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Advantages and disadvantages of mechanized construction during Covid-19 period

M.I. Khan, A.S.M. Nuruzzaman, R. Haque, M.M. Rahman & F. Azam
The Kanchpur, Meghna and Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation Project (KMGP), Roads and Highways Department, Dhaka 1000, Bangladesh

ABSTRACT: The global Corona virus pandemic has severely affected the construction industry all over the world. Transport restrictions, social distancing and lockdowns have disrupted the supply chain system regarding Labor, Material and Finances with resulting delays and increased costs. Civil construction is highly susceptible to such pandemics since close physical proximity of workforce is inevitable for field operations. However, modern mechanized construction practices can be a solution to this problem and has the potential to address the vulnerability of the construction industry on Pandemics. Mechanization allows the projects to continue field construction without risking the workers being exposed to contamination. Social distancing, which is essential in Pandemics such as Corona virus, is achievable by using machines where manual labor is required. Being immune to all kinds of diseases, a machine can freely perform tasks which are not safe for humans in such situation. It also enables the managers to reschedule tasks that may be considered hazardous to health and foster spread of the disease. Thus, the detrimental effects of the Pandemic on the construction industry can be minimized and delays can be avoided. However, the use of machines introduces some new challenges as well. Since a machine can replace several humans, it often creates unemployment, especially in populous developing countries such as Bangladesh. Moreover, over dependence on machines can also create loss of human skills and finesse required for delicate artistic works. In this article, such advantages and disadvantages of mechanized construction practices have been discussed in light of the global pandemic crisis.

1 INTRODUCTION

The construction industry depends heavily on manpower. Until now, construction industry has depended a great deal on manual labor for certain types of work, such as tiling, fabricating steel gratings, plastering etc. Many of these workers have little training and do not have any knowledge or proper skills to work in the industry. This not only increases the number of injuries and fatalities, but also decreases the level of construction productivity on sites. As a result the conditions in the construction sites are often not conducive for operation during emergency situations such as COVD 19 pandemic.

Designs of buildings/structures are becoming more and more complex, and space on construction sites is becoming more and more limited. As a result of this, many countries are trying to adopt different type of advanced technology and mechanization to increase productivity. For example, the Malaysian construction industry, facing problems such as low productivity, labor shortages, decreasing quality, safety issues etc., is trying to adopt innovative technology such as the industrialized building system (IBS) as an alternative to conventional construction methods. Hong Kong's Housing Authority has adopted prefabrication technology for its projects, and this has proven to be beneficial in terms of environmental degradation, material wastage, and productivity (Awolusi et al. 2018). It is recommended that wider adoption be achieved through government regulation and controls, and the provision of incentives. Some construction companies in Nigeria also relied heavily on labor, which caused delays and low quality outcomes. The Productivity Innovation Project (PIP) Scheme is part of the S$250 million Construction Productivity and Capability Fund (CPCF) introduced by Singapore's government to help the construction industry improve its productivity and capability. The aim of the PIP Scheme is to encourage prefabricators and contractors in Singapore to begin development projects that will improve their site processes and to build up capability to achieve higher on-site productivity. This scheme also helps contractors to adopt labor-efficient technologies, or to re-engineer site processes to improve productivity or reduce the dependency on on-site workers (Zhiqiang et al. 2018).

These problems were solved by mechanization. As an added advantage, the introduction of mechanization can be beneficial in emergency situations such as pandemics since it enables workers maintain social distance and often minimizes the need for human intervention altogether.

Concern for personal safety of the Engineers, Technicians and Workers, during pandemic has reached alarming levels and continues to be a primary source of concern to industry stakeholders. Due to the close physical proximity of the people involved in a Construction Project, it is considered more hazardous than other major industries such as manufacturing. However, high rates of technology implementation are expected to lead to improved health safety performance.

The primary objective of this article is to summarize the benefits and drawbacks of the use of technology alternatives in the construction industry in facing the new challenges created by the global pandemic. A preliminary, unstructured review of literature and a case study of the Kanchpur Meghna Gumti Bridge Construction Project under Roads and Highways Department, Ministry of Road Transport and Bridges has been used in this article.

