

Leveraging Technology in Advancing Construction Workers Safety

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Abstract

Construction worker safety is a top priority in the construction business. It refers to the procedures, protocols, and practises put in place to ensure the safety and physical well-being of construction workers. Because of the presence of heavy gear, high work zones, and possible exposure to different dangers such as falls, equipment accidents, toxic chemicals, and structure collapses, construction sites are inherently hazardous settings. Safety for construction workers cannot be stressed. Construction safety is a guideline that construction safety managers follow and implement. It is the consequence of proper equipment use, worker safety, frequent site inspections, and risk assessments. Compliance with regional safety and health requirements is a critical component of construction safety. In many nations, ensuring worker safety is not just a moral imperative, but also a legal necessity. Construction businesses must offer a safe working environment and follow safety regulations and guidelines to avoid accidents, injuries, and fatalities. To reduce the occurrence of construction accidents and enhance the safety record of construction projects, dangerous elements must be identified by monitoring construction workers' behaviours. The aim of this study is to look at the implementation and adoption of technologies for construction workers safety as well as the opinions and perspectives of the construction industry towards these technologies.

Keywords: Worker Safety, Safety Norms, Personal Protective Equipment (PPE), Technology, Wearables, Robotics, Automation.

1. Introduction

Construction worker safety is a team effort that necessitates the dedication and active engagement of companies, employees, supervisors, and regulatory agencies. The construction sector may seek to provide a better place to work for construction employees by prioritising safety, adopting preventative measures, and promoting a safety culture. The fundamental reason for emphasising worker safety is to protect employees' lives and well-being. Construction sites are fraught with dangers, and employees can suffer serious injuries or even death if sufficient safety precautions are not taken. Ensuring workplace safety is a moral obligation that respects human life and promotes worker well-being. In many nations, worker safety is a legal obligation. To safeguard employees' rights and guarantee a safe working environment, governments and regulatory agencies enforce safety norms and standards. Construction businesses must follow these standards in order to avoid legal responsibilities, penalties, and potential litigation. Workers can focus on their duties with more trust and peace of mind when they feel safe and secure [1]. A safe work environment enhances productivity and efficiency because employees can execute their jobs without worrying about their safety. Furthermore, safety precautions such as well-maintained equipment as well as effective workflows lead to more efficient operations and increased output. Prioritising worker safety develops a healthy organisational culture that appreciates employees' well-being. Workers are more inclined to be loyal and dedicated to their employers when they feel cared for and protected. Companies that prioritise safety are more appealing to prospective workers, resulting in greater recruitment and retention rates. A strong dedication to worker safety improves a construction company's image and in stills trust in stakeholders such as clients, investors, and regulatory agencies. Proactively addressing safety not only improves relationships with stakeholders, but it also raises the likelihood of getting contracts and recruiting investment.

Importance of Worker safety in construction industries [2]:

- Preservation of Human Lives
- Improved Productivity and Efficiency
- Reduced Costs and Financial Losses
- Enhanced Reputation and Client Confidence

- Positive Company Culture and Employee Morale



Figure 1. Impact of technology in Construction Workers Safety

2. Influence of Technology on Construction Worker Safety

Technology, such as IoT sensors and wearable devices, provides real-time monitoring of building sites for possible risks. These sensors can monitor temperature, humidity, air quality, noise levels, and even gas leaks or harmful chemicals. Early detection and monitoring of dangers allows for early action and preventative measures. Material and design advancements have resulted in the creation of enhanced personal protective equipment (PPE) that provides employees with more protection and comfort. Lightweight yet durable helmets, safety goggles with greater visibility, gloves with improved grip, and high-visibility apparel with integrated safety elements, for example, all contribute to improved worker safety and comfort[3].

