MAJOR FACTORS IMPEDING THE IMPLEMENTATION OF WASTE MANAGEMENT IN AUSTRALIAN CONSTRUCTION PROJECTS

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ABSTRACT

This article aims to identify barriers to implementing waste management practices in construction projects and their interrelationship, based on the particular context of Australia. Interviews and a questionnaire survey were conducted as the primary data collection methods supported by the findings of a charrette. The findings reveal twenty critical barriers to implementing waste management practices in Australian construction projects. Four underlying factors that impede waste management practices are extracted based on results of an exploratory factor analysis. These include rigidity of construction practices, construction project characteristics, awareness, experience and commitment, and the nascent nature of waste management. The study also finds that while both human factors and technical factors act as barriers to implementing waste management practices in Australian construction projects, human factors are more dominant. Thus, it is essential to address all these barriers in the early stage of construction projects for reducing waste generation.

KEYWORDS

barriers, waste management, construction projects, factor analysis, Australia

1. INTRODUCTION

As one of the major consumers of energy and natural resources (del Río Merino et al., 2010, Ding, 2008), the construction industry generates a large amount of waste (Hao et al., 2008; Jaillon et al., 2009; Manowong, 2012). According to Wilson (2015), construction and demolition waste is the highest waste generating category at the global level, and it contributes to 36% of global waste generation.

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Moreover, due to the growing focus on sustainability (Sustainable Development Goals of United Nations 2015), construction waste management (CWM) has gained special attention due to its contributions to conserving resources and preserving health in order to minimise the burden to future generations (Tammemagi, 1999).

It is well recognised that both waste minimisation and resource efficiency play a critical role in attaining sustainable development (Phillips et al., 1999). Hao et al. (2008) identified CWM as a complex system which involves planning, organising and coordinating activities. The system is deemed even more complicated due to various factors such as the presence of different waste management practices, natural and technical restrictions, and conflicting objectives related to evaluation criteria for alternative CWM systems (Kourmpanis et al., 2008). Over the years, previous studies have identified measures for promoting CW minimization, as well as different ways of implementing waste management practices (Hao et al., 2008, Tam and Tam, 2006). However, waste generation continues to be an issue in the construction industry. As Manowong (2012) suggested, effective implementation of waste management practices depends on the compatibility of CWM practices with the actual situation. In line with the CWM practice in Australia as shown in Figure 1, several barriers exist to implementing waste management in construction projects, and it is thus important to identify these barriers for waste minimization. This article aims to address the gap in the existing body of knowledge relating to the identification of both human and related technical barriers to implementing waste management practices in the Australian construction industry and their interrelationships.

2. LITERATURE REVIEW

Previous studies have claimed that barriers to implementing waste management practices in construction projects vary a lot depending on various practices. From these studies a non-exhaustive list of barriers is presented in Table 1.

FIGURE 1. Per capita construction and demolition waste generation for each state and territory (excluding the ACT), 2010–11 (Australian Government, 2013).

