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Sustainable Management using Recycle and Reuse of Construction Waste Materials in Malaysia

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ABSTRACT

Ineffective construction waste management has become a serious problem that impacted significantly to environmental pollutions especially in a developing country like Malaysia. Despite the enactment of law by the government, Malaysia is still far behind as compared to other countries like Denmark and Hong Kong in terms of implementation of recycling and reuse of construction waste. Recycling and reuse of waste materials seems to be a profitable method that will boost the lifetime of landfills and cut down the usage of virgin natural resources. This paper discusses the practices of recycling and reuse of construction waste materials in the Klang Valley. A questionnaire survey was administered to 117 respondents from construction companies. The most common types of construction waste materials that can be recycled and reused are concrete, metal, asphalt, brick, plastic, cardboard, timber and glass. A descriptive analysis using Relative Important Index (RII) was used to rank the items asked in the survey. It was found that the most frequent types of recycling and reuse of construction waste materials based on ranking is timber, while the key benefit of recycle and reuse of construction waste is reduction of landfill space. On the other hand, the key challenge that affects recycling and reuse of construction waste is the risk of contamination. This study is beneficial for all parties involved in construction activities to achieve a more sustainable construction in Malaysia and throughout the world.

Keywords: construction waste; environment; recycle; reuse; sustainable construction

1. INTRODUCTION

Construction industry plays a major role in socio-economic development of any country in the world and has been growing immensely especially in developing countries. The rapid growth is due to the increase in standard of living, demands of infrastructure projects, changes in consumer habits and increase in population. All these have contributed significantly in waste generation from construction activities [1]. A number of published studies have been conducted on the impact of construction waste towards social, economic and environment ([2], [3], [4]). It was evident that large amount of waste was produced and accounted more than 50 % of the waste to the municipal solid waste stream ([5], [6] [7]).

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Thus, ineffective construction waste management has become a serious problem in every country in the world especially in a developing country like Malaysia due to its immense growth in construction industry. It was found that construction sector consumes around 40% of materials for construction work [8]. Many researchers and practitioners indicate that waste emanates especially during the construction stage. In addition, environmental pollution is commonly linked to the construction activities, which is known as non-environmentally-friendly industry by nature [9]. For example, construction industry consumed at least 50% of the natural resources [10] in European countries.

Several studies have discussed the recycling of construction and demolition waste particularly on the adoption of technology [6], recycling practices [13], [14] and decision analysis [15]. Construction waste is produced from various activities during construction stage [16]. Various types of waste are generated during construction stage which depend on different types of construction work and practices on site deter mining the amount and type of construction waste [17]. In addition, it is also generated from the materials and debris of buildings which have been demolished. In Malaysia, disposing construction waste directly to landfill sites is the most common approach in managing construction wastes. This method is chosen among contractors in Malaysia because the waste materials is assumed to have little premium value [11]. Hence, disposing construction waste irresponsibly would have jeopardized the environment [18]. This resulted in waste generation up to 33 000 tonnes per year in Malaysia and caused the government to have spent RM 1,135.0 million in order to dispose the solid waste [19]. The most effective strategy in waste minimization is through reduction of waste [20] since recycling of construction and waste demolition is limited despite the many recycling schemes introduced [21]. In addition, waste management approaches to effectively minimize construction waste must take into consideration the dynamism of construction activities [22]. Usually, in the countries where natural resources are expensive with limited raw materials and landfill sites show aggressiveness and willingness in consuming recycled materials [9].

In general, recycling of construction waste is a process of converting waste into a new material, while reuse of construction waste is the practice of using the construction material again without reprocess into new materials. The construction waste can be reused provided that the material is still in good or partially good in condition but, recycled materials can be processed into a totally different and new material under different composition. However, recycling and reuse of construction waste is limited only to certain materials.

In Malaysia, several studies on construction waste have been reported in literature focusing on analysing the economic impact [23], minimization practices [24] and determining stakeholders' perspective [25]. It was estimated that if 50 % of recycling rate can be achieved in 2025, the environmental impacts will be reduced by 33.2 % and it will be further reduced by 46.0 % if 100 % of recycle and reuse of waste materials is carried out effectively [12]. A limited attention has been given on the adoption of recycling and reuse as part of strategies to minimize construction waste dumped onto the landfill. Thus, more attention needs to be paid to determine different types of construction waste that can be recycled and reused to preserve the environment and minimize landfill usage.

