Management of concrete and cementitious waste: an assessment of practices and strategies in South Africa

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ABSTRACT

The construction industry is among the top three waste producers in South Africa. There is limited literature on the contribution of concrete and cementitious material to waste generated in the Construction and Demolition (C&D) category. The government outlines waste management strategies in the State of Waste Report (SoWR) which aim to minimise waste production levels and landfill issues; however, there is a poor understanding of the link between these strategies and practices in the industry. This study assesses the practices and strategies for the waste management of concrete and cementitious material on construction sites based in Braamfontein, Midrand, Rosebank, Menlyn and Johannesburg Central Business District. The results indicate that there is limited published literature on the management of concrete and cementitious waste produced in construction projects; also, that there is a partial practice of the Reduce, Re-use and Recycle strategies. There is poor adherence to the recent waste hierarchy model stated in the SoWR because practitioners are unfamiliar with the report. The study contributes to sustainable development practice in South Africa and recommends that the private and public sector should actively participate in transferring knowledge to practitioners, thus encourag-ing them to consciously practice sustainable waste management in the SoWR.

Keywords: Concrete, Construction and demolition, project life cycle, waste management hierarchy, landfill.

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The construction industry is among the top three waste producers in South Africa. There is limited literature on the contribution of concrete and cementitious material to waste generated in the Construction and Demolition (C&D) category. The government outlines waste management strategies in the State of Waste Report (SoWR) which aim to minimise waste production levels and landfill issues; however, there is a poor understanding of the link between these strategies and practices in the industry. This study assesses the practices and strategies for the waste management of concrete and cementitious material on construction sites based in Braamfontein, Midrand, Rosebank, Menlyn and Johannesburg Central Business District. The results indicate that there is limited published literature on the management of concrete and cementitious waste produced in construction projects; also, that there is a partial practice of the Reduce, Re-use and Recycle strategies. There is poor adherence to the recent waste hierarchy model stated in the SoWR because practitioners are unfamiliar with the report. The study contributes to sustainable development practice in South Africa and recommends that the private and public sector should actively participate in transferring knowledge to practitioners, thus encouraging them to consciously practice sustainable waste management in the SoWR.

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1. INTRODUCTION

In 2018, the South African Department of Environmental Affairs (DEA) published a State of Waste Report (SoWR) which contained waste management legislations from 1989 to 2018 [1]. These legislations inform the management of waste produced in South Africa including construction and demolition (C&D) waste, organic waste and municipal waste, among others. The SoWR, issued in 2018, [1] indicated that C&D waste contributed the third largest (13%) proportion of the total waste produced in the country. C&D waste can comprise a variety of materials including concrete, ceramics, glass, timber, and metals. However, the report does not provide this breakdown. Therefore, the proportion of concrete and other cementitious material waste in the lump sum C&D figures in the DEA report is potentially unknown.

In South Africa, a large proportion of all the wastes produced end up in landfills. This strategy is common even in the disposal of C&D waste from the construction industry and poses several environmental challenges. To overcome this challenge, the DEA legislation encourages practitioners to have proper Waste Management Plans (WMP) that are environmentally friendly [2].

2. SIGNIFICANCE AND SCOPE OF THE STUDY

The study reported in this paper focused on the management of concrete and cementitious waste which is part of C&D waste considering that concrete is one of the most used materials in the construction industry and the second most used material in the world [3]. Although there are studies that have been conducted on C&D waste in South Africa [2], there is limited published literature on the management of concrete and cementitious waste specifically. One of the envisaged outcomes of the study is to create awareness of the current practices and strategies for waste management of concrete and cementitious waste in South Africa, and thus presenting a case for the need for improved approaches to managing concrete and cementitious waste. The findings of the study also contribute to the promotion of sustainable practices, thereby supporting the National Development goals of South Africa which call for the urgent implementation of the Nationally Appropriate Mitigation Action (NAMA) [4].

This study critically reviewed the current management practices and strategies for concrete and cementitious waste generated by construction projects in South Africa, China, Australia, Germany and Kenya. Due to time and cost constraints, the study was carried out on selected construction projects in South Africa's Gauteng province.

