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Effect of Equipments on Productivity in Construction

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Abstract: ***The greatest influence to construction cost occurs at the front end of the project. Assumptions made by design engineers during the conceptual and design phases of a project dictate the choice of equipment that will be used for the particular project, just as it will dictate the choice of materials used in construction. It is important for design engineers and construction engineers to be knowledgeable about construction equipment. Construction equipment and integral part of the construction process. The cost of construction is a function of the design of the construction operation. The contractor's equipment policy and equipment management system have a great impact on the profitability of a firm, especially for contractors with large investment in equipment. The cost of equipment in civil engineering construction projects can range from 25-40% of the total project cost. In this report information given about how the planned and proper maintenance is important for construction equipment for better production. The data given is monthly equipment utilization on site & various reasons for losses in construction equipment production. Proper planning, selection, procurement, installation, operation & maintenance of construction equipment play important role. Therefore, creating database is necessary for maintaining equipment records. It is also necessary to maintain equipments maintenance records.***

Keywords: ***Construction Equipment Maintenance, Maintenance database, Equipment Productivity , Losses due to Breakdown***

I. INTRODUCTION

Whether a construction contract is unit price, lump sum, or cost-plus; whether the construction project is to be linear (i.e., concept, design, Procurement, construction) or fast-track (i.e., design/build) the cost of construction is a major factor in all projects. The major factors that impact construction costs are materials, labor, equipment, overhead, and profit. The cost of equipment for civil engineering construction projects can range from 25 to 40% of the total project cost.

The greatest influence to construction cost occurs at the front end of the project. Assumptions made by design engineers during the conceptual and design phases of a project dictate the choice of equipment that will be used for the particular project, just as it will dictate the choice of materials used in construction. Thus, sometimes the design may, in fact, restrict the best and most cost-effective solutions from being utilized. For example, many sewer projects are designed on the basis of traditional specifications, materials, and equipment, when more advanced materials, techniques, and equipment may, in fact, be safer, more environmentally and socially acceptable, and more cost-effective. This is especially true of sewer projects in urban areas, where modern construction techniques, such as micro tunneling and pipe bursting are replacing the traditional dig and replace methods of sewer construction.

It is important for design engineers and construction engineers to be knowledgeable about construction equipment. Construction equipment and integral part of the construction process. The cost of construction is a function of the design of the construction operation The purpose of this study is to evaluate the traffic flow of construction equipment and how it affects the efficiency of construction operations. A large construction project requires large quantities of construction equipment. Thereby reduces the overall efficiency of construction operations. It is necessary to evaluate whether a project can be completed in a given time even if additional construction equipment is brought to the construction site. However, to date, limited researches have been performed to evaluate these effects in planning for equipment utilization. The high failure rate and extreme competitiveness of the construction business demands that contractors continuously look for new ways to reduce costs. Many companies seek to gain competitive advantages by reducing labor and raw material costs or by increasing service and controlling losses. One way that companies in the industrial sector have found effective in increasing profit margins is by effective equipment maintenance.

Most construction companies tend to concentrate maintenance efforts on unscheduled breakdowns or emergency repairs. These tend to be the most costly in production losses, maintenance department overtime and in expediting parts for repairs. Typically, a construction company's largest assets are in the equipment it owns. By anticipating and preventing these unplanned events a company can protect its equipment assets from production downtime, unscheduled loss or expensive failures, while improving safety factors.

II. LITERATURE REVIEW

Athanase I. Tsimberdonis and E. LileMurphree Jr. Equipment Management Through Operational Failure Costs. ASCE

States operational failure costs, Presents a method for their development, and examines their usefulness as a means of equipment management. It considers variables related to the projected use of the equipment in the context of the production team and construction site as a whole as well as importance of each piece of equipment. In addition, it takes in to account, the point of view of the company in light of management objectives and the number of projects in undertakes concurrently. Furthermore, this paper examines the magnitude and importance of costs caused by equipment failure; demonstrates the importance of equipment assignment; examines the relative equipment importance within a project; avoid the concept of unit cost that is considered a weakness in linear programming approaches; examines the use of operational failure costs as a decision –support tool for equipment purchase, retirement, replacement, rent, and lease; and evaluates detailed operations plans as well as contingency plans. Finally, it presents an application of the method in a typical earthmoving project using SLAM II as a Simulation Software.

