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Level of safety in installation of precast concrete members versus conventional method

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Abstract
Construction accidents are a very important issue to be considered by construction industry practitioners because they can result in death, permanent disability, project delays and even temporary suspension of construction activities. Precast concrete construction is also hazardous in its construction process, especially during the installation of precast components. Industrialized building system (IBS) introduced to provide challenges and fulfill demands for Malaysia's development in construction in order to become a fully developed country, However, aside from positive effects there are negative consequences arising from the incremental installations of large components and the usage of various equipment and machinery which will increase hazards in construction activities. Hence, in order to ensure a safe and conducive working environment, hazard identifications, risk assessment and risk control as in order to implement HIRARC. This study aims to contribute to a better understanding of safety by comparing installations precast concrete members and the conventional method during on site construction process. The scope of the study is focuses on activities beam, slab and wall during installation for both methods and involving the safety aspect, which is use by the contractor. The data collected through document study, interview, and industrial visit in order to identify the safety requirements in precast concrete and conventional method. The whole interviews and research surveys conducted by contractors who have experience in conducting both methods. Results indicate that the safety measures adopted by contractor during in precast construction process is good in safety aspect compared to conventional method during workflow activity in construction sites. In conclusion, this study can increase boost up knowledge and give detailed information about safety in both methods and implementation of HIRARC in construction industry to increase awareness until 0% of accident achieves.

Keywords: Industrialized Building System (IBS), Conventional, Precast Concrete, environment hazard identification, risk assessment, risk control

Introduction
In order to realize the 2020 vision, Malaysia is heading towards in industrial era. In Malaysia, construction sectors are growing rapidly because the number of people in the construction sector has increased from 91,000 people (1970) to 769,300 people (2001) according to the Ministry of Finance's economy report. Some of the mega projects using Industrialized Building System (IBS) are PETRONAS Twin Tower (KLCC), Kuala Lumpur International Airport, Sepang International Circuit (SIC) and Shopping Complexes. (CIDB, Malaysia 2006)

In Malaysia in the early 70's, first precast concrete members introduced but recognized in the 1990's. Many bridge, fly-over, and tunnels constructed using the precast concrete member structures. However due to development, the demand of precast concrete members is rising. A new construction method, which is more effective and systematic needed to reduce cost and duration of construction as well as to maintain quality(Li, Fang, & Wu, 2020) [8]. (Sheppard & Philips 1989)

However, behind the achievements, there are big scarifies which have to be borne by everybody. Environment pollution and the most important is safety in construction site where most of the labors and workers are disposed to hazardous waking conditions. According to the study by the Construction Industry Development Board (CIDB) Malaysia, accident in construction site is the highest compared to other industries.

The government have been undertaken efforts to reduce increasing accident in construction site. Government has also taken initiatives to solve this problem by enforcing safety rules and regulations. However, accident rate still increases unknowingly. Many safety aspects have revised and enforced but still accident happens. This is because of the management or maybe the construction methods use in the construction sites. Conventional method is not appropriate to be use in the site because it is not

environmental friendly due to the waste of wood formwork, concrete and steel reinforcement bar. It will also make the site dirty and provide more hazards to the workers. Precast concrete members have much more advantages will also provide hazard during the installation process. Both of this method has their own advantages, disadvantages and their own safety aspect and level. This study discussed comparison in term of safety aspect during installation of both construction methods.

Previous Work

There are various categories of hazards at construction sites, categorized as hazardous for workers and dangerous to the public. Workers at a construction site are exposed to hazards caused by the altitude, load, electricity, motor, sharp objects, lift, chemicals, dust, noise, limited restrictions, and so forth. Hazards for workers depend on works involves.

It is note that 50% of the construction workers in Malaysia are working under unsatisfactory conditions. The condition includes failure to wear safety helmets and boots, construction sites failing to adhere to pre-requisite safety requirements, and using unauthorized heavy machinery. According to the Ministry of Human Resource, the workplace accident in Malaysia has decreased from 21.2 to 10.3 per 1000 workers, they found that fatal injuries among non-governmental employees in all occupational sectors declined (Ayob, Shaari, Zaki, & Munaaim, 2018) [1]. Figure 1 below shows the recorded industrial accidents in Malaysia and The numbers of cases recorded are high, but they are decreasing year by year, partly due to better awareness of safety. Figure 2 and sources of work-related injuries.

