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DETERMINATION OF THE RATE OF CONSTRUCTION AND DEMOLITION WASTE GENERATION IN KHULNA

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ABSTRACT

Hundreds of Civil engineering projects i.e., (Buildings, bridges, roads, dams, and culverts) are constructed every year all over the country, producing an enormous amount of construction and demolition (C & D) waste. This waste causes great economic losses and poses risks to the environment and human health. Thus, estimating C & D waste is necessary for the proper implementation of waste management. Adequate reuse and recycling of C & D waste can significantly reduce the import of new raw materials for civil works. This study investigated C & D waste generation rates at five different places in Khulna city. According to the investigation, the primary elements in the C & D waste process are steel, plaster, brick, and concrete. From the data analysis of KMC, KU, and Sonadanga Residential Area, the construction waste like steel, plaster plus concrete, and brick waste generation rates were found as 98, 1005, and 262 lb per 1000 sqft, respectively, whereas demolition waste generation rates for KUET and Nirala Residential Area were found as 1615, 12320, and 2670 lb. per 1000 sqft per year respectively. This rate of demolition waste generation is around 10 times higher than construction waste.

INTRODUCTION

Construction waste is a significant source of municipal solid waste in all cities around the world, accounting for 10% to 30% of total waste dumped. Construction waste, for example, accounts for 30% to 40% of the total waste in Hong Kong. In 2005, the amount of construction waste delivered to landfills was 6556 tons per day, accounting for 37.08% of total waste landfilled (17,503 tons per day) (Wong et all, 2005). In 2007, Chicago generated 4,656,037 tons of construction waste, accounting for 60.71% of total waste generated (7,669,097 tons) that year (Van Waning., 2010). In the same way, huge amounts of construction and demolition (C&D) waste are generated in Bangladesh due to the rapid development of the building industry. Along with a rapid increase in GDP, Bangladesh has been one of the countries with the highest production of C&D waste in the world over the last decade. C&D waste is the by-product of the construction and demolition of buildings, roads, culverts, bridges, and other civil works. Because of the increasing rate of construction of new buildings, and bridges, more C&D waste is produced over the present time. Because of the improper management of this waste environment is badly affected as well as the resources are decayed. Recycling and reuse of C&D waste is the best way to reduce the total waste about 80% of waste can be reused (Erlandsson & Levis., 2005). Management of C&D waste has become an important issue for cost efficiency and reducing the adverse effect on the environment (Trankler et al.,1996). For better management and handling of C&D waste, the total amount of waste per year should be estimated to develop a central management system like landfills, in that case, the total amount of waste generation should be estimated properly. Similarly, for the installation of new concrete and steel waste recycling factory waste generation rate, should be known to select the size of the recycling factory. In many countries like Bangladesh, real data regarding C&D waste is not available. But many researchers try to estimate the waste generation rate in a different way. Table 1 summarizes and lists the key information from previous studies that can be used to compare C&D waste generation in different countries or regions.

Khulna is the third largest city and is located in the southern part of Bangladesh, has given little attention to the amount of C&D waste that is generated. Therefore, it is imperative to comprehend how C&D waste is produced in this rapidly developing area, and more research should be done to determine the precise amount of C&D waste that is produced annually in Khulna. The main goal of this research is to give a precise analysis of the quantity and make-up of C&D waste in Khulna, Bangladesh. There will also be some discussion and introduction of the region's recycling management strategies as well as lessons learned regarding the waste index per capita per year. In fact, the proposed estimation methodology will be useful for evaluating the accumulation of C&D waste in other rapidly developing regions. The main objectives of this research are:

- To estimate Construction & Demolition (C&D) waste generation rate in the Khulna City area.
- To calculate total C&D waste in the selected area in Khulna City.
- To investigate the existing practice of recycling and reuse of C&D waste.

