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Analysis of Construction Waste Generation and Its Effect in a Construction Site

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***Abstract*—**The generation of solid waste and its effective management are debated topics in Sri Lanka as well as in the global environment. It was estimated that the most of the waste generated in global was originated from construction and demolition of buildings. Thus, the proportion of construction waste in solid waste generation cannot be underestimated. The construction waste, which is the by-product generated and removed from work sites is collected in direct and indirect processes. Hence, the objectives of this research are to identify the proportion of construction waste which can be reused and identify the methods to reduce the waste generation without reducing the quality of the process. A 6-storey building construction site was selected for this research. The site was divided into six zones depending on the process. Ten waste materials were identified by considering the adverse effects on safety and health of people and the economic value of them. The generated construction waste in each zone was recorded per week for a period of five months. The data revealed that sand, cement, wood used for form work and rusted steel rods were the generated waste which has higher economic value in all zones. Structured interviews were conducted to gather information on how the materials are categorized as waste and the capability of reducing, reusing and recycling the waste. It was identified that waste is generated in following processes; ineffective storage of material for a longer time and improper handling of material during the work process. Further, the alteration of scheduled activities of construction work also yielded more waste. Finally, a proper management of construction waste is suggested to reduce and reuse waste.

***Keywords*—**Construction waste, effective management, reduce, reuse.

I. Introduction

SOLID waste management is paramount of importance not only in Sri Lanka but also in the global environment.30% of the waste generated in global was originated from construction and demolition of buildings [1]. And according to the estimations, it is about 2 to 3 billion tons per year [2]. This construction and demolishing wastage includes all the wastage generation during the construction, renovation and demolishing activities such as cleaning of sites, demolishing works, construction of buildings, etc. [3]. In this context, the proportion of construction waste in solid waste generation cannot be neglected. On contrary, the Sri Lankan construction industry showed a recorded growth rate of 9.3% in the recent past (ICRA) and hence expected to grow also at a rapid pace in future.

Different materials are used in construction sites depending on the categorization as structural or non-structural work. It was observed that when the material usage is high, the generated waste is also at a higher rate at most of the construction sites [4]. The concept of sustainable development plays a major role in the modern construction industry in which the public mainly focuses on economic, society and environmental consideration. Although a proportion of it can be reused or recycled, the effective management of construction waste is not occurred at most of the sites [5]. Those generation of wastage cannot be handle properly if there are no any proper identification of a process to take necessary action to reduce the wastage generation. In the large construction sites with the material usage, the wastage is high, and the wastage materials are neglected without recycling or reusing. But, when it comes to the quality of those materials, it can be readily use for the other construction processes to minimize the effect of the wastage materials, when it removes to the environment. Most of the wastage materials which are generated from the construction processes can be reused and recycled to maintain the sustainable goals to achieve the sustainable development. There are no proper wastage management systems in countries such as Indonesia, China, Malaysia, India, Sri Lanka, and Thailand, as well as in Africa and South America. When it considers the Asian countries, there are no proper laws, policies and regulations which are directly connected with the management of C&D waste [6]. In many countries, there is now tendency to find out the causes for this C and D wastage generation [7]. According to the findings, there are identified causes for the wastage generation at construction sites. Due to the lack of skilled, experienced workers and demolition contractors, materials are not carefully handled in construction activities, inappropriate methods for loading and transportation of building materials to sites and within the site premises, waste due to reworks and change of orders, inappropriate packaging, inventory of building materials [8]-[11].

When it considers the construction sites, there are so many processes and applications which can be replaced by the wastage materials. The proper specifications can be developed in order to convert those waste materials to ensure the applications process at the construction sites. There are many methods which can be considered to reuse those waste materials. Through that process, the adverse effects to the human beings and environment can be minimized.

Through the identification of the most critical wastage materials, it can be easily reused or recycled. Most of the country research works show that there is high amount of wastage generation in the construction processes compared to the total wastage generation. It was found that the total wastage

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generation is 18% from the purchased materials, according to the research carried out by the Western countries (United Kingdom, Australia) and the Asian countries (China) [8]-[10].

