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Overcoming barriers to the reuse of construction waste material in Australia: a review of the literature

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Although much has been written on how to improve the management of construction waste and increase the use of recycled materials, little progress has been made to address the reuse of construction waste. Yet there is a consensus in the literature that waste reuse practices have a decisive role to play in improving reduction of waste, and that institutional barriers are the most problematic obstacles to implementing identified reuse strategies. This paper examines the literature from the last 10 years on the issues facing different stakeholders around reuse of construction waste in Australia, and the causes and effects of the institutional barriers encountered. Key texts from before this period are also referenced. The findings reveal that institutional impediments are related to problems outside of the construction industry, such as social, economic and political barriers to change. A number of constraints are identified: lack of interest and demand from clients; attitudes towards reuse practices; and training all of which act as disincentives to a proactive and sustainable application of construction waste reuse strategies. Above all, it is argued that legislation should be better implemented to ensure that all states in Australia are required to implement strategies to reuse waste construction materials.

Keywords: construction waste; institutional barriers; waste management; reuse of construction material

Introduction

Construction and demolition waste is defined as the solid waste generated in the construction industry; specifically, the waste that arises from the processes of construction, renovation and demolition (Yuan & Shen 2011). Shen et al. (2004) defined construction waste as:

> Building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation (p. 473).

Thus, while construction and demolition are different activities, the literature tends to group together the waste products from each. A considerable amount of construction and demolition (C&D) waste is generated globally each year. For instance, approximately 136 million tonnes of C&D waste is produced annually in the US (Sandler & Swingle 2006). A study by the UK Department of the Environment, Transport and the Regions (DETR 2000) shows that around 70 million tonnes of C&D materials ends up in landfills in the UK. China generates 29% of the world's municipal solid waste annually, and the construction sector contributes nearly 40% of it (Wang et al. 2008). In Australia, waste generated from the construction sector constitutes about 44% of the total amount of annual waste across all industry sectors.

Adverse impacts of C&D waste generation are various, including environmental pollution, health hazards for humans and financial burdens on companies and governments. Unnecessary loss of natural resources has occurred due to lack of waste management and/or infeasible waste management strategies – e.g. the Zero Waste policy of the South Australian government, which has set what has been described as an unachievable target to reduce waste going to landfill (Chiveralls et al. 2012).

With the need to identify and evaluate effective C&D waste management strategies clearly significant, a large number of studies have addressed this gap during the last decade. But while much recent research has concentrated on technological solutions for reducing C&D waste, little progress has been made to address the reuse of this waste. There is, however, a consensus in the literature that waste reuse practices have a decisive role to play in improving reduction of waste and that, as will be shown in the systematic review presented in this paper, institutional barriers are the most problematic obstacles to implementing identified reuse strategies.

This paper examines the literature on the issues facing different Australian stakeholders around reuse of C&D waste, and the causes and effects of the institutional barriers encountered specifically in Australia – where the federally

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structured legislative framework is different to other global contexts. This review aims to: explore the current obstacles to implement reuse of construction material; investigate the perceptions and attitudes of the various stakeholders towards current reuse trends within the industry; and investigate opportunities to minimize institutional barriers. By addressing these issues from the perspective of five categories of stakeholder – homeowners/end users, architects, contractors, developers and the legislative bodies – the review will address the problem of a lack of sector-wide targeted strategies for reducing C&D waste, and begin to answer the research question: 'what strategies might stakeholders adopt to overcome present obstacles to increasing the reuse of construction waste in Australia?' The key contribution of this paper to construction management research is a syntheses of recent research on C&D waste reduction relevant to the Australian context that identifies: strategies for sector-wide stakeholder groups to better reuse construction materials; and future research that might evaluate these strategies and address outstanding issues.

