The Association between the Number of Labour at IBS Precast and IBS Aluminium Formwork Site to the Productivity of Labour

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Abstract. The Industrialised Building System (IBS) has many advantages as one of the initiatives towards a better construction method compare to the conventional one especially in term of productivity of the labour and quality of the construction. This paper discusses the outcome of a study aimed to investigate the association between the numbers of labour at IBS precast and aluminium formwork site to the productivity of labour in construction. A list of benefits of IBS in construction and the factor related to labour that influence the labour productivity during the installation of IBS components is discussed in this paper as well as their significant relationship. The data were collected through questionnaire survey, site visit and record review which involved several IBS construction sites in Johor Bharu. The findings show that there is no linear relationship between the numbers of labour towards the productivity of the labour in construction work. This study indicates that the type of IBS itself controlled the productivity of construction labour work.

Introduction

According to the Construction Industry Master Plan (2005-2015), the issues of sustainability in Malaysia have been strongly highlighted as one of the main factor in the Malaysian construction industry. The industry is facing the problem on the availability of cheap foreign labour which encourages labour-intensive construction methods compare to the use of more innovative methods [1]. Thus, the use of IBS-related system may help to reduce the dependency on labour as well as increasing the productivity and quality of construction.

Background The IBS agenda in Malaysia started during the early 1960's when the officers of the Ministry Of Housing and Local Government of Malaysia visited a number of European countries and evaluated their housing development programmes [2]. In action to their visits and recommendations, the government started an IBS preferably (known then) pilot project in 1964 with the proposed to speed up the delivery time in the building of quality low cost or affordable houses. The main objective of IBS implementation in Malaysia is to gradually reduce the dependency on foreign labour and saving country's loss in foreign exchange. The IBS which enable on site prefabricated or pre-cast building component manufactured off site, will enable cost saving and quality improvement through the reduction of labour intensity and construction standardization. Besides that, IBS also offers minimal wastage, less site materials, cleaner environment, controlled quality, and lower construction cost [3]. The use of IBS in local construction industry is strongly supported by CIDB to reduce the dependency on foreign labour [4]. In conventional construction method, reinforced concrete frame and brick, beam, column, wall and roof are cast in situ using timber formworks while steel reinforcements are fabricated offsite. The work is labour intensive as it involves formwork fabrication, steel bending and concreting. Hence it needs many skilled workers to deal with as well as the issues of unfavourable site and bad weather conditions.

Problem Statement The high percentages of labours give the picture on the dependency of them in the construction industry. Most of the foreign workers are usually unskilled when they first arrived

in Malaysia. In term of work it may affect the completion time and the quality of it. Other than that, the communication barrier between the labours may cause misunderstanding which also could reduce the productivity and quality of the work.

In conventional construction method, the processes are usually associates with quality issue, unfavourable site condition, lack of skilled labour and bad weather condition. Meanwhile the industry is under a constant pressure to deliver and to solve the issues on performance, safety, shortage of labour, sustainability, dependency on foreign labour and demand in affordable housing. The IBS has many benefits as one of the initiatives towards a better construction method compare to the conventional one.

Hence it comes out with questions what are the factors related to labour that influence the labour productivity during the installation of IBS components? Is there any correlation between the factors related to labour that influence the labour productivity to the benefits of IBS in construction? What are the association between the numbers of labour at IBS precast and aluminium formwork to the productivity of labour in construction.

Aim The aim of this study is to investigate the association between the numbers of labour at IBS precast and aluminium formwork site to the productivity of labour in construction.

Objectives The objectives of this study are as follows:

1. To identify the benefits of IBS related to labour in Malaysia construction industry.
2. To identify the factor related to labour that influence the labour productivity during the installation of IBS components
3. To test the association of factor related to labour that influence the labour productivity during the installation of IBS components to the benefits of IBS related to labour in Malaysia construction industry.
4. To determine the association between the numbers of labour at IBS precast and IBS aluminium formwork site to the productivity of labour in construction.

Scope of Study This study will be conducted within Johor Bahru area. This research will be focused on the association between the numbers of labour at IBS precast and aluminium formwork site to the productivity of labour in construction. The limitation of this study is involving the communities of construction industry and is limited to contractor from IBS site only. The community such as the workers, engineers and other company staff related are approached to take their views, perceptions and suggestion.

