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Perspectives of construction workers on the management of Concrete Waste on Construction Sites: A Case study of Ho Municipality, Ho, Ghana

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Abstract. Many countries worldwide are experiencing rapid population expansion and urbanization, which increase building activity and, therefore, waste generation. To reduce and manage waste, a thorough understanding of the factors that contribute to its formation is required. This study examines concrete waste management on construction sites in the Ho Municipality of Ghana. The purpose is to examine the reasons behind on-site concrete waste and the techniques for managing it. The study's findings demonstrated that the main factors contributing to on-site concrete waste were rework because of broken equipment, workmanship error, negligence, and supervisor neglect of inspection. The recycling of concrete waste generated on-site, disposal of concrete waste generated at permitted landfills, and reuse of concrete waste generated on-site are the most efficient means of handling and disposal of concrete waste on-site. The study discovered that training workers on ways to handle concrete to avoid wastage, using proper mix during production to avoid waste, and proper and effective supervision when producing and placing concrete were efficient ways of minimizing concrete waste at construction sites. The study recommended that an adequate construction waste management plan is required to aid professionals in minimizing waste and to involve all other stakeholders in such a plan.

Key words: Construction; Concrete Waste; Construction Sites; Waste Management; Construction Waste Factors; Kendall's Coefficient of Concordance; Relative Important Index.

1. Introduction

Ready-mixed concrete (premixed concrete) or site-mixed concrete are the two most common forms of concrete that are used on construction sites for both substructures and superstructures. Concrete is one of the primary materials that are used extensively in construction activities, making it a significant and valuable commodity on construction sites (Bazli et al., 2020; Formoso et al., 2002). However, even though it is a valuable building material, waste does occur because of poor handling methods, leading to cost implications for the company. In an assessment of material waste in Hong Kong building activities, Kamal (2022) and Shen et al. (2002) stated that needless waste handling procedures and project delays are the causes of concrete waste. The primary cause of concrete waste is an imbalance between the quantity of concrete required in the event of a ready-mixed concrete supply and the quantity of concrete ordered. In the case of on-site mixing, many factors lead to the wastage of concrete, including the inability of workers to read and understand specifications, lack of inspection by supervisors, human error and carelessness, and improper methods of placing concrete. Rapid urbanization and population growth worldwide have spurred a surge in construction activity, inevitably leading to higher volumes of construction waste. Ghana is no exception; its urban population has expanded considerably in recent years, fueling a boom in building projects across both major cities and secondary towns, while waste management practices have lagged behind this rapid development. Ho Municipality, the capital of Ghana's Volta Region exemplifies these dynamics at the local level, as a rapidly growing city where accelerated construction activity is accompanied by rising concrete waste generation. By focusing on Ho as a case study, this study bridges the global urbanization narrative to Ghana's context, demonstrating how worldwide construction waste trends manifest in a fast-growing Ghanaian municipality and why this local perspective is vital for informing sustainable waste management strategies.

2. Materials and methods

Aggregate, cement, and water are combined to create concrete. Concrete compaction is greatly influenced by the aggregates' overall behaviour (Debnath et al., 2023; Manju et al., 2018; Barry, 1996). Various varieties of cements, each with a different composition and intended usage, are employed as binding materials in building. (Dunuweera and Rajapakse, 2018) Some of the most popular types of Portland cement are Ordinary Portland cement, rapid-hardening Portland cement, sulfate-resisting Portland cement, White Portland cement, low heat Portland cement, Portland blast furnace cement, water repellent cement, air-entraining cement, and hydrophobic cement. Aggregates, which are Natural aggregates, artificial aggregates, and fine and coarse aggregates, depend on particle size and form approximately 70–80% of the total volume of concrete, making it a very important constituent in concrete (Buertey et al., 2018). Water, which forms an essential part of concrete production, is mixed with the cement in concrete to produce cement paste that adheres to the aggregates. Water should be clean and in small quantities to prevent the weakening of the concrete (Babu et al., 2018; Olugbenga, 2014). Additionally, it is mentioned that too many contaminants in the water can lead to efflorescence, corrosion of the reinforcement, staining, and an impact on the strength and setting time of concrete (Awoyera et al., 2020; Saputra and Sulistyo, 2018; Pokorný et al., 2017; Zhang et al., 2019).

2.1. Construction Waste

Unlike municipal waste, construction waste is generally produced during the building, destruction, and renovation of roads, buildings, and other constructed facilities (Nagapan et al., 2012). Waste generated during the building, remodelling, or demolition of structures is referred to as construction and demolition (C & D) debris. Concrete, asphalt, wood, metals, gypsum wallboard, and roofing are among the materials that make up the C & D trash (Ogunmakinde et al., 2019). In England, the only trash produced on building sites is that which comes from demolition and construction (Oko & Itodo,2013). Building demolition, as well as road, rail and building maintenance, including digging, are the main sources of construction debris in Australia (Osmani et al., 2019; Osmani et al., 2006). Everything that results from construction activities that is left on construction sites in Hong Kong is considered waste from construction, regardless of whether it is used or stored (Lee et al., 2021; Othman et al., 2005). Construction waste in Hong Kong is separated into two categories: (1) non-inert construction waste, which makes up 20% of all construction waste and is composed of bamboo, wood, plants, packaging, and other organic materials; and (2) inert construction waste, which is mostly composed of construction materials, stone fragments, soil, asphalt, and concrete that can be used to adjust the construction area. While some parts were disposed of and dumped in landfills, others may be recycled. The term "waste from construction materials" in this paper refers to a variety of materials used in construction that are destroyed throughout the process and cannot be reused.

