

Construction Workforce Safety

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Construction work is a hazardous job. Some construction site jobs include: building houses, roads, tree forts, workplaces and repair and maintain infrastructures. This work includes many hazardous task and conditions such as working with height, excavation, noise, dust, power tools and equipment. The most common fatalities are caused by the fatal four: falls, being struck by an object, electrocutions, and being caught in between two objects. Construction work has been increasing in developing and undeveloped countries over the past few years. With an increase in this type of work occupational fatalities have increased. Construction workforce safety is a multidisciplinary field concerned with the safety, health, and welfare of people at a construction site. The goal of the construction workforce safety is to foster a safe and healthy construction environment.

construction workforce safety

sensor

visualisation

1. Overview of Construction Workforce Safety

The construction industry has long been plagued by safety issues. According to statistics, there has been no significant reduction in the number of occupational fatalities in major countries or regions from 2014 to 2019. According to the China state administration of work safety, 3843 fatalities occurred in China in 2017. In the U.S., the death toll was 1038 in the construction industry in 2018, accounting for one-fifth of all industry fatalities. The uniqueness and complexity of construction projects make it difficult for the sector to avoid occupational injuries and fatalities. For example, site engineers may lack situational awareness and fail to take measures to identify and prevent imminent hazards. Accident causation models have been widely introduced to explain the cause of construction safety problems^{[1][2]}, revealing that construction environment safety, behaviour safety, and safety awareness are the main factors of risk occurrence. A review of these factors is presented below.

2. Construction Environment Safety

Construction activities are highly influenced by temporal and spatial conditions^[3]. Different spatial locations have different risks. For example, if a worker is on the ground, they need to watch out for vehicles and falling objects, but if they are on the roof, they need to worry about falling from a height. The construction workplace is dynamic. Construction involves multiple groups working independently in the same temporal and spatial environment. The progress of all the groups results in constant changes to working environment of the site. A complex and dynamic construction environment is bound to generate a lot of dynamic information. Therefore, construction environmental safety management involves the collection and processing of massive amounts of information.

The management of a construction environment involves all aspects of the site, including the temperature, amount of workspace, and correct setting of safety facilities. Most countries have construction safety regulations. Taking Australia as an example, the Work Health and Safety (Construction Work) Code (2015)^[4] requires that the risks of slips and trips caused by surfaces in a workplace be controlled, areas with a risk of falling objects need to be restricted to avoid unauthorised entry, and physical barriers need to be placed around the roadway and fixed parking areas to avoid traffic accident injuries. These regulations summarise the knowledge of previous accidents and help improve the safety of the construction site. However, for complex and dynamic construction sites, the implementation of the regulations is the main challenge as it involves safety planning in the pre-construction stage and construction environment monitoring during the construction stage.

3. Behaviour Safety in Construction

Workers' unsafe behaviours have been proven to be a major factor leading to accidents^{[1][5]}. The management of unsafe behaviours is an important means to reduce occupational casualties. In construction activities, whether workers can behave safely largely depends on their safety knowledge and experience. Therefore, safety training for workers is the standard means to reduce unsafe behaviours. The Australian code^[4] requires that general construction induction training, workplace-specific induction training, and other necessary training must be completed before a worker performs a particular construction activity. However, because trainees are different in culture, educational background, knowledge, experience, personality, and preference, their requirements for training are also heterogeneous, so a one-size-fits-all approach to safety training is inefficient. Therefore, researchers have focused on the combination of training and construction activities to supplement the deficiencies of traditional training.

A theory called behaviour-based safety (BBS) was proposed to help improve workers' future behaviour by actively observing and recording their unsafe behaviour and providing feedback to workers^[6]. The BBS approach provides workers with a more personalised approach to improving their safety knowledge and experience through observation, feedback, and training. If a worker acts unsafely, it is observed and recorded by a safety inspector, and then reported back to the worker. Specific safety training programs are also developed to reinforce the impression and avoid similar situations in the future. The BBS approach was proven to significantly improve workers' safety performance. Unfortunately, because a large amount of human resources is needed to monitor and provide feedback on unsafe behaviours, BBS is rarely applied in the construction industry. If the identification of unsafe behaviours is accurate enough and the feedback is timely enough, then dangerous behaviours can be stopped in time to avoid accidents.

4. Safety Awareness in Construction

Similar to behaviour safety, safety awareness is heavily dependent on workers' safety experience. During the construction process, various kinds of interference occur, and the nature of the interference is intrinsically stochastic^[7]. Unsafe conditions are inevitable in construction activities, but the risks can be controlled within an

acceptable range using appropriate means. Issues related to safety awareness refer to the situation where workers have relevant knowledge and understand the existence of unsafe conditions, but do not take appropriate measures and persist in construction activities. Safety awareness is difficult to measure directly, but it can be reflected in workers' behaviour. For example, the situations where a worker works around damaged guardrails, and a worker refuses to equip themselves with personal protective equipment (PPE) when working at heights indicate the workers lack safety awareness. Workers know these behaviours are wrong, but the unsafe behaviours often occur out of a lack of concern for their safety. The reasons for insufficient safety awareness are complex, including personal factors, social influences, environmental conditions, and so on^[8]. The most immediate factor is the workers' failure to assess the risks properly. For some low-probability risks, because the accident has not yet happened, people will gradually pay less attention to it. This kind of fluke mentality can have serious consequences when an accident does occur.

The cultivation of safety awareness largely depends on long-term training and practice. In practical projects, workers' safety awareness cannot be permanently improved in a short time. To counter the insufficient vigilance and underestimation of risks, safety signs have been designed and set to provide a warning at the construction site for a temporary increase in safety awareness^[9]. The Australian code^[4] recommends providing clear instructions at the construction workplace, such as "no entry", "PPE required" and other signs showing hazards. The relationship of the location of signs and the surrounding environment was found to significantly affect the information provision scope of signs^[10]. Chen et al. ^[9] developed an objective measurement paradigm to evaluate the cognitive load of different design features and evaluated the perceptual effects of workers in different attention situations. Based on these findings, visual cues need to consider multiple factors, including location, shape, and colour, to enhance the impact of safety warnings.

Safety signs raise people's safety awareness to a certain extent by providing repeated prompts to people entering dangerous areas, but their limitation is obvious. Static signs are easily obscured by dynamic construction objects. Workers do not have to respond to a safety sign, so a sign will be ignored over time. Portable safety warning approaches, such as ringing or vibration, increase the situational awareness of workers as to when there is a hazardous situation^[11]. This kind of real-time reminder can make people pay attention to the environment and reassess the risk in a short period of time, avoiding accidents. However, studies about warning mechanisms aimed at the construction industry remain rare. Large amounts of research are needed to help workers switch their attention from their work to hazards when a sudden danger arises.

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