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Enabling Factors Towards Safety Improvement for Industrialised Building System (IBS)

Nasyairi Mat Nasir, Zulhabri Ismail, Faridah Ismail, Sharifah Nur Aina Syed Alwee, and Masnizan Che Mat

***Abstract*—**The utilisation of Industrial Building System (IBS) in construction industry will lead to a safe site condition since minimum numbers of workers are required to be on-site, timely material delivery, systematic component storage, reduction of construction material and waste. These matters are being promoted in the Construction Industry Master Plan (CIMP 2006-2015). However, the enabling factors of IBS that will foster a safer working environment are indefinite; on that basis a research has been conducted. The purpose of this paper is to discuss and identify the relevant factors towards safety improvement for IBS. A quantitative research by way of questionnaire surveys have been conducted to 314 construction companies. The target group was Grade 5 to Grade 7 contractors registered with Construction Industry Development Board (CIDB) which specialise in IBS. The findings disclosed seven factors linked to the safety improvement of IBS construction site in Malaysia. The factors were historical, economic, psychological, technical, procedural, organisational and the environmental factors. From the findings, a psychological factor ranked as the highest and most crucial factor contributing to safer IBS construction site. The psychological factor included the self-awareness and influences from workmates behaviour. Followed by organisational factors, where project management style will encourage the safety efforts. From the procedural factors, it was also found that training was one of the significant factors to improve safety culture of IBS construction site. Another important finding that formed as a part of the environmental factor was storage of IBS components, in which proper planning of the layout would able to contribute to a safer site condition. To conclude, in order to improve safety of IBS construction site, a well-trained and skilled workers are required for IBS projects, thus proper training is permissible and should be emphasised.

***Keywords*—**Enabling Factors; Industrialised Building System; Safety Improvement.

I. Introduction

INDUSTRIALISED Construction System or Industrialised Building System (IBS) has been identified as a potential solution to improve the overall performance of a project including the safety aspect. It is a system which uses industrial production techniques either in the production of components or assembly of the building or both. The utilisation of IBS components leads to a safer working environment at minimum work is required on-site, cleaner sites due to timely material delivery, systematic components storage, reduction of construction material and waste [1].

The IBS Roadmap 2003-2010 published by the Construction Industry Development Board (CIDB) outlines several well-thought strategies and aggressive steps to promote the usage of IBS in Malaysia. The government is taking the leading role in persuading the construction industry to adopt a more systematic approach and methodology in construction. The effort which started in 1998 is a strategic change in the construction industry [2].

The innovation of IBS as a construction method and the promising features such as improve quality, cost, time and safety have inevitably made IBS an excellent option for the parties in the industry. However, apart from all the advantages of the system, weaknesses are still found in the IBS construction concerning to its safety issues. This has proven through numerous construction accidents which mostly includes involvement of cranes and fallen objects which take a big part in the IBS construction method [3].

Health and safety is still an issue despite of all the steps taken by the government and other related agencies through enforcement of various rules, regulations, policies and Acts. This also includes camping by voluntary agencies. There are three basic laws that govern Health and Safety which are Factories and Machinery Act 1967, Occupational Safety and Health Act 1994 (Act 514) and Construction Industry Development Board (Act 520). There are also training/awareness and enforcement programmes created in order to put safety a priority such as Green Card under CIDB and Coupon System under DOSH. In order to materialise the Construction Industry Master Plan (2006-2015), which targets of zero number of accidents and fatality rates, it is important to examine all areas of construction and disclose methods that can improve it.

Utilisation of IBS components reduces dependency on foreign workers,improving quality, cost effectiveness, safety, waste reduction and productivity. The development of IBS in Malaysia started with the implementation of precast concept when the government launched two pilot projects in the year 1964; the construction of Tuanku Abdul Rahman Flats or known as Pekeliling Flats in Kuala Lumpur and the Rifle Road Flats in Penang. A survey conducted by the Construction Industry Development Board (CIDB) Malaysia revealed that the level of IBS usage is at 15% [1]. However, the released of the Treasury Circular of 7/2008 makes it a mandatory for all government projects to accommodate 70% of IBS components.

Authors are with the Faculty of Architecture, Planning and Surveying, Universiti Teknologi Mara, 40450 Shah Alam, Selangor Darul Ehsan, Malaysia (corresponding author to provide phone: +603 5544 2272; fax: +603-5544 4353; e-mail: zulhabri_ismail@yahoo.co.uk).