Previous Studies

In this section, the background of the study is being discussed where it is also covered the researching techniques that has been employed in previous studies.

IBS Definition From the Malaysian Construction Industry Development Board (CIDB) IBS Digest Bulletin Issue 02 2010, IBS is termed as a construction process that utilises components of building systems which involve prefabricated components and on-site installation. Five standard criteria of IBS are prefabrication, offsite production, mass production, standardised components and modular design coordination [3], [5]. As been highlighted, these characteristics have the potential to contribute to sustainability to a building constructed. But, to prevent unnecessary additional cost, unpleasant community disturbance and decrement of environmental performance, a proper planning and strategies are required. There are five categories of IBS which is popularly used in Malaysia which include precast concrete framing, panel and box system, formwork system, steel framing system, prefabricated timber framing systems and block work systems.

Advantages of Using IBS Apart from the potential contribution of IBS towards sustainable construction, The IBS also bring many other benefits to the construction. They are:
Reduce Build Time. One of the main ideas to use IBS in construction is to reduce the construction build time. By using standardised components and also simplified construction process, IBS project has proven to complete faster than the conventional construction project. This is because the on- site and manufacturing are usually undertaken at the same time. Therefore it will reduce the duration of the work and simplifies the processes by reducing on-sites activities and number of trades.

Labour reduction. IBS is efficient in saving labour and material cost, as the number of labour forces required in IBS is far lower than those required in conventional method [6]. However, in IBS although it used fewer workers they still need to be trained to ensure the skill is suitable with IBS implementation. It is expected that the trained skilled worker in IBS would be more quality then the unskilled labour doing manual jobs in conventional construction.

Solving skill shortage. IBS deal with the issue of skills shortage in construction since all the construction elements are manufactured at factory. IBS reduce the extensive use of carpentry work, bricklaying, bar bending and manual job at site [6]; [5]; [7].

Fewer disturbances to community. The fewer number of construction workers visiting site in IBS projects has reduced local disturbance [8]. This situation will be useful to the area such as hospital, school and hotel refurbishment projects, especially in the city centre area.

Increase construction build rate. The IBS improves the build rate of housing scheme dramatically by increasing the number of house completion over certain duration. This will help developers to fulfil the demand in housing and contributes to government's aim to provide sufficient supply of affordable housing [9]; [10].

Clean site condition and reduce safety and health risk. IBS construction site have shown that it is more clean and organized compare to the wet and dirty conventional method sites. There are no use of temporary work such as timber formworks and props in IBS site which is wastage in normal conventional construction site. Therefore it reduces the risk related to health and safety by promoting safer working condition [9]; [10].

Improvement in construction quality. Since the IBS products are factory made, it offers improvement in quality, productivity and also efficiency. It hence reduces the possibilities of poor workmanship and lack of quality control. The quality of the final IBS products are normally much superior to the conventional work as the former are produced under rigorously controlled condition [7]. Complex shapes and finishes of the IBS components will be inspected and any defects to the components will be rejected before it is to be installed into the structure. IBS also as observed provide high quality surface finishes where joint sections is the only part to be grouted, eliminating the requirement of plastering [3].

Waste reduction. Most of the building components for IBS construction site are prefabricated offsite and hence proved that wastage can be reduced. The system offers the potential to minimise the environmental impact of construction in various ways. Prefabrication in factory has controlled production and standardise process which enables waste reduction through the entire process. IBS also promotes economic and environment sustainability as component moulds could be used repeatedly for different projects, allowing economic of scale and reduce the amortisation cost [3].

Potential cost and financial advantage. With the elements in IBS, it could be in some ways a cheaper method of construction compared to conventional method for example the use of lesser

labours will reduce the cost of hiring labour. IBS can also be cheaper if one consider the whole life costing of the building. There are direct cost saving in material, construction over-head, whereas indirect cost saving include faster completion of the building construction. This advantage is essential for the construction of small shops and offices. Construction of prefabricated elements in IBS also results in considerable reduction in the use of scaffolding, shuttering and other temporary support as compared to conventional construction site

Factors Related Labour that Influence Labour Productivity This study focus is only on factors related to labour that influence labour productivity.

Experience and skill of labour. The labour productivity in construction industry can be increased by increasing skills and experience of workforce [11]. Personal attribution of labours also can contribute to the factors that directly affect productivity [12]. These attributes include:

- Labour's skills, experience, training and qualifications.
- Natural physical and mental ability.
- Intensity of the application of both skills and natural ability to the production process.