The use of systematic methods to reduce worker exposure to workplace hazards and mitigate potential safety risks on the jobsite has been observed. The result of the study indicated that there are several technological controls used to mitigate workplace hazards during construction. Although virtual reality and building information modeling (BIM), other technologies such as wearable sensing devices, warning systems, drones, and robotics can play significant role in protecting and/or alerting workers from potential workplace hazards during pandemic.

2 WORKPLACE SAFETY PROTOCOLS DURING PANDEMIC

2.1 *Personal Protective Equipment (PPE)*

Use of Personal Protective Equipment (PPEs)is an effective method to mitigate workplace safety hazards during pandemic. They can become more effective when wearable sensing devices (WSDs) and sensors are embedded in them. Physiological sensors such as temperature and heart rate detectors can be equipped in hard hats and safety vests to provide real-time health conditions of workers, and alert both workers and supervisors of potential safety risks such as fatigue and physical complaints. Locating techniques such as global position systems (GPS) and radio frequency identification (RFID) can also make PPEs more effective in mitigating workplace safety risks.

The severity of hazard in the workplace is not reduced by using PPEs but the integration of PPEs improves awareness among workers and enhances interactive communication between workers and managers/supervisors.

2.2 *Administrative Interventions*

Administrative controls are typically used to improve employee awareness of potential workplace hazards and reduce potential severity of injuries if an accident occurs. In recent years, the incorporation of technology to enhance administrative safety controls has received substantial attention. With respect to training, technology has been utilized in multiple ways to enhance safety training programs.

Teizer et al. developed interactive training methods using three-dimensional immersive data visualization tool to train workers on performing steel erection tasks safely in a virtual, indoor environment (Teizer et al. 2013). In addition, technology is frequently used to create real-time digital safety signage on construction jobsites. Digital safety signage is an effective method to warn workers of potential workplace hazards and remind them of necessary safety precautions.

2.3 *Engineering Interventions*

Engineering interventions aim to aid in the performance of the jobs and physically isolate workers from potential workplace hazards thus reducing the risk of being exposed to infection. Advanced technologies have been increasingly adopted in the construction industry as effective engineering methods to make workplace safer.

2.4 *Contamination Risk Substitution and Elimination*

Substitution and elimination of contamination risks are considered the most effective methods of workplace safety during pandemic. These methods are often feasible only if implemented early in the design process. In Pandemic situation, physical proximity and spatial collision are two potential sources of jobsite hazards that

can be detected and eliminated during the design process. However, identifying and eliminating such kinds of collisions using traditional, two-dimensional (2D) drawings is challenging. To overcome potential challenges, technology, such as building information modeling (BIM), can be utilized using a simulation approach to visualize the physical characteristics of a workplace and identify potential collisions and other jobsite hazards (Zhang et al. 2013). Enhanced team interaction and communication are critical factors to maintain high levels of jobsite safety.

2.5 *Hierarchy of Measures*

It is important to acknowledge the hierarchy of measures taken for workplace safety management many industries to minimize or eliminate workplace contamination risks. It is an effective means of determining what measures to implement and how to implement them effectively to ensure that the workers get the maximum protection against contagious diseases. Manuele defines the hierarchy of controls as "a systematic way of thinking and acting, considering steps in a ranked and sequential order, to choose the most effective means of eliminating or reducing hazards and the risk that derive from hazards" (Manuele 2008). The hierarchy of controls is divided into five levels of safety controls—1. Personal Protective Equipment (PPE),administrative controls, engineering controls, substitution, and elimination—as shown in Figure 1. The rationale behind the hierarchy is that some levels of safety control are more effective in mitigating workplace risks than others. Typically, high order levels at the top of the hierarchy, such as hazard elimination and substitution, are perceived as the most effective and reliable measures of safety control as opposed to levels that are low in the hierarchy such as PPE. Safety measures that are low in the hierarchy are considered reactive; reactive safety measures are usually less reliable and more expensive to implement onsite than proactive safety measures. Reactive safety measures typically require worker involvement in the activation of the system. Accordingly, they are perceived as less effective at mitigating workplace risks than proactive measures.