2.2. Empirical Review of Related Studies

According to the literature study, there were a lot of previous research that looked at how construction waste is generated. Faniran and Caban (1998) examined the effectiveness of a waste-reduction approach using a survey of construction firms. While many organisations were found to lack a defined waste-reduction strategy, others were found to have taken steps to decrease waste at the source, such as avoiding construction debris. The five main causes of construction waste have been identified as follows: modifications to the building's design, unspent materials, packaging waste, errors in the design or details, and unfavourable weather (Mbadugha et al., 2021; Tafesse, 2021; Alwadhenani, 2021).

The main variables of construction waste generation, according to research by Fitri et al. (2019), Ali et al. (2021), and Alwi et al. (2002), are six: repair work, waiting times for materials, schedule delays, the presence of unskilled workers, waste of raw materials on-site, and a lack of supervision. A significant source of waste at construction sites in Singapore was discovered in the areas of design, operation and material handling (Ekanayake & Ofori, 2004) A review of the trash produced during the design and construction phases has been carried out in the United Kingdom. Architects and contractors gave last-minute alterations the highest ratings, according to research by Osmani, Glass, and Price (2006) (Amaral et al., 2020). Hong Kong's mechanical and electrical engineering projects are beset by waste at every stage because of poor design and insufficient coordination (Li et al., 2023; Wan et al., 2009). Contractors' perceptions of waste sources in the United Arab Emirates included a lack of understanding, off-cuts from bad design, rework, and variances (Belpoliti et al., 2018; Batoul and Amna, 2019; Al-Hajj and Hamani, 2011).

Construction waste can be attributed to five main factors, as per a study by Nagapan et al. (2012) conducted in Malaysia: inadequate supervision and management of the site, inexperience, inadequate planning and scheduling, design errors, and mistakes made during the construction process itself. Muhwezi, Chamuriho, and Lema (2012) list a number of wasteful practices in Ugandan construction, including the absence of qualified workers or subcontractors, non-compliant products, inappropriate material storage, and altering orders or instructions. According to research done in Kenya by Mbote, Kimtai, and Makworo (2016), the most significant sources of construction waste were complicated or bad designs, inadequate security, poor working conditions, and geography. High material waste was found to be a result of inefficient task control and rework as well as a lack of proper handling of materials (John and Itodo (2013). Adewuyi and Otali (2013) and Chidiobi et al. (2021) both claim that building waste is a significant issue in Nigeria. The three main sources of construction-related material waste are waste from distinctive shapes and forms, rework, and design amendments (Tongo et al., 2021). There are five main waste factors in Vietnamese high-rise building projects: time spent checking and monitoring employees, waiting for others to finish their jobs, accidents, time used by workers to carry equipment and supplies, and the rest of the time during construction (Nguyen et al. 2019; Van Tuan, 2018; Kilintan et al., 2022; Lockrey et al., 2018; Khanh & Kim, 2014).

3. Methodology

This study set out to investigate the handling of concrete waste on construction sites in Ghana's Ho Municipality. It used a quantitative approach which allows researchers to generalise their findings from a sample of the population by using structured questionnaire surveys.

3.1. Study Population and Sample Size

A planar, three-bay, six-story RC frame is considered in this study. The frame is assumed to be located in a building that is symmetrical in both directions. The plan view of the building and an overview of the considered frame are presented in Figures 1 and 2. The building is assumed to be fixed at its base.

The target group in Ho Municipality consisted of registered building construction companies. A total of 202 patients were the target group. The Association of Building and Civil Engineering Contractors, Volta Regional Branch, provided this information.

To gather the necessary data, a structured questionnaire contextualised for this issue and built on material from the literature was created.

4. Data analysis

With the use of Kendall's Coefficient of Concordance (W), the collected data were examined. A measure of agreement between several judges (respondents) who evaluate a specific set of objectives (quality perceptions) is called Kendall's Coefficient of Concordance (Legendre, 2005). W is an index that calculates the ratio between the observed variance of the rank sum and the highest rank variation that is feasible. This index's concept is to calculate the total of the ranks for each ranked quality impression.

The relationship follows Legendre (2005) and Kendall's coefficient of concordance (W):

$$w = \frac{12S}{p^2(n^3 - n)} - p^T \quad (1)$$

where

w is the Kendall's concordance coefficient. P is the number of respondents who ranked the modalities' quality attributes, n is the number of quality perceptions, T is the tie-rank correction factor. Over the row sum of ranks (Ri), S= sum of squares statistics, as provided by:

$$s = \sum_{i=1}^{n} (R_i - R)^2 \quad (2)$$

R represents Ri's mean. Given below is the tied rankings (T) correction factor:

The total ranks in all m tie groups is denoted by t^3.

In addition, since this strategy can reorder the components under study, the Relative Importance Index (RII) was utilised to create an index (Holt, 2014). Using RII, Othman et al. (2005) assessed the relative significance of various factors influencing changes in building projects. The RII was utilised by Gündüz et al. (2013) to rank delay factors in construction projects. This study employed the same methodology. The respondents' scores for each factor were entered into the Statistical Package for Social Science (SPSS). After that, statistical analysis was performed on the response surveys.

4.1. Results Discussions

The findings and discussion are shown in this section. The results of the study's particular objectives are presented after the respondents' demographic information.

4.1.1. Demographic Characteristics of the Respondents

The findings in Table 1 demonstrate the respondents' demographic characteristics. The results showed that 95.7% of the respondents were male and 4.3% were female. This suggests that males dominate the building and civil engineering sectors. The findings also show that 17.1% of the respondents were under the age of 25 years, 35.2% were between the ages of 26 and 35 years, 39.5% were between the ages of 36 and 35 years, 6.7% were between the ages of 46 and 55 years, and 1.4% were 56 years or older.