Table 1 Past Research on production of C&D waste in various nations and regions(Ding & Xiao, 2014)

Country	Year	Area Type	Waste Type	Conclusion about C & D
US	2003	Residential and nonresidential	Construction and demolition waste	170 million tons, with 39% coming from residential and 61% from nonresidential sources
Florida in the US	2000	Residential and nonresidential	Construction and demolition waste	3.75 million tons and concrete were the major component of the waste representing 56%
Netherlands	1996	Residential	Construction waste	1–10% of the building materials delivered on-site becomes waste, with an average of 9%
Seoul in Korea	1999	Residential and nonresidential	Construction and demolition waste	8.63 million tons in the year 1999 and following an increasing trend
Hong Kong	1998	Residential and nonresidential	Construction and demolition waste	32 710 tons of C&D waste were generated per day and waste concrete occupies the most

METHODOLOGY

Description of the Study Area

The five important places in Khulna city on which this study was conducted are KUET, Khulna University, Khulna Medical College Hospital, Nirala Residential Area, and Sonadanga Residential Area.

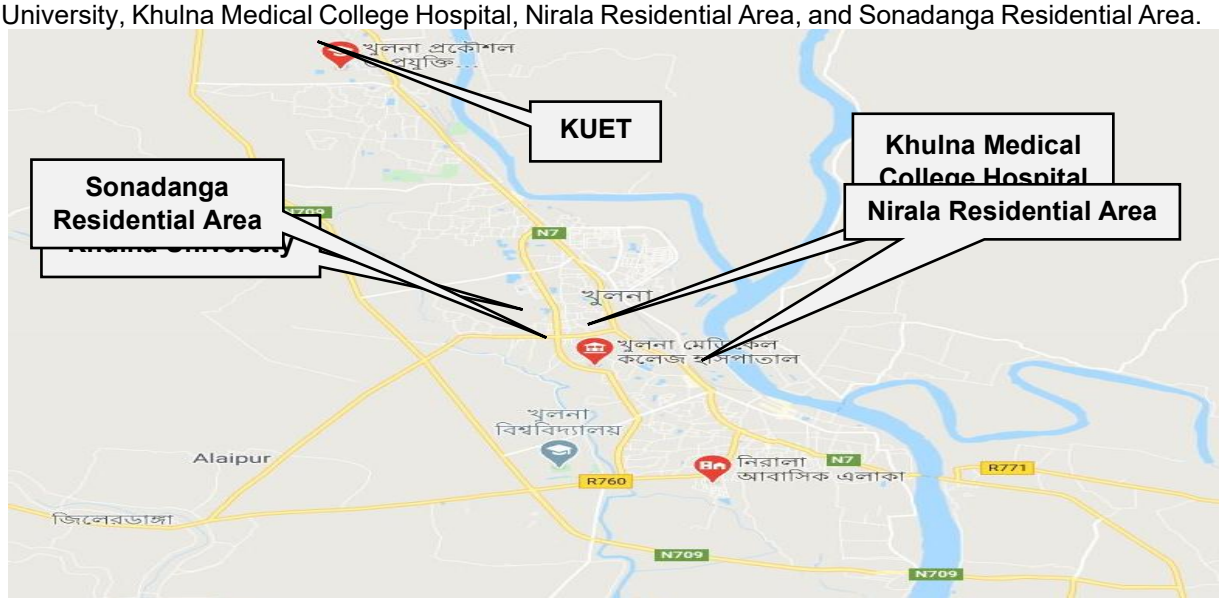

Figure 1 Location of study area

Table 2 Latitude and Longitude of the Study Area

Location	Latitude	Longitude
KUET	22° 53' 58.88" N	89° 30' 9.40" E
Khulna University	22°48'42.3"N	89°32'37.3"E
Khulna Medical College Hospital	22° 49' 44.71" N	89° 32' 13.34" E
Nirala Residential Area	22°48'02.0"N	89°33'14.5"E
Sonadanga Residential Area	22°49'08.0"N	89°32'38.1"E

Data Collection

Data for this study are gathered through a field survey and a questionnaire survey. Direct and indirect measurements were used in the field survey.

