iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IV **Month of publication:** April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69705

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

The Role of Personal Protective Equipment (PPE) in Reducing Injuries Among Construction Workers

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Abstract: ***The purpose of this study is to examine the effectiveness of Personal Protective Equipment (PPE) in preventing construction workers from getting injured. In construction projects, the principles of the working environment are expected to be safe, but unfortunately, the environment is notorious for accidents happening periodically. They are unconscious, conscious, interpersonal, and situational occupational hazards, and the variety and application of PPE, as well as factors that influence the use of PPE, are also highlighted. Drawing on statistical data derived from the number of accidents reported to the insurance companies and workers' perception of workplace safety through surveys, it investigates the effects of PPE conformity on accident rate and the employer's and workers' roles, respectively.***
Therefore, from the above analysis, it can be concluded that the higher the PPE usage, the less likely an employee is to suffer an injury. Some of the challenges named include discomfort, lack of training, and weak enforcement as possible inhibitors. The final discussion provides recommendations for our next steps in enhancing the practice of PPE use, supporting the implementation of related policies, and contributing to existing data regarding the effects of smart PPE and longer-term safety results.
Keywords: Personal Protective Equipment (PPE), Construction Safety, Occupational Hazards, Injury Prevention, Worker Compliance, Safety Training, Risk Management, Workplace Accidents, Employer Responsibility, Smart PPE

I. INTRODUCTION

The construction industry remains one of the most dangerous business segments in the world because of the risks inherent in the kind of work that is expected to be done. Construction site workers experience several risks such as falling objects, slips and falls, contact with hazardous substances, and operating big machines. These risks account for several fatalities and accidents in construction sites every year, thereby making worker safety an issue of great concern to employers, the government, and other stakeholders.

Despite the implemented safety rules and measures, construction sites are among those that experience extensive numbers of risky incidents most of the time. This is a perpetual concern, showing that there is a lack of compliance with safety regulations, such as the wearing of Personal Protective Equipment (PPE) [1]. Personal protective equipment is taken to have a basic role of safeguarding the workers against workplace incidentsof injuries, but still, many workplaces lack consistency in its use.

Therefore, to meet this research objective, this paper will focus on exploring the fulfillment of PPE in minimizing construction worker injuries.

The research aims to evaluate the protection offered to workers through the use of PPE and establish the extent to which workers observe the use of PPE and the issues likely to hinder or encourage the use of PPE. Hence, the outcomes of this study are vital to several stakeholders, including construction employees, employers, site safety officers, and policymakers. Analyzing the effects serves as a helpful means of creating better and safer working conditions as a result of implementing PPE [2]. In this paper, various sections have been adopted to achieve the research objectives of the study.

Against this backdrop, the literature review shall give a detailed discussion of the research that has been conducted in the area of PPE and safety in construction. This is then succeeded by the conclusion, which explains the observation made concerning the specific objectives of the study. The last two are respective recommendations and conclusions that give an overall perspective of all the insights drawn.

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II. LITERATURE REVIEW

1) *Overview of Occupational Hazards in Construction*

Fig. 1 Occupational Hazards in Construction

Construction is among those industries that offer numerous risks that may put the health and safety of the workers at risk. Most employees working in the construction field are vulnerable to work-related accidents and injuries that emanate from exposure to hazardous substances, fatiguing work schedules, complex machinery, and other related factors that are associated with construction activities. In construction work, one of the biggest risks is safety hazards, or slips, trips, and falls that occur from an unbalanced deck or floor, unfastened or unstable scaffolding, and lack of protection against falls [3]. Accidents resulting from falls from height are still ranking second when it comes to the rate of construction site fatalities globally. In addition to this, equipment failure and improper arrangement of the site also contribute to the high possibility of an accident occurrence.

According to Figure 1, Physical hazards such as excessive noise from machinery, extreme temperatures, and radiation exposure also pose serious threats. Effects of ill health that arise from working with construction tools are: Hearing impairment is one of the consequences of working with loud construction tools and equipment [4].