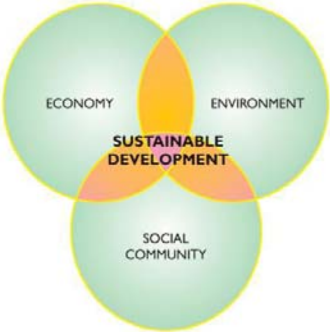

Fig. 1 Sustainable development cycle

The construction site which was divided into six zones depending on the construction processes. 4- to 6-storey buildings were selected for the analysis work of the construction wastage materials. Most critical ten construction materials were selected depending on the economic value and the adverse effect on the human health and environment. The generation of the construction waste was recorded per week, for five months to identify the most critical pattern of wastage generation. Structured interviews were carried out to gather necessary information on the storage systems and critical situation when handling of the construction materials to identify the pattern of the wastage generation. The results revealed that the cement, sand, wood and steel materials make more contribution for the generation of the construction waste. It was found that, most of the times, those wastage materials are developed during the storage of the materials and the handling of those construction materials during the process. Therefore, the necessary actions can be taken to reduce the wastage generation from the construction sites and the methods and places can be identified. All those processes will govern the relevant project to achieve sustainable goals which are clearly answered for the economy, environment and social effects.

II. Results

Table I shows the most critical construction waste materials identified at all six zones in the site. Considerable amount of sand volume has been collected due to the improper storage and due to the trans-portion inadequacy. This accumulation of the sand volume can be reduced by proper storage of the sand by providing definite storage volumes which can be prepared by form work waste, nails and 2 by 2 wooden bars. After some times, the sand is mixed with the dust, which cannot be used to build the permanent structures.

In the high rise buildings, at the higher elevations, there are considerable amount of wind. Fig. 2 shows a way of the storage of sand in the construction site premises. When the sand is not properly stored and covered at those elevations, it will cause to generate the waste, mixing with the dust and chipped waste. This also causes to build inconvenient situations for all living beings with the development of the dusty conditions with the sand particles. This may also cause to discolor the architectural appearance of the modern and ancient structures in that area. The cost for the renovation of those damaged structures will be high and the value will also be lowered due to variation of the original appearance of the structures. The considerable amount of solidified and non-solidified cement bags was collected at the site. As Table II shows, the cost for the 50 kg cement bag is about Sri Lankan 930 rupees. Considering the above site, nearly seven bags were collected as wastage. The cement wastage can be reduced by providing proper storage facilities, which can also be prepared by the construction wastes, nails, form work and two by two bars.

Fig. 2 Sand storage

At most of the construction sites, it can be clearly seen that small amount of cement is remained at the corners of the bag. This amount is very much considerable when it is considered as a collection of bags. This small amount can be collected by using containers, which can also be prepared by the wasted glass or form work pieces along with the waste nails. Solidified cement can be used as chipped waste or dust waste. New mixing methods can be identified to enhance the quality of those dust and chipped waste to use in the construction processes such as temporary applications.

TABLE I
Wastage Materials Considered.

	Wastage material	Watage Generation Per week					
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
i.	Sand (cubes)	0.2	0.5	0.2	0.1	0.6	0.2
ii.	Cement bags	1.5	1	1	0.5	2	0.5
iii.	Steel rods	2	3	5	3	4	2
iv.	Nails	23	24	16	43	20	19
v.	2 by 2 bars Woods 3 m	10	14	16	12	14	17
vi.	Wood form work	15	17	19	21	14	17
vii.	Dust (large Bags)	10	15	17	20	19	21
viii.	Paint Cans, volume ¼ of cans	2	4	3	2	3	2
ix.	Glass (1 m by 3 m)	1	3	3	2	2	4
x.	Broken tiles 600 mm (Pieces width)	5	4	3	4	2	4

The steel rods can be reused to construct temporary structures as a frame work which can be used as containers to store small construction equipment and also to repair broken containers, to repair broken parts of the construction equipment, to build material handling equipment, etc. Those steel rods can also be used to strengthen the permanent and temporary parts of a structure. By collecting of those rods together, it will make a useful soil digging equipment for the construction purposes. Those steel materials can also be used to build ladders to access to higher elevations which are very much used in the construction sites. Most of the site safety issues are due to the nails, which are removed in the form work construction process and which are wasted due to the insufficient storage methods and application processes.

