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RESEARCH PAPER

Relationship among Safety, Quality and Productivity in Construction Projects

[1]Asfandiyar [2]Dr. Shahan Mehmood Cheema

1. M.S Scholar, Business & Management Sciences, The Superior University, Lahore, Punjab, Pakistan
2. Assistant Professor, Business & Management Sciences, The Superior University, Lahore, Punjab, Pakistan

***Corresponding Author:** aliutman89@gmail.com

ABSTRACT

Construction is thought to be the most dangerous business due to its unique nature. To reduce risks and boost productivity in the construction industry, quality and safety management is required. The research examines productivity, quality, and safety in terms of their participation in and effects on the execution of building projects. Safety is given first priority throughout construction, with a focus on hazard detection and the prevention of workplace injuries and accidents. There is an examination and provision of the legislation requiring safety programs, training, and obligation to safety standards. Underlined the significance of safety issues at the design stage. The research also discusses safety of building and the importance of building codes in preventing structural failure, as well as factors that influence building failure and techniques for preventing them. The paper introduces quality through the lens of recent total quality management. Quality control, quality management, quality assurance, and Six Sigma concepts are addressed with examples in relation to building quality and structural integrity. Finally, concepts of productivity are provided, with an emphasis that good project management reduce productivity losses and the use of lean construction and lean Six Sigma methods to complement them. Finally, the report summarizes the relationship among safety, quality, and productivity.

KEYWORDS Construction Safety, Productivity, Quality, Six Sigma

Introduction

For project managers the quality, safety and productivity is a major and increasing concern. Defect or failure in constructed facilities can result in very large cost even with minor defect, reconstruction may be required using the same resources as used before. This result in increased cost and delay.

Due to introduction of new tools and techniques project implementation has recorded large success over years but nevertheless, construction projects have also documented several work-related injuries and accidents. Due to its unique nature construction industry is the most hazardous industry(Ogwueleka, 2013). Construction workers are three times more prone to dying and two times more to getting injured than any other worker of other industry globally(Sousa & Teixeira, 2004). This implies that a large proportion of workforce has chances to injuries and fatalities. Most of the injury cases are simply due to poor decision making, which can be mitigate through sufficient safety culture(Ahmed et al., 2018). Economic losses and human suffering are often caused due to accidents and compromising safety results in escalated cost and decreased profit(Hinze, 2000). Recent studies shows that safety leads to quality, similarly working in safe environment can enhance productivity(Husin et al., 2008).

Accidents that occur during the building process can also cause suffering, death, and personal injury. Health and safety issues may appear at the time of construction due to unsafe conditions such as improperly guarded and defective equipment, unsafe storage and

hazardous procedures to handle equipment and workplace hazards such as infectious diseases, chemical and other hazardous materials. Construction continues to have the greatest rate of workplace injuries than any other major industry, according to the Occupational Safety and Health Administration (OSHA). Safety is greatly impacted by how well quality management is implemented throughout a construction project. The project manager's objective is to finish the project by assuring safety and quality while maintaining strict control over the project's budget and timeline. This indicates that the productivity of the workforce must be taken into consideration. If quality is improved and job sites are made safer, construction output may be boosted and projects can become more profitable. Although the relationship between productivity, quality, and safety may appear distant and accidental, they are really more interconnected than one may imagine. Unfortunately, little is known about the link between safety, quality, and productivity in construction. As a result, there is a widely held belief that time and money spent on safety and quality undermine productivity by delaying projects and driving up prices.

Systems for ensuring quality should start at the project's initiation and design phases and last all the way through construction. Clients, designers, contract administrators, contractors, and subcontractors must all be convinced that quality assurance is beneficial to their own businesses for it to function well(Amani, 2017). The decisions made during the planning and design phases have a significant impact on safety during the building project. Safety also largely rely on education, alertness, and teamwork during the construction process. Workers should avoid taking needless risks and remain continually aware of the potential for accidents(Amani, 2017).