C. William Ibbs, Jr. and Kenneth R. Terveer. Integrated Construction Preventive Maintenance System. ASCE

States about maintenance of heavy construction equipment is a vital function for many construction contractors. A regular, structured preventive maintenance program can be a worthwhile investment for several reasons: Reduced field breakdowns; more efficient equipment and operator utilization; elimination of unnecessary parts damage and reductions in inventory requirements; preservation of warranties; more productive mechanics; and longer-lasting repairs.

Ilias Naskoudakis. A thematic review of main researches on construction equipment over the recent years. Science Direct 2016

Stated that a considerable body of literature has been dedicated to research studies on construction equipment. Many topics were discussed and analysed, and various conclusions have been reported. However, research papers published regarding construction equipment, are highly diversified, and there is a lack of systematic analysis and classification. Hence, a complete understanding of the topic is not possible, nor is the assessment of any future research direction. A meta-analysis of the latest journal papers dedicated to construction machinery would not only delineate the fields the academic research was concentrated on but would additionally reveal potential gaps for future research. In the current study, through a systematic review of the academic literature published over the last decade, primarily identified via online databases, main research themes such as optimisation, maintenance/downtime, productivity, robotics and automation, operator competence, innovation, and environment are determined and discussed, with future research directions suggested. The outcome of this paper will facilitate future researchers to develop a body of knowledge of progress on construction equipment and its potential functions and provide future research directions on this issue. Furthermore, some pointers will be provided regarding the optimum selection of fleet equipment as a key factor for the success of any construction project. These will be given as part of the necessary holistic and strategic approach required to deliver a construction project successfully.

M. Waris.Criteria for the selection of sustainable onsite construction equipment. Science direct. 2014

Hinted that Today's construction projects are highly mechanized and becoming more so every day. With the growing industrialization of construction work, the role of onsite equipment and machineries is vital in achieving productivity and efficiency. During the construction phase, selection of right equipment has always been a key factor in the success of any construction project. This decision is typically made by matching equipment available in a fleet with the tasks at hand. Such analysis accounts for equipment productivity, equipment capacity, and cost. However, the emerging notion of sustainability in construction has emphasized energy conservation, efficiency, green environment, economy and human well being. In this context, selecting the most appropriate equipment from the available options is highly challenging. Therefore, this paper aims to determine a selection criteria based on the fundamental concept of sustainability and provides an assessment framework. A questionnaire survey was conducted among a classified group of Malaysian contractors to elicit information pertaining to the sustainable selection of onsite machineries. The findings of this study will guide the decision makers to appraise the selection process of construction equipment on the triple bottom line of sustainability.

Major Virendra Singh Phogat. Selection of Equipment for Construction of a Hilly Road using Multi Criteria Approach. Science Direct 2013

Stated that Planning and construction of a road in hilly region is very challenging which involves complex processes such as reconnaissance and survey to fix the alignment, formation work and construction of various layers of pavement. It has always been a daunting task for implementing agencies to select proper equipments effectively during construction of a road by taking into consideration of both tangible and intangible factors so as to maximize the benefits of the limited resources. An application of five multi-criteria decision making techniques to a typical selection of equipments used for hilly road construction is presented. Three criteria representing earthwork operations, operational efficiency and convenience of manager have been considered with six sub

criteria each for selection of seven different construction equipment alternatives .Five multi-criteria decision making techniques: Analytical Hierarchy Process, Simple Additive Weights Method, Distance Based Method ,Preference Ranking Organization Method and Elimination Et Choice Translating Reality methods are examined as potential decision-aid tools to select the appropriate management scheme. Comparison of the results shows that these quite different multi-criteria decision making techniques lead to a similar subset of recommended solutions. Finally, a case study of Katra-Reasi road of 26 Km length has been carried out to evaluate correct equipments/machinery used for construction of the road hereby optimizing the output. The study clearly demonstrates that alternative dozer D80 is the best choice among the alternatives which has maximum output of 48 cum/hr.