Number of labour during construction work. The number of labour at construction site always associated with site congestion. High numbers of labour are usually linked to inappropriate construction site arrangement and overcrowding of the labours in some workplaces. The situation can cause obstruction to the desired productivity and quality. The overcrowding of workers are usually results from inappropriate general planning of construction site activities.

This issue has been supported by previous study [13]; [14]; [15]; [16]. [17] has showed that a labour density greater than one man per 30m² will lead to a decrease in productivity. As working space decrease from 30m² to 10m² per operative, it shows 40% of productivity loss.

Motivation of labour. [18] defined motivation as why people tend to react or behave in a certain situation. Unmotivated labour will effect in high turnover of employees, absence of labour, tardiness and disciplinary problems [19]. Therefore, labours will be motivated if their requirements are addressed as project goals reached [18]. Level of motivation and effectiveness of the labour will also affect their productivity [18].

Low wages of labour. Based on studies conducted by Construction Industry Development Board (CIDB), the average wage rate in 2007 was RM70.00 per day for skilled workers and RM51.00 per day for semi-skilled. There are two models of wage-efficiency called as Shirking Model and Give Exchange Model that being studied to find the labour productivity [20]. The Shirking Model determine that increase in wage level will make labour force more motivated to keep their jobs and hence will try to increase their level of productivity as to avoid being deported and the Give Exchange Model determine that wages change the relationship between employer and employee.

Language Problem Issue. Problem in communication make it hard for the employer to order work as the workers do not understand it. In Malaysia construction industry, there are many foreign labours in this country as it fulfils the need of construction workers due to lack of local work force. [21] explained that in Australia the language problem rise among the foreign labour affects the activity that involved compliance with work safety and health. From the survey conducted by [21], 13.9% of the respondents said that the language is the barrier to effective implementation of work safety and health in the construction industry.