Simply expressed, productivity is the proportion of input to output. Volume, area, length, etc. are all examples of outputs, whereas labor hours, equipment runtimes, material consumption, and principle capital are examples of inputs. There are several factors which effect the productivity among which violation of safety precautions is one of the significant factor(Rahman et al., 2019). Construction productivity is significantly impacted by safety-related factors such as accidents, disregard for safety rules, inadequate lighting, poor ventilation, working at heights, unemployed safety officials on the job site, and noise(Enshassi et al., 2007).The results were validated by Thomas & Sanders (1991), who claimed that accidents have a considerable influence on labor productivity. There are three types of accidents:

- Accidents that result in the death of an injured worker; these accidents result in a lengthy period of no employment.
- Accidents that result in an injured worker spending at least 24 hours in the hospital; these accidents reduce the productivity of the crew on which this wounded worker was working
- Small accidents caused by nails and steel wires; these have a limited impact on production (Sanders & Thomas, 1991).

Quality refers to certain specifications and standards and the methods and process by which those specifications and standards are achieved, maintained and improved. Quality is any aspect of producing products with high degree of perfection. It is the ratio of performance to expectations (SINGARAVEL, 2017). Quality Factors such as inefficiency of equipment, poor quality of raw materials and high quality of required work decrease construction productivity.(Enshassi et al., 2010).

Construction Safety

Safety is the condition of being substantially free of risk, harm, or damage. It is considered as failure of engineer to establish and implement environmentally and structurally sound design and construction in an unsafe way during or after project

execution(Usmen & Vilnitis, 2015). When such circumstances occur, a safety hazard develop, which leads to an accident that causes workplace injuries and fatalities during construction. Similar to this, if a structure has a safety issue like an overload, it makes the building unstable and might possibly collapse. Loss of life and property destruction are the most frequent effects.

Occupational safety deals to identify and minimize personal and environmental hazards at the construction site. The US Bureau of labor statistics (BLS) reported in 2021 that total of 5190 fatal work injuries were recorded in which 850 injuries were from construction increased from 805 in 2020. In construction occupational deaths were 951 in 2021(BLS, 2021).

Similarly according to Pakistani Federal Bureau of Statistics, the percentage of occupational accidents and injuries sustained during the 2020 – 2021 fiscal year was around 3.5% of the labor force whereas the percentage in rural areas is 69.33% while in urban areas was 30.67%. Agriculture (29.25%) [Fertilizer-poisoning. Insecticide poisoning, insect bites, snake bites, cuts, wounds, etc.] Manufacturing (19.11%) and Construction (19.7%)(staistics, 2021) which was 15.24% in 2012-13.

Numerous variables influence efforts to improve site safety, but the economic impact is the most important one. The workers directly benefit from safe working conditions because they are most at risk for accidents, but construction businesses may also increase profits by preventing losses. Owners, businesses, families, and societies in general are indirect beneficiaries(Mossink & de Greef, 2002). Researchers have shown that, accidents cost a lot of money, thus by increasing site safety, companies and their subcontractors may save a sizable amount. The hidden (Uninsured) cost of accidents borne by contractors comprises rescheduling and work delays, equipment repair, extra safety after accident, fines, investigative reports, payment to injured labor while not working, training new worker etc. The ratio of uninsured cost to insured cost have been found to vary from 2 to 20 percent(Usmen & Vilnitis, 2015). According to several research, using quality and process improvement tools improperly might have a negative impact on health and safety(Stimec & Grima, 2019). Unsafe conditions and unsafe acts sometime in combination causes safety hazards. The unsafe conditions are improper guarding of equipment and platforms, improper lightening and ventilation, chemical and explosives, poor housekeeping, improper dress, unsafe construction practices and poor maintenance of equipment. Unsafe acts encompasses use of tools and equipment unsafely, using faulty equipment, no use of personal protective equipment (PPE), handling material unsafely, not following safe procedures and employee attitude problems etc.(Goetsch, 2012).

A methodical strategy to reducing and eradicating injuries and fatalities on sites is required for controlling safety losses. There are safety plans or safety programs for accomplishing this aim that may be used by designers, contractors, subcontractors, and owners. There are rules that can be applied generally or specifically to a project. Guidelines for safety programs are provided by US federal law through the Occupational Safety and Health Administration (OSHA). The key elements placed an emphasis on worksite analysis, hazard prevention, safety training, and management commitment.

