

# Review paper on Modernization of Safety Helmet Wearing Management System by Using Artificial Intelligence Tools

**Mr. Gaurav Vispute<sup>1</sup>, Dr Sandeep Choudhary<sup>2</sup>, Dr Matam Mohan Babu<sup>3</sup>**

<sup>1</sup>*Research Scholar, Department of Civil Engineering, IES University, Bhopal, Madhya Pradesh, India*

<sup>2</sup>*Associate Professor, Department of Civil Engineering, IES University, Bhopal, Madhya Pradesh, India*

<sup>3</sup>*Principal and Professor of civil engineering, Shri Venkateswara College of engineering & technology (Autonomous), Chittoor, Andhra Pradesh, India.*

## **Abstract:**

*The construction industry is one of the foremost industries in the world, and with it comes the involvement of risks while doing work in it. Wearing safety equipment on the construction site is a very important and necessary thing to do, whether construction activities are going on or not. Wearing a safety helmet is a must and should be worn by all the people who are present on site, especially the laborer. There are very serious and deadly consequences of neglecting safety rules and regulations, as accidents like falling material, being pierced by sharp things, cuts, bruises, etc. happen unpredictably and result in severe injuries or even death. There are various cases of accidents occurring due to not wearing safety equipment, and almost 70% of them are due to not wearing a safety helmet. Depending on the type and severity of accidents, they may cause temporary or permanent disability; in the worst-case scenario, death is also possible. These accidents also impact the organization's cost and reputation as it must compensate injured workers or their families. After the accident, the organization has to face various types of criticism from people and workers. To minimize accidents on construction sites, the government has issued various laws and regulations that should be followed by employers and employees (laborers); they also require constant physical supervision to enforce safety, which makes things a little bit tedious. We need to implement enhanced supervision management to ensure that workers should at least wear safety helmets all the time. This study should help make improvements to the traditional safety helmet while proposing a new enhanced monitoring management to ensure safety.*

**Keywords:** *Accidents on Construction Site, Safety Management System, PPE Kit.*

## I INTRODUCTION

The construction industry has a large workforce, and most of the activities and work are mostly done manually. Some of these activities are dangerous, so without taking preventive measures, the probability of accidents increases. To minimize such unpredictable and unfortunate accidents, safety management systems were implemented. As per the literature survey and case study, it is observed that in response to the issue, the government enforced various laws and also organizations took part in it to implement various types of safety measures, like providing PPE kits and conducting safety-related seminars to enlighten workers. But despite these arrangements, accidents still happen on construction sites, and their severity directly depends on the use of protective gear. So the aim of this project is to understand the accident situation happening on site, their consequences, the implementation of a safety management system, and the challenges for its fulfillment. It is important to at least wear a safety helmet while on site. According to the literature survey, it is observed that workers' own attitude toward their own safety, a lack of self-motivation, and the discomfort of wearing safety helmets are the few causes of accidents. Further, it is also observed that on larger construction sites, continuous physical supervision or monitoring of laborer to determine if he/she is wearing a safety helmet or not is not feasible. This is also one of the major challenges in safety management implementation. The purpose of this study is that it will serve as the basis for future research and improvements to the existing issues in safety management by proposing an enhanced safety helmet wearing management system that can be implemented remotely and will monitor the status of workers to determine whether they are wearing helmets or not, ensuring they must wear them all the time on the job site.

### **Problem Statement:**

1. Due to various reasons labors tend to neglect wearing safety helmets irrespective of regulations.
2. Lack of suitable enforcement for wearing safety helmet on construction site.
3. It makes difficult for construction manager to constantly supervise and enforce to wear safety helmet physically on larger and multilevel construction site.

## II LITERATURE REVIEW

### **2.1 “Safety Helmet Wearing Management System for Construction Workers Using Three-Axis Accelerometer Sensor”.**

Sung Hun Kim, Changwon Wang, Se Dong Min, Seung Hyun Lee, et al. [1] studied the Korean construction industry. They deduce that failure to wear safety helmets seems to be one of the major causes of the increase in accidents, and so it is necessary to develop technology to monitor whether or not safety helmets are being used. However, the approaches employed in existing technical studies on this issue have mainly involved the use of chinstrap sensors and have been limited to the problem of whether or not safety helmets are being worn. But it is observed that improper wearing, such as when the chinstrap and harness fixing of the safety helmet are not properly tightened, has not been monitored. To

Remedy this shortcoming, the authors have developed a safety helmet with a three-axis accelerometer sensor attached. Experiments were performed related to development in which the sensing data were classified as to whether the safety helmet was being worn properly, not worn, or worn improperly during construction workers' activities. According to the results, it is verified that it is possible to differentiate between the wearing status of the proposed safety helmet with a high accuracy of 97.0%.