Here are a few examples of how technology has improved construction worker safety:

2.1 Wearable Technology for Worker Safety

Sensors and communication capabilities are built into wearable devices such as smart helmets and safety vests [4] [6]. These devices may monitor vital signs, detect falls, and notify supervisors or emergency personnel in the event of an accident or a medical emergency, allowing

for a quick reaction and immediate aid. Here are some examples of worker safety wearable devices:

Smart Helmets: Smart helmets resemble ordinary hard hats in design, but they have built-in technology such as tracking tools, sensors, and augmented reality. The device may alert workers to potentially hazardous circumstances and provide warnings to team members if any workers require assistance. Engineers can also use a smart helmet to access site planning tools. Smart helmets are fitted with a variety of sensors and technology to improve worker safety. They can detect possible health concerns or crises by monitoring vital indicators, including blood pressure, body temperature, and fatigue levels. Smart helmets may also incorporate integrated cameras, and heads-up displays (HUDs), including augmented reality capabilities that deliver real-time information and aid with tasks, boost situational awareness, and minimize accidents.[4]

Case study: WakeCap, a Dubai-based start-up, has created a helmet that creates and sends data via the Internet of Things (IoT). This dramatically improves safety on construction sites. Furthermore, building procedures may be better coordinated.[5]

Safety Vests and Jackets: A variety of sensors may be added to jackets and vests to make them part of the linked safety system. Safety vests and jackets are rapidly being integrated with technology such as GPS, RFID, and Bluetooth to track the whereabouts of workers on construction sites. These devices help to keep workers safe by allowing supervisors to follow their movements and respond quickly in the event of an emergency or accident.

Case study : Redpoint and Skanska have cooperated to create a vest that records the wearer's position and emits LED warning signs when they reach a defined region. An MIT jacket can assess altitude in addition to environmental factors including air quality, noise levels, and airborne contaminants. Workers can wear a vest beneath their garment that analyses breathing and heart rate, sweat, and orientation and sends sensations to the user as an alert signal when safety criteria are exceeded.

Personal Gas Detectors: Personal gas detectors are small, wearable devices that identify and track the presence of dangerous chemicals in the workplace. When harmful gas levels are discovered, these sensors give real-time alarms and warnings, allowing workers to take rapid action to safeguard themselves as well as evacuate if required.

Case study : Construction workers are exposed to a wide range of dangerous gases, including carbon monoxide (CO), chlorine dioxide (CLO₂), methane (CH₄), oxygen (O₂), hydrogen sulphide (H₂S), and volatile organic compounds (VOC's). Crowcon provides high-quality equipment with a specific focus on protecting teams against toxic, flammable, and poisonous gases.[7]

Exoskeletons: Exoskeleton suits are wearable devices that support and enhance the physical capabilities of construction workers. They reduce the risk of musculoskeletal injuries and provide additional strength and stability, particularly when performing heavy lifting or repetitive tasks. Exoskeletons can help prevent worker fatigue and improve overall safety and productivity.

Case study: Exoskeletons might seem like something out of a superhero comic, but they are quickly becoming a feasible answer. Although these supreme wearables have applications in healthcare as well as a number of other industries, companies such as Panasonic of Japan and Ekso Bionics of the United States are providing construction workers with superhuman strength. Exoskeleton devices not only make building easier, but they also prevent muscle, joint, and bone damage caused by severe and repetitive work.

Smart Boots and Insoles: Smart boots and insoles are outfitted with pressure sensors and motion detection technologies to monitor construction workers movements and detect possible risks such as slips, trips, and falls. They give real-time feedback and notifications to workers and managers, supporting safe and firm footing on construction sites.

Case study: Shoes and boots are entering the Internet of Things not just as a source of data but also as a source of energy. Sole Power, an American shoe business, is seeking to tackle the practical challenge of powering wearables. SolePower's boots not only include GPS, WiFi access, safety lights, and motion sensors, but they also have kinetic chargers that create power with every step the wearer makes. MIT has created shoes that protect workers' feet as well as their complete body. Load sensors implanted in the shoes detect weight and vibrate when a worker tries to lift an object that exceeds pre-set limitations.