Background

Waste impact minimization strategies can be divided into five levels of environmental impacts, from low to high: Avoid, Reduce, Reuse, Recycle, Treat or Dispose. After avoidance of use, Reduction, Reuse and Recycle are clearly the most effective ways to save natural resources and protect the environment. Coordination between these three main impact minimization strategies in the demolition, design and construction processes is fundamental, and is a basic principle of waste management. Reduction of C&D waste provides two major advantages: minimizing the generation of solid waste and reducing the cost of waste transportation, disposal and recycling. Thus reduction of waste is considered the most effective waste impact minimization strategy. Nevertheless, the generation of some C&D waste is unavoidable, and reuse and recycle strategies are practical methods to reduce the amount of C&D waste disposed to landfill sites.

'Reuse' usually indicates using the same material in construction more than once, including utilizing materials again for different functions, such as structural steel and wooden shuttering and doors. Waste materials that cannot be reused will either be recycled for new construction or end up in landfill. Reuse is the most preferable choice for waste reduction due to the minimal requirement for processing and energy (Yuan & Shen 2011). Buildings and their users are responsible for nearly a quarter of Australia's greenhouse emissions (DSEWPaC 2012). Embodied energy (EE) is an important element in measuring the environmental impact of construction and the effectiveness of building material choices, particularly for CO_2 emissions. In order to reduce EE, reuse of construction waste is more effective than recycling as recycling involves energy-intensive processes that generate pollutants. If the produced waste cannot be reused, a recycling method should be considered.

The construction industry is recognized as a major contributor to environmental degradation and pollution (Lu & Yuan 2011). According to the Australian Bureau of Statistics, in Australia the construction and demolition sector generated 38% of waste from all sectors combined, totalling 19 million tonnes (ABS 2010). Of this total of C&D waste, approximately 8.5 million tonnes was disposed to landfill. The Australian government reported in 2012 that C&D waste has used 33% of landfill space in Australia and that this waste can be reduced by 80–90% through better waste management practices (Chiveralls et al. 2012). The amount of overall waste (i.e. across all sectors) generated by Australia has more than doubled over the last 20 years, and it is predicted there will be a twofold increase again between 2011 and 2020 (Lehmann & Crocker 2013). In fact, Australia is in the top 10 of OECD nations producing the highest levels of solid waste (Chiveralls et al. 2012). Therefore, managing construction waste in a sustainable manner in Australia can be considered a priority.

In Australia, different state governments have initiated a number of construction waste reduction projects, and proposed multiple strategies for reuse and recycling of construction materials. For instance, the government of the Australian Capital Territory (ACT 2011) promotes reuse of C&D waste on-site. In Western Australia, the Waste Authority provides members of the Master Builders Association Western Australia with information and tools to reduce waste and increase reuse and recycling (Li & Du 2015). Furthermore, the Australian Building Codes Board (ABCB) enforces the Building Code to implement sustainable building practices. Despite these well-developed strategies for C&D waste management, the implementation of these methods in practice is far from optimum. Research by Tam (2008) has shown that such implementation depends on effective waste management plans, which contractors often fail to devise due to the detailed and radical pre-project planning required. Such planning difficulties mean that contractors try to reduce construction waste in different ways, such as using fewer finishing trades by utilising prefabricated components, and by hiring experienced labourers.

The main barrier for promotion of waste management in construction is concern about the extra cost of processing for reuse or recycling, and the quality of reused or recycled materials. Lack of information also contributes to another key cause of the limited effectiveness of C&D waste management, namely the different perspectives and often conflicting

interests of the major stakeholders involved in C&D waste management (Yuan & Shen 2011). External parties – including the legislative authorities, the general public and non-governmental organizations – tend to emphasize concern for environmental impacts, such as minimizing the waste entering landfill, while internal stakeholders – project clients, builders and contractors – are more concerned with the financial aspects of C&D waste management. Hence, aligning stakeholder perspectives on C&D waste management is essential for the uptake of better practices.

Methodology

This research is a systematic review of recent literature. Data collection and analysis was informed by published works on systematic review (e.g. Khan et al. 2003). Specifically, a five-step process was adopted: (1) framing of research questions; (2) identifying relevant studies; (3) assessing the quality of studies; (4) summarizing the evidence; and (5) interpreting the findings. Following these guidelines, searches and review of peer-reviewed journal articles and conference papers were conducted between February and May 2015 using the Scopus and Avery Index online databases. Scopus was chosen due its wide coverage of journals and its special features in keyword searching and citation analysis, and the Avery Index was chosen because it offers a comprehensive listing of journal articles published specifically on construction, architecture and design.