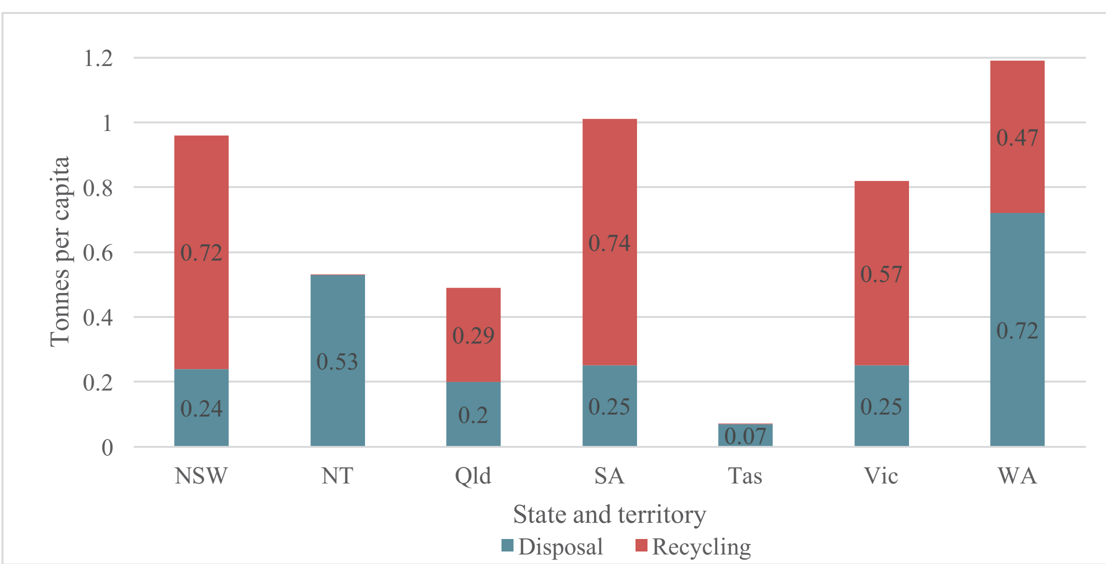


TABLE 1. Barriers to implementing waste management practices in construction projects.

Code	Barriers to implementing waste management practices	References
B1	Resistance to change	Wong and Yip (2004)
B2	Attitudes and behaviours towards waste management practices	Baetz et al. (1991)
B3	Short-term profit-driven nature of the construction industry	Hao et al. (2008); Manowong (2012); Wong and Yip (2004); Yuan and Shen (2011)
B4	Lack of commitment or responsibility for waste management from stakeholders	Al-Sari et al. (2012); Ling and Lim (2002); Lingard et al. (2000); Osmani et al. (2008); Teo and Loosemore (2001); Yuan et al. (2011)
B5	Lack of awareness of construction waste management	Teo and Loosemore (2001); Wong and Yip (2004); Yuan et al. (2011)
B6	Fragmented nature of the construction industry	Johnston and Mincks (1995); Lingard et al. (2000)
B7	Inadequate experience, skills and knowledge on waste management	Ling and Lim (2002); Osmani et al. (2008); Skoyles and Skoyles (1987); Teo and Loosemore (2001); Yuan et al. (2011)
B8	Higher cost and lack of financial incentives for construction waste management	Al-Sari et al. (2012); Ling and Lim (2002); Lingard et al. (2000); Teo and Loosemore (2001); Wong and Yip (2004); Yuan et al. (2011)
B9	Intense competitiveness	Johnston and Mincks (1995); Lingard et al. (2000); Wong and Yip (2004); Yuan et al. (2011)
B10	Poor coordination	Kulatunga et al. (2006); Teo and Loosemore (2001)
B11	Traditionally, waste management is not a priority in construction project management	Hyder Consulting et al. (2011); Johnston and Mincks (1995); Leenders et al. (1989); Ling and Lim (2002); Teo and Loosemore (2001); Yuan et al. (2011)
B12	Limited site space	Yuan et al. (2011)
B13	Traditional procurement methods and conventional practices	Jaillon et al. (2009)
B14	Absence of a proper market for waste materials and construction waste products	Yuan et al. (2011)
B15	Lack of effective construction and demolition (C&D) waste management methods	Yuan et al. (2011)
B16	Lack of advanced technology to deal with waste	Baetz et al. (1991)

(Continued)

TABLE 1. *(Continued)*

Code	Barriers to implementing waste management practices	References
B17	Confrontational relationships	Zuo, Zillante and Coffey (2009)
B18	Unique nature of construction projects	Craven (1994 cited in Teo and Loosemore, 2001)
B19	Insufficient industrial performance standards for and regulation of waste management	Lingard et al. (2000); Teo and Loosemore (2001); Yuan et al. (2011)
B20	Reluctance to use recycled materials	Wong and Yip (2004)

