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Quantitative Study of the Origins of the Construction Waste

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Abstract: Improvement of construction materials, productivity and advancement of building technology processes include creation of promising research areas to improve the productivity and environmental benefit of building waste. Construction waste has an environmental impact including soil pollution, water degradation and landscape deterioration. Because of the need to replace waste material, building waste often has a negative economic effect. Even so, building administrators need to consider management strategies to reduce waste, including waste reduction, recycling, or disposal. Reduced waste management solutions have the main value, but without sufficient recognition of the waste capital effective reduction cannot be accomplished. The aim of this paper is therefore to present a report on the contribution levels of 9 established building waste sources. Increasing the contribution levels of various waste sources would improve the decision-making process based on expertise in designing the correct strategy to reduce waste from buildings. The methods used in this study to assess the extent and severity of contribution of waste sources were followed through the use of the survey questionnaire. Some of the findings of the analysis was that the most significant addition to construction waste was residual waste, such as material off cuts. This research thus showed that waste contributes significantly to construction costs.

Keywords: Construction Waste, Demolition Waste Management, Sustainability, Waste Management, Wastes.

INTRODUCTION

Construction waste quantity and composition tend to change because of the complex nature of building activities. Therefore, various building methods and techniques, as well as similar project phases and specificity do not necessarily quantify it [1]. There have been many attempts to calculate the amount of waste generated in different building projects and phases. Construction waste contains 24-31 percent of total worldwide solid waste [1], According to the statistics available, building and demolition waste in many sites around the world often accounts for 11-32 per cent of waste [2] . The European Union 's building cycle produces 531 million tons of waste per year and produces about 33% of all waste streams [2]. Last year in the United States there has been a survey showing around 135 million tons of construction-related and demolition debris [3]. The Netherlands waste roughly 2-11% of the amount purchased for each building material, depending on the material form. Roughly 71 million tons of soil and C&D content ended last year in the United Kingdom [4]. The total solid waste generated each year in Australia contributed 15 to 43 percent of construction waste [5].

In China, almost 41 percent of the total municipal solid waste generated every year contributes to building activities [6] According to another report, 31-42 percent of total solid waste produced annually in China is produced by construction activities. Construction waste was estimated to contribute 39% in Hong Kong [7], while 31%–42%was estimated for other studies [8]. In 2007, residential building waste produced was recorded at 4,454,037 tons, which represents 64% of the total waste created that year (7,469,094 tons) [9]. In two separate studies, almost 21 percent and 2031 percent of the total weight of materials at site was recorded in the waste generated at building sites in Brazil [10].

In Malaysia, the quantity of building waste produced is around 185,000 tons per year in Kuching, with nearly 100,000 tons created in Samarian [11]. The annual production of solid waste in India amounts to 48 million tons, of which 24%, i.e. some 13 million tonnes, is extracted annually. Researcher also found that during construction operations 24% of building materials are wasted. Studies have revealed that the amount of building waste produced in Mumbai, India, is 5.4 million tons per year. In Pakistan, construction, and demolition waste accounts for up to 31 % of the total solid waste produced.

Kinds of Waste Construction:

Construction is responsible for producing a wide range of waste. The study categorized construction waste into three major classes of waste materials, labour and machinery [12]. Construction material waste can also be categorized as waste cutting, waste disposal, waste transit and theft and vandalism [13]. Waste can also be categorized as construction , demolition, civil works and renovation waste [14].The EWC describes building waste in eight separate categories, e.g., tiles, bricks, concrete and ceramics; glass, wood and plastic; bituminous mixtures, tar and tarred products; scrap, rocks, soil and stones dredging; materials insulating and asbestos-containing materials; etc. Buildings are split into inert and reactive building waste (non-ICW) in Hong Kong [15].

Construction Composition Waste:

The company's manufacturing works include paper, wood, metal, cement, packaging material, concrete, dry wall, roofing material, organic material, plastics, carton etc. The usual components of building waste are wood, iron, concrete, drywall, roofing, brick and other [16]. A research at 30 construction sites shows that the most significant waste was produced in the construction fields was concrete (13.34%), metal (10.61%), brick (7.57%), plastic (0.53%), wood (68,10%) and others (2.1%). The largest portion of building waste was estimated in another report. However, concrete is among the huge construction waste sources for the construction project [8]. In addition, waste (41-51%), wood (21-32%) and diverse (21-32%) in construction waste have been identified in another survey [17].