Three search terms were used to find published research: 'reuse of construction material', 'barriers to construction waste management' and 'barriers to reuse of construction material'. The choice of the search criteria was based on the need to capture relevant and current evidence-based literature on the subject. As issues around the area of enquiry are rapidly changing, only papers that were published in the last 10 years (from 2006 to 2015) were included. In addition, for the targeting of key papers prior to 2009, Crabtree and Hes (2009) provided a valuable reference.[1] In all, 27 items were found that were relevant to the Australian context, comprising: 23 (17 Scopus + 6 Avery) articles for *reuse of construction material*, 10 (7 + 3) articles for *barriers to construction waste management* and 3 (2 + 1) for *barriers to reuse of construction material*.[2] Initial screening involved the review of both the titles and abstracts of the 27 articles. This screening identified which full texts would be included in the review, and was based on one evaluation criterion: the degree of relevance of the article to the research question of the study. Each article was rated '1' for low relevance, '2' for medium and '3' for high relevance. The chief parameter used to assess the degree of relevance was the applicability of the key results of the studies to the Australian context. Articles reporting findings rated as '3' or '2' in terms of relevance were included.

Through this process, only 17 articles were considered relevant to the subject under investigation. Each selected article was reviewed, and since the data was mainly qualitative in nature, context analysis was used in the analysis. This involved identification of the different perceptions, motivations, opinions and behaviours of stakeholders towards sustainability in the building industry. Meta-analysis was neither appropriate nor feasible for data synthesis for two reasons: first, the research design and questions of the studies reviewed are not identical or similar to the current study (see Whittemore & Knafl 2005); and, second, evidence from the different studies could not be combined using statistical methods.

Findings

Analysis of the papers using matrices of common themes and results suggested that strategies for overcoming barriers to construction waste reuse can best be discussed within the contexts of five groups of key stakeholders: homeowners, architects, contractors, developers and the legislative bodies.

Homeowners/end users

A variety of legislative frameworks from all levels of government, private industry and stakeholder representative groups have developed around sustainable building practices and materials. Nevertheless, the aims of such frameworks are not reflected in the residential house purchase decision-making process by typical homebuyers or residential property investors. Technologies and social expectations regarding environmental sustainability remain largely unfamiliar to homebuyers and society in general.

There is often a lack of coherence and consistency between homeowners' environmental concerns and pro-environmental behaviours and attitudes. In particular, growing consumer demand for large new homes is often contradictory to a willingness to reduce energy use and use sustainable building materials in properties (Thomas et al. 2012). Willingness to contribute towards an environmentally sustainable home is not often a major factor for Australians in purchasing or renting a home. According to Reed and Mills (2007), the cost of a house is the most significant factor for first homebuyers, not environmental factors. In Australia, the cost of housing is an important element to consumers, especially for the lowest- to

middle-income earners. Homebuyers deem that the high cost of environmentally sustainable products pushes up the cost of properties, and that discourages capital investment in such products (Thomas et al. 2012). In reality, the additional building cost to improve a single dwelling to a five green-star level was in 2008 only approximately $3000 (Reed 2008). This cost should reduce in future as accessibility to building techniques and materials becomes easier.

Furthermore, homeowners are aware of operating energy issues through the direct cost of electricity/gas, but consumers have less comprehension of the contribution that EE has towards the carbon footprint of their homes (Thomas et al. 2012). Embodied energy is the amount of energy that is inherent in producing and transporting materials, which should be minimized for reducing carbon emissions. Thus, reusing or choosing sustainably sourced construction materials can significantly reduce the EE of new homes.