2.1 Characteristics of construction projects

Waste management has not gained adequate attention in construction projects due to characteristics of construction projects, such as intensive time pressure (B9 - coding used in Table 1) (Teo and Loosemore, 2001, Lingard et al., 2000); intensive cost pressure (B9) (Johnston and Mincks, 1995); and intense competitiveness (B9) (Yuan et al., 2011). Similarly, the unpredictable nature of the construction project environment (B18) and the unique nature of construction projects (B18) act as barriers to implementing waste management practices in construction projects (Craven 1994 cited in Teo and Loosemore, 2001). Resource optimisation has been widely regarded as one of the major objectives of organisations. However, less attention has been paid to waste management due to the perception that waste has no value (B11) (Leenders et al., 1989). Supporting this view, Peng et al. (1997) pointed out that construction waste has no value due to the high possibility of different waste materials being mixed.

2.2 Human factors

Baetz et al. (1991) suggested that both human (B2) and technological (B16) factors can act as barriers to implementing waste management practices in construction projects. Wong and Yip (2004) highlighted that resistance to change (B1), reluctance to use recycled materials (B20) and traditional tender procedures (B5) also act as barriers to implementing waste management practices in construction projects. Due to the fragmented nature of construction activities (B6) and the belief that time spent in managing construction waste is a loss of productivity (B11), construction practitioners are not actively involved in adopting an industry consensus viewpoint on waste management actions (Johnston and Mincks, 1995).

2.3 Cost related factors

Researchers have asserted that construction practitioners place more focus on profit maximisation than on reducing the environmental impacts of construction actions (B8) (Wong and Yip, 2004, Yuan and Shen, 2011). Hao et al. (2008) suggested that profitability was one of the critical decision criteria for companies to adopt environmentally friendly waste management measures (B3). Similarly, clients still perceive that profit maximisation is more important than construction waste management (B3) (Manowong, 2012). In addition, construction method selection processes are mostly based on time, cost and quality without necessary consideration of waste reduction ability (B13) (Jaillon et al., 2009). However, the environmental impacts of development decisions cannot easily be equated with monetary value (Graham and Smithers, 1996).

Furthermore, previous studies indicated that construction managers do not always consider waste as a variable in the cost equation (Gavilan and Bernold, 1994). Similarly, if construction waste cannot be sold, construction companies are even willing to pay somebody to haul waste away (B11) (Leenders et al., 1989).

2.4 Different perspectives of stakeholders

Furthermore, Al-Sari et al. (2012) revealed that these attitudes vary according to the category of contractor. Osmani et al. (2008) highlighted that the urgency of implementing construction waste management during the design process is not identified by designers due to the perception of architects that contractors are liable for waste minimisation (B4). Moreover, the lack of knowledge from architects about what causes design waste generation (B7) also impedes the implementation of waste management in construction projects. The additional time involved in improving environmental performance (B11), less support from clients (B4) and lack of subcontractor cooperation (B4) also negatively affect waste management practices in construction projects (Ling and Lim, 2002).

Hyder Consulting et al. (2011) stressed that the 'once a waste, always a waste' approach (B11) is more than a philosophical problem of environmental regulators and that it impacts on the resource recovery industry and the ability to market products. Other barriers identified by researchers include: lack of communication (B10) (Teo and Loosemore, 2001, Kulatunga et al., 2006); lack of financial incentives (B8) (Wong and Yip, 2004, Ling and Lim, 2002); and the culture of the construction industry (B9) (Wong and Yip, 2004, Yuan et al., 2011). According to Teo and Loosemore (2001), industrial performance standards (B19) and managerial commitment (B4) are lacking for waste management. In addition, they pointed out that even operatives consider waste as an inevitable by-product (B11) and that individual responsibilities for waste management are poorly defined (B4). Teo and Loosemore (2001) highlighted that it is hard to enhance the performance of waste management practices owing to the rigidity of existing work practices (B5), the profit-oriented nature of waste reduction actions (B8) and the inequitable distribution of financial benefits from waste management (B8).

