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The On-Site Waste Minimization Practices for Construction Waste

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Abstract – The exponential growth of the construction sector has caused increased building waste. This is a scenario that has many adverse environmental, cost, manufacturing, time, social and economic impacts. In particular building schemes are the source of construction waste, due to increasing insufficient waste management practises. In the disposal of construction waste, efficient maintenance practises can also be underlined. This paper identifies waste management practises that reduce waste on site. 54 behaviours have been discovered in recent research publications. This research analyses various structural designs that contribute to waste reduction and includes management techniques to minimize building waste.The mapping methodology was used to assess the time of each practise.

Keywords – Structural Design, Construction Waste, Waste Reduction Strategies, Civil Construction Projects and Waste Management Practises

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1. INTRODUCTION

The increasing awareness regarding "environmental impacts from construction wastes has led to the development of waste management as an important approach for construction project management. Managing construction wastes is vital in order to cope with future sustainable development. The practices of waste management for construction activities comprised with the aim to protect the environment and with the recognition that wastes from construction and demolition works contribute significantly to pollution of the environment [1]. [2] defined waste management as the discipline that encompasses solid waste generation, storage, collection, transport, processing, and disposal by considering the environmental, economic, aesthetics and public concerns. In addition, the management of waste includes monitoring, collection, transport processing and waste disposal.

There are many efforts that have been carried out by the Indian government to minimise the generation of waste. Nevertheless, many contractors failed in implementing good waste management which led to the mismanagement of construction waste [3]. There are several approaches to construction waste management. The process of managing construction waste goes far beyond the disposal of the wastes itself. It is encompassing a strategy to effectively utilize construction resources, with the view to reduce the quantity of waste and utilizing the generated waste in the most effective manner. In India, disposing the wastes directly to landfill sites is the most common approach in managing construction wastes. This method is chosen among contractor in India because the waste materials is assumed to have a little premium value. However, the practices will no longer be applicable for a long term since construction industry had generated significant amount of wastes and there is increasing of construction wastes year by year that will further congest the already over-flowing landfills. As the evidence, it was reported that among 289 landfills which also includes dumpsites, 113 of these landfills are no longer in operation due to protest from surrounding residents or have reached their full capacity [4]. This has prompted the need for alternatives of waste prevention and the initiatives to reduce, reuse and or recycle wastes produced which are referred to as the 3R's of construction waste management.

Fig. 1. Waste management hierarchy [4]

Basically, construction wastes need to go through a pre-treatment process before being disposed to landfills. It should be treated according to proper waste management hierarchy as shown in Fig. 1 [4]. There are 3R concepts in waste management that need to pass through before being disposal at landfills. The criteria of waste management started with waste reduction, reuse, recycling and lastly disposed to landfills. The process of construction waste management at the end will end up at landfill [2]. Hence, it is vital to effectively utilise the construction resources in order to reduce the generation of wastes" [5].

2. REDUCE, REUSE & RECYCLE STRATEGY

The word waste reduction is linked to practises to reduce the production of waste at the source. Which ensures that the waste is reduced until it gets any larger. In building projects, all operations and processes leading to waste generation should be reduced or avoided. The reduction approach can now be applied and consistently incorporated into the whole building cycle as early as the planning phase [6]. The most powerful and reliable way of managing building waste is the removal of construction waste. However, before the reduction approach can be applied, it is extremely necessary to consider the contributing factors in waste generation. These factors included change in architecture, poor manipulation of materials, lack of laboratory capacity, poor management preparation, poor site quality, acquisition of building materials and external factor (weather) [7].

Reducing waste from building sources not only reduces waste generation, but also reduces cost of storage, treatment and recycling of waste. Waste cannot be avoided entirely except at the most sustainable building site. Certain forms of waste would certainly be generated on site and this is referred to as inevitable waste. The next move is the reusability of such building waste materials such as the use of broken brick and cement as an access road for the site, because waste produced is not completely avoidable [4]. [6] also noted that recycling is described as using building materials, such as wood coating, either through the same purpose or not, more than once. The recycling strategy is known as the method by which items that were formerly regarded as waste but made into new item are collected, reused and even unused [8]. These products are sorted within or outside the premises and are shipped to the manufacturing centre for transformation into raw materials or to be re-produced in new or identical products. The waste can be sorted as an on-site or off-site waste disposal technology for recycling purposes.