The study demonstrated that 54.3% of the respondents were single and 45.7% of the respondents were married. Regarding the level of education, 9% of the respondents had diplomas, 5.7% were bachelor's degree holders, 16.2% were master's degree holders, 18.1% were senior high school graduates, 37.1% had certificates, and 13.8% were junior high school leavers.

The study also found that 20.5% of the respondents were labourers, 25.7% were masons, 14.8% were Foremen, 23.3% were site supervisors, and 15.7% were in other trade specialisations. Regarding the duration of employment in the construction sector, 5.7% of participants had worked for less than a year, 40% for one to five years, 33.3% for six to ten years, 11.4% for eleven to fifteen years, 3.8% for sixteen to twenty years, and 5.7% for twenty-one years or longer.

Respondents were asked whether their company operated any concrete waste management plan at the site. It was found that 34.3% of the respondents claimed that their company operates in any concrete waste management plan on-site, and 65.7% of the respondents claimed that their company did not operate in any concrete waste management plan on-site. The study also demonstrated that 76.2% of the respondents claimed that concrete waste is avoidable, and 23.8% of the respondents claimed that concrete waste is unavoidable. We also asked the respondents if they were aware of any laws pertaining to the disposal of concrete trash.

Table 1: Demographic Characteristics of the Respondents

Demographic	Category	Frequency	Percentage
Gender	Male	201	95.7
	Female	9	4.3
Age	Under 25 yrs	36	17.1
	26–35 yrs	74	35.2
	36–45 yrs	83	39.5
	46–55 yrs	14	6.7
	56 yrs and above	3	1.4
Marital Status	Single	114	54.3
	Married	96	45.7
Highest level of formal education	Diploma	19	9.0
	Bachelor's degree	12	5.7
	Master's degree	34	16.2
	SHS	38	18.1
	Certificate	78	37.1
	JHS	29	13.8
Trade Specialization/s	Laborer	43	20.5
	Mason	54	25.7
	Foreman	31	14.8
	Site Supervisor	49	23.3
	Others, please specify	33	15.7
Number of years working in the construction industry in Ghana	Less than 1 year	12	5.7
	1 -5 years	84	40.0
	6-10 years	70	33.3
	11-15 years	24	11.4
	16-20 years	8	3.8
	21 years and above	12	5.7
Does your company operate in any concrete waste management plan on the site?	Yes	72	34.3
	No	138	65.7
Is concrete waste avoidable?	Yes	160	76.2
	No	50	23.8
Do you know of any legislation on the management of concrete waste?	Yes	86	41.0
	No	124	59.0
Is concrete waste management a good practice?	Yes	178	84.8
	No	32	15.2

Based on the survey results, 41% of participants stated they were aware of laws pertaining to the management of concrete trash, while 59% stated they were unaware of any such laws. The findings showed that 84.8% of respondents thought that managing concrete waste was a good practice and 15.2% thought that it wasn't.

4.1.2 Causes of Concrete Waste on Site

The findings about the reasons behind on-site concrete waste are presented in this section of the chapter. The ranking of the causes of on-site concrete waste was tested for agreement using Kendall's Coefficient of Concordance (W). To ascertain whether Kendall's Coefficient of Concordance was statistically significant, the F-test was employed. Table 2 shows that respondents had 62.3 percent agreement on the ranking of volunteer duties, with a Kendall coefficient (W) of 0.623. The resultant figure was 354.875. Kendall's Concordance Coefficient indicated that W was at a significance level of 1 percent, based on the asymptotic significance of 0.000 (Siegel et al., 1988). We employed the Chi-square distribution to ascertain the significance of the Coefficient of Concordance (W). As a result, alternative is accepted rather than the null hypothesis, Ho.

The reasons of on-site concrete waste are ranked in Table 2. The respondents ranked works due to the use of damaged equipment; human error and carelessness; lack of inspection by supervisors; poor site management practice by management and workers; lack of concrete management plan; inability of workers to read and understand specification; employing unskilled labour force by management; and unfavourable weather conditions impact the concrete mix's quality as the first, second, third, fourth, fifth, sixth, seventh, eighth, and ninth, in that order. Among all the ninth causes of concrete waste on site that were ranked among the respondents, reworks due to the use of damaged equipment, human error and carelessness, and lack of inspection by supervisors are ranked as the three most severe causes of concrete waste on-site. This implies that work due to the use of damaged equipment is a contributing factor that causes concrete waste on-site.

Table 2: Views on Causes of Concrete Waste on Site

	Mean	Std. Deviation	Ranking
Inability of workers to read and understand specification	3.82	1.242	6th
Lack of inspection by supervisors	3.88	1.370	3rd
Mistakes and changes in specification	3.81	1.143	7th
Human error and carelessness	3.93	1.092	2nd
Slow decision making by workers and management	3.67	1.262	12th
The pre-notion that allowance is made for wastage	3.63	1.338	4th
Improper method of placing concrete	3.70	1.259	9th
Poor exhibition of concrete producing skills by workers	3.63	1.331	13th
Using excessive quantities of materials during mixing than the required	3.68	1.328	11th
Inclement weather condition affecting the quality of concrete mix	3.70	1.166	9th
Employing unskilled labour force by management	3.73	1.273	8th
Lack of concrete management plan	3.87	1.255	5th
Provision of insufficient information amongst project participants	3.65	1.215	12th
Reworks due to the use of damaged equipment	3.95	1.203	1st
Poor site management practice by management and workers	3.88	1.118	3rd

Test Statistics	
N	208
Kendall's W[a]	.623
Chi-Square	354.875
df	14
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

4.1.3 Handling and Disposal of Concrete Waste on Site

Based on the data analysis and analysed factors, Table 3 displays the respondents' opinions regarding the on-site processing and disposal of concrete waste. They make use of the relative significance index (RII).