3. LITERATURE REVIEW

Between 2011 and 2017, South Africa reported a relatively small per capita decline of 0.19 in the total waste produced in the country [1]. This period also coincided with the introduction of waste management policies as reported in the SoWR which can lead to the conclusion that the policies contributed to the decline. However, it is difficult to apportion how much of the decline can be apportioned first, to C&D waste, and second, to concrete and cementitious waste. There is a gap for studies focusing on classified waste such as concrete, glass, wood, etc.

When a concrete structure is demolished, the rubble material can be either be disposed of in a landfill or re-used or recycled on site. Disposal in a landfill is the last phase and least preferred option in the life cycle of a concrete structure [5]. Barnes [6] reported that in South Africa most concrete and cementitious materials waste is transported to a landfill but there are no records of exactly how much of the waste is disposed of. Abel [7] reported that there is a problem of illegal dumping of concrete waste in South Africa; this can be attributed to

the country's potential shortage of technology for processing waste material and limited published literature on the waste produced in construction sites.

Strategies should be put in place to encourage the practice of re-using and/or recycling of the materials, and disposal on landfill last when managing concrete and cementitious waste. This is a grave-to-cradle approach that has been shown to have the capacity to decrease the quantities of concrete dumped in landfills [8]. Further studies are required to understand the capacity and limits on the utilisation of recycled concrete and other cementitious materials, and the perception of contractors on the utilisation of recycled concrete and other cementitious materials.

4. METHOD

A qualitative approach was adopted for the study which was conducted in 2019. According to Minchiello [9], this method focuses on understanding human behaviour from the informant's perspective and assumes a dynamic and negotiated reality. The data is collected through participant observation and interviews. In the method, data analysis is carried out through themes informed by the informants' descriptions. This approach allowed for the exploration of an untapped area of study for C&D waste management in South Africa. Sinaga [10] reports that the advantage of the qualitative method is that it enables the researcher to "identify new and untouched phenomena; provide a deeper understanding of mechanisms; provide verbal information that may sometimes be converted to numerical form and reveal information that would not be identified through pre-determined survey questions". However, the disadvantage with qualitative method is that it can restrict the researcher as the results are "general to the population, easily applied in statistical methods, and easily assessed in relations between characteristics" [10].

Construction practitioners formed the target population, with non-probability and purposive sampling methods being used to select the samples. According to Showkat & Parveen [11], non-probability sampling is characterised using; non-randomised methods to select the sample and judgement, convenience and access to the sample. It is less expensive, less complicated, and easier to apply. The results lack generalization of the sample to an entire population and generate valuable insight on an existing phenomenon or developing a new one. The sampling techniques include Convenience Sampling, Purposive Sampling, Quota Sampling and Snowball Sampling.

In addition to the critical review of literature, case studies were carried out on five selected construction sites located in Braamfontein, Midrand, Rosebank, Menlyn and Johannesburg's Central Business District (CBD), all in South Africa's Gauteng province – see Table 1. The five construction sites comprised of one small, two medium and two large projects, as per the project classification criteria presented in Table 2 [12].

A survey questionnaire (available online at https://bit.ly/39GTFEv) was developed to source information from the target population. The development of the questionnaires was guided by the aim and objectives of the study, as well as a review of available literature. Ethics clearance was obtained from the University before commencing the study to facilitate the collection of data. A response rate of 22% was received on the questionnaires. The questionnaire feedback was the primary data for analysing the findings in conjunction with the interviews held on site. The [informal] interviews were conducted with the construction practitioners on site during the site visits and while distributing the questionnaires. The [informal] interviews were essential in the understanding and interpretation of the data collected. An inductive method was used to code the data, a process that facilitated a holistic view of the results to enable the generalization of the outcomes of the study albeit with the limitations mentioned earlier.

The respondents in the study comprised civil engineers, site managers, safety officers, site agents, forepersons, managing directors and general workers. Also, they had varying site and professional experiences ranging from interns, junior workers to senior personnel. In terms of site experience, and considering all the respondents, 27%, 37%, 18% and 18% had 0–1, 1–3, 10–15 and over 15 years of working experience.

As indicated in Table 2, none of the construction sites provided information on the sizes of the project teams. Table 2 can be interpreted as follows [12]:

(i) Completion time takes less than six months, six to twelve months and more than 12 months for, respectively, small projects, medium projects and large projects.

