INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 13, Issue 4, (2023) E-ISSN: 2222-6990

Scaffolding Transportation in Horizontal Way

Jannatun Naemah Ismam, Norsyahira Muhammad, Nor Azizah Talkis, Nor Asma Hafizah Hadzaman

Department of Built Environment Studies and Technology, College of Built Environment, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, 32610 Perak, Malaysia

Email: janna001@uitm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v13-i4/16539 DOI:10.6007/IJARBSS/v13-i4/16539

Published Date: *15* April 2023

Abstract

Scaffolding is important equipment in either conventional or IBS construction. Both are needed for the renovation and supporting scaffolding of workers and materials during building operations, structural repairs, or cleaning. Work-related musculoskeletal disorders (WMSDs) are a common health concern among construction workers. Workers are also affected by pain in their shoulders, lower back pain, knee pain, leg tiredness and feet due to their occupation. WMSDs are the main issue faced by the scaffolders or workers at the construction site due to lifting and carrying the scaffolding component from transport to the workplace. By identifying the main issue, it provides the opportunity and platform to propose an innovation idea for solving such an issue. Due to that issue, an innovation has been proposed known as scaffolding transportation in a horizontal way. The objectives of the innovation project are to identify the problems associated with the scaffolding transportation method in construction sites and to propose an innovative product to improve the scaffolding transportation method in construction sites. In order to achieve the following objective, the method used for the development of the proposed innovation idea included desk studies on the previous article on the relevant topic and questionnaire surveys to strengthen the innovation idea. This innovative idea has a good impact on the construction industry and it is in line with IR4.0 as well.

Keywords: Scaffolding, Transportation, Horizontal Transportation

Introduction

The first role of scaffolding is to ease positioning. The strategic positioning that scaffolding gives staff is very beneficial. For example, scaffolding puts workers in front of areas of the roof or wall where they must work, which benefits them greatly. Other than that, scaffolding provides a guarantee of safety to the workers. Safety is the top priority at construction sites. Therefore, to create a safe and efficient workspace for employees working at high altitudes during the construction phase, the use of scaffolding is necessary. Another important advantage of the use of scaffolding is that it provides a stable and balanced work platform that makes it possible for many workers to work on the site simultaneously. It leads to the

quick construction of many structures. For scaffolding equipment, it is easier to maintain a balance for workers, which reduces the likelihood of avoidable injuries. In addition, scaffolding requires handrails on the top platform to reduce the likelihood of injury. These are equally important for the protection of pedestrians and the public. Next is the ease of workers' accessibility. Nonetheless, high-rise buildings are considered complex to construct. There are many sections to the tower and their complex location also makes it difficult for staff to access on their own. Scaffolding is the solution to this complex problem, which provides workers with a safe and stable platform to perform their tasks (Herber, 1993).

Nowadays, the construction sector is also one of the riskiest. In most local Malaysian newspapers, accidents involving scaffolding on buildings that use the IBS system have become a hot topic (Ismail & Ghani, 2012). Thousands of people are injured or killed each year as a result of construction site accidents. Based on the Social Security Organization (SOCSO) report in 2000, the accident rates in the Malaysian building industry were three times higher than in other places of work. Some studies have dealt with bodily injuries that caused non-occupational accidents such as musculoskeletal problems. Scaffolds must be erected and dismantled, necessitating vexing postures such as twisting and holding overhead, bending, and lifting (Yuan & Buvens, 2015). Before the erecting process begins, the scaffolding needs to go through the loading and transportation process, which exposes it to the MSD. MSDs are one of the most common occupational health conditions and construction workers are at a higher risk for MSDs. In 2015, 708 cases of occupational musculoskeletal disorder were identified, as per an analysis by the Social Security Organization (SOCSO). The levels of musculoskeletal disorders in building manufacturers have been substantially higher than in other sectors, as seen in recent studies and estimates. In addition, statistics on occupational disease by private employees from the National Employees Social Security Organization in Malaysia from 2002 to 2006 indicate that the average incidence rate was 2.8 per 100,000 MSD workers (Ganesh CS, 2016). Due to the issues highlighted, which are musculoskeletal disorders, it was recommended to create a machine or robot that assists the workers in transporting the scaffolding components from the lorry transportation area to the workspace area.

Applications of Scaffolding

Industrialised Building System (IBS) is a concept used to describe the adoption of building industrial development and prefabrication of components in construction by industry and government in Malaysia. In Malaysia's economy, the construction sector of the IBS plays an important role and is one of its main industries. Scaffolding work is one of the activities involved in the construction industry. Scaffolding is a temporary structure used to secure the height and supplies building or structural repair material during the construction process (Błazik-Borowa & Szer, 2015).