The respondents ranked the "Recycling of concrete waste generated on site" factor as the most efficient means of handling and disposing of concrete waste on-site, with RII equal to 0.74. Out of all the parameters investigated, the disposal of concrete waste generated at designated landfills had the second-highest influence, indicating an effective method for processing and disposing of concrete trash on-site. Among all the parameters examined, the impact of reusing the concrete waste created on site placed third, demonstrating the effectiveness of on-site treatment and disposal of concrete waste.

Table 3: Views on Handling and Disposal of Concrete Waste on Site ($N = 210$)

Ways of Handling and Disposal of Concrete Waste	1	2	3	4	5	MN	RII	RNK
Recycling of concrete waste generated on site	16	30	12	93	59	3.71	0.74	1
Disposal of concrete waste generated at permitted land fills	20	28	32	81	49	3.53	0.71	2
Reuse of concrete waste generated on site	35	19	14	103	39	3.44	0.69	3

4.1.4 Ways of Minimizing Concrete Waste on Construction Site

Table 4 presents the opinions of the respondents regarding strategies for reducing concrete waste on building sites based on factors that are assessed and for data analysis. Utilised is the relative importance index (RII).

The respondents ranked the "Training workers on ways to handle concrete to avoid wastage" factor as the most efficient way of minimising concrete waste at construction sites, with RII equal to 0.902. One of the most effective approaches to reduce concrete waste at building sites is to use the suitable and right mix during production. This strategy scored second in terms of effect among all the aspects we looked at. Proper and effective supervision when producing and placing concrete ranked third in its effect among all explored factors, which shows the efficient ways of minimising concrete waste at construction sites.

Giving project participants adequate information was found to have the fourth-highest impact out of all the parameters examined, demonstrating effective strategies for reducing concrete waste on building sites.

Among all the parameters investigated, the appropriate technique for placing concrete placed sixth in terms of effect, demonstrating effective means of reducing concrete waste on building sites. Among all the parameters examined, the benefit of accurately measuring ingredients during manufacture or mixing ranked sixth, demonstrating effective methods for reducing concrete waste at construction sites.

The diagram integrates findings from Table 3 (waste handling/disposal methods) and Table 4 (waste minimization strategies) under the 3R concept, with priority given to waste reduction measures (e.g., worker training, accurate mix proportioning, thorough supervision). On-site reuse and recycling of concrete waste are the next preferred options, and disposal at a landfill is treated as a last resort once all 3R opportunities are exhausted.

As shown in Figure 1, the proposed flowchart emphasizes a hierarchical approach to managing concrete waste on site. This reflects the survey results, wherein the highest-ranked strategies in Table 4 focus on reducing waste generation at the source. For example, training workers to handle concrete properly and using the correct mix design were the top measures (RII = 0.902 and 0.886, respectively). Subsequent steps in the hierarchy involve finding value for any waste produced: reusing concrete debris on-site for other purposes and recycling waste into new construction material. Indeed, respondents rated on-site recycling as the most effective waste handling method, followed by proper landfill disposal and on-site reuse. The flowchart highlights that landfill disposal should only occur after all feasible reduction, reuse, and recycling options have been attempted, reinforcing the 3R principle.

Table 4: Views on Ways of Minimizing Concrete Waste on Construction Site

Ways of Minimizing Concrete Waste	**1**	**2**	**3**	**4**	**5**	**MN**	**RII**	***RNK***
Training workers on ways to handle concrete to avoid wastage.	1	0	6	87	116	4.15	**0.902**	1
Using proper and right mix during production to avoid waste.	0	6	3	96	105		**0.886**	2
Proper and effective supervision when producing and placing concrete.	2	4	10	86	108	4.41	**0.880**	3
Provision of e2ugh information to project participants.	2	2	7	101	98		**0.877**	4
Proper method of placing concrete	3	7	7	89	103	4.35	**0.866**	5
Using accurate quantities of materials during mixing or production.	3	5	8	101	93	4.14	**0.863**	6
Studying weather conditions before placing of concrete mix to avoid waste.	1	9	10	95	95		**0.861**	7
Proper planning for pouring of concrete	0	2	15	107	83	4.54	**0.850**	8
Proper and effective site management practice.	0	8	8	98	92	4.11	**0.850**	8
Concrete production should be close to place of placing.	1	8	20	87	92	4.38	**0.843**	10
Employing skilled labour force for the production and placement of concrete by management.	4	10	25	85	86	4.41	**0.828**	11
The production speed should match with the pouring to avoid waiting time.	4	11	17	95	82	4.32	**0.826**	12
The use of powered equipment rather than manual means for manufacturing and placing.	7	11	17	90	85	4.43	**0.824**	13
Ensure accurate and 2n-ambiguous specification.	1	9	27	103	70	4.48	**0.821**	14
Recycling of concrete waste generated on site	16	30	12	93	59	4.35	**0.742**	15
The use of excess concrete elsewhere to avoid hardening.	24	21	22	69	71	4.25	**0.727**	16
Disposal of concrete waste generated at permitted land fills	20	28	32	81	49	3.70	**0.706**	17
Reuse of concrete waste generated on site	35	19	14	103	39	4.19	**0.688**	18

The practical implication for Ghanaian construction is that project teams must strengthen upfront waste reduction practices. Implementing formal waste management plans (as recommended by this study), investing in worker training, and ensuring diligent site supervision can significantly curtail avoidable concrete waste at its source. The flowchart underlines the need for careful planning of concrete works (e.g., accurate quantity estimation and timely placement) to prevent excess material. Moreover, establishing means to reuse leftover concrete (for non-structural work or backfilling) and to recycle waste (e.g., crushing into aggregate) can divert substantial waste from landfills. Such initiatives require commitment and capacity-building among stakeholders, given the current absence of formal waste plans and limited reuse/recycling facilities on many sites.