Construction Waste Factors and Resources:

Due to inadequate or diverse handling, poor storage and safety, the over-ordering of materials, poor site management, lack of training, improper controls on stocks and material damage during distribution were recorded waste production at construction sites [18]. The surplus building materials are the main contributors to the production of construction waste [19]. In addition, flawed designs, improper material management, lack of preparation, insufficient sourcing, mishandling and other procedures also include causes and sources of waste.

Work attitudes and behaviour, material and design coordination [20], the zone, the structural and functional form, above ground, underground and total surface area, the size of the project , the construction method, type of construction, human error, technical problems and the storage system, [21] are several additional factors which affect the generation of building waste. Furthermore, lack of knowledge and insufficient design errors [22], frequent design adjustments and inadequate oversight and control are another reason for construction waste generation [22].

Waste sources under production:

Design, logistics and physical construction processes are the result of building material waste. Construction waste is part of the material supplied to an area for reuse, re-use or recycling that has been destroyed in the context of this analysis. According to Ekanayake and Ofori Contribution to waste at buildings is the production, organizational procurement, and material handling attributes[23]. Osmani et al. calculated the project design to contain approximately 33 percent of on-site waste[8]. Consequently, the waste reduction should not be the sole responsibility of the organization as customer and designers will agree on the program of specifications and designs in an environmentally friendly way. Research designate that, as calculated by construction companies, waste of materials typically amounts to higher than average figures [24]. However, although some building waste levels are unavoidable, there is a significant potential advantage to avoid waste generation on site. In addition, waste management requires both reductions at source as well as recycling to reduce the volume and risk of recycling is an aim of sustainable growth.

Most earlier studies on quantification of waste have focused on the separation of waste from sources of waste for specific materials and on the volume of waste produced. The research of Bossink and Brouwers was carried out in five sites in the Netherlands on waste segregation, showing waste components in percentages for a total waste produced and the research showed that the materials delivered to the sites were wasteful between 1% and 10% for each material form. In order to determine how much was to be produced, Formoso et al. performed an observational research study on materials delivered to Brazilian buildings, materials extracted from storage, material movement and construction processes[24]. The study revealed an average 27,6% waste volume across sources, such as inadequate quality control, storage, cut-offs and job errors.

In Spain, Solis-Guzman et al. developed a model for waste quantity to assess and categorize total waste volume into destroyed, ruined and packaged waste [12]. The model is evaluated in a standard new project and showed that 82% of waste produced by the project is debris. However, while the previous studies were based on the amount of waste, the gravity (in amount) and frequency of contribution of sources was singularly calculated in this analysis in order to extract the contribution's multiplicative effect. This study will therefore analyze the contribution rates of the building waste sources identified in previous studies, enhancing an accurate estimate of waste costs and developing an appropriate waste mitigation strategy. The precise cost forecasts would make it easier to reconcile accurately with the costs of measures to reduce waste. A survey was conducted to obtain the above aim, so that building contractor perceptions of contributions from different building waste sources could be generated [12][25].

RESEARCH QUESTION

Question 1- What is construction waste management?

Question 2- What are the types of construction waste management?

Question 3- What are the waste sources under production?

Question 4- What are the reasons and resources of construction waste?

LITERATURE REVIEW

Recycle, Reduce, and Reuse:

The 3R Theory, which aims to eliminate, reuse, and re-treat waste [26], has been adopted by the Us, the North America, Europe, and different areas of Asia. Reasons for the 3R Principle 's support in building construction is economic and environmental benefits. The environmental advantage involves expanding the lifespan of landfills, decreasing the usage of raw materials, decreasing the effect on the environment from the mining of raw materials, and modern manufacturing methods of products, the longevity of natural resources and reducing emissions to harm to human health and well-being. The economic benefits include reducing project expense, improve business chances, reduce the risk of conflicts over waste and demonstrate the commitment to reduce construction 's environmental impact [27].

Construction Waste

Development waste is different from municipal waste and typically comes out of renovation, development, modifying and demolition of roads, construction sites and other built installations the building and demolition waste (C&D) is a waste generated during the building, renovation or demolition process. Concrete, concrete, wood, steels, gypsum, and roofing [28] are part of the C & D waste. Components Building and demolition waste in England is now the only waste that is produced at the site [28]. Construction waste in Australia is caused by destruction of homes, including constructing, road construction, railway construction and repair, including digging.