Wall Scaffolds

The use of horizontal diagonal bracing is recommended on high scaffolds, it should normally be positioned close to the same height increments and levels as the building ties. Although not always used, horizontal bracing does impart additional rigidity to the scaffold. To facilitate installation, braces should be positioned also at the lowest frame level to ensure squareness of frames concerning each other, all brace connections have sufficient tolerance of fit to allow a non-square scaffold (Pallett & Filip, 2018). A scaffold that is used for brick masonry and is

also known as a bricklayer's scaffolding. Single scaffolding consists of poles, putlogs, ledgers, etc., that correspond to the wall at a distance of about 1.2 metre. There is an interval between 2.0 and 2.5 metres between the parameters. Ledgers join the standards at an upright gap of between 1.2 and 1.5 metres. Putlogs are removed from the gap left in the wall to one end of the ledgers. Putlogs are positioned at a gap between 1.2 metre and 1.5 metres (Anupoju, 2016). Used for masonry, they provide the facility of providing alternating work-level positions at the intermediate height of the frame, allowing easier reach to the work and more convenient height location than offered by frame support bars (Pallett & Filip, 2018).

Rolling Tower (Mobile Scaffolds)

Most adaptable to almost any work requirement. Ranging from a single-width, single-bay tower, it can be expanded in both frame width and brace length directions. The large rolling tower should always use ties connecting the tower legs so that there is multiplied resistance against excessive deflection caused by one leg or caster hitting a hole or obstruction. All frames in rolling towers should be attached in vertical sections utilising positive-locking rods, as shown in the preceding paragraph. That style of building is always more common as a result of uplift than most other forms of construction.

Interior Scaffolds

The application of large-area interior scaffolds provides limitless access to almost any wall or ceiling surface, which can be achieved using ingenuity and preplanning the use of the various correct accessories. Typical scaffolds often use spanning trusses, brackets, tubes and clamps to reach the various surfaces. All open sides of such scaffolds require guardrails to be installed following the criteria mentioned earlier. The availability of various-sized cross braces facilitates dimensional adaptability to existing seat row spacings, which are essentially the same as those of the tube and clamp scaffolds. Nevertheless, because the standard fastening is nailed with a little moment of rigidity, wood scaffolds need a considerable amount of diagonal bracing on both transverse and longitudinal planes.

Work-related Musculoskeletal Disorder Risk Factors

The term "musculoskeletal disorders" denotes health problems of the locomotor apparatus, for example, muscles, tendons, the skeleton, cartilage, ligaments, and nerves. Musculoskeletal disorders include all forms of ill-health, ranging from a mild, transitory disorder to an irreversible, disabling injury. Such work-related musculoskeletal disorders are supposed to be caused or intensified by work, though often activities such as housework or sports may also be involved (Bauer, 2016). The WHO has characterised WMSDs as multi-factorial and has recognised the impact of musculoskeletal 'work-related' diseases, indicating that several risk factors contribute to and exacerbate these diseases (Sauter, 1993).

WMSD is working on diseases that can affect the top limbs, lower back and lower limbs. The diseases are related to or exacerbated by the work. WMSD may be characterised by body structural damage such as musculoskeletal, joint, tendon, ligament, nerve, and localised blood circulation systems, which are mainly caused or exacerbated by work or by the working environment (Nunes, 2009a). Musculoskeletal disorders (MSD) are one of the most common occupational illnesses in Malaysia, according to Social Security Organization (SOCSO) statistics compared with other illnesses, such as workplace accidents and respiratory diseases.

It is well known that the effect of WMSD is closely related to working conditions and work-related physical hazards such as noise, high repetition, excess strength, repetitive activity, cold and vibration. Work and stress increase and other psycho-social factors are also increasingly contributing to the onset of these problems. The WHO refers to WMSD as multifactorial ethology, which indicates that the worker is subjected to certain work-related risks that tend to cause such disorders (WHO, 1985). In addition to these work-related risk factors, other factors, namely those that are intrinsic to workers and unrelated to work, contribute to their development. A risk factor is any cause or condition that is potentially injurious or contributes to disease development. The diversity and complexity of factors contributing to the appearance of these disorders account for the often-encountered difficulties in determining and controlling the best ergonomic intervention in a given workplace (Nunes, 2012). Three factors must be considered: physical, psychological and individual factors.

Physical Factors

A thorough study assessing the risk factors for WMSD has been conducted (NIOSH, 1997). The study classified the WMSD by part of the body, including the neck, shoulder, elbow, hand, wrist and back. Repetition, strength, posture, vibration, extreme temperature and static posture are the widely accepted physical or task-related risk factors (McCauley Bush, 2011). Several work-related risk factors, including environmental and biomechanical risk factors including postures, resistance, tension, intense external pressure, friction and cold, form physical risk factors. Another risk factor affecting all risk factors is duration. Because WMSD develops in connection with the joints for each joint of the human body, it is necessary to control each of these risk factors.

