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Barriers to improving the environmental performance of construction waste management in remote communities

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Abstract

The construction sector represents one of the most significant contributors to global waste production and is responsible for over 30% of the waste that ends up in landfill. Sending construction waste to landfill results in a broad range of environmental consequences including: degradation of land, habitat destruction, contamination of soil and groundwater, and release of methane. There is a growing awareness of the need to divert construction and demolition (C&D) waste from landfill for reuse or recycling. This helps maximise the value of the resources embodied in these materials and reduce the demand for virgin raw materials and the associated environment effects resulting from their extraction, processing and manufacture. However, diversion of C&D waste to reuse or recycling in remote communities can be difficult and costly. This poses a significant challenge for improving the environmental performance of construction waste management in these communities. A housing refurbishment project in Alice Springs, a remote town in central Australia, was used to identify the barriers associated with improving the environmental performance of construction waste management in remote communities. This study considers the materials removed as part of the demolition phase of the project. Material types and quantities were documented and on-site and off-site waste management practices observed. Reasons for waste management decisions were recorded. The study identified a range of barriers to improving the environmental performance of construction waste management in remote communities. These include cost and time associated with on-site waste management, industry culture, lack of education, competing project priorities, and lack of financial incentive. Greater incentives to encourage the diversion of C&D waste from landfill are needed, in particular. This and other strategies for improving construction waste management practices in remote communities must be targeted at the context of individual communities though, due to their unique characteristics.

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1. Introduction

The construction sector produces a significant amount of waste as a result of both the construction and demolition processes. This waste results from surplus or damaged materials, on-site processing, packaging, refurbishment, replacement and eventual demolition. Waste materials are either sent to landfill or diverted to resource recovery and recycling facilities. Approximately 6.25 million tonnes of construction and demolition (C&D) waste is sent to landfill in Australia on an annual basis, representing around 34% of the waste that ends up in landfill [1]. The disposal of construction waste in landfill results in a broad range of environmental consequences including the use and degradation of land, habitat destruction, contamination of soil and groundwater, and release of methane.

A considerable amount of resources is needed to produce construction materials, including energy, water and raw materials. Material manufacturing processes as well as the associated processes of resource extraction, processing and transportation also result in the emission of pollutants and greenhouse gases into the environment. The disposal of these materials into landfill means that they are no longer available for use and their embedded resources are 'locked-up' and lost forever. Environmental concerns as well as resource availability issues have led to a growing awareness of the need to divert C&D waste from landfill for reuse or recycling. By recovering materials that would otherwise have been disposed of in landfill, not only are the landfill-related consequences avoided, but the resource value embedded in these materials can also be maximised. Materials can either be reused in their current state or recycled into new materials. This reduces the demand for virgin raw materials as well as a large proportion of the associated energy and water requirements and waste and emissions that occur as a result of the material manufacturing processes. Avoiding or reducing waste and recovering waste materials for reuse or recycling are considered to be much more environmentally beneficial strategies for waste management than sending waste to landfill [2,3].

Diversion of C&D waste to reuse or recycling in highly populated cities is becoming increasingly common due to ease of access to resource recovery and recycling facilities. Increasing landfill levies and raw material prices have also been key contributors to increasing waste recovery rates [4]. However, in remote communities, diversion of waste materials to reuse or recycling can be much more difficult and costly. Recycling facilities are often not easily accessible or are limited to only a small range of materials. In many cases the only option is to travel long distances to the closest recycling facilities, but this is usually cost prohibitive. Because of this, the most feasible option is usually to send the waste to landfill. This poses a significant challenge for improving the environmental performance of construction waste management in remote communities. There is also likely to be other reasons why diverting waste from landfill in remote communities may be difficult. Despite this, there is limited research into what these barriers are. A deeper understanding of the critical barriers to improving waste management in remote communities is needed in order to identify policies and solutions for addressing the environmental concerns associated with current waste management practices.