In Hong Kong, building waste is all that has taken place as a result of building activities and has stayed, whether used or deposited, on construction sites [29]. Building waste was split into two categories: (1) buildings waste inert, which is largely made up of building materials, fragments of stone, dirt, asphalt and concrete for use in the construction area; and (2) non-inert structural waste which accounts of 20% of all waste, and is composed of bamboo, wood, plants, packaging, and others. Some sections may be recycled, some discarded and sent to a wastewater treatment facility. Waste from building materials in this paper includes specific building materials that are not reusable, remaining useful materials and materials that are damaged during construction or handling.

Classification of Construction Material solid waste aspects:

Scholars from around world have been studying construction waste for decades. Critical features that contribute to the generation of waste construction have been identified and grouped together [30]. A review of previous research and literature identified the categorization of different factors in groups of up to 10 categories, including design, procurement, construction methods, equipment, materials, labour and human behaviour, proprietor, project and climate. The study reclassified such factors into four classifications: Materials and Purchasing (MAPR), Construction and Planning (COPL), Design and Documentation (DEDO), and Human Resources (HUMA) [31].

Documents and Design (DEDO)

Design is the initial step in the evolution of construction projects before the start of the construction method. Some of the causes of construction waste are the lack of attention on the part of the designers in the construction process and the buildability of the design intention. Specifying many materials and sizes in the construction project may result in ordering large quantities of material on the basis of minimum order or production requirements from suppliers. This information isn't used in actual construction and may remain on site and end up as a waste material. Designs that do not take into account standard sizes may generate waste by cutting to fit the size or shape of the configured area [32][33]. The lack of awareness of the standard size of the actual building materials on the market is also the cause of construction waste and the production of waste in the design process is caused by having fault information and improvements [34]. The design and documentation play a significant role in the building process.

Procurement and Material (MAPR)

Gavilan and Bernold said that the factors of building generation of waste from the procurement process can include: 1) more materials than the actual amount necessary, 2) less than the actual amount of material used in the errors in communication or details, and 3) incorrect materials[34]. In the previous study showed that inadequate handling and storage of materials resulted in the waste of building. The key sources of material waste were insufficient handling and insufficient transportation [10]. Transport of the substance from the production facility to the construction site or within the site without a method can harm the content and later turn it into waste. Ajayi et al. recommended that 4 components defined a waste efficient procurement and logistics process: the participation of suppliers in low-waste measures, the management of waste materials, effective materials management and efficient waste management bills [35].

Planning and Construction Methods (COPL)

Complexity, due to building structure and function, construction techniques, the project design, project size/ scale, conditions on the site and the surrounding environment[36], is a key feature of building projects. The degree of complexity defines the global approach to a project, in particular the appropriate resources and preparation, the methods and techniques. Each experience is different and complex and needs a great deal of work. These works directly affected the amount of waste generated by construction. Researcher demonstrated also that waste and during construction process was mainly due to pre-construction planning and preparation, but there were still several other reasons that contributed the waste during the construction process. Waste during the construction phase can be generated as a result of poor coordination and control, incorrect choice of construction techniques and redesign [37] [38] [39].

METHODOLOGY

The research methods proposed in this research was the quantitative method in the form of surveys of the sample questionnaire. Quantitative research is described as a study of a social or human issue premised on the testing of a hypothesis made up of factors with statistics and a numerical analysis to determine whether the hypothesis is true. Quantitative research techniques are typically sample surveys and studies. Research work is depending on the researcher attempting to manipulate certain controlled conditions in order to establish the relationship between specific variables and to explain the relationship between cause and effect. Statistical methods are used to generate a representative sample in the survey of questionnaires to derive results that can generalize the entire population.

DESIGN

The use of numbers to convey implied meanings is an agreed way of expressing the strength of opinions. The response rates were given to respondents on a 5-point scale as follows:

1. Contribution severity: the measure was one (nobody), two (tiny), three (reasonable), four (great), and five (exciting);
2. Incidence of role: the measure was one (not once), two (hardly), three (occasionally), four (regularly), and five (continuously).

Severity level is a function of the effect on the amount of waste produced while the frequency rating tests how much the sources contribute to building waste. The effect of the intensity of the source and the frequency ratings is significant.