Individual or Personal Risk Factors

The ergonomics field does not try to display employees as a potential target for elimination. Personal risk factors can be recognised through education, administrative controls and awareness. The probability of a WMSD can be affected by personal or individual risk factors (McCauley Bush, 2011). These factors may be age, gender, smoking, physical activity, weight, anthropometry and previous WMSD, as well as degenerative joint diseases based on the research (McCauley Bush, 2011).

i. Gender

Women also deal with strong hormonal changes during pregnancy and menopause that make them more likely to suffer from WMSD, due to increased fluid retention and other physiological conditions (McCauley Bush, 2011). Other reasons for the increased presence of WMSDs in women may be attributed to differences in muscular strength, anthropometry, or hormonal issues. Generally, women are at higher risk of musculoskeletal disorders between the ages of 45 and 54. Then, the risk increases for both men and women as they age. Some studies have found a higher prevalence of some WMSDs in women (Bernard et al., 1997), but the fact that more women are employed in hand-intensive jobs may account for the greater number of reported work-related MSDs among women. Likewise, Fransson-Hall (1995) reported that men were more likely to have musculoskeletal disease than women and attributed this to the more frequent use of power hand tools. It is not fully understood whether the gender difference in some studies with WMSD is due to physiological differences or exposure differences.

ii. Physical Activity

Studies on physical fitness level as a risk factor for WMSDs have produced mixed results. Physical activity may cause injury. However, the lack of physical activity may increase susceptibility to injury, and after injury, the threshold for further injury is reduced. In construction workers, more frequent leisure time was related to healthy lower backs and severe low-back pain was related to less leisure time activity (Holmström, 1993). On the other hand, some standard treatment regimens have found that musculoskeletal symptoms are often relieved by physical activity. The National Institute for Occupational Safety and Health (NIOSH, 1991) stated that people with high aerobic capacity may be fit for jobs that require high oxygen uptake but will not necessarily be fit for jobs that require high static and dynamic strengths and vice versa.

Musculoskeletal Disorder among Construction Workers

Construction is well-known for its job risks and the health effects associated with them. The construction industry is seen as one of the world's biggest sectors because there are so many ongoing projects every day (Choi, 2016). Masons, carpenters, electro-powered workers, sheet-workers, roofing machines, ironworkers and scaffolders are the type of trades or occupations involved in this industry. Because the construction industry is one of the world's most dangerous, these trades are exposed to hazardous environments on a daily basis. MSDs are the major cause of productivity loss at work, physical impairments and permanent disability for construction workers. Employees in different building professions are, however, at risk for various MSDs.

These complaints reduce the willingness and ability of employees to work until retirement. To retain construction employees, these complaints must be monitored, possible action and the physical impairment of these workers must be prevented (Boschman, 2012). The essence of construction work is closely related to the dangers of people and these risks are present in their daily work. Where working conditions and the nature of work in connection with heavy load transport are factors that have an important connection with back pain because the load is too heavy at work (Rahmah et al., 2008). The prevalence of back pain among workers doing work, such as drilling, that involves body twisting, particularly bending or walking is notable. The findings of a position-related risk in the building industry were the highest compared to other industries based on the European Working Conditions Survey 2012.

Comparison Between Various Method of Material Transportation

The Hoist Pulley Device has been used in a wide range of applications, from work and entertainment to home storage. A pulley hoist is a device used to raise the load using a drum or a raise wheel that is wrapped around the cord or chain. The thread, fibers, or cabling can be used as its lifting medium and can be operated by hand, electrically, or pneumatically. A pulley hoist provides a way of greatly increasing the ability to lift heavy loads with the use of multiple pulleys rigged together. By installing a hoist pulley system, it can reduce the physical burden of manual lifting. The system allows the scaffold to be transferred to the workplace for the efficiency of scaffold workers. The pulleys work through a grooved wheel that pivots around an axle. When the pulley is fixed to a solid anchor and a rope is threaded through the

grooves on the pulley's wheel, it can be used to lift heavyweights and it is easier than manual lifting.

A pallet cart that used to eliminate horizontal transport of materials on the shoulder. The pallet cart is a trolley for the raising and lowering of the load. It is designed for lifting and transporting pallets. Normally used in warehouses, storage rooms, and other areas with the use of wooden pallets. But in other cases, most of the construction site does not use this equipment due to uneven topography.

An electric winch that lifts materials and prevents manual vertical transport. The safety bolt is mounted around the scaffolding frame and is locked against the harness cords to prevent scaffolders from dropping. This equipment is suspended from a building scaffold or building to lift the scaffolding materials to the workers. It can save time, effort, and money. The electrical winch also has many other uses across all industries because it was designed to be used outdoors, have high lift heights, and have very fast lifting speeds.

