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Quality Control at Site; Effectiveness of Training

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Abstract: ***Quality and safety is one of the important aspects for construction projects. The level of success of construction projects depends upon the safety and quality performance. Most construction projects in India do not fully achieve the main management function, namely safety and quality. Therefore it is necessary to find out the factors responsible for poor performance of the safety and quality in construction project. An overview of previous study shows the striking similarities between safety and quality management. This study aims to investigate the factors responsible for accident at construction site. Questionnaire survey was conducted by collecting data from various groups. Data collected were analyzed using important index analysis method and critical factor were ranked based on severity, frequency of occurrence, and important index. Correlations between the different groups were analyzed using Spearman's rank correlation method. The result shows the positive correlation between the respondents from different group. Attitudes of worker's towards safe work practices, effectiveness of safety training given to new workers, control on subcontractor's safety behavior, frequency of safety inspection carried out and implementation of safety practices on site are found to be the top five critical factor responsible for accident at construction sites. Result shows the necessity of providing the safety training to the workers at construction site. Effective safety training to the worker at construction will help to reduce the accident at construction site and also will help to maintain quality at construction site.***

List Of Nomenclature

F.I.	Frequency index
(S.I.)	Severity index
(Imp. I.)	Important index
(TQM).	Total Quality Management
OSHA	Occupational Safety and Health Administration

I. INTRODUCTION

Construction industry plays an important role in the development of any country. The development of construction industry depends on the quality of construction projects. Quality is one of the critical factors in the success of construction projects. Improvement in the quality of construction projects is linked with quality management in the project life cycle. Although quality management at every stage of project life cycle is important but the quality management at the execution stage contributes significantly on final quality outcome of construction projects. Quality has become a very popular subject in recent years due to conceptual changes in the construction industry. Quality and quality systems are topics which have been receiving increasing attention worldwide. The product in any industry should be manufactured to a required standard, one that provides customer satisfaction and value for money. Quality is one of the critical success factors in construction industry. The need for achieving quality of the finished product construction industry is very important. The high cost of construction projects makes it necessary to ensure quality of the finished product. Quality is an essential element for sustainability and customer satisfaction. In construction projects, quality performance is considered as vital for client satisfaction. Quality can be defined as consistently 'meeting' or 'Exceeding' the customer expectations', or 'compliance with customer specification'. No matter what definition we follow for quality, it becomes very complex when we try to put it into actual practice. Developing a quality system is the first step towards improving quality in construction industry. Quality is one of the critical factors in the success of construction projects. Quality of construction projects, as well as project success, can be regarded as the fulfillment of expectations of the project participants. The construction industry in India has been struggling with quality issues for many years. A significant amount of the budget is spent each year on infrastructure

and other development projects. Since the quality outcomes of the projects are not according to required standards, faulty construction takes place. Consequently additional investments are required for removal of defects and maintenance work. A construction project in its life span goes through different phases. The main phases of a project can be described as conceptual planning, feasibility study, design, procurement, construction, acceptance, operation and maintenance. Quality of construction projects, as well as project success, can be regarded as the fulfillment of expectations of the project participants. The construction industry in India has been struggling with quality issues for many years. A significant amount of the budget is spent each year on infrastructure and other development projects. Since the quality outcomes of the projects are not according to required standards, faulty construction takes place. Consequently additional investments are required for removal of defects and maintenancework. During the last decades construction industry has been heavily criticized for its performance and productivity in relation to other industries. With the turn of the new millennium, it appears that the construction industry is going through an intense period of introspection, which is exacerbated by increased technological and social change. These changes are altering the tempo of the environment within which construction operates. Moreover, such changes extensively affect the way business is carried. No organization operating in the construction industry, whether large or small, private or public, can afford to ignore its changing environments if it is to survive. Many of the management practices used to support construction organizations are being challenged. The industry's clients are moving forward. Clients demand improved service quality, faster buildings and innovations InTechnology. It is no accident that the construction industry has turned to the manufacturing sector as a point of reference and source of innovation.