Methodology

The flow chart of research methodology for this study is shown in Figure 1

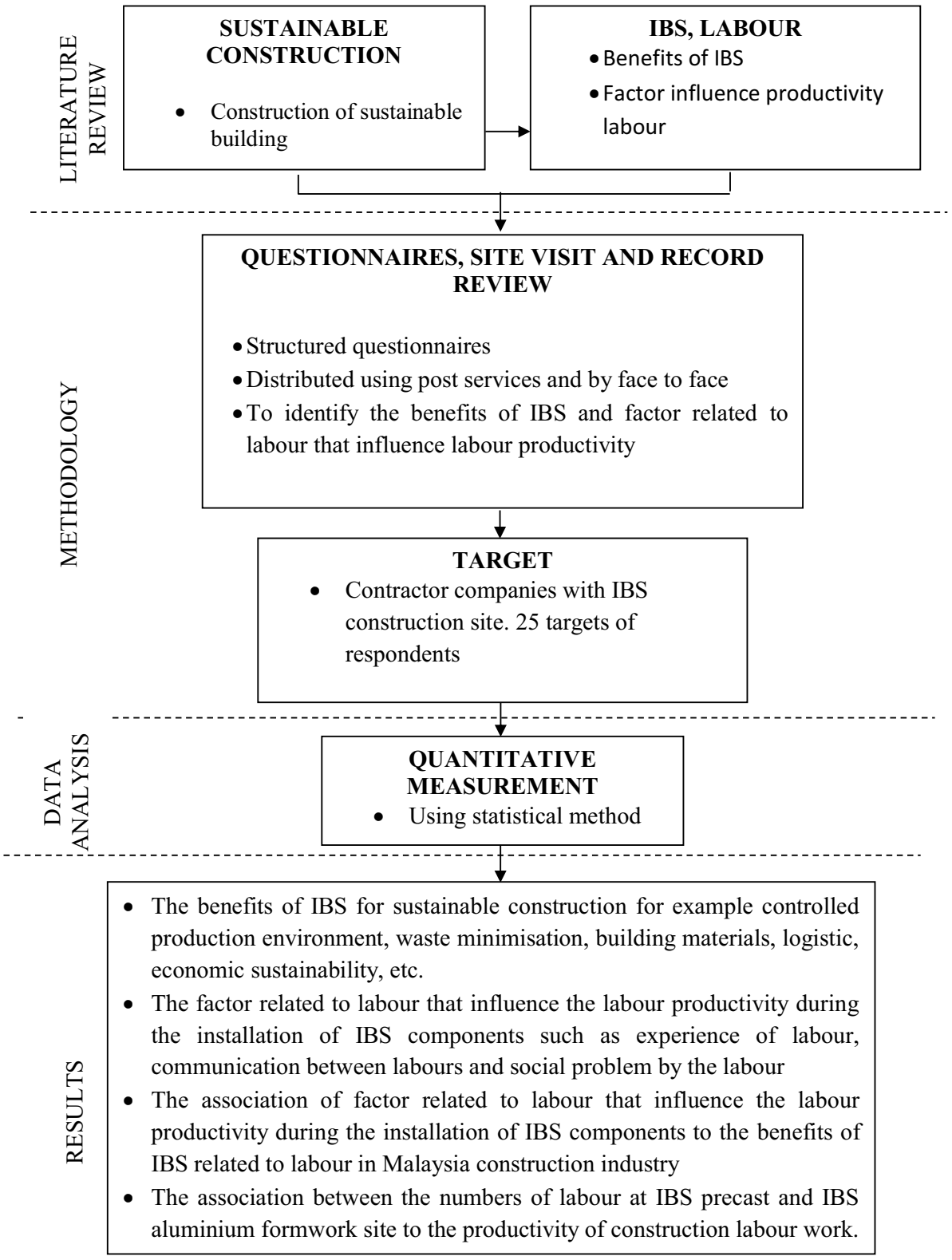

Figure 1: Methodology Flow Chart

Data Analysis

Collected data for this study was analysed using SPSS Inc Ver.18 and Microsoft Excel 2010 software.