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The extent to which the utilisation of IBS components leads to a safer working environment in practice is not known. The questions arise on how to improve the safety aspect on the IBS construction method. Enabling factors may help fill this gap. Hence, IBS shall be rigorously implemented and called for the need on the enabling factors that foster a safer working environment to be addressed. This topic has not been researched before and is an early attempt to investigate this matter.

II. Improving the Safety Aspect of Industrialised Building System (IBS) Construction

In construction industry, innovation of building system is considered necessary in order to cater to the increasing demand of industry products. Moreover, the conventional system is normally labelled as time consuming and labour intensive. Applying industrialisation principles to the construction industry is a technique in handling this problem and increasing the productivity of the construction industry [14].

Industrialised Building System is also known as the complete assembly construction: a construction system where components are manufactured at factories on or off site, transported and then assembled into a structure with minimum work'[4]. In 2003, CIDB addressed this problem by redesigning its strategies and created a roadmap based on 5M strategy. The 5M includes manpower, materials-components-machines, management-processes methods, monetary and marketing [5]. This roadmap aimed to have an industrialised construction industry and achieving Open Building by the year 2010 [1].

It is important to note that IBS can be categorised into three phases which are manufacturing, delivery and also the construction phase. Then, the most important element during the sequence of construction is the planning. During the manufacturing phase, the IBS components are usually done at the factory. Plants and equipment such as mixer, dust collector and others are used with high voltage power. It will be stacked at the factory or manufactured just in time upon the request of the contractor. Transportation of logistics plays a major role in selecting or developing an appropriate prefabrication system. This includes considering the aspect of size and weight, route restrictions, availability of lifting equipment and site accessibility.

In IBS, during delivering phase, the safety aspect is not only at the site but also on the road during which the transportation is in progress for example during the delivery process, precast components should be secured by a single rope after each stack onto a truck had resulted into the rope giving its way. Otherwise, segments of the components would fell onto the road and were then rejected [6]. The method of securing segment was later improvised to prevent the occurrence of such incidents and wastage of resources.

The construction phase is the most challenging stage as it involves several activities. The activities include the lifting, placing, bracing, connecting and grouting of the IBS components.

It differs from the traditional method as mostly the components and structures are large in size and they need to be cast on site. Therefore, the safety aspect of it may also differ.

A. The Enabling Factors Influencing Safety Improvement

It is important to identify the aspect that can be improved in order to enhance the safety performance of construction sites. Although IBS researchers have pointed that safety is one of the advantages associated with IBS construction, but there are times it can turn out to be disastrous. Being said, targeting zero accidents on construction sites is a good policy and therefore safety should be managed properly due to strong humanitarian, financial and legal reasons.

According to [7] and [8], the factors that are linked to the level of site safety are historical, psychological, technical, procedural, organisational and environmental factors. The historical factor is assessed by the background and characteristics of the individual, such as age and experience. The older and experience a worker gets, the more aware and alert he is towards safety at construction site [7]. The same task done at a younger age will be analysed and handled differently when doing it at a later age. Due to this ability to adjust, one can continue with a highly skilled activity. The factor can be used to investigate whether IBS workers are employed based on age and experience. This is important especially when IBS is using large a big equipments.

Under the economical factor, assessment is done by assessing the reward and punishment system. Based on the Operant Conditioning Theory [9], there are four tools that managers can use to motivate high performance and prevent workers from engaging in other behaviours that will detract from organisational effectiveness. These tools can be described as the positive reinforcement, negative reinforcement, extinction, and punishment. According to this theory, to motivate workers to perform their jobs in a safe manner, contractors should offer incentives such as monetary rewards, bonuses and job promotions.

On the other hand, the psychological factor is assessed by the safety behaviour of fellow workers on site including supervisors. These are such factors as the effect of the Malaysian Health & Safety at Work Act of 1974, influence of training levels, propensity to accept danger or risk taking, skill levels, supervisor carefulness, worker carelessness and others [8]. Psychological factors will help a worker to behave in safe manners since the lack of psychological awareness has been proven to be among the largest causes of construction accidents. A study [10] in Hong Kong has reported that two climate dimensions (management commitment and workmates' influence) will greatly influence the workers' safety behaviour than their own personal experience when attending the training programme arranged by their employer.

Nevertheless, education and training is still important to maintain a good safety performance record. A firm is obliged to provide sufficient, adequate and continuous training to all workers [11]. The training scheme must be supplemented with job-specific information if necessary. The training (both basic and specific) increases the workers' skills to behave safely in the workplace. As a result, organisations with better-trained workers will have a larger stock of safety human capital.