Forklift trucks are used to move goods and materials that are on pallets or in bundles. They can move pallets horizontally and vertically from one place in an installation to another. They are most useful in company-level warehouses and industrial sites, and they are very popular. The forked platform can be placed on the front and lowered for placement under cargo to be pushed or lifted. Most of the time, materials and goods are moved to and from construction sites as part of the process of making things or as part of the process of making things.

In 2018, KEWAZO is designing a smart robotic system for the scaffolding industry. The Geruestbot robotic system provides secure, cost-effective, and safe transport of the scaffolding parts during the scaffolding (dis-)assembly phase. Newly founded German start-up to offer the world's first smart onsite scaffolding transportation system, optimising the scaffolding assembly process. Kewazo partnered with Infineon Technologies robotics experts to build a robot that can bring products to staff where and when they need them. The robot of Kewazo moves up, down, and along with the scaffolding structure. It was used with a special loop connected to the vertical poles of the scaffold (Kewazo, 2018). The intelligent robotic scaffolding transport device from Kewazo provides an economical and safe means of transporting the parts of scaffolding (Figure 2.15). Their approach tackles understaffing and productivity issue and providing just-in-time and just-in-place parts during assembly will reduce assembly costs by at least 30 percent. The designers found that 80 percent of assembly and striking (disassembly) scaffolding times compensated for the manual transport of components. Kewazo seeks to reduce costs by up to one-third in addition to the possible savings in time. It may also reduce the risk of manual handling injuries or long-term health issues (Smisek, 2018).

Table 1
Comparison Between Various Methods of Material Transportation

	Function	Application
Hoist Pulley System	Used to lift or lower the load	Lifting and transporting canoe kayak
Pallet Cart	To lift & transport pallets	Can be found in the warehouse, stockrooms, and other environments
Electrical Winch	Suspended from a building scaffold to lift the scaffolding materials to the workers	Used for backstage mechanics in the film industries & for industrial purposes on sailboats
Forklift Truck	To transport materials & goods on pallets or packs	Used in warehouse and industrial sites.
Kewazo	To transport of the scaffolding parts during the scaffolding assembly phase in vertical way.	Used in construction sites for erection of scaffolding

Research Methodology

A case study via desk study and simulation was conducted. The method is believed to provide empirical inquiries that investigate contemporary phenomena. Moreover, the purpose and focus of the method are to describe the meaning, provide deep understanding and interpret the textual information derived from the method. Choosing the right method is very important to ensure that all the data needed can be collected. The data collected is regarding the details of the innovation idea, such as components, design, materials, and others. The simulation method is one of the best ways to show how the innovation idea works in the real scenario of the construction industry. Google SketchUp Pro 2019 is the application used for this simulation method. Google SketchUp Pro 2019 is suitable software to create desirable design ideas and visualise 3D imagery of the innovation idea. Each component was being sketched one by one to make sure the imagery and visual of the innovation idea can be seen clearly for the assembly process. In order to make the product movable, extensions from Google SketchUp 2019 are used known as Keyframe Animation. The research methodology was illustrated in detail in Figure 1.