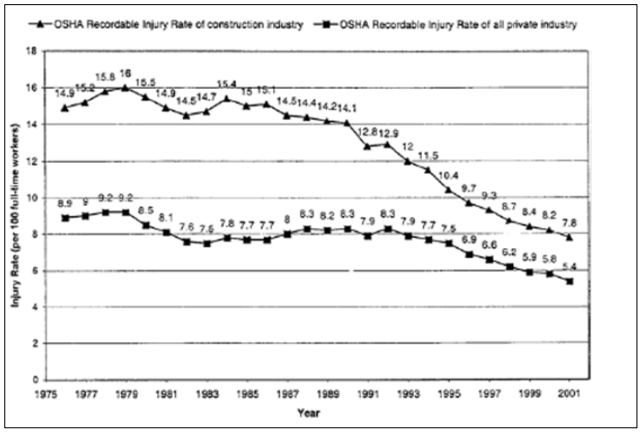

Fig 1: Total Industrial Accidents in Malaysia 1975-2001

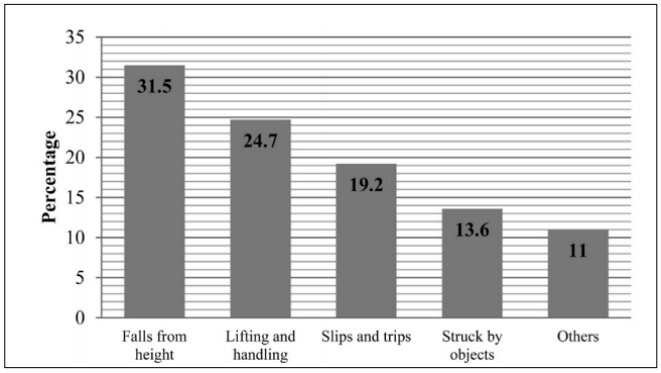

Fig 2: Source of work-related injuries (Zerguine, Tamrin, & Jalaludin, 2018)

Based on the Social Security Organization (SOCSO) report in 2000, the fatality rate in the construction industry in Malaysia was of more than 3 times of all workplaces. The State Occupational Safety and Health Department (OSHD) Director mentioned that most cases in the construction sector involved falling from heights or being injures by a falling object. They recommended that onsite execution process, the implementation of policy, and adherence to safety procedures be reviewed regularly (Ayob et al., 2018) [1]. Whereas, the total expenditure for rehabilitation under the return to work programme in SOCSO are as follows; 230,560.56 RM in 2007, 267,377.00 RM in 2008, 747,486.00 RM in 2009 and 1,231,846.00 RM in 2010 (Kim, 2012) [7]. As the hidden or indirect cost of an accident is eight to 33 times more than direct costs, the total cost of accident can run into billions of ringgit (CIDB, Malaysia 2004).

Accident data prepared by the Bureau of Labor Statistics show that the construction industry has performed much worse than the average of all industries (Figure 2). Although the safety performance of the construction industry has improved dramatically in the 1990s, injury rates in the construction industries are still 50% higher than that of all industries, lagging all industries by about 10 years. With an average employment of approximately 7% of the industrial workforce, the construction industry has regularly accounted for over 1,100 construction worker deaths per year or nearly 20% of all industrial worker fatalities.

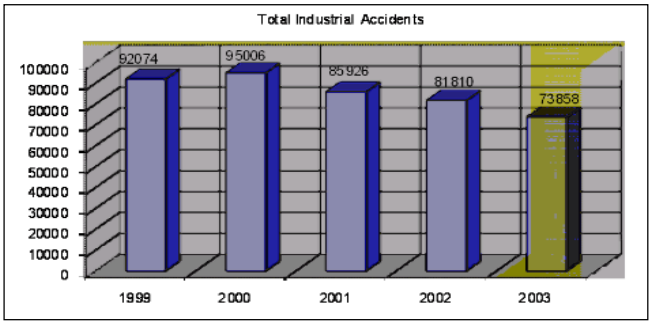

Fig 3: Injury Rate of Construction and All Private Industry

Department of Occupational Safety and Health (DOSH), the developer, Construction Industry Development Board (CIDB) and the various parties involved in the construction industry plays an important role in minimizing accidents and deaths on construction sites and in other workplaces. Statistics of accidents and deaths on construction sites issued by DOSH is quite infuriating. Even though regulations on occupational safety and health in Malaysia are quite comprehensive, enhance the knowledge and awareness of construction workers and management of job-related injuries to decrease the incidence of fatal occupational accidents (Ayob et al., 2018) [1].

Research Method

There were two techniques applied in this study, which are primary data and secondary data to achieve the objectives of the study. Firstly, the primary data for this study taken from field visits and interviews. Site visits conducted within selected companies. The site visits and interview session conducted with the Safety and Health Officer himself. They informed about how the HIRARC process is applies in each activity. The selected companies were Konsortium

Kontraktor "ABC", "DEF" Sdn. Bhd., "GHI" Sdn. Bhd., "KLM" Sdn. Bhd., and "OPQ" Sdn. Bhd.. Thus, all the findings collected by site visits and interviews will be compare with the secondary data. From this analysis, where the potential hazard occur can be identifies and the effective control measures can be proposed. Main hazard occurs in precast concrete members and conventional method. The HIRARC process shown in Figure 3

Primary Data

Classifying Work Activity

A comparison between conventional work activity method and precast concrete conducted. In this study, the selected activities, such as wall, beam and slab are identified with HIRARC process to find out the safety level in each activity (Department of Occupational Safety and Health Ministry of Human Resources, 2008) [2].