III. THEORY OF CONSTRUCTION EQUIPMENT MAINTENANCE.

A. Planning for Construction Equipment

Equipment planning on major construction projects includes besides its selection, the decision about working shifts, number and size of machines, the matching of units working in a team, procurement schedule and the arrangement of necessary technical staff to operate, service and repair of the equipment. Planning of workshop and store facilities is also an important aspect of equipment planning.

The type of equipment selected usually depends upon soil and valley conditions and upon the characteristics of material to be handled. The number and size of machines selected depend upon the magnitude of work, working days available and number of shifts worked in a day. Size matching of all equipment's working in a group is vital. The procurement plan must be in line with the construction schedule. Also, planned with equipment procurement should be the spare parts for it and supplies of fuels, oils, lubricants etc. for its operation. Suitable service facilities are vital to realize the planned output rate of equipment's.

Availability of operation and maintenance staff in adequate quality and number for the operation of equipment is essential to obtain full production. The use of mathematical models of the operation of equipment can be used for planning and selection of construction equipment.

B. Equipment planning shall include the following Aspects

1) Selection of equipment.
2) Number and sizes of units.
3) Matching capacities.
4) Schedule of procurement.
5) Arrangement of skilled staff for operation and maintenance.
6) Establishment of service and repair facilities.
7) Maintenance of spare parts inventory.
8) Decision regarding number of shifts per operation.

C. Selection of Equipment

A contractor is frequently confronted with the problem of the selection of the most suitable equipment as he plans to construct the projects. Equipment purchase involves initial heavy investments. In the long run, equipment adds to the profitability by reducing the overall costs, provided the equipment is properly planned, technically scrutinized, economically procured and effectively managed. The rapid development in equipment technology during the past several decades has brought in to market wide range of equipment making their selection more and more difficult.

The proper selection of equipment judicious development of the same on work is one major factor, which will go a long way in helping the contractor to maintain the completion targets of his contract within the estimated cost. Selection of an equipment to perform an assigned task depends on many interrelated factors.

D. Task Consideration

Different tasks related to equipment are required to be studied in details. Therefore analysis of the tasks based on following areas require due consideration.

1) Nature of task and Specification.
2) Daily or hourly forecast of planned production.
3) Quantity of work and time allowed for completion.
4) Distribution of work and time allowed for completion.

5) Distribution of work at site.
6) Interference expected and interdependence with other operation.

E. Site Constraints

Every project has some constraints on which Equipment size ,capacity requires special consideration in as same following points,

1) Accessibility to location.
2) Working space restriction.
3) Altitude and weather condition.
4) Working season and working hours.
5) Availability of local resource of manpower, materials and equipment.
6) Availability of equipment hiring. Repair and maintenance facilities, locally.
7) Availability of fuel, oil and lubricants.

F. Equipment Suitability

In deciding selection of equipment following areas also requires consideration.

1) Type of equipment considered suitable for the task.
2) Make models and sizes of special purpose, and general- purpose equipment available that can handle the task.
3) Production capability, serviceability condition and delivery time of each equipment available.
4) Usefulness of the suitable equipment available for other and future task.

G. Operating Reliability

Before procurement or hired each equipment reliability is required to be considered. As following points requires consideration.

1) Manufacturer's reputation.
2) Equipment components, engine-transmission, brakes, steering operator's cabin.
3) Use of standard components.
4) Warranties and guarantees.
5) Vendors after sale service.
6) Operator's acceptability, adaptability and training requirements.
7) Preventive maintenance programs.
8) Safety features.
9) Availability of fuel, oil and lubricants.
10) Maintainability
11) Ease of repair and maintenance.

H. Economic Consideration

When an Investing cost in equipment's following points requires considered. Also following points should be taken in consideration while arranging the finance for Equipment.