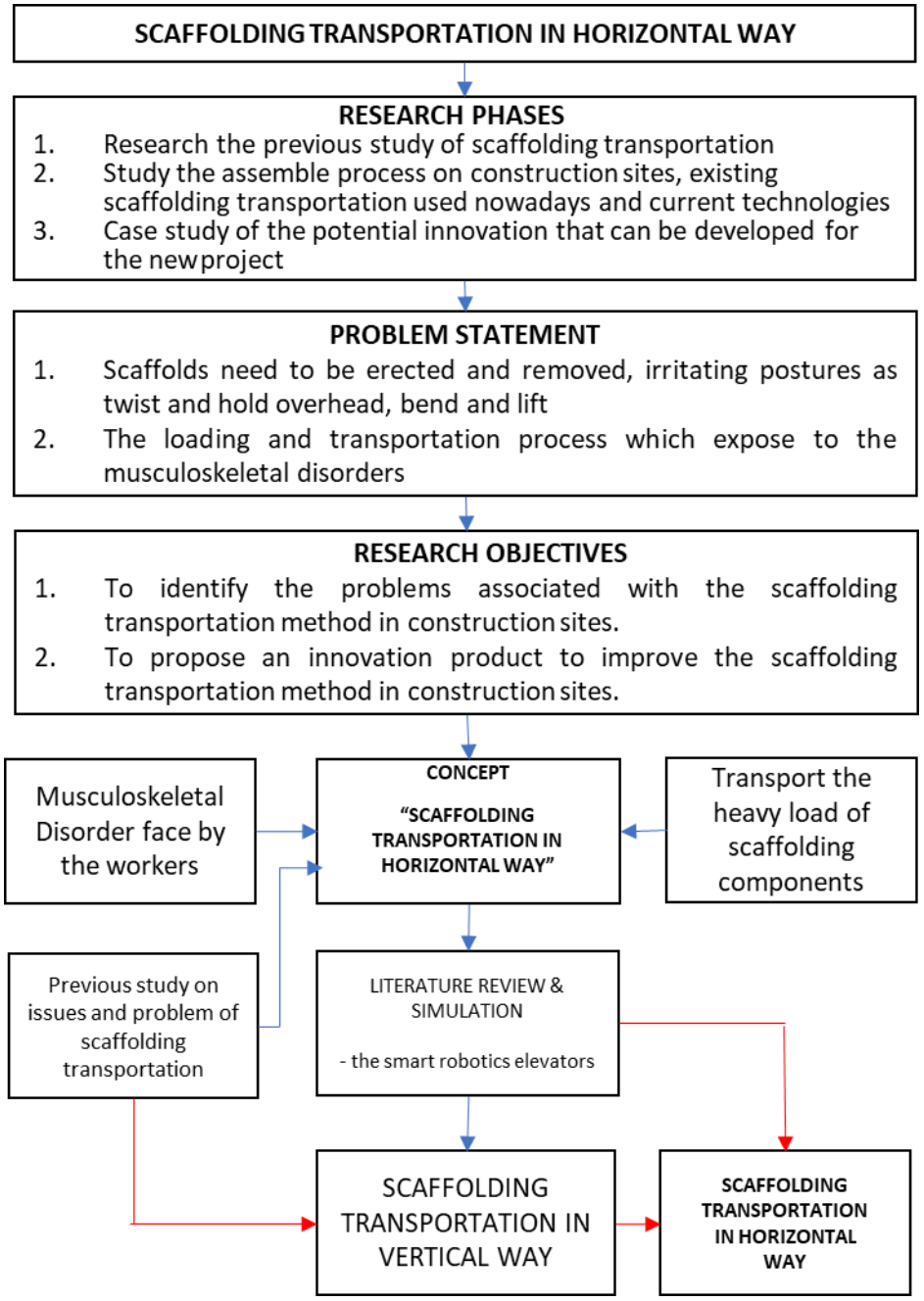

Figure 1: Design Framework of Innovation

Results and Findings

Identifications of Current Issues and Problems in the Transportation Process of Scaffolding Components to the Workspace Based on Previous Studies.

According to the first objective of this study, which is to identify the problems associated with the scaffolding transportation method in construction sites. The chapter 2 had answered the objectives and explained the use of scaffolding in the IBS industry with various technologies and the evolution of the transporting methods in line with IR 4.0 nowadays. The problems mostly related to the transporting of scaffolding components are musculoskeletal disorders that the workers face because they need to manually transport the scaffolding components from the lorry transport to the workplace. This problem is the main problem being highlighted

in many research papers. The features and performance of the innovation idea were created to provide a solution to musculoskeletal disorders faced by workers.

The significance of the Proposed Innovation Idea

Safety and health are some of the important features of IBS construction. Despite the government's and other relevant agencies' efforts to ensure compliance with various laws, policies, and Acts, safety and health are still at risk (Nasir et al., 2012). Musculoskeletal Disorders (MSDs) are one of the most common occupational health problems, and workers in the construction industry are at higher risk of developing MSDs (Lop et al., 2017). Recent studies and statistics have revealed that the rates of musculoskeletal injury or disorder among construction workers are significantly higher than those of other industries. These worst MSDs and injuries maybe caused by manual handling of heavy material, which includes lifting, lowering, carrying, pulling, pushing and being forced to work overtime for long hours, such as 12-hour shifts and six days a week (Santos et al., 2014). Before the assembling process of scaffolding started, workers needed to manually carry and lift the scaffolding parts from the lorry transport to the workplace. It will cause a serious musculoskeletal disorder to the workers because of the heavy lifting of the scaffolding components.

The significance of scaffolding transportation in horizontal way lies in the fact that it allows for safe and efficient movement of materials and equipment at height. By providing a stable and secure platform for workers to stand on, scaffolding enables them to reach areas that would otherwise be inaccessible, while horizontal way transportation ensures that materials and equipment are moved safely and quickly to where they are needed. This innovation is particularly important in construction projects where large quantities of materials need to be moved quickly and efficiently. This could include moving bricks, concrete blocks, steel beams, or other heavy materials from ground level to upper floors or roof levels of a building.

The use of scaffolding transportation in horizontal way also helps to reduce the risk of accidents and injuries on construction sites. By providing a secure and stable platform for workers to stand on, scaffolding minimizes the risk of falls from height. Similarly, horizontal way transportation helps to prevent accidents and injuries caused by manual lifting and carrying of heavy materials, which can lead to back injuries and other musculoskeletal disorders.