Consultation

To further the study, interviews conducted on individuals who are involved in the construction using precast concrete and conventional methods. This includes individuals who supervise the work of installation of both methods and Safety Officer of Konsortium Kontraktor "ABC", "DEF" Sdn. Bhd., "GHI" Sdn. Bhd., "KLM" Sdn. Bhd., and "OPQ" Sdn. Bhd. The purpose of the interviews were find out the work activities in installation of both methods on site. Safety aspects of this work identified through the interviews that conducted.

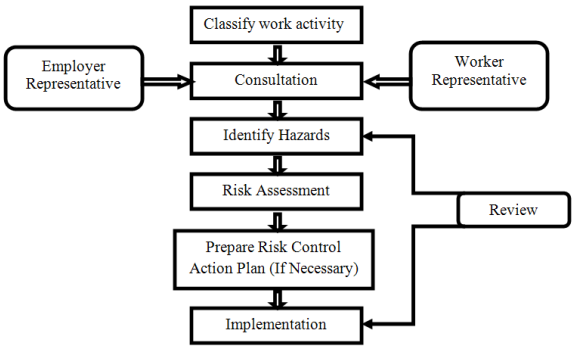

Fig 4: Flowchart of HIRARC process (DOSH, 2008)

Identify Hazards

There are many types of hazards, which potentially exposed to workers. The most common and serious hazard, are gravitational hazard, manual handling hazard, electrical hazard, noise and vibration hazard and chemical hazard**.** **(**Hazard Identification & Risk Manual for Builders, 1997)

Gravitational Hazard

This hazard include anything that can fall, whether it be people, tools, equipment, structure, and slips or trips on slippery or steep work surface, or due to poor housekeeping. The severity of injury from a fall depends on three factors:
Velocity of an initial impact
Magnitude of deceleration due to hardness of the surface
Orientation of the body impact

Chemical Hazard

Chemical hazard can cause injurious effect such us cancer, mutations and other diseases. Workers can injured or got sickness by chemicals through chemicals fumes contact with skin, as well as it can cause explosion, fire and pollution.
Based on the Hazard Identification & Risk Manual for Builders, hazardous substances may be in the form of solid, liquid, gas, vapor, mist, fume or dust. Examples of hazardous substances on site are follows:

1. Petrol
2. Diesel
3. Thinners
4. Paints
5. Acid
6. Concrete curing products
7. Adhesive

Electrical Hazard

Exposure to electrical current may cause injury or death. The voltage is not so important as the amount of current. There are four principle categories of electrical hazards:

1. Shock. Electrical shock is a sudden and accidental simulation of the body's nervous system by an electrical current. Look for bare conductors, insulation failures, buildup of electricity, and faulty electrical equipment.

Table 1: Potential Hazard for Conventional Method

Work Activity	Sequence of job	Potential hazard
1) Wall	a) Erecting of brick wall	• Fall from height • Collapsed of brick wall • Collapsed of scaffold
	b) mixing of mortar	• Wet cement to hand/skin
2) Beam	a) erect formwork and temporary support	• Collapsed of Support
	b) concreting works	• Fall from height
3) slab	a) erect formwork and temporary support	• Collapsed of support
	b) concreting at edges	• Fall from height
	c) Leveling the concrete	• Skin contact with wet concrete

Table 2: Potential Hazard for Precast Concrete

Work Activity	Sequence of job	Potential hazard
1) Wall	a) Lifting the wall panel	i) Crane topple ii) Fall from height
	b) Connection between wall	i) Collapsed of precast

2) Beam	a) lifting beam and place accurately onto the column's corbel	i. Fall from height
		ii. Chain break
	b)install/prepare connection to the column	i. Collapsed of precast
3) slab	a) lifting the panel and place accurately onto the beam	iii. Fall from height
		iv. Chain break
	b)placing conduit/ trunking/ M&E services	i) Electrical shock

Ignition of combustible (or explosive) material. Ignition is usually caused by a spark, arc, or corona effect (ionized gas allows a current between conductors).
Overheating. High current creates high heat that can result in fires, equipment burnout and burns to employees.
Electrical explosions. Rapid overheating of circuit breakers, transformers and others equipment may result in an explosion.
Example of potential hazard in this study showed in Table 1 and Table 2.

Risk Assessment
During the site visit, in order to evaluate the HIRARCs process implemented on site conducted an interview session with the safety and Health Officer was. The safety and Health Officer been made to take into account when filling the form. Risks presented in variety of ways to communicate the result of analysis to make decision on risk control. Risk analysis of Likelihood and severity result in a risk matrix (see Table 3) is a very effective way of communicating the distribution of the risk throughout a plant and area in workplace.

Table 3: Risk Matrix

	Severity				
Likelihood (L)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
Legends	High	Medium	Low		

In mathematical term, risk calculated by the equation:

L X S = Relative Risk
Where, likelihood (L) is an event likely to occur within the specific period or in specified circumstances. Severity is outcome from an event such as severity of injury or health of peoples, or property damages, or degradation of the environment, or any combination of those caused by the event. The likelihood of an occurrence and severity of hazard indicated using the following values as shown in Table 5 and Table 6
To use the Risk Matrix, the severity column that best describes the outcome of risk has should be examine first. Then follow the likelihood row to find the description that best suits the likelihood that severity will occur. The risk level given in the box where the row and column meet. The relative risk value used to prioritize necessary actions to effectively manage work place hazards. Table 4 above shows the description of risk. (DOSH, Malaysia 2008).