## **2.2 “Automatic detection of Safety Helmet Based on Head Region Location”.**

Yuwan Gu, Yusheng Wang, Lin Shi, Ning Li, Lihua Zhuang, Shoukun Xu, et al. [2] observed that detection of safety helmets is difficult and low precise while worn in the complex pose of a construction worker. So to address this issue, a method for detecting safety helmet wear based on pose estimation was proposed. For that, they used the YOLO V4 method to detect the safety helmet region. With this method's help, they designed the pose estimation model for an open pose. The residual network optimized feature extraction was introduced to obtain the skeletal point information of the construction worker, and then the pose of the worker was estimated based on the skeletal point information. According to their experimental results, it was shown that the detection accuracy of the method was higher than other methods and that its adaptability to the environment was stronger.

## **2.3 “Analysis of the Influence Factors of Safety Helmet Comfort.”**

Wu Hao, Luo Shan, Wang Yang, Wang Jingjing, Li Chenyan, Zou Yun, et al. [3] observe that personal labour protection equipment and wearing a safety helmet correctly can help prevent and control collision damage. But in actual operation, there are still some workers who are affected by the lack of comfort of a safety helmet, and they were not willing to wear a safety helmet. It is also surveyed about the factors that lead to discomfort from wearing a helmet. Also, 15% of injuries are caused by not wearing a safety helmet. On some level, the paper shows safety helmet comfort research, but we have not further studied the influencing factors of safety helmet comfort.

## **2.4 “A Series of Student Design Projects for Improving and Modernizing Safety Helmets.”**

Johannes De Boer, Margot Stilma, Karin Van Beurden, and Wouter Teeuw, et al. [4] observed that at construction sites, workers are required to wear personal protective equipment during their work. But there is often a lack of motivation to wear them. The series of projects consist of raising intrinsic motivation to wear safety helmets by adding features and making the safety helmet more comfortable to wear. The first project got a clear view of the problems and why workers were having trouble while wearing safety helmets. Later projects focused on designing prototypes, constructing prototypes so that they could become more wearable and effective, and eventually conducting usability studies with construction site workers.

## **2.5 “Construction Site Accident Avoidance.”**

M. Saniya, Amulya, A. Sahiti, B. A. Nagarani, Dr. M. Shanker, et al. [5] visually examine the site and understand the failure in wearing the safety helmet. A video tape monitoring system

was used for real-time results. They also develop a deep learning-based system for the real-time monitoring of a safety helmet at the construction point by using the YOLO algorithm, which also includes a module that is able to detect whether the worker is working or idle and also analyze the movement of the worker in real-time. They also suggest using colored safety helmets according to the employee profile. so that it will be easier to monitor safety helmet management.

## **2.6 “Deep Learning-Based Safety Helmet Detection in Engineering Management Based on Convolutional Neural Networks.”**

Yange Li, Han Wei, Zheng Han, Jianling Huang, and Weidong Wang et al. [6] used the same method for research and monitoring as mentioned in paper [5], and additionally they proposed a method by using the SSD-Mobile Net algorithm, which was based on convolutional neural networks. They also add an image set obtained from video monitoring of a safety helmet, which is then further divided into a training set, a validation set, and a test set. According to experimental results, it was demonstrated that the presented deep learning-based model using the SSD-Mobile Net algorithm is capable of detecting the unsafe operation of not wearing a helmet at the construction site with satisfactory accuracy and efficiency.

## **2.7 “Smart Helmet 5.0 for Industrial Internet of Things Using Artificial Intelligence.”**

Israel Campero Jurad, Sergio Márquez-Sánchez, Juan Quintanar-Góme, Sara Rodriguez, Juan M. Corchado, et al. [7] observe that paradigms such as the Industrial Internet of Things (IIoT) and Artificial Intelligence (AI) make it possible to generate PPE models feasibly and create devices with more advanced facilities such as monitoring, sensing the environment, and risk detection, among others. A comparative study of the state-of-the-art models of supervised learning was carried out. Also, the use of a deep convolutional neural network (ConvNet or CNN) was proposed for the detection of possible occupational risks.

## **2.8 “An Estimate of Fatal Accidents in Indian Construction.”**

Dilip A. Patel, Kumar Neeraj Jha, et al. [8] observe that in some countries there is an absence of standard recording and notification systems for construction accidents, while in countries such as India, the systems exist but their implementation is an issue. They also estimate fatal accidents in the construction sector for all states in India. So that by analyzing those statistics, stakeholders and organizations should take remedial actions.