In summary, the significance of scaffolding transportation in horizontal way lies in its ability to provide a safe and efficient means of moving materials and equipment at height, thereby increasing productivity and reducing the risk of accidents and injuries on construction sites.

Visualization of Proposed Innovation Idea

The idea of innovation is created based on the issue and problems with the current situation of the scaffolding assembly process at the construction site. The idea for the product was inspired by an existing product that transports scaffolding parts in vertical ways, called Kewazo Robot 2019. Thus, the innovation idea is created to provide a horizontal way of transporting scaffolding. The main function of the robot is to transport the heavy load of scaffolding components to the workspace. Besides, the innovation idea was created to reduce the problems faced by the scaffolders, which are musculoskeletal disorders. The temporary

track will be installed from the truck transport area to the workspace area to ensure the robot can be moved smoothly. The robot will be programmed to move forward and backward only.

Scaffolding Transportation in a Horizontal Way is made up of important parts that are broken down into smaller parts in a mobile automotive robot. The chassis, motor drive, and steel compartment are the main components of the system, which is equipped with a rechargeable lithium battery and a switchboard with the help of infrared sensors and monitoring devices to help with the moving process of the robot (Figure 2). Performance and suitable materials based on their versatility were chosen to ensure the long-term reliability and solidity of the structure during the scaffolding transportation processes at the IBS construction site.

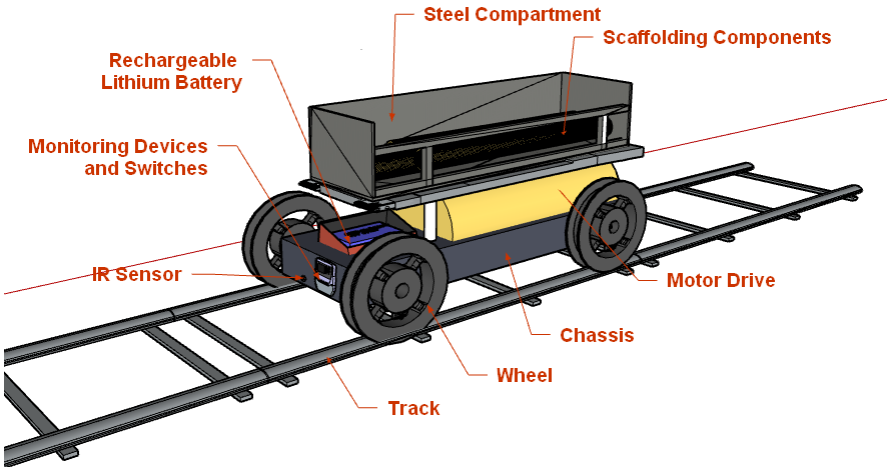

Figure 2: The Components of the Proposed Idea

Components of Scaffolding Transportation in Horizontal Way

Chassis and Motor Drive

The chassis is the mainframe for the robot, which moves easily with the help of motor drives on its track. On the chassis, four wheels enable the robot to easily move on the track. The frame and wheel are made of steel to restrain the heavy loads of scaffolding components. The type of steel that is used is high-strength low alloy, which is stronger and has better corrosion resistance. The chassis and wheels were automated by the motor drive that was installed inside the chassis frame.

Wheel and Track

Wheels and tracks act as moving mechanisms to ease and smooth the movement of the robot from the truck to the workspace. The steel track wheel is made of high-strength steel and has the perfect shape to stay fit on the track while moving. The track is made of high-strength steel that can bear the weight of the whole robot. The track functions as a temporary track as it can be installed and uninstalled at any time and any place before the transporting method begins.

Steel Compartment

The steel compartment plays the main role in this robot, serving as its carrier. The scaffolding compartment is used to place the scaffolding compartment during the transport process. The

length of the compartment is suitable for the typical length of each scaffold. The material used for this compartment is Type 304 stainless steel which has excellent corrosion resistance and is designed to withstand the heavy loads of scaffolding components. The steel compartment can fit five to eight of the scaffolding components at one time.

Assembly Method of Proposed Innovation Idea

The problems and issues during the scaffolding transportation process have been identified. Thus, the proposed idea has been created, which is Scaffolding Transportation in a Horizontal Way, which consists of essential parts like a chassis and motor drive, a steel compartment, track, and lithium battery to allow functionality and smooth the movement during the transportation process.

Operation Process of Scaffolding Transportation in Horizontal Way

The assembly of this robot started with the track wheels that ease the movement of the chassis and wheels. The track is installed on the ground from the lorry transportation to the workspace. The trackwheel was inspired by the dolly track that is usually used by the film industry. The length of the track wheel is installed according to how far the distance is. Next, the chassis, which consists of sub-frames and four wheels attached to the chassis. the chassis is the main part of the robot that serves as its main body. Then, the motor drive was built into the chassis and was being connected to the wheels to operate the robot and ease the movement. To operate the robot, the rechargeable lithium battery is being placed in the battery compartment and attached to the chassis hood. Last but not least, the chassis will be attached to the steel compartments that are used to place the scaffolding components. The summary of the assembly of the proposed innovation idea is shown in Figure 3.