Chemical dust risks are some of the risks that people undergo after being them to materials such as asbestos, cleaning compounds, paints, and pesticides, among others. The materials, such as lead and asbestos, used in some parts also pose some risks to human health in terms of causing respiratory diseases, skin diseases, cancer, and organ diseases.

As for occupational hazards, the construction workers are most exposed to ergonomic hazards; this is because the construction workers are involved in many movements that may cause lifting of objects and weakened effects for many hours [5]. Such activities may cause MSDs and chronic debilitation, pain, and reduced performance in the long run.

Working conditions that are inherent in construction sites are also marred by biological hazards. Some of them consist of molds, insects, or pests, communicable diseases from either dirty environments or places with the least washing facilities.

2) *Types of Personal Protective Equipment*

The construction site is one of the most dangerous places to work due to the many risks which are associated with the site, and this is why Personal Protective Equipment (PPE) is very important. Wearing PPE depends on the activity that is being executed and the hazards of the activity in question. A Safety helmet is a companion to any ordinary worker because it reduces the risk of head injuries due to falling objects or any accidental impacts [6]. These are regularly used in all construction activities, especially where ceiling activities are being conducted. It is worth mentioning that protective gloves are designed to shield hands from harm originating from sharp-edged instruments, abrasive substances, chemicals, or heat. The purpose of the glove is to affect the type of protection, ranging from electrical insulation gloves for electric lines usage or cut-resistant gloves for usage with sharp implements. Wearing glasses or face shields is mandatory when there are flying particles or objects, chemical splashes, or sparks.

Safety shoes that have reinforced toes and include toe caps also guard the workers' feet against heavy falling objects and sharp objects on the ground. The use of high-visibility vests is important since it is used to ensure that workers are easily seen, especially at night or in areas of high human traffic [7]. Personal protective equipment, including masks or respirators, is necessary when working with dust, fumes, and other harmful materials. The selection of PPE must therefore correspond to each task to enhance the efficiency of using protection gear in discouraging the occurrence of any accident.

3) The Hierarchy of Controls Theory in Construction Safety

The Hierarchy of Controls, as a theory on managing precautionary issues in the line of work, refers to a conventional guideline in occupational health and safety of particular relevance in construction. The hierarchy of control presented by the National Institute for Occupational Safety and Health (NIOSH) places the methods of hazard control in an order of effectiveness: elimination, substitution, engineering controls, administrative controls, and personalprotective equipment (PPE) [8]. In construction, elimination, and substitution of hazards are usually not advisable because of the inherent nature of tasks that are being undertaken. Hence, PPE is an ultimate preventive measure that people use when other precautionarymethods cannot eliminate risks. Even though PPE does not entirely prevent the risks in the workplace, it greatly helps in minimizing the extent of contact with hazards and enables one to have a minor or no injury at all in case of an accident [9]. Thus, the theory negates that involving the usage of PPE is adequate in safety management since it fails to cover other significant areas. However, it should be conducted as part of other plans such as training, supervision, and risk assessments. Applying the hierarchy of control ensures that construction managers prioritize the different measures he or she would take to prevent accidents, as PPE is often a key control measure in protecting the welfare of workers at construction sites in cases where the above measures can hardly be implemented.

III. BARRIERS TO EFFECTIVE PPE USE

Since there is evidence of success with the usage ofPPE in reducing work-related accidents within the construction industry, various challenges have been observed in the uptake of the full potential of the equipment. Among the issues that were identified as paramount is non-compliance by the workers, especially due to discomfort posed by Personal Protective Equipment (PPE). For instance, safety helmets, gloves, or masks are likely to be seen as burdensome, uncomfortable, or heavy, and many workers adjust them or even eliminate them when performing a physically strenuous task [10]. Insufficient training is another factor that contributes to the failure to use Personal Protective Equipment appropriately or even use it at all. The reasons include the remaining employees' lack of knowledge on how to properly don and care for their PPE, or their inability to comprehend the danger of working without it. Numeracy blindness crops up next, and this element also alters the perceived importance of using condoms consistently. Other system factors include cultural and managerial factors that have an impact on the system. In certain workplace environments, safety measures are not respected, and the utilization of PPE could be considered an inconvenience [11]. Also, when supervising staff and managers do not practice adequate use of PPE or vigorously enforce the usage policies, employees are likely to disregard them. These are issues of education, comfort assurance on PPEs, and encouragement of a culture that embraces safety championed by the management.