Lingard et al. (2000) pointed out that it is a challenge to implement waste management practices in construction projects due to the conflicting goals of stakeholders (B6) and to the fact that goals related to waste reduction are often implemented at the company level without consideration of specific construction site contexts (B19). The results of Lingard, Graham and Smithers' (2000) study, based on the perceptions of employees in large contracting organisations, suggested that these different perceptions have an impact on the implementation of waste management plans (WMPs). While some researchers have noted the inclusion of environmental considerations as a fourth objective in construction projects (Ofori, 1992), researchers have suggested that construction managers focus less on environmental issues than on time, cost and quality issues due to their perception that the latter issues are more important (Lingard et al., 2000). However, studies have found that construction workers have the opposite perception, and they believed that environmental considerations are more important than other objectives of construction companies (Lingard et al., 2000). Effective implementation of company policies relating to waste management is sometimes difficult because construction workers think construction waste management is beyond their control (B4), not cost-effective (B8) and that there are insufficient efforts by senior management (B4) (Lingard et al., 2000). The idea that time spent on construction waste management is a loss of production time is inaccurate because the construction industry should see waste management as a profitable venture (Johnston and Mincks, 1995).

2.5 Standards and current practices

Al-Sari et al. (2012) revealed that, when there is no regulatory framework to monitor their waste management efforts, the voluntary involvement of contractors in WMPs is driven by direct economic benefits (B8). Yuan et al. (2011) identified the difficulties in applying existing regulations in practice (B19), and that there is a lack of a well-developed market for waste recycling (B14). They stressed that both these obstacles are related to regulation support from the authorities (B19). Yuan et al. (2011) highlighted that, even though training can be used to improve construction skills and education can enhance the awareness of waste management practices, there is the lack of continuous education for related practitioners (B7). Researchers ascertained that the lack of expertise, knowledge and experience in waste management hinders the performance of waste management practices (B7) (Loosemore et al., 2011, Ling and Lim, 2002). Yuan et al. (2011) summarised a list of obstacles to the implementation of waste management practices in construction projects such as poor governance of construction and demolition (C&D) waste management (B4), lack of effective C&D waste management methods (B15), cost implications (B8); materials waste on construction sites (B11), limited site space (B12), and insufficient awareness of C&D waste management (B5).

Based on the above, it is essential to analyse the applicability of these barriers to the Australian context. Thus, this article aims to identify barriers to implementing waste management practices and their interrelationship in construction projects in Australia. This would significantly contribute to improving CWM practices in Australian construction projects. Similarly, this study explores the dominance of each of these barriers as well as their interrelationships in the context of Australian construction industry to promote waste reduction at its source.