II. OBJECTIVE OF THE STUDY

A. To review relationship between construction safety and quality.
B. The aim of the present study was to investigate the major factors that are mostly affecting the safety and quality at construction site.
C. Analyses for identifying the factors that significantly influence safety and quality at construction site.
D. To rank factors which affect safety and quality based on their frequency index, severity index ad importance index.
E. To check accuracy of collected data using statistical method.

III.LITERATURE SURVEY

This chapter aims to build a theoretical foundation upon which the research is based, by reviewing the relevant literature to identify research issues in the area of safety &quality management systems and organizational culture in construction. It is well established that the project cost, quality, safety, and duration are the four critical elements that contribute to projectsuccess. An overview of construction quality and safety reveals many striking similarities for these two management concept. Construction has the highest accident rates of any industry and the leading cause of death is falls. To understand the subject matter, a literature survey has been conducted to review safety & quality management system, in construction industry.

A. Previous study on safety and quality management.

1) *HusrulNizam, HusinHamimah Adnan, KamaruzamanJusoff (2008), "Management of Safety for Quality Construction" [12]:* HusuralNizam, HusinHamimahAdan, KamaruzamanJusoff provide a basis framework to delineate the relationship between safety and quality management and the importance of these two areas in the real construction field in Malaysia. A proposed model which is also a framework is seen as a procurable method on defining the basic concept of safety management meant to achieve the expected quality level. In the aspect of proposing safety application model, a directive method of the Total Quality Management is used. A basic management application model as suggested by Walker (1993) is proposed to be used as a generic model to highlight the key features. Findings from individual survey are used to delineate the key points or processes of the safety application model.

   Based on the findings of the study, the provided information indicates that unsatisfactory safety culture and lack of responsibility towards safety in general are what happened in the real construction field in Malaysia. There was inadequate imagination and ideas in propagating safety at work. Lack of management control leads to a lowering of performance standards; these standards may be training, communication, program, etc. According to management theory, management's functions are to plan, organize, command, coordinate and control, and all managers are expected to fulfill these functions.

2) *T. Subramani, R. Lordsonmillar (2014), "Safety Management Analysis In Construction Industry" [27]:* The Indian society and economy have suffered human and financial losses as a result of the poor safety record in the construction industry. The

purpose of this study is to examine safety management in the construction industry. The study will collects data from general contractors, who are involved in major types of construction. Collected data include information regarding organizational safety policy, safety training, safety meetings, safety equipment, safety inspections, safety incentives and penalties, workers' attitude towards safety, labor turnover rates and compliance with safety legislation. The study will also reveal several factors of poor safety management. Thus the paper will conclude by providing a set of recommendations and strategies to contractors for improving their safety performance.It can be inferred from the survey data that safety managers have the opportunity to influence and enhance the sense of safety and the quality of the work environment. Owners of large projects can more actively participate in construction safety management in each stage of project execution including project design contract selection, contract development, the construction phase, selecting safe contractors, and developing the safety culture on the projects through safety training and safely recognition programs.

3) *John Wanberg, Christofer Harper, Matthew R. Hallowell, SathyanarayananRajendran (2013), "Relationship between Construction Safety and Quality Performance" [16]*John Wanberg, Christofer Harper, Matthew R. Hallowell, SathyanarayananRajendran, studied relationship between safety and quality performance in construction projects. Past literature has established theoretical relationships between construction safety and quality on the basis of opinions of industry experts. This is the first empirical inquiry into the relationship between safety and quality, testing the null hypothesis that there is no statistical relationship among .quality performance indicators and safety performance indicators. To test this hypothesis, empirical data were collected from 32 building construction projects. Several quality metrics] were used as predictor variables and first aid and Occupational Safety and Health Administration (OSHA) recordable injury rates were used as response variables. Linear regressions among the predictor and response variables showed that there are two statistically significant relationships: the OSHA recordable injury rate is positively correlated to rework and the first aid rate is positively correlated to number of defects. To understand why these relationships exist and to identify specific strategies that promote both safety and quality, open-ended interviews were conducted with project managers.