IV. RESULTS AND DISCUSSION

1) Relationship Between PPE Usage and Injury Rates

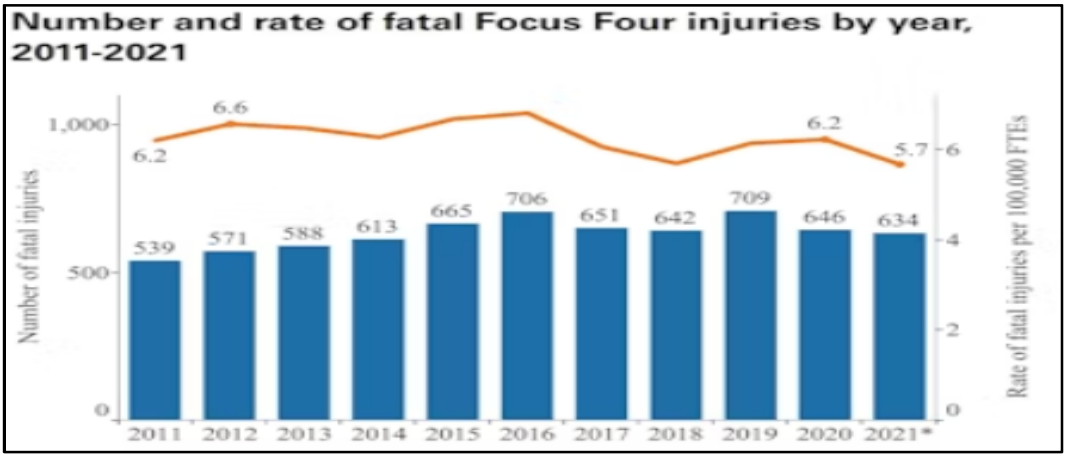

Fig. 2 Number and rates of fatal focus four injuries by the year 2011-2021

Based on the trends of working injury records in the prior decade, it is evident that there is a strong relationship that exists between the constant use of Personal Protective Equipment (PPE) and the decline of working injuries in the construction sector for construction workers. According to Figure 2, fatality statistics from the years 2011 to 2021, it has been seen that fatal accident trends are not always rising or falling in a particular order and these four major fatal hazards identified by the Occupational Safety and Health Administration or OSHA commonly known as the Fatal Four are the following Fall, getting struck by an object, getting electricity and getting caught between [12]. The construction industry experienced 539 lost lives in 2011, more of which rose to 571 in 2012 and 706 in 2016. While it will havereduced to 634 by 2021, the fatal injury rate per 100,000 full-time equivalent workers (FTEs) workers still recorded at 5.7 %. These statistics show that although safety has been improving, the number of deaths that occur at the workplace remains high, implying the possible failure in following measures and the use of protective gear. These cases show that OHS risks ensue from non-use, improper usage, or improper enforcement of the PPE guidelines, which emanate from a lack of proper training, inadequate management enforcement, or non-compliance [13]. On the other hand, construction sites that rigorously enforce PPE rules and have more compliant situations have lower injury likelihood. This relationship confirms that while PPE is often used as an intervention measure, its application should be preventive to minimize workstation injuries and fatalities.