1) Owning costs.
2) Operating Costs.
3) Re-sale or residual value after use.
4) Replacement cost of existing.
5) Unit cost of production.

I. Equipment Acquisition Options

A project has multifarious activities where plant can be employed effectively and efficiently, but this does not justify purchasing plant to perform all activities. Purchase of plant requires heavy investment of capital, and no contractor can afford the luxury of owning all types of plant and machinery required in a project. Contractors have a number of options for acquiring plant. These include the following:

1) Purchase
2) Outrigh

3) Guaranteed buy-back
4) Renting
5) Leasing and Hire-Purchase
6) Outsourcing

This is a job, which needs the exact balance between availability of spares and low inventory cost. On one hand it should provide proper assurance for availability of desired spare parts in proper time and quantity. And on other hand should not result in excessive stocking or blocking up of capital. Proper planning is very essential to get the best result.

J. Equipment Maintenance Plan-

1) *Equipment Maintenance Plan:* The Equipment Maintenance Plan as it is commonly a document in table format, that is used when developing the tasks needed to properly maintain facility, plant or process equipment. The Equipment Maintenance Plan helps lead the person or persons developing the required maintenance tasks by ensuring that the development is done consistently for all equipment. Each Equipment Maintenance Plan should include one or more maintenance tasks designed to ensure the continued operation and maintenance of an equipment item, process or system. Each of these tasks has the following characteristics:

a) A descriptive title for each maintenance task to be performed
b) A frequency assigned for performing of each task
c) Assignment of a specific craft or workgroup and the number of each craft or workgroup required to perform the task
d) Equipment condition required for performance of the task (i.e. running or shut down)
e) Type of Work – Preventive Maintenance (PM), Predictive Maintenance (PdM), Corrective Maintenance (CM), Situational Maintenance (SIT), etc.
f) Procedure number – Unique identifier for the task, or file name if linked to another document that gives the individual task instructions
g) Estimated time to perform the task
h) Special tools, materials and equipment required to perform the task

The Maintenance plan determines the quality of maintenance work. A singular aspect of maintenance activities is the difficulty of accessing the quality of work done. If maintenance work is poorly done it may lead to a breakdown because of the intervening time lag, whoever it is hard to judge whether the breakdown was due to maintenance errors or defective parts. In other words the quality of maintenance must assure the quality of the work itself. To accomplish thus, each individual member of the maintenance crew must have sense of responsibility and consider methods for preparing, executing, and validating his or her own work.

K. The benefits of Creating Maintenance Plan Can be Summarized as Follows

1) The number of operational steps can be reutilized.
2) Human resource required can be planned so that required personnel's are available.
3) Errors in the procurement of material, spare parts and subcontracting work can be prevented.
4) Quality can be checked and better material can be procured.
5) By devising related work detail plans, schedules can be set so that they are coordinated with production plans.
6) Repair cycle can be identified so that measures can be taken in a timely fashion.
7) Standardization patterns for repair work can be identified enabling the work to be done efficiently.
8) Simultaneously repair plans can be devised.
9) People's sense of responsibility can be encouraged.
10) Through planned work activities large volume of work can be more efficiently accomplished.

L. Key Elements of Equipment Maintenance Plan-

When preparing good equipment maintenance plan following key elements are very useful. They requires to consider for equipment maintenance plan.

1) Organizational Planning and Support
2) opportunities through loss histories.
3) Standards and Practices
4) Training-

M. Equipment maintenance

Maintenance costs are commonly considered the highest percentage of cost related to operating a piece of equipment. It is also referred to by Peurifoy and Schexnayder (2002) as the highest percentage of cost related to the equipment's entire life cycle. The breakdown given was 37% is related to maintenance and repair, 25% to depreciation, 23% to operating costs and 15% to overhead . As other factors will exist whether the piece is rented, leased or bought, the maintenance costs can shift hands in the process. The secondary impact condition is the level of service to the equipment directly impacts its life and therefore the hourly rate or cost calculations.