Field Survey

a.) Field Survey

Direct measurement is done by measuring its volume. According to (Lau et al, 2008) for stockpile waste, the waste is assumed pyramid. In this case total volume calculated by the equation mentioned below:

$$V_s = \frac{1}{3} L' \times B' \times H' \quad (1)$$

Where V_s is total volume of stock pile, B' is base width, L' is base length and H' is height of the pyramid.

For gathered waste it is assumed cubic and total waste volume is derived from

$$V_g = L' \times B' \times H' \quad (2)$$

After calculating the volume, mass of waste is obtained by multiplying its density.

b.) Indirect Measurement

The number of trucks and the volume of each truck used for waste collection are required for indirect measurement. This information was gathered through interviews with the contractor and the truck driver. The total volume of waste is calculated by multiplying the number of trucks by the volume of a single truck, and the total mass of waste is calculated by multiplying the volume of total waste by the density of waste.

Questionnaire Survey

The questions used in the Questionnaire survey are listed below:

- How long does it take to construct the building?
- How many floors have completed so far?
- What is the area of the plinth on each floor?
- What is the volume and number of trucks used for the collection of waste?
- How much scrap metal is produced?

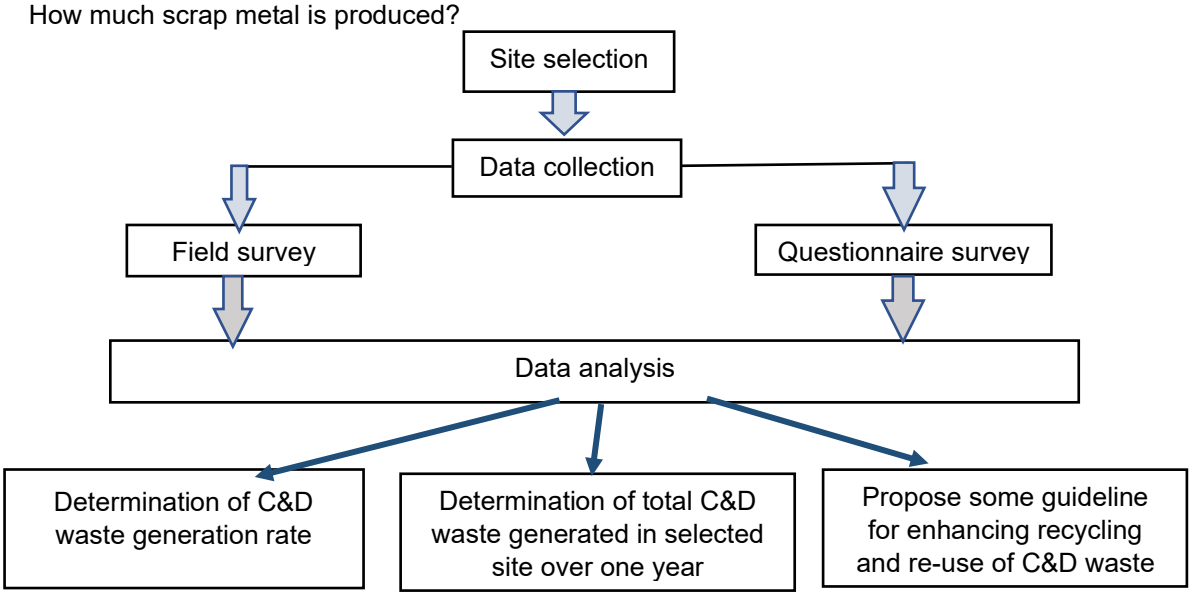

Figure 2 Framework for Methodology

Data Analysis

Initially, the rate of construction and demolition waste generation per 1000 ft^2 plinth area is determined. Then total waste is determined by the following equation proposed by (Yost & Halstead, 1996)

$$W = CW + DW$$
$$= CA \times G_c + GA \times G_d \quad (3)$$

Where W is total weight of building related to C&D waste generated per one year. CW is total construction waste and DW is total demolition waste. CA is total construction area and DA is total demolition area over one year. G_c is construction waste generation rate per unit construction area and G_{dt} is demolition waste generation rate per unit demolition area.