2) Workers' Perceptions and Attitudes Toward PPE

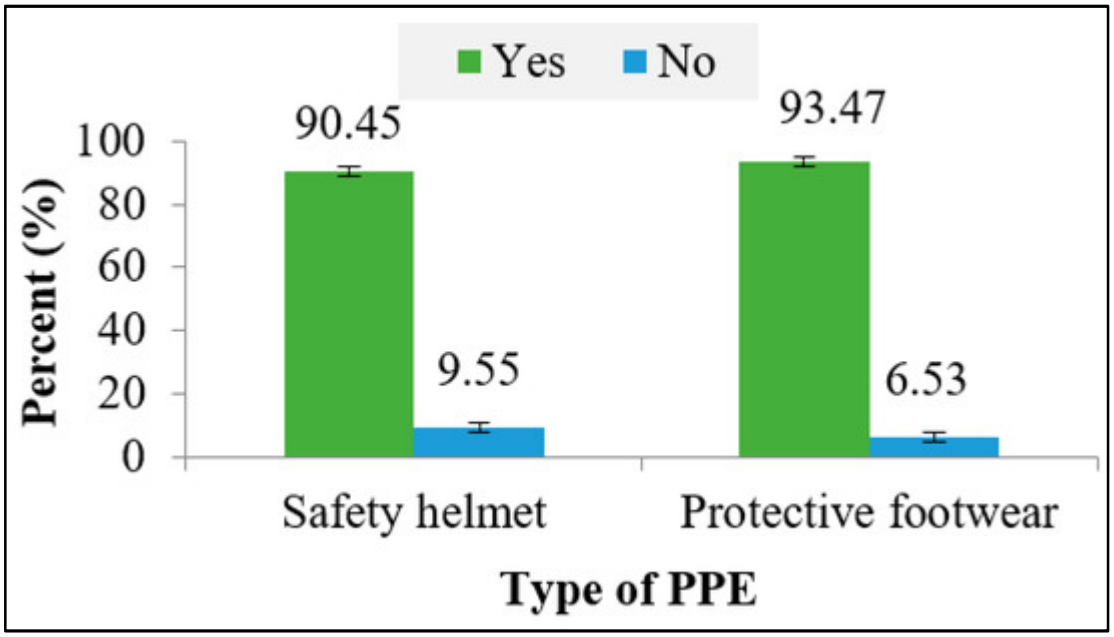

Fig. 3 Type of PPE

Concerning the use of PPE, several workers' perceptions and attitudes have a significant impact on the construction site. According to Figure 3, the survey of 2000 construction workers was done to get valuable information on how Construction workers understand and deal with PPE. From the foregoing findings, it can be concluded that there is an acceptable level of compliance with some forms of PPE. For instance, 90.45% of the respondents observed that they wore safety helmets every working day, and 93.47% wore protective shoes every working day. From these statistics, it can be deduced that most of the workers understand the necessity of such measures to minimize head injuries and foot-related accidents that prevail in construction sites [14]. At the same time, the survey notes certain difficulties and obstacles to the use of PPE. Nevertheless, 9.55% of the workers specifically do not opt for helmets, while 6.53% are not consistent with protective footwear. This means that a small proportion of workers either fail to perceive the risks or consider PPE as uncomfortable, which is usually associated with the absence of a proper safety climate or education. Other reasons that contributed to suboptimal PPE use reported by workers stated that some pieces of PPE equipment were bulky or constricting, especially those that workers were required to wear in construction jobs that entailed manual labor, leading to the workers not adequately using the PPE [15]. Therefore, awareness and acceptance concerning the use of PPE are well established, but it is worth noting that several attitude factors, such as comfort, practicality related to work, and its importance of issues, affect the willingness of the worker to wear PPE without compromising its use in countering threats to health safety.

