressed concrete yards during the months of June to July 2019 by using face-to-face interviews.

After the analysis of obtained data, it was found that there were differences between the costs of items among pre-cast concrete technology and conventional concrete construction technology. Overall cost comparison was done to single story building and two story building separately using cost rates of conventional method and pre-cast method. The outcome of the analysis revealed that, 30% - 38% of cost effectiveness can be obtained using pre-cast methods for single story building and using those methods for two story building, 29% - 32% of cost effectiveness can be gained.

Keywords: Cost comparison; Cost effectiveness; National Engineering Research and Development center; Pre-cast concrete

I. INTRODUCTION

Houses are used by humans as one of their crucial needs as residences. Different improved technologies and materials are used to build residences. The conventional building methods and materials used by Sri Lankans since the selection of a site to build their houses step by step and finally in residing in their houses are unambiguous and distinctive (De Silva 2017). It is based on social stages, beliefs, and religions of humans.

As the civilization and urbanization occur through the society, people tend to build more durable shelters as their houses, but they have to face many problems such as inadequacy of resources and facilities, higher prices of construction materials and shortage of labor. According to the Sunday Times newspaper, in Sri Lanka, more than 80% of the households have no access to home financing, about 7% lack homes, and one third live in semi-permanent housing and 6% live in line room estates and shanties. Building a house with an affordable cost is a problem for most of the Sri Lankans. Most engineers and developers suggest that pre-cast concrete technology as one of the best answers for all that problems.

It is different from conventional construction technology. This study was conducted to compare the cost incurring for conventional construction method and pre-cast construction method. Pre-cast concrete technology which was introduced in late 1940's to Sri Lanka has no significant growth in the construction industry (Weerasiri and Nanayakkara 2003). The reason could be, no awareness about the technology and its benefits among the people. Therefore, the main research question of this study is designed as, "Can economic benefit be gained by pre cast technology rather than conventional construction technology?".Considering these points, this study aims to conduct a comparative analysis of cost for the precast construction and conventional construction of small-scale concrete building.

II. LITERATURE REVIEW

Building construction involves assembly and erection of structures. It is an ancient human activity that began with the functional need for a controlled environment to moderate the effects of climate (De Silva 2017). Sri Lankans used to use different methods of construction as they civilized over the centuries. The construction materials and technologies have transformed over the generations due to rapid urbanization and industrialization.

The most common and conventional concrete casting method is the “in-situ cast concrete” method, and the other is “pre-cast” concrete method (Weerasiri and Nanayakkara 2003).The first application of pre- cast concrete in Sri Lanka was in port related structures in 1949. As a solution to deterioration of Reinforced Cement Concrete (RCC) maritime structures, pre stressed pre-cast concrete was introduced where a well-known Sri Lankan civil engineer Mr.A.N.S. Kulasinghe has played a major role (Weerasri 2007).

Mr. A.N.S. Kulasinghe has introducedNERD center floor slab system in early 1987 especially for domestic buildings which are used by middle income families in Sri Lanka. The NERD system consists with 50 mm thick in-situ concrete slab retain on trapezoidal shape pre-stressed beams which are placed by keeping 600 mm interval between each (Sanjaya *et al* 2016).

When consider about the present situation of the pre-cast industry in Sri Lanka, the overall production has shown a gradual developmentsince 1999. Moreover, partially pre-cast constructionis popularthan the fully pre-cast constructionin the industry, which may be due to the comparatively low cost for available construction materials, erection facilities, transport and handling in partial pre-cast production (Weerasri and Nanayakkara 2003).

Demand for housingas well as the capital cost for construction is constantly increasing in Sri Lanka asconstruction materialssuch as soil, stones, cements etc. are depleting. Due to this reason, traditional construction methods are becoming expensive and has become an serious problem to house builders and developers (Dayananda 2011).

According to updated records of the NERD center, NERD composite floor slab system saves 35% of cost, compared to the conventional slab system.