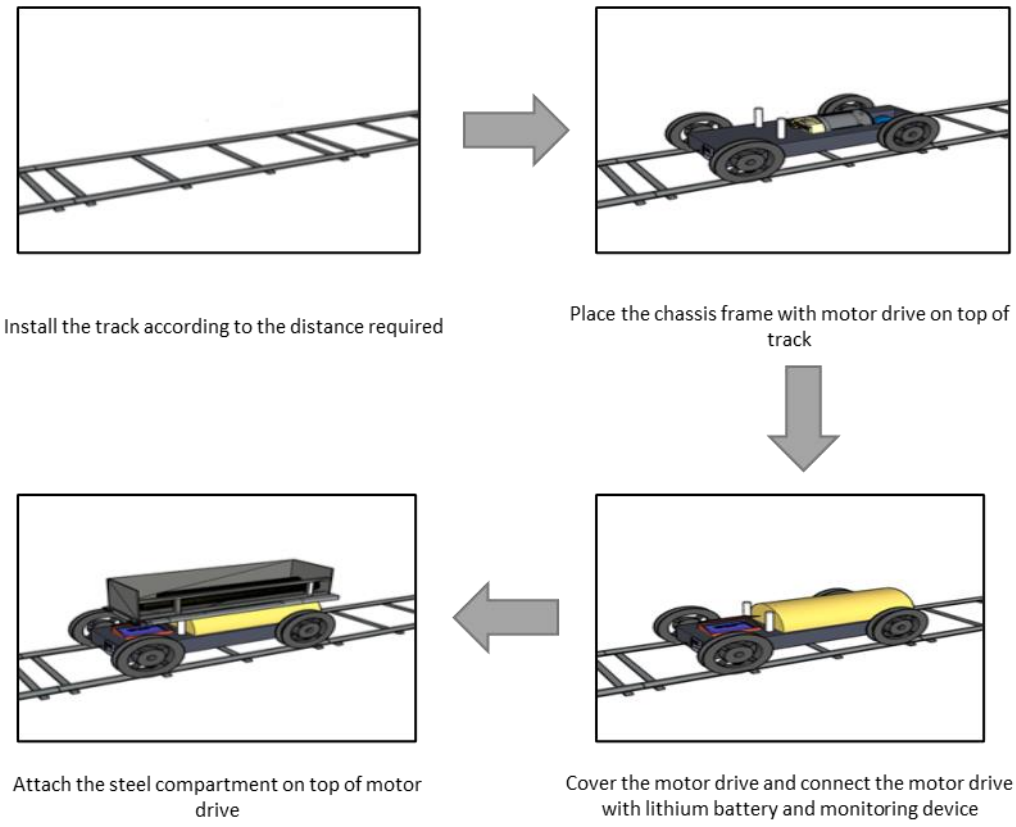

Figure 3: The Assembly of Scaffolding Transportation in Horizontal Way

Discussion on the Marketability of Scaffolding Transportation in Horizontal Way

The marketability potential of horizontal scaffolding innovations will depend on a number of factors, including the specific design and features of the scaffolding system, the target market and industry, and the competitive landscape. Some potential advantages of horizontal scaffolding could include:

i. Increased safety: Horizontal scaffolding can provide a safer work environment for workers who would otherwise be working at height.
ii. Improved productivity: By providing a stable and level work area, horizontal scaffolding can help workers complete their tasks more efficiently and effectively.
iii. Greater flexibility: Horizontal scaffolding can be used in a wide range of applications, from tunnelling and excavation to bridge and road construction.

However, there may also be some challenges to overcome in terms of marketing and selling horizontal scaffolding systems. For example, potential customers may need to be convinced of the benefits of this type of scaffolding compared to traditional vertical scaffolding systems. Additionally, the cost and complexity of designing and manufacturing horizontal scaffolding may be higher than for vertical scaffolding systems.

Overall, the marketability potential of horizontal scaffolding innovations will depend on a variety of factors, including the specific design and features of the scaffolding system, the needs and preferences of potential customers, and the competitive landscape within the industry.

Conclusion

In conclusion, the proposed innovation idea was made because of the current problem and the problems that always happen when scaffolding parts are moved. The transport method involves lifting the scaffolding components from the truck to the workspace area. The idea was mainly focused on solving the issue of musculoskeletal problems among workers. The scaffolding transportation in horizontal way comprises several components such as a motor drive, chassis, track wheel, steel compartment, IR sensor, monitoring devices, and switches, with help of rechargeable lithium-ion battery. Every feature and component proposed is further explained by its functionalities, which help make the robot more powerful than the current transportation method. The assembly method of the idea has been explained as the assembly process of the components included with the safety features to maintain a safe environment on the construction site. Comparison findings show that scaffolding transport in the horizontal way outperformed human manual lifting performance. The content of this chapter has answered the objective of number one (1) and two (2), which are “to identify the problems associated with scaffolding transportation methods in construction sites” and “to propose an innovation product to improve scaffolding transportation methods in construction sites.”