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3) Employer Responsibilities and Enforcement Mechanisms

Fig. 4 Employer Responsibilities

Construction Industry employees have every legal and moral right to expect their employers to provide for their welfare. This can be achieved through proper evaluation of the site and its setting through site inspections and ensuring employees are trained in safe practices and adherence to company policies [16]. They also ensure that in case of any observed risks, the requirements on the need to use different forms of Personal Protective Equipment (PPE) are considered and taken. Training is crucial in a way that it addresses on correct usage and handling of PPEs as well as their importance and care. These not only serve the purpose of creating awareness but also ensure that stakeholders work in compliance environments that embrace safety. Employers have the general responsibility of ensuring that people within their companies use PPE, supplying the correct PPE that complies with the recommended standard, and ensuring discipline is taken against those who violate the PPE policies. According to Figure 4, beyond physical safety, employers are obligated to uphold non-discrimination and fair treatment, offer compensation for injuries, comply with child labour regulations, and provide employee advantages [17]. The thing is, all these responsibilities indicate the company's overall concern for workers. When these duties are met and coupled with the right bias for enforcement, employers avoid work-related injuries, improve productivity, employee morale, and follow legal requirements as expected in the construction industry.

V. COMPARATIVE ANALYSIS

A comparative study of construction sites and areas that have low or high usage of PPEs shows that areas with higher usage of PPEs have lower rates of incidence. High PPE adherence employment venues that score 90% plus for personal protective equipment (hard hats, shoes, gloves, spectacles) show an overall lower average for injury frequency of 2.3 per 100 full-time employees per year. Such work environments include practicing safety training and conducting safety regularly, and these ultimately enhance a strong safety culture[18]. Those areas or worksites with lower PPE use performing below 70% have a noticeably higher incidence rate of injury, with rates rising above 6.7 per 100 full-time employees. These environments often do not have established health and safety programs, have inadequate supervision, and do not strongly enforce rules and regulations (Aryana et al. 2024). Hence, the workers in these areas are at a higher risk of getting involved in falls, electrical hazards, and other accidents with falling substances. Additionally, there was a flow that showed a direct relation between management commitment and proper use of PPE. The organizations with more manager engagement and explicit safety management commitment demonstrated not only increased PPE utilization but also improved worker contentment and decreased rates of absenteeism [19]. Such comparative conclusions go along with the overall argument that raising awareness of PPE requirements among construction workers through training, enforcement, and leadership intervention changes the safety trend of construction sites.

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VI. RECOMMENDATIONS

The following strategic recommendations are derived from the analyses to improve the use of PPE in preventing construction workers' injuries.

1) *Improving PPE Compliance:* This combination of consequences indicates that employers and regulatory bodies must develop extensive awareness and training programs to remind all participants of the importance of PPE. There is also a need to stress on proper usage and management of equipment [20]. Alleviating discomfort is also another way of enhancing the compliance of PPE since uncomfortable and inconvenient wear is another reason for noncompliance.
2) *Strengthening Policy and Enforcement:* The crucial and sustainable solution that would help to attain and maintain high levels of PPE compliance, however, is more rigid standard implementations and corresponding sanctions. This involves the use of sanctions for non-adherence to the safety measures, audits, and modification of safety standards to meet existing or new hazards and requirements on site [21]. Employers and workers must be encouraged to protect the legal dimension of safety measures at the workplace.
3) *Future Research Directions:* Future research should examine the long-term effects of PPE on the control of injuries and productivity in healthcare organizations. On the same note, studies on technological advancements, for instance, smart PPE designed with a monitoring system or alarms, could be other areas of improvement of safety performances in the construction industry [22].

VII. CONCLUSION

The importance of Personal Protective Equipment (PPE), having considerable significance in alleviating injuries in the construction industry, has been explained in this study. To date, injury rates are still shocking, even after the formulation of safety measures, a clear indication that PPE should be used and maintained at all times. The studies highlighted the fact that the usage of PPE reduces the rate of conventional construction site accidents, especially where standards of implementation and training are adhered to. Thus, factors like discomfort, perceived lack of training, and lack of managerial interest remain negative factors. It is quite clear that strategies for increasing awareness, evolving PPE design, or strengthening the enforcement of policies would go a long way to improving outcomes in the safety of healthcare workers. Also, the use of advanced technologies is considered a future trend in management. In general, PPE is essential in the protection of construction workers, and enhancing the quality of occupational health in this sector makes it imperative to further the promotion and use of this fundamental tool in enhancing the safety of workers on construction sites.