TABLE II
COST OF WASTAGE MATERIALS CONSIDERED

	Wastage material	Quantity/ Measurement	Sri Lankan Rupees	US dollars
I.	Sand	1 cube	15000	96.75
II.	Cement	1 bag	880	5.68
III.	Steel rod	1 bar	500	3.23
IV.	Nail	1 kg 1 inch	180	1.16
V.	Paint Can	1L	780	5.03

Fig. 3 Chipped waste

This nail waste can be reduced by reusing for the construction of temporary structures at the site, labours accommodation, toilets, etc.

There are so many reusable form works which can be used along with 2 by 2 bars, nails, steel to renovate the labourer accommodation and to build temporary barriers and ladders. The steel rods cost about 500 Sri Lankan rupees, which are much expensive, and according to Table I, there are 19 full sized abounded steel rods at the site.

Dust particles are adversely affected on the human health. Those dust particles are not easily controllable due to the immediate motion under gravity. In the large construction sites, those dust practices cannot be controlled properly, if those are not collected and stored properly. At the site premises, the dust particles are collected to the large bags. Those dust particles can also be used for the construction works as a novel technique using specific application and mixing methods with other materials. With this regard, proper specifications can be allocated to enhance the quality of the mixer to apply for the specific application.

The collected paint cans are not the average value, due to the specific usage of the paint in the finishing work. The one-liter paint cans are about 780 Sri Lakan rupees. There were 16 1-L cans which were collected from the site. This collection was done only for the 1-L cans. There were small paint cans, which got solidified due to the improper storage.

Fig. 4 Usable wood form-works

Due to improper installation and handling of glasses, the wastage is considerably high which should be clearly answered with proper handling. Especially, it was noticed that, when it carried to the lower level from the higher level in a particular building, the considerable amount of glasses was damaged due to the slipping it on to the floor and due to contact with the installed form works, scaffolding parts and walls. Those wastage glass parts can be properly arranged to apply inside the building to enhance the architectural appearance.

It was observed that, there were also considerable collection of the broken tiles, which can be considered for the landscape design.

IV. CONCLUSION

According to the collected data, considerable amount of waste materials was generated from the sites. Those materials can be easily collected to use for the other materials or equipment to fulfill the other construction needs. Some of those construction wastes cause to the health effects on human beings, all other living and non-living beings. In the large construction sites, the wastage materials will be considered to be large amount. Therefore, those materials can be collected according to the requirement. Those materials can be categorized to minimize the cost and time to maintain the process smoothly.

When it considers the final outcome of this analysis, mainly the construction waste generation effect can be categorized in three ways; by considering social issues, economical issues, and environmental issues.

In the social consideration, the analysis will answer for the health issues, to reduce the health problems of the community which are resulted by the wastage materials. In most of the cases the generation of the wastage materials will result in the illness from least dangerous effects (cough) to the most dangerous effects (cancer). The identification of the wastage materials will help to reduce those effects by maintaining the appropriate disposal and reuse. When considering the economic aspects directly, the cost can be reduced by minimizing the generation of those wastage materials. Proper methods and processes can be identified to minimize the wastage generation from the construction sites and to enhance the usage of the construction wastage materials at sites.

Correct identification of the materials will help to reuse for the other processes. The reduction of the wastage means the reduction of the cost. In the environmental consideration, the effects on environment by this wastage generation (air pollution, water pollution, disturbance to the eco chains) can be reduced and removed after the identification of the wastage materials and generation.

There are other materials, which are effected by the storage at the construction sites. Those materials will be directly disturbed by the weather conditions, if those materials are not properly arranged and it will become a wastage material. Especially, it can be seen at most construction sites, the bricks and blocks are stored as Fig. 4 shows, which are adversely effected by the weather conditions such as rain. Those arrangements should be properly done to minimize the wastage generation. Chipped stones are also arranged similar to the blocks and bricks arrangements.

Fig. 5 Bricks and blocks storage arrangements

Most of the time, after the concreting process is completed, three will be some small amount of concrete, remaining in the container truck, and it is observed that those remaining concrete placed on the ground to be solidified.

Fig. 6 Solidified concrete

Those wastage generations should be avoided. Proper methods and installments can be identified to collect those remaining concrete amount and use for a specific task.

According to the analysis, considerable amounts of the wastage generation from the construction sites could be identified. By identifying appropriate methods and processes, the sustainable developments goals can be achieved.

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