As a new innovation of NERD center of Sri Lanka, Cement Stabilized Earth Blocks (CSEB) can be used as an alternative building material for burnt clay bricks and cement, sand blocks. This is also a cost-effective pre-cast wall construction material. It is environmentally friendly green product and NERD center says that 15%-50% cost can be saved using compressed stabilized earth blocks. Moreover, NERD center has introduced cost effective 6” ×6” pre-stressed / pre- cast concrete columns and these are not required shuttering work. It saves 20% of cost compares to 9”×9” RCC columns.

According to the literature, there are some findings on cost effectiveness in pre-cast concrete technologyas compared to traditional methods. Nevertheless, there are no or few findings available forcost comparison for an entire building using these technologies. Therefore, this research was conducted to do a comparative analysis in terms of cost for an entire small-scale building using pre-cast and traditional concretetechnologies.

III. METHODOLOGY

A. Methods Of Data Collection

The resource persons from the NERD Centre were met and face-to-face interviews were conducted to obtain data and information about the different types of pre-cast items introduced by NERD Centre and their prices. Also, data were collected through direct interviews and telephone interviews with NERD Centre registered contractors. More information was obtained from two contractors and two manufacturers accredited by NERD, and pre-cast housing project site.

B. Methods Of Data Analysis

Collective cost of a linear feet (Lft) of a pre-cast column, square cost of a Slip Form Wall (SFW), square cost of a Compressed Stabilized Earth Blocks (CSEB) and cost of a square feet of a slab were analyzed adding item cost, labor cost, labor handling cost, and transport cost as a rate analysis. The cost for same purpose using conventional method was calculated using Building Schedule of Rates (BSR).

Cost comparison was done for each pre-cast item comparing with same purpose items of conventional method. Two drawings were designed to one story and two-story buildings. Considering single story building, cost was calculated separately for traditional method and for pre-cast method with pre-cast column and CSEBs. Then the cost effectiveness was calculated. Another calculation was done to traditional method vs. pre-cast method with pre-cast column and SFW. Cost comparison was also done for two story building separately using traditional method and pre-cast method with 1. Pre-cast columns + CSEB + slab, 2. Pre-cast columns + CSEB and 3. Pre-cast columns + slab. Finally cost effectiveness was calculated for the two-story building. Cost for conventional method was calculated using BSR and some values were changed according to the purpose of the study.

IV. DATA ANALYSIS AND RESULTS

Prior to calculate the cost effectiveness between conventional construction method and pre-cast method, a cost comparison was done between pre-cast items and traditional construction items. The comparison was done for following items.

Table 1: Conventional Construction Items and Respected Pre-Cast Construction Items

Conventional construction	**Pre-cast construction**
Concrete column (225mm×225mm,12mm tore steel, grade 25)	Pre-cast column (150mm×150mm, 5mm high tensile wire 8 Nos, grade 30)
In situ concrete slab (100mm thick, 10mm tore steel, grade 25)	Pre-cast slab (pre-cast purlin 3 Nos high tensile wire, ferrocement1200mm×600mm, 50mm×50mm welded mesh, grade 30)
Cement block (150mm×100mm×300mm)	Slip Form Wall
Cement block (150mm×100mm×300mm)	Compressed stabilized earth block (150mm×100mm×300mm)

Cost rates of the conventional concrete items and pre-cast items were calculated as below.

Table 2: Cost Rates of The Conventional Concrete Items And Pre-Cast Items

Item	Unit	Traditional construction method (Rate) RS.	NERD technology (Rate) RS.	Cost effectiveness RS.
Column	Lft.	710	635	75
CESB vs. Wall	Square	40200 (with plaster)	27000	13200
Slip form wall	Square	40200 (with plaster)	22900	17300
Slab	Ft^2	672	422	250

According to the calculated cost rates, below graph was obtained.