This study focuses on the practices of recycling and reuse of construction waste materials in Klang Valley, Malaysia to determine the availability of different construction waste that can be recycled and reused, as well as the benefits and challenges in using of the waste. Thus, this

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study contributes to the current body of knowledge on the recycle and reuse of construction waste in order to reduce waste generation and preserve the environment.

2. LITERATURE REVIEW

2.1 Current Practices in recycling and reuse of construction waste materials

Previous research has established that the increased volume of construction waste is mainly due to the inefficient waste management practices in the construction projects. A recent study focuses on the statistical data on the volumes of formation and processing of construction and demolition waste, confirming the relevance and need for attention to the area of construction waste disposal [12]. Less attention has been given on the practices of recycling and reuse of waste as part of strategies to minimize construction waste dumped to the landfill. Thus, improving awareness and education of workforces regarding construction waste management together with proper handling of construction materials is very important in order to encourage on-site construction waste reduction to achieve on-site waste minimization [11].

2.2 Types of recycling and reuse of construction waste materials

There were many studies related to different types of recycling and reuse of construction waste materials. In construction industry, recycled timber is commonly obtained from old buildings or houses. These were disassembled and collected to be sold to tradesmen who processed them further by scanning via metal detector, de-nailing and cut to specific sizes and later sold the recycled timber in the form of timber flooring, beams and decking once re-milling were carried out. A significant amount of timber has been generated from construction and demolition waste throughout the world [21]. Reclaimed timber is defined as a waste material which, in the past was used in construction and directly re-used in the absence of reprocessing, while cardboard is known as corrugated paper [26] which is a wood-based paper material. The sources of cardboard waste are from cardboard boxes, cardboard packaging materials and box boards [27].

Another popular construction material is recycled aggregate concrete or known as RCA which is used as partial or full replacement in both coarse and fine aggregates [28]. The huge amount of daily RCA produced from construction and demolition wastes is now an environmental concern [22]. Recycled aggregates are materials that have been reprocessed and been used previously in construction. Masood, Ahmad, Arif, and Mahdi [29] found that recycled aggregates are capable of functioning as aggregate for application in many construction work such as concrete roads, drainage work and more. Another type of material is asphalt that can be recycled which is known as Reclaimed Asphalt Pavement (RAP) [30]. In construction of asphalt pavement, a rehabilitation method known as Hot In-Place Recycling involves processes such as heating, scarifying, mixing, levelling and compacting bituminous surface [31]. It is called in-place method because it rehabilitates the wear out asphalt pavements hence reducing the consumption of new materials.

The separation of recycled masonry debris occurs at the place of origin. Thus, to avoid damage on the clay bricks, the masonry should be demolished separately on site. Thermal treatment used to regain clay brick from masonry debris. The thermal treatment makes it viable to regain up to 50% of clay bricks [32]. Another waste material is ferrous metal and non-ferrous metal which are the subdivision of metals. Ferrous metal contains mostly iron and amount of other

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metal to reach the required properties is small. Developed market for ferrous metal is superior if compared to other construction materials hence, it is well known that this material is profitable and recyclable. Non-ferrous metal waste usually found in construction are aluminium, zinc, copper and lead [33].

Common types of recycled and reused plastics materials are polypropylene, polyvinylchloride, polyethylene and polystyrene. Plastic waste separately collected and cleaned is advised due to the fact that the recycling process is hard to conduct when the plastics waste is mixed with contaminants and different types of plastics [34]. Next material is glass waste from construction site that can be reused for variety of applications. For example, window glasses from demolition can be reused directly if they were properly handled and maintain a good and acceptable condition. Recycled glass is also being used in Japan as an isolation material for ceiling board and acoustic insulation board.

