

Construction Site Safety Performance Analysis For Improving Industrial Safety And Reducing Workplace Incidents

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Abstract

Construction environments are inherently hazardous due to the dynamic nature of activities and constant human-machine interaction. Workplace mishaps not only compromise worker well-being but also impact project timelines and budgets severely. This research explores the multifaceted causes behind construction site accidents and delves into how these incidents degrade safety performance. Emphasis is placed on understanding both behavioral and situational contributors to accidents, including human error, lack of training, insufficient supervision, and poor environmental conditions. A comprehensive literature review was conducted by examining previous scholarly works that focus on construction safety management and accident analysis. The study further classifies critical influencing elements such as demographic factors like age, psychological aspects including behavior and stress, ergonomic mismatches, inefficiencies in communication, gaps in safety policies, and ineffective site supervision. Each of these components is critically examined to understand their linkage to accident frequency and severity. Findings reveal that both the awareness and implementation of safety procedures among site personnel are inadequate. Also, an aging workforce contributes to increased vulnerability, highlighting the need for ergonomically adaptive solutions. Enhanced communication strategies, continuous training programs, and strong managerial commitment were found to be essential in minimizing risks. In conclusion, the study presents a strategic framework involving preventive measures and practical solutions aimed at elevating safety standards and minimizing future occupational hazards in construction sites.

Keywords: Construction Safety, Workplace Hazards, Accident Prevention, Ergonomics, Risk Management, Safety Performance

- **1.Introduction:**

The nature of construction site is unique, dangerous and dynamic (Fang and Wu, 2013). Different working process is carried out in the construction site and it is a large workplace where many workers are involved in their work. Workers working in the construction site are exposed to various types of occupational health hazards due to occupational health risks (OSHA). Accidents are caused because of numerous unsafe acts and unsafe condition in the construction site. Comparing with other industries there are lot of tools and equipment in the workplace which can easily injure the worker and the percentage of risk is high during working. Therefore the accident possibility is high. According to National Safety Council the rate of fatal work injuries escalated from 8.9 to 9.2 from the year 2018 to 2019 (National Safety council).

Safety is highly considered because it affects the image of the organization as well as the employees at the highest level in the organisation. For completing a project successfully the key elements are estimated cost, duration of the project, quality and the most important element safety (Wanberg et al., 2013). According to ILO (International labour Organization) every year across the world approximately 2.3 million workers both men and women die due to work related diseases and accidents. According to International Labour Organisation (ILO) annual report of work related illness and occupational accident worldwide is around 160 million and 340 million (Occupational Safety and Health – ILO). According to 2014 Poland accident statistics, the Poland construction industry accident rate was very high. The accident rate was 7.45 people injured per 1000 workers. Out of 88,000 accidents 263 peoples were killed (Statistics Poland). Comparing with the smaller construction companies bigger construction companies are likely to encounter with at least one fatal accident even though they have good safety atmosphere (Arquillos et al., 2012). The construction companies currently aims at resulting in zero accidents in workplace (Sanni-Anibire, et al., 2020).

Amiri et al. (2017) explained about the various assessment techniques that were introduced over the years by combining various methods. Management, man, machine, material and environment are the five major accident contributing factors (Shao et al., 2019). Heinrich proposed theories to mitigate the accidents like domino theory and many research are also made to prevent the accident but still the accidents continue to happen in the workplace. In Albert et al. (2017) experimental study identified that workers cannot identify 55% of hazards, if hazards are not identified accidents can't be mitigated. According to

Hallowell and Gambatese (2009) 20% of fatal accidents are reported in the United States construction industries but the amount of employees working are only 6% in the workplace.

In addition there are six factors that will affect the construction safety they are educating workers and supervisor with safety knowledge, safe working condition, contractor and sub-contractors control, safety training, assigning duty to all workers and management and finally safety training. Further studies conducted by Hinze and Gambatese (2003) found some elements that will improve the construction site safety like implementing drug alcohol test and contractors should reduce the worker overturn. Tam et al. (2004) study found out that safety performance affecting elements in Chinese construction industry is reckless working, poor training, reduced safety awareness of management and managers. In addition Aksorn&Hakidusumo (2008) research concluded that the eminent element was management support.

Omran et al. (2010) study found that the good communication is one of the factors along with active employee participation, resource allocation and developing safety committee will provide an impact on safety performance in the workplace. Jitwasinkul&Hadikusumo (2011) study found that in Thailand construction industry 7 factors were identified to improve the safety in the workplace they are reward system, leadership, safety learning, culture, management commitment and communication with employee. Hasan and Jha (2013) study found six important factors to develop safety performance from 32 Indian construction projects that is safety equipment, labor training, safety committee, safety equipment's, penalty, special attention to risky operation and finally incentives. Physically demanding work is needed in the construction workplace; since there may be many distraction or barriers in the site. Each person has a role to reduce hazard (Mroszczyk., 2015). It also provides job for many people (Mohammadi et al., 2018). Over the years more amount of research has been developed yet construction accidents are increasing more and more.

2. Methodology

2.1. Literature search and article selection

Literature papers collected are associated with the safety practices and safety problems in construction sites. The journals used in these studies were collected by manual search in Google scholar, Google search engine and in various databases such as Taylor &

Francis Online, Scopus database and American Society of Civil Engineers (ASCE) library. The manual search includes the key terms like construction site accidents and injuries, causes of injuries, human behaviour, ergonomics in construction, workplace hazard and trench work. Next, based on the manual search performed in the databases and search engines yielded 535 reference papers. This search includes journals and conference papers. The collected paper titles, abstract, key words were reviewed and some papers that are not relevant to the key terms were excluded on the first stage.

On further screening in the second stage papers are classified in accordance with the inclusion criteria, 1) The document should emphasize on the work related accidents in construction site, 2) Health hazards and injuries caused in construction site, 3) Unsafe condition and behaviours in the construction site, 4) Ergonomics influencing construction safety, 5) Safety performance, 6) Age and drug/alcohol factor, 7) The journal was in English, 8) It was published in an peer-reviewed journal. Altogether 259 articles were selected which fit the criteria. However, on the final stage the screening process continued by selecting the papers having a relationship between the inclusion criteria and the construction industries. Finally it was decided to choose 90 papers for review which was matching all the given criteria.

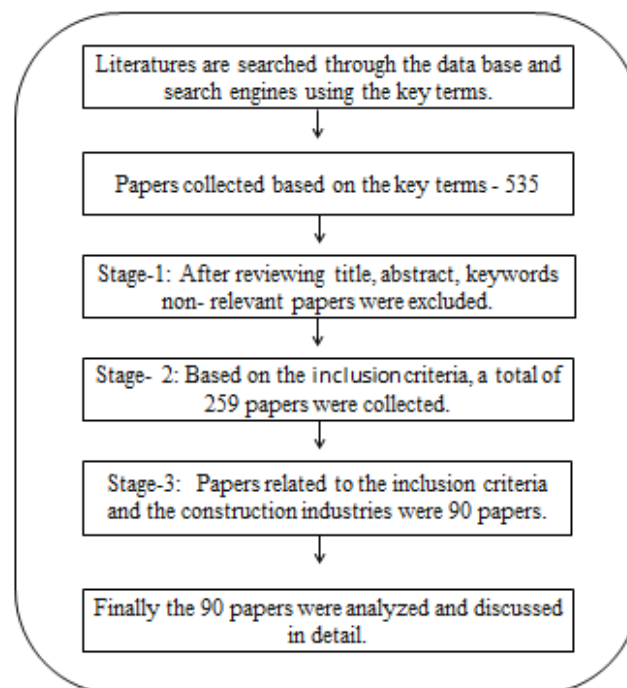


Figure 1- Methodology Flow Process

3. Result

After analyzing the 90 literature papers, factors affecting the construction site safety and the workers performance were categorized and discussed. A sample literature review is represented in table.5 from the collected 90 papers. Several site safety affecting factors are classified and described; further the factors are classified into sub sections and discussed in detail. All kinds of construction accidents and the cause of the accident are also discussed.

4. Discussion

All the factors causing accidents and affecting safety performance are categorized separately and discussed in detail (Figure.1).

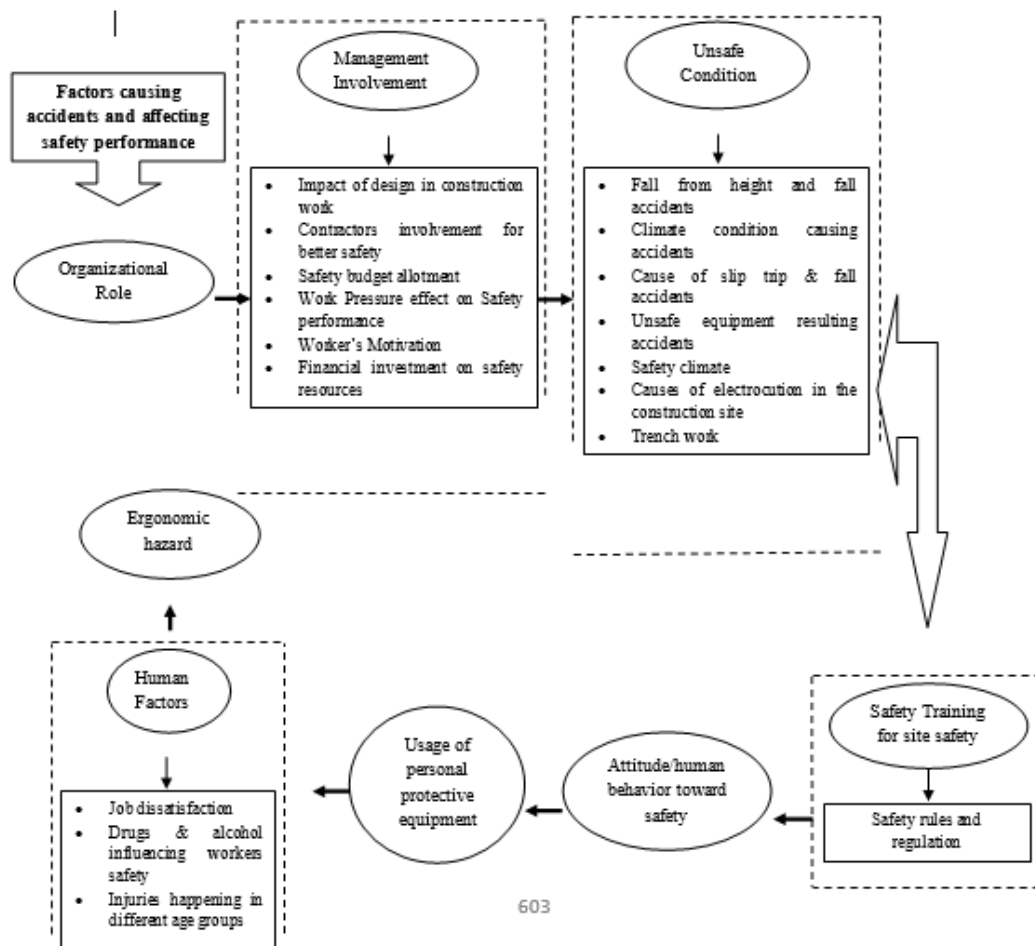


Figure. 1. Factors causing accidents and affecting safety performance.