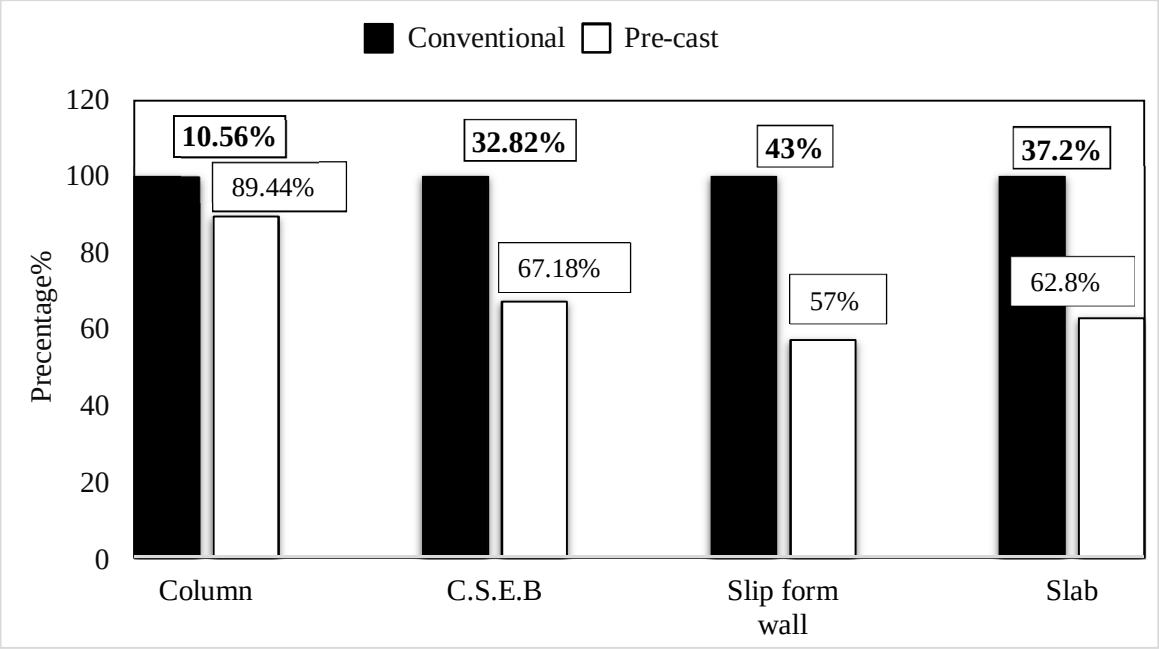

Figure 1: Pre-Cast Items Vs. Conventional Concrete Items- Cost Effectiveness

Figure 1 shows the data which was obtained by basic rate analysis. The blue color column shows relative value for each item and it is 100%. The cost for each item is shown against that column and the cost effectiveness of each item isshown inpercentage wise.
Traditional concrete column and pre-cast column were compared and the value for linear feet (Lft) was obtained from each. According to the analysis 10.56% of cost can be saved for a linear feet.
The NERD Centre has stated that, a 150mm × 150mm pre-cast column has the same strength as a 225mm × 225mm conventional concrete column. The reason for that is NERD columns have been pre-tensioned with 10kN. Therefore, the reinforcement, high tensile wires and low concrete volume leads to get a cost saving of 10.56% for the pre-cast column than conventional concrete column.
Cost for Compressed Stabilized Earth Blocks which are made by compressing cement and soil mixture, was compared with the cost of cement blocks for a square (150mm × 100mm × 300mm). Plastering is not required for CSEBs. But plastering should be done for traditional blocks in masonry. Considering these facts, comparative analysis was done to CSEBs and cement blocks. The result showed that 32% of cost can be saved using CSEBs.
Cost comparison for SFW was done also with cement blocks. Here SFW does not require plastering as it has the best finishing. Therefore 43% of cost effectiveness can be gained using SFW rather than cement blocks.
Finally, the cost for 4” slab with 10mm reinforcement was compared with the cost for pre-cast slab with purlins and ferrocement panels. There are several reasons which are affected to cost difference between two slab types such as; the pre-cast slab does not require jacks and formwork, the concreted thickness is less in pre-cast slab (2”), reinforcements are not used for pre-cast slab but 50mm×50mm welded mesh is used. Purlins are pre-stressed to give the tensile strength of 17kN. Therefore 37.2% cost effectiveness can be obtained using pre-cast concrete slab.
Then the costs for single storey building and two-store building were calculated by combining both conventional and pre-cast concrete technologies.