Findings from the study indicated that the most compelling reason for the strong positive correlation between rework and injuries is the fact that rework involves demolition, schedule pressure, and unstable work processes. They also noted that devoting resources to preplanning, allowing the necessary time to complete tasks correctly the first time, encouraging leadership at the workface, and encouraging workers to take pride in their work are all strategies that promote both safety and quality.

IV. METHODOLOGY OF WORK

The present study was conducted to establish to measure real time safety management performance on construction sites and is designed to address the problem identified and objectives outlined in previous section. It was considered essential to obtain a full understanding of the study by setting out the various elements in a logical sequence, so as to avoid misunderstanding at any point in the research. The research was conducted using a questionnaire survey and experimental method. The study conducted through the following sequential steps.

A thorough literature review was done and also the expert opinions from industry experts were taken through which a number of factors responsible for construction accidents were identified in the local construction industry scenario.

Numbers of factors were finalized to made part of the survey questionnaire. Questionnaire was developed to obtain information about safety management analysisin construction projects.

These questionnaires were distributed and it was asked to rate those initially identified factors according to their frequency and severity.

Data receive from the survey was analyzed to find out the frequency, severity and important index of the significant factors which are responsible for accident at construction site.

Factors responsible for accident at construction site because were raked according to their importance index.

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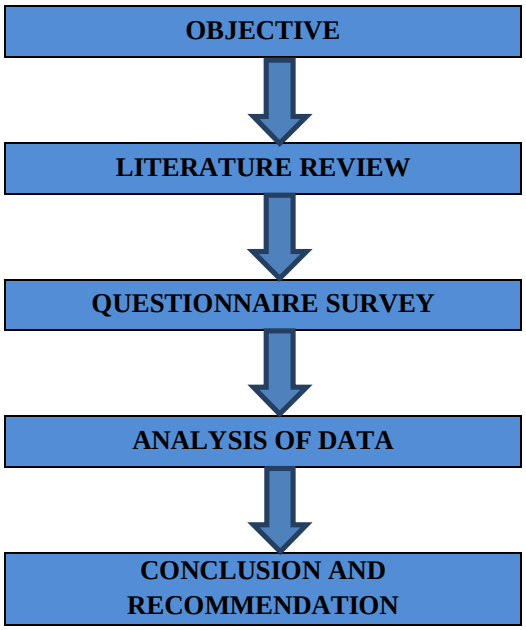

Figure No. 4.1 Flowchart for methodology of work

Table 4.1 Factors responsible for accident at construction site

Sr No	Factors responsible for accident at construction site
1	Placement of safety posters symbols
2	Worker management relationship
3	Control on subcontractor's safety behavior
4	Safety policy of company
5	Adequacy of in-house safety rules and regulation
6	Understanding of safety rules and regulation
7	Implementation of safety practices on site
8	Familiarity with type and method of construction by safety in charge
9	Effectiveness of safety training given to new workers
10	Attitudes of supervisor's towards safe work practices
11	Attitudes of worker's towards safe work practices
12	Workers safety performance
13	Complexity of construction
14	Application of new technology in the project
15	Usage of heavy equipment
16	Provision of personal protective equipment by the company
17	Usage of personal protective equipment by workers

18	Usage of personal protective equipment in preventing accidents
19	Proper handling of tools by workers
20	Identification of unsafe practices on site
21	Identification and control of hazardous activities
22	Accident due to failure of shoring/scaffolding/formwork
23	Accident due to improper usage of ladders
24	Accident due to failure of equipment and plants
25	Frequency of safety inspection carried out
26	Co-ordination, control and management of subcontractors
27	Workers language and communication barrier
28	Workers adaption towards working environment
29	Degree and level of punishment in terms of fines
30	Degree and level of punishment in terms of suspensions from work
31	Introduction of incentives for safe workers
32	Overtime work for labor
33	Lack of innovation technology