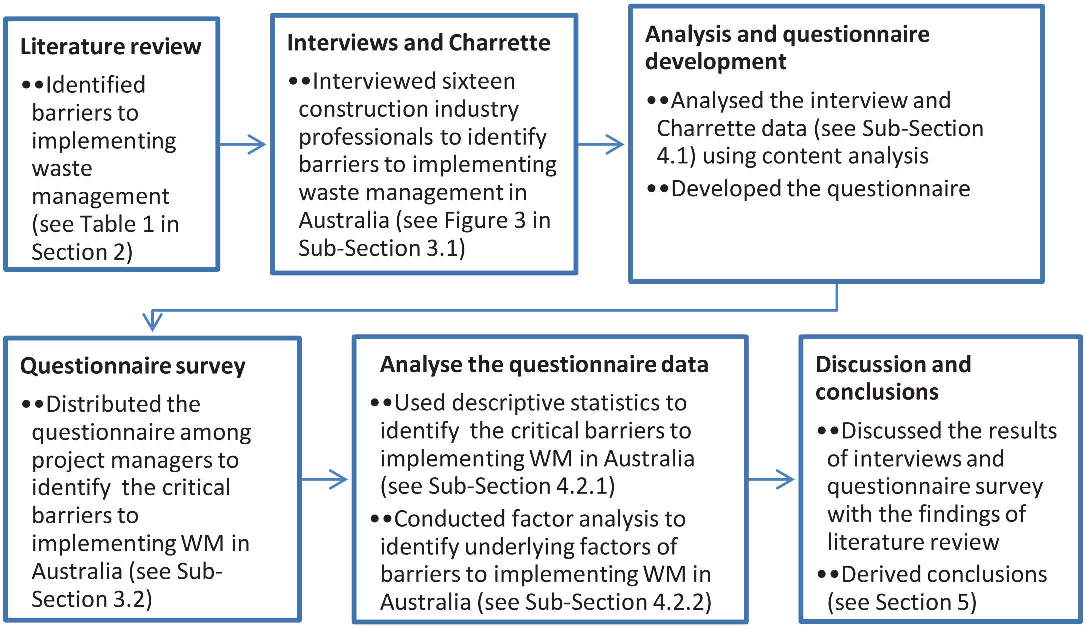
3. RESEARCH METHODOLOGY

Collecting data using multiple methods from multiple sources provides research rigidity (Sekaran, 2003), and it also allows the researcher to overcome inherent weaknesses in each method (Dawson, 2009). In this article both qualitative and quantitative research approaches were adopted. A similar approach was employed in some of the recently published CWM articles (see Yuan (2013), Ng et al. (2013). Thus, in this article, interviews and questionnaire surveys were conducted as the primary data collection methods, supported by the findings of a charrette. The following diagram provides a graphical representation of the research method employed.

3.1 Interviews

In this study, 16 semi-structured interviews were conducted with stakeholders in commercial construction projects in South Australia. These include architects, clients, construction managers, design managers, development and technical managers, engineers, facilities managers, general manager – contractors, QHSE (quality, health, safety, environment) managers, sustainability advisors, urban design and planning architects, waste contractors and waste program coordinators. The duration of interviews was around one hour. Benefits of semi-structured interviews include adaptability of questions and constant interactions between researcher and interviewees during the session (Sekaran, 2003). The semi-structured interview has been widely utilized in sustainability related studies, especially for waste management (Graham-Rowe et al., 2014; Wang et al., 2014; Udawatta et al., 2015; Milovantseva and Fitzpatrick, 2015). One of the selection criteria was having worked in the construction industry for at least 10 years with

FIGURE 2. Overview of the research process.



at least 5 years related experience on waste management. The initial list was drawn from the academic and industry networks of researchers. This was followed by a snowballing process where each industry practitioner contacted was asked to nominate qualified interviewees. Figure 3 represents the details of interviewees and interviewees are labelled using alphabetical letters from 'A' to 'P'.

Content analysis was conducted to identify emerging themes. As a data gathering technique, content analysis allows coding information into pre-defined categories, which facilitates a

FIGURE 3. Details of interviewees.

better understanding of vast amounts of information (Guthrie et al., 2004). NVivo 10 software was used to assist the management and analysis of interview data.

3.2 Questionnaire survey

In the second phase of data collection a questionnaire survey was conducted to gather data related to barriers to implementing waste management practices in construction projects. The findings from the literature review and the preliminary interviews, as well as the results from the Charrette exercise of the project, 'Re-considering sustainable building and design: A cultural change approach' were used to develop the questionnaire. According to Clayton et al. (1998), the charrette is widely used by architects as an intensive design exercise to solve practical problems in designs under time pressure. In the Charrette exercise, the industry representatives involved construction project managers, service engineers, facilities managers, project managers, architects, ecologically sustainable development (ESD) consultants, building certifiers, financers, owners and occupiers. During the Charrette exercise, the invited stakeholders were seated in stakeholder groups (at eight tables) and asked to list barriers to waste generation over the building life cycle. Thus, the results of this exercise could be directly used to refine the questionnaire for this research.