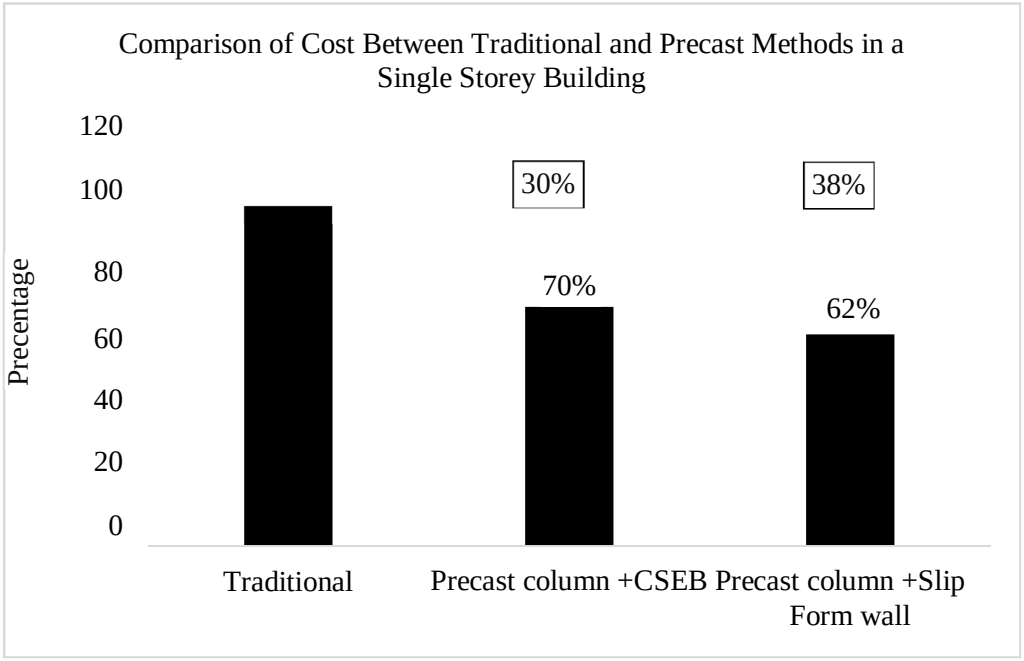

Figure 2: Cost Comparison Between The Pre-Cast And Conventional Methods In A Single-Storey Building

By using the rate analysis done for each item, combined analysis for a single-storey building was done (Figure 2). Instead of 225mm × 225mm columns and cement blocks which are used in traditional method, pre-cast 150mm × 150mm columns and CSEBs can be used and 30% of cost can be saved from the expenditure for the house. If pre-cast columns and SFW are used instead of above combination, 38% of cost effectiveness can be obtained as compared to the conventional method.