4.1. Organisational role

A wide range of studies explain about the organisational function in construction projects. According to Cheng et al. (2010) small and medium construction enterprises have an impact on safety growth because the rate of accident is high in relation to the big construction companies. These higher accident rate is due to some reasons like failure in labour safety law, poor management skills, poor safety awareness, fail to enforce H&S (health and safety) policies and insufficient safety measures (Cheng et al., 2010). Feng et al. (2015) found that indirect cost in accident is incurred by large projects and small or medium enterprises will not consider safety as a main objective. Cheng et al. (2010) explained about employee's not giving importance to health and safety practise is a factor causing occupational accidents in small construction companies. Small construction firms conduct work with poor OHS (occupational health & safety) supervision. Fung et al., (2010) stated that applying various risk assessment techniques will effectively help in identifying the hazards and then eliminating it one by one from the workplace. Using various other safety performance tools will also improve the site safety (ex: Fuzzy risk assessment) (Amiri et al., 2017). Sanni-Anibire et al. (2020) stated that through a proper risk assessment technique safety performance and hazards can be eliminated. This includes select a safety performance, identify the potential hazard & causes, estimate risk score, estimate hazard severity, rate the overall risk, after risk acceptance & documentation process eliminate the identified risk immediately.

4.2. Management involvement/commitment

Management commitment is a key in safety performance (Lai et al., 2011). Management guidance and its full commitment are essential to achieve successful employee safety by implementing health and safety programs (OSHA guidelines). The primary reason behind the accident is due to management, thus management holds the responsibility to prevent the accidents. From Heinrich's point of view the reason behind accident is management and people. Safety management is the mostly advised technique to upgrade safety in construction site. The key to attain safety in an organisation and to improve organisational performance is through safety management. Fatal construction accident causes heavy financial loss to the organization and personal loss also (Forteza et al., 2017; Feng et al., 2015). The study revealed a lack of accident investigation from management side had an impact on the injury and accident rate. Accident investigation is an effective method;

investigating accidents can prevent the accident and eliminate the hazard (Hoła and Szóstaka, 2017). To prevent the similar accidents happening again and again, investigate about the previous accident root cause to implement safety system and to avoid the accident (Al-Khaburi et al., 2018).

Employer should supply adequate resources to protect workers and to maintain workplace safety. It should look forward to eliminate the hazard in the workplace and the management should value workers health (OSHA Guidelines). According to Choudhry et al. (2007) management commitment and involvement towards effective training can build a good safety culture. Management should frame or introduce equipment maintenance system replacing the old equipment with safe equipment (Birhane et al., 2020). The managers should have safety records about previous accidents, injuries and incidents for future use like accident investigation (Mohammadi et al., 2018). Top management personal safety behaviour & work attitude will affect the worker behaviour (Jitwasinkul and Hadikusumo, 2011). Singh and Misra (2021) states that exceptionally strong safety performance can be seen once there is a top management involvement is established.

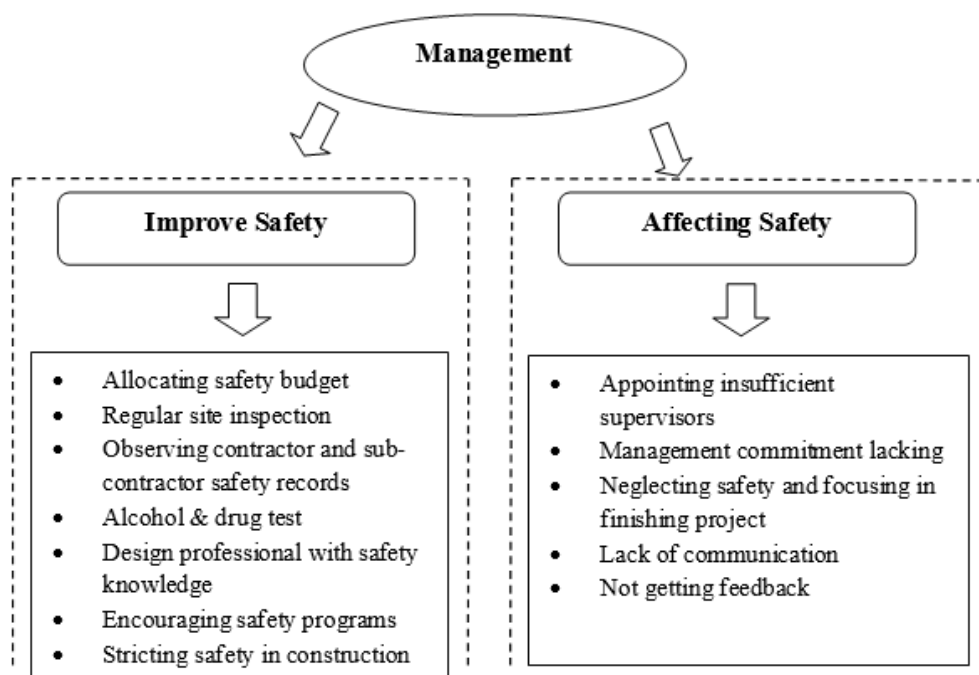


Figure. 2 Factors which improve and affect site safety.

Management commitment & involvement will be an example for safe behaviour among workers (Stoilkovska et al., 2015; Jiang et al., 2014). Top level management have to value safety to develop a safety culture. Stoilkovska et al. (2015)explained that safety programs can be designed by getting feedback on safety climate awareness fromworkers.Hallowell & Gambatese (2009) declared about these important safety programs that are top management support, commitment and sub-contractors selection. For bettersafety compliance worker and management can discuss about safety awareness measures and establishing the safety ruleseffectively. Additionally, to avoid safety challenges hazard identification needed to be completed prior to construction(Hallowell et al., 2013).In Chi et al.(2013) study result,supervisors and top management need to pay more attention on risk factors to control them andgain a safe workplace.

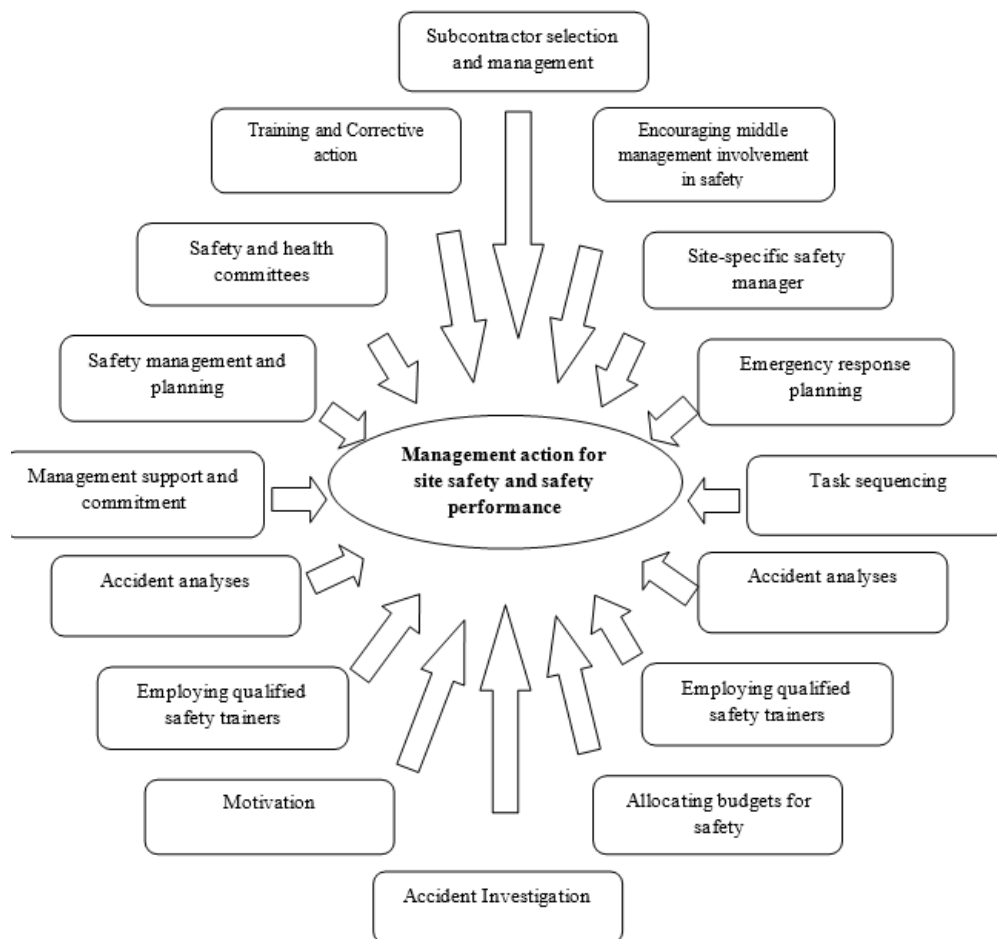


Figure. 3Management action for site safety and workers safety performance.

Other factors to mitigate construction injuries are management have to allocate appropriate budgets for site safety (PPE, Safety training) and management have to take necessary corrective action against all workplace employees with unacceptable actions (Birhane et al., 2020). Management can increase the workers safety performance and site safety through positive management commitment, support, planning, safety and health committees, accident analyses, employing qualified safety trainers, task sequencing, emergency response planning, site-specific safety manager, encouraging middle management involvement in safety training, subcontractor selection and management, motivation, allocating budgets for safety, corrective action and accident Investigation (Figure. 3).