As highlighted by Alreck and Settle (2004), sampling is necessary in questionnaire surveys due to the enormous amount of time, cost and personnel required to survey every individual in a population. As project managers have a vital involvement in promoting and maintaining the project culture in the construction project environment (Sousa-Poza and Henrie, 2005, Yan and Cao, 2011, Anderson, 2003, Riley and Clare-Brown, 2001), project managers were selected as the target group to distribute questionnaires. The sample was selected from project managers who were registered in the Australian Institute of Project Management (AIPM), the Australian Institute of Building (AIB) and the LinkedIn business networking website. The online survey tool 'Survey Monkey' was used to indicate the level of agreement or disagreement of respondents on barriers to implementing waste management practices in construction projects by using a five-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The electronic link of the survey was published in the monthly newsletter of AIPM and AIB with a brief introduction to the research. Project managers who are working in the Australian construction industry were sorted from LinkedIn and an electronic link to the survey was distributed among them. One hundred forty responses were received and out of those only 104 were used in the final analysis due to the incompleteness of questionnaires.

It was noted that 88% of respondents had more than 10 years of professional experience in the construction industry, while 64% had more than five years of professional experience in the field of waste management, thus making them well-qualified to answer the questionnaire. The data were analysed using the IBM SPSS Statistics 22 software. To analyse the data, descriptive statistics and exploratory factor analysis (EFA) were used in this research.

Factor analysis and principal components analysis (PCA) can be used to identify the underlying dimensions of a data set (Field 2009). Principal components analysis (PCA) is used as a data reduction method (Costello & Osborne 2005) since it helps to summarise many variables into fewer components (Henson & Roberts 2006). According to Gorsuch (1997, p.533), 'the purpose of factor analysis is to identify the fewest possible constructs needed to reproduce the original data'. As Henson and Roberts (2006) explained, by conducting factor analysis, it is possible to identify a smaller set of latent constructs to explain a larger set of measured variables. Fabrigar et al. (1999) noted that factor analysis has certain advantages over principal components analysis (PCA) in the process of identifying the latent variables from a set of variables. Therefore, in this research, factor analysis was carried out instead of principal components analysis (PCA). EFA was conducted to identify underlying latent variables of barriers to implementing waste management practices in construction projects. In this research principal-axis factoring (PAF) was used as the factor extraction method as it does not entail any assumptions on the type of distribution (Fabrigar et al., 1999). There is no consensus on the required sample size to conduct EFA (Costello and Osborne, 2005). However, some researchers recommend having a minimum of 100 in a sample to conduct a factor analysis (Gorsuch, 1983; Coakes and Ong, 2011; MacCallum et al., 1999). At the same time, various tests are available to check the sample adequacy, such as the Kaiser–Meyer–Olkin (KMO) test and Bartlett's sphericity test (Child 2006; Izquierdo, Olea & Abad 2014). KMO measure of sample adequacy is recommended when variable to participants ratio is less than 1:5 (Williams, Brown & Onsman 2012). According to the KMO measure of sample adequacy, a sample should have at least a 0.5 KMO value in order to proceed with factor analysis (Kaiser, 1974). In Bartlett's sphericity test, the value of Sig. should be less than 0.05 for the sample to be considered as adequate. Therefore, in this research a KMO test and Bartlett's sphericity test were carried out to measure the sample adequacy to conduct the factor analysis. The Kaiser-Meer-Olkin measure verified the sampling adequacy for the analysis, KMO = 0.803 and all KMO values for individual items were > 0.564, which is above the acceptable limit of 0.5. Bartlett's test of sphericity X2 (325) = 1316.355, ρ = 0.000, indicated that correlations between items were sufficiently large for the exploratory factor analysis.