2.3 The benefits of recycling and reuse of construction waste materials

Previous studies indicated many benefits of recycling and reuse of construction waste materials. Profit maximization and cost saving is one of the benefits [35] since it decreased the cost of removing and hauling [9] of construction waste to landfill, thus reducing the landfill fees. In addition, it lessens the request for landfill spaces since the landfills received lesser quantity of construction waste [35]. Moreover, this practice will also improve the image of the construction company [35]. Furthermore, productivity will be improved if this practice is correctly implemented. Productivity is improved by preventing delay caused by (re)purchasing and reordering the materials previously used. Besides, it will cause the resource management to be improved [35]. This study found that improving awareness and education of workforces regarding construction waste management is very important to achieve on-site waste minimization. In addition, the practices of the usage offsite products and component (low waste construction technology), provision of waste skips for specific materials (waste segregation), standardization of design and material, and proper handling of construction materials are also important in order to encourage on-site construction waste reduction.

2.4 Challenges of recycling and reuse of construction waste materials

It is important to know the challenges which hinder the construction industry to practice recycling and reuse of construction waste materials. One of the challenges is not having enough technologies and facilities [18]. Current technologies like landfilling and recycling centre are unable to catch up with the rapid increment rate of waste generation. Secondly, lack of a well recycling market due to the lack of competitive marketing efforts to find market and trade in high price thus, preventing the effectiveness in utilized recycling. Next, lack of standards causes contractors and designers to have doubt of recycling and reuse of construction waste [36]. Apart from that, there are lack of fund and support from the government where incentives are needed in order to increase their motivation in implementing waste management techniques [18].

Moreover, the insufficient regulation is also one of the major causes of why it is difficult for the contractors to practise recycling and reuse of construction waste [18]. Collection and transportation costs are another challenge of recycling and reuse of construction waste [36]. Transformation and disposal costs will also have great effect towards the decision of disposing construction waste [36]. Apart from that, risk of the construction waste being contaminated is

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one of the reasons that hinder such method [21]. Furthermore, the collection and the separation of construction waste is time consuming and tedious [37]. Lack of planning [36] and lack of awareness are also the challenges identified [18]. In addition, one the barriers in implementing waste management in a local authority in Malaysia is due to the lack of authority to monitor the management of construction waste on site [38].

3. METHODOLOGY

This study incolves a systematic process that include various activities as shown in Figure 3.1 [39].