Further to improve site safety allocate safety budget, carry out regular site inspection, observing contractor and sub-contractor safety records, conducting alcohol & drug test, appointing design professional with safety knowledge, encouraging safety programs and stricting site safety in construction (Figure.2). However there are other elements which have an impact on site safety like appointing insufficient supervisors, management commitment lacking, neglecting safety and focusing in finishing the project, lack of communication between workers and supervisors and not getting feedback from worker (Figure.2). Further the safety management includes the impact of design in construction work, contractor's involvement for better safety, safety budget allotment, work pressure effect, worker motivation and financial investment on safety resources.

4.2.1 Impact of design in construction work

Construction safety design can be used in construction; it can avoid a lot of dangerous operation reducing the chance of incidents and accidents. Whenever possible, design professionals have to eliminate the hazards by changing the design of the project (Mroszczyk, 2015). Designers should think about workers safety before designing the project (Ex: avoiding work at height, stairs used instead of scaffolding) and maximum reducing the usage of hazardous materials in the work. Safe design planning can be developed for a construction building to prevent the hazards and to mitigate risk, if not other methods like engineering methods and safety devices can be implemented (Mroszczyk, 2015). Hallowell et al. (2013) stated that 42% of the construction fatalities are connected with the project design phase. Simultaneously Choudhry (2015) stated that safety can be improved through a better safety design. Wanberg et al., (2013) research about quality and safety came to an end stating that the workers injury rate in OSHA records is due to rework occurred in the construction site.

4.2.2 Contractor's involvement for better safety

Construction site is a workplace with multiemployer. A project has more than one contractor along with a subcontractor and site safety responsibility is in the hands of general contractor (Mroszczyk, 2015). Everyday general contractor must monitor and oversee the subcontractor operations and also has the responsibility of removing the workers due to their unacceptable behaviour or unsafe acts (Toole, 2002). The contractor must comply with the contractor health and safety rules, once the project is handed to the contractor (Hallowell and Gambatese, 2009). Monitor the workplace and check with contractor for any safety assistance, discuss about upcoming work safety and have toolbox talk with workers (Mroszczyk, 2015). More than profit, contractors mind should stick to safety. As the project works moves from one subcontractor to another subcontractor there is a risk of not noticing the hazard or the hazard becomes undetected as the project meets to its deadline. Most of the contractors provide only basic training, 11% of the contractors doesn't provide training, 65% of contractors provide training once in a while and only 24% of contractors provide a proper training (Tam et al., 2004). Subcontractor should make sure individually that the employee is trained and he is technically, mentally and physically capable for the job. General contractor should ask subcontractors to submit their training program of every specific work in the site. Subcontractors also need to conduct regular inspection, training about hazard identification and hazard avoidance and develop a site safety plan (Mroszczyk, 2015).

4.2.3 Safety budget allotment

One of the major elements challenging the construction workplace safety is lack of initial budget allotment (Durdyev et al., 2017). In most of the construction industries fund allocation from project budget for health and safety is very less (Kemei and Nyerere, 2016). Allocate a safety account to assign the cost, adopt a monthly reporting system about accident cost. Due to poor safety performance some countries invest on safety standards to reduce the injury level (Sanni-Anibire et al., 2020). Voluntary safety investment is a worthwhile investment and more effective in preventing accidents (Feng, 2015). From financial aspect the project cost affecting factors are design errors, contract price, quality and rework (Mohammadi et al., 2018). Spending budget on safety will reflect in high productivity, this is a general assumption between production and safety but the truth behind this is that both support each other (Jiang et al., 2014). Cost of the project is reduced by reducing the safety budget but the side effect of long term exposure to high risk will result in occupational

injuries. Completing a project within the given time is a main issue in construction companies (Choudhry and Fang, 2008). The project must be finished by giving importance not only to time, quality and cost but also to the workers' health.

4.2.4 Work pressure effect on safety performance

To achieve the target workers are forced (work pressure) to extend their working hours and not following proper procedures and taking shortcuts to end the work quickly (Choudhry and Fang, 2008). Various work pressure influence safety in construction site. Work pressure includes workload, working time, production pressure, working pace, schedule delay, overtime and fatigue. Construction site is always under more pressure mostly because of work delay (Guo et al., 2015). Han et al. (2014) study emphasis about work delay or schedule delay is an important factor influencing accident occurrence. Considering the production and safety the production wins more often, under production pressure more priority is given to the production than safety (Guo et al., 2015; Han et al., 2014). The production pressure cause the supervisor to focus less time on site safety, even support workers to take shortcut to equalize the delayed work schedule.

Han et al. (2014) explained that when work load exceeds the worker potential, then task becomes hard and affects safety. Increasing the working time and pace can increase the productivity and steadily meet the schedule delay. Patel and Jha, (2015) discussed that when workers are under work pressure frequently they adopt hazardous behaviour to finish the job quickly. Work pressure is increased when quoting a worker, saying "hurry up" "finish it fast" and the person responsible should be aware of the importance of performing the task at a fast pace in the workplace (Hoła and Szóstaka, 2017). Moreover, the cause for fatigue is work overload which will affect the workers' health condition (eg: lack of sleep) (Jiang et al., 2014). Exhausted workers are at a greater risk of accidents and also become a victim of mental disorder (Jiang et al., 2014).

4.2.5 Workers motivation

Motivation in a work can be described as job satisfaction, reward and wages (Asad et al., 2005). The prime motivational element to improve contractors and workers performance is to provide incentives (Hasan and Jha, 2013). Effective incentive programs are given to the workers who are showing appropriate safety behavior in the workplace (Hasan and Jha,

2013). By motivation, construction workers compliance towards safety rules can be achieved (Shin et al., 2015).

4.2.6 Financial investment on safety resources

Financial investment on safety resources represent the amount of safety personals appointed to handle the safety issues, along with the availability of safety equipment, materials and other safety resources on the workplace (Jiang et al., 2014). So, shortage of supplying protective equipment in the workplace plays a crucial part in increasing the occupational injury. It also indicates the occurrence of occupational accidents when PPE's are not used correctly, when workers ignoring warning signs of hazards and not following safeguard policy (Cheng et al., 2010). Safety resources are needed for supplying the essential facilities and equipment's along with good safety procedures (Fraizer et al., 2013; Jiang et al., 2014). Safety equipment's must be supplied on construction sites to safeguard workers using fences, barricades, PPE's and other necessary facilities to perform the work safely (Feng, 2013). However using safety equipment will not reduce the accident, because worker has to perform the job safely. To perform the work safely and to control the accident worker should know the appropriate equipment that will suit the job, history of last maintenance and inspection must be known and finally carry out the work with the equipment (Toole, 2002). As a result that knowing the equipment maintenance & periodic inspection, selection of equipment and the proper way of using it are the factors which will improve the safety standards and productivity at the workplace (Chi et al., 2013).

4.3 Unsafe condition in the workplace

Construction site is a changing environment. Construction activities are complicated because of outdoor operation (Khosravi et al., 2014). The workplace has high range of hazards which makes it difficult to create safety and the fatal accident rate is also still high (Mroszczyk, 2015). Occupational accidents are influenced by the working environment or by work system (Shin et al, 2015). Construction operation happens in a continuously evolving environment with growing site conditions. Work condition covers a wide range of additional factors like unsafe condition, health and safety condition and the workplace environment. Unsafe act and unsafe condition is the key reason for accident in the workplace (Tam et al., 2004). There are various concepts which explain the happening of unsafe acts and unsafe condition this concepts will be Domino concept, Multiple Causation concept and Human Factor concept (Ali et al., 2010). Different projects have different accident patterns but

proceeding with the accident pattern is reliable (Shao et al., 2019). Construction work needs large number of work force so increased number of workers in the workplace can result in a risk of causing accident (Mersha et al., 2017).

Safety managers or supervisors can eliminate the unsafe act by terminating the specific unsafe condition (Chi et al., 2013; Choudhry, 2015). Cheng et al. 2010 concluded that unsafe condition lead to occupational accident occurrence. Human error and individual negligence can be controlled by the working personal because it's within their ability. Construction operations are often risky due to complicated design, work at height, worker behaviour toward safety and equipment operation (Choudhry & Fang, 2008). Other reasons behind crane accidents are poor operator skills, overturning, improper assembly or erection, lack of maintenance and inspection (Figure.4)(Sanni-Anibire, et al., 2020). According to Sanni-Anibire, et al. (2020) other noted factors leading to accidents are lack of maintenance inspection and improper assembly.

Table 1

Cause of chronic health hazard in the workplace

No	Cause of chronic health hazard
1	Asbestos (insulation board, ceiling tiles)
2	Corrosive materials (Concrete, brick)
3	Compressed air Surroundings (tunnels)
4	Polluted ground and contaminated substances (Ancient buildings, gas work)
5	Hazardous Materials
6	Harmful radiation (Welding)
7	Improper Housekeeping
8	Physical hazard (Heat,Noise,radiation from nuclear power plant)
9	Vibratory tools

Taking shortcuts, misperception of risk, tiredness, fatigue, poor communication, inadequate space, poorly assembled scaffolding and lack of sufficient light are some accident causing elements (Mroszczyk, 2015). Job hazard analysis also has to be done regularly to eliminate

the occupational hazards. Employees at the worksite are subjected to different health hazards such as dust, noise, chemicals, radiation and temperature (heat & cold) (El-Shafei et al., 2018). If the exposure to silica is continued then the worker would encounter serious injuries. So monitor the dust and smoke level in the workplace environment to avoid health hazards because Silica and sand dust can cause respiratory problems. In addition usage of asbestos in the workplace, corrosive material, compressed air surroundings, harmful radiation, polluted ground and contaminated substance, Hazardous material, improper housekeeping, physical hazard and vibratory tools will cause chronic health hazard (Table.1);