A five point scale of 1 to 5 is adopted for evaluating the effect of each factor. These numerical values are assigned to respondent rating, 1= very low, 2 = low, 3 = medium, 4 = high, 5= very high for severity and 1 = Never, 2 = Rarely, 3 = Occasionally, 4 = Almost every time, 5 = Every time for frequency was considered

V. RESULT ANDDISCUSSION

A. Analysis based on ranking indices

Data collected from questionnaire survey were analyzes using importance index technique to investigate factors responsible for accidents at construction sites. Critical factor were identified based on severity index, frequency index and importance index. Rank is assigned to the factor as per frequency of occurrence, severity and importance index of causes.Table 5.1 shows the rank assigned to factors responsible for accident at construction site based on frequency index, severity index and importance index.

Table 5.1 Ranking of factor responsible for accident on construction site based on FI,SI& Imp I

Sr No	Factors responsible for accident at construction site	FI	Rank	SI	Rank	Imp. Index	Rank
1	Placement of safety posters symbols	0.49	23	0.49	23	0.24	23
2	Worker management relationship	0.46	32	0.50	20	0.23	28
3	Control on subcontractor's safety behavior	0.62	9	0.72	2	0.44	5
4	Safety policy of company	0.62	6	0.68	6	0.42	6
5	Adequacy of in-house safety rules and regulation	0.62	7	0.65	7	0.40	7
6	Understanding of safety rules and regulation	0.72	2	0.71	5	0.51	2
7	Implementation of safety	0.68	3	0.71	4	0.48	3

	practices on site						
8	Familiarity with type and method of construction by safety in charge	0.50	21	0.49	24	0.24	20
9	Attitudes of worker's towards safe work practices	0.82	1	0.80	1	0.65	1
10	Workers safety performance	0.58	12	0.60	10	0.35	10
11	Complexity of construction	0.47	27	0.48	28	0.23	29
12	Application of new technology in the project	0.45	33	0.47	32	0.21	33
13	Usage of heavy equipment	0.50	20	0.48	27	0.24	21
14	Provision of personal protective equipment by the company	0.48	25	0.50	19	0.24	22
15	Usage of personal protective equipment by workers	0.56	14	0.57	12	0.32	14
16	Usage of personal protective equipment in preventing accidents	0.52	17	0.51	18	0.26	18
17	Proper handling of tools by workers	0.58	13	0.57	11	0.33	11
18	Identification of unsafe practices on site	0.62	8	0.60	8	0.37	8
19	Identification and control of hazardous activities	0.53	16	0.54	14	0.28	15
20	Accident due to failure of shoring/scaffolding/formwork	0.54	15	0.52	17	0.28	16
21	Accident due to improper usage of ladders	0.48	26	0.49	26	0.23	26
22	Accident due to failure of equipment and plants	0.50	19	0.49	22	0.25	19
23	Frequency of safety inspection carried out	0.61	10	0.60	9	0.36	9
24	Co-ordination, control and management of subcontractors	0.48	24	0.49	25	0.24	24
25	Workers language and communication barrier	0.46	31	0.47	30	0.22	31
26	Workers adaption towards working environment	0.47	29	0.47	31	0.22	30

27	Degree and level of punishment in terms of fines	0.47	28	0.50	21	0.23	27
28	Degree and level of punishment in terms of suspensions from work	0.49	22	0.48	29	0.23	25
29	Introduction of incentives for safe workers	0.58	11	0.56	13	0.33	12
30	Overtime work for labor	0.62	5	0.53	16	0.33	13
31	Lack of innovation technology	0.47	30	0.47	33	0.22	32

