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THE IMPLEMENTATION OF BUILDING INFORMATION MODELING (BIM) TO MINIMIZE THE STRUCTURAL REINFORCEMENT BAR WASTE IN THE CONSTRUCTION INDUSTRY IN SELANGOR MALAYSIA

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ABSTRACT

The Malaysian construction industry is responsible for producing a huge amount of structural reinforcement bar wastes which has a major impact on the environment, the society and economy. Thus, the minimization of reinforcement bar waste has become a persuasive issue in the construction industry. This paper investigates the causes of the rebar waste generation from different construction projects in Selangor, Malaysia as to determine later what are the construction waste minimization (CWM) tools and techniques currently available for the construction industry. A quantitative research approach was adopted using a survey method utilizing questionnaires. Descriptive analysis was employed to process the data for this study. Thus, this paper, explores the potential application of BIM to design out rebar waste. An in-depth literature review was conducted to provide a foundation for the study to evaluate if the use of BIM will assist as a possible platform for the reinforcement of waste minimization.

Keywords: *Building Information Modeling (BIM), structural reinforcement bar*

1.0 INTRODUCTION

Building waste is becoming a serious environmental issue in many large countries around the world (Chen et al., 2002). In Malaysia, a huge quantity of building waste is being generated by the construction sector, whereby one of the critical waste produced is the reinforcement bar, which is the main focus of this study. Thus, waste minimization is a significant area of concern in the administration of building waste management in the Malaysian construction industry specifically in Selangor.

In most construction projects, reinforcement bars are the one of the main sources of construction waste (Yung W. P., 2011). Chen et al., 2005 mentioned that poor integration brings forth uneconomical designs and this results in an increase of construction waste. A. Porwal and K. N. Hewage, 2012 added that this problem is mainly due to the absence of coordination and modifications in structure models taking into account architectural and structural requirements.

Building information modeling (BIM) makes it probable to collaborate between stakeholders in the structure design procedure to examine diverse design choices more skillfully by escaping the time-wasting and error-prone technique of re-forming all the structure geometry features to a modification in structural study and design. Creating structural and architectural objects from the same fundamental database can control this difficulty. BIM approach allows a design team to repetitively change the structure model to examine the most appropriate cutting patterns of the lengths of rebars (A. Porwal and K. N. Hewage, 2012).

This research paper will first mention the causes of the reinforcement bar waste at construction sites, followed by determining ways to minimize the reinforcement bar waste by these firms and finally assess whether the Building Information Modeling (BIM) system can assist in reducing the quantity of reinforcement bar waste in the Selangor construction industry in Malaysia.

2.0 METHODOLOGY

This study was conducted in Selangor to identify ways to minimize reinforcement bar waste. There were 50 consultants who had taken part in the surveys conducted with 40 questionnaires returned by the subjects. Both qualitative and quantitative methods were used to analyze the data obtained using SPSS software. Data was examined using descriptive analysis.

3.0 DATA ANALYSIS AND FINDINGS

3.1 DEMOGRAPHIC DATA

This study analyzed the subjects' age, category of company, position in the company, academic qualification, experience, and nature of the business. As shown in Table 1, 62.5% of respondents were aged between 20 and 30, 20, 6% between 30 and 40, and 17.5 % were more than 50 years old. The largest groups of respondents accounting for 82.5% of the subjects were registered specialist contractors.

Table.1 Demographic data

Variables	ITEMS	Percentage (%)
Age	20-30	62.5
	40-50	20.0
	More than 50	17.5
Categorize of company	Registered specialist contractor	82.5
	Developers	17.5

3.2 REALIBILITY SCALE

The results of the factor analysis as described and discussed in the previous section demonstrated the construct validity of all 12 factors. Each scale reliability score was then calculated and rechecked for this sample, using the test for reliability. Therefore, the next step was to test the internal consistency of each factor, utilizing Cronbach's alpha, as illustrated in Table 2. The 12 multi-variable factors used in this study have gone through several successive reliability testing treatments. The statistical information for seventeen variables shows that Cronbach's alpha score were at least 0.702 (Causes of design variation leading to the rebar waste generation), which means the entire construct was deemed to have adequate reliability.