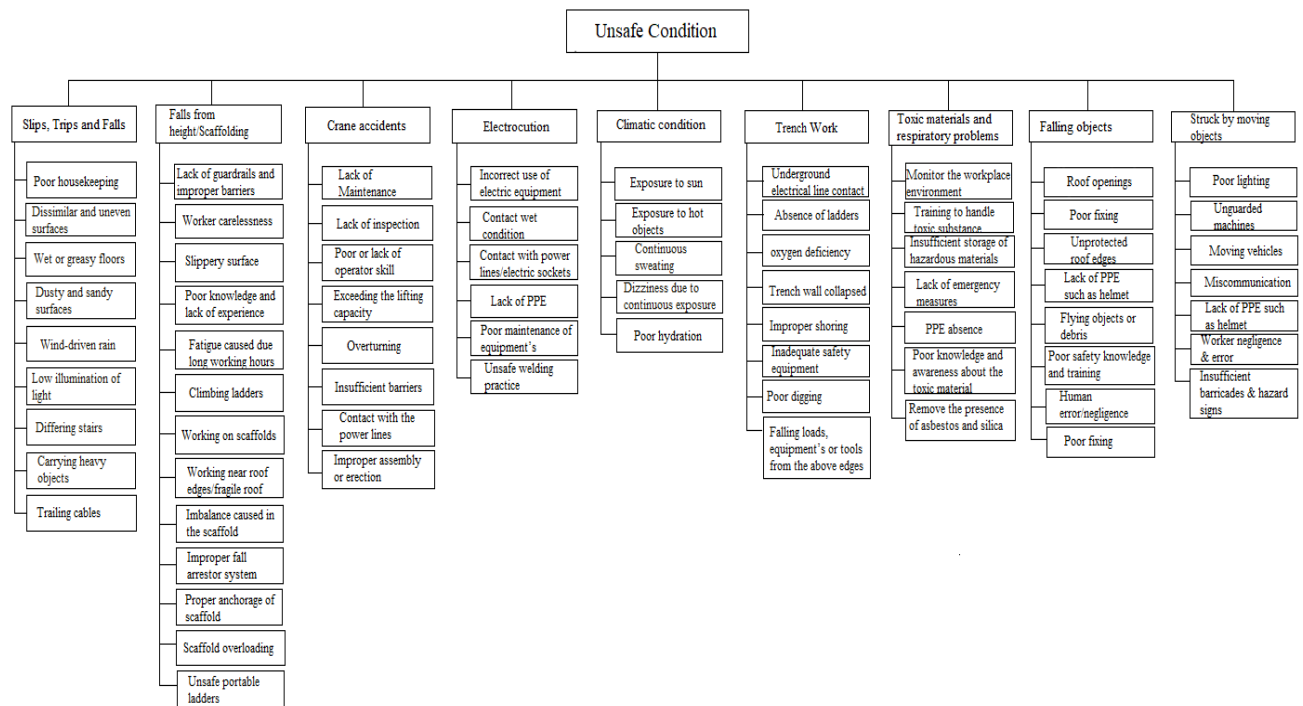


Figure. 4 Unsafe condition factors

continuous exposure will result in fatality. Toxic materials and respiratory problems arise due to insufficient storage of hazardous materials, PPE's absence, poor knowledge and awareness about the toxic material, remove the presence of asbestos and silica, lack of emergency measures, not given training to handle toxic substance and not monitoring the workplace environment (Figure. 4). During the start of the work or the operation, workers fail to identify the unsafe condition due to this the workplace becomes unsafe and accidents and injuries happen (Ali et al., 2010). Hazardous materials could increase the severity of workers health due to poor knowledge/awareness about toxic material, insufficient storage of hazardous material, PPE absence and lack of emergency measure (Yilmaz, 2015; Fung et al., 2010). Workers must be well trained to handle the toxic and hazardous materials (Sanni-Anibire, et al., 2020). The mostly occurring unsafe acts are ranked (Figure. 5).

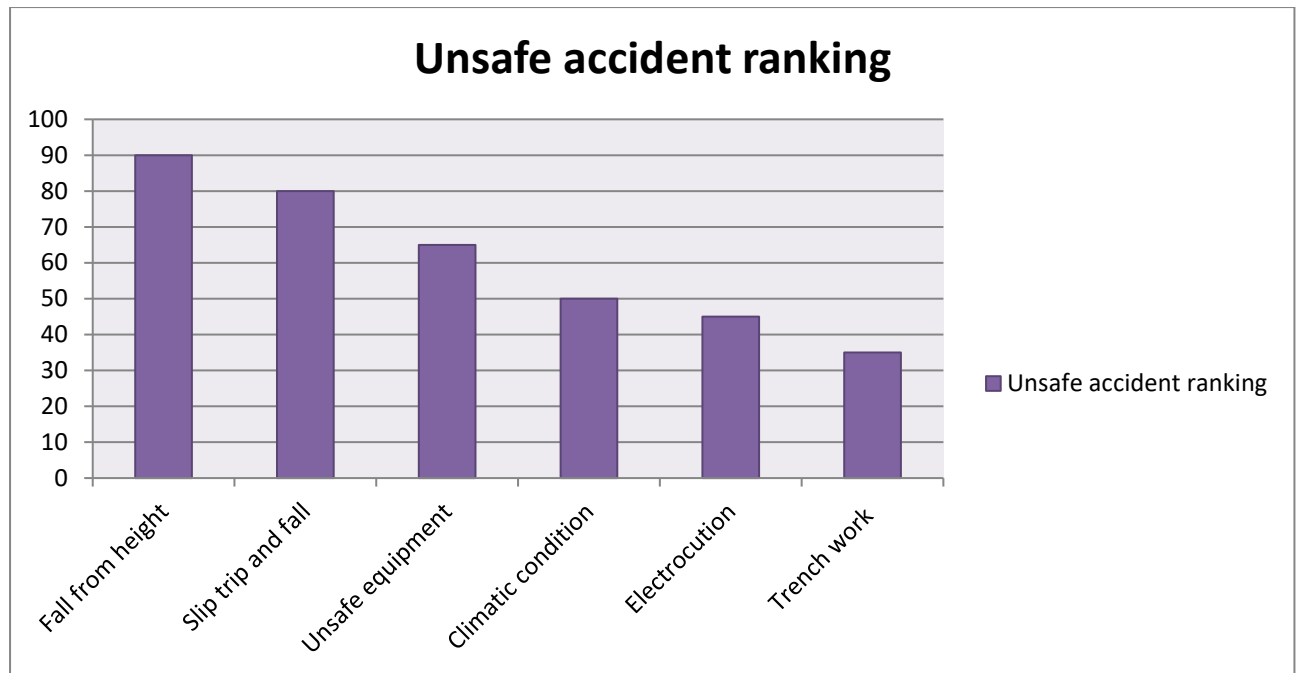


Figure. 5 Unsafe condition ranking

4.3.1 Fall from height & fall accidents

Fall from heights, hit by falling objects, machinery related accidents are the frequently reported accidents in some studies (Khashaba et al., 2018; Zerguine et al., 2018). Construction work is normally related to scaffolding and ladders, often workers have to work at heights. In Seokho chi (2013) analysis out of 3124 accidents 1114 was due to fall from height (fall from ceiling floors, scaffoldings and ladders). According to the report of Great Britain Health and Safety executive, the main kind of fatal accidents occurred is like struck by falling or moving objects and fall from height. Comparing with other industries the number of fatal accident is high in construction industries (Health and safety executive). In addition from the analyses fall from height hazards include climbing ladders, workers working near roof edges, slippery surface, working on scaffolds, scaffold overloading, proper anchorage of scaffold, unsafe portable ladders, imbalance in the tubular scaffold (occurs when the worker stretch his body while he is standing in the scaffolding platform), fatigue, lack of guardrails, Poor knowledge and lack of experience, worker carelessness, improper fall arrestor system and unsafe roof corners (Figure. 4) (Fung et al., 2010; Haslam et al., 2005; Sanni-Anibire et al., 2020).

Falling objects are because of tools equipment kept in unprotected roof edges, roof openings, lack of PPE such as helmet, flying objects or debris, poor safety knowledge, human

error/negligence and poor fixing (Figure. 4). Struck by moving objects is also a major threat in workplace, these accidents happen due to poor lighting, working with unguarded machines, moving vehicles in the construction site, lack of PPE such as helmet, worker negligence & error, miscommunication, insufficient barricades & hazard signs in the workplace (Figure. 4). From statistical analysis it is concluded that male workers fall often in outdoors and female workers fall often inside (Chi et al., 2005). For example, when a worker is standing on a tubular scaffold, there is a chance that the tubular scaffold will breakdown due to the imbalance caused by the steel plate that is present beneath the scaffolding and not properly installed fall arrestors will fail to prevent the worker from falling. Proper erection of scaffold with proper support to make the structure immovable, barriers, fall arrestors, guard rails and safety belts must be used during work at height (Sanni-Anibire, et al., 2020). Ladder usage can be avoided if stairs are installed early. Installing guardrails, anchors and barriers will help preventing the fall and for protection (Mroszczyk, 2015). If the working height is over 3 meters then correct use of designed equipment to prevent the fall, suitable PPE, emphasis safety training and safety awareness for workers before the work (Worker safety series, Construction Pocket guide).

Hit by falling objects or debris can result in serious injuries this is caused because of placing the objects at the edge of the scaffolding or roof edge and keeping the tool or equipment unfenced (Yilmaz, 2015). Along with human error, poor fixing, unprotected roof edges, lack of PPE (helmets), poor safety knowledge and roof opening can lead to fatal accidents (Haslam et al., 2005; Fung et al., 2010; Sanni-Anibire, et al., 2020). Struck by moving object in the workplace can cause similar injuries as hit by falling objects and fall from height. Impact of struck by moving object is because of poor lighting, unguarded machines or equipment (ex: circular saw), moving vehicles in the workplace, lack of proper PPE's, miscommunication, insufficient barriers and worker error or negligence (Yilmaz., 2015). The injuries caused are major injuries like broken bones and neck fracture. From the studies it is noted that the most commonly injured body parts are lower limbs, upper limbs, hands, trunk skull fracture, pelvic fracture, intra thoracic injury and vertebral fracture (Khashaba et al., 2018).

4.3.2 Climatic condition causing accidents and health hazards

In construction industry large numbers of self-employed and migrant workers are employed, they are unaware of the job and they are not familiar with the working process.

Further, employees are exposed to bad weather and working in this type of weather condition can cause health related problems to the workers. It will be even more risky when the weather is bad along with complicated site plan and complicated site condition (Goldenhar et al., 2003). This kind of climatic condition will be due to continuous exposure to sun, exposure to hot objects, continuous sweating, dizziness due to continuous exposure and Poor hydration (Figure. 4). Working in a place where the temperature is high or the exposure to hot objects will likely increase the heat stress of the worker (Dalia et al., 2018). Working for a long duration of time under hot or humid climate can affect the worker health condition, so this can cause heat stroke (Bhole, 2016). Heat exposure affects both workers health and working performance (Fung et al., 2010; Yilmaz, 2015). Heat exposure can cause several health effects like heat stroke and damage to organs. Heat stroke can occur due to hot condition and tissue damage due to cold condition. The heat effect also includes heat rash, heat cramps and heat edema. Dutta et al, (2015) reported that symptoms of heat illness are dry mouth, dark coloured urine and sweating. Heat illness symptoms identified are dizziness, cramps, muscle pain and sweat (Dalia et al., 2018).