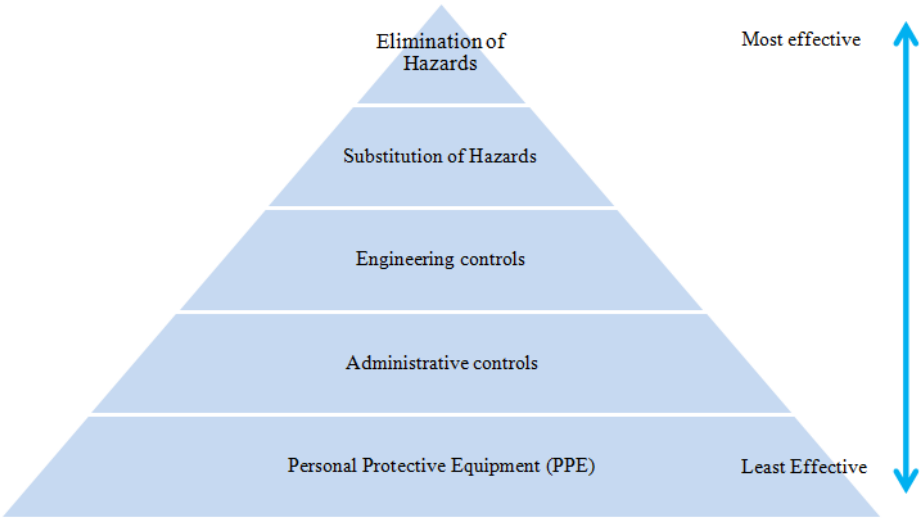

Figure 1. Hierarchy of measures.

3 ADVANTAGES OF THE USE OF MACHINES DURING PANDEMIC

There are numerous benefits of using mechanized constructions.

– Use of machines enable Workers, Technicians and Engineers to maintain social distancing and abide by health and safety rules. Machines can be used to perform tasks that may be considered as health risk during Pandemics. For example, by using mixing plants and conveyor system, large quantity of Concrete can be produced and carried to the actual location without deploying large workforce. Similarly, if Asphalt Plants are used to lay the top surfaces of a Road, the workers can stay away from each other and avoid close contact in order to minimize the risks of contamination. Unmanned aerial vehicles (UAVs), also known as drones, are proven to improve monitoring and safety inspection processes on the jobsite (De Melo & Costa 2017). High-resolution images and videos captured by UAVs can provide accurate information of jobsite conditions, as well as detailed reports about onsite compliance with safety procedures thus reducing worker exposure to potential contaminations through physical proximity. Previous studies have also evaluated the

effectiveness of Automated Assistance Devices as a potential technology to provide engineering safety controls in highway work zones (Finley 2013). This system automates the traffic control process—enabling a worker to remotely control the traffic—thereby eliminating the need for a construction worker to work in close proximity to common mass. Furthermore, positive protection systems such as truck mounted attenuators (TMAs) and mobile barriers are utilized in highway work zones to reduce worker exposure to hazards and isolate them from potential risks resulting from moving traffic passing by.

