Evaluation of Construction Labor Safety for High Rise Buildings

[1]Rahul S.Chaudhari,[2]A. K.Gaikwad, [3]Pradnya Lokhande

[1]Assistant Professor, Pimpri Chinchwad college of Engineering, Nigdi, Pune.

rahul.chaudhari@pccoepune.org

[2]Associate Professor, Pimpri Chinchwad college of Engineering, Nigdi, Pune.

ajay.gaikwad@pccoepune.org

[3] PG Construction Management Student at Pimpri Chinchwad college of Engineering, Nigdi, Pune.

Abstract

The construction sector is very concerned about labour productivity. A fast-growing area in Maharashtra is the Pimpri Chinchwad Municipal Corporation (PCMC) area. This research focused on evaluating worker safety, particularly for high-rise structures in the PCMC area. 35 sites for the construction of high-rise buildings were used to gather the necessary data. In SPSS software, the varimax rotation approach is combined with the principal component analysis method. Five aspects are identified as a result of the factor analysis: management, dangerous working conditions, and the peculiarities of the sector, human and divine components, and harmful equipment. Also, the Pearson correlation approach identifies the correlation between the variables. It was determined that using safety nets, PPE kits, and safety boards, hiring safety officers, giving safety training, and appointing a third party like CQRA are all effective ways to prevent accidents in high-rise buildings.

Keywords *– Labor safety, High rise buildings, Accidents, labour productivity, workers safety by KMO and Bartlett's Test.*

1. Introduction

Planning and Management is a kind of way to avoid unplanned or uncertain events. Accidents are uncertain events, and to prevent injuries at the job site, effective safety management is necessary. Safety management should be through all the job phases, from estimating to the last step of work. Construction work includes various activities, and to perform those multiple parties are involved in it, to increase safety performance at the job site, all parties must be included in it. John, D. (2013). As the construction industry is more dangerous and physically demanding, the economy of most developing countries is more from the construction sector. Most workers tend to be unskilled; also they migrate from one region to another, sometimes with family or without it, throughout the country for employment. Due to migration from a different part of workers, can create communication gaps, religious beliefs, and culture and impact safety performance.

Safety laws in India are not strictly embedded, which is why construction safety is still in its early years. Basic safety laws and rules are ignored by the contractor to avoid this and to improve safety practices Government has staged particular legislation like the Compensation Act of 1923 (modified in 1962), the Minimum Wages Act, the Workmen's and the Contract Labor (Regulation and abolition) Act of 1970. Also, guidelines for regulation of construction activities there is National Building Code of India 2005. In the construction industry,the builder, contractor and engineers frequently push labour safety to the bottom of priorities. In developing, country authorities failed to implement safety rules. That is why safety-related knowledge is necessary to be known by professionals to reduce the rate of accidents and avoid the direct and indirect reduction of the project cost. In developing countries like India,

efforts should be made to spread awareness about health and safety among employees and workers to increase the efficiency of safety practices.

According to International Labor Organization (ILO), 337 million occupational accidents happens worldwide annually, which causes the death of 2 million 310 thousands worker and injured worker's number is up to 160 million, which causes a loss of around 1.2 $. In the Indian Construction sect, the number of people dying from 11,641 to 22080. Around 24.20% of Approximately fatality is added by the Indian construction sector alone annual India. This is because of the lack of implementation of health and safety legislation and practices. (Edwin Sawacha, ShamilNaoum, & Daniel Fong,1999).

In order to strategies in working methodology to reduce the accidents and save the worker's life the study of an accident causing factors is important. Theseaccident causation models and methodologies whichidentify the accident-causing factors.

2. Literature Review

In order to develop the strategies in working methodology to reduce the accidents and save the worker's life the study of an accident causing factors is important. There are various accident causation models and methodologies, which are helpful to identify the accident-causing factors.

2.1 The single event concept

In this model, all the blame is given to employees because it is convenient to blame the victim when an accident happened. For example, if a worker falls into the pit and got injured then his/her lack of awareness is considered as the reason for the accident which means all the fault is of the employee. Investigators who investigate this accident will not produce aquality report under this concept.

2.2 The determinant variable concept

In this concept,the accident gradient was statistically clearance by verifying available data. In this concept, the data is gathered in such a way that statistical comparison will allow fair estimates of the influence of variables in specific factors on the probability of an accident.