Builders and developers could provide more cost-competitive low-EE products for consumers and better educate homebuyers about the benefits of reuse of construction materials. Furthermore, government bodies could offer incentives or rewards for using sustainably sourced, low-EE, recycled or reused building materials. While economic incentives have been established through government policy initiatives to overcome consumer reluctance to invest in sustainable housing, there are no incentives to increase the reuse of materials for new construction or renovation work (with lower EE impacts through their reuse).

Architects

Architects have a significant role to play in construction waste management. Architects are responsible for three major roles in this respect: educating clients, implementing a waste minimization strategy at the design stage and improving design (Osmani et al. 2008). Clients could be better informed by architects about the impacts and benefits of reuse of construction material. The waste minimization framework – including reusing materials – should be passed onto clients by consultants at an early design stage, so that clients are aware of reuse strategies and are able to choose to implement them. The addressing of a number of waste management issues by architects at a project level is important: design life, initiating waste reviews at the design stage, use of construction waste and prefabricated materials, design for deconstruction and reuse of building materials.

Osmani et al. (2006) have identified a number of obstacles to strategic waste minimization practices: lack of interest from clients, unavoidable waste generation, unclear individual responsibilities and lack of training, final client variations resulting in construction waste during the build stage. Furthermore, it is shown that architects tend to take a passive role in promoting or facilitating waste reduction strategies and do not generally become directly involved in waste management (Osmani et al. 2006). Nor are strategies of waste minimization often utilized by architects during the design stage, even though a significant amount of construction waste could be avoided with careful planning during design. Improved awareness and a change of attitude towards proactive strategies for construction waste minimization are required from architects in order to implement waste strategies that include planned reuse.

Higher education of architects and Continued Professional Development can play major roles in achieving such change. Legislation could also persuade practitioners to improve waste minimization, including financial incentives for contractors through government initiatives that might create bottom-up, contractor driven demand for architect expertise in this area.

Contractors and sub-contractors

Teo and colleagues (2000), in a key text predating our review period, surveyed the factors preventing operatives from implementing waste management on eight construction projects in central Sydney. They suggested that motivation to reduce, reuse and recycle waste could be achieved via influencing the behaviour of construction workers. According to the study, construction operatives believed all stakeholders should be equally responsible for waste management, and that the biggest impediment to reducing waste was time pressure followed by insufficient facilities to manage construction waste, lack of knowledge and space constraints. Raising awareness of waste management through training at all levels in the construction industry, for all sizes of contractors and projects, could overcome these barriers that, 15 years after the Teo study, clearly remain. The need is still clear for educating Australian contractors and sub-contractors about the benefits of waste management plans; including training about what waste might be produced by a project, how to avoid it going to landfill, and identifying what types of construction waste can be reused or recycled. Importantly, contractors should not neglect sub-contractors when establish training programmes and policies for waste management.

Reuse of construction waste material has not proliferated or been generally accepted and facilitated by the construction industry. The industry tends to be conservative and slow to adopt new technologies and systems, and attitudes to reusing construction waste are informed and reinforced by society-wide indifference towards recycling and reutilizing materials.

Education and training is required to overcome such entrenched attitudes and practices, and this must be driven at industry level by revision to building regulations if, as is the case at present, the market provides little incentive. Government could also encourage waste minimization through legislation providing contractors with financial incentives.

According to Dong and Wilkinson (2007), workers in the construction industry need to be educated and trained for new skills if sustainable building practices are to be successfully adopted. The implementation of ambitious energy efficiency initiatives has created a skills shortage in Europe, where it was estimated that 2.5 million workers in this field would be needed by 2015, up from 1.1 million in 2011 (European Commission 2011). As yet, this demand has not been met. The need for employability skills in this area is just as urgent in Australia. In *Improving Energy Efficient, Sustainable Design and Construction in Australia – Learning from Europe*, Morris (2013) highlighted the need for 'skills to implement successful collaborative and multidisciplinary learning environments for building design, engineering, building and construction trade students' (p. 9). If a more sustainable approach to waste management was taken, it is argued that there could be a substantial increase in workload for professionals within sustainable design and construction areas (Building Commission 2004). Udawatta et al. (2015a) found that while there is a move towards more environmentally friendly construction, contractors' attitudes and behaviours are based on financial returns and hence financial incentives are the most effective at improving waste management practices. A further study of contractors by Udawatta and colleagues (2015b) found 26 critical solutions for waste management that could be grouped into five factors: team building and supervision; strategic guidelines in waste management; proper design and documentation; innovation in waste management decisions; and lifecycle management. They also found that 'both technologies and attitudinal approaches require improvement to eliminate/minimise waste generation in construction projects' (p. 73).