Montazer et al. (2013) study using USG (Urine specific gravity) found that the construction workers hydration level is low creating a high risk of heat illness. Excessive sweating is also considered as causing distress, discomfort and behavioral changes resulting in accidents. Azhar et al. (2014) mentioned that dizziness, loss of coordination, sweating, headaches, are mostly seen symptoms in site. To minimize health hazards, accidents and injuries due to heat proper hydration to body will prevent heat illness (Buniyaet al., 2020).

4.3.3 Cause of Slip trip and fall related accidents

The STF (slip trip and fall) accidents are caused due to carrying and movement of the worker from one level to another level resulting in serious injuries or death (Hoła and Szóstaka, 2017). The cause for slip trip and fall can be because of various activities like liquid spills (oil), floor tiles which are dissimilar, uneven surfaces, dusty/sandy surfaces, wind-driven rain, low illumination of light, debris (wood dust), damaged or differing stairs with no hand supports, wet or greasy floors, ladders, poor housekeeping, trailing cables and ramps without skid-resistant surfaces (Figure.4) (Fung et al., 2010; Haslam et al., 2005). Pulling and carrying heavy objects in the stairs can be a hazard as it may lack railing and surfacing (Lipscomb et al., 2006). Hoła and Szóstaka (2017) analysis show that worker movement on flat area when returning or going to another level resulted in fatal accidents

(slip, trip and fall) causing death or severe injury. Slip and fall will also cause non-fatal injuries like sprain, contusions, dislocations of bones, cuts, bruises and in some cases there is a chance of occurring fatal injury also. The body parts affected due to slip, trip and fall is head, trunk and neck (Lipscomba et al., 2006). Providing anti-skid mats for wet floor and good housekeeping can reduce the risk of accident (Sanni-Anibire, et al., 2020).

4.3.4 Unsafe equipment resulting accidents

Using unsafe equipment can increase the risk of accident in a workplace with potential hazard (Haslam et al, 2005; Ali et al.,2010). The use of unsafe equipment leads to work related injuries and accidents. The reason behind unsafe equipment is due to lack of equipment maintenance and use of old equipment's (Al-Khaburi et al., 2018). According to Hamid et al. (2008) operating equipment without any safety measures or without any safety devices will result in incident. Carpenters' using handheld machines or defective tools has higher risk of happening finger injuries during the work (Ali et al., 2010).

4.3.5 Safety climate

Safety climate is multidimensional (Goldenhar et al., 2003). There are many studies on safety culture and safety climate on the construction site over the years (Meliá & Becerril, 2009). Safety climate provoking factor in one workplace will not be the same in another workplace. Less management commitment to occupational health and safety is a reason behind unsafe work climate (Buniya et al., 2020). Safety climate can be achieved by transformational leadership; through transformational leadership safety knowledge can be imparted, so this will have an influence on safety behaviour and can build a safety culture (Shen et al., 2017). Safety culture is viewed as a safety attitude guideline and organization value about safety, safety climate is a picture of safety culture in a workplace (Wu et al., 2015). Feng (2013) identified that without improving safety culture, safe environment cannot produce good safety performance. The organisation has to develop a safety culture which will improve worker potential, skills, worker participation in identifying hazards and reporting incident on the workplace (Jiang et al., 2014). It's always safe to make sure safety climate in the working environment because it is a main factor to prevent illness and accidents. To achieve positive safety culture, from previous studies it is identified that worker commitment, supportive environment, management involvement, competence, attitude all of these contribute to the safety climate drawback (Pinto et al., 2011). Strong leadership will impact safety behaviour of the working personals (Jitwasinkuland Hadikusumo, 2011). Owners

leadership and involvement in construction site is the primary requirement to create and improve safety management, project foreman strong leadership determine quality and crew safety because foreman act on behalf of the management (Wanberg et al., 2013). In fact foreman guidance and communication are the elements that will develop a good safety climate in the workplace (Wu et al., 2015).

4.3.6 Cause of electrocution in the construction site

It is found that fatal accidents are caused due to electrocution and this could be prevented if lockout tagout system is used (Demirkesen and Arditi, 2015). Electronic equipment's should be used by keeping the floor dry, thus electrical shock can be avoided. In addition unsafe welding practise, incorrect use of damaged equipment, poor maintenance of equipment's, lack of PPE's, unsafe welding practice, contacting wet condition and contact with power line or sockets(Figure. 4) (Fung et al., 2010; Sanni-Anibire, et al, 2020). For example when welding, the connection wires will be lying around in the ground so by keeping the ground dry and free from water, electrocution can be avoided.

4.3.7 Trench work

Trench can cause serious damage if it collapses. Machinery kept near the trench can collapse the wall, causing damage to the worker working inside the trench (Khosraviet al., 2014). Improper shoring, flooding, inadequate safety equipment, underground electrical line contact, falling loads and equipment's from the top edges, trench wall collapse, absence of ladders, oxygen deficiency and poor digging will be some causes for accident(Haslam et al., 2005; Sanni-Anibire, et al., 2020). Trench is used in the construction work and it should be used properly using necessary safety (shoring and trench boxes) or in another case avoid trenching and plan another method instead of trench by changing the design (Mroszczyk, 2015).

4.4 Safety training for site safety betterment

Safe working environment can be created by implementing health and safety programs (Senoucia et al., 2015). Successful enforcement of a safety plans and performance can shape a positive safety in the workplace (Al Haadir and Panuwatwanich, 2011). Always safety performance indicates the project success (Hasan and Jha, 2013). If the worker involvement is poor then there is a lack of safety knowledge and commitment (Shin et al., 2015). If safety can be implemented in a group of workers then it can be transferred to other

co-worker's creating a positive safety culture (Aksorn and Hadikusumo, 2008). Demikesen (2015) states that, sharing experienced workers safety knowledge with inexperienced workers is a kind of safety training and safety learning for inexperienced workers. Safety training can be improved with proper safety training, creating safety awareness in training, giving first aid training, sharing workers experience, sharing previous accidents root cause and results, conduct exams or quiz after training sessions, break language barrier and proper safety planning (Figure. 6). However, improper training, sharing less safety knowledge, inexperienced safety trainers, lack of training for workers and less interaction with worker are also some of the elements which affect safety performance (Figure. 6).

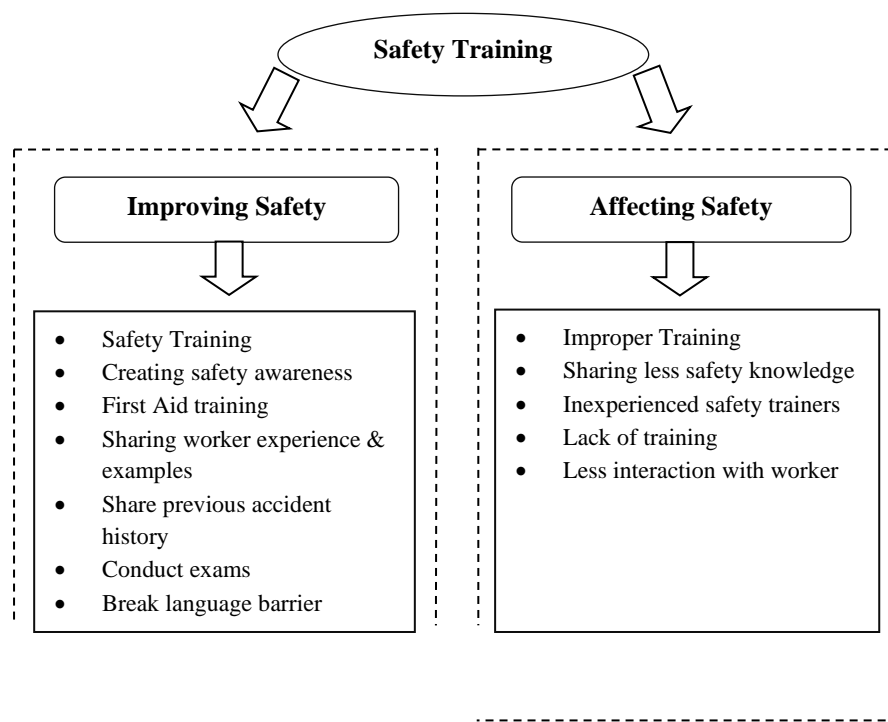


Figure. 6 Factors which improve and affect site safety.

4.4.1 Safety rules and regulation

Safety rules and regulation are majorelements of safety management (Mohammadia et al., 2018). However this rules and regulation involves huge amount of paperwork(Guo et al., 2015). Better communication with workers and management will be useful for safety rule compliance, additionally safety investments, frequent inspection and heavy fines will improve small and large scale construction firm's(Chen et al., 2015). In safety training workers should interact and raise questions to make it effective, conducting exams after training will be helpful to assessworkerslevel of understanding (Demirkesen and Arditi, 2015). Hallowell (2012) study found that safety knowledge for workerscan be transferred

through presentation, communication among employees, training, tool box talks and also workers can understand better when explained with examples. There are other factors which make the working environment unsafe such as poor awareness about safety, lack of safety policy, poor safety climate, increased working hours, lack of written safety policy, poor site management, negligence in maintaining a safe distance and fail to cut off the electrical system power supply (Birhanet al., 2020). Birhanet al. (2020) stated that lack of routine inspection and poor housekeeping notably contribute to workplace injuries along with worker pressure.

From the beginning stage itself safety planning, safety knowledge and special training must be provided for workers, if the work location is being changed in a non-habitual workplace. Regular training has to be given along with various methods to create alertness (Sanni-Anibire, et al., 2020). First aid training is an essential one in order to save a life in the workplace and provide some special training for workers who are illiterates because workers who are having less educational level are the accident victims who are injured (Arquillos et al., 2012). Training has to be given to the workers by showing the pictures and films this will help the non-educated workers to understand easily. Put the dos & don't pictures in the notice board or put the picture in the place where all the workers can see (canteen). Considering the positive reinforcement as a part of safety program will be helpful for workgroups instead laying harsh penalties will result in fear and uncooperative workers (Chen et al., 2013). Annually auditing should be done along with training new employee and providing PPE to all workers.