## **2.9 “Why Does an Indian Construction Worker Fail to Wear Personal Protective Equipment (PPE) at Workplace?”**

Vigneshkumar Chellappa, Urmi Salve, et al. [9] surveyed and made a questionnaire to understand why workers are not wearing safety helmets on site. By analyzing their opinions, authors deduce and make an analysis about the factors that affect the wearing of a safety helmet. They conclude from their results that the design of the helmet and the worker’s own lack of motivation are major reasons for not wearing a helmet, along with other minor factors as well.

### **2.10 “Effect of helmet design on impact performance of industrial safety helmets.”**

Michael Bottlang, Gina DiGiacomo, Stanley Tsai, Steven\_Madey, et al. [10] studied various factors related to the design affecting the performance of the industrial safety helmets. Comparative studies of different helmet designs were performed to determine differences in helmet performance. They also perform various tests like impact tests, falling object energy generation, and sustainability of helmets, but they conclude that present helmets do not necessarily deliver improved protection from impacts and falls compared to traditional hardhat helmets.

## **III RESEARCH METHODOLOGY**

The research will be conducted according to the following stages:

1. The first phase will consist of theoretical data, which will be gathered through a variety of sources, including textbooks, past research, the internet, news, research papers, and surveys. This theoretical section will lead to a better understanding of the gap between the theoretical and practical aspects of wearing a safety helmet and its management.
2. The 2<sup>nd</sup> phase will consist of collecting information and facts related to specific case studies, the current situation, and issues of not wearing a safety helmet in a construction project.
3. determining the problem statement by studying existing literature data.
4. Aims and objectives will be determined according to the information to overcome existing safety management issues.

### **3.1 Accidents on Construction sites:**

Construction is an often hazardous, predominantly land-based activity where site workers may be exposed to various risks, some of which remain unrecognized. Generally, accidents happen due to two main reasons: one is due to man-made errors like not following safety regulations on site, carelessness in handling and operating heavy machineries, ignorance in work, etc., and the other is due to failures of machines like lack of maintenance, improper handling, etc. Site risks can include working at height, moving machinery and materials, using power tools and electrical equipment, and handling hazardous substances, plus the effects of excessive noise, dust, and vibration. The leading causes of construction site fatalities are falls, electrocutions, crush injuries, and being caught between injuries. Now, the severity of these accidents varies from scratches to death.

### **3.2 Safety Management System for Construction:**

Safety in construction sites is an aspect of construction-related activities concerned with protecting workers and others from death, injury, disease, or other health-related risks. A good safety management system can go a long way toward preventing these accidents and occupational hazards. An effective safety management system goes beyond the typical "do this, don't do that" approach to construction safety. Early safety management systems were already in use when construction managers still used paper notepads, design sheets, and slide rules. Based on the safety regulations of the time, "one size fits all." Government inspectors checked that construction companies were operating according to the laws. assuming the company was legal and safe. In present time, when managers started using calculators, PCs,

and construction management software. Safety management systems have also fundamentally changed. Instead of following the government's prescriptions for safety, companies had to assess their own health and safety requirements. They were taking all reasonable measures to keep their employees and other related people, like subcontractors, suppliers, customers, and members of the public, safe throughout the workday. Many construction companies had figured out that there were at least three reasons to have an effective safety management system:

- 1. Moral obligation:** Employees and associated people should not be put at risk by the company by any means.
- 2. Regulations:** Most states and nations make it a legal responsibility for companies to promote and maintain secure working conditions.
- 3. Cost-effectiveness:** Time, effort, and money spent on preventing accidents is less than the expense of dealing with accidents afterwards.

### **3.3 Implementation of Safety Management System:**

A safety management system for construction is a systematic way of identifying hazards and managing risks relating to the construction workplace. The system must include the construction company's policies, procedures, systems, organizational deployment, and accountabilities for making sure that the necessary precautions have been taken and are being maintained for the safety of all associated people. It must be embedded in the culture of the company so that it is applied by all. A properly performing safety management system will typically include the following:

1. Identification of all safety hazards relating to the company's activities and assessment of the risk associated with each hazard.
2. Risk management procedures to keep risk from hazards down to acceptable levels.
3. Continual monitoring with regular evaluation of safety performance.
4. Continual improvement of the effectiveness of the safety management system.