The management's responsibilities start with improving and effectively communicating the health and safety policy to all staff members. They then extend to all activities by instilling responsibility for safety, adhering to safety regulations, looking at accident reports, holding periodic safety meetings, and engaging both workforce staff and management in safety activities. Significant elements include allocating duties to support safety operations, providing resources to achieve the goals, combining safety into company procedures, and rewarding employees for safe behaviors.

Worksite analysis involve assessing all workplace activities for health and safety risks, reevaluating workplace activities when process changes occur, identifying existing

hazards during site inspections and taking preventive measures, machines and materials, and setting up a reporting system for employees to report hazardous conditions. This role entails investigating every accident and narrow escape to identify the underlying causes.

OSHA guidelines for hazard prevention and control are implemented through on-site training and inspections. Hazard prevention and control is possible through the hierarchy of control principle, which provide the following approaches.

1. Get rid of the hazards from site
2. Replace the hazard.
3. Implementing engineering controls, such as guardrails and alarm systems.
4. Administrative control
5. Personal protection equipment (PPE)

A safety program must include training addressing health and safety. Planning, program development using printed instructions, video, demonstrative, PowerPoint, and interactive tools, program delivery using lectures, and training output evaluations using surveys, posttests, and pretest observations are all components of an efficient and effective training program. Three stages of evaluation are possible: trainee learning assessment, learning measurement, and safety performance indicator (Goetsch, 2012).

Safety of structure relates to the understanding and vanishing of causal elements and prevention of failure whether total or partial collapse. Some of the failure in the world have been quite well documented for example on June 24, 2021 a 12 storeys Champlain tower south in Florida partially collapsed which is one of the deadliest building collapse in US history with 98 people confirmed deceased(Kong & Smyl, 2022). In Ontario the roof of Algo Mall fail due to an overload of critical connection in 2012. The main cause of which was poor water proofing of the top roof parking in which 20 people were injured and 2 were died. Detailed investigation revealed a construction defects and there was no structural redundancy in the design. The failure occur due to simply supported beam's failure(Usmen & Vilnitis, 2015). Collapse of Rana plaza, an eight storeys commercial building in Savar, Dhaka Bangladesh in 2013 resulted in 2500 injuries and about 1200 deaths(Awoyera et al., 2021). In 2014 at least 116 deaths resulted from collapse of synagogue church building in Lagos, Nigeria(Awoyera et al., 2021). In Mecca, Saudi Arabia 184 deaths were caused due to tower crane failure. Similarly in Uyo, Nigeria the Uyo church collapse cause 60 deaths(Mathebula & Smallwood, 2017). There are 47 building collapse recorded from 2000 to 2010(Ede, 2013).

Eldukadr and Ayyub's study reveals that 57% of structural failures led to collapse, 44% during construction, 51% as a consequence of design mistake, and 57% as a result of construction error. Contractor failure accounted for 60% of failures, and structural designers were 40% at fault (Eldukair & Ayyub, 1991). Poor building techniques, unanticipated load behavior brought on by insufficient connecting elements, confusing contract language, and contract agreement violations are some of the primary causes. Natural disasters, the environment, inadequate project management, resource mismanagement, and poor workmanship are secondary reasons. The lack of proper planning and control, disregard for safety rules, and inadequate inter-stakeholder communication were the main causes, according to management.

To avoid structural and building failure Education, industry association gatherings, research, database failure, and adherence to construction rules are among Eldukader and Ayyub's recommendations(Usmen & Vilnitis, 2015).

Codes in Building

Local, county, and state building safety experts create building standards with major participation from the design and construction sectors. The majority of jurisdictions in the United States now use the International Building Code (IBC), which addresses a variety of subjects including building usage classifications, interior finishes, building heights and areas, foundation, wall, and roof construction, fire alarm and protection systems, construction materials, elevators and escalators, and means of egress. Some of the most often utilized codes and regulations are the Pakistan Building Code (PBC 2007), the International Mechanical Code (IMC 2009), the Plumbing Code (IPC 2009), the Fire Code (IBF 2009), the Fuel Gas Code (IFGC 2009), the Electric Code (NEC2002), and the International Residential Code (IRC 2003). (IECC 2003). Under the following circumstances, the main objective is to enact regulations that are consistent with the scope of a building code and adequately safeguard public health, safety, and welfare. (a) avoid unduly raising building costs, (b) restricting the utilization of new goods, construction techniques, or materials, and (c) treating certain material classes or types, products, or construction techniques unfairly.