Maintenance of a piece of equipment is the operation of keeping its various components in their original form as far as possible with the view to ensure that safety and production in operation do not deteriorate. It includes servicing, inspection and adjustment, small repairs in the field, major repairs and overhaul in main workshops and proper is of laid-up machine.

IV. DATA COLLECTION AND DATA ANALYSIS

Following data was collected from site and analysed .

TABLE IL OSSES IN TIME DUE TO BREAKDOWN

SR. NO.	EQUIPMENT DESCRIPTION	PRODUCTION		HOURS WORKED		PROD/ HOUR ACTUAL	PROD/ HOUR PLANNED	BREAK DOWN HOURS	LOSS IN PRODUCTION DUE TO BREAK DOWN	REMARK
		PLANNED	ACTUAL	PLANNED	ACTUAL	IN CUM	IN CUM		IN CUM	
January										
1	Concrete Pump 1	1125	650	84	50	13.4	13	34	342	Actual Prod/hour is more as planned for achieving target of production.
2	Concrete Pump 2	1120	640	84	47	13.8	13.3	37	407	Actual Prod/hour is more as planned for achieving target of production.
3	Concrete Pump 3	1035	595	79	45	13.1	13.2	34	375	Total Actual working hour is less. So prod/hour actual & planned nearly same for achieving target of production.

February										
1	Concrete Pump 1	250	245	20	20	12.5	12.4	-	-	No breakdown less loss in production.
2	Concrete Pump 2	1000	780	77	46	13	17	31	341	Actual Prod/hour is less as planned so minimise in production.
3	Concrete Pump 3	975	580	75	44	13	13.2	31	345	Efficiency is less as per planned prod/hour.
March										
1	Concrete Pump 1	820	455	65	35	12.6	13	30	330	Efficiency is less as per planned prod/hour.
2	Concrete Pump 2	1100	700	84	48	13	14.6	36	396	Fewer breakdowns less loss in production. Less working hour effect on total production.
3	Concrete Pump 3	1000	540	76	41	13.1	13.1	35	385	Actual Prod/hour is same as planned.

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ACTIVITY	EQUIPMENT	REQUIRED LABOUR	NO	PAYMENT OF LABOUR PER MONTH	PAYMENT OF LABOUR PER DAY	PAYMENT OF LABOUR PER HOUR	IDLE DUE TO BREAKDOWN & FAILURE IN HOURS.	LOSS IN RUPEES DUE TO BREKDOWN	MAINTENANCE REQUIRED IN 3MONTH	TOTAL LOSS IN RUPEES
CONCRETING	**CONCRETE PUMP 1**	OPERATOR	1	12000/-	400/-	50	60	3000	7415	**20615**
		LABOUR	3	8000/-	270/-	34		6120		
		HELPER	2	8000/-	270/-	34		4080		
	CONCRETE PUMP 2	OPERATOR	1	12000/-	400/-	50	104	5200	156526	**179406**
		LABOUR	3	8000/-	270/-	34		10608		
		HELPER	2	8000/-	270/-	34		7072		
	CONCRETE PUMP 3	OPERATOR	1	12000/-	400/-	50	100	5000	16589	**38589**
		LABOUR	3	8000/-	270/-	34		10200		
		HELPER	2	8000/-	270/-	34		6800		

TABLE 2ECONOMIC LOSSES DUE TO BREAKDOWN

IV. CONCLUSIONS

Equipment plays an important role in today's construction projects which is more demanding need to be completed in stipulated time with best Quality. The cost of equipment in a project varies from 10-30 % of the total cost of project, depending upon extent of mechanization. Proper planning, selection, procurement, installation, operation, maintenance and equipment replacement policy plays important role in equipment management for successful completion of project.

From data collected it is seen that Equipment Utilization on site has to be Studied in details. There can be various reasons which ultimately affect the overall productivity in construction activity on the project. Mainly Due breakdown more loss in time and money is occurred. We can minimize these losses by using proper maintenance schedule per Equipment.