RESULTS AND DISCUSSIONS

From the study it has been found that the main waste that are generated during the construction and demolition process are the plaster waste, broken brick, scrap metal like steel waste, concrete waste etc.

(a)

(b)

(c)

(d)

Figure 3 Waste type in C & D Process, (a) Brick Waste (b) Plaster Waste (C) Concrete Waste (d) Steel Waste

C&D Waste generation rate in selected site

Once all of the values in Equations (3) are known, it is possible to calculate the accumulation of all of the C&D waste produced in recent years using the sum of CW and DW. Table 2 illustrates the basic numerical data of the 12 Constructions projects in three different location of Khulna city. Among those 1-3 are non-residential whereas 9 projects (4-12) are residential. Concrete, aggregate, steel reinforcement, and cement are the main materials in building construction. Therefore, those materials are the dominating components of constructions and demolition waste. For being lower in amount, other types of waste are not taken in this study.

The estimated waste composition by weight is displayed in Table 3. Information on the composition of construction waste enables developers to take strategic actions with regard to waste separation, waste material trading opportunities, and storage planning. The 12 construction projects are estimated to have generated 323946 lbs of garbage altogether. The waste sampled falls most heavily into the concrete/plaster group (77%) followed by brick waste (16%). 13% or so of the total garbage is made up of steel and metal.

The expected demolition debris from five non-residential projects in two institution is shown in Table 4. In addition to scrap metal, concrete/plaster, and brick/block make up the majority of demolition trash. There was no waste from internal finishes because the construction project was abandoned at

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the structural stage, as shown by the demolition case study waste composition. The partial selected demolition approach used for the demolition operation made on-site waste separation easier. It was discovered that concrete and plaster rubbish still dominated (88%) followed by brick (9%), and scrap metal/steel (only 3%). The secondary market value of the steel scrap, which has a high degree of secondary recycling potential, is used to offset the contractor expenses. However, only a small portion of the enormous volume of concrete waste is used for improving the land whereas most of them was instead sent to a dump site.

Table 3 Generation of Construction Waste in selected are

Project	KMC			Sonadanga Residential Area							KU	
Building	1	2	3	4	5	6	7	8	9	10	11	12
Total Floor Area (ft^2)	1500000	15000	10000	2700000	3240000	1800000	1440000	1380000	1890000	9600	3500000	3300000
Steel Waste (lb)	2210	2090	150	1985	2165	1240	885	2120	1590	794	4630	1322
Plaster & Concrete waste	1830000	1940000	11150	1323000	1452000	5955	9554	1235	3995000	1235	7495	300266
Brick Waste (lb)	3580	3660	--	4410	4852	2870	6514	7308	5523	1453	6920	3480

Table 4 Generation of Demolition Waste in selected area

Project	KUET	Nirala	
Building	1	4	5
Total Floor Area (Sft)	5200	3600	2800
Steel Waste (lb)	10400	4600	4380
Plaster+Concrete waste (lb)	78260	42660	36570
Brick Waste (lb)	16325	7340	7900

Table 5 Determination of construction waste generation rate

Project	KMC			Sonadanga Residential Area							KU	
Building	1	2	3	4	5	6	7	8	9	10	11	12
Steel Waste (lb/1000sft)	148	139	150	73.5	66	68	61	153	84	83	132	42
Plaster + Concrete waste (lb/1000 sft)	1220	1304	1150	490	331	331	644	896	2116	1287	2142	910
Brick Waste (lb/1000 sft)	238	245	--	164	151	159	463	530	293	151	198	106

Table 6 Determination of demolition waste generation rate

Project	KUET	Nirala	
Building	1	1	2
Total Floor Area (lb/1000 Sft)	5200	3600	2800
Steel Waste (lb/1000 sft)	2000	1280	1565
Plaster+Concrete waste (lb/1000 sft)	15050	11850	13060
Brick Waste (lb/1000 sft)	3140	2040	2830