Local or federal governments are in charge of administering and enforcing the building code. They select building officials to interpret the building code and create rules and procedures that make it clear how the requirements of the code should be enforced. The duties of the building officials are listed below.

a. In order to apply the code, they examine applications and grant permits pertaining to building construction activity.

b. Carry out any required building inspections.

c. Make announcements and commands to make sure that the code is being followed.

d. Maintain official records for all applications, permits, inspections, and other relevant activities.

To enforce the code and guarantee the security of the structure, building officials will have the authority to access a construction site. As a consequence of this procedure, they are absolved of one's own responsibility for any harm caused by any act or omission against a person or property while carrying out official responsibilities. Position and layout, site security, the location of utilities, plans and profiles, standard specifications and details must all be included in documents presented to construction officials for the purpose of obtaining permits. A permit would not be valid if the legally permitted fees are not paid. A certificate of occupancy is given if officials investigate the building and discover no violations of the building regulations or other laws that are upheld by the building department.

Quality Management in Construction

The significance of quality management in building projects has increased. While contractors are more concerned with productivity and the safety of their workers the majority of project's owners are concerned with the quality of their projects (Ogwueleka, 2013). Effective quality control may contribute to project success and firms sustainability, while ignoring safety can lead to fatalities and injuries in the construction industry which may result in decreased worker productivity. Therefore, quality can be ensured from safety culture (Husin et al., 2008). For example it will be difficult for labor to work at height without safety belt. The failure of structural elements, workers inefficiency, and accidents may all be reduced by combining quality and safety management systems (Hoonakker et al., 2003). In quality management quality control (QC) and quality assurance (QA) are process that are integrated and run together. To ensure adequate confidence that structure's components will function as intended and that the project's requirements have been met, quality assurance (QA) involves all systematic and planned efforts. Procedures used in quality

control (QC) assist in performance by ensuring that the demanded standards of quality will be fulfilled. QC/QA systems are currently obsolete, but the idea of quality management is still relatively new. Total quality management (TQM) is a complete and systematic method of managing a company that boosts revenue and competitiveness by improving the quality of output products (ASCE, 2012; Rose, 2013). Numerous statistical techniques are utilized to perform TQM for quality improvement and measurement. Fishbone diagrams, Pareto charts, control charts, flow charts, and the failure mode and effect analysis (FEMA) method are a few of the often used ones (Usmen & Vilnitis, 2015). Six sigma and ISO 9000/9001 are the two instruments used by TQM technique for implementation. The ISO family of standards was created to assist businesses in guaranteeing that they satisfy the needs of consumers and stakeholders. Six sigma is a method that enables businesses to provide goods that are almost faultless. Sigma level 6 is defined as having 3.4 faults per million things. Six sigma involve a series of steps that is Define, Measure, Analyze, Improve and Control (DMAIC) which consist of statistical tools like Pareto charts, fishbone diagrams, checklists etc.(Hoyle, 2009; Isa & Usmen, 2015).

Challenges of Quality Management in Construction

Since each project has a distinct output and a longer product life cycle, several types of quality management are required for construction projects. Poor construction management includes factors including a lack of training, managers who are not aware of safety, reluctant workers who are not concerned with safety, and carelessness operations (Tam et al., 2004). The installation of a safety management system must meet the expectations of clients, insurance companies, and employees(Law et al., 2006). Work is completed in accordance with the specifications and standards when quality management is used in construction. Excluding interstate highways and nuclear power plants, there are no extensive quality requirements that are applicable to the whole sector (Usmen, 1994). To manage quality, the customer, consultant, service providers, and regulatory authorities must collaborate to check, report, and fix any flaws. Specifications, benchmarks, and quality criteria are provided in contract documents for construction. Building officials check a project to make sure it complies with contract requirements, zoning restrictions, and national and local legislation. The required certification and training, the QA/QC process and system, shop drawings and other submittals like temporary structures, samples, and traffic plans, checking and testing, maintaining records, correction, verification, and quality management audits are all outlined in the quality management plan for construction projects (Alarcon & Seguel, 2002).