1.1. Aim and scope

Therefore, the aim of this study was to identify the key barriers associated with improving the environmental performance of construction waste management in remote communities. This study considers the waste produced from gate to grave. It does not include waste produced as part of the material manufacturing processes, but rather the waste generated as part of the construction, refurbishment and demolition of a construction project.

2. Background

The proportion of C&D waste sent to landfill and recycled varies considerably across the various jurisdictions within Australia. The most populated and urbanised jurisdictions (NSW, Vic, Qld, SA) have a much higher rate of waste recycling than jurisdictions with a larger proportion of remote communities (Tas, NT, WA) (Fig. 1).

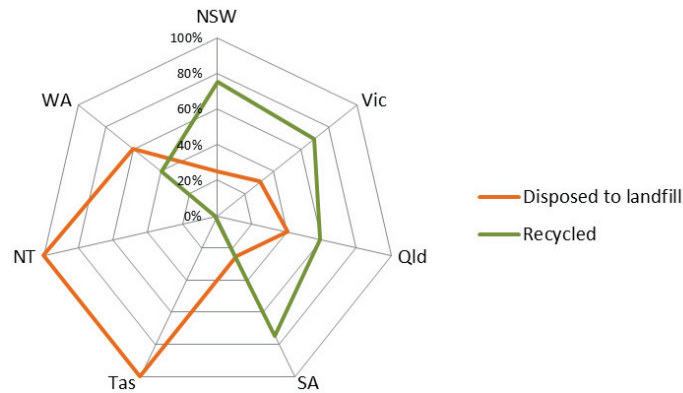


Fig. 1. C&D waste treatment in Australia 2010-11, by jurisdiction. Source: [5]

In metropolitan cities, landfill fees and levies provide an incentive for recycling heavy materials such as concrete, bricks and asphalt. At the same time access to reprocessing centres has increased recovery rates for high value materials such as metals and hardwood timbers [6]. The amount of waste produced from a construction project and how that waste is managed is not only influenced by the on-site construction practices but also by decisions that are made during the planning and design processes. The project client and architect/designer often make decisions that predetermine how waste will be managed (through detailed waste management plans, or lack thereof) or the types and quantities of waste that will be produced (through material selection, chosen construction methods, and the extent of standardised components).

2.1. Waste management in remote communities

While individual remote communities rarely produce a significant amount of waste or encounter the issues of land availability for waste disposal that larger cities do, collectively these communities produce an amount of waste that is not insignificant. Land access for waste disposal can sometimes also pose a challenge in remote communities. For example, it is anticipated that in Alice Springs, Australia the local landfill will reach its capacity by 2020 at the current waste residual rates [7]. This is of critical concern in Alice Springs since the land around the town is almost all Aboriginal-owned, so obtaining a new landfill site will either be impossible or expensive.

Unlike for larger cities, where access to a range of waste recovery and recycling facilities is common, these services are often quite limited or even non-existent in remote communities. For example, free collection of plasterboard offcuts is offered by some plasterboard companies in metropolitan Australian cities and modular carpet manufacturers take back carpet tiles at the end of their use for reuse or recycling at no additional cost [6]. In remote communities such material recovery and recycling is not usually feasible as it would involve transporting materials over long distances.

In order to implement the National Waste Policy [8], the Regional and Remote Australia Working Group was one of seven groups established. It recognised that remote Australia faced a number of challenges in managing waste and required 'tailored' solutions for increasing capacity for recycling and reusing waste. The primary challenges identified by the group included 'access to markets for recyclables, distances and road conditions between town and waste facilities and the recruitment and retention of staff' [9]. In addition to these overarching challenges, smaller remote communities suffer in particular from very few transportation options, poor economies of scale, sporadic waste collection services, wet weather and the need for dry storage space for recyclables, theft of steel, and poor environmental management of landfill sites [9]. For these reasons, one of the key objectives of the National Waste Policy is 'to support improved waste management and re-use of waste in regional, remote and Indigenous communities'.