Developers

The number of dwelling units approved to be built has increased over the years in Australia, and is a symptom and cause of urban sprawl (Australian Bureau of Statistics 2004). The responsibility of house developers to utilize land and recourses sustainably is significant. The eco-home research project, by Crabtree and Hes (2009), interviewed 12 developers and 35 builders in Australia to find the main barriers to adopting Ecologically Sustainable Design (ESD) practices for building new homes. The results showed the main barriers to be local/state/federal government regulations and processes, which not only prevent innovation but also fail to provide incentives. Regulatory impediments were also perceived as the biggest hurdle to implementing waste management strategies. Udawatta et al. (2015a) similarly found that, as private developers are more price-driven than government clients, legislation is needed to improve waste management until such practices become culturally embedded across the supply chain. In addition, developers and builders saw that the responsibility for applying the precepts of ESD lay with the other party; and both stakeholder groups perceive customers as the main barrier, closely followed by government bodies.

The market also plays a critical role in development. For instance, Udawatta et al. (2015a) found that end users' motivation towards waste management was 'key to encouraging stakeholders of construction projects and improving their attitudes and behaviours towards waste management practices' (p. 137). More effective waste management could be attained if market demand for it was high or if the government regulated developers or provided market incentives. Better financial or legislative encouragement for developers could significantly increase reuse of construction waste materials due to the overall influence that developers hold in the construction industry.

Legislation and the legislative bodies

A considerable barrier to implementing sustainability can be traced to the legislation and standards from the governmental level downwards. The Australian government's approach to environmental policy as a whole has been erratic. Although Australia is known as one of the biggest global per capita energy users and greenhouse gas emitters, the National Coalition Government driven by the ex-Prime Minister John Howard declined to sign the Kyoto Protocol in 2005 (Chiveralls et al. 2012). A more pro-environmental policy was authorized after the election of the Rudd Labour Government in 2008, and gained further support under the Gillard leadership. However, since the Coalition regained power, the advancement of environmental issues has been impeded by a lack of effective support from Australian politicians, although the Green Party has gained some balance of power in the federal Senate. At state and local council levels the legislation around sustainable building can be inconsistent – specifically around the reuse of construction waste material, which is largely discouraged due to high requirements for certification and documentation. Obtaining building approval from local authorities is challenging, and there are no clearly defined and or enforced objectives in Australian federal legislation for reusing construction materials (Hradil et al. 2014).

The National Waste Policy – Less Waste, More Resources – was established as a sustainability framework for Australia in 2010 and continues to integrate within Australia's policy and regulatory framework (DEWHA 2010). Here there are two strategies regarding C&D waste: Strategy 10, which aims to improve waste avoidance and reuse of primary materials in commercial and industrial waste; and Strategy 11, which declares that all state governments are to encourage best practice of waste management resource recovery for construction and demolition projects. In addition, Sustainable Procurement 2006, from the Australian and New Zealand Government Framework, has influenced the policies of lower levels of government (Hyder Consulting Pty Ltd. 2011). Nevertheless, as Chiveralls et al. (2012) have pointed out, the Australian Federal Government does not directly legislate in relation to C&D waste management.

Sustainability has only become a prominent aim of building regulation in Australia since 2004, whereas building codes have existed for over 150 years (Dong & Wilkinson 2007). But of course, the building code is not a static document but is consistently enhanced; with practitioners required to know the alterations. The code could therefore provide a clear motivation for changing practices.