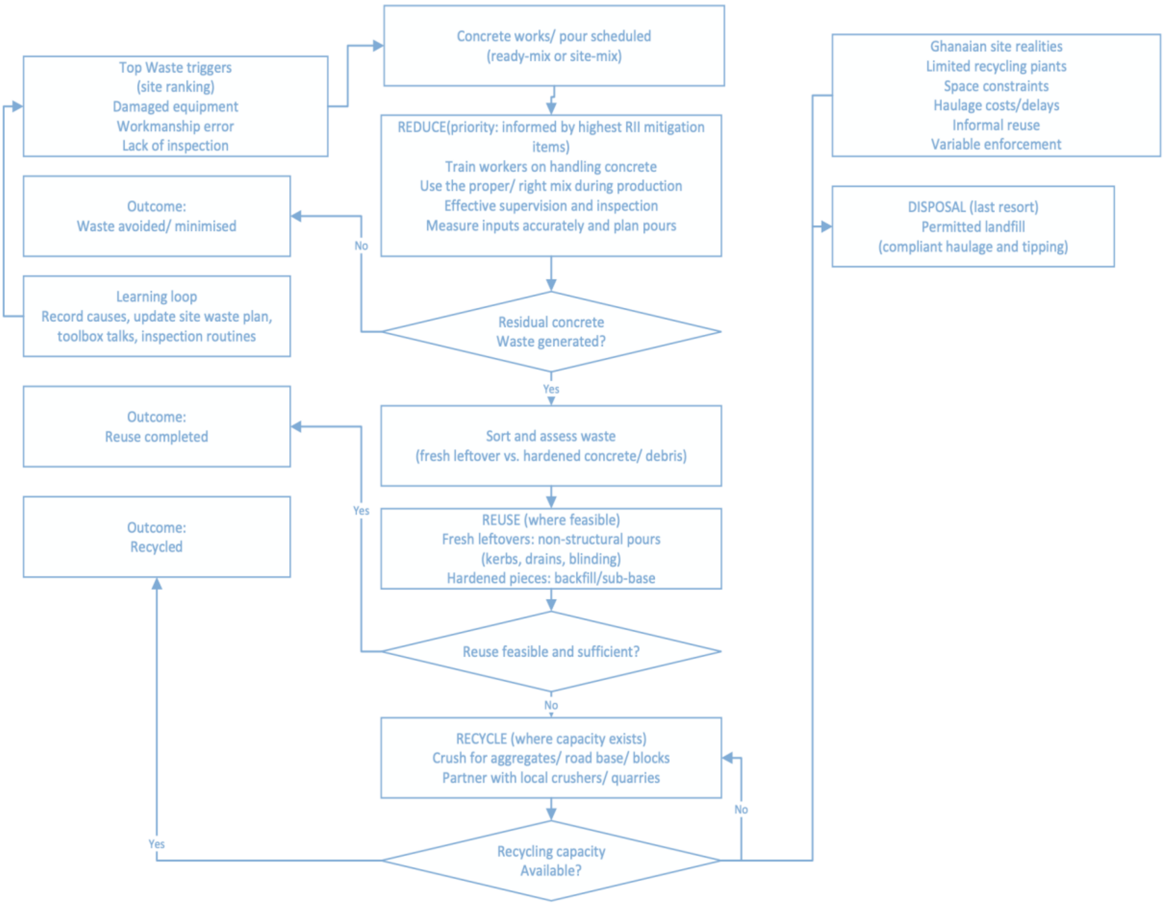

Figure 1: Specialized 3R hierarchy for managing concrete waste on construction sites in Ho Municipality, Ghana

4.2 Discussion

The results of the study showed that the causes of concrete waste on-site included the issue of reworks due to the use of damaged equipment, human error and carelessness, lack of inspection by supervisors, poor site management practice by management and workers, lack of concrete management plan, inability of workers to read and understand specifications, employing an unskilled labour force by management, and inclement weather conditions affecting the quality of the concrete mix. Luangcharoenrat et al. (2019) concluded that design and documentation, human resources, building techniques and planning, and material and procurement are the areas that contribute most to construction waste in light of these findings. Each category's components were identified and assigned a grade. Design modifications, careless work habits, ineffective scheduling and planning, and material storage were some of the factors that most affected how much waste was produced in each category of construction. Alwi, Mohamed, and Hampson (2002) conducted a study in Indonesia and found that the main factors contributing to the generation of construction waste were repair work, waiting times for materials, schedule delays, non-skilled workers, waste of raw materials on-site, and a lack of supervision. Six variables were shown to be the most significant in determining the rates of waste generation in construction enterprises by this study. Research was carried out in Malaysia by Nagapan et al. (2012), They came to the conclusion that the five main causes of construction waste were inexperience, poor planning and scheduling, insufficient site management and monitoring, mistakes made during the construction process, and design faults. Muhwezi, Chamuriho, and Lema (2012) state that modifications made to a building's design during construction are among the elements that cause waste in Uganda's construction industry. Also, a lack of skilled workers or subcontractors, products that do not comply with regulations, inappropriate material storages, and shifting orders and instructions.