SAMPLE

The sample has been chosen to represent construction and engineering contractors in the United Kingdom in order to acquire views from contractors operating at regional and national level across the board. The KOMPASS online database, which is a search engine 'business to businesses for design and design engineering companies, has acquired contacts. The list of companies is given for KOMPASS, with 221 companies randomly sample and contacted; 52 completed and 4 uncompleted responses were received, with 50 (22.2% of the original survey). According to researcher, it is anticipated that a small sample may suffice in a homogenous society where most people will answer a question in the same way. Furthermore, the more uniform and reliable the populace, the smaller the sample that can be taken from it for research purposes. Therefore, a sample size of 21 was considered acceptable in this study because the population of respondents is anticipated to be consistent and their responses are expected to be compatible in relation to the problem of waste generation.

INSTRUMENT

In order to calculate the opinions of building contractors on the extent and frequency of inputs of these sources with a Likert-scale, a survey questionnaire was built with independent variables using a multi-item measuring scale in which the response level is set to consecutive integer and symmetrical to a neutral core. The use of numbers to convey implied meanings is an agreed way of expressing the strength of opinions. The survey was split into two sections. The first part analysed the respondents' context, their scale, their project catchment area, annual revenue and headcount. The second component aimed at calculating waste sources' intensity and frequency.

DATA COLLECTION

All contractors working locally and nationally in the area and internationally having projects in other countries are the population of construction and civil engineering contractors from whose replies were obtained. The answers should also be consistent as the target respondents are highly skilled building professionals. The profiles of respondents and the business classification correlated with their responses are shown in Tables 1 and 2. Table 1 reveals that 76 per majority of people are construction professionals with comprehensive knowledge of the sources that lead to building waste, having over 20 years of experience. Table 2, which shows the participants' perception of construction waste rates across India and other countries, shows that 68.3% of companies operate at the domestic and foreign stage.

Table 1: Positions and Experience of Respondent's Expertise

Roles	Number of responses	% of responses	Years of experience	Number of responses	% of responses
Director/senior management	23	46	0–11 12–21	4 8	8 16
Managers	13	26	22–26	15	30
Others	14	28	>26	23	46
Totals	**50**	**100%**	Totals	**50**	**100%**

Table 2: Arrangement of Defendant's Companies

	Number of answers	% of answers
Work catchment areas		
Regional contractors	15	32.38
National contractors	21	38.23
International contractors	14	28.42
Size by annual turnover £M sterling		
>1.8 M but ≤7.9 M	6	14.72
>9.5 M but ≤53 M	22	42.16
>42 M	22	44.9
Size by headcount		
Up to 11	3	4.93
11–51	12	22.54
51–251	14	28.42
Over 251	22	46.11

DATA ANALYSIS

In order of the intensity and frequency of input from building waste sources using SPSS software, questionnaire answers were evaluated using a standard logistics regression to determine the likelihood of the ranking categories (1,2,3,4, and 5). Each category's likelihood (e.g., 2) is the number of people who choose the category divided by the total number of people in the survey. The outcome of an ordinal study of logistic regression of design severity in building waste. Such probabilities were aggregated in order to derive severity and frequency indices, based upon deriving probabilities of individual categories of severity and frequency of contribution for-source of waste. In the calculations of severity and frequency indexes the probabilities of category 1 (X1 or Y1) were omitted because they reflect "never" or "none" on the Likert scale, which means that category 1 has a corresponding zero weight in the measure of the source contribution to waste construction.

Test of the Significance of the Statistics:

Chi-Square test was used to analyze the statistical magnitude and frequency of variables. Essential level tests are used to estimate the likelihood of the sample trend in the population. The study starts by assuming the null hypothesis of a particular trend in the population. Typically, a critical value is set at 0.05, but it may be adjusted to just 0.01 or to 0.1. The adjustment decision is based on the two forms of error tolerance which is either to reject the zero-hypothesis true or not to reject the incorrect one. A Type II mistake is to deny the null hypothesis, because it is valid, while accepting the false hypothesis. Implementing 0.05 mean that there is a greater likelihood that a true hypothesis is rejected while 0.01 means less chance that a real hypothesis is rejected, and that a false hypothesis is accepted. The likelihood of committing either of these errors is difficult to assess, but 0.05 is a negotiation that tries to minimize the likelihood that both types of errors are committed.

RESULTS

The contribution chart is a calculation including its contribution value of each building waste source. The scale's minimum contribution index is 0.17 (Si = 3/6 Fi = 3/6), while it is 1 (Si = 6/6 = Fi = 6/6). The shows that the highest contribution from residuals is Fig. 1.