Building regulations present major barriers to waste management from many stakeholder perspectives, because the Building Code of Australia (BCA) requires a low level of consideration for sustainable use of materials. While the building industry clearly requires criteria to evaluate the effectiveness of strategies for the sustainable use of construction materials, the BCA provides no quantifying method to measure the effectiveness of sustainable building practices (Stewart et al. 2012). According to the Australian Building Codes Board, the limited scope of the BCA, such as in its lack of consideration of building lifecycle versus construction and running costs, might be considered the main obstacle to implementing more sustainable construction practices (Dong & Wilkinson 2007).

Limitations on the scope of the BCA and other legislation have long since been related to specific behavioural patterns common to political institutions, where institutionalized collective unwillingness to change is related to conservatism and resistance to learning, adopting and cooperation (see, for instance, Chini 2001). Additionally, the complex or opaque aims of politic institutions, distributed links between actions and consequences, and short-termism can lead to embedded attitudes that are difficult to change once established (Foxon 2002). Dong and Wilkinson (2007) found that Australian building surveyors and architects agree that a major barrier to change presented by the BCA is that the regulations require minimum permissible standards that fall short of the much higher standards required for building practices that can be shown to be truly sustainable. The majority of participants in the study also felt that a significant barrier to implementing change for sustainability in the BCA would be increased professional workloads. The workload issue is echoed for contractors, for which poor working environments – such as the labour-intensive nature of building and persistent time pressures – can influence the quality of work and motivation for workforces in all aspects of construction. This includes practices around minimizing waste and implementing sustainable building practices, where regulations as yet provide little incentive for improvement.

Building regulations around sustainability are mainly concerned with energy efficiency. Other aspects of sustainable building remain neglected by the regulations – such as waste management, reuse and recycling. Furthermore, issues concerning training and education around such practices are largely neglected in the regulations. Broadening the scope of regulations can encourage contractors and professionals to better uptake of waste management methods. Professional accreditation also neglects higher education around sustainable building practices, resulting in a skills gap that needs addressing.

In sum, legislated standards of design, deconstruction and product certification should be established around sustainability, since the BCA requires only a minimum acceptable level of construction and does not consider the difference between raw and reused materials during the design stage (Dong & Wilkinson 2007).

Recommendations

It is clear from the literature that stakeholder attitudes, motivations, perceptions and behaviours towards construction waste management are a key issue. In most recent studies, stakeholders are revealed as reluctant to implement waste management strategies. These include professionals such as architects and surveyors, even though they clearly acknowledge that minimizing waste is critical to more sustainable development. Thus in the following section we summarize the key stakeholder issues identified from our systematic review of the literature, with some recommendations given to overcome stakeholder barriers to more effective construction waste management. The issues are grouped into five stakeholder perspectives.

- *Homeowners/end users* are more concerned about high initial investment costs than the ethics of sustainable development and the threat that human overconsumption poses to the natural environment. In addition, while individuals are largely aware of the energy issue, they have less comprehension of other aspects, such as the reuse or recycling of materials. Better dissemination to homeowners is needed of the relationship between initial investment and

lifecycle costs in relation to energy and resource consumption. Client awareness of the short and long-term benefits of reusing construction materials needs to be increased.