2.2. Environmental performance of construction waste management

Improving the environmental performance of construction waste management is assumed to involve the following strategies, starting from greatest potential benefit:

- Avoiding waste production from construction activities
- Reducing waste production from construction activities
- Recovering waste materials for reuse
- Diverting construction and demolition waste from landfill to recycling facilities.

The more waste that is produced, the greater the effect on the environment there is likely to be. If no waste is produced, then there is no effect on the environment. Reducing the amount of waste produced lessens the effect on the environment associated with waste disposal, to an extent related to the amount and type of waste avoided (as different types of waste will have different environmental consequences). It is important to consider that with many waste management processes (such as transportation, reuse and recycling) comes the need for additional resources (materials, energy and water), resulting in their own effects on the environment. While these resource demands are likely to be insignificant in the context of the benefits achieved, they must still be considered. How well a particular waste management strategy performs from an environmental perspective will depend on the type and quantity of resources needed for waste recovery, transportation and processing. In considering the benefits of a particular strategy, the environmental performance depends on the extent to which it assists in reducing environmental effects of land degradation, energy and water use, climate change, pollution, and resource depletion, especially when compared to landfilling. But what are the main barriers to achieving these benefits?

3. Research method

This study uses a single residential building project located in Alice Springs, Australia to gain greater insight into the barriers facing improvements to waste management practices in remote communities. While this limits the broader applicability of the findings, the in-depth nature of the study attempts to uncover some of the critical barriers to recycling and reusing waste that exist in remote communities.

3.1. Case study

Alice Springs is located in central Australia, within the Northern Territory, 1,500 km from the closest major city, Darwin and with a population of 27,972 [10]. Construction is the second largest industry (\$313 million) in this region after mining (\$552 million) [11]. Managing construction waste is of critical concern in Alice Springs since the local landfill is predicted to be filled by 2020. Waste is a significant issue in the Northern Territory and the Northern Territory Environmental Protection Authority (NTEPA) has dedicated significant resources to developing waste and pollution reduction projects. Despite this, there has been no, to very little change in the disposal practices for C&D waste streams in remote communities, like Alice Springs. This study attempts to gain a greater understanding of waste management practices in remote communities by:

- a) documenting the actual C&D waste and waste management practices for a construction site in Alice Springs, providing insight into the scale of the waste produced and areas for greatest potential for waste reduction in the local construction industry;
- b) interviewing key project stakeholders (architects, builders, project managers).

A detached single-storey brick veneer residential construction project, refurbished in early 2017 was used as the basis of the study. The 100 m² two bedroom house was renovated into a three bedroom house with the addition of one bedroom, a second toilet, large verandah and a new kitchen and laundry and a raised roof.

3.2. Data collection

This initial study considers the materials removed/waste generated as part of the demolition phase of the residential construction project. Waste was loaded into skips and material quantities were determined in metric tonnes from the weigh bridge receipts. Material types were determined where possible.

Three semi-structured interviews were conducted, with the architect, builder and the site manager for the project. The aim of the interviews was to gain insight into the decisions that were made in relation to waste reduction and management for the project. Interview questions were designed to better understand the attitudes, behaviors and decision making associated with C&D waste reduction and management in a remote community such as Alice Springs. Questions focused on the primary causes of waste generation and suggestions for efficient waste management strategies were also included.

4. Results

This section presents the findings from the observation of waste management practices and quantification of waste produced for the case study building as well as the interviews with key project stakeholders.