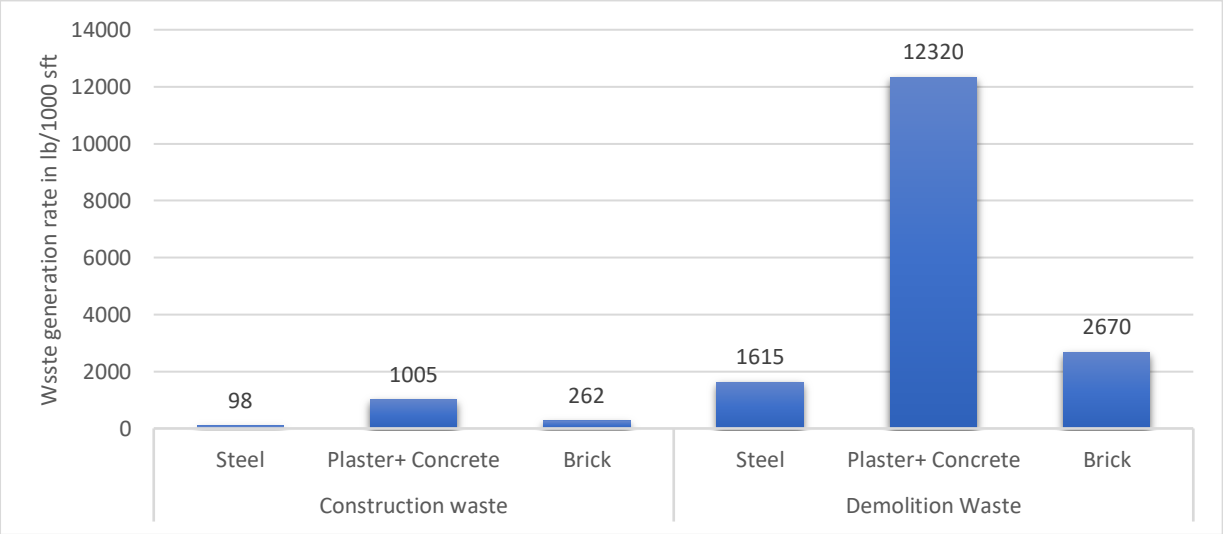

Figure 04 Different Types of Waste Generation Rate at C & D Site

Results show that the different construction project generate waste at different rates (Table 5). The waste generation rate (WGR) is a useful performance measure in managing waste across a spectrum of project sizes (Mah et al., 2016). A higher WGR indicates a less efficient project. On average, the WGR for CW is estimated at 1390 lb per 1000 sft. This study also finds that the generation rate (GR) is approximately same for residential and non-residential project. Every project employs contemporary construction techniques (MCM) As a result, the WGR is considerably lower than with conventional methods. The GR in MCM less than 50% of CCM. Therefore, the predicted WGRs may still be a valuable indicator of the benefits of using such a building method for reducing WGRs (Mah et al., 2016). The common metho for removing of other kinds of CDW material like rubble, drywall, concrete, Plastic, timber, brick and roofing is to dumping in landfill. Scrap metal, a CDW resource that typically has a high market value, will be recovered at the source site irrespective of disposal costs (Llatas., 2011). It is also found that demolition waste is around 10 times higher than construction waste.

CONCLUSIONS

The research was conducted to determine C&D waste generation rate and total C&D generation over one year at five different locations in Khulna. It was found that the total C&D waste generated per year at five selected sites is 1701.5 tons. The findings of this study shows that the plaster waste is still the dominating waste produced from construction process in both residential and non-residential area. Other types of waste i.e., Steel and Brick waste are produced at lower amount, and they are recycled and reused effectively. However, Plaster waste now becomes the matter of concern. The Present practice of plaster waste management is dumping at landfill. This waste can be crushed and graded for using less important construction work and ground improvement. In the Khulna region, the generation and management of C & D waste are considered to be of the least importance. Effective measures are therefore needed to limit waste production and properly manage. Skills and knowledge should be increased to eliminate lack of confidence of recycled material. Environmental labelling should be provided to recycled material to increase awareness of sustainable waste market. All the stakeholder of any construction project should be aware about the C&D waste to ensure a sustainable constructions work.

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