It is noticed that even in few major items substantially loss in Time & Cost get attributed to breakdown of Equipment's

Which needs detailed study on such important building construction Projects.

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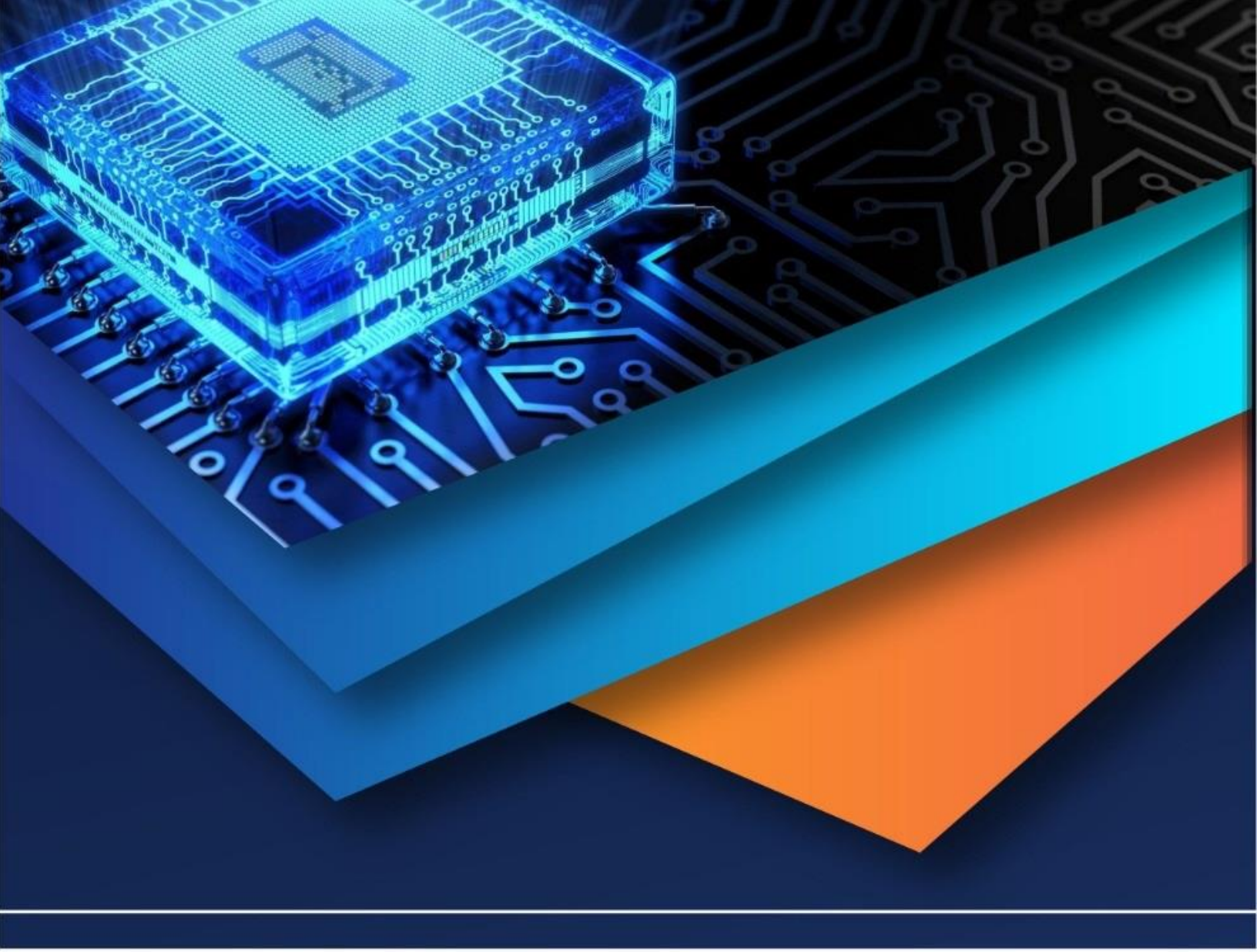

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