Table 5.2 Ten most Factors responsible for accident at construction site based on FI
Table 5.3 Ten most Factors responsible for accident at construction site based on SI

Sr No	Factors responsible for accident at construction site based on FI	FI	Rank
1	Attitudes of worker's towards safe work practices	0.82	1
2	Understanding of safety rules and regulation	0.72	2
3	Implementation of safety practices on site	0.68	3
4	Effectiveness of safety training given to new workers	0.65	4
5	Overtime work for labor	0.62	5
6	Safety policy of company	0.62	6
7	Adequacy of in-house safety rules and regulation	0.62	7
8	Identification of unsafe practices on site	0.62	8
9	Control on subcontractor's safety behavior	0.62	9
10	Frequency of safety inspection carried out	0.61	10

Sr No	Factors responsible for accident at construction site based on SI	SI	Rank
1	Attitudes of worker's towards safe work practices	0.80	1
2	Control on subcontractor's safety behavior	0.72	2
3	Effectiveness of safety training given to new workers	0.71	3
4	Implementation of safety practices on site	0.71	4
5	Understanding of safety rules and regulation	0.71	5
6	Safety policy of company	0.68	6
7	Adequacy of in-house safety rules and regulation	0.65	7
8	Identification of unsafe practices on site	0.60	8
9	Frequency of safety inspection carried out	0.60	9
10	Workers safety performance	0.60	10

Table 5.4 Ten most Factors responsible for accident at construction site based on Imp. I

Sr No	Factors responsible for accident at construction site based on SI	Imp. I	Rank
1	Attitudes of worker's towards safe work practices	0.65	1
2	Understanding of safety rules and regulation	0.51	2
3	Implementation of safety practices on site	0.48	3
4	Effectiveness of safety training given to new workers	0.46	4
5	Control on subcontractor's safety behavior	0.44	5
6	Safety policy of company	0.42	6
7	Adequacy of in-house safety rules and regulation	0.40	7
8	Identification of unsafe practices on site	0.37	8
9	Frequency of safety inspection	0.36	9

	carried out		
10	Workers safety performance	0.35	10

B. Correlation analysis

It is essential to check collected data using statistical method. In this research, ranking criteria by respondents from various groups are checked by using Spearman's rank correlation coefficient. To carry out Spearman's correlation coefficient analysis rank assigned to factors responsible for accidents on construction site based on the importance index is analyzed.

Table 5.5 Spearman's correlation coefficient

Sr No	A	B	C	d1	d2	d3	d1^2	d^2	d^3
1	16	19	32	-3	-13	-16	9	169	256
2	18	23	33	-5	-10	-15	25	100	225
3	2	5	8	-3	-3	-6	9	9	36
4	5	6	5	-1	1	0	1	1	0
5	7	7	7	0	0	0	0	0	0
6	5	2	2	3	0	3	9	0	9
7	3	4	3	-1	1	0	1	1	0
8	18	22	29	-4	-7	-11	16	49	121
9	4	3	4	1	-1	0	1	1	0
10	14	16	27	-2	-11	-13	4	121	169
11	1	1	1	0	0	0	0	0	0
12	8	10	12	-2	-2	-4	4	4	16
13	28	29	25	-1	4	3	1	16	9
14	32	32	31	0	1	1	0	1	1
15	21	20	30	1	-10	-9	1	100	81
16	18	21	26	-3	-5	-8	9	25	64
17	8	13	15	-5	-2	-7	25	4	49
18	16	17	16	-1	1	0	1	1	0
19	8	11	14	-3	-3	-6	9	9	36
20	8	9	10	-1	-1	-2	1	1	4
21	21	18	11	3	7	10	9	49	100
22	15	15	16	0	-1	-1	0	1	1
23	24	26	16	-2	10	8	4	100	64
24	21	25	16	-4	9	5	16	81	25