Lean Construction and six sigma

Toyota Company implemented the lean methodology in 1970 to minimize waste from their manufacturing process. Using less of everything while generating more value is known as lean. Lean construction focuses on optimizing efficiency by eliminating waste utilizing methods like just-in-time, value stream mapping, continuous improvement, and last planner system(Rengarajan et al., 2020). The waste in construction are identified by lean six sigma approach are: Defects, Overproduction, Delays, Intellectual, Transportation, Inventory, Motion and Downtime. A large amount of monetary and non-monetary losses are caused by low quality construction work (Aman, 2017). However, several studies show that lean construction is the most effective and practical method for enhancing quality, safety, and productivity in the construction sector (Franz, 2018; Oakland & Marosszeky, 2017; Sacks et al., 2017). In the construction sector, waste affects every project activity. When an activity is disturb, the firm's business is disturbed with negligible profit, and if the schedule is affected, productivity is reduced, costs rise, and safety risks arise (Indira & Jyothsna, 2017). Productivity is raised, duration and accidents are decreased, and waste generation is considerably reduced by implementing lean construction tools and techniques (Mossman, 2009).

Construction Safety vs Productivity

Construction productivity is affected by a variety of elements, including health and safety, workers relations and hygienic welfare facilities. Productivity can be impacted by a variety of human issues, including worker health and safety, domestic conflict, salaries, daily wages and excessive effort(Alwi, 2003). It is very important to bring together safety and productivity, firms might try finding relation between working safely and being productive(Schwerha et al., 2017). When deciding how much attention and money should be devoted to safety programs, small and medium-sized businesses must consider the relation between safety and productivity. The following issues must be taken into account by the project managers:

1. Does safety have a positive or negative impact on productivity?
2. How important is the relation between productivity and safety?
3. Can the expense of safety programs result in a net benefit in terms of project cost savings?
4. Does safety compliance cause construction work to take longer, spend more money, and produce less output?
5. How are productivity and safety achieved simultaneously?

Construction projects are unique products with different objectives regarding cost, time, schedule, quality, safety and productivity. Although it appears that these characteristics are in conflict with one another, there is a relation between them. Due to pressure to boost productivity and reduce costs, workers begin engaging in unsafe behavior in the hope of becoming more productive.

However, there is a pervasive belief in the construction sector that there is no relation between productivity and safety (Alarcon & Seguel, 2002; Gusta, 2015; Kaminetzky, 2001). The notion that production and safety are inversely correlated is little supported by the available data. Although, there is enough evidence to support the stronger hypothesis that productivity does not suffer as a result of safety precautions being taken. According to studies to support negative relation, workers may not rigorously adhere to safety rules because of concerns about productivity. According to recent data, 59% of construction sites do not adhere to safety regulations(Usmen & Vilnitis, 2015). The study discovered that this lack of attention for safety is brought on by concern about spending time not for work but to learn advanced safety measures, cost of safety, lack of knowledge and insufficient training. According to results of another study, management personnel think that taking safety precautions on the job site lowers worker efficiency. One of the studies found that one reason for non-compliance is workers' concern that they may lose their jobs if they are less productive owing to safety. It was also discovered in a survey of roofers that tight safety regulations significantly reduce productivity.

Strong evidence suggests a positive relationship between safety and productivity, and studies conducted in the UK have found that safety violations lower productivity. A similar study discovered that safety management had a favorable impact on productivity. According to Hinze's distraction theory, employees perform better after they realize that risks are small rather than clinging to the idea that they are working in a dangerous setting (Hinze, 2000). When employees become preoccupied with reducing safety risks due to hazards, productivity suffers. A recent study came to the conclusion that management should treat productivity and safety as a together rather than in competition. According to a Maudgalya research based on 18 case analyses, many businesses saw a return on their safety investment in considerably less time than a year. Additionally, the study indicated that cost-benefit ratios improved by 71% and productivity rose by 66%. Safety may assist a company in accomplishing the long-term advantage of operational sustainability(Maudgalya et al.,

2008). Reduced schedules, benefit/cost savings, increased return on investment (ROI), enhanced reputation and quality are just a few of the positive business outcomes contractors are seeing as a result of safety initiatives (Hill, 2013).