Risk Control
From the Guidelines for Hazard Identification, Risk Assessment and Risk Control, control is elimination or inactivation of a hazard in a manner such that hazard does not pose a risk to workers who have to enter into an area or work on equipment in the course of schedule work. Hazard must controlled at their source where the problem created.
Selecting a control often involves:
1. Evaluating and selecting short and long term controls
Implementing short term measures to protect workers until permanent controls can be put in place; and
Implementation of long-term controls reasonably practicable.

Type of Risk Control
Hazard must controlled at their source (where the problem created). The closer a control to the source of the hazard the better it is. This method often referred to as applying engineering controls. If this does not work, hazard often controlled along the path to the worker, between the source and the worker.
This method could referred to as applying administrative and engineering controls. If this is not possible, hazards must be controlled using personal protective equipment (PPE), although this is the least desirable control.

Table 4: HIRARC conventional method for Konsortium Kontraktor "ABC"

Risk score	Description	Action
15-25	High	A high risk requires immediate action plan to control the hazard as detailed in hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion
5-12	Medium	Action A medium risk requires a planned approach to controlling the hazard and applies temporary measure if required. Actions taken must be documented on the risk assessment fom1 including date for completion
1-4	Low	A risk identified as Low maybe considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measure should implemented and recorded.

At the Source of Hazard
1. Elimination - Getting rid of a hazardous job, tool, process, machine or substance is perhaps the best way of protecting workers. For example, a salvage firm might decide to stop buying and start cutting up scrapped bulk fuel tanks due to explosion hazards.

Substitution - Sometimes doing the same work in a less hazardous way is possible. For example, a hazardous chemical can replaced with a less hazardous one. Controls

must protect workers from any new hazards that created.

Engineering Control

1. Redesign- To make the jobs and processes should reworked. For example, containers can made easier to hold and lift.

Isolation – If a hazard cannot eliminated or replaced, it can sometimes be isolated, contained or otherwise kept away from workers. For example, an insulated and air-conditioned control room can protect operators from a toxic chemical.
Automation- Dangerous processes can be automated or mechanized. For example, computer- controlled robots can handle spot welding operations in car plants. Care must take to protect workers from robotic hazards.
Barriers- A hazard should blocked before it reaches workers. For example, special curtains can prevent eye injuries from welding radiation. Proper equipment will protect workers from contact moving parts.
Absorption- Baffles can block or absorb noise. Lockout system can isolate energy sources during repair and maintenance. Usually, the further a control keeps hazard away from workers, the more effective it is.
Dilution – Some hazards diluted or dissipated. For example, ventilation systems can dilute gasses before they reach operators.

Administrative Control

1. **Safe work procedures –** Workers can be required to use standardized safety practices. The employer expected to ensure that workers follow these practices. Work procedures should periodically reviewed with workers and updated.

Supervision and training – Initial training on safe work procedures and refresher training should offered. Appropriate supervision to assist workers in identifying possible hazards and evaluating work procedures.
Job rotations and other procedures can reduce the time that workers are exposed to a hazard. For example, workers can rotated through jobs requiring repetitive tendon and muscle movements to prevent cumulative trauma injuries. Noisy processes can scheduled when no one is in the workplace.
Housekeeping, repair and maintenance programs- Housekeeping includes cleaning, waste disposal and spill cleanup. Tools and machineries are less likely to cause injury if they kept clean and well maintained.
Hygiene – Hygiene practices can reduce the risk of toxic materials absorbed by workers or carried home to their families. Street clothing should kept in separated lockers to avoid contaminated by working clothes. Eating areas must segregated from toxic hazards. Eating should forbidden in toxic work areas. Where applicable, workers should be required to shower and change clothes at the end of the shift.

Table 5: Control measure for conventional method

Work Activity	Sequence of job	Average Rating
1) Wall	a) Erecting of brick wall	12.4
	b) mixing of mortar	4.4
2) Beam	a) erect formwork and temporary support	15.6
	b) concreting works	12.8
3) slab	a) erect formwork and temporary support	13.4
	b) concreting at edges	6.4
	c) Leveling the concrete	4.8

Table 6: Control measure for precast concrete

Work Activity	Sequence of job	Average Rating
1) Wall	a) Lifting wall panel	8.8
	b) Connection between wall	4
2) Beam	a) lifting beam and place accurately onto the column's corbel	13.6
	b) install/prepare connection to the column	5.2
3) slab	a) lifting the panel and place accurately onto the beam	8.8
	b) placing conduit/ trunking/ M&E services	4.8
	c) prepare joint connection between slab panel and beam	4.4

The propose control measure in this study is based on the determination of the most potential hazard obtained from the comparison between primary and secondary data. The propose control measures are shown below. Refer to Table 5 and Table 6.