(ii) The complexity levels of small projects are manageable, the problem is easily understood, and the solution is readily achievable. In medium projects, the

Table 1: Construction sites sampled as Case studies.

Case study No.	Location	Type of construction	Project size
1	Braamfontein, Johannesburg	Multi-storey accommodation	Medium
2	Midrand, Johannesburg	Multi-storey hotel with office space	Medium to large
3	Rosebank, Johannesburg	Multi-storey office	Medium
4	Menlyn, Pretoria	Multi-story office, apartment and shopping centre	Large
5	Johannesburg Central Business District (CBD)	Multi-story residential	Small

Table 2: Project sizing criteria of Case studies based on the guidelines by Wilson [12].

Project aspect considered	Construction site														
	Case study 1			Case study 2			Case study 3			Case study 4			Case study 5		
	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Size of project team (full-time equivalent)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Completion time	☐	☒	☐	☐	☐	☒	☐	☒	☐	☐	☐	☒	☐	☒	☐
Timeframe	☐	☒	☐	☐	☐	☒	☐	☒	☐	☐	☐	☒	☒	☐	☐
Complexity	☒	☐	☐	☐	☐	☒	☐	☒	☐	☐	☐	☒	☒	☐	☐
Strategic importance	☐	☐	☒	☐	☒	☐	*	*	*	☐	☐	☒	☒	☐	☐
Reputation importance	☐	☒	☐	☐	☒	☐	☐	☒	☐	☐	☒	☐	☒	☐	☐
Total cost	☐	☐	☒	*	*	*	*	*	*	☐	☐	☒	*	*	*
Level of change	☐	☒	☐	☐	☐	☒	☒	☐	☐	☐	☒	☐	☒	☐	☐
Dependencies and inter-related projects	☒	☐	☐	☐	☒	☐	☐	☒	☐	☐	☐	☒	☒	☐	☐
Overall project size	Medium			Medium-to-large			Medium			Large			Small		

S: Small-sized project
M: Medium-sized project
L: Large-sized project
*: Information confidential
'–': Information not available/provided

problem is either difficult to understand or the solution is unclear or difficult to achieve while in large projects, both the problem and the solution is difficult to define or understand and the solution difficult to achieve.

(iii) Strategic importance in small projects is of internal interests only and thus have no reputation implications. In medium projects, there could be some direct impact on a low priority initiative with some reputation implications. Large projects affect core university service delivery and/or directly relates to key initiatives in a strategic plan and there are major reputation implications.

(iv) In small projects the total costs are less than USD 25K, medium projects range from USD 25K to USD 200K and in large projects the costs are more than USD 200K.

(v) Small projects have no major dependencies as their changes impact a single area. Medium projects have some low-risk dependencies and changes could impact several areas. Large projects have high-risk dependencies, and the changes could impact the entire project.

5. RESULTS

From the data collected, 46% of the respondents indicated that there was a designated strategy for the management of concrete and cementitious waste on site while 27% indicated that there was no strategy. The remaining 27% of the respondents were not sure if there were designated strategies for concrete and cementitious waste management. Amongst the respondents who indicated the presence of waste management strategies on site, "reduce, reuse and recycle" were the most cited strategies for managing concrete and cementitious waste – see Table 3. Based on the observations made during the site visits, there were waste management plans in all construction sites. It was therefore clear, from the responses received, that all the site workers were not familiar with the [formal] site waste management plans in place. Possible reasons for this may include (i) poor communication of the waste management strategies on the construction sites, or (ii) poor inculcation of a waste management culture in the organisation and on site.

50% of the respondents in Table 3 indicated that backfilling is the primary form of re-use strategy for managing concrete and cementitious waste. 'Reuse' is one of the preferred methods of waste management in the SoWR. 39% of the respondents indicated that 'Disposal' is the next most used strategy after re-use. According to the respondents interviewed on site, the waste is collected from the site by formal waste management collectors for disposal in landfills. These findings corroborate the findings of previous studies [6] that South Africa faces excessive amounts of waste disposed of in landfills. The survey results indicate that ´selling´ (or exchange of waste for money) is not utilized by any of the construction sites as a waste management strategy. The insufficient use of the exchange for money strategy suggests that there exists an opportunity to develop incentives that will encourage practitioners to sell waste as a form of managing the waste.