The onsite technique of recycling is the insulation of building waste which is then applied in other building procedures as a raw material, accordingly [9]. In the meantime, the off-site disposal approach is the separation and transport of the building waste by various organisations. In order to ensure a competitive recycling scheme in the building sector, Government involvement is key. In addition to reducing adverse environmental effects, recycling would mean the products will be available in the future.

3. MAPPING PROCESS AND ANALYSIS OF THE ON-SITE WASTE MANAGEMENT PRACTICES

Based on the "on-site waste minimization management practices in Table 1, the highest frequency for the waste minimization practices are presented in Fig. 2 with accordance to the code given.

Based on the Figure 2, the most significant practices to minimize on-site construction wastes is A1 (Human resources group) practice following respectively by E1 (Regulation group), C1 (Construction Method group), D1 (Administrative group) and B1 (Material and Equipment group). In 'Human and Resources' group, 18 out of 20 researchers agreed that education and awareness is the important factor to engender waste minimization. A study by [10] found that the major barrier in the industry is the lack of awareness among local contractors, construction labour and architects about waste management techniques and approach. They perceived that conducting construction waste management usually will increase the project costs and therefore will reduce company profits. The construction practitioners are giving more focus on the cost, time, and the quality specified in the contract, less attention is giving towards waste reduction [11]. Thus, the construction industry practitioners' awareness regarding resource saving and environment protection is a vital driver for construction waste minimization. Education and awareness aspect regarding waste management at site will lead construction actors to implement effective practices in reducing generated wastes. However, the awareness of having a proper management of construction wastes is still lacking in India. Hence, there is an urgent need to improve the education and awareness of construction industry practitioners in India. The second highest frequency of on-site waste minimization practices is E1 which is the usage of off-site products and components in construction project. In 'Regulation' group, as much as 16 researchers admitted that this practice is able to provide directly waste minimization at site. Construction Industry Development Board (CIDB) India, has been dynamically encouraging the practice of industrialized building system (IBS) and other off-site construction techniques in local construction industries since 1998 as a method to overcome construction waste problem, conserve landfill capacity and also helping to achieve the concept of sustainability [12]. Waste reduction is one

of the major benefits when using this practice compared with conventional construction. According to [13], the offsite construction techniques such as prefabrication, is perceived as a solution to major causes of waste generated during both the design and construction stages. This practice also contributes to other benefits on-site such as improved quality control, provide clean and safer working place, improved the environmental performance, and reduction in construction time and labour requirements. Unfortunately, because of the higher initial cost that incur during the construction process, there is a significant percentage of construction projects do not adopt the use of off-site construction techniques in India. Hence, it is important for local authority to force a regulation regarding the application of off-site techniques in construction projects. This practice not only able to reduce construction waste generation at site, but also will lessen the burdens related with its management and disposal. Next, the third practice for on-site waste minimization is C1, by providing waste skips for specific materials (waste segregation). In Construction Method (on-site practice) group, about 13 of 20 researchers stated this practice is able to reduce waste generated at site. In order to reduce total waste generated, there is a need for effective separation of waste, by providing waste skips for specific materials. This approach is based on the understandings that recycling construction material is one of the best options to reduce negative impact on the environment which also includes in 3R concept of waste minimization. Although waste segregation itself is not a strategy for waste reduction, but it is a requisite act to ease the construction materials reuse and recycling. This practice is applied as a method to facilitate construction waste for the recycling purposed after the waste generated in construction site. It is because, the application of construction waste recycling requires sorting of generated waste into recyclable and non-recyclables during the construction activities or at the recycling site. This practice will ease recycling operations and ensures accurate separation of inert and non-inert materials. By providing waste skips for waste segregation, there is likelihood of on-site reuse of the materials in waste skips or for other projects [23]. This practice also contributes in preventing waste mixture" with soil [14].