- Large-scale production of goods owing to the power of machines to multiply products allows for avoidance of involving large workforce in the production area which is potentially risky during contagious Pandemics. For example, pre fabrication factories are able to produce large number of components/members at short time, and without involving many laborer, welders, technicians etc.
- Mechanized systems provide with relief to labourers owing to lessening of actual physical work. The use of lifting equipment/mechanized cranes/forklifts for loading and unload-ing serves two purposes at once- it enables heavy loads to be lifted without risking injury to labourers and at the same time, it is possible to maintain social distancing to avoid physical contacts during rigorous manual operations.
- Use of mechanized procedure in construction during the Pandemics gives the involved personnel a sense of security and allows them to concentrate on the job at hand. Consequently, the performance of the projects can be maintained at desired level.
- Precision tools increases the skill and precision of technicians considerably. There are some jobs that that require precision tools to be performed accurately. For example, measuring instrument (Total station, Laser distance meter, Global Positioning System Location Devices etc.) testing machines (Deflectometer, Profilometer etc.) etc. are absolutely necessary for modern construction projects to maintain desired level of accuracy. They also enable the users to minimize physical presence by giving information from remote locations. For example, laser distance meters allows the user to measure distance accurately without actually reaching out to the other end..
- Mechanized construction process shorten duration of Construction because of quick-yielding power of machines. As a result, long delays can be avoided which often complicates the project operation due to limited availability of resources during the Pandemic.
- Production of goods of the same standard and of the same precision (e.g. production of identical members, slabs, road barriers, hand rails etc. of the same specification and standard)
- Low cost of production and consequent low prices of standardized goods manufactured with the help of machines.
- Increase of intelligence and alertness of labourers owing to constant working with machines
- Correct calculation of different quantities with the help of computers and other electronic appliances.

4 DISADVANTAGES OF THE USE OF MACHINES

- The most prominent disadvantage of use of Machines in Construction process is the reduction of employment opportunities that may lead to rise in unemployment in times of crisis such as COVID19 Pandemic. Machines can perform tasks of several workers at once in much shorter time. As a result, the human labor requirement decreases dramatically with the advent of machines. In pandemic situations, when opportunities for work shrinks with Lockdowns and Multi-faceted restrictions, the reduced labor requirement may lead to further worsening of the Unemployment situation.
- Mechanized Construction process may demand increased investment cost at the initial stages of projects due to procurement of expensive equipment. This may become even more complex during Pandemic due to the fact that availability of finances often become scarce in these situations.
- Loss of initiative of laborer who become a part of, and a slave to, machines;
- Loss of artistic skills and initiative of laborer who become too much dependent on machines
- Increase of the risk of work owing to the possibility of frequent accident
- High initial cost may deter potential investors
- Maintenance of sophisticated machines may become problematic in Pandemic due to less availability of spare parts/ technicians.

5 MECHANIZATION IN CONSTRUCTION: A CASE STUDY OF THE KANCHPUR MEGHNA GUMTI BRIDGE CONSTRUCTION PROJECT UNDER ROADS AND HIGHWAYS DEPARTMENT

The Kanchpur Meghna Gumti Bridge Construction Project (KMGP) is one of the most successful Projects in Bangladesh. It is a mega project where three major bridges on the main National Highway of the country were

rehabilitated as well as three new bridges built. Quiet uncharacteristically, the Project was completed in due time within stipulated budget which as very rare for a project of this size and complexity. Near the closing stages of the Project, the Global COVID pandemic appeared and forced most of the construction projects to almost shut down. However, the KMGP, was not affected as severely as other projects mainly because most of the works had been completed by then. However, it was less vulnerable to such pandemic situations due to the various measures taken during the construction phase.

5.1 *State of the Art Mechanization: Prefabrication*

The technology used in the KMGP is considered to be most advanced in Bridge Construction industry all of the world. The superstructure consists of composite deck slab on Pre-fabricated narrow box steel girder. Sub-structure was constructed with composite foundation on pre-fabricated Steel Pipe Sheet Piles. Prefabrication of Steel Pipe Sheet Pipes allows the Project Managers to outsource the fabrication process away from the Project site and avoid contamination due to close physical contact with the workers.

Figure 2. Use of precision laser cutting machine in prefabrication of narrow box steel girder in Vietnam.

5.2 *Construction of Foundation: Mechanized Pile Driving*

The foundation consists of mostly SPSP piles which were drive by either Hydraulic or Vibro Hammers. This driving process requires only a few people (one crane operator, one technician and one engineer who can work at a distance from each other without physical contacts.