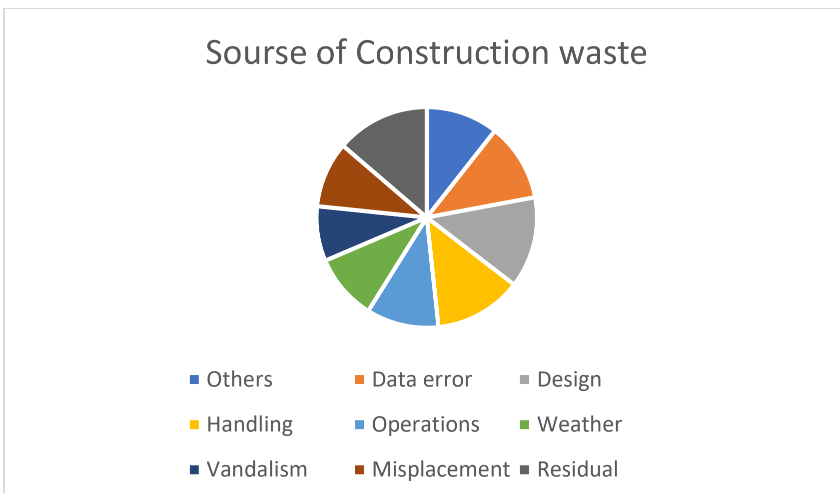

Fig. 1: The Amount of Exposure of the Building Waste Sources

The waste source contains off-cuts from length and packaging materials. Secondly, architecture, though vandalism is the cause of waste with the lowest contribution. Existing studies affirm the results of this report. Project design accounts for about 32 percent of the building waste, according to the researchers. If design dimensions are adapted to standard material dimensions, residual wastes could be minimized. These two main sources represent 26.3 percent of constructed waste, as established in this study, and relate to project construction. In addition, the Chi-Square test results indicate the importance of the study's findings.

The gravitational and frequency P values for waste sources were below 0.06; in other words, the null hypothesis must be refused, and statistically valid results of this study may be accepted. The findings of the Chi-Square test are responsible for the reliability of the results of the study. The more accurate the questionnaire survey's scale is, the more likely it is to obtain meaningful data, according to Decoster and Claypool.

The rejection of the null hypothesis in the observational test thus demonstrated the value of the findings of such an analysis and showed the sample 's reliability. The agreement of this study's results with the results from an earlier study also demonstrated the validity of the criterion which, as Black and de Vaus claim, is how a new measure of a concept relates to the concept's existing measures. Cronbach measures in alpha the data on the extent and frequency of the building waste sources to demonstrate further the validity of the findings of this study and the reliability of the internal accuracy for the multi-item scales. The alpha in Cronbach is considered the most common subjective reliability indicator of inner accuracy (interrelationship) of multiplications. The coefficient of reliability ranges between 0 and 1; more closely the factor to 2.0, the more accuracy internally is. Although the low and top limits of the coefficient of Cronbach are not subject to hard and fast laws, reasonable rates differ from 0.8 to 0.85.

CONCLUSION

Reliability is the consistency and efficacy of interaction between federal, regional, municipal governments and representatives of processing and construction companies as well as participants in investment activities, Construction Waste management is a highly varied and complex task. Application of modern information technology (BIM) and their adaptation to resource saving activities are the reserves for increasing the performance rates of waste flow management. A method of estimating the costs of construction waste has been developed by this research. Pre-construction activities would provide policy makers with a realistic estimate of construction waste costs to better understand the cost consequences of waste production and strengthen their decision-making in developing an effective waste-reducing strategy. For example, awareness about the magnitude of the involvement as well as the cost implications of misplacement can assist in making decisions on ICT-based monitoring systems like RFID, which can minimize misplacements and material abandonments at large building sites. Furthermore, following the results of the analysis, waste can be minimized by design, for example, by taking into account standard material measurements, the work needed by careful handling of building materials, sufficient storage to avoid damage, etc. In fact, the results of this study indicate that waste contributes significantly to construction costs. A minimum of 30 percent of the cost of waste is planned. In the face of financial problems of reduction approaches, focus should also raise contribution levels and the related ranking of the waste sources. The 1st, 2nd and 3rd building waste contributors are waste material (cuts to design dimensions), change in design and handling of the material, respectively. For the future, key project stakeholders will use the method developed during this study to assess the probable volume and cost of waste.

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