Procedural factor is assessed by the provision of training and handling of safety equipment on site and how the operation of equipments is correctly managed on site. Items such as plant and equipment and asbestos as well known failures that contributed to the accident and property damage on site [8]. Such items are likely to cause accidents if they are not correctly handled with care and in accordance with set procedures. Some of the procedures that can enhance the firm's safety effort is through the active monitoring system. It includes procedures for examining the physical conditions of the workplace and installations [11]. This can also be reviewed as an important role and responsibility of a supervisor. However, the question remains whether this factor is suitable within the context of IBS construction or will it be a matter of interference to the sequence of construction work.

Organisational factors were considered as items such as group interactions/interrelationships, trade union involvement, safety policy and safety propaganda and others. These have been labelled as "organisational and risk management systems". [12] considered these items as "organisational changes within a feedback loop". Effective project management can be seen to be dependent upon the project manager's competency and authority [13]. Organisational factors are beyond than just the role of a project manager but include trust and communication skill from top management to the bottom management. The importance of trust in safety research was demonstrated by [14], where they have figured out that the relationship between safety leadership and safety citizenship behaviour was subjected by safety-specific trust in management.

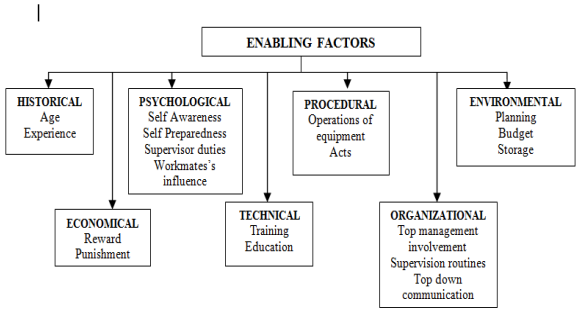

Fig. 1 Enabling Factors

The environmental factors are the factors that relate to the site conditions, the interrelationships between the construction groups, such as inter and intra group co-operation, control and supervision of work activities, site tidiness, influence of site planning and also worker safety observance. This can also be investigated through the management and leadership style of an organisation [7] and [8]. The above discussion on enablings factors has have been summarised in Fig. 1.

III. Methodology

The data analysis for this research was derived from the total feedback of 36 respondents (n= 36/ 314) of Grade 7 to Grade 5 contractors listed under the Construction Industry Development Board (CIDB), a Directory which utilises the Industrialised Building System within Malaysian construction industry. In the questionnaire survey, five Likert- scale were used to measure all dimensions (1= strongly disagree and 5= strongly agree). The questionnaire survey is divided into two sections. The first section is to gain the demographic information of the construction companies. The second section questions investigate the factors to improve safety issues in IBS construction. All questions were designed based on the variables obtained through the literature review. With a response rate of 11.46%, the assessment of the factors was deduced by using the mean score. The collected data from questionnaire feedbacks were analysed by using frequency analysis as the preliminary analysis. In order to generate results, the researchers used the Statistical Package for Social Science (SPSS) software program for Windows for processing the analysis.

IV. Results and Discussions

Reliability test was applied to prove the researched data consistency. The result showed that the Cronbach's Alpha = 0.890 of 45 items. As the value is close to 1, therefore, this shows the data has good internal consistency.

A. Safety Issue

The safety issues regarding IBS have been collected from literature reviews and related to the typical IBS activities found on construction sites. The issues were further categorised into three, the impact of IBS construction, the most important aspects of safety for IBS construction and where accidents usually occur. This section aimed to identify the general view regarding safety in IBS.

TABLE I
Safety Issues of IBS

	Factors	Mean	Std. Deviation	Category Ranking
Impact of IBS construction:-				
1.	Increase safety precaution	3.86	0.96	1
2.	Waste	3.17	1.29	5
3.	Suppliers/Manufacturer's poor performance	3.25	0.99	4
4.	Higher construction cost	3.52	1.08	3
5.	Labour and equipment productivity	3.75	0.99	2
The most important aspect of safety for IBS construction:-				
6.	Transportation of components	3.97	0.84	3
7.	Lifting system of components	4.16	0.87	1
8.	Placing of components	3.83	0.87	4
9.	Bracing process of components	3.83	0.91	4
10.	Connection and jointing of components	4.11	0.85	2
Accidents or near misses usually occur during :-				
11.	Transportation of components	3.58	0.96	3
12.	Lifting system of components	3.69	0.85	1
13.	Placing of components	3.61	0.93	2
14.	Bracing process of components	3.58	1.02	3
15.	Connection and jointing of components	3.52	0.97	4

The respondents identify variables that they perceived by responding to a scale from 1 (strongly disagree) to 5 (strongly agree). The five rating Likert Scale is, 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 strongly agree. The mean of each factor has been calculated and the ranking of these factors determine the most critical safety issues of IBS in Malaysia.