References

Anupoju, S. (2016). The Constructor. Retrieved from The Constructor- Civil Engineering Home: https://theconstructor.org/building/types-of-scaffolding-in-construction/11845/

Bauer, J. H. (2016). Preventing Musculoskeletal Disorders in the Workplace. Zentralblatt fur Arbeitsmedizin, Arbeitsschutz und Ergonomie, 202-204.

Bernard, B. P. (1997). Musculoskeletal D isorders and Workplace Factors. *Department of Health and Human Services*, 97–141.

Boschman, J. S.-D. (2012). Musculoskeletal disorders among construction workers: A one-year follow-up study. BMC Musculoskeletal Disorders, Volume 2.

Błazik-Borowa, E., & Szer, J. (2015). The analysis of the stages of scaffolding "life" with regard to the decrease in the hazard at building works. *Archives of Civil and Mechanical Engineering*, *15*(2), 516–524.

Choi, S. Y. (2016). Musculoskeletal Disorders in Construction Practica. Solutions From the Literature, 26–32.

Ganesh, C. S., & Krishnan, R. (2016). A review of occupational injury research in Malaysia. *Medical Journal of Malaysia*, *71*(June), 100–104.

Herber, H. J. (1993). Teaching in Content Area with Reading, Writing and Reasoning. Allyn & Bacon : Needham Height, M.A.

Ismail, H. B., & Ghani, K. D. A. (2012). Potential Hazards at the Construction Workplace due to Temporary Structures. *Procedia - Social and Behavioral Sciences*, *49*, 168–174.

Isabel.L, M. P. (2012). Work-Related Musculoskeletal Disorders Assessment and Prevention. Ergonomics - A Systems Approach.

Kewazo. (2018). Kewazo Assembling The Future. Retrieved from Improving On site Construction Logistics Through Robotics and Data Analytics: https://www.kewazo.com/

Lop, N. S., Kamar, I. F. M., Aziz, M. N. A., Abdullah, L., & Akhir, N. M. (2017). Work-related to musculoskeletal disorder amongst Malaysian construction trade workers: Bricklayers. *AIP Conference Proceedings*, *1891*(October 2017).

McCauley Bush, P. (2011). Ergonomics: Foundational Principles, Applications and Technologies. an Ergonomics Textbook; CRC Press, Taylor & Francis, Boca Raton, FL.

Nasir, N. M., Ismail, Z., Ismail, F., Nur, S., & Syed, A. (2012). *Enabling Factors Towards Safety Improvement for Industrialised Building System (IBS)*. *6*(12), 1115–1120.

NIOSH. (1997). NIOSH Publication No. 97- 141. Retrieved from Musculoskeletal Disorders and Workplace Factors: http://www.cdc.gov/niosh/docs/97-141

Nunes, I. L. (2012). *Ergonomics - A Systems Approach*. IntechOpen.

Nunes, I. L. (2009a). FAST ERGO_X – a tool for ergonomic auditing and work-related musculoskeletal disorders prevention. WORK: A Journal of Prevention, Assessment, & Rehabilitation, Vol. 34(2): 133-148.

Pallett, P. F., & Filip, R. (2018). *Temporary Works: Principles of design and construction* (2nd Editio). ICE Publishing.

Rahmah, M., Rozy, J., Halim, I., Jamsiah, M., & Shamsul, A. (2008). Prevalence of back pain among nurses working in Government Health Clinics and Hospital in Port Dickson, Malaysia. *Journal Community Health*, *14*(2), 11–18.

Santos, A., Ramos, H. M., Ramasamy, G., & Fernandes, C. (2014). Improving Workers Health in Projects Based Work: Job Security Consideration. *International Journal of Managing Projects in Business*, *9*, 606–623.

Sauter, S. H.-A. (1993). Summary of two NIOSH field studies of musculoskeletal disorders and VDT work among telecommunications and newspaper workers. Elsevier Science

Publishers, B.V.

Smisek, P. (2018). *Meet The Robot That Transports Scaffolding*. https://www.theb1m.com/video/meet-the-robot-that-transports-scaffolding

WHO. (1985). Identification and control of work-related diseases. Technical report series nº 714, World Health Organization.

Yuan, L., & Buvens, M. (2015). Ergonomic Evaluation of Scaffold Building. *Procedia Manufacturing*, *3*(Ahfe), 4338–4341.