25	12	8	13	4	-5	-1	16	25	1
26	26	24	23	2	1	3	4	1	9
27	31	31	24	0	7	7	0	49	49
28	29	33	28	-4	5	1	16	25	1
29	26	28	22	-2	6	4	4	36	16
30	29	27	16	2	11	13	4	121	169
31	13	12	6	1	6	7	1	36	49
32	24	14	9	10	5	15	100	25	225
33	33	30	16	3	14	17	9	196	289
Total							309	1357	2074

C. Correlation analysis between top and middle management

Correlation between top and middle management based on Spearman's rank correlation is worked out as follows.

$$\rho = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

$$\rho = 1 - \frac{6 \times 309}{33(33^2 - 1)}$$

$$\rho = 0.95$$

Spearman's rank correlation coefficient between top and middle management is 0.95 which shows strong positive correlation between these two groups.

D. Correlation analysis between middle and lower management

Correlation between middle and lower management based on Spearman's rank correlation is worked out as follows.

$$\rho = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

$$\rho = 1 - \frac{6 \times 1357}{33(33^2 - 1)}$$

$$\rho = 0.77$$

Spearman's rank correlation coefficient between middle and lower management is 0.77 which shows strong positive correlation between these two groups.

E. Correlation analysis between top and lower management

Correlation between top and lower management based on Spearman's rank correlation is worked out as follows.

$$\rho = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

.

$$\rho = 1 - \frac{6 \times 2074}{33(33^2 - 1)}$$

$$\rho = 0.65$$

Spearman's rank correlation coefficient between top and lower management is 0.65 which shows strong positive correlation between these two groups.

V. CONCLUSION

Quality and safety are found to the most critical factors responsible for the success of the construction project.
An overview of construction quality and safety reveals many striking similarities for these two management concept. Programs that have been developed to improve quality and safety performance have many elements in common.
Attitudes of worker's towards safe work practices, effectiveness of safety training given to new workers,control on subcontractor's safety behavior, frequency of safety inspection carried out and implementation of safety practices on site are found to be the top five critical factor responsible for accident at construction sites.
Spearman's correlation shows the positive correlation between respondent from different groups.
It can be inferred from the survey data that safety managers have the opportunity to influence and enhance the sense of safety and the quality of the work environment.
Owners of large projects can more actively participate in construction safety management in each stage of project execution including project design contract selection, contract development, the construction phase, selecting safe contractors, and developing the safety culture on the projects through safety training and safely recognition programs.
Effective safety training to the worker at construction will help to reduce the accident at construction site and also will help to maintain quality at construction site.

A. Limitation of the study

1) The study reported should be considered with some limitations in mind. The study focused on construction projects from a holistic point of view.
2) The findings might vary from one construction project type to the other. However, the basic principles certainly encompass all forms of construction.
3) The study has been done on small scale and may not represent the entire universe.
4) The number of samples collected were limited.
5) The respondent's interest varies in answering the questionnaire, as it may be an interruption to their regular work.

B. Recommendation

1) Employers and contractors should provide suitable programs that are consistent with national Laws and Regulations to ensure the health and safety of workers. This includes maintaining a workplace that has minimal risks and accidents that can result in injury or death. They should also ensure that a competent person inspects the construction project site at suitable intervals to ensure safety guidelines are adhered to.
2) Employers must make an assessment of the health and safety risks to which employees and others are exposed on construction sites. The significant findings must be recorded where five of more people are employed. Since managing health and safety is different from managing any other aspect in construction there need to do a risk assessment to find out about the risks, and to put sensible measures in place to control them, and make sure they stay controlled.
3) Contractors must keep accident registers at sites, and make record of all kind of accidents from minor bruises to major and fatal accidents, and submit reports to Directorate of Occupational Health and safety services. All employees must be given health and safety induction training when they start work, which should cover basics such as first aid and fire safety. Training must also be provided if risks change, and refresher training when skills are not frequently used.