Risky operations using powered tools should be allowed to handle by well trained workers. Furham (2005) mentioned that timely feedback will improve safety performance. In addition, it is also identified that giving feedback improves skills, communication between worker and supervisors. Safety knowledge and awareness has to be obtained to reduce safety risks. Filling workers mind with safety rules and regulation will not assure that they work safely because of less safety awareness (Mohammadia et al., 2018). However Hinze and Gambatase (2003) mentioned that incentives or reward program can't guarantee effective safety performance. There is no willingness in worker to use the PPE and to obey the safety rules, were noted as the reason for the cause for unsafe practices.

4.5 Attitudes/human behaviour towards safety

Attitude and behaviours are other factors affecting site safety. Many factors under safety behaviour were identified from the analysed papers such as workers negligence, local

society, work place environment, national culture, language problems and aged workers and young workers (Figure. 7). In addition, worker behaviour, worker attitude, risk accepting behaviour, risk perception, supervisor attitude, behaviour feedback, supervisor involvement, safety compliance, aware about behaviour control, safety participation, emotional state, safety effort, perceived safety state, personal responsibility and worker involvement are some of the factors which affect safety behaviour. Domino theory presented that unsafe objects and unsafe behaviour (Human characteristic) are the two utmost factor of an accident.

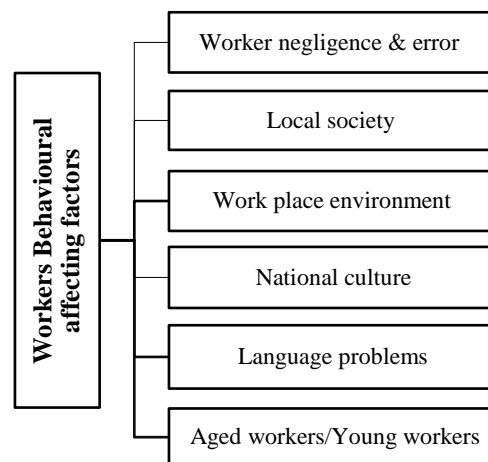


Figure. 7 Workers Behavioural affecting factors

Worker unsafe act contribute to high occupational accidents (Cheng et al., 2010). However, not only workers are responsible for this misconduct. In addition unsafe act is the major reason for construction accidents and when they get united or combined with unsafe condition it leads to more fatal accidents (Chi et al., 2013). Over the past few years, the attitude of workers in the safety program and training process has been influencing construction site accidents (Shin et al., 2015). To solve this issue, good emotional state can improve the worker performance effectively (Wu et al., 2015). In addition underestimating the risk and taking shortcuts to finish the job are negative attitude, developing a great threat to site safety. Wu et al. (2015) study stated that safety performance can be strengthened through changing the workers behaviour. Haslam et al. (2005) study identified that workers and work team in the workplace caused 70% of the accidents. Cigularov et al. (2013) also mentioned that safety attitude depend on how well worker is aware about safety and risk. Meliá and Becerril (2009) described that factors affecting supervisor relation with workers and occupational stress is due to poor communication and inadequate management support,

other studies also agreed in the same factor. Even taking into account the role of foreman for site safety still workers contribution over safe work procedures, programs and safety practises can be promoted by exhibiting safe behaviour (Wacher and Yorio, 2014). If safety practise influence is increased by a worker then it will have an effect on co-worker, it will encourage other worker to adopt the safety practise (Wacher & Yorio, 2014). Job hazard analysis, tool box talks, performing inspection may include in health and safety activities (Hallowell & Gambatese, 2009).

Khosravi et al, (2014) analysed eight factors regarding unsafe behaviour like society, individual character, work place environment, organisation project, supervisor and contractors. Worker motivation, age, experience and attitude showed a connection with worker unsafe behaviour (Khosravi et al., 2014). Employees try to do the risky work by breaching the safety rules and not wearing PPE's to show that they are not afraid to take risk (risk accepting behaviour) (Birhane et al., 2020). Another reason for not wearing PPE is because employee's intentions of fear, that he will be teased by the co-worker if he doesn't perform the same work in the same way. In addition people culture, local society, language problems and race can be one of the factors influencing worker safety attitude (Choudhry and Fang, 2008). Some studies stated that workers above 35 years are more likely to be met with accidents and older workers have higher rate of accident occurrence (Jazari et al., 2018; Adane et al., 2013).

To improve the site safety all level of employees should follow good safety practises (Birhane et al., 2020). Performing PBBS (Proactive behaviour-based safety) will develop safety awareness among workers thus performing all the activities in a safe way. Using PBBS based safety will create a good safety performance in workplace and improve the efficiency of safety management. The more the workers follow the procedures better the workers attitudes and fewer the accidents (incidents, near miss) (Hendricks and Peres, 2021). In construction site positive reinforcement for worker by means of applause on verbal praise will motivate the worker to repeat the safety behaviour (Hallowell et al., 2013). Co-worker can also influence workers safety behaviour by improving their communication and trusting each other (Mohammadia et al., 2018). Incentives and rewards are essential elements for a safety management system while punishing workers with fair penalties for exhibiting risky behaviour in the workplace can create positive safety (Frazier et al., 2013). Peer pressure can also change worker safety behaviour. It is necessary that peer pressure can produce a positive

awareness because positive peer pressure encourages safety attitude or behaviour (Guo et al., 2015).

4.6 Usage of Personal protective equipment's (PPE)

The likelihood of injuries in the construction workplace is due to insufficient and decreased usage of PPE (Phawchamnan and Nathapindhu, 2018). In some workplace employer lack in providing PPE and workers don't value the PPE and its importance (Al-Khaburi et al., 2018). Traditional training, inadequate supervision and poor instruction are one of the factors that employees are not using proper safe guarding equipment's (Connell et al., 2007; Kemei and Nyerere, 2016). From Sehsah et al. (2020) study the major elements why worker not using PPE is due to uncomfortable. Dust mask and respirators shape were disliked by the workers. Not many construction employees replace the lost or torn PPE because the employers suggest the workers to use it anyway (Sehsah et al., 2020). Workers felt uncomfortable wearing goggles as a result of fogging and normally they don't have the habit of using it regularly (Zheng et al., 2010). Many workers will take off their PPE while working because of PPE falling off is making the job harder (Sehsah et al., 2020). Safety gloves, safety boots, safety goggles, Hi – Viz jackets, ear muffs and earplugs were hardly used and hardhats are often used in the construction site (Tam et al., 2004). Worker negligence along with absence of PPE leads to injury (Hamid et al., 2008). In most of the construction sites the reason for the accidents are because of workers not following the work procedures in the workplace and working at elevated places without utilizing the proper safety equipment.

Workers using PPE are those who are taken training previously, aged workers and educated workers. The most common identified accident were by falling objects, equipment or machine accident, fall from height accidents and injury of lifting heavy weights (Sehsah et al., 2020). PPE comfort level should be improved and provide proper PPE to prevent sun burns (Sanni-Anibire, et al., 2020; Sehsah et al., 2020). Use equipment with necessary safety devices to avoid the injury (Jazari et al., 2018). Most frequent injuries are cuts, eye injury and gash fracture, contusions, prick, blunt trauma and burns (Mersha et al., 2017).

4.7 Human Factors

Workers underestimate the potential hazard by having a little knowledge about the work. So to mitigate the accidents caused by carelessness is through continuously reminding

the health and safety rules (Al-Khaburi et al., 2018; Connell et al., 2007). There are different categories of employments in the work site, like technical, skilled and semi-skilled work force. All three workforces are at the risk of being injured; which may be minor injury or major injury or maybe even death (Ali et al., 2010). Ferrel theory states that human error is one of the reason towards accidents that is may be because of the following reasons (1) overloading the worker more than his /her capacity; (2) not knowing about the job; (3) improper response. Other human factor causes are stress, job dissatisfaction, work pressure, insufficient rewards, Monday effect, language barrier and lack of feedback (Figure. 8).

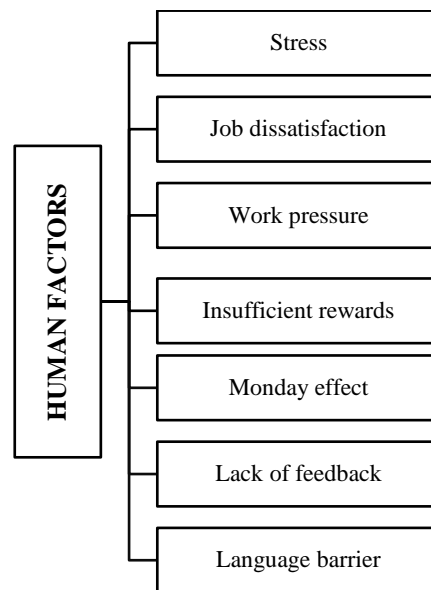


Figure. 8 Human factors

4.7.1 Job dissatisfaction

Job dissatisfaction increases the risk of occupational injuries. Job dissatisfaction is due to several factors such as, insufficient rewards, work pressure and quarrel between the workers. This affects the worker's productivity by loss of concentration which in turn reduces the better use of their skills (Adane et al., 2013). Pressuring or forcing workers can lead to unsafe act. Work pressure can make the working environment unsafe, thereby causing accidents. From previous studies it is identified that in a week more injuries happens on Monday during mid-morning and mid-afternoon. Many construction industries mentioned that weekend accidents happened on Monday for claiming the insurance amount (Arquillos et al., 2012). In Shao et al. (2019) study accident pattern shows that fatal accidents occur in the month of July and August. In addition Monday effect also becomes a reason for fatal accidents and fall accidents (Shao et al., 2019). Some researchers analyzed and reported that the

possibility of married workers involved in accidents is also high due to family stress (financial problems) loss of concentration and fatigue (Sehsah et al., 2020). Meliá and Becerril (2009) study showed that poor communication with superiors; insufficient management support and lack of feedback were also identified as the factor of stress. Permanent disability, absenteeism and project delays are the outcome of construction accidents (Fung et al., 2010). Rodriguez Garzón et al. (2013) mentioned in his work that Spain workers behavioural attitude are influenced by worker emotional state or job satisfaction and immigrant workers meet with fatal accidents than the native worker due to language barrier. Job satisfaction can be built by management support in turn workers become aware and realize safety in their work (Mohammadia et al., 2018). Safety awareness and job satisfaction can have an effect to follow rules and safety performance (Stoilkovska et al., 2015).