From the result of impact of IBS construction (refer the Table I above), safety ranked in the first category, which was fairly a surprise. This was followed by labour and equipment productivity, higher construction cost, suppliers/manufacturers poor performance and waste. The most important aspect of safety for IBS construction occurred during the lifting system of components. This was followed by connection and jointing of components and also followed by transportation of components in the third rank. Moreover, placing of components and bracing process of the components came together in the fourth place. The results prove that safety precaution is an issue that should not be taken lightly as it ranked as one of the highest impacts of IBS construction. This is because safety is an important aspect of construction, regardless of the system used.

This also has proved that IBS construction was not as safe as it has been reported through various literatures. Lifting system of components was the most crucial aspect where safety is considered exposed as it is obvious that IBS involves large components and panel. Moreover, lifting IBS components requires large and heavy equipment. Without proper guideline and manual, some equipment can break down due to incompetent of workers assuming equipment carrying more workload than it can which later cause harm to the workers on site.

B. Improving Safety of IBS

Several factors were collected through literature reviews as bases for determining the crucial factors to improve the safety issues of IBS construction. The factors have been categorised under seven main categories which are historical, economical, psychological, technical, procedural, organisational and environmental factors (refer the Table II).

TABLE II
FACTORS TO IMPROVE THE SAFETY ISSUES OF IBS

Factors	Mean	Std. Deviation	Category Ranking	Overall Ranking
Historical Factors				
1. Older workers are more sensitive to safety issues.	3.86	0.86	1	6
2. Experience workers less involve in accidents.	3.77	0.92	2	7
3. Workers are educated in IBS field.	3.25	0.76	4	16
4. Only skilled labours for IBS construction.	3.69	0.70	3	10
Economical Factors				
5. Bonus pays leads operatives to perform faster and unsafely.	3.27	0.91	1	15
6. Safety bonus payment is practiced in my company.	2.94	0.98	2	19
Psychological Factors				
7. Site supervisor is much involved on site regarding safety.	3.72	0.74	3	9
8. Safety and Health act impacts the workers working behavior.	3.72	0.74	3	9
9. Adequate safety training is provided for employees at all levels.	3.86	0.72	2	6
10. I have been pressured to put production before safety.	3.16	1.05	4	18
11. I am aware of safety and put it as my individual priority.	4.19	0.74	1	1
Technical Factors				
12. IBS components are transported under safety officer supervision.	3.36	0.93	4	14
13.IBS components arrive in original condition without any damages.	3.55	0.69	3	13
14.Only experienced workforces are duty to operate machine for installation.	3.69	1.06	2	10
15.Workers are given adequate training and explanation before operating machine.	3.88	0.97	1	5
16. Use of ladders and scaffolding in IBS construction face higher possibility of accidents happening.	3.16	1.02	5	18
Procedural Factors				
17. IBS installation requires more safety equipment	3.58	1.13	5	12
18. Workers are trained on using safety kit, clothing and equipment	3.69	0.70	3	10
19. Delay of inspection leads to unsafe behavior.	3.75	0.93	2	8
20. Contract of Employment should impose punishable offense for failure to use safety equipment.	3.91	0.84	1	4
21. All the safety rules for my project really work.	3.61	0.59	4	11
Organisational Factors				
22. Management is open to discussing safety issues.	3.77	0.72	2	7
23. Project management routinely checks on safety.	3.75	0.80	3	8
24. Project management encourages safety efforts.	4.02	0.65	1	2
25. Project management pays attention to safety only after accidents have occurred.	3.22	1.04	4	17
26. Safety information (accidents,hazards,goals,etc) is communicated to me in a timely manner.	3.75	0.64	3	8
Environmental Factors				

27. Design stage has included safe working conditions for IBS construction.	3.55	1.05	4	13
28. Storage is important for IBS components.	3.94	0.67	1	3
29. Proper planning for machinery and equipment impact the safety aspect in IBS construction.	3.88	0.74	2	5
30. Adequate budget is provided for maintaining a safe work environment.	3.61	0.83	3	11

C. Ten Vital Factors for Improving Safety of IBS

From the variables that have been categorised in the above analyses, the next step identifies the variables (refer to Table III) that can be considered as the vital factors to improve the IBS in construction activities. There are 18 variables fell into the 10 top-ranking factors because of the same mean of some variables.