Secondary Data

In this study, ten literature reviews that were chosen. All selected literature reviews then discussed and analyzed as the secondary data.
Based data analysis, it shows that workers falling from one level to another was in the first rank, followed by workers injured by sharp objects and sharp edges of certain tools. On the second rank was the workers injured by lifting, pulling and carrying heavy objects. Followed by environment hazards created by dust and excessive noise and workers get jammed in between moving machineries in the third rank. The fourth rank was workers exposed to heavy machineries, workers positioned to machine are potentially dangerous, contacted with chemical containers and electric charged equipment, and workers injured when handling steel and encountered hot solution and steam. Finally, workers exposed to adverse weather conditions was the fifth rank. It concluded that the gravitational hazard was the main and most critical hazard found in construction industries based on the literature review. Gravitational hazards include anything that can fall such as people, tools, equipment or structures, and slips or trips on slippery or steep work surfaces, due to poor housekeeping.

Data Analysis

Safety level comparison between precast concrete and conventional methods

The graphs below show the safety level comparison between precast concrete activity and conventional method for Konsortium Kontraktor "ABC". From the graphs, conventional methods have higher risk rating for beam and slab construction compared to precast concrete members. Activity for conventional method is higher in risk compared to precast concrete members, which have medium risk rating. This shows that precast concrete is safer compared to conventional methods.

The graphs below show the safety level comparison between precast concrete activity and conventional method for Bina "DEF" Sdn. Bhd. From the graphs, conventional methods have higher risks for constructing brick wall, constructing formwork, concreting edges and constructing formwork beam work compared to precast concrete members, which only have higher risk on lifting panel work. This shows that precast concrete is safer compared to conventional methods.

The graphs below show the safety level comparison between precast concrete activities and conventional methods for "GHI" Sdn. Bhd. From the graphs, conventional methods have higher risk rating for constructing brick walls, constructing formwork, concreting at edge and constructing formwork beam work compared to precast concrete members which only having higher risk on lifting panel work and medium safety level. This shows that precast concrete is safer compared to conventional method.

The graphs below show the safety level comparison between precast concrete activities and conventional methods for "JKL" Sdn. Bhd. From the graphs, conventional methods have higher risk rating for constructing of brick wall and constructing formwork for activity beam while precast concrete members have a higher rating at lifting panel for slabs compared to other companies. However, it is still in medium range. This shows that precast concrete is safer compared to conventional methods.

The graphs below show the safety level comparison between precast concrete activities and conventional methods for "OPQ" Sdn. Bhd. From the graphs, conventional methods have higher risk rating for constructing brick walls and constructing formwork compared to precast concrete members which only having higher risk on lifting panel work for lifting beam only. However, it is still in medium range. This shows that precast concrete is safer compared to conventional methods.

Safety factor during Installation Precast Concrete Members

Safety factor is important in the process of building a system of precast concrete. This is because the elements lifted by crane installed is very heavy. However, workers need a lot of attention during the installation process (erection). Each element of the structure must also securely installed that it does not easily collapse. It is important for high-rise buildings, because strong wind loads will have a major impact on the structural elements.

Lifting

The lifting component process is the most critical and complicated in the process of installing pre-cast components. This is because workers exposed to hazards that can cause severe injury or death. This process involves the transfer of large size and weight components. Workers and anyone who are in the site area should not be under the component when the work carried out. There is must be vigilance in noting where the wind is blowing.

This is because the transfer of work during the high winds is a big risk for fearing the crane cannot well controlled and will lead to accidents. In addition, the lift component during the night and rain not recommended.

Placing

The work alignment components, or in preventing components from colliding with other components, use of tools such as bars and shims is necessary. Using hand to work strictly prohibited as it can cause danger and injury to workers. If the work should conducted in a high position, employees must wear the appropriate number of security tools such as safety harness.

Propping

Propping method used to support component whose aim is to produce compressive forces, such as a beam or slab. Proper installation is crucial to ensure that a prop will support the weight of pre-cast components. Safety aspects at propping work is to be in consideration and carried out correctly. The correct method of installation and inspection tools propping must emphasized. This is because the failure to sustain propping can fail to accommodate concrete components.

Propping must be flat and level in its position to be able to move the load evenly. Soil and surface for propping area should be strong and able to bear loads from propping.

Crane operation safety

Crane is an important vehicle for the installation of pre-cast concrete. Among the cranes used for component assembly work are moving cranes, tower cranes and derrick cranes. Crane should be kept in a safe condition, so that the work can been carried out smoothly and can avoid accident.

In addition, there are some other things need to be checked before installation work begins. Among them, the site area for the cranes at work then sufficient strength to support the crane must make sure. Crane operators must ensure that means of communication are in good condition. In addition, the component positions to ensure that the work carry out smoothly.

Safety factors in conventional construction method

Accident is common with the conventional method. It often caused by a lack of precautions such as**:**

1. Failure to wear safety helmet while doing brickwork.
2. Failure to wear safety boot when working.
3. Failure to wear protection such us gloves.