2.3 Domino theory

According to Heinrich (1936) accident is a series of events in a predetermined methodology. In this concept,the investigator believes that removing any such activity or event which causes an accident will eliminate the accidents. For example, eliminating sharp surfaces of working to avoid future accidents.

2.4 The fault tree analytical methodology (FTA)

This methodology was developed by H.A.Watson. This methodology follows a logical pattern to develop arraying events in a flow chart with the procedure. It determines all the possible causes of accidents. The undesirable event accumulates the top event of the Fault tree diagram and represents all the possible reasons for failure or accidents.

2.5 The Energy Barriers Targets model

This model in which compared the rate of energy released and relates it to the kind of and severity of the accident. This model prevents the energy to store up in an uncontrolled way. For example separation of workers and machinery operative points by providing fixed barriers between them to avoid any kind of injury or accident.

2.6 The Management Oversight and Risk Tree (MORT, 1992)

This modelidentifies the accident-causing and contributing factors in the system. It investigates what barriers are failed and how they are failed.

- **Petersen's Multiple Causation Model**

  In this model, it is considered that human error directly causes accidents. This model includes three elements.

  i. Overload- Factors causing overload
  ii. Traps- traps are occurred due to un-control
  iii. The decision to err- these are caused due to illogical decisions taken under the situation

2.7 Swiss Cheese Model of human error and the "resident pathogens" or "Latent failures"

Defense and safeguards play a key role in the system. High technology has many defensive layers like signals, alarms etc. Some rely on people like doctors, operators etc. and others depend on procedures and rules. In an ideal world, each defensive layer would be intact, they are like slices of cheese, having many holes and the presence of any holes in any slice doesn't create a bad outcome. Usually, this can happen when the holes in many layers line up to permit a way to the accident.

In Construction Industry there are 55% of unskilled labour and 27% of skilled labour, and the remaining are technical and supportive staff. (Hemant J. Katole, 2016)

Following are the key challenges faced while adapting the labour Act:

Lack of training, improper risk management, cost, reporting shortfalls, insufficient H&S professionals, poor H&S policies, improper data collection of shortfalls, lack of H&S education, communication and workers' attitudes towards Health and Safety. (YuliaSetiani, &MuhdZaimiAbd Majid,2019).

3. Methodology

The methodology followed for the study and analysis is briefly explained in **Figure 1.**

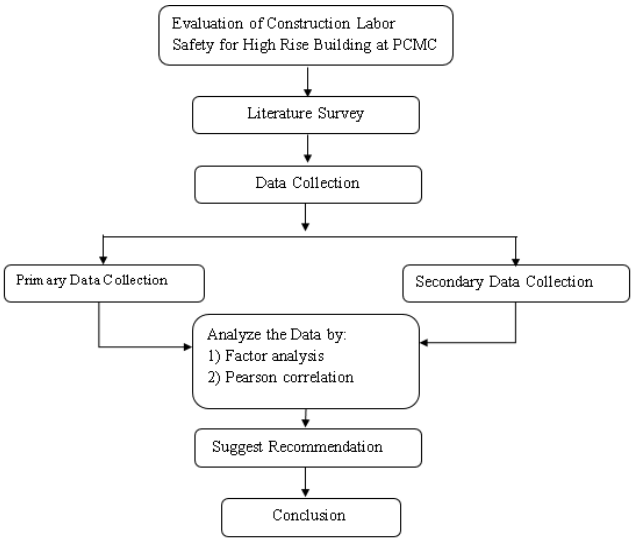

Figure 1 Methodology adopted

3.1 Preparation of questionnaire

For the analysis, part data was collected from 35 high-rise buildings in the PCMC area of Pune. This research is conducted by reviewing the literature on Construction safety published by health and safety executives and some academic journals. This was followedby preparing a questionnaire and by conducting a pilot study. Then, the Project Manager, Site Engineer and Safety officer filled out a questionnaire. The questionnaire consisted of 21 variables. Almost all the operative persons who filled out the questionnaire were so interested while filling it. The response to each question was based on the Likert Scale starting from "Strongly agree", "Agree", "Neither agree", "Disagree", and "Strongly Disagree". For data analysis,SPSS 24 was used.