Table 2. Cronbach alpha's result based on main studies

Variable	**N. Of Items**	**Cronbach's Alpha**
Causes of the Reinforcement bar wastage in a project were identified in four major sources listed below	4	.740
Most common root causes of rebar waste are listed below	12	.710
Specific reasons for loss of rebar	6	.720
Causes of design variation leading to the rebar waste generation	6	.702
Factor affecting the construction method	5	.790
The construction parties, are responsible for the generation of the reinforcement bar waste in the construction industry	6	.810
The origins why the reinforcement bar waste are generated	6	.800
The reinforcement bar wastage reduction practice is considered in construction stages	3	.730
Extend do you think the construction parties should be involved in the waste minimization of the reinforcement waste	5	.740
Listed below are statements concerning unwillingness in rebar waste minimization	9	.714
Issues considered by the designer to avoid the rebar waste in the construction industry?	5	.761
The BIM provide solutions, in the following listed areas, required to minimize the reinforcement bar waste in the construction industry	6	.713

3.3 THE CAUSES OF REINFORCEMENT BAR WASTE GENERATED BY THE CONSTRUCTION INDUSTRY IN SELANGOR.

Major specific causes influencing the waste rate of rebar were identified from several management processes. These included rebar work; causes of design variation leading to the rebar waste generation; factors affecting the construction method selection; the construction parties responsible for the generation of the reinforcement bar waste in the construction industry; and the origins from where the reinforcement bar waste was generated. Table 3 shows the amount of reinforcement bar waste produced in the construction industry whereby the analysis conducted using the observational checklist was 72.5 % 'yes' and 27.5% 'no'.

Table 3. The amount of reinforcement bar waste produced by the construction industry is massive

Items	Percentage (%)
Yes	72.5 %
No	27.5 %

Frequency distribution and measurements in the form of means for the causes of the reinforcement bar wastage in a project were identified in four major sources listed below as shown in Table 4. The analysis conducted using the observational checklist shows the mean scores of items ranging from 3.45 to 3.65.

Table 4. Four major causes of reinforcement bar wastage in a project

Item	SD	D	N	A	SA	M	Median	Mode
Design	15.0	5.0	27.5	25.0	27.5	3.45	4.00	4.00
Procurement	25.0	20.0	37.5	10.0	7.5	2.55	4.00	4.00
Material handling	15.0	0	25.0	25.0	35.0	3.65	3.00	3.00
Operational	0	12.5	30.0	50.0	7.5	3.53	4.00	4.00

The means for the most common root causes of rebar waste are listed below and presented in Table 5. It can be observed that the mean scores of most common root causes of rebar waste was failure to fulfill its functional variables such as improper planning, poor storage and poor handling, which have a high level of correlation. Complex drawings, design or detailing errors, improper planning, wrong taking-off, ordering errors, supplier error, poor storage, poor handling, wrong bending, and inexperienced workers received moderate mean scores.

Table 5. The most common root causes of rebar waste

Item	SD	D	N	A	SA	M	Median	Mode
Change in design	0	15.0	25.0	27.5	32.0	3.78	4.00	4.00
Complex drawing	20.0	5.0	42.5	32.5	0	2.87	4.00	5.00
Design/detailing errors	15.0	0	50.0	32.5	2.5	3.07	4.00	4.00
Improper planning	0	2.5	15.0	45.0	37.5	4.17	4.00	5.00
Wrong taking-off	22.5	5.0	20.0	40.0	12.5	3.15	3.00	3.00
Ordering errors	12.5	17.5	37.5	25.0	7.5	2.97	4.00	4.00
Supplier error	32.5	5.0	35.0	22.0	5.0	2.62	4.00	4.00
Poor storage	22.5	5.0	52.5	12.5	7.5	2.77	3.00	3.00
Poor handling	22.5	0	27.5	42.5	7.5	3.12	3.00	3.00
Wrong bending	15.0	7.5	40.0	30.0	7.5	3.07	3.00	3.00
Wrong cutting	0	30.0	17.5	45.0	7.5	3.30	3.50	4.00
Inexperienced workers	7.5	15.0	35.0	35.0	7.5	3.17	3.00	3.00

3.4 WASTE MANAGEMENT USED FOR REBAR WASTE MINIMIZATION BY THE CONSTRUCTION INDUSTRY IN SELANGOR

The analysis emphasized on the waste management practices used to minimize rebar waste in the construction industry. The percentage of the companies implementing the Computerized Numerically Controlled (CNC) machine was 15%, Computer Integration and feature-based design concepts were 37.5%, Automatic Rebar Detailing Algorithms (ARDA) was 17.5%, and other practices were 30%. The result is tabulated in Table 6.