Human errors are often associated with the cause of the accident. Therefore, workers and employers should emphasize safety to avoid accidents from happening. The number of accidents are likely to be reduce as long as the individuals involved in the construction site take precautions and noted safety measures.

Scaffolding Operation Safety

Before using the scaffold, there are some basic requirements to ensure that the scaffold fulfill safety aspects:

1. The scaffold has to be strong enough to bear the entire loads placed on it. Beam platforms should not place too

far away and a single tube should not support too much load.
2. The scaffold has to be stable and not sagging, and moves in all directions. Proper installation of bracing across the scaffold is very important.
3. The platform installed must be safe to work on and no traps left on the board platform. Warnings against possible accidents occurring due to the movement of platform by the board of the cart and so on.
4. Materials and equipment must not fall from the working platform.
5. Safety of all workers on site must be protect by taking consideration of the safety of each place that can cause the accident.

Building Regulations aim to incorporate all the things that must be express before and the primary requirements for scaffolding are:
1. All materials used must be of high quality and safe.
2. Each scaffold must be construct properly.
3. Each scaffold must be properly maintain.
4. Parts of the scaffold cannot be remove or open at will, but according to the rules or by displaying a notice, with a warning that the scaffold cannot be use, and any attempt to use them should be prevent.
5. Scaffolding beams positioned exactly vertical or slightly tilted towards the building and installed close to the building to help stabilize the scaffold.
6. Base of the scaffold must strongly built.
7. Crosstie with strong binding on the beam or scaffolding. When supported by the wall, the bar must have protractile binders in the wall to provide adequate support.
8. As a general rule, the distance between the crossbar fastener must not exceed:
   a) 1 m for 31 mm thick boards.
   b) 1.5 m for 38 mm thick boards.
   c) 2.59 m for 50 mm thick boards.
9. Scaffolding must be secure and properly supported, and braced or connected to a strong the building to ensure its stability.
10. Loose bricks, drainage pipes, and other inappropriate material should not be use in the construction of scaffolding.
11. However, the bricks or blocks use as a support platform that does not exceed 600 mm above the ground or floor where it can provide strong support.
12. Parts of the building cannot be use as the support scaffolding, except if the structure of the material is appropriate and safe.

Personal protection equipment

The workers should be provide with personal protective equipment (PPE) for protecting workers during construction work in progress. The employer is responsible for providing safety equipment such as helmets, eye or face protection equipment, safety shoes and safety harnesses. It is a basic need to be ware by workers at a construction site and as one of the basic steps to protect workers (Kaliba, Muya, & Mumba, 2009).

Face and eye protection

Most cases of injury to workers in the eyes and face are due to workers not wearing protective eye and face protection devices. It can be cause by inappropriate use, poor quality or damaged protection equipment. Protective equipment used improperly can invite danger to the worker. It is the responsibility of the employer to ensure safety quality the use of protective equipment. Selection of protective equipment depends on several factors:
1. Attempt to protect from hazards or accidents during work.
2. Convenience to users while carrying out the work.
3. Avoid blocking the vision or movement.
4. Durable and easy maintenance.

Head protection

Injuries due to the head are very dangerous, because it can cause severe injury or death to workers. The individual workers or anyone in the construction area must wear a safety helmet as a precondition for being in the area, to prevent injury to the person of falling sharp or hard objects that may fall and protrude. Head protective device is able to withstand penetration of sharp objects, to absorb shock, to resist water resist and to slow burning (Dumrak, Mostafa, Kamardeen, & Rameezdeen, 2013).

There are three types of helmets:

Class A: Able to provide protection against any infiltration and impact. It is also able to provide protection against high voltage to 2.200 volts.

Class B: It gives high protection against the dangers of electric shock as high as 20.000 volts and capable of providing protection against any infiltration and impact.

Class C: To provide protection against any shock, but do not provide protection against electric shock.

Leg protection

Leg protective equipment is essential to the workers to protect their feet from falling or rolling objects and sharp objects. This is because there is a layer of steel on the foot that can prevent penetration of sharp objects out of danger(Halim, Jaafar, Kamaruddin, Kamaruzaman, & Jamir Singh, 2020).

Ears protection

Noise pollution is usually more than 80 dB (A) and the pollution is in accordance with the situation. This pollution can be divide into four sections, namely noise, continuous noise, the noise fluctuations and the sound echoes. If workers are force to be expose to noise for an extended period, the worker must wear hearing protection against noise, earplugs (Ear Plug) and Earmuff.

Hand protection

Protection of hands is one of the most important protective equipment. This is because all of the work involves the complete use of hand. Hand protection is essential to protect the hands from any injury that may occur, such as wounds, burns, fractures, broken bones, bruises, etc. There are various types of protection with their respective functions for the work to be carry out. Selection of hand protection for the type of work done depends on comfort, size and thermal protection. This is because the choice for the right hand of protection can guarantee the functionality of the gloves while simultaneously avoiding accidents.