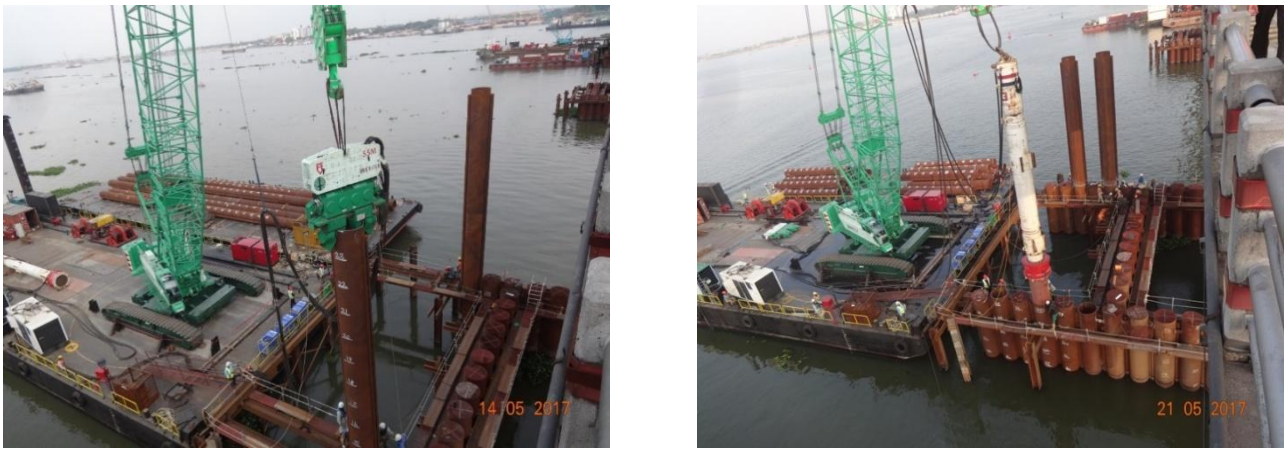

Figure 3. Driving of piles using vibro hammer (left) and hydraulic hammer (right).

5.3 *Moving and Lifting Heavy Loads with Machines*

All the heavy lifting ranging from few kilograms to several tones were done with the help of lifting equip-ment, forklifts etc. This allowed for less accidents due to fewer human involvement and faster completion of tasks.


Figure 4. Lifting of heavy loads with forklifts and cranes.

5.4 *Use of Personal Protective Equipment (PPE)*

In every type of operation, the workers used appropriate PPEs that were assigned for that specific task. As a result, the health hazard arising out of the risk of contamination could be minimized.

Figure 5. Use of PPEs by the workers during superstructure construction.

5.5 *Use of Modern Road Construction Equipment*

Use of modern road construction equipment allowed the Project Managers to expedite the work with greater efficiency and minimize human interaction.

Figure 6. Use of modern road paving equipment and light drilling machine during road works.

Figure 7. Use of nose girder for narrow box girder erection.

5.6 *Use of High Precision Testing Equipment*

Use of high precision testing equipment allowed for more accurate production of prefabricated components of the Bridge.

Figure 8. Use of high precision equipment.

Due to efficient use of mechanization and strict adoption to good health practices, the KMG Project is a good instance of how the construction industry can cope with Pandemic situation and continue operation through minimizing risks of contamination.

6 CONCLUSIONS

Mechanization allows the projects to continue field construction without risking the workers being exposed to contamination. Social distancing, which is essential in Pandemics such as Coronavirus, is achievable by using machines where manual labor is required. Being immune to all kinds of diseases, a machine can freely perform tasks which are not safe for humans in such situation. It also enables the managers to reschedule tasks that may be considered hazardous to health and foster spread of the disease. Thus, the detrimental effects of the Pandemic on the construction industry can be minimized and delays can be avoided. However, the use of machines introduces some new challenges as well. Since a machine can replace several humans, it often creates unemployment, especially in populous developing countries such as Bangladesh. Moreover, over dependence on machines can also create loss of human skills and finesse required for delicate artistic works.

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