The main factor is from the psychological factors category which is self awareness of safety and putting it as an individual priority. This is important because no one is capable of providing safety for us if we are not aware of this issue ourselves. Moreover, this helps workers to understand and be transparent to other factors influencing safety improvement when they are highly aware about safety. Most crucial improvement factor is followed by project management encourages safety efforts from the organisational factors' category. Project management has always been an important aspect in encouraging the workers. Even the encouragement from top management can make a big difference.

TABLE III
TEN VITAL FACTORS IMPROVING SAFETY OF IBS

Factors	Mean	Std. Deviation	Category Ranking	Overall Ranking
1. I am aware of safety and put it as my individual priority.	4.19	0.74	1 (Psychological Factors)	1
2. Project management encourages safety efforts.	4.02	0.65	1 (Organisational Factors)	2
3. Storage is important for IBS components.	3.94	0.67	1 (Environmental Factors)	3
4. Contract of Employment should impose punishable offense for failure to use safety equipment.	3.91	0.84	1 (Procedural Factors)	4
5. Workers are given adequate training and explanation before operating machine.	3.88	0.97	1 (Technical Factors)	5
6. Proper planning for machinery and equipment impact the safety aspect in IBS construction.	3.88	0.74	2 (Environmental Factors)	5
7. Older workers are more sensitive to safety issues.	3.86	0.86	1 (Historical Factors)	6
8. Adequate safety training is provided for employees at all levels.	3.86	0.72	2 (Psychological Factors)	6
9. Experience workers less involve in accidents.	3.77	0.92	2 (Historical Factors)	7
10. Management is open to discussing safety issues.	3.77	0.72	2 (Organisational Factors)	7
11. Delay of inspection leads to unsafe behavior.	3.75	0.93	2 (Procedural Factors)	8
12. Project management routinely checks on safety.	3.75	0.80	3 (Organisational Factors)	8
13. Safety information (accidents,hazards,goals and others) is communicated to me in a timely manner.	3.75	0.64	3 (Organisational Factors)	8
14. Site supervisor is much involved on site regarding safety.	3.72	0.74	3 (Psychological Factors)	9
15. Safety and Health act impacts the workers working behavior.	3.72	0.74	3 (Psychological Factors)	9
16. Only skilled labours for IBS construction.	3.69	0.70	3 (Historical Factors)	10
17. Only experienced workforces are duty to operate machine for installation.	3.69	1.06	2 (Technical Factors)	10
18. Workers are trained on using safety kit, clothing and equipment	3.69	0.70	3 (Procedural Factors)	10

This research has also found that training is an important factor in improving the safety of IBS construction, especially training that is provided before operating machines. IBS construction involves many equipments and heavy machines.

Lack of training can result in accidents or near misses occurring. The results above also shown that planning layout for an IBS construction site is an important aspect. This can be seen within the top ten vital factors, which include the variables of storage for IBS components and proper planning for machinery and equipments as the important aspects in IBS construction.

It is also illustrated that delay of inspection leads to unsafe behaviour. This can be related to the responsibility of the safety officer. Most safety officer takes lightly their jobs and only pays attention when accidents have occurred. Furthermore, some safety officers are not well equipped with construction knowledge or background. This may interfere with the process on site as they are not giving full commitment to the workers safety. The delay in inspection also leads the workers to unsafe behaviour because they would want to finish their work as fast as possible and ignore the safety elements.

V. CONCLUSION

From the findings, it can be concluded that:

a) Workers must be knowledgeable and high self awareness in order to have a safe construction site. They must put safety as a priority.
b) Training given to workers may increase their self awareness.
c) Workmates behaviour also influences oneself to act in a safe manner at construction sites.
d) Most of the vital factors to improve safety at IBS construction site can be categorised as psychological factors.

Several suggestions and recommendations have been identified and on how to improve the safety of IBS construction:

- Allow only certified installers by CIDB to involve in IBS construction.
- Have an organisational safety policy for the proper administration of safety;
- Provide formal safety training for their workers;
- Conduct daily "tool box" safety talks;
- Conduct weekly formal safety meetings at the project level;
- Always post safety signs and posters at the job site;
- Conduct weekly safety inspections from Government Safety bodies;
- Reward workers for their safe behavior;

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