Conclusion

Evidences concludes all findings that lead to the achievement of the objectives of this study are to identify the potential hazard in installation work activities of precast concrete and conventional method, to identify the safety aspect during the installation process and to compare safety level for both methods..

The results indicate that the safety aspect implemented by contractor involved in precast construction process is good compare to conventional methods during workflow activity for construction sites. However, IBS in the construction industry is still not widely used. The tables below show the comparing data based on average rating between precast concrete members and conventional method. It concludes that conventional methods has a higher rating for each activity compared to precast concrete and the most potential hazard occurring between this two methods is gravitational hazard.

Appendix

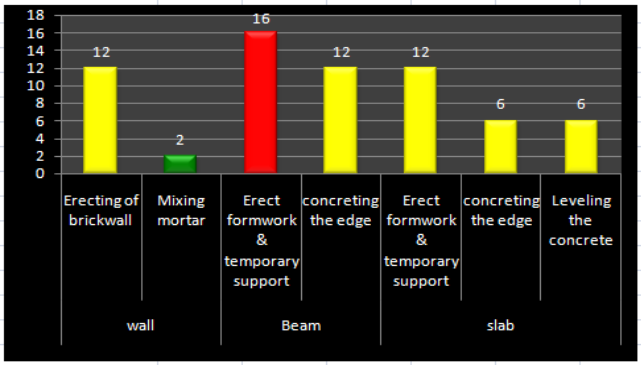

Fig 4: HIRARC conventional method for Konsortium Kontraktor "ABC"

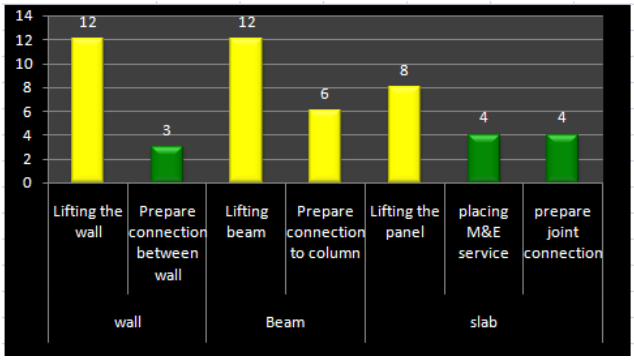

Fig 5: HIRARC Precast Concrete for Konsortium Kontraktor "ABC"

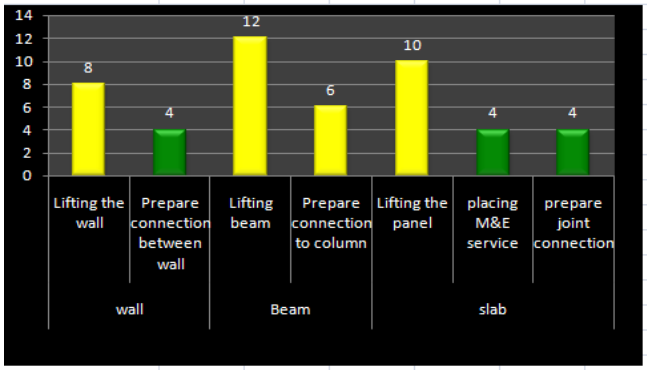

Fig 7: HIRARC Precast Concrete "DEF" Sdn. Bhd.

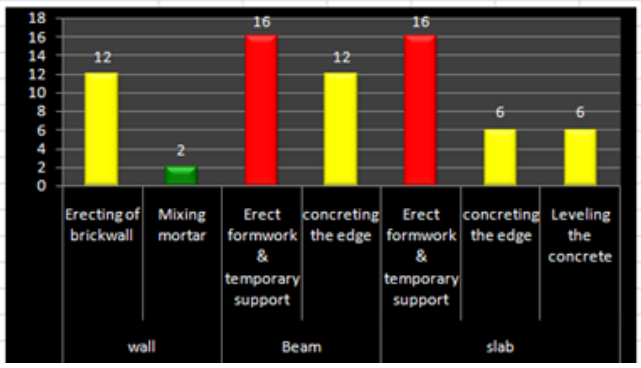

Fig 6: HIRARC conventional method for "DEF" Sdn. Bhd.

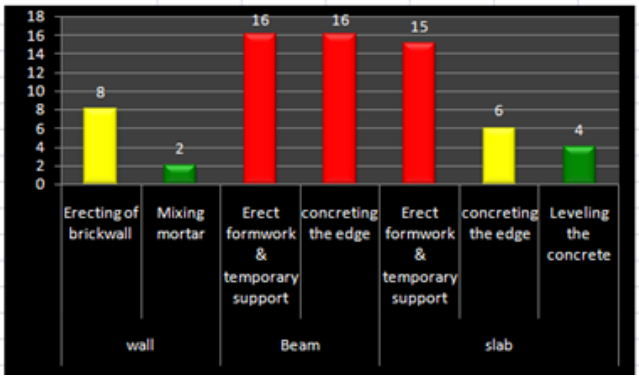

Fig 8: HIRARC conventional method for "GHI" Sdn. Bhd.