As such, waste segregation provides "both short and long-term benefits of on-site materials reuse and ease of waste recycling. The highest frequency for the practice in 'Administrative' management group is the standardization of design and material. Standardization is defined as the extensive use of components, methods or processes in which there is regularity, repetition and a background of successful practice. The aim of this practice is mainly to improve the buildability of a structure along with the benefit in reducing construction waste. This study found that 12 out of 20 literature review had stated this practice is able to minimize on-site waste generation. Standardisation has the potential to dramatically reduce the current production of construction waste. This argument is supported by [22] that a substantial reduction in offcuts construction materials could be achieved by designing room areas and ceiling heights in multiples of standard material sizes. Nowadays, the increase in complexity of a structure had caused a lot of design changes in construction projects. This situation raised due to the increased integration of components making it more likely that a change in one area of the design will require other areas to be redesigned [29]. This issue will directly contribute towards the generation of construction waste at site. Hence, administrative management play a vital role in the implementation of standardize practice for design and material in order to increase the buildability of a structure. This practice at once will contribute efficiently in reducing on-site construction waste. Based on the 'Material and Equipment' management group, the study found that the highest frequency of on-site waste minimization is the proper material handling. There are 8 journals out of the 20 review journals stated that the proper material handling practice could reduce waste production. Generally, improper handling of construction material is one of the causes waste generation in construction project. This issue often arises because of the wrong material handling by construction workers at site which contribute towards waste production [15]. The incompetent supervisor and project manager, lead to poor workmanships and improper material handling done by construction workers. Besides that, the used of improper equipment in handling of material will cause damage and loss on the construction materials, subsequently will contribute to waste generation at site. This issue normally occurs during delivery process where the wrong equipment is used to bring down construction material at site. In order to overcome this problem, it is important to use the right piece of handling equipment which aiming to prevent waste due to breakage and loss on the construction materials. In addition, the wrong materials handling by construction workers can be overcome by assigning a good and dedication supervisor at the site [17] – [20]. Table 2 presented the most significant practices in reducing on-site construction waste for each management groups." These factors are prominently able to engender on-site waste reduction in construction project" [16].

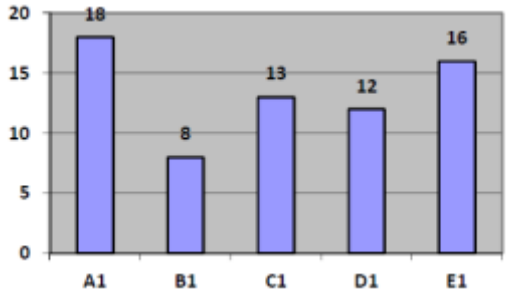

Figure 2. Frequency for the highest practices in each group based on the given code

Table 1. Construction management practices in reducing on-site construction waste