Table 6. Waste management used to minimize rebar waste in construction industry

System	Percentage (%)
Computerized numerically controlled (CNC) machine	15.0
Computer Integration & feature-based design concepts	37.5
Automatic Rebar Detailing Algorithms (ARDA)	17.5
Others	30.0

Table 7 shows the reinforcement bar wastage reduction practice which is considered in the construction stages. The analysis conducted using the observational checklist illustrates that the mean scores of items ranged between 3.35 to 4.05.

Table 7. Stages that considered the reinforcement bar wastage reduction

Item	SD	D	N	A	SA	M	Median	Mode
Pre-construction Stage	2.5	15.0	25.0	30.0	27.5	3.65	3.00	3.00
Construction stage	0	0	35.0	25.0	40.0	4.05	3.00	4.00
Post-construction stages	2.5	5.0	52.5	35.0	5.0	3.35	3.00	3.00

Table 8 shows that the construction companies should be involved in waste minimization of the reinforcement waste. The analysis conducted using the observational checklist indicated that the parties that should be involved in rebar waste minimization were Engineers and Contractors with a mean score of 4.10, Quantity surveyors with a score of 3.95, Project managers with a score of 3.92 and Architects with a score of 3.35.

Table 8. Parties that should be involved in reinforcement bar waste minimization

Item	SD	D	N	A	SA	M	Median	Mode
Architect	0	22.5	37.5	22.5	17.5	3.35	3.00	3.00
Engineer	0	10.0	7.5	45.0	37.5	4.10	3.00	3.00
Quantity surveyor	0	0	35.0	35.0	30.0	3.95	3.00	3.00
Project manager	7.5	0	20.0	37.5	35.0	3.92	3.00	4.00
Contractor	10.0	0	7.5	42.5	40.0	4.10	3.00	3.00

3.5 THE IMPLEMENTATION OF BUILDING INFORMATION MODELING (BIM) IN MINIMIZING THE QUANTITY OF REINFORCEMENT BAR WASTE IN THE CONSTRUCTION INDUSTRY IN SELANGOR

Data analysis and findings of the implementation of the Building Information Modeling (BIM) will assist in minimizing the quantity of reinforcement bar waste in the construction industry in Selangor, Malaysia. There were nine points highlighted for the utilization of the Building Information Modeling (BIM) as a new tool or system to minimize the reinforcement bar waste in the construction industry. Instead of using other current rebar waste management methods, a wide range of BIM software applications can be used for various project performance purposes. For example, BIM software applications are capable of giving a detailed bar bending schedule for rebar optimization analysis and provide solutions required to minimize the reinforcement bar waste in the construction industry. In the long run, implementing the Building Information Modeling in an organization will be very beneficial to as it assists in minimizing the reinforcement bar waste.

Table 9. Suggested solution provided by building information modeling (bim)in minimizing bar waste in construction industry

Item	SD	D	N	A	SA	M	Median	Mode
Conflict, interference and collision detection	0	20.0	45.0	17.5	17.5	3.32	3.00	4.00
Construction sequencing and construction planning	0	0	45.0	50.0	5.0	3.60	3.00	3.00
Reduction rework	0	5.0	37.5	40.0	17.5	3.70	3.00	3.00
Synchronizing design and site layout	0	2.5	50.0	35.0	12.5	3.57	3.00	3.00
Detection of errors and omissions (clash detection)	0	5.0	47.5	12.5	35.0	3.77	3.00	4.00
Precise quantity taking-off	10.0	0	35.0	25.0	30.0	3.65	3.00	3.00

Table 9 provides suggested solutions required to minimize the reinforcement bar waste in the construction industry. The analysis conducted for construction sequencing and construction planning; reducing rework Synchronizing design and site layout Detection of errors and omissions (clash detection), Precise quantity taking-off scored a high-level mean between 3.70 to 3.57. In addition, conflict interference and collision detection scored a moderate mean (3.32).