### **3.4 PPE for Construction Site:**

To implement the safety management system, a PPE (Personal Protective Equipment) kit was introduced. According to the Personal Protective Equipment at Work Regulations of 1992, it needs to be ensured that PPE must be worn and put to use on the construction site to avoid any injuries from accidents. According to the Health and Safety at Work Act 1974, PPE items should be provided free of charge by the employer, and employees will not be charged for or contribute to the provision and maintenance of PPE. PPE generally includes the following equipment:

1. Safety Helmet
2. Protective Cloths
3. Safety Gloves
4. Safety Spectacles
5. Hearing protection gearing
6. Foot protection gear
7. High Visibility Vest

## 8. Safety Harness.

### 3.5 Factors affecting on safety helmet wearing:

We focused our study on the safety helmet from the PPE kit because it protects the most important part of the body, i.e., the head. An injury to the head may lead to temporary or permanent damage to the body, and a safety helmet proved to be a good way to minimize that. According to the study, a survey was conducted on 36 people about the discomfort or hesitation behind not wearing a safety helmet. In that study, the following factors were observed as reasons for not wearing safety helmets:

Table No. (1) Factors affecting on wearing a safety helmet.

Percentage of total surveyed labors / workers	Reasons for not wearing helmet
25 %	Vision
22 %	Hotness, Sweating, Itching
14 %	Nape strap
11 %	Chin strap
8 %	Sweating, Itching
8 %	Itching
6 %	Sweating
6 %	Nape strap, Chine strap

### 3.6 Identification of Challenges in enforcing Safety Management on Construction Site:

Now, even though we identify as uncomfortable with wearing a safety helmet, one's own safety is in their own hands, but still, as an employer, it is the responsibility of the supervisor to strictly enforce safety management on site. Rules and regulations must be followed on the site so that no employee gets injured directly or indirectly. For a small-scale project, it is easy to monitor physically or by video monitoring, but on large scale projects, it is very difficult to track laborers' status, whether they are wearing safety helmets or not. We need to overcome that issue by trying to enhance the monitoring system.

## IV CASE STUDY

According to the study by the International Labor Organization, 165 out of 1000 construction workers are injured daily in India. In Gurugram on February 4, 2019, a construction worker in Gurugram Sector 4 died in a tractor accident due to not wearing a safety helmet. worker was sitting next to the driver on a mudguard but got stuck between the tractor and trailer when the line got bucked and the tractor flipped in 90 degrees. According to the police, the victim did not survive because he was not wearing a safety helmet and got a blow to the head. People pull him out, but he reaches the hospital and is declared dead. The driver of the tractor barely escaped that accident with minor injuries. The victim's name was Harshad; he was 26 years old, and he had children and a wife. A complaint was filed against the owner of the building and the contractor under Section 304A of the IPS. Now, what we observed here is

that if he had worn a safety helmet, he might have escaped with some minor injuries, like a driver, but unfortunately, it resulted in his death, which will impact both his family and employers. On the other hand, employers have to face legal, economic, and social consequences.

## **V RESULTS**

Researching, reviewing literature and studying case studies, we obtained the following results:

1. Workers were not wearing PPE, which resulted in on-site accidents like falling objects and impacts to the head. These accidents can be minimized by wearing personal protective equipment, especially safety helmets.
2. Traditional hard hats provide much more protection to important body parts like the head than any other designed safety hats, so at the very least, wearing a safety helmet is a must, but it was also not followed on some sites.
3. There's a lack of motivation to wear a safety helmet in the workplace. To improve that, we will need some enhancements to traditional safety helmets in the future.
4. It is ideally expected from safety officers to supervise safety regulations and determine whether they are followed or not, but it is observed that safety officers are also not working motivationally.
5. It is also observed that physical supervision on large construction sites is not as feasible as on small sites.
6. As per the accident included in case study, we also observe that the worker's death on site not only impacted his family but also his employer's reputation and lives.

## **VI CONCLUSION**

According to above study and result we made conclusion as follows:

1. The construction industry is dangerous and following safety regulations is important for both employees and employers.
2. Wearing PPE kit is a must, especially safety helmets, all the time whenever present on site. Most of the injuries happened on site; more than 70% are due to not wearing a safety helmet.
3. Workers tend to feel uncomfortable wearing safety helmets due to various reasons (Table No. 1), but irrespective of that, for the greater good and to ensure safety, there should be strict supervision from the employers.
4. It is also understood that physical supervision is not possible all the time on a large-scale construction site.
5. This study should help enhance the traditional helmet by developing smart helmets and proposing a new safety management system that will help supervisors monitor whether the workers are wearing safety helmets or not.

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