Finding for Objective 1: The Benefits of IBS Related to Labour in Construction

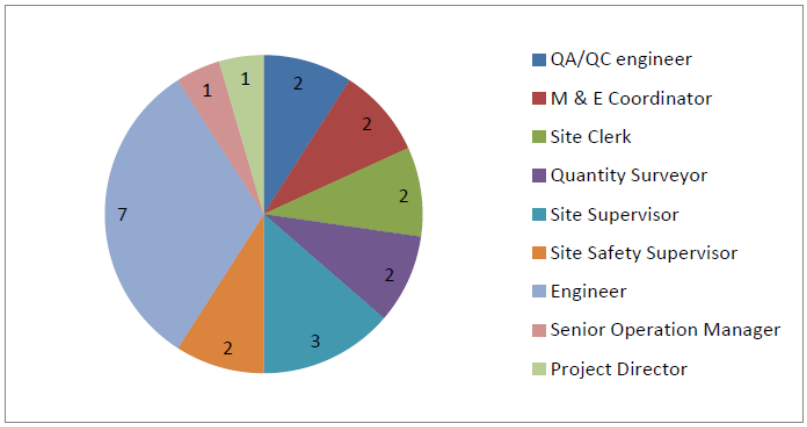

Figure 2(a): Respondent's Current Job Position

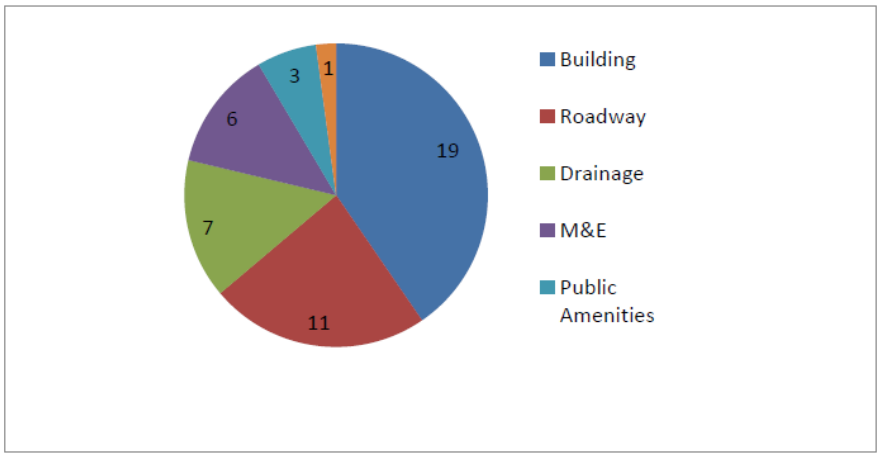

Figure 2(b): Respondent's Field of Expertise

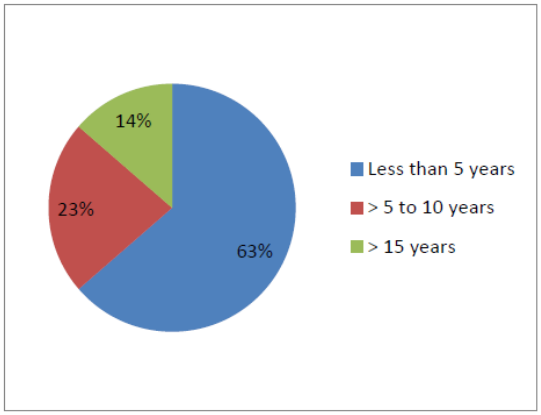

Figure 2(c): Respondent's year of experience

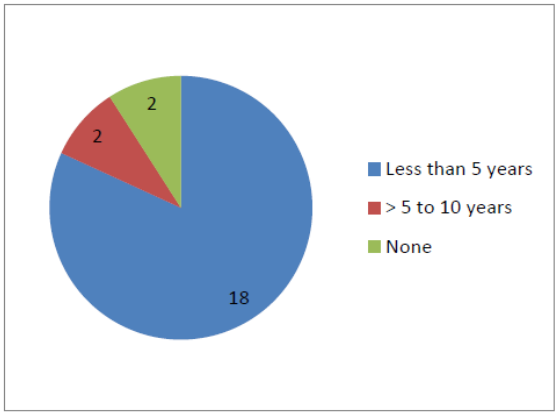

Figure 2(d): Respondent's years of Involvement

There are 22 respondents from 8 contractor companies. The respondent's current jobs position, field of expertise, years of working experience in construction industry and years of involvement in IBS construction method are determined.

In this findings, 7 of the respondents are engineer when refer to Figure 2(a). In Figure 2(b), it shows that 19 of the respondents have expertise in building area. While, when refer to Figure 2(c) and Figure 2(d) majority claimed that they have less than 5 year experience in construction industry, 14 and less than 5 year involvement in IBS, 18.

Table 1: Benefits of IBS related to labour in Construction

No	Benefits	Mean score	Rank	Standard deviation
1	Reduce the number of labour required at construction site	4.14	1	1.25
2	Labour work in a neater and clean site condition with IBS implementation	4.14	2	1.17
3	Lightweight of precast material that ease the installation process by the labour	4.14	3	1.16
4	Increase speed of construction labour work	4.09	4	1.15
5	Increase safety of labour at site due to less in situ casting	4.05	5	1.29
6	Increase safety of labour at site with clear working space	4.05	6	1.21
7	High quality and finishes of work due to high quality and accuracy of IBS components	4.05	7	1.17
8	Less construction process. e.g (wet work)	3.95	8	1.33
9	Reduce cost of hiring labour	3.91	9	1.34
10	Easy installation of IBS components by the labour	3.82	10	1.30
11	Effective in dealing with non-specific jobs	3.59	11	1.33

Table 1 show the benefits of IBS in construction. There are 3 benefits chosen by the respondent with the highest and same mean score. They are reduce the number of labour required at construction site, labour work in a neater and clean site condition with IBS implementation and lightweight of precast material that ease the installation process by the labour.

Therefore the analysis by using standard deviation was done to determine which benefit has the highest score. Reduce the number of labour required at construction site has the highest standard deviation with score of 1.25 and is ranked 1 followed by labour work in a neater and clean site condition and lightweight of precast material that ease the installation process by the labour.

Increase speed of construction labour work was chosen as the fourth important benefit with mean score of 4.09 and standard deviation of 1.15. There are also other 3 benefits have same mean score with 4.05 that is increase safety of labour at site due to less in situ casting, increase safety of labour at site with clear working space and high quality and finishes of work due to high quality and accuracy of IBS components.

The other benefits with mean score more than 3.5 are less construction process (wet work), reduce cost of hiring labour, easy installation of IBS components by the labour and lastly effective in dealing with non-specific jobs.