4. Result and Discussion

4.1 Respondent Statistics

As this research work consists of a total of 35 sites, the questionnaire was filled by 35 respondents, which consist of opinions of project managers, contractors, site engineers and safety officers. From graph 4.1 the no. of the respondent of site engineers are higher compared to others. Then2nd most respondents are safety officers then project managers, and the least one responseis from contractors. Details about the respondents are given in **Figure 2.**

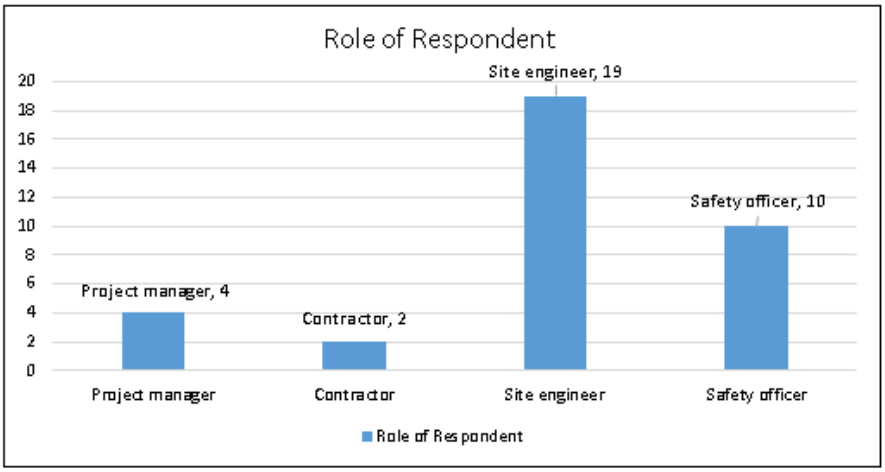

Figure 2 Details of Respondent

4.2 Respondent's work experience in the Construction field

Following Figure 3 shows the work experience of respondents. According to the survey, the maximum work experience of 37% of the respondent is 6-10 years, work experience of 22% of the respondent is 16-20 years, work experience of 19% of the respondent is 11-15 years, work experience of 12% respondent is 0-5 years, work experience of 10% respondent is 20 years. As maximum workexperience (over 20 years) respondents are only 10% compare work experience between year 6-10 years which held 37% of total respondents. Details about the work experience were given in **Figure 3.**

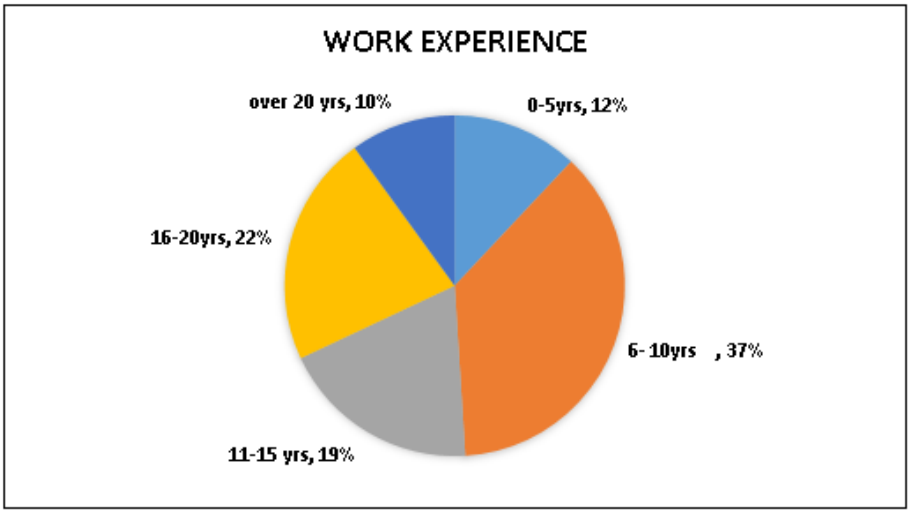

Figure 3 Work experience of respondents

4.3 Sites-wise Distribution of PCMC area

For this project work, total of 35 sites were surveyed from PCMC area. According to statistics Ravet has maximum 31% high rise sites compared to Chikhli, Theregaon, Tathwade and Chinchwad which have 14%, 12%, 11% and 11% respectively high rise sites. The remaining sites have very less no.of sites hence their percentage is less as Akurdi, Moshi, Bhosari, Pimpri, Wakad has a percentage of 3% each and Rahatani has 6% high rise sites