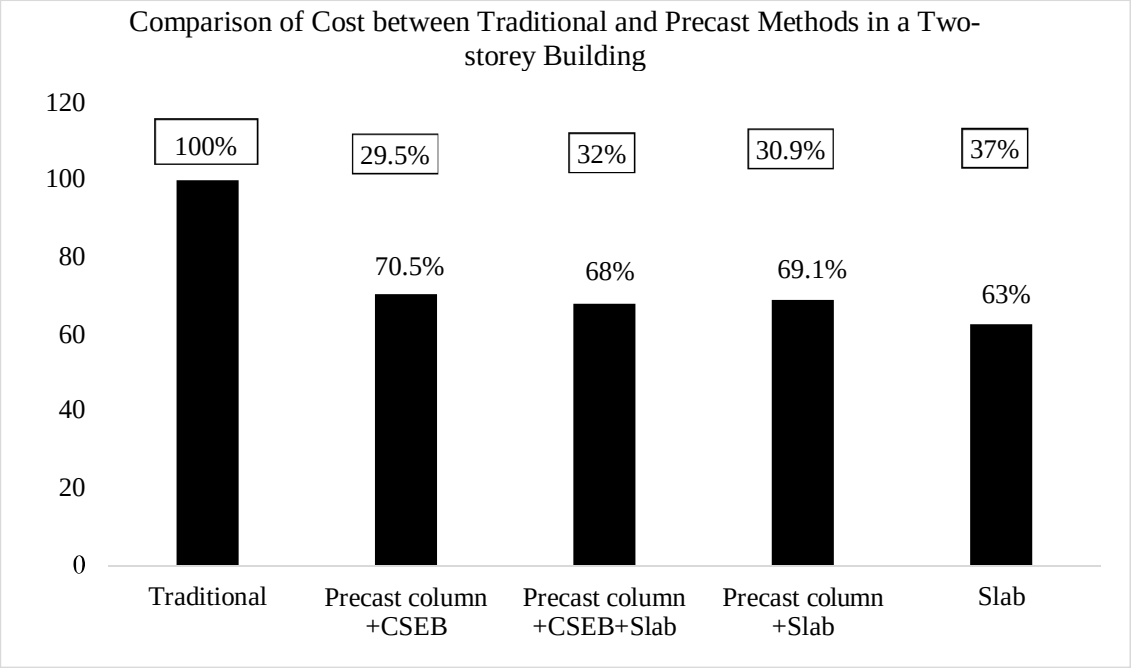

Figure 3: Cost Comparison Between The Pre-Cast And Conventional Methods In A Two-Storey Building

The first column of the Figure 3 shows the relative value of 100%. Instead of conventional method,byusing pre-cast column and CSEBs, 29.5% of cost effectiveness can be obtained. If pre-cast column + CSEBs + slab combination is used for the designed two-storey building, 32% cost effectiveness can be gained.

When using pre-cast column with pre-cast slab for the designed two-storey building, instead of in-situ slab, 30.9% cost effectiveness can be acquired.

If the pre-cast slab is only used for the designed two-storey building, there will be a 37% of cost effectiveness. Generally, when finishing an in- situ slab, soffit plaster should be used. Yet, the finishing of ferrocement panel of the pre-cast slab is better than in-situ slab. Therefore, soffit plaster is not required for pre-cast slab. This fact is also considered when calculating the cost effectiveness for the slab.

V. CONCLUSIONS

In conclusion, the results obtained from this study for the cost effectiveness of pre-cast items and the previous results obtained by NERD Centre for teach item are within the range.

Using pre-cast columns, CSEB, slip form wall, and slab, respectively 10.56%, 32.82%, 43% and 37.2% of cost effectiveness can be obtained as compared to conventional method. In consonance with the literature, NERD Centre reported that using CSEB can saves 15% - 50% of cost and pre cast column saves 20% of cost. The reason for the fluctuations may be because of variations of material costs and labor costs.

According to the literature review, pre cast technology was introduced for domestic buildings for middle income families. The results of the study prove that strongly. Nevertheless, the popularity of pre-cast technology is low among the society. However, a house can be built at an affordable cost using pre-cast column, CSEB, slab and slip form wall.

There are registered contractors under NERD Centre but no adequate skilled labourers. There were only seven licensed manufacturers available island wide as of 2019. Therefore, it was comparatively difficult to find the relevant information during the study. This study was conducted in Kurunegala and Gampaha districts. Because of that, the results may be varied and some fluctuations can be seen, when applying these data to other districts in Sri Lanka. However, since there was a huge cost difference between conventional and pre-cast concrete methods, mandatory cost effectiveness can be gained using pre-cast concrete technology of any district in Sri Lanka.