The respondents ranked the “Recycling of concrete waste generated on site” factor as the most efficient means of handling and disposing of concrete waste on-site, with RII equal to 0.74. The effective treatment and disposal of concrete waste on-site is demonstrated by the fact that the disposal of concrete waste generated at permitted landfills scored second in its effect among all the criteria examined. Among all the parameters examined, the impact of reusing the concrete waste created on site placed third, demonstrating the effectiveness of on-site treatment and disposal of concrete waste. As part of the 3R principle, countries worldwide have adopted waste minimisation, resource conservation, and resource repurposing strategies (Allwood et al., 2011). Construction workers embraced the 3R principle for a variety of reasons, including its favourable effects on the economy and environment (Coventry et al., 1999). Some of the environmental benefits include prolonging the life of landfills, lowering the use of raw materials, lessening the environmental impact of extracting and producing raw materials, extending the useful life of natural resources, and lowering the quantity of pollution that is detrimental to human health and welfare. According to Ogunmakinde et al. (2019), the financial advantages of building are cost reduction, enhanced company prospects, a decreased risk of waste-related legal actions, and a demonstration of a readiness to mitigate the adverse environmental effects of the construction process.

The study also discovered that training workers on ways to handle concrete to avoid waste, using proper and right mix during production to avoid waste, proper and effective supervision when producing and placing concrete, provision of sufficient information to project participants, proper method of placing concrete, and using accurate quantities of materials during mixing or production were efficient ways of minimising concrete waste at construction sites. Regarding waste minimisation, as defined by Greenwood et al. (2003) and Oladiran, Shant, and Daphene (2014), the term refers to cutting down or recycling existing materials to reduce waste and its environmental impact. It was also pointed out that the primary objective in decreasing waste is to avoid waste by reducing waste at the source. A well-planned design stage will lead to the perfection of design criteria such that little or no change may be necessary during construction, identifying characteristics that have little or no functional impact, and efforts to eliminate them. The authors of the study Shant and Daphene (2014) also suggested that waste created during construction might be reduced or eliminated by including alternative building methods and materials into the design process. Because they may be dismantled and reused in other projects, modular metal-form systems have been recommended as an alternative to wood for concrete construction. Identification of waste types, sources, and mitigation measures for each type of waste is an effective waste minimisation strategy, as noted by Ghanim (2014) and Gray (2013). This action also forms the basis for developing a waste management strategy that is highly recommended for every construction project (Seydel et al., 1998; cited in Shant & Daphene, 2014). As a general rule, the project's waste and rubbish will be depicted in the plan as well as the steps needed to deal with it.

5. Conclusion

The goal of this study was to examine the Management of Concrete Waste on Construction Sites in the Ho Municipality of Ghana. Therefore, this study aims to analyse the causes of concrete waste on-site and methods of handling and disposing of concrete waste. Sustainable development, which focuses on reducing human dependence on Earth's resources while also embracing alternative forms of development to preserve resources for future generations, is receiving a lot of attention these days because of the worldwide push to reduce ecological footprints. The necessity for cost-effective and environmentally friendly buildings has also grown in importance since the economy has entered a deep recession, and product costs have risen as a result. Furthermore, with landfills running low in space and little prospect of a suitable successor, it is imperative that construction-related trash be minimised. Inadequate planning, poor material management and storage, theft, etc. have all been recognised as sources of construction waste. According to research, there are three main ways to reduce waste: reducing, reusing, and recycling. When the three Rs have proven ineffective in dealing with waste that has been created, only disposal should be considered. As part of effective waste management, it is important to identify, analyse, and quantify waste before prescribing mitigation actions. However, given the current state of environmental consciousness and commitment to sustainable practices in the country, this study concludes that there is a lack of appreciation for the consequences of waste, and that unless significant action is made, initiatives to embrace green practices may not make much progress. There has been little or no success in implementing and enforcing environmental regulations through anecdotal evidence, suggesting that there is a lack of cooperation between governments and stakeholders in the management of trash in all forms. Therefore, the aggregate effort required to have a significant influence may not advance. Therefore, the study recommends an adequate construction waste management plan to aid construction professionals in minimising waste and involve all other stakeholders in such a plan.

Practical Implications

The global economy heavily relies on the construction industry. The amount of garbage generated by the construction sector rises at a rate similar to of that the business itself. Construction material waste is generated at an alarming rate in Ghana because of the lack of emphasis on waste minimisation and management. Ghana's construction industry faces several challenges, many of which are intertwined with the issues of illegal landfill disposal and project cost variance. Overall, this study outlined the most critical strategies that may be used on construction sites to manage waste materials. As the research was conducted in the Volta region of Ghana, more research may be required to ensure that the findings can be applied to other locations and building industries. This study should be interpreted as a Ho Municipality case study based on responses from registered construction firms and their site personnel. The analyzed sample is adequate for the study’s primary purpose, which is to establish a defensible hierarchy of perceived causes, handling options and minimization strategies using RII and Kendall’s Coefficient of Concordance, rather than to estimate municipality-wide prevalence values. Nevertheless, the findings should be generalized cautiously, given the potential for sampling and non-response bias and the fact that some firms/sites may not be represented. Future work could strengthen external validity by extending data collection across additional firms, sub-municipal zones and regions beyond the Volta/Ho setting and by combining survey results with site audits or waste-quantification measures.

6. References

Abdol Chini S. and William J. Mbwambo (1996), Environmentally Friendly Solutions for the Disposal of Concrete Wash Water from Ready Mixed Concrete Operations. CIB W89 Beijing International Conference, 21-24 October, 1996.

Adewuyi, T. O., & Otali, M. (2013). Evaluation of causes of construction material waste: Case of River State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 6(6), 746-753.

Al-Hajj, A., & Hamani, K. (2011). Material waste in the UAE construction industry: Main causes and minimisation practices. Architectural engineering and design management, 7(4), 221-235.

Ali, S., Memon, A. H., & Ali, T. H. (2021). Classification of construction waste generation attributes in project life cycle. Pakistan Journal of Engineering & Technology, 4(2), 56–61. https://doi.org/10.51846/vol4iss2pp56-61

Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2011). Material efficiency: White paper. Resources, conservation and recycling, 55(3), 362-381.