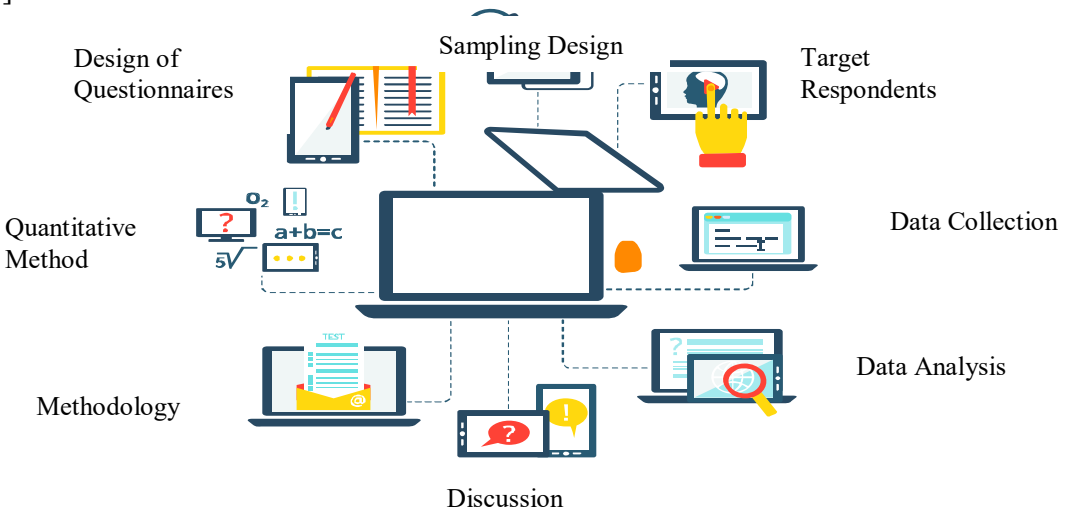

Figure 3.1: Overall methodology process

This study adopted a quantitative method using a self-administered questionnaire survey. The units of analysis are the Malaysian contractors with experience in managing construction projects. A sampling frame is provided by the CIDB website. There are 4589 grade G7 contractors under CE21 (Civil Engineering) in the Klang Valley. Thus, using Krejie and Morgan table [40], the target number of respondents is 354 which include employers and employees with various position who work under the contractor grade G7 and registered under CIDB. They consist of project director, project manager, general manager, construction manager or other roles in their company. The design of questionnaire survey is based on parameters identified from previous studies which are structured into five (5) sections. Section A is the demographic background of the respondents; Section B: Identification of the common types of recycling and reuse of construction waste materials practised by the G7 contractors in the Klang Valley; Section C determines the key benefits of recycling and reuse of construction waste materials; Section D identifies the key challenges that affect the recycling and reuse of construction waste materials and Section E allows the respondents to make comments and suggestions. The acquired data were then analysed through descriptive, reliability and relative important index (RII) to rank the respondents' feedback on the statements related to types of wastes, key benefits, key challenges and suggestions for improvement, which was indicated by the index values in the questionnaires, where the Likert rating scale was incorporated. The RII ranged from 0 to 1. Following is the formula of RII, which was input in Microsoft Excel 2016 to calculate the index:

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$$\text{Relative Importance Index} = \frac{\sum W}{AN} = \frac{5n5 + 4n4 + 3n3 + 2n2 + 1n1}{5N}$$

Where:
w = The range of weight provided by the participants, which is from 1 to 5;
n_1 = The number of participants who choose 'Not Important';
n_2 = The number of participants who choose 'Less Important';
n_3 = The number of participants who choose 'Moderately Important';
n_4 = The number of participants who choose 'Important';
n_5 = The number of participants who choose 'Very Important';
A = Maximum weight (5); and
N = Overall number of participants.

4. RESULTS AND DISCUSSION

4.1 Respondent's Position

Based on Section A, out of 354, 117 contractors have responded to the questionnaires survey giving a response rate of 33%. Figure 2 shows the background of respondents in terms of their company position. The chart shows that almost 50% are project engineers, 25.6 % are project managers, followed by project directors (18.8 %) and a small percentage are general managers (6 %).

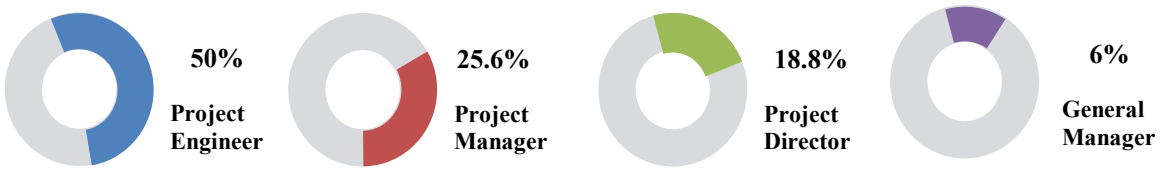

Figure 2: Position of respondents

4.2 Different Types of Recycled and Reuse of Construction Materials

Different types of waste are related to the efficiency of the processes, equipment or personnel, and are more difficult to be measured because the optimal efficiency is not always known [41]. Based on Section B of the questionnaire, Table 1 shows the ranking of different types of recycling and reuse of construction waste.

Timber is ranked first as the most frequent recycled and reused material compared to other materials (RII = 0.749). The main reason is because wood/timber can be recycled and reused several times as mould or formwork. Many contractors in the Klang Valley transformed timber

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waste from the formwork into timber/wood hoarding at site and temporary quarters for the workers. Due to the high generation of timber on site, up to 30 % were reused to avoid wastage [42]. However, recycling of timber material is tedious because it involved more work especially timber that had been nailed.