4.1. Waste production and waste management practices for case study building

Demolition was carried out by one builder and two labourers. The demolition process took less than three weeks. The first loads of waste were generated from cleaning the area surrounding the house to have a clean site for demolition and new construction works. This was done by a subcontractor who used a tipper truck to remove three loads of waste - one mixed waste and two of clean fill. Since clean fill is free to dispose of at the waste transfer station, builders tend to keep this separate. Once demolition started, the waste was collected in piles outside the house, close to the driveway for future loading into tipper trucks. Only the items to be reused were stored inside the house. Materials for recycling were collected in one pile and everything else was thrown into a mixed pile of waste. Two loads of waste were removed when the company's tipper truck became available. This removed the bulk of the demolition waste. After this point, a hired skip was used to collect waste. This saved double handling the waste since wheelbarrows could be taken to the skip and emptied directly. Once the skip was full the skip hire company left another empty skip and carried the full skip to the waste transfer station. At the waste transfer station, that waste was emptied in areas marked for demolition waste. The proportion of main waste types taken to the waste transfer station is shown in Fig. 2. The only materials saved for reuse were those marked in the drawings for reuse such as the laundry sink, some doors and windows. Timber studs were saved by the builder to reuse in the new walls. Copper pipes, roofing sheets and aluminum window sections were separated and saved to be sold to recyclers.

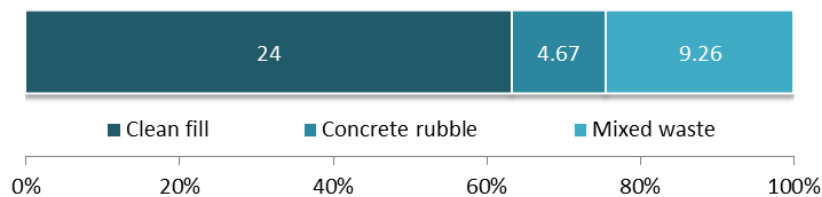


Fig. 2. Proportion of waste types taken to waste transfer station during demolition of case study house (tonnes).

4.2. Interviews with key project stakeholders

The interviews helped provide insight into the main decisions associated with waste management for the case study building as well as broader insights into the barriers to more environmentally conscious waste management in Alice Springs and similar remote communities.

When asked what the key contributors to waste generation on site were, most factors identified by the builder were aspects controlled by the architect or client. These included design changes, design complexity, design errors, missing information, and a design not using standard material sizes. Other factors included lack of a waste management plan, time pressures, on-site material processing and packaging.

It was believed that there is more potential to recycle and reuse C&D waste than to avoid or reduce it through on-site practices. Reuse of materials is usually more likely where there is a clear financial incentive to do so. This was likely to be in relation to saving on the cost of new materials, but it was important that any reused materials meet performance requirements (structural, functional etc.). Materials that are recycled are done so as there is also a financial incentive, in the form of reduced costs of landfill or inherent material value (such as copper).

Where it wasn't a key driver for the project, improving waste management wasn't seen as financially viable by the builder. The time needed to sort most waste materials comes with little financial benefit – definitely not enough to make it worthwhile. Minimising waste from over-ordering materials was seen as important to the builder as it affects their bottom-line, in terms of extra material and disposal costs. Plastic waste was also identified as a large contributor to non-recycled waste, especially from packaging.

While there was some understanding of the importance of better waste management practices and the effect of waste disposal on the environment, a large range of barriers to improving the environmental performance of construction waste management in remote communities were identified by those interviewed, as listed in the next section.

4.3. Barriers to improving construction waste management

The identified barriers are grouped according to the key strategies for improving the environmental performance of construction waste management (Table 1).

Table 1. Barriers to improving the environmental performance of construction waste management.

Waste management strategy	Barriers
Avoiding waste production from construction activities	Construction industry culture No business case Lack of awareness of environmental implications of waste disposal Assumption that waste generation is inevitable and can't be reduced Traditional construction methods
Reducing waste production from construction activities	Construction industry culture Lack of awareness of environmental implications of waste disposal Design not using standard sized materials No benefits to sorting packaging materials Assumption that waste generation is inevitable and can't be reduced
Recovering waste materials for reuse	Construction industry culture Builder's attitude Demolishing carefully to avoid damage Lack of space for on-site storage Lack of certainty about condition Greater certainty of performance for new materials Lack of time/time needed for material separation Limited budget/costs of material separation Disconnect between design instructions and construction/demolition realities Incomplete/confusing documentation
Diverting construction and demolition waste from landfill to recycling facilities	Limited recycling options Poor economies of scale