Group	On-site Waste minimization practices	Code	References																				Freq.
			[21]	[22]	[11]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[16]	[20]	[33]	[34]	[35]	[36]	[37]	
(A1) Human Resources	Improved education/ awareness regarding on-site waste management of workforce m/and staff	A1	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	18
	Appointment of waste manager on-site	A2						*									*			*			3
	Appointment of labors solely for waste disposal	A3															*			*			2
	Preventing of waste materials by labors	A4															*			*			2
(B1) Material and Equipment	Using mechanical handling to reduce damage on the material during delivery (proper handling)	B1						*				*	*	*	*	*	*			*			8
	Prevention of over ordering of material	B4		*		*		*					*			*			*	*			7
	Proper selection of materials (e.g. avoiding fragile material being used)	B2			*					*						*	*		*	*	*		7
	Use materials with a high content of recycled material	B3					*				*		*				*	*		*			6
	Prevention of double handling materials	B5				*									*	*	*			*			5
	Buy materials avoiding unnecessary packaging	B6			*		*						*						*				4
	Just in Time Deliveries (JIT) ensure less material waste	B7	*	*								*	*										4
	On-site materials shredders or compactors machine	B8		*		*	*		*														4
	Store construction materials collectively in a separate area	B9			*	*							*										3
(C1) Construction Method (on-site)	Provision of waste skips for specific materials (waste segregation)	C1	*	*	*	*	*	*	*			*	*				*		*	*		*	13
	On-site reuse construction materials	C2	*		*	*		*	*			*	*		*		*	*	*		*		12
	Provide adequate and safe storage to lessen the amount of damaged material on-site	C3	*					*	*				*	*			*			*			7
	Set-up an effective line of communication at construction site to avoid bad practice	C4			*		*			*		*				*					*	*	7
	Provide sufficient space to ease the management of C&D waste	C5				*	*		*								*			*			5
	Providing bins for collecting wastes for each subcontractor	C6				*	*										*			*			4
	Setting up temporary bins at each building zone	C7				*	*										*			*			4
	Periodic check on the use of C&D waste containers	C8				*	*								*								3
	Soil remains to be used on the same site	C9				*	*														*		3
	Storing waste at an easily accessible area	C10															*		*	*			3
	Noticing staff to reuse recycle materials	C11															*	*		*			3
	Preventing waste mixture with soil	C12				*											*			*			3
	Detect the construction activities that can admit reusable materials from the construction	C13				*	*					*											3
	Follow the project drawings / design	C14				*	*																2
	Informing methods to deal with the rest of wastes after recycling	C15															*			*			2
	Keeping the site clean to minimize loss of material and waste generation	C16											*	*									2
	Time scale of project can ensure effective waste reduction on-site	C17	*										*										2
	Use of demolition and excavation materials for landscape	C18				*																	1
	Central areas for cutting and storage	C19				*																	1
(D1) Administrative	Standardization of design and material to improve buildability	D1		*	*	*			*	*		*	*	*	*		*			*	*		12
	Adequate supervision of waste management activities with clear instruction	D2								*	*	*	*			*	*			*		*	8
	Ensure fewer design changes during construction process	D3			*	*					*	*			*	*			*			*	8
	Supply chain alliances with supplier and recycling companies	D4	*	*	*			*				*	*									*	7
	Waste auditing to monitor and record on-site waste management	D5		*		*		*							*		*			*		*	7
	Making sub-contractors responsible for waste disposal (cooperation)	D6				*			*			*					*			*		*	6
	Contract suppliers managing their product waste	D7		*			*					*	*				*			*			6
	Plan layout of construction projects properly (site planning)	D8			*				*					*	*	*					*		6
	Designing out waste will reduce material management issues on-site	D9	*				*											*			*		4
	Recycling target to be set for every project phases	D10				*						*			*			*					4
	Involvement of contractors and product manufacturer during design stage	D11				*							*									*	3
	Positive incentive for decreasing or recycling by contractors/ subcontractors	D12															*		*	*			3
	Rules on dealing with waste-generators	D13															*			*			2
	Shortening a period of collecting waste in a site	D14															*			*			2
	Design management to prevent the over specification of materials	D15		*																	*		2
	Corrective actions to reduce waste when a change has happened	D16																				*	1
	Adequate planning to stabilize work process on-site	D17																				*	1
(E1) Regulations	Usage of offsite products and component (low waste construction technology)	E1		*	*	*	*	*		*	*	*	*	*			*	*	*	*	*	*	16
	The use of a Site Waste Management Plan (SWMP) is important.	E2	*					*	*	*		*	*		*		*	*		*	*	*	12
	Contractual clauses to penalize poor waste performance	E3		*	*							*	*				*			*			6

Table 2. The highest frequency of on-site waste minimization practices based on management groups

Management group	On-site waste minimization practices
Human Resources	Improved education/ awareness regarding on-site waste management of workforce or/and staff
Material and Equipment	Using mechanical handling to reduce damage on the material during delivery (proper handling)
Construction Method	Provision of waste skips for specific materials (waste segregation)
Administrative	Standardisation of design and material to improve buildability
Regulation	Usage of offsite products and component (low waste construction technology)

4. CONCLUSION

This research was performed with the goal of identifying strategies in building maintenance to minimise building wastes on site. There have been over 20 investigative papers analysed and mapping methods clarify the results of the most important activities for each management department. Waste minimization can be integrated and prepared at the initial level of building processes. The careful planning must be carried out in different phases of building and control points must be established. Training to reduce duplication is often to be carried out and exercised by workers on-site. The project team should highlight environmental responsibility. In order to gather waste generation data, to identify the major areas of waste generation and to analyse the reasons why waste is generated, and to provide input to working people working on these main fields, the waste management system is proposed as part of site management functions. The waste management system will also provide executive management with complex input and can use the information to work more efficiently in the organisation, with different sub-contractors and divisions.

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