Table 1: Data Analysis on Types of Recycling and Reuse of Construction Waste

Types of Recycling and Reuse Construction Waste	**Frequency Analysis (FA)**			**Total Frequency**	**Relative Index**	**Rank**
	1	2	3			
Concrete	95	18	4	117	0.401	4
Asphalt	109	8	0	117	0.356	7
Brick	58	41	18	117	0.553	3
Metal	44	27	46	117	0.672	2
Plastic	101	13	3	117	0.388	5
Glass	104	8	5	117	0.385	6
Timber	32	24	61	117	0.749	1
Cardboard	112	5	0	117	0.348	8

The second ranked material is metal waste (RII = 0.672). The recycling market for metal waste especially ferrous, copper and brass are quite satisfactory due to its high value and most profitable compared to other materials [33]. Like timber formwork, metal formwork also can be reused several times. What makes metal waste eligible and legit to be recycled and encouraged to do so is because recycling of metal waste of the same material can be done over and over again without degradation of the material itself [33]. The third ranked waster material is brick (RII = 0.553). Bricks can be crushed to form filling materials and hardcore [21] which can be also be used as a backfill. However, most contractors in the Klang Valley opted not to recycle the brick as there is a high chance of the brick being contaminated due to demolition. Next material is concrete selected as one the popular recycling and reuse construction wastes (RII = 0.401) which is commonly crushed to become recycled aggregate concrete (RAC) [43]. The fifth ranked material is plastic (RII = 0.388). As compared to materials like timber and metal due to the low generation of the material in construction site hence the contractors were not interested to recycle and reuse this material as the profit is low if they are not in bulk amount. Glass is ranked sixth in the types of recycling and reuse of construction waste material (RII = 0.385). Similar with plastic, the demand for recycling glass material is also high in Malaysia recycling market however the generation of the glass material in construction site is quite low if compared to timber, concrete and metal. The glass waste can be used as fine aggregates in concrete. The seventh ranked in recycling and reuse construction waste materials is asphalt (RII = 0.356). Most common method of recycling asphalt in Malaysia is Cold-In Place Recycling (CIPR). There are many advantages of this method causes the contractors in Malaysia eager to use this method of asphalt recycling. The advantages include reduced disposal, construction cost, construction time and less machinery at site which indirectly reduce the usage of fuel. Cardboard is the most unpopular type of material to be recycled and reused and ranked last (RII = 0.348). This is due to low generation of the material at site. The profit obtained from recycling cardboard is low compared to metal, plastic and glass due to the lightweight of the material. Although this waste does not contribute much in weight it contributed up to 30 % in volume.

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4.3 Benefits of Recycle and Reuse of Construction Waste

Based on Section C of the questionnaires, the ranking on benefits of recycle and reuse of construction waste was determined and shown in Table 2.

Table 2: Ranking of the Benefits of Recycling and Reuse of Construction Waste

Benefits	**Frequency Analysis (FA)**					**Total Frequency**	**Relative Index**	**Rank**
	1	2	3	4	5			
Cost Saving and Profit Maximization	1	3	13	76	24	117	0.803	2
Reduce Demand for Landfill Spaces	0	1	9	76	31	117	0.834	1
Improve the Image of the Construction Industry	2	9	55	38	13	117	0.687	5
Improve Productivity	0	11	28	57	21	117	0.750	3
Improve Resource Management	1	21	24	46	25	117	0.725	4

The top ranked benefit of recycling and reuse of construction waste is to "reduce demand for landfill spaces" (RII = 0.834). The reduction of the amount of construction waste will reduce the cost associated with the operation of the landfill. Many possible environmental hazards can be prevented and avoided if contractors recycle and reuse their construction waste. The second ranked benefit is "cost saving and profit maximization" (RII = 0.803). Thus, recycling and reuse of construction waste can save cost and increase the profit gained by the construction company in terms of transportation cost and company can get extra income from this source as they can sell the construction waste to the recycling center [17]. The third ranked benefit is to "improve productivity" (RII = 0.750) in order to delay avoidance and prevention. The fourth ranked benefit chosen by the respondent is to "improve resource management" (RII = 0.725). A minimization of construction waste resulted in efficient resource management and improved in monitoring and control in using of resources [35]. "Improve the image of construction industry" is ranked fifth benefit (RII = 0.687). This may be due to the image of the construction industry due to the complex nature of the construction industry.

4.4 Challenges Faced by Contractors to recycle and reuse construction wastes

Based on Section D of the questionnaires, the ranking on the challenges faced by the contractors in recycling and reuse of construction waste in construction is shown in Table 3. In term of challenges faced by the contractors "transformation and disposing costs" is ranked first (RII = 0.897). According to Bolden et al. [44], some construction waste materials that can be recycled counterbalance the benefits due to expensive operation procedure which increase the cost of transformation.