Construction industry culture
Lack of time/time needed for material separation
Lack of awareness of environmental implications of waste disposal
Lack of awareness of material recycling requirements/processes
Speed of construction/demolition
Lack of financial incentive
Lack of policy/regulations
Lack of contractual requirement for reusing materials
Assumption that waste transfer station will separate materials
Lack of space on-site for bins

5. Discussion and conclusion

The waste management practices observed for the case study building reflected what is often quite common with smaller construction projects. There was an urgency to move the materials off the site to ensure access for demolition activities. Time was also considered critical, being a key driver for the profitability of a project, and so the quickest solution for managing waste was to put everything in the tipper truck rather than sorting or saving it. The use of untrained labour made selective demolition difficult and limited options for recycling meant that most of the materials ended up as mixed waste. Mixed waste represented a large proportion of the waste produced. The mixed waste then ended up in landfill due to limited capacity for sorting at the waste transfer station. The materials saved had some economic value, either as a means of reducing costs of disposal or reducing the cost of the new construction (through reuse).

This study found that there is a range of barriers to improving the environmental performance of construction waste management in remote communities through the diversion of construction waste from landfill. The most recurring barriers tended to be the costs and time associated with sorting and recycling waste, lack of incentives, industry culture, and a lack of education.

Construction industry culture was mentioned by the architect as the single biggest barrier to improving waste management practices. A lack of focus on environmental aspects during their education means that a culture of considering waste as an inherent part of the design process does not generally exist for many currently working in the construction industry. The architect believed that this may be changing with newer generations of architects much more likely to consider this as an integral part of the design process.

The builder seemed to believe that many waste management decisions were out of their control. This may indicate an element of not wanting to take responsibility, but also highlight the typical disconnect between design and on-site practices. From the builder's perspective, there seemed to be some interest in recycling, but it would need to be part of a redefined culture, with waste minimisation and recycling an embedded element, supported by incentives or fines.

As highlighted by the builder, the architect has a key role to play in reducing waste generated as part of a project but also in how that waste is managed. Strategies such as minimising design complexity, considering buildability, ensuring accurate and complete documentation, and use of standard material sizes may also play an important part in improving the environmental performance of waste management in remote communities. Some of the other possible strategies include:

- Educating stakeholders of the importance of more environmentally conscious waste management practices and recycling services available;
- Providing incentives for recycling and reusing waste;
- Providing disincentives for disposing of waste to landfill (although this can result in illegal dumping);
- Waste management plan that requires sorting of waste materials on-site.

The solutions for improving construction waste management practices in remote communities must be targeted at the context of individual communities due to their unique characteristics. For example, Cochran and Townsend [12] emphasise the importance of understanding the material composition of the waste streams before suggesting solutions to manage these as there are specific techniques in dealing effectively with each type of material waste. Several other countries have demonstrated significant construction waste recovery rates, over 80% in some cases [13]. This has been achieved by regulatory mechanisms, education, taxes and compulsory separation of waste [14].

This initial study was limited in terms of using a single case study and interviewing only a small number of stakeholders. This will be expanded in future work to consider a broader range of building projects and stakeholder insights. Further research is needed to determine the environmental benefits of alternative, more environmentally conscious waste management practices in remote communities, like Alice Springs. This would include quantifying the reduction in landfill-related environmental effects as well as the amount of energy, water and raw material demand avoided through the reuse or recycling of waste materials.

A better understanding of the environmental benefits and current barriers of recovering and recycling C&D waste in remote communities may help inform policymaking, including the development of a regulatory framework for managing C&D waste in these communities. Potential incentives and drivers for encouraging the diversion of waste from landfill should also be explored.

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