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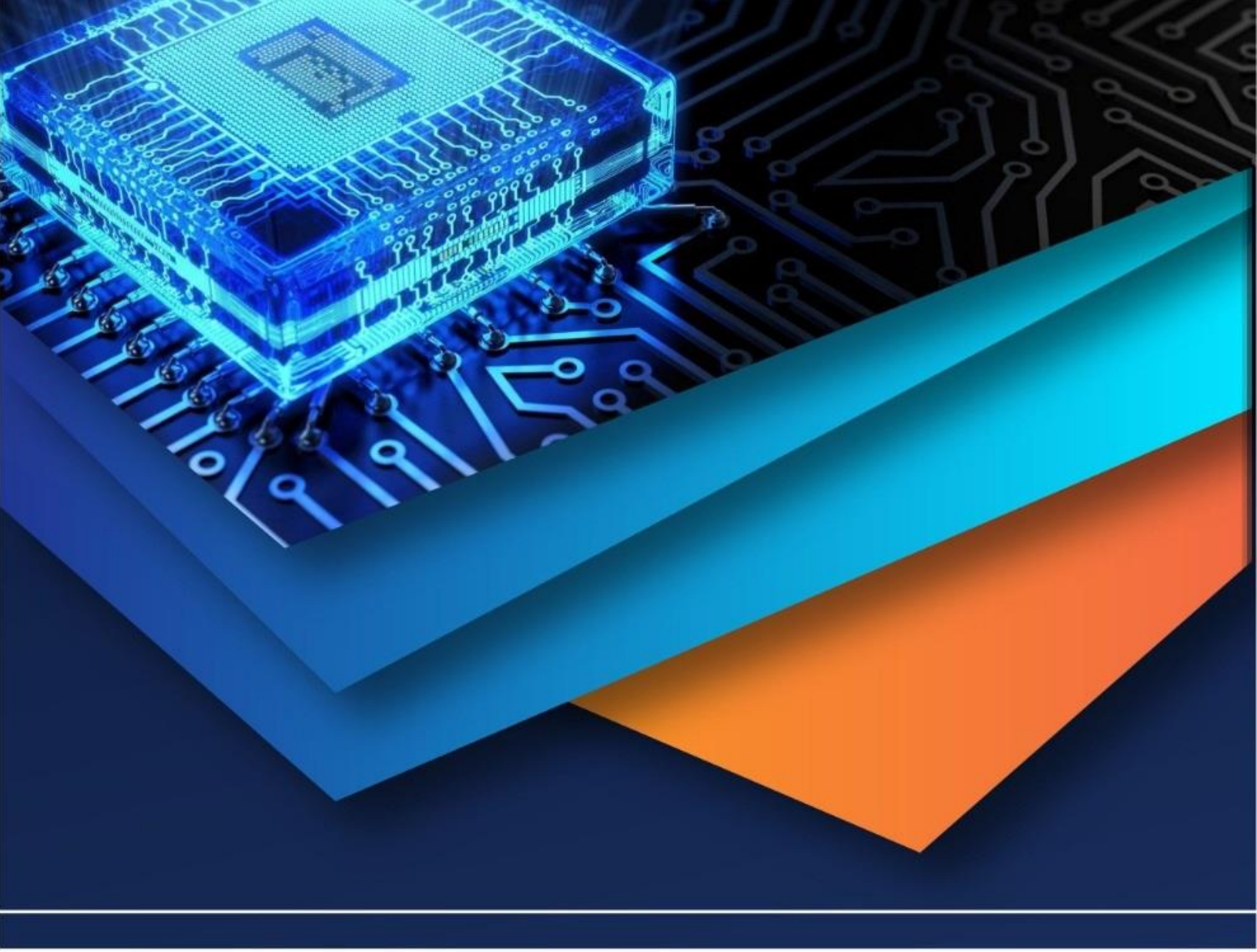

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