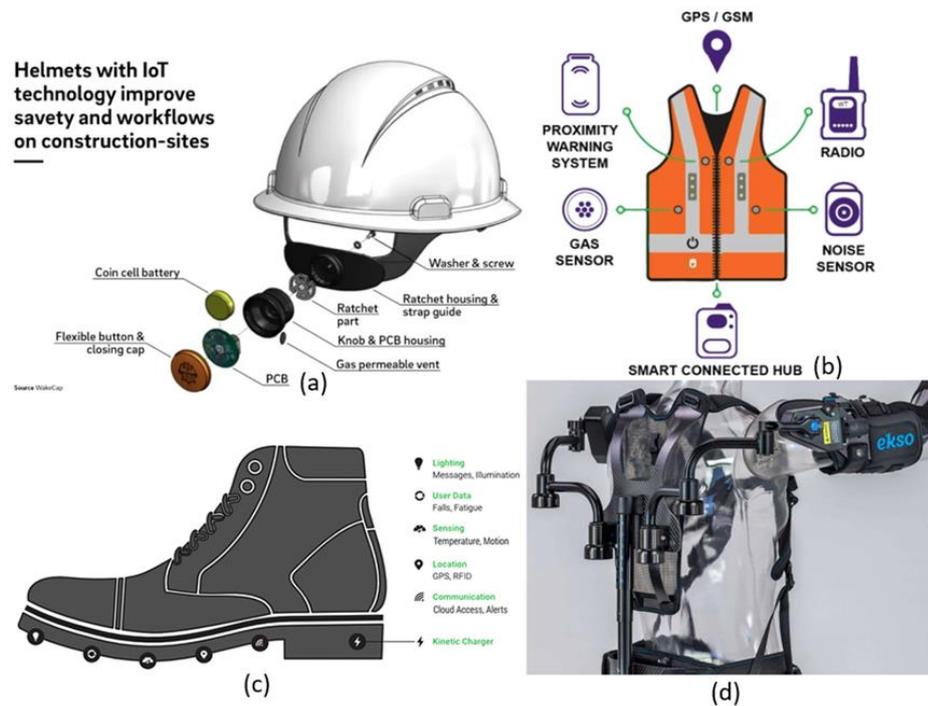


Figure 2. (a)IoT based Smart Helmet for Construction Company

<https://www.aecplustech.com/tools/wakecap>

(b) Multi Sensor Safety Vests

<https://www.bell-integration.com/capabilities/transform/iot-solutions/smart-garments/>

(c) Sole Power Smart Work Boots

<https://www.professionalroofing.net/Articles/Research-Tech--12-01-2017/4139>

(d) Exoskeletons by Ekso Bionics

<https://web.stanford.edu/class/engr110/2019/pdf/06a-Strausser.pdf>

These wearable devices not only increase construction worker safety but also communication, real-time data collection and useful insights for safety management and preventative actions. They help to make the construction sector a safer place to work by lowering the risk of injuries and accidents and improving overall worker well-being.

2.2 Drones to Keep Workers Safe

Drone technology is becoming more widespread on building sites. These crewless vehicles can soar high to inspect the quality of work on multi-story structures, fit into tight locations for a better perspective, and assist you in understanding the effects of changing site circumstances. Drones are ideal for construction enterprises since they can be used to perform an aerial examination of their site, providing a comprehensive picture of the region and its surroundings. Because of their capacity to reach lofty locations and potentially dangerous areas, the examination is significantly more precise and efficient. With this technology, any safety dangers may be identified prior to work being performed, allowing any necessary procedures to be implemented. Drones reduce the need for workers to climb scaffolds or access dangerous zones, lowering the risk of falls or injuries. They also give supervisors an up-close view of the location, assisting them in identifying any safety hazards.

2.3 Predicting Safety using AI

Today is the word of artificial intelligence. It is powerful and capable of detecting patterns in data sets. AI can collect information, forecast events, and derive insights more efficiently and swiftly than humans. While the technology is slowly being accepted by building owners, its potential is tremendously exciting. It is easy to forecast the future by looking at prior safety statistics. A remote video surveillance system powered by AI analytics can detect burglars, alert site managers to stolen objects, and continuously monitor the building site for other activities without stopping, providing for improved protection and significantly faster replies. Video analytics enabled by AI may be used to monitor building sites and detect possible safety issues. Cameras using AI algorithms may detect risky behaviours such as workers not wearing protective equipment, unauthorised persons entering restricted areas, or equipment misuse. When such behaviours are discovered, supervisors can get timely notifications, allowing them to take necessary action. Construction employees confront considerable hazards on a daily basis, and employers must take the necessary precautions to make them as safe as possible. Fortunately, VSaaS, AI, and cloud technologies are assisting in the modernization of on-site monitoring by enabling real-time reactions to undesired behaviours and critical occurrences.[8]