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Table 3: Data Analysis on the Challenges of Recycling and Reuse of Construction Waste

Challenges of Recycle & Reuse of Construction Waste	Frequency Analysis (FA)					Total Frequency	Relative Index	Rank
	1	2	3	4	5			
Insufficient Technologies and Facilities	0	1	30	77	9	117	0.761	6
Lack of Well-Recycling Market	0	0	14	72	31	117	0.829	5
Lack of Standards	0	2	56	48	11	117	0.716	8
Lack of Fund and Support by the Government	0	2	49	55	11	117	0.728	7
Insufficient Regulations	0	3	51	56	7	117	0.715	9
Time Consuming and Tedious	0	0	9	63	45	117	0.862	2
Risk of Contamination	0	2	7	52	56	117	0.877	1
Transformation and Disposing Costs	0	0	28	42	47	117	0.833	4
Collecting and Transport Costs	0	3	10	58	46	117	0.851	3
Lack of Planning	3	25	50	32	7	117	0.626	10
Lack of Awareness	19	37	37	18	6	117	0.523	11

The second rank goes to "collection and transport costs" (RII = 0.862). For debris in mixed state there is a need for labor-intensive separation which means that there is need for a team that specialized in material separation which will increase the cost apart from the transportation cost for delivering the waste materials to the recycle center [45]. The third ranked challenge is the "risk of contamination" (RII = 0.833). Wastes from time to time will have contaminants for instance lead paint which make it troublesome to reuse it for constructing new building. The end product of recycling is often not up to required standards [44]. The fourth ranked challenge is the "time consuming and tedious" (RII = 0.831). Debris that is in blended condition need tiresome and labor-demanding for the separation of the debris [45]. The fifth ranked challenge is the "lack of well-recycling market" (RII = 0.829). There is a lack of competitive marketing efforts to find market and trade in high price will prevent the effectiveness in utilize recycling [18]. "Insufficient technologies and facilities" was ranked number sixth (RII = 0.761) where the current technologies like landfilling and recycling center unable to catch up with the rapid increment rate of waste generation [18]. The seventh rank is "lack of fund and support by the government" (RII = 0.728) where incentives are needed in order to increase their motivation in implementing waste management techniques [18]. Next is the "lack of standards" that has imposed a challenge to the contractors (RII = 0.716) where, currently, there is no specific standard for recycled construction waste [44]. The ninth ranked challenge is the "insufficient regulations" (RII = 0.715), where permits are needed for some materials [44]. This is also due to the lack of authority to monitor the management of construction waste on site[38]. The tenth rank goes to the "lack of planning" (RII = 0.626) which is due to no specific portion of area where there is a special space exclusively to put recyclable and reusable material at the construction site. The lowest rank challenge is "lack of awareness" (RII = 0.523). Even though, numerous policies are introduced, but the lack of awareness by the contractor and understanding on the management of construction waste had caused such problem [9].

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5. CONCLUSION

Ineffective construction waste management has become a serious problem in a developing country like Malaysia due to its immense growth. In recent years, it is evident that construction companies are practicing recycle and reuse of construction waste which helps to reduce the disposal cost. However, in most of the developing countries the practices are mainly due to the monetary aspects instead of environmental concern as compared to the developed countries where natural resources are expensive with limited raw materials and landfill sites show more efforts and willingness in using recycled and reused materials. This study focuses on the practices of recycle and reuse of construction waste materials by contractors in the Klang Valley, Malaysia. Questionnaires were administered to obtain the respondents' feedback to determine the availability of different types of waste that can be recycled and reused, the benefits and challenges to recycle and reuse of the waste. In a nutshell, this study found that the most common and popular recycled and reused construction waste is timber since the resource to provide wood/timber is widely available and timber can be recycled and reused several times during construction activities. The most important benefit of recycle and reuse of construction waste is to reduce demand for landfill spaces due to the lesser amount of construction waste and consequently reduce the cost associated with the operation of the landfill. Risk of contamination is the main challenge in the practice of recycling and reuse of construction waste materials. Thus, this study contributes to the current body of knowledge on the recycling and reuse of construction waste in order to reduce waste generation and preserve the environment.

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