Parallel analysis (PA) is used as the factor retention criteria in this research and the "rawpar" programme, which was developed by O'Connor (2014) has been used to determine the number of factors to be retained in the factor analysis. PA is identified as the most accurate factor retention method for factor analysis (Hayton et al., 2004; Henson and Roberts, 2006; Baglin, 2014; Thompson and Daniel, 1996; Field, 2009). As recommended by researchers, oblique rotation was used in this research since it allows for the correlation of factors (Izquierdo et al., 2014, Fabrigar et al., 1999, Field, 2009). The two types of oblique rotations available in SPSS are direct oblimin and promax. Promax is normally designed for large data sets (Field 2009). Therefore, this research used the direct oblimin method. By changing the parameter 'delta' in the direct oblimin method, the obliqueness of data can be changed. Solutions will be most oblique when delta equals zero (0), which is called quartmin. When delta equals 0.5, it is called biquartimin, and when delta equals one (1), it is called covarimin (Basto & Pereira 2012). In this research, the direct oblimin method was used by setting delta to zero to allow the greatest obliqueness in the solution. According to Stevens (2009) for a sample size of 100, factor loading should be greater than 0.512. Therefore, 0.512 was used as a cut-off point. Kahn (2006) emphasised that when naming the factors, it is more appropriate to use structure coefficients and more emphasis should be given to strong structure coefficients while identifying common aspects of the variables. Therefore, structure coefficients were used to name the factors.

4. RESEARCH FINDINGS AND DISCUSSIONS

4.1 Findings of interviews

Table 2 shows the barriers to implementing waste management practices in construction projects as identified from the preliminary interviews and Charrette exercise. These barriers were grouped according to their similarities and 20 main barriers were found.

TABLE 2. Barriers to implementing waste management practices in construction projects identified from interviews and Charrette exercise.

Code	Group name	Barriers to implementing waste management practices
B1	Resistance to change (2)	Resistance to change (2), *Resistance to change*
B2	Attitudes and behaviours towards waste management practices (9)	Attitudes and behaviours of contractors (1), Attitudes of designers (1), Attitudes of clients (2), Behaviours of subcontractors (3), Behaviours and attitudes of construction project participants (2), *Attitudes*, *Ego/Creative aspirations*, *Professionals' expectations*, *Market/client expectations*
B3	Short-term profit-driven nature of the construction industry (7)	Cost-driven nature of the industry's activities (2), Price-driven nature of the clients (2), Trying to build buildings faster and cheaply (1), Contractors more focused on cost savings (1), Difficult economics of alignment (1), Fees are time-based (1)
B4	Lack of commitment or responsibility for waste management from stakeholders (2)	Hard to convince clients about the benefits of waste management (2)
B5	Lack of awareness of construction waste management (2)	Traditional practices of suppliers (1), Lack of awareness of waste management (1), Specifications and the contract (1), *Contractual liability*, *Perceived risks*, *Traditional procurement methods and conventional practices*
B6	Fragmented nature of the construction industry (2)	Lack of individual motivation (1), Layered formation of subcontractors (1), *Short-term profiteering*
B7	Inadequate experience, skills and knowledge on waste management	*Inadequate experience and knowledge*
B8	Higher cost and lack of financial incentives for construction waste management (12)	Higher cost (9), Lack of funding (1), Lack of incentives (2), Cost of labour (2), Cost of monitoring, Cost of disposing of waste (1), Merit-based nature of waste management (1), *Higher cost*
B9	Intense competitiveness (5)	Cutthroat market (1), Competitiveness (1), Time (4), *Culture and ingrained thinking*, *Time*
B10	Poor coordination	*Poor coordination*
B11	Traditionally, waste management is not a priority in construction project management	*General understanding is that waste is only the end of the cycle*
B12	Limited site space (6)	Limited site space (6), *Physical space constraints*
B13	Traditional procurement methods and conventional practices	*Churn: Client/consultant roles change/are no longer involved*

TABLE 2. *(Continiued)*

Code	Group name	Barriers to implementing waste management practices
B14	Absence of a proper market for waste materials and construction waste products (5)	Availability of recycler (2), No manufacturing industry (1), No market for those recycled products (1), No value for some waste materials (3)
B15	Lack of effective construction and demolition (C&D) waste management methods	*Complexity of managing performance-based systems*
B16	Lack of advanced technology to deal with waste (2)	Technology (2)
B17	Confrontational relationships (1)	Stretched nature of site staff (1), *Unwilling to admit mistakes*
B18	Unique nature of construction projects	*Bespoke designs*
B19	Insufficient industrial performance standards and regulations on waste management	*DTS (deemed to satisfy) and prescribed solutions/outcomes*, *Fear of legislation*, *Lack of tools and market acceptance of existing tools*, *Legalistic approach*, *Legal 'impost'*
B20	Reluctance to use recycled materials (1)	Reluctance to use recycled materials (1)