4.4 Reliability of Data By Cronbach's Alpha test

To measure the reliability of data or internal consistency of data Cronbach's alpha test is used. It describes the extent to which the items are closely related to each other. This test gives results as given in **Table 1**

Table No. 1 Cronbach's Alpha Value

Reliability Statistics	
Cronbach's Alpha ($\propto$)	N of Items
0.916	21

As $\propto$ calculated is 0.916, which is greater than 0.9, it means the data set contains excellent internal consistency.

4.5 Factor Analysis

Factor analysis is a technique thatis used to reduce the large data set into fewer no. of factors. "Principal Component Analysis" (PCA) using SPSS software is used. To extract maximum common variance and put it into the common score.

i) Kaiser-Meyer-Olkin Measure of Sampling Adequacy

It is a statistic that measures the proportion of variance in a variable. Values less than 0.50 indicate that factor analysis is not suitable forthe given data set. For this project work, this value is 0.652, which is greater than 0.50 so we can proceed to factor analysis.

ii) Bartlett's Test

It tests that the correlation matrix is an identity matrix and each variable are unrelated. Small values, which is greater than 0.05 significance level indicate that factor analysis may be useful with the data which is given in **Table 2**.

Table No. 2 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.652
Bartlett's Test of Sphericity	Approx. Chi-Square	535.569
	df	210
	Sig.	0.000

Table No.3 shows that the rotated factor matrix gives five-factor. The given values show that these values are included in the factors. From Table3, Q8 is in factor 1 and has a maximum value of 0.884.

Table No. 3 Rotated factor matrix

Rotated Factor Matrix					
	Component				
	1	2	3	4	5
Q_8	0.884				
Q_5	0.851				
Q_4	0.836				
Q_7	0.771				
Q_6	0.770				
Q_{10}	0.659				
Q_9	0.616				
Q_{14}		0.799			
Q_{12}		0.700			
Q_1			0.885		
Q_3			0.679		
Q_{16}			0.656		
Q_{19}				0.872	
Q_{21}				0.622	
Q_{18}				0.558	
Q_{15}					0.879
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]					
a. Rotation converged in 6 iterations.					

Table No. 4 shows the result of factor analysis. In the Rotated factor matrix, we can see the groups of variables.we just need to put them together as a group and assign a group name that formed a complete factor with a group of variables.

Table No. 4 Extracted Factors

Factor	variables	Group Name
1	Q_8, Q_5, Q_4, Q_7, Q_6, Q_{10} and Q_9	Management
2	Q_{14}, Q_{12}	Unsafe method of working
3	Q_1, Q_3, Q_{16}	Unique nature of industry
4	Q_{19}, Q_{21}, Q_{18}	Human and God Element
5	Q_{15}	Unsafe equipment

4.6 Pearson correlation coefficient

The Pearson correlation coefficient method was used to examine the complex interrelationship between the variables. **Table No. 5**shows the significance level at less than 'p'.

Table No. 5 Extracted Factors

Sr. No.	Variables	Significance level <p	Pearson correlation coefficient	Correlation order
1	Limited working area	0.031	0.365	18
2	Transient workforce	Not significant	Not significant	No order
3	Variable hazard	0.000	0.633	14
4	Poor policies	0.000	0.758	3
5	No warnings	0.000	0.772	2
6	No motivation	0.000	0.687	9
7	Poor inspection	0.000	0.786	1
8	No education	0.000	0.691	8
9	Poor site management	0.000	0.705	6
10	Poor ventilation	0.000	0.591	15
11	Poor illumination	0.000	0.696	7
12	Disobey procedure	0.000	0.757	4
13	Incorrect adaption of procedure	0.000	0.659	11
14	Knowledge level	0.001	0.556	16
15	Failure of equipment	Not significant	Not significant	No order

16	Not ergonomic	0.000	0.654	12
17	Less body effort	0.000	0.663	10
18	Less or no experience	0.000	0.734	5
19	Negligence	Not significant	Not significant	No order
20	Attitude towards work	0.000	0.651	13
21	Act of God	0.001	0.548	17