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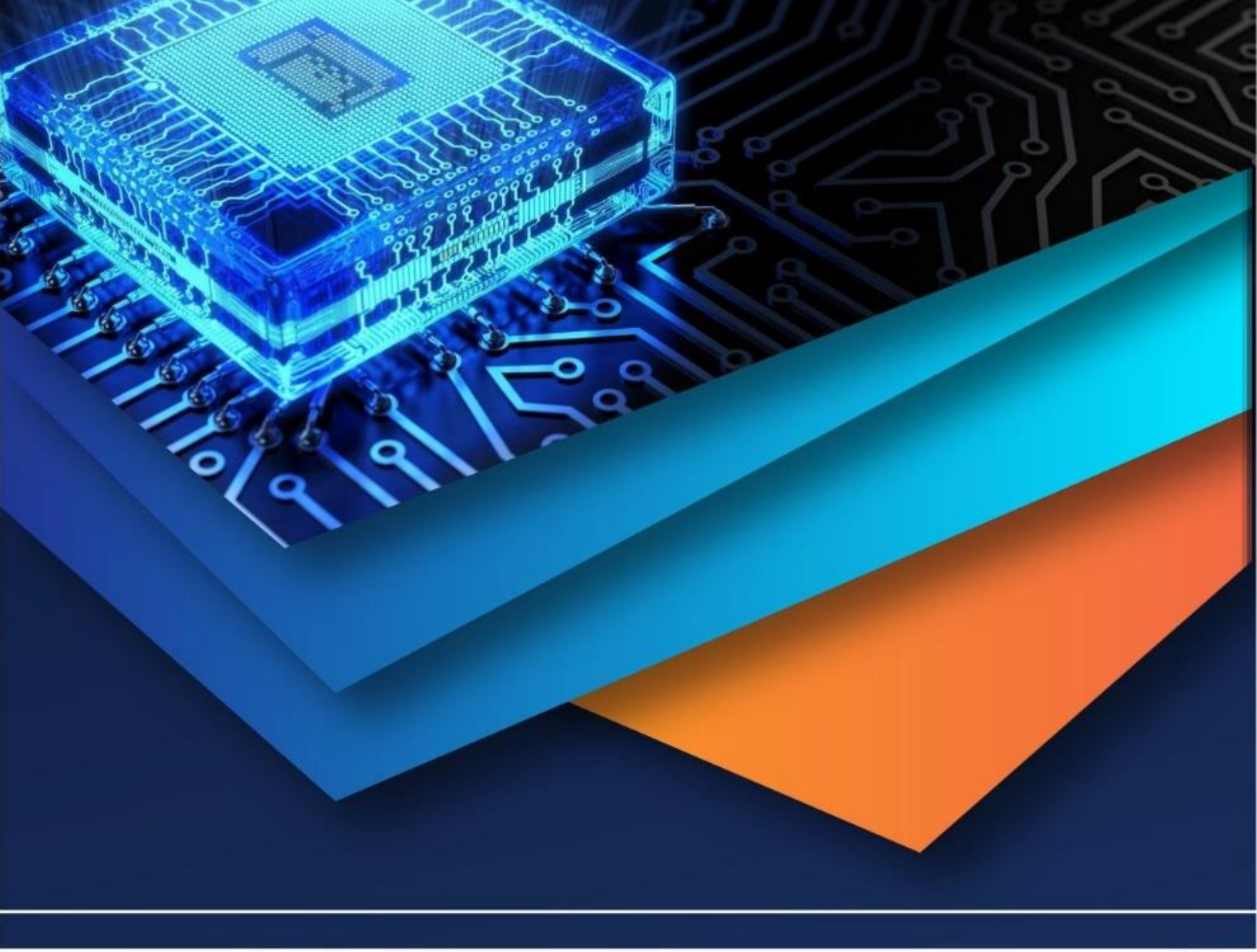

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