Finding for Objective 2: To identify the factor related to labour that influence the labour productivity during the installation of IBS components

Table 2: Factors Related to Labour that influence the labour productivity during the installation of IBS components

No	Factors	Mean score	Rank	Standard deviation
1	Experience of labour	3.82	1	0.73
2	Labour had attend training	3.82	2	0.66
3	Communication between labours	3.77	3	1.06
4	Number of labour during construction work	3.64	4	1.22
5	Wages of labour are not fixed	3.59	5	1.14
6	Motivation of the labour	3.09	6	1.11

From Table 2 and, it shows the factor related to labour that influence the labour productivity during the installation of IBS components. According to the data collected, experience of labour and labour had attend training have the highest and same mean score with 3.82. However, experience of labour is ranked higher with standard deviation of 0.73 compare to labour had attend training with standard deviation of 0.66. The third important factors is communication between labours with mean score 3.77 and followed by the number of labour during construction work with mean 3.64, wages of labour are not fixed with mean 3.59. The least factor chosen by the respondents is motivation of the labour with mean score 3.09, which can be eliminated as the factor related to labour that influence the labour productivity during the installation of IBS components

Finding for Objective 3: To test the association of labour productivity factors to the benefits of IBS in construction

Table 3(a): Variable 1

Benefits	Mark
Effective in dealing with non-specific jobs	BEN1
Increase speed of construction labour work	BEN2
High quality and finishes of work due to high quality and accuracy of IBS components	BEN3
Reduce the number of labour required at construction site	BEN4
Less Construction process (wet work) at site	BEN5
Labour work in a neater and clean site condition with IBS implementation	BEN6
Increase safety of labour at site due to less in situ casting	BEN7
Reduce cost of hiring labour	BEN8
Increase safety of labour at site with clear working space	BEN9
Easy installation of IBS components by the labour	BEN10
Lightweight of precast material that ease the installation process by the labour	BEN11

Table 3(b): Variable 2

Factors	Mark
Social problem by the labour	FCT1
Experience of labour	FCT2
Wages of labour are not fixed	FCT3
Labour had attend training	FCT4
Communication between labours	FCT5
Number of labour during the construction work	FCT6

Table 3(c): Correlation Analysis

Benefits	Factors	FCT 1	FCT 2	FCT 3	FCT 4	FCT 5	FCT 6
BEN 1	Pearson Correlation	.091	-.226	-.209	.020	-.035	.374
	Sig. (2-tailed)	.688	.312	.350	.931	.877	.087
	N.	22	22	22	22	22	22
BEN 2	Pearson Correlation	.130	-.142	-.116	.177	.008	.436*
	Sig. (2-tailed)	.564	.529	.607	.431	.972	.043
	N.	22	22	22	22	22	22
BEN 3	Pearson Correlation	.253	-.267	.015	.072	-.029	.312
	Sig. (2-tailed)	.257	.230	.949	.750	.897	.157
	N.	22	22	22	22	22	22
BEN 4	Pearson Correlation	.100	-.137	-.008	.028	-.103	.573**
	Sig. (2-tailed)	.657	.544	.971	.902	.649	.005
	N.	22	22	22	22	22	22
BEN 5	Pearson Correlation	.003	-.156	-.019	.044	-026	.284
	Sig. (2-tailed)	.990	.488	.935	.845	.908	.200
	N.	22	22	22	22	22	22
BEN 6	Pearson Correlation	.335	-.076	.075	.031	.204	.600*
	Sig. (2-tailed)	127	.737	.741	.890	.363	.003
	N.	22	22	22	22	22	22
BEN 7	Pearson Correlation	.180	-.318	-.043	.102	-.212	.569**
	Sig. (2-tailed)	.423	.149	.850	.652	.344	.006
	N.	22	22	22	22	22	22
BEN 8	Pearson Correlation	.198	-.163	-.006	.087	-.051	.533*
	Sig. (2-tailed)	.377	.469	.980	.699	.820	.011
	N.	22	22	22	22	22	22
BEN 9	Pearson Correlation	.315	-.044	-.020	.188	.192	.592
	Sig. (2-tailed)	153	.847	.928	.403	.391	.004
	N.	22	22	22	22	22	22
BEN 10	Pearson Correlation	.211	.164	-.117	.181	.107	.469*
	Sig. (2-tailed)	.346	.465	.604	.420	.637	.028
	N.	22	22	22	22	22	22
BEN 11	Pearson Correlation	-.009	.028	-.361	.089	-.083	.411
	Sig. (2-tailed)	967	.900	.099	.694	.713	.057
	N.	22	22	22	22	22	22