The value of Pearson's correlation coefficient with their significance level.As for the significant level at 95% confidence interval value of $\propto \leq 0.05$, values above 0. Are insignificant.
As Degree of Freedom (DF) = N-2 = 35-2 = 33

The value of 'Z' is critical . If 0.338 if Zc< Z obtained then it is acceptable. (rectoerring correlation table at df 33). The results are discussed below

- **Poor inspection (0.786**) – This variable shows the highest correlation coefficient as (sig. level p=0.031 <0.05) and (0.786,>which338), it means it is highly correlated with the data set and that is why it is ordered at number 1 position. Accidents or minor Injuries inspection on a daily or at least weekly basis should be done.
- **No warnings (0.772**) – It has (sig. level p=0.000 <0.05) and (0.772>0.338) and hence ordered at 2nd place.If something fatal is in the working a or if something related to which may cause a hazard to work should be warned before starting actual work on site. This can prevent even minor injuries.
- **Poor policies (0.758)** – It has (sig. level p=0.000 <0.05) and (0.758>0.338), it has less correlation compare to first two factors and hence ordered at 3rd position. Construction companies should involve policies which include the betterment of labour's safety. Also,the compulsoryuse of safety equipment should be included in the safety policy program. If a person met with accident, there should be company policies that compensation to the labour.
- **Disobey procedure (0.757)** – It has (sig. level p=0.000 <0.05) and (0.757>0.338) and hence ordered at 4th number. To avoid accidents while working, the worker should follow a particular procedure. Also, it should be under inspection whether a worker is following the procedure or not.
- **Lessor no experience (0.734)** - It has (sig. level p=0.000 <0.05) and (0.734>0.338) and ordered at 5th number.This component can be a cause of the accident, as if there is no experience about the work or work procedure, someone may adopt the t procedure in the wrong way which can be fatal to their lives.
- **Poor site management (0.705**) – It has (sig. level p=0.000 <0.05) and (0.705>0.338) it has ordered 6th number.Proper site management is necessary to avoid injuries site management includes assigning of work, regular inspection, time management, labour management etc. if all these things are managed well then there are very few chances of accidents.
- **Poor illumination (0.696)** – It has (sig. level p=0.000 <0.05) and (0.696>0.338) and hence ordered at 7thnumber. While working proper illumination/ lighting is necessary.

When high-rise buildings are under construction and the worker is working at night time then there are high chances of falls, cuts and short circuits. To avoid this proper illumination should be provided in the working area or to avoid working at night time.

- **No education (0.691)** – It has (sig. level p=0.000 <0.05) and (0.691 >0.338) and ordered at 8th number.Labours are not that educated or we can say some of them are illiterate so to convey a safety-related instructions to the labour use of signboards should be used on-site so that they can avoid the hazard.
- **No motivation (0.687**) – It has (sig. level p=0.000 <0.05) and (0.687>0.338) and hence ordered at 9th number. As the construction industry is a very hazardous industry and for labourers to do physical work is like an exaggeration. So to keep their enthusiasm high motivation should be given in terms of allowing holiday, providing relaxation in working hours and by increasing payment.
- **Less body effort (0.663)** – It has (sig. level p=0.000 <0.05) and (0.663>0.338) and ordered at 10th number. Giving lack of body efforts by labour can be a cause of the accident. Sometimes due to lack of body effort work is going to fail as some work need manpower to make it work out better.
- **Incorrect adaptation of procedure (0.659)** – It has (sig. level p=0.000 <0.05) and (0.659>0.338) and ordered at 11th number. The procedure should be followed by given instructions to labour as if labour trying to handle the things in his way can mislead the procedure at lead it towards the fatal incident. For that training should be given to labour-related to the procedure of work and machinery.
- **Not ergonomic (0.654)** – It has (sig. level p=0.000 <0.05) and (0.654 >0.338) and ordered at 12th number. By doing the same type of work can create muscularly or any type of pain to the worker's body. This can affect their body posture also so possible design work so that it should not do such damages to labours body.
- **Attitude towards work (0.651)** – It has (sig. level p=0.000 <0.05) and (0.651 >0.338) and ordered at 13th number. Labours attitude define everything, whether he/she going with the procedure given or not, whether he/she listens to the instruction carefully or not? It depends on their attitude towards their safety.
- **Variable hazard (0. .633)** – It has (sig. level p=0.000 <0.05) and (0.633 >0.338) and ordered at 14th number. Variable hazards include cuts by sharp edges, struck by objects, burns etc. This can lead to damage to the labour body. So labour should be aware of this type of hazards.
- **Poor ventilation (0.591) –** It has (sig. level p=0.000 <0.05) and (0.591>0.338) and ordered at 15th number**.** Proper ventilation should be provided to avoid breathing-related damages, the working area should be airy to avoid any breath stroke to labour.
- **Knowledge level (0.556)** – It has (sig. level p=0.001 <0.05) and (0.556 >0.338) and hence ordered at 16th number.Labours at least should have proper knowledge about the working procedure, working instructions, safety precautions to avoid any kind of accidents on site.
- **Act of God (0.548)** – It has (sig. level p=0.001 <0.05) and (0.548 >0.338) and hence ordered at 17th number. This includesearthquakes, Cyclones,extreme weather conditions which can create a problem for construction high-rise buildings. As chances of building collapse are highest in this condition.**Limited working area (0.365**) – It has (sig. level p=0.000 <0.05) and (0.365 >0.338) and hence listed at 18th