Case study 1 (a medium multi-storey accommodation construction site) indicated that their construction project produced an estimate of 0.07 cubic meters of concrete and cementitious waste per day. Case studies 2, 3, 4 and 5 did not have an estimate and records of quantities of concrete and cementitious waste material produced on their construction projects. Due to minimal information provided by other sites, results from case study 1 cannot be generalized. These findings demonstrate why there is limited [published] literature on the amounts of concrete and cementitious waste generated in construction sites. Construction practitioners should be encouraged and incentivised to document the type and quantity of waste generated in their projects.

The survey results in Table 4 indicate that up to 73% of the respondents support the notion that the management of waste concrete and cementitious material is necessary and important. However, the implementation of this seems to be poor based on the response rate of 64% indicating a non-committal (neutral) stance. Nevertheless, these results present an optimistic perception of advancing the waste management of concrete and cementitious waste because the practitioners understand the underlying value.

6. CONCLUSIONS

The study focused on current practices and strategies for waste management of concrete and cement-based materials in the South African construction sector. A desktop study (critical literature review) and a qualitative approach were used in the study in which questionnaires and informal oral interviews were used to collect data in five selected construction sites in Gauteng province, South Africa. The target population was site construction practitioners.

The results showed that practitioners are generally aware of the traditional waste management hierarchy (i.e., reduce, re-use and recycle) and how it is implemented. However, they are unaware of the current waste management hierarchy in the State of Waste Report (SoWR).

Table 3: Waste management methods on the construction sites.

Waste management method	Response rate
Re-use	50%
Disposal	39%
Recycling	11%
Selling (exchange for money)	0%

Table 4: Responses on practices and strategies for managing concrete and cementitious waste.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The management of waste concrete and cementitious material is a necessary practice in the South African industry	0%	0%	18%	73%	9%
The use of a waste management plan for waste concrete and cementitious material is well adapted in the South African construction industry	0%	0%	64%	36%	0%

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Nevertheless, the SoWR is a useful tool that construction practitioners should not only familiarise themselves with but also put in place systems in construction sites to implement. Given that construction sites are the primary sources of waste, accurate data on the type and quantity of waste generated, and how it is managed can be obtained therein. There is a need for the government to encourage and incentivise construction practitioners to collect and share this data.

The waste hierarchy outlined in the SoWR should be implemented in construction sites. Practitioners should, in particular, be encouraged to put in place systems that aim at waste avoidance and reduction. The policies and legislation need to encourage practitioners to quantify the different types of waste produced in construction sites. This will improve the data available in South Africa and enable an objective up-to-date analysis to be carried out. Stakeholders involved in construction need to be educated on the importance of waste management. Stakeholders that need to be educated on waste management include construction practitioners, and in particular the Environment, Health and Safety (EHS) practitioners. This can be done through workshops, awareness campaigns and by creating website groups (including social media). The government should ensure that EHS practitioners are aware of the latest policies and legislations in the SoWR.

The responses received did not indicate 'avoidance' and/or 'reduction' of concrete and cementitious waste material. If practitioners are educated on these practices, there will be a reduction in the amount of waste disposed of in landfills. According to the findings of this study, practitioners acknowledge that the management of concrete and cementitious waste is necessary; therefore, both the private and public sectors should work together to incentivise construction practitioners to pro-actively consider recycling concrete and cementitious waste before resorting to disposal of the same in landfills. None of the construction sites sampled in this study indicated using recycled concrete; it will be beneficial to conduct studies to obtain the views of construction practitioners on the use of recycled concrete. Concrete and cementitious waste can be disposed of by sending the material to recycling plants to be crushed or recovered for reuse (e.g., aggregate or blocks) through waste management collectors. For recycling, the concrete and cementitious waste can be sent, through waste management collectors, to cement and concrete manufacturing plants and/or other similar plants that recycle the waste material.

The scope of this study did not extend to investigating the role of the construction sector in self-regulating and developing organisational cultures that promote responsible generation and management of concrete and cementitious waste within the industry. Future studies are recommended to find out how the industry, and contractors, in particular, view self-regulation and development of cultures that promote responsible generation and management of concrete and cementitious waste.

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