By referring to Table 3 (a), (b), (c), it has been found that the factor number of labour during construction work at IBS construction site correlate highly with all the benefits of IBS related to labour in construction. The highest correlation score is labour work in a neater and clean site condition with a Pearson Correlation of 60% and a significant two tailed of 0.003<0.01. The second highest correlation is the increase safety of labour at site due to clear working space with Pearson Correlation of 59%. The third highest score of Pearson Correlation is the reduce number of labour required at construction site with score of 57% and followed by increase safety of labour at site due to less in situ casting also with score 57%. The other benefits that correlate more than 50% with the factor number of labour during construction work at IBS site is reduce the cost of hiring labour with Pearson Correlation of 53% and a significant two tailed of 0.011<0.05.

Finding for Objective 4: To determine the association between the numbers of labour at IBS precast and IBS aluminium formwork site to the productivity of construction labour work.

Table 4(a): IBS aluminium formwork construction site

No of Labour	Built area/floor	Duration of completion	Area/labour (Productivity)	(Labour x duration)/ Area) (Speed of work)
118	740m²	7 days	6m²	1.11

Table 4(b): IBS precast construction site

No of Labour	Built area/floor	Duration of completion	Area/labour (Productivity)	(Labour x duration)/ Area) (Speed of work)
11	730m²	21 days	66m²	0.32

In these two sites of site visit and record review there are significant outcomes that can be concluded:

1) IBS precast concrete site use less labour and result in high productivity because of easy installation of IBS components.
2) Number of labours provided to IBS precast concrete will determine the duration of completion. More labour will speed up the installation process with high productivity.
3) IBS with aluminium formwork system is utilising many labour for installation
4) In comparison with number of labour and built up area, IBS with aluminium formwork resulted in low productivity with the use of many labour.

In comparison for speed of work, IBS precast concrete resulted low ratio of speed of work (0.32 man days/ m²) compared to IBS aluminium formwork (1.11 man days/ m²). It can be concluded that speed of work of IBS precast concrete is approximately 3 times higher than aluminium formwork system.

Conclusion

Conclusion for Objectives 1: The Benefits of IBS Related to Labour in Construction The benefits of IBS related to labour in construction are which score a mean average above 3.5 can be summarized as:

- Reduce the number of labour required at construction site;
- Labour work in a neater and clean site combination with IBS implementation;
- Lightweight of precast material that ease the installation process by the labour;
- Increase speed of construction labour work;
- Increase safety of labour at site due to less in situ casting;
- Increase safety of labour at site with clear working space;
- High quality and finishes of work due to high quality and accuracy of IBS components;
- Less construction process (wet work);
- Reduce cost of hiring labour;
- Easy installation of IBS components by the labour
- Effective in dealing with non-specific jobs

Conclusion for Objectives 2: To identify the factor related to labour that influence the labour productivity during the installation of IBS components The factor related to labour that influence the labour productivity during the installation of IBS components with mean score above 3.5 are:

- Experience of labour
- Labour had attend training
- Communication between labours
- Number of labour during construction work
- Wages of labour are not fixed

Conclusion for Objectives 3: To test the association of factor related to labour that influence the labour productivity during the installation of IBS components to the benefits of IBS related to labour in construction Overall, there was a high correlation between the factors numbers of labour

during construction work to the all of the benefits of IBS related to labour in construction. Among all of the benefits, the following are the one that correlate more than 50%:

- Labour work in a neater and clean site condition with IBS Implementation
- Increase safety of labour at site due to clear working space
- Reduce the number of labour required at construction site
- Increase safety of labour at site due to less in situ casting
- Reduce the cost of hiring labour

Conclusion for Objectives 4: To determine the association between the numbers of labour at IBS precast and IBS aluminium formwork site to the productivity of construction labour work. From the analysis, it can be seen that the number of labour is not linear to the productivity of the construction work since the IBS precast site has low number of labour but high productivity of construction labour work. The site visit and record review analysis conclude that the high numbers of labours for the aluminium formwork site against the hypothesis as it produce low productivity of construction work. Hence, it can be summarized that the type of IBS itself controlled the productivity of construction labour work.

Recommendation

I. Identify the challenges, and the factor influence successful IBS implementation in construction industry.
II. Identify others factor related to productivity of IBS construction site such as management, material, plant and equipment factors

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