Alwadhenani, A. (2021). Potential Benefits from Practices in Construction Waste Material Controls. https://doi.org/10.33915/etd.7809

Alwi, S., Mohamed, S., Hampson, K. (2002). Waste in Indonesian Construction Projects. Proceedings of the 1st CIB-W107 International Conference-Creating a Sustainable Construction Industry in Developing Countries (pp. 305-315). CSIR.

Amaral, R. E., Brito, J., Buckman, M., Drake, E., Ilatova, E., & Rice, P. E., Sabbagh, C., Voronkin, S., & Abraham, Y. S. (2020). Waste Management and Operational Energy for Sustainable Buildings: A review. Sustainability, 12(13), 5337. https://doi.org/10.3390/su12135337

ATA Olugbenga (2014), Effects of Different Sources of Water on Concrete Strength: A Case Study of Ile-Ife, Vol. 6, No. 3. Civil and Environmental Research Journal

Awoyera, P. O., Adesina, A., Olalusi, O. B., & Viloria, A. (2020). Reinforced concrete deterioration caused by contaminated construction water: An overview. Engineering Failure Analysis, 116, 104715. https://doi.org/10.1016/j.engfailanal.2020.104715

Babu, G. R., Reddy, B. M., Ramana, N. V. (2018). Quality of mixing water in cement concrete "a review." Materials Today: Proceedings, 5(1), 1313–1320. https://doi.org/10.1016/j.matpr.2017.11.216

Batoul, H., & Amna, I. (2019). Construction waste management in uae: an exploratory study. WIT Transactions on Ecology and the Environment, 238, 679–686. https://doi.org/10.2495/SC190581

Bazli, M., Bazli, L., Rahmani, R., Mansoor, S., Ahmadi, M. M., & Pouriamanesh, R. (2020). Concrete filled FRP–PVC tubular columns used in the construction sector: A review. Journal of Composites and Compounds, 2(4), 155–162. https://doi.org/10.29252/jcc.2.3.7

Belpoliti, V., Abbas, H. S., Ali, M. A., & Khulaifi, A. M. A. (2018). Design from waste: Review of the UAE waste management sector and experimentation on recycled materials to support the development of a sustainable and energy-efficient building market. 2018 Advances in Science and Engineering Technology International Conferences (ASET), Dubai, Sharjah, Abu Dhabi, United Arab Emirates, 1-6,. https://doi.org/10.1109/icaset.2018.8376765

Chidiobi, C. C., Booth, C. A., & Lamond, J. (2021). A review of the causes of construction waste generation in Nigeria and recommendations. Proceedings of the Institution of Civil Engineers, 1–10. https://doi.org/10.1680/jwarm.20.00020

Chooi Mei Mah, Takeshi Fujiwara and Chin Siong Ho (2017), Concrete Waste Management Decision Analysis Based On Life Cycle Assessment. Chemical Engineering Transactions Vol. 56, 2017. https://doi.org/10.3303/CET1756005

Coventry, S., Patel, V., & Woolveridge, C. (1999). Waste minimisation and recycling in construction-Boardroom handbook. Ciria.

Debnath, B., Sarkar, P. P., & Deb, P. (2023). Effects of compaction on the properties of pervious concrete made with local aggregates. Proceedings of the Institution of Civil Engineers,1–12. https://doi.org/10.1680/jcoma.23.00024

Dunuweera S. P. and Rajapakse R. M. S. (2018), Cement Types, Composition, Uses and Advantages of Nanocement, Environmental Impact on Cement Production, and Possible Solutions, Advances in Materials Science and Engineering, Vol. 2018, Article ID 4158682, 11 pages, 2018. https://doi.org/10.1155/2018/4158682

Ekanayake, L. L., & Ofori, G. (2004). Building waste assessment score: design-based tool. Building and environment, 39(7), 851-861.

Faniran, O. O., & Caban, G. (1998). Minimizing waste on construction project sites. Engineering, construction and architectural management.

Fitri, L. N., Hatmoko, J. U. D., & Hermawan, F. (2019). Managing construction waste in developed countries: lessons learned for Indonesia. IOP Conference Series, 366(1), 012016. https://doi.org/10.1088/1755-1315/366/1/012016

Formoso, C.T., Lucio Soibelman, M., De Cesare, C. and Isatto, E.L. (2002). Materials Waste in Building Industry: Main causes and prevention. Journal of Construction Engineering and Management, Vol 128(4), pp. 316-325

Gündüz, M., Nielsen, Y., & Özdemir, M. (2013). Quantification of delay factors using the relative importance index method for construction projects in Turkey. Journal of management in engineering, 29(2), 133-139.

Holt, G. D. (2014). Asking questions, analysing answers: relative importance revisited. Construction Innovation.

Joseph Ignatius Teye Buertey, Samuel Wilberforce Offei, Theophilus Adjei Kumi, Felix Atsrim (2018), Effect of aggregates mineralogy on the strength of concrete: Case study of three selected quarry products in Ghana, Vol. 9(1), pp 1-10. https://doi.org/10.5897/JCECT2017.0472

Kamal, M. M. (2022). Effect of construction wastes as coarse aggregates in cement concrete: a review. Cement Based Composites, 3(3), 1–8. https://doi.org/10.36937/cebacom.2022.5724

Khanh, H. D., & Kim, S. Y. (2014). Identifying causes for waste factors in high-rise building projects: A survey in Vietnam. KSCE Journal of Civil Engineering, 18(4), 865-874.