4.7.2 Drugs and alcohol influencing worker safety

Workers consume alcohol, cigarettes, and intake of drugs will increase the work related injuries (Ntili et al., 2015). Lack of alcohol & drug test will lead to worker consumption of drug & alcohol in the workplace. If there is no alcohol and drugs test in the workplace then the chance of taking alcohol and drugs by worker will be high (Zerguine et al., 2018). Many construction labours are addicted to chewing drugs like khat, betel quid and cannabis abuse. This type of drugs will have an impact on the worker working ability, efficiency, concentration and behaviour. Poor decision making and mistakes will be easily made (Khashaba et al., 2018). Use of drugs and alcohol can cause some serious accidents (Ali et al., 2010). Smoking employees has less chance of meeting an accident because nicotine increases concentration and vigilance, so it reduces the risk of falling asleep. But consumption of alcohol can lead to behaviour change, loss of concentration, memory loss, hallucinating and blood pressure (Table.2) which can lead to fatal accidents/injuries (Mushi and Manege, 2018).

Table 2 drug and alcoholic safety

No	Drugs and alcohol issues threatening site safety
1	Loss of concentration
2	Memory loss
3	Poor decision making
4	Change in behaviour
5	Hallucination
6	Blood pressure

4.7.3 Injuries happening in different age groups

High occupational accidents occurred are linked with the sort of work, worker involved and workers age (Cheng et al., 2010). At the workplace more number of fatalities occurred are for the aged workers (60-65 years old) and the young age group workers (20-24 years old) mostly met with light accidents. The aged employees are more exposed to risk; this may be due to balance vision, reduced strength, other mental or physical capabilities and increased risk accepting attitude (Table.3) (Adane et al., 2013; Betsis et al., 2019). Stoilkovska et al. (2015) study found about young labours encountering more accidents but aged workers possibility of serious accidents is less. Lacking experience means hazard exposure will be high and the rate of injury occurring will also be high (Jazari et al., 2018). Young labours with no experience are more vulnerable to incidents and accidents because later they learn through experience and become aware of the work (Choudhry and Fang, 2008).

Even the less experienced workers (4-12 months) don't experience fatal accident but the workers with years of experience (4-10 years) meet with fatal accidents (Arquillos et al., 2012). The experienced workers developed an attitude of accepting risk during the work to show that "it won't harm me or nothing will happen to me" (Brace et al., 2009). Experienced workers neglect to follow safety rules and co-worker also encourages the worker to continue to do so (Birhane et al., 2020). It is observed that workers absent days after a light accident are longer (16-30 days) because the injury takes time to heal or to recover (Arquillos et al., 2012). Workers with less experience are more likely to report incident/accident than the worker with more experience (Hendricks and Peres, 2021).

The injury happened during serious and fatal accidents are bone crushing, multiple lesions, heart attacks, strokes and internal injuries. Special training for aged workers and checking there fitness level has to be frequently done.

Table 3 ages wise survey of workers

No	Age/experienced workers
1	Balanced vision
2	Less strength
3	Less mental/physical capability
4	Risk accepting attitude

4.8 Ergonomic hazard in construction site

Ergonomics hazards are involved more in the construction workplace. Ergonomic hazards must be identified in its early stage through risk evaluation and modify the work position and movements. This hazard can have health issues such as work-related musculoskeletal disorders, back injury and sprain/strain to labours. To resolve these issues, materials used in the construction work are heavy to use so the material weight should be reduced, providing a good healthy exercise to workers will make them flexible before the work and the tools used should be designed ergonomically (Choi, 2012). The injury can't be prevented just by changing the nature of the work. Workers don't expose their pain which happen to them when they continuously and repeatedly carry out the work because of the fear that they will lose the job. In many sites, production is given more importance than workers safety. Although Boatman et al. (2015) discussed that workers accept that work-related musculoskeletal disorders are a part of the job, to get a solution for the accidents the workers unions and contractors has to work as a team. Ergonomic risk elements in construction site should be identified and the musculoskeletal disorders caused because of ergonomic hazards must be redesigned ergonomically. Lumbar Spine, Eye Injury, Lacerations and Upper Extremities were found as the major injuries causing parts due to ergonomics hazard (Pradeep Kumar et al., 2016). In addition, Back injury and sprain were the common injury occurred to workers (Choi, 2012; John Smallwood et al., 2018).

Shoulder, neck, wrist and spine joints caused discomfort for masons and the helpers had pain mostly in their shoulders, spine and in elbows because repeatedly lifting sand and bricks. Carpenters work by standing and stretching their muscles for a long period so they

suffer from neck, spine and shoulder pain, various types of repeated tasks are done like mixing the cement and sand, loading and unloading bricks, stretching, bending, uncomfortable work postures and walking from ground to top, carrying heavy weights on head can make them tired. This continuous work can affect the worker physical body, so resting and taking break can reduce the effect on workers. Handling tools may be difficult and cause accident due to continuously standing in the same posture for a long time (Ratri Parida and Pradip Kumar Ray, 2015). Haslam et al. (2005) analysed about 100 construction work-related accidents in the worksite in an ergonomic perspective way and concluded that unsafe equipment handling can result in accidents. Sneller et al. (2017) concluded that most of the workers have not completed training regarding ergonomics because management has not offered ergonomic training.

The ergonomic risk factors in construction site include force exerted on gripping the vibratory tools and equipment's, pulling and lifting heavy materials, doing a job in an awkward or uncomfortable posture and work repetition. The possibility of injury will increase if the worker doing the same job again and again in a very hot or cold condition. If continuous pressure is applied in tendons and muscles (contact stress) when worker holding the equipment for a long time (Ex: drilling) and uses force to do the job can cause injury and it will take time for healing (Jaffar et al., 2011). Working ergonomically than working in a traditional way differs very much, there is lot of advantage if construction sites are working ergonomically. Working ergonomically can increase the productivity but some contractor's point of view is that increasing the work timing and doing hard work will improve the productivity. Risk elements in ergonomics can be decreased when the workplace is designed ergonomically, proper interaction between the lower worker (helper) and contractor and educating the workers by training them not just orally but also through writing and picture will improve their understanding better (Abdul-Tharim et al., 2011). Ergonomic is a new idea in construction industry, in most of the construction industry ergonomics are given less importance and because of that the musculoskeletal problems are increasing. For many workers ergonomic training is not provided, in addition to that morning exercise can be provided to the workers to start the day actively. This ergonomic issue has to reach the top level managers in order to have an improvement regarding ergonomic hazard in the workplace (Sneller et al., 2017).

There is no permanent base for construction its temporary, once the work is finished it is moved. The equipment and tool can be altered to avoid wrist injury and hand arm

vibration. The most used parts in the body during the work is lower back, hand and feet, this parts are highly exposed to ergonomic risk due to handling and storing materials in the workplace (John Smallwood et al., 2018). Choi (2012) concluded that ergonomic program implementation can increase the profit, but it can also reduce the workers injuries and illness. To reduce the ergonomic hazard avoid working in awkward posture in the workplace, avoid working in uncomfortable positions, Repetition work must be reduced, reduce the muscle and tendon stress, reduce overexertion, workplace ergonomic hazard risk assessment, redesign or modify the work, avoid lifting heavy weights, proper space for the work (restricted space), prevent fatigue causing factors, avoid static work and make the tools or equipment adjustable (fit for the work).

4.8 Improving safety measures from previous studies

Learning from previous accident cases can help the construction industries to upgrade their safety measures (Guo et al., 2015). In addition from past injuries /incident experience, safety knowledge and attitude of workers can be boosted (Wacher and Yorio, 2014). This previous experience are reviewed in construction industry and recorded as fatality rates, accident rate and total recorded injury frequency rate (TRIFR) (Guo et al., 2015). Accident will have severe effect on project work and profit, so this will make client dissatisfaction.

Supervising measure such as safety inspection will enhance safety; this also refers to management inspection about working condition and unsafe behaviour (Chi et al., 2013; Jiang et al., 2014). However worksite inspection should be conducted by contractor insurance provider or by a safety consultant, committee and safety manager (Hallowell & Gambtaese 2009). Until now when an accident occurred, the ultimate aim of the management will be to investigate and prevent the likelihood of the accident occurring again and again (Wachter and Yorio, 2014). Developing safety measures and finding the root cause is the main purpose of accident investigation to prevent accident (Hallowell et al., 2013).

4.9 Conclusion

Different kinds of working process exist in the construction site so there is a high possibility of getting hurt in the workplace. Generally, construction site include complex, risky and long process (Mroszczyk, 2015). In every construction projects the project cost, time taken to complete a project and worker safety are very important. Accidents can cause damage to the property and injury to the person but there will be a temporary and permanent

loss to the construction company. This study aims to realize the construction site risk elements affecting safety performance, health hazards involved during the work and the reason for accidents caused due to poor safety practices. For a proper site safety, it has to have an organisational safety policy, safety training and management commitment.

Analysing from the collected literature this study discussed about construction workplace accident causing elements such as management, unsafe condition, safety programs, worker behaviour, PPE and ergonomic factors. The key to attain safety in an organisation and to improve organisational performance is through safety management. Safety management is the mostly advised technique to upgrade safety in the construction site. Some of the management related factors are,

- Management support and motivation.
- Active participation in the construction activities should be made available.
- Having good communication between the contractors, sub-contractors and workers, then knowing their feedback can improve the site safety.
- Allocating safety budgets, conducting accident investigation, planning with design professional having good knowledge about safety.

Several contractors and sub-contractors are available in a workplace, they should conduct,

- Safety training and provide PPE.
- Avoid work pressure.
- Perform all necessary safety measures to eliminate hazard.
- Operating the equipment without having basic safety knowledge and improper training should be avoided.
- Share some real time accidents that occurred before, this may help to build the safety practices among the workers.
- For all the workers at least once in 6 months, safety officer must conduct an awareness program and mock drill
- Educate the workers through practical training and safety behaviour.
- Poor safety practices can be avoided by workers following safety rules and regulation.
- Conducting safety training, health and safety programs.
- Comply with safety rules and regulation.
- Create safety awareness and safety culture.

- Analyse and investigate about the human factors.

There is a need of conducting awareness program in the construction site as well as conducting on and off-site awareness program for the workers will improve their knowledge and enhance active safety management so this can be applied or executed among the employees. Not only among the workers the awareness program should be conducted but also among the contractors, managers who are involved in the project and this awareness program should be conducted actively (Tam et al., 2004).