Conclusion

The purpose of this paper was to examine how quality, safety, and productivity are related to one another because some construction organizations compromise safety and quality over production. Safety was examined in relation to ongoing construction projects as well as completed projects. The responsibilities of building regulations and building officials, as well as other factors influencing building and construction failures, corrective and preventive actions, and the significance of quality management in achieving safety, were examined. The following inferences were drawn from this research:

- In contrast, there is a positive link between safety and productivity, meaning that productivity does not reduce while investing in safety programs. Therefore, there are very few situations in which taking preventive measures regarding safety may decrease productivity.

- Quality management and safety management work together. A safe project will back quality efforts.

- In construction projects for safety and quality lean principles can apply which play a vital role in boosting productivity, there is monergy among aspects of construction projects.

Relationship among safety, quality and productivity in construction projects are not in compact and combine form therefore, further research regarding safety, quality and productivity is recommended.

References

Ahmed, S., Sobuz, M. H. R., & Haque, M. I. (2018). Accidents on construction sites in Bangladesh: A review. *4th International Conference on Civil Engineering for Sustainable Development*,

Alarcon, L. F., & Seguel, L. (2002). Developing incentive strategies for implementation of lean construction. *Proceedings International Group of Lean Construction 10th Annual Conference, Universidad Federal de Rio Grande do Sul*,

Alwi, S. (2003). Factors influencing construction productivity in the Indonsesian context. *5th EASTS Conference*,

Aman, A. (2017). *Punishment for low-quality construction*. The daiy star. thedailystar.net/backpage/punishment-low-quality-construction-1357573.

Amani, M. (2017). Quality control and safety during construction. *Int. J. Mech. Eng. Technol*, *8*, 108-113.

ASCE. (2012). *Quality in the Constructed Project: A Guide for Owners, Designers, and Constructors,* ASCE

Awoyera, P., Alfa, J., Odetoyan, A., & Akinwumi, I. (2021). Building Collapse in Nigeria during recent years–Causes, effects and way forward. *IOP Conference Series: Materials Science and Engineering*,

BLS, U. (2021, 16 Dec, 2022). *Bureau Of Labor Statistics*. News release. Retrieved 4 feb, 2023 from https://www.bls.gov/news.release/pdf/cfoi.pdf

Ede, A. N. (2013). Building collapse in Nigeria: The trend of casualties the last decade (2000-2010). *International Journal of Civil & Environmental Engineering*, *10*(6), Page-37.

Eldukair, Z. A., & Ayyub, B. M. (1991). Analysis of recent US structural and construction failures. *Journal of performance of constructed facilities*, *5*(1), 57-73.

Enshassi, A., Mohamed, S., Mustafa, Z. A., & Mayer, P. E. (2007). Factors affecting labour productivity in building projects in the Gaza Strip. *Journal of civil engineering and management*, *13*(4), 245-254.

Enshassi, A., Mohamed, S., Mustafa, Z. A., & Mayer, P. E. (2010). Factors affecting labour productivity in building projects in the Gaza strip. *Journal of Civil Engineering and Management*, 15 (3), 269-280

Franz, B. (2018). Total construction management: lean quality in construction project delivery. *Engineering, Construction and Architectural Management*, *25*(2), 295-296.

Goetsch, D. L. (2012). *Construction Safety & Health*. Pearson Higher Ed.

Gusta, S. (2015). Tragedy in Zolitude–a lesson for contemporary society. *International scientific conference Rural Development 2017*,

Hill, G. (2013). *Safety Management in the construction Industry: Identifying risk and reducing accidents to improving site productivity and project ROI*. In: McGraw Hill Construction Smart market report.

Hinze, J. (2000). Incurring the costs of injuries versus investing in safety. *Construction Safety and Health Management, New Jersey: Prentice Hall*, 23-42.

Hoonakker, P., Loushine, T., Kallman, J., Carayon, P., Kapp, A., & Smith, M. J. (2003). Accidents, Injuries, Worker's compensation, Safety and Safety Policy in Construction Industry: The effort/results paradox. *policy*, *45*, 55.

Hoyle, D. (2009). *ISO 9000 Quality Systems Handbook-updated for the ISO 9001: 2008 standard*.

Husin, H. N., Adnan, H., & Jusoff, K. (2008). Management of safety for quality construction. *Journal of Sustainable Development*, *1*(3), 41-47.