Another main reason for using pre-cast concrete technology is that, it reduces the material wastage which is highly taken place in conventional concrete technology. Therefore, it is an environmentally friendly and sustainable construction method.

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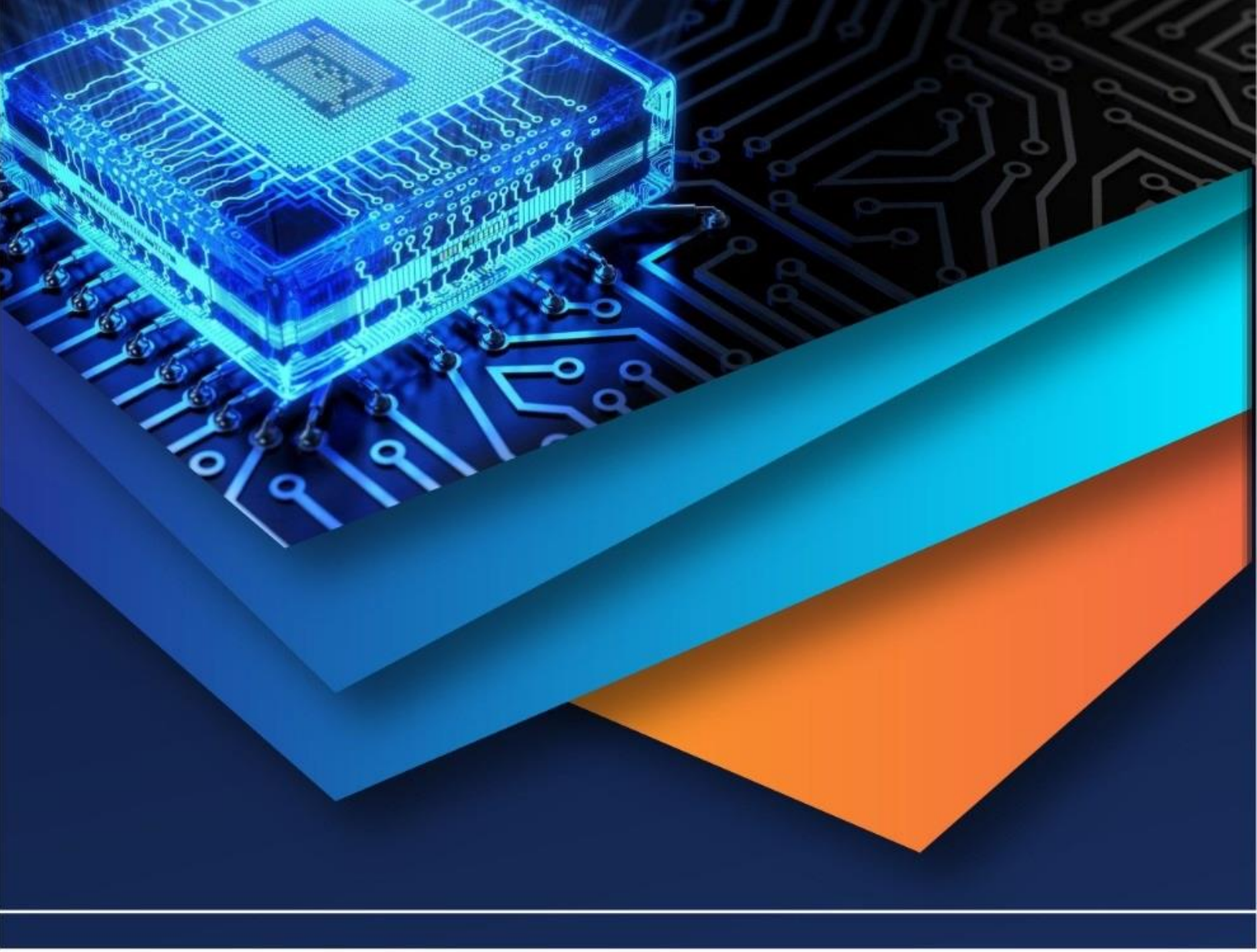

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