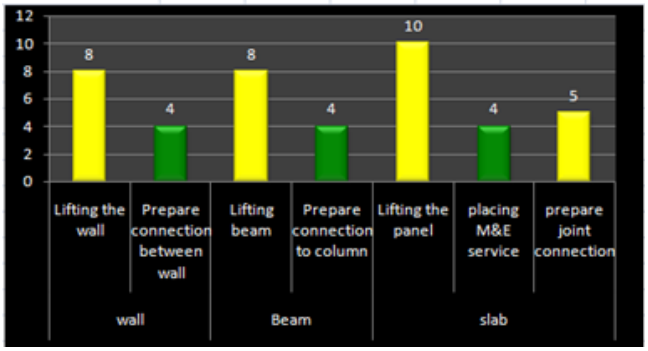

Fig 9: HIRARC Precast Concrete for "GHI" Sdn. Bhd.

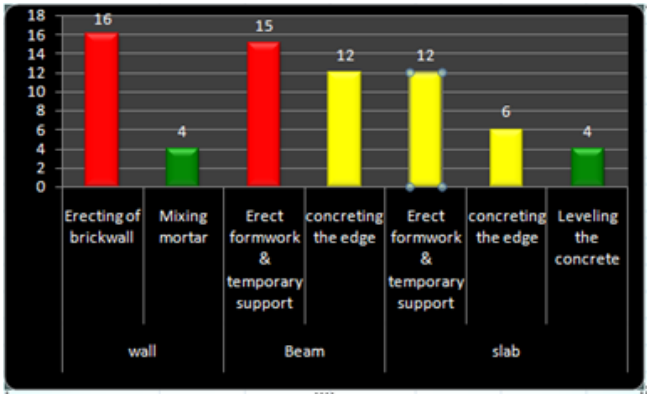

Fig 10: HIRARC Conventional Method for "KLM" Sdn. Bhd.

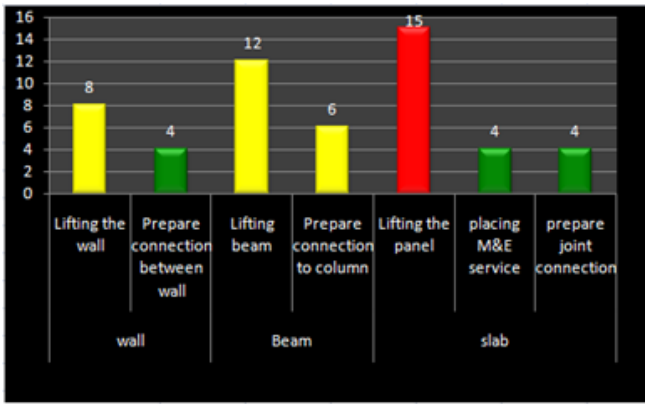

Fig 11: HIRARC Precast Concrete for "KLM" Sdn. Bhd.

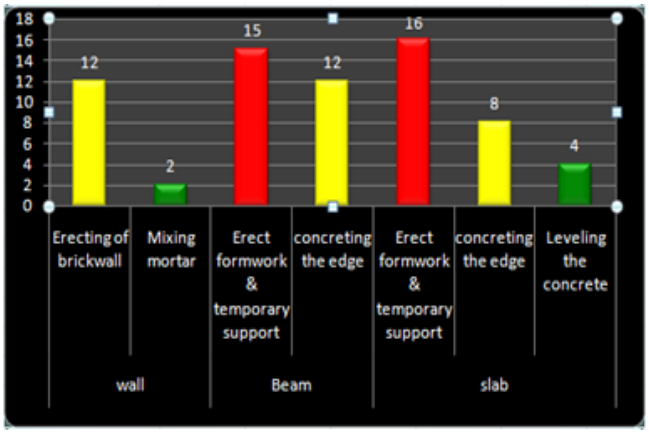

Fig 12: HIRARC Conventional Method for "OPQ" Sdn. Bhd.

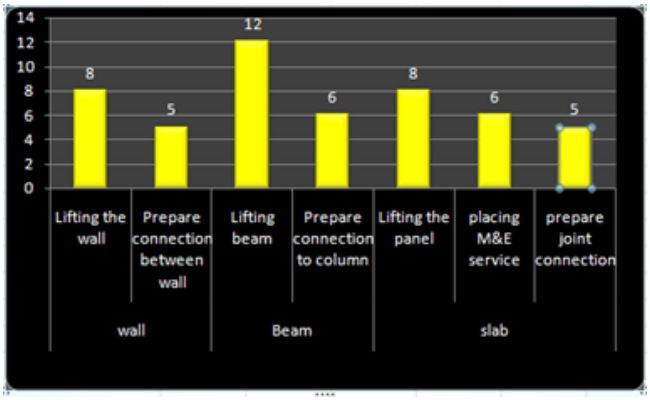

Fig 13: HIRARC Precast Concrete for "OPQ" Sdn. Bhd.

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