Indira, M., & Jyothsna, M. V. (2017). An approach to effective construction management based on lean construction techniques. *International Journal of Civil Engineering and Technology (IJCIET) Volume*, *8*, 1954-1959.

Isa, M. F. M., & Usmen, M. (2015). Improving university facilities services using Lean Six Sigma: a case study. *Journal of Facilities Management*, *13*(1), 70-84.

Kaminetzky, D. (2001). *Design and construction failures: Lessons from forensic investigations*. Galgotia Publications.

Kong, X., & Smyl, D. (2022). Investigation of the condominium building collapse in Surfside, Florida: A video feature tracking approach. *Structures*,

Law, W., Chan, A. H., & Pun, K. (2006). Prioritising the safety management elements: a hierarchical analysis for manufacturing enterprises. *Industrial Management & Data Systems*, *106*(6), 778-792.

Mathebula, A., & Smallwood, J. (2017). Religious building collapses: The heavy price of short cuts in places of worship and pilgrimage site construction. *Procedia engineering*, *196*, 919-929.

Maudgalya, T., Genaidy, A., & Shell, R. (2008). Productivity–quality–costs–safety: A sustained approach to competitive advantage—a systematic review of the national safety council's case studies in safety and productivity. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *18*(2), 152-179.

Mossink, J., & de Greef, M. (2002). *Inventory of socioeconomic costs of work accidents*. Office for Official Publications of the European Communities Luxembourg.

Mossman, A. (2009). Why isn't the UK construction industry going lean with gusto? *Lean construction journal*.

Oakland, J. S., & Marosszeky, M. (2017). *Total construction management: Lean quality in construction project delivery*. Routledge.

Ogwueleka, A. C. (2013). A review of safety and quality issues in the construction industry. *Journal of Construction Engineering and Project Management*, *3*(3), 42-48.

Rahman, I. A., Memon, A. H., Memon, A. Q., Shaikh, M. A., & Siddiqui, F. (2019). Factors affecting the labour productivity in construction projects of Pakistan. *MATEC Web of Conferences*,

Rengarajan, V., Sankararaman, G., Dinesh, S., Surulivel, S., & Anand, V. V. (2020). MINIMISING CONSTRUCTION WASTE-A STUDY BY APPLYING THE LEAN CONSTRUCTION TECHNIQUES. *Journal of Critical Reviews*, *7*(17), 2465-2471.

Rose, K. H. (2013). A guide to the project management body of knowledge (PMBOK® Guide)—Fifth Edition. *Project management journal*, *3*(44), e1-e1.

Sacks, R., Seppänen, O., Priven, V., & Savosnick, J. (2017). Construction flow index: a metric of production flow quality in construction. *Construction management and economics*, *35*(1-2), 45-63.

Sanders, S. R., & Thomas, H. R. (1991). Factors affecting masonry-labor productivity. *Journal of Construction Engineering and Management*, *117*(4), 626-644.

Schwerha, D., Boudinot, A., & Loree, N. (2017). Integrating safety with process improvement for sustainable manufacturing. *Proceedings of the 2017 IISE Annual Conference, Pittsburgh, PA*,

SINGARAVEL, V. (2017). *GE6757-TOTAL QUALITY MANAGEMENT*. (Pearson Education Asia)

Sousa, S., & Teixeira, J. (2004). Prevention measures to reduce risk of falling from heights. *IX National Symposium of ISMAI*,

staistics, P. B. o. (2021). *Labor force publications*. LF Publications. Retrieved 4 feb, 2023 from https://www.pbs.gov.pk/sites/default/files/labour_force/publications/lfs2020_21/tables/Table_28.pdf

Stimec, A., & Grima, F. (2019). The impact of implementing continuous improvement upon stress within a Lean production framework. *International Journal of Production Research*, *57*(5), 1590-1605.

Tam, C. M., Zeng, S., & Deng, Z. (2004). Identifying elements of poor construction safety management in China. *Safety science*, *42*(7), 569-586.

Usmen, M., & Vilnitis, M. (2015). Evaluation of safety, quality and productivity in construction. *IOP Conference Series: Materials Science and Engineering*,

Usmen, M. A. (1994). Construction Safety and Health for Civil Engineers: Instructional Module.