Personal protective equipment awareness has to be created among the workers when they are exposed to hazardous substance in the workplace and to use proper PPE during the work (Al-Khaburi et al., 2018; Sanni-Anibirea et al., 2020; Sehsah et al., 2020; Kemei and Nyerere, 2016). Ensure all the employees received the proper personal protective equipment according to their work, according to the workers need and according to the working condition not only hats and boots should be supplied to the workers but all kind of life protective equipment should be made available for the workers (Tam et al., 2004). Management should insist subcontractors to issue all the needed safeguarding equipment's and supervisors shouldn't allow workers to use the damaged or broken PPE (Sehsah et al., 2020). Workers should always remember to wear PPE inside the workplace.

Unsafe conditions in the construction site are a common hazard. Fall from height, Slip trip and fall and unsafe equipment's are the cause for accidents (Ali et al., 2010). Other causes will be like change in climatic condition, electrocution, workers attitude towards safety and low skill level of the workers (Dalia et al., 2018; Bhole, 2016). All level employees from top level to the bottom level everyone must take safety seriously into consideration. Workers attitude towards safety plays a major role in safety performance. Through worker safe behaviour safety climate can be achieved. Worker unsafe behaviour is also an element causing accidents in construction sites (Goldenhar et al., 2003). Workers must be trained regarding unsafe attitude and behaviour, even young workers and experienced workers must include in these training. Good safety practise can be achieved through workers safe attitude and thereby creating a strong safety culture.

Aged workers must be given special training because of their reduced abilities and they are more prone to workplace hazards. Ergonomic hazards in the workplace must be identified and the work has to be ergonomically designed if it's posing any threat to the worker health.

So, ergonomically friendly environment will reduce accident and injury rate. To improve the workplace ergonomically,

- Avoid awkward posture.
- Avoid working in uncomfortable position or redesign /modify the work.
- Repetition work must be reduced and avoid lifting heavy weights
- Reduce the muscle stress and overexertion.
- Prevent fatigue causing factors and avoid static work.
- Avoid stretching and bending for a long period.
- Avoid lifting and pulling heavy weight.
- Provide morning exercise for worker flexibility.

Table 4: The major risk factors from the literature review

No	Caterory	Sub-Category/Risk factors
1	Organisation	Organisation safety and safety committee (Amiri et al., 2017; Frazier et al., 2013; Hallowell and Gambatese, 2009; Hasan and Jha, 2013)
2	Management	<p>Project contract cost, rework, accident cost and Return of investment (Cheng et al., 2010; Feng, 2013, 2015; Feng et al., 2015; Guo et al., 2015; Han et al., 2014; Kemei and Nyerere, 2016; Mroszczyk et al., 2015; Wanberg et al., 2013)</p> <p>Work pressure and schedule delay (Feng, 2013, 2015; Guo et al., 2015; Han et al., 2014; Jiang et al., 2014; Patel and Jha, 2015; Wanberg et al., 2013; Wu et al., 2015)</p> <p>Job satisfaction and motivation programs (Adane et al., 2013; Feng, 2013, 2015; Frazier et al., 2013; Guo et al., 2015; Hasan and Jha, 2013; Shin et al., 2015; Stoilkovska et al., 2015; Wu et al., 2015)</p> <p>Construction Safety design (Feng, 2015; Hallowell et al., 2013; Han et al., 2014; Mroszczyk, 2015; Terwel and Jansen, 2014)</p> <p>Contractor and sub-contractor role (Al-Khaburi et al., 2018; Feng et al., 2015; Hallowell and Gambatese, 2009; Hasan and Jha, 2013;</p>

		<p>Hinze and Gambatese, 2003; Mroszczyk, 2015)</p> <p>Safety climate and culture (Buniya et al., 2020; Fang and Wu, 2013; Feng, 2013, 2015; Frazier et al., 2013; Goldenhar et al., 2003; Han et al., 2014; Meliá & Becerril, 2009; Patel and Jha, 2015; Shin et al., 2015; Stoilkovska et al., 2015; Terwel and Jansen, 2014; Wu et al., 2015)</p> <p>Investigation about past Accidents and incidents (Choudhry, 2015; Feng, 2013; Frazier et al., 2013; Hallowell and Gambatese, 2009; Jiang et al., 2014; Wu et al., 2015)</p>
3	Unsafe condition	<p>Unsafe working Environment (Ali et al., 2010; Bhole, 2016; Cheng et al., 2010; Chi et al., 2005; Chi et al., 2013; Choudhry, 2015; El-Shafei et al., 2018; Feng, 2013, 2015; Goldenhar et al., 2003; Hamid et al., 2008; Haslam et al., 2005; Lipscomba et al., 2006; Rodriguez Garzón et al., 2013; Senoucia et al., 2015; Seokho chi., 2013; Shin et al., 2015; Sanni-Anibire, et al., 2020; Toole, 2002; Yilmaz, 2015)</p> <p>Safety equipment (Ali et al., 2010; Al-Khaburi et al., 2018; Cheng et al., 2010; Chi et al., 2013; Choudhry2015; Feng, 2013, 2015; Hasan and Jha, 2013; Haslam et al, 2005; Jiang et al., 2014; Shin et al., 2015)</p>
4	Safety program and training	<p>Safety training, Safety awareness and safety programs Adane et al., 2013; Al-Khaburi et al., 2018; Buniya et al., 2020; Fang and Wu, 2013; Feng, 2013, 2015; Frazier et al., 2013; Al Haadir and Panuwatwanich, 2011; Hallowell et al., 2013; Hallowell and Gambatese, 2009; Han et al., 2014; Hasan and Jha, 2013; Hinze and Gambatese, 2003; Jiang et al., 2014; Jazari et al., 2018; Jiang et al., 2014; Kemei and Nyerere, 2016; Khashaba et al., 2018; Mersha et al., 2017; Mohammad et al., 2015; Patel and Jha, 2015; Senoucia et al., 2015; Shin et al., 2015; Tam et al., 2004; Toole, 2002; Wachter and Yorio, 2014; Wu et al., 2015)</p>

		<p>Safety policies and procedures (Aksorn&Hadikusumo, 2008; Birhane et al., 2020; Cheng et al., 2010, 2015; Feng, 2013, 2015; Frazier et al., 2013; Guo et al., 2015; Hallowell and Gambatese, 2009; Mohammadia et al., 2018; Patel and Jha, 2015; Senoucia et al., 2015; Shin et al., 2015; Wu et al., 2015)</p>
5	Unsafe workers' behaviours	<p>Worker attitude and behaviour towards safety (Al-Bsheish et al., 2017; Al Haadir and Panuwatwanich, 2011; Birhane et al., 2020; Cheng et al., 2010; Chi et al., 2005; Chi et al., 2013; Choudhry and Fang, 2008; Fang and Wu, 2013; Guo et al., 2015; Hamid et al., 2008; Han et al., 2014; Haslam et al., 2005; Hendricks and Peres, 2021; Heng et al., 2015; Jiang et al., 2014; Jitwasinkul and Hadikusumo, 2011; Khosravi et al., 2014; Meliá & Becerril, 2009; Shin et al., 2015; Terwel and Jansen, 2014; Toole, 2002; Wu et al., 2015)</p> <p>Risk accepting Behaviour and workers involvement (Cheng et al., 2010; Feng, 2013, 2015; Frazier et al., 2013; Hallowell and Gambatese, 2009; Patel and Jha, 2015; Pinto et al., 2011; Shin et al., 2015; Wu et al., 2015)</p> <p>Supervisor Behaviour and attitude (Aksorn&Hadikusumo, 2008; Cheng et al., 2010; Choudhry, 2015; Frazier et al., 2013; Han et al., 2014; Shin et al., 2015; Toole, 2002; Wu et al., 2015)</p> <p>Worker risk perception/worker feedback (Chi et al., 2013; Feng, 2013, 2015; Guo et al., 2015; Han et al., 2014; Jiang et al., 2014; Patel & Jha, 2015; Tam & Fung, 2012)</p> <p>Attitude towards using PPE (Adane et al., 2013; Aksorn&Hadikusumo, 2008; Ali et al., 2010; Al-Khaburi et al., 2018; Cheng et al., 2010; Chi et al., 2005; Choudhry and Fang, 2008; Connell et al., 2007; Jazari et al., 2018; Kemei and Nyerere, 2016; Mersha et al., 2017; Tam et al., 2004; Zheng et al., 2010)</p> <p>Alcohol and Drug usage (Ali et al., 2010; Khashaba et al., 2018;</p>

		Mushi and Manege, 2018; Ntili et al., 2015) Negligence (Ali et al., 2010; Al-Khaburi et al., 2018; Kemei and Nyerere, 2016; Mersha et al., 2017)
6	Age	Age impact on safety (Adane et al., 2013; Betsis et al., 2019; Hendricks and Peres, 2021; Kemei and Nyerere, 2016; Stoilkovska et al., 2015) Experience (Durdyev et al., 2017; González et al., 2016; Jazari et al., 2018)

Table 5A sample table about the data analysed from the review papers

N o	Year	Author Name	Title	Analytical method	Country	Findings
1	2020	Muizz O. Sanni- Anibire, Abubakar S. Mahmoud, Mohammad A. Hassanain, Babatunde A. Salami	A risk assessment approach for enhancing construction safety performanc e	Quantitative & Qualitative analysis	Saudi Arabia	Excessive wind in the workplace has caused more number of fall from height accidents.
2	2019	Betsis S, Kalogirou M, Aretoulis G, Pertzinidou M	Work accidents correlation analysis for construction projects in Northern Greece 2003–2007: A	Descriptive Analysis	Greece	Age was the prominent factor.

			retrospective study			
3	2018	Al-Khaburi, Sakina, Amoudi, Omar	Analysis of accident causes at construction sites in Oman	Descriptive analysis	Oman	Lack of training, poor contractor and worker awareness, poor supervision by foreman, poor scaffolding and poor equipment maintenance
4	2017	Jo, Lee, Kim, Khan R. M. A.	Trend analysis of construction industrial accidents in Korea from 2011 to 2015.	Regression Analysis	South Korea	Workers above 40 years are influencing more occupational accidents.
5	2015	Guo, B.H, Yiu, T.W, González, V.A.	Identifying behavior patterns of construction safety using system archetypes	Qualitative analysis	New Zealand	Incentive programs, safety policies and regulation and Safety management

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