- *Architects* perceived that clients present the main barrier to implementing improved construction waste management. Client requirements for variation late in the design process increases waste materials during construction, and there is a general lack of interest or support from clients towards reusing construction material. While architects tend to take a passive role in waste reduction, this contrasts with their enthusiasm for the use of recycled construction materials.
- *Contractors* are less keen on using recycled materials, but must take the leading role for onsite waste management. Unsurprisingly, both architects and contractors often blame each other for poor reuse practices, thereby exacerbating the problem. Contractors and sub-contractors are more proactive in implementing reuse of construction materials than architects, developers and homeowners. However, constructing site operatives require more time and better facilities to adopt waste management strategies, and their managers need to provide working environments that encourage and facilitate minimizing construction waste. Extended Producer Responsibility (EPR), which normally makes manufacturers responsible for the entire lifecycle of their products, including take-back, recycling and final disposal, could inform a legislative approach for managing construction waste in Australia.
- *Developers* perceive regulatory obstacles as the biggest hurdle to utilizing waste management. Developers see that builders have responsibility for this management, while builders feel developers should at least share that responsibility. Developers, like builders, perceive that lack of customer interest and demand together with lack of legislative incentive are major barriers to the reuse of construction waste. As developers seek to make profit from construction; financial incentive is the best driver for uptake of waste management, and additional cost the prime obstacle.
- *Government* is aware of sustainability issues and has regulated policies for many years, but there is no overall governing body to effect policy, leading to pass-the-buck attitudes between bodies. The limited scope and minimal standards of the BCA are perceived by processionals as major obstacles to implementing more sustainable construction practices. Building regulations regarding sustainability must widen in scope beyond energy efficiency, and legislation should drive the reuse of construction materials. Incentives should be established to motivate all construction stakeholders towards sustainable building practices. As voluntary approaches are generally not successful, mandatory approaches are necessary. Financial penalties should be considered, such as increasing the landfill levy or the imposition of fines for poor waste management. While monetary reward systems are more desirable for stakeholders aiming at cost-effective projects, these can be difficult to design and costly to implement. Federal government should set clear guidelines and targets, with legislation that is readily and consistently implantable by state legislative bodies. Clear definition of measurable standards is needed, such as simplifying the certification processes for reused products. Legislation could make mandatory the Green Star Construction and Demolition Waste credit, which evaluates management practices in minimizing construction and demolition waste from base building and/or interior fit-out works that are sent to landfill. Professionals agree with contractors that lack of legislative and financial incentives are the main barrier to adopting effective waste management plans. Lack of political will is at the root of entrenched resistance to regulatory change.

Discussion

Looking at the construction industry as a whole, the chief barriers to materials reuse sector-wide in Australia can be characterized as primarily socio-economic, and can be discussed in terms of three spheres of reluctance: (1) economic, (2) institutionalized and (3) political.

First, the key economic reluctance is simply due to the fact that the overall cost of reusing materials in the construction and demolition process is higher than using new materials (Hradil et al. 2014). The economic barriers to reusing construction waste are in line with attitudes in general among clients and developers to implementing more sustainable methods of building, where financial concerns about affordability and additional costs have significant influence (Dong & Wilkinson 2007). The attitudes and behaviours of stakeholders do not generally support waste management because of profit-driven constraints (Udawatta et al. 2015a). With regard to the wider use of sustainable building practices, a number of cost issues have been identified: commercializing of the product of sustainably designed and constructed buildings, sustainable certification, additional cost in deconstruction planning and design costs of new construction (Hradil et al. 2014). The long payback periods associated with sustainable building features represent a further problem. For as occupiers, rather than owners or developers, pay operating costs, there is little market incentive for including such features. Similarly, as the reuse of construction waste is perceived to increase building costs, clients have little incentive to promote the greater reuse of construction waste in building (Building Commission 2004).

The lack of an established market for reused construction materials is also a significant economic barrier. There is currently only a small demand for second-hand building materials, the number of material recovery facilities is insufficient, accessibility to information about such facilities is lacking, and intricate coordination is required between provider and users. A lack of waste reuse specialists in deconstruction and shortage of designers willing to apply reused elements increases the cost of reusing materials. In contrast, landfill-tipping fees are low for disposal of construction waste: the average tipping fee in Australia in 2009 was only $24 per tonne, which was half of the average cost in the USA (Tam et al. 2009). Moreover, the current landfill levy system is not efficient – e.g. the levy in New South Wales makes up only a small proportion of total landfill disposal costs. Hence, it is argued that higher landfill tipping fees and levy prices are required for viable investment in waste recovery.