4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The findings of the diverse components of this study were synthesized in respect to the research objectives. Three objectives were proposed for this research whereby the first objective was to identify the causes of reinforcement bar waste generated by the construction industry in Selangor, Malaysia. The second objective was to determine the waste management used for the rebar waste minimization by these construction industry, and the third objective was to assess whether the Building Information Modeling will be able to assist in reducing the quantity of reinforcement bar waste in the construction industry.

The data analysis and findings showed that the causes of reinforcement bar waste generated by the construction industry in Selangor, Malaysia were categorized into four major sources which lead to rebar waste. The top three causes are as follows; 1-Material handling; 2-operational; and 3-design. Table 5 supports the fact that the most common root cause was material handling which is due to the improper planning. Whereas, last minute requests by clients were the main cause of design variation leading to rebar waste generation. The most important factor influencing the Selangor construction industry is to finish projects within the allocated cost and time. The construction parties such as contractors and designers who are responsible for the reduction of the rebar waste generation, seem to neglect the waste reduction measures. Therefore, the rebar waste is still present in the Selangor construction industry due to the lack of knowledge, lack of commitment and negligence to the existing rebar waste minimization measures employed.

The findings of the study showed that the majority (87.5%) of companies in the construction industry do employ a waste management plan. The two common waste management practices used in Selangor are the Computerized System and the Green Building Index (GBI), which indicates that "Engineers and Contractors are the most prone construction parties who need to be involved in the rebar waste minimization effort", as mentioned by the respondents. This is supported by the results obtained in this study. Moreover, 68 % of the respondents answered that the waste management practices they use to reduce rebar waste in the Selangor construction industry work efficiently. However, this figure is not considered very high due to the unwillingness by the respondents in rebar waste minimization for the following reasons: lack of promotion, construction culture and behavior, complicated subcontracting system, competitive market, lack of well-known effective waste management methods and lack of proper training and education. Therefore, half of the respondents believed that the overall waste management practice is helpful to reduce the rebar waste production in the Selangor Construction Industry whereas the other half do not support this notion

The implementation of BIM will assist in minimizing the quantity of reinforcement bar waste in the Selangor construction industry. Slightly more than half of the respondents possess knowledge about BIM whereby 93% of them are willing to use a new waste management system to reduce rebar waste. However, they believe that BIM will be more helpful as opposed to what they have been implementing which accounts for 63% of responses, however, it is not due to the main reason stated in the earlier section (lack of knowledge and the construction culture and behavior and lack of promotion). Slightly less than the half of the respondents are resistant to adapting BIM as an alternative to what they have been doing so far in the construction industry. 75% believe that the Selangor construction industry needs to implement the BIM to minimize rebar waste while 50% expect that BIM will be effective work in reducing rebar waste in the organization. Another 58% think that the BIM system will be beneficial to the organization. These three statistics show that the figures obtained are moderate. This means that the implementation of BIM will take time (within 10 years) before it is completely integrated into the Selangor construction industry. A higher percentage indicates that the implementation will soon begin in the construction industry in Selangor.

4.2 RECOMMENDATION

- There are several measures that can be considered to find new policies in order to avoid and reduce the impact of causes of wastage. Some of these strategies and root causes of waste reduction have been discussed in the first part of the literature.
- Intervention should be focused on the pre-construction stages, particularly during the design stage, where virtual waste (computer-generated waste by BIM technology during design stages), as opposed to actual waste (physical onsite waste), could be effectively identified, estimated and reduced.
- A higher disposal cost for rebar waste generated should be imposed by the government.
- The BIM program should be integrated into the curriculum of universities as a compulsory subject for students in the engineering and construction management faculties.
- Promotion of waste minimization measures such as the BIM system should be done extensively and with more incentives from government agencies.

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