Kilintan, K., Perera, B., & Kajavathani, P. (2022). Factors affecting construction time performance in high-rise building projects in Sri Lanka. WCS - 2022 [76] Proceedings of the 10th World Construction Symposium 2022. https://doi.org/10.31705/wcs.2022.40

Lee, W. M. W., Lu, W., & Xue, F. (2021). Understanding construction waste recycling in Hong Kong: SWOT analysis of the Government's prevailing initiatives. In Springer eBooks (pp. 1379–1395). https://doi.org/10.1007/978-981-16-3587-8_94

Li, C. H., Lee, T. T., & Lau, S. (2023). Enhancement of Municipal Solid Waste Managementin Hong Kong through Innovative Solutions: A Review. Sustainability, 15(4), 3310. https://doi.org/10.3390/su15043310

Lockrey, S., Verghese, K., Crossin, E., & Nguyen, H. (2018). Concrete recycling life cycle flows and performance from construction and demolition waste in Hanoi. Journal of Cleaner Production, 179, 593–604. https://doi.org/10.1016/j.jclepro.2017.12.271

Luangcharoenrat, C., Intrachooto, S., Peansupap, V., & Sutthinarakorn, W. (2019). Factors influencing construction waste generation in building construction: Thailand's perspective. Sustainability, 11(13), 3638.

Manju, K., Kumar, B., Kumar, S. S., & Kumar, S. (2018). Behaviour of concrete by using artificial aggregates a review. International Journal of Engineering & Technology, 7(2.21), 255. https://doi.org/10.14419/ijet.v7i2.21.12183

Mbadugha, L. C., Ozumba, A., & Shakantu, W. (2021). The need to improve current waste management practices in the area of construction waste reduction. IOP Conference Series, 654(1), 012008. https://doi.org/10.1088/1755-1315/654/1/012008

Mbote, R. P., Kimtai, A. K., & Makworo, M. (2016). An Investigation on the Influence of Factors Causing MaterialWaste on Construction Cost of Residential Building Frame. A Case of Northern Region of Nairobi. International Journal of Engineering Research & Technology (IJERT), 5(09), 436-447.

Muhwezi, L., Chamuriho, L. M., & Lema, N. M. (2012). An investigation into materials wastes on building construction projects in Kampala-Uganda. Scholarly Journal of Engineering Research, 1(1), 11-18.

Nagapan, S., Rahman, I. A., Asmi, A., Memon, A. H., & Zin, R. M. (2012). Identifying Causes of Construction Waste "Case of Central Region of Peninsula Malaysia. International Journal of Integrated Engineering, 4(2).

Nguyen, Van, Tuan. (2018). Current status of construction and demolition waste management in vietnam: challenges and opportunities. International Journal of Geomate, 16(52) doi: 10.21660/2018.52.7194

Ogunmakinde, O. E., Sher, W., & Maund, K. (2019). An assessment of material waste disposal methods in the Nigerian construction industry. Recycling, 4(1), 13.

Oko John, A., & Emmanuel Itodo, D. (2013). Professionals' views of material wastage on construction sites and cost overruns. Organization, technology & management in construction: an international journal, 5(1), 747-757.

Osmani, M., Glass, J., & Price, A. (2006, May). Architect and contractor attitudes to waste minimisation. In Proceedings of the Institution of Civil Engineers-Waste and Resource Management (Vol. 159, No. 2, pp. 65-72). Thomas Telford Ltd.

Othman, A. A., Hassan, T. M., & Pasquire, C. L. (2005). Analysis of factors that drive brief development in construction. Engineering, Construction and Architectural Management.

Phong, Thanh, Nguyen., Khoa, Dang, Vo., Phuong, Thanh, Phan., Quyen, Le, Hoang, Thuy, To, Nguyen., Vy, Dang, Bich, Huynh. (2019). Optimization of Main Factors Affecting Construction Waste by the Supply Chain Management. International Journal of Supply Chain Management, 8(5):275-278.

Pokorný, P., Tej, P., & Kouřil, M. (2017). Evaluation of the impact of corrosion of hot-dip galvanized reinforcement on bond strength with concrete – A review. Construction and Building Materials, 132, 271–289. https://doi.org/10.1016/j.conbuildmat.2016.11.096

Robin Barry (1996), The Construction of Buildings Volume 4, Fourth Edition. Oxford; Boston: Blackwell Science.

Saputra, A., & Sulistyo, D. (2018). Effect of water content and water type on the physical properties of concrete. Journal of Physical Science, 29(Supp.2), 159–173. https://doi.org/10.21315/jps2018.29.s2.12

Sealey B. J., Paul S. Phillips, G. J. Hill (2001), Waste management issues for the UK ready-mixed concrete industry, Resources, Conservation and Recycling 32 (3-4) 321-331, 2001

Shooshtarian, S., Maqsood, T., Wong, P. S. P., Khalfan, M., & Yang, R. J. (2019). Review of energy recovery from construction and demolition waste in Australia. Journal of Construction Engineering, Management & Innovation, 2(3), 112–130. https://doi.org/10.31462/jcemi.2019.03112130

Tafesse, S. (2021). Material waste minimization techniques in building construction projects. The Ethiopian Journal of Science and Technology, 14(1), 1–19. https://doi.org/10.4314/ejst.v14i1.1

Tom Napier (2016), Construction Waste Management, Construction Waste Management | WBDG - Whole Building Design Guide

Tongo, S., Adeboye, A. B., & Oluwatayo, A. A. (2021). Life Cycle Assessment Of Material Waste Generation From Building Construction Projects In Southwest Nigeria. IOP Conference Series, 665(1), 012061. https://doi.org/10.1088/1755-1315/665/1/012061

Wan, S. K., Kumaraswamy, M. M., & Liu, D. T. (2009). Contributors to construction debris from electrical and mechanical work in Hong Kong infrastructure projects. Journal of Construction Engineering and Management.

Zhang, G., Li, X., & Li, Z. (2019). Experimental study on static mechanical properties and moisture contents of concrete under water environment. Sustainability, 11(10), 2962. https://doi.org/10.3390/su11102962