Second, while construction waste has been identified as an issue in Australia for many decades, and technological and/or practical knowledge for reducing it is increasing rapidly, it is clear from the research that institutionalized reluctance to change is preventing the practical application of such knowledge. The difficulty of changing such entrenched attitudes is increased by a lack of communication between and distrust among stakeholders. Many stakeholders involved in the construction industry blame each other for the lack of reuse of construction materials. Practitioners (architects, surveyors and contractors) and developers see lack of interest from customers as a main barrier, and this includes unwillingness to pay for the perceived increased cost of reusing construction materials. Regulatory obstacles, and lack of consistent and clear legislation are perceived by the majority of stakeholders as the biggest institutionalized hurdles to improving waste management and reusing construction materials. Education and training can help overcome sector-wide institutional barriers. Effective training can encourage the sharing of responsibilities between contractors and professionals, and improve awareness and interest from would-be homeowners, clients and developers. Skills should encompass knowledge of the relationships between building lifecycle, running costs, construction costs and embodied energy so that all stakeholders are aware of the longer-term considerations of sustainable building practices. Of course, other factors lie behind these institutional barriers – e.g. technical difficulties with reusing materials, lack of guidance and education, liability concerns for innovative technology, user conservatism and obsolete specifications.

Third, the political motivation for change in relation to resource consumption reduction in Australia has always been dampened by the long-held perception of the Australian economy as being underpinned by the supply of natural resources such as mineral ores and coal. Of course, such a perception of the Australia economy can also be recognized as an institutionalized form of reluctance to change, and can even be identified as part of the 'national character' of Australia. Yet even since Tony Abbot claimed as recently as October 2014, in a now infamous statement that seemed 30 years out of step, at the opening of the Caval Ridge Mine in Central Queensland that 'coal is good for humanity, coal is good for prosperity, coal is an essential part of our economic future, here in Australia', the political climate has changed with a new prime minister seemingly more in sympathy with the global imperative for change reflected by the Paris 2015 United Nations Climate Change Conference. It is the hope that when the imperative and will for the reduction of resource and energy consumption becomes de-politicized (i.e. acknowledged by all the major Australian political parties), the impetus for change will become both top-down and bottom-up, providing the construction industry with both stick (legislation) and carrot (market demand) to improve its practices with regard to the consumption and reuse of construction materials.

Future research

Some future research opportunities exist in the construction waste management field particularly regarding the reuse of construction materials. The following questions require consideration:

- How might the effectiveness of construction waste management be improved through Extended Producer Responsibility approaches?
- How can the competitiveness of reused material be increased in comparison to new materials or those made via recycling?
- What are the perspectives of large non-governmental organizations (NGOs)? While studies have examined the attitudes of practitioners, NGOs such as financial institutions and insurers, which have considerable investment influence in the construction industry, have been poorly consulted.

Conclusion

This paper sought to consider the research question: what strategies might stakeholders across the Australian construction industry adopt to overcome present obstacles to increasing the reuse of construction waste? A systematic review of global research in this area relevant to the Australian context was undertaken. The review found only 17 relevant studies

published since 2009. The review identified current obstacles to implement reuse of construction material; investigated the perceptions and attitudes of five stakeholder groups – homeowners, architects, contractors, developers and the legislative bodies – towards current reuse trends within the industry; and suggested five strategies to minimize institutional barriers to increasing the Australian reuse of construction waste. The strategies are: (1) sector-wide education and training around construction waste management, including better dissemination to homeowners of the relationship between initial investment and lifecycle costs in relation to energy and resource consumption, and increasing client awareness of the short- and long-term benefits of reusing construction materials; (2) better communication between architects and contractors to coordinate materials reuse; (3) more effective legislative and financial incentives across all stakeholder groups; (4) better on- and off-site waste management facilities; and (5) Extended Producer Responsibility. But perhaps it is the small number of relevant studies found that expresses most clearly the key finding of the study. For while operational consumption in buildings in energy, water and other finite resource has increasingly become the focus of research, it is clear that in Australia a great deal of work remains in the area of lifecycle consumption and its relationship to construction processes materials reuse.

Notes

1. Note that some points made by key texts identified in Crabtree and Hes that predate 2006 have been included in the review when these points are still relevant to the current context.
2. Some articles appeared in more than one search.

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