2.4 Power of Augmented Reality in Construction Workers Safety

AR refers to experiences, and it is a technology that brings computer-generated things into the physical world, such as building augmented reality glasses. Construction businesses may use augmented reality to help them obtain more jobs, enhance safety, and interact with team members. Workers may immerse themselves in virtual settings that imitate real-world construction scenarios, allowing them to practice safety protocols, danger detection, and emergency response [11]. As it gains popularity, the AR/VR industry is predicted to rise at a 77% CAGR between 2019 and 2023. AR technology can help increase worksite safety. Some augmented reality (AR) equipment (such as glasses or mobile devices) may scan tags or labels placed in specified regions or items. These labels can then display text or even 3D models to give information about safety or hazards.[7]

2.5 Robotics and Automation in Construction Sites

Construction robots and automated technology are increasingly being used to do hazardous or repetitive activities, lowering the risk of worker injury.[9] According to a global survey, 81% of construction companies will adopt or enhance their usage of robots and automation over the next decade to solve skills shortages and improve workplace safety. Falls, being struck by an item, electrocutions, and becoming entangled in or between gears are the most prevalent causes of construction deaths. The biggest cause of construction deaths is falls. Robotics and other kinds of automation provide the potential to lessen the risk of accidents by taking on risky jobs and keeping employees out of harm's way. [10]

Remote Control: Work may be done wherever it is safest because of remote-controlled and teleoperated machinery. A remote-controlled excavator, trencher, or bulldozer removes the operator from the cab and places him or her in a stable position with the best view, safeguarding both the operator and others on the job site. This can lessen the possibility of being injured by items falling or other risks.

Autonomous Devices: Autonomous jobsite equipment may undertake repetitive and difficult activities such as lifting or placing bricks. This lowers the need for human employees to be in risky situations, such as working in trenches or on high platforms, as well as the necessity for tough physical labor.

3. Limitations of Construction Workers Safety before Integration of Technology

Manual methods, such as paper-based safety plans, checklists, and inspections, were heavily used in safety measures. This method was time-consuming and susceptible to human error resulting in a dangerous hazard. Safety regulations and procedures were taught orally or in writing, which may not have been as successful as interactive and immersive training approaches.

Construction workers, managers, and project teams communicated mostly through face-to-face contacts or phone conversations. This might cause delays in conveying safety-related information or changes to all parties involved.

4. Advantages

Construction organizations' use of technology has improved, reducing time demands and increasing flexibility. Power tools have long been useful resources for a variety of businesses, assisting individuals from a variety of specialties. Power tools, with features such as a strong engine, improved torque, decreased noise, less vibration, assist in removing difficult manual labor.

5. Open challenges

Although the use of technology-based object detection, tracking, and action identification technology has advanced in the field of construction safety monitoring, there are still limitations and problems. In object detection, there is currently little study on scene comprehension, visual occlusion, and tiny target recognition. The accuracy of object tracking is influenced by the complex 3D architectural environment and the irregularity of monitoring object motions. In terms of action recognition, relevant researchers are frequently confused by the small sample size in motion data sets as well as the accuracy of human posture capture. [12] It is envisioned that future research will address these limits and obstacles.

6. Future scope

The future scope of technology in construction worker safety is broad, with plenty of opportunity for progress. Researchers, policymakers, employers, and practitioners must foresee

and plan for the introduction of new hazards, as well as the exacerbation of existing hazards, as a result of workplace modernization and other developments in the construction sector. The future of construction offers enormous opportunity for creative solutions to address these problems and improve worker safety, health, and well-being.

7. Conclusion

Finally, technology has had a significant and positive influence on increasing construction worker safety. Safety equipment and gear developments have increased protection against various threats. Monitoring and alarm systems give real-time data on worker health and safety, allowing for proactive accident prevention actions. Building Information Modeling (BIM) technology aids in the identification and resolution of safety concerns during the design process, thereby decreasing hazards during construction. Furthermore, the use of wearables, drones, and robotics allows for remote inspection and monitoring of dangerous locations, reducing worker exposure to risk. Overall, technologies continue to play an important role in assuring construction workers' well-being by improving safety measures and minimising the likelihood of accidents and injuries.

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