number. Performing so many activities at the same time in the same limited area can create confusion and leads to injuries. To avoid this there should be separate areas for separate working activity.

4.7 To increase safety following suggestions are made to implement on-site to avoid accidents

- **Safety boards-** To avoid any kind of accident various signboards on which short safety instructions are given should be provided. As some of the laborers are illiterate so by this way we can convey safety-related instruction to them by demonstrating all the safety practices.
- **Use of Personal protective kit (PPE)-**Personal protective kit (PPE) kits should be provided to every worker on site. As PPE includes-
  - Eye protection- for Blowing dust and particles, metal shaving, acid or caustic liquid, welding light
  - High visibility hat, vest, pants- for errant drivers, for distracted drivers.
  - Hand Protection- for hot and sharp objects, chemicals, biological or electrical hazards.
  - Harness lanyard- for working more than 6 feet or more above a lower level.
  - Foot protection- for falling or rolling objects, sharp or heavy objects, wet and slippery surface, prevention for electrical hazards.
  - Chaps pants- Protection for chainsaws
  - Hearing protection- To avoid loud noise of construction.
- **Safety Officer** -Safety officers always work for the health and safety of labour. Giving training to laborers, to motivate laborers for work to convey the importance of safety among all the workers is the work of Safety officer. Due to appointing one responsible person for health and safety, there are fewer chances of occurring accidents. From the survey, it is concluded that about **31.43%**of sites don't have appointed responsible person/ safety officer for health and safety.
- **Safety helmets-** Helmets should be provided to everyone who works in a place of uncertainty
- **Safety Nets-**For high rise building construction safety nets should be provided to protect the fall of any kind of material or heavy object on labour to avoid any kind of serious injury.
- **CQRA** -There is one agency called Construction Quality Rating Agency (CQRA) which is appointed as a third party by the construction company which monitored all the things going on so if the things are related to health and safety then this agency suggest it to the company. This can control the accident rate.
- **Safety Training-** Safety related training should be provided to the labour before starting actual work on site. As this can reduce injuries at the site.
- **Use of IS code on site-**All the high rise buildings should follow Indian standard IS code 16700: 2017 on 'Criteria for Structural Safety of Tall Concrete Buildings' which gives guidelines to structural safety and serviceability of tall buildings

Conclusion

1. The administration of the project, unsafe working practises, peculiarities of the industry, the role of God and humans, and unsafe equipment are the main accident-causing causes for the high-rise buildings in the PCMC area of Pune.
2. 2. Only 40% of the sites agreed that the value of labour safety impacts project costs. If some businesses don't take this into consideration, they should. The cost of workers' safety equipment or welfare is a major factor in the value of labour safety.
3. Proper training should be given to the workers at high rise construction sites to prevent accidents and injuries; an appointed safety officer should help with this.
4. Costs associated with worker safety have grown because to the present COVID-19 pandemic situation. Masks, sanitizer, and weekly COVID-19 testing should all be provided.
5. Realism in setting up each worker's safety responsibilities can help to lower the likelihood of accidents. additionally contribute to enhancing the building site's safety performance.

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