Note: Numbers at the end of each statement indicate the number of interviewees who agreed on particular points. Non-italic font was used to indicate findings were drawn from interviews and *Italic* font was used to indicate findings were drawn from Charrette exercise.

As shown in Table 2, 75% of the interviewees highlighted cost as a main barrier to implementing waste management practices in construction projects. Furthermore, 44% of the interviewees highlighted that, due to the short-term profit-driven nature of the construction industry, most decisions are made based on financial returns and cost savings. Interviewee N stressed that, as cost is one of the main considerations in construction projects, only materials that have financial returns are recycled in construction projects. Interviewee F mentioned that, even though the government promotes recycling or recycled products, sometimes individuals do not have sufficient motivation to recycle or use recycled products as most projects are cost-driven. Thus, cost is seen as a main barrier to implementing waste management practices in construction projects.

As highlighted by 31% of the interviewees, the intense competiveness of the construction industry also acts as a barrier to implementing waste management practices. For example, Interviewee A stressed that when the construction industry is in a recession, 'they [builders] are desperate for work, and they're cutting each other's throats to actually get work'. They further added that when the construction industry is experiencing a boom, builders may say 'sorry we [are] just too busy; we just need to concentrate on how we get this work done'. They mentioned that it is when the market is 'sort of' average that there is the potential to make people think about embracing waste management. Time also acts as a barrier to implementing waste management practices: Interviewee N stated that 'time is money' and that general resourcing and staffing also tend to be impediments to waste management practices. However, they pointed out that the cost of waste disposal is increasing every year. In particular, when contractors have competitive tenders in which they try to find all possible ways to save money, it is difficult to motivate them to implement waste management if that impacts on their profit margins.

The fragmented nature of the construction industry was identified by 12.5% of the interviewees as a barrier to implementing waste management in construction projects. Interviewee E mentioned that the performance of waste management practices is obstructed due to the layered arrangements of construction projects which involve main contractors, subcontractors and materials suppliers. They stated that, as a result of these layered arrangements, the initial processes of waste management set at the higher levels of the project have to filter down through the pyramid of subcontractors: the further away they are from the principal, the more their practices can vary.

Similarly, 56% of the interviewees stated that the attitudes and behaviour of construction practitioners do not help to minimise waste generation. Resistance to change was identified as a barrier to waste management practices in construction projects by 12.5% of the interviewees. For example, Interviewee A noted that, even though recycling is being embraced in the construction industry, there is always a level of resistance to change. Lack of commitment or responsibility for waste management from stakeholders was identified by 12.5% of the interviewees as a barrier to implementing waste management practices in construction projects. Of the interviewees, 12.5% highlighted the lack of awareness of construction waste management as a barrier to implementing waste management practices. These findings highlight the importance of considering human factors in waste management in order to improve the performance of waste management practices in Australian construction projects.

The unavailability of recyclers and the unavailability of a proper market for recycled products was identified by 31% of the interviewees as a barrier to implementing waste management practices. Furthermore, Interviewee N affirmed that designers are keen to recycle; however, the lack of availability of recycling facilities impacts on waste management practices. Interviewee F added that, most of the time, recycling is expensive and not cost-effective to implement and highlighted the necessity of a secondary market for recycled products. Similarly, the interviewees emphasised that recyclers have to demonstrate that the quality of recycled materials is as good as that of virgin (new) materials. This presents a significant barrier to the use of recycled materials.

The lack of advanced technology to deal with waste was identified by 12.5% of the interviewees as a barrier to implementing waste management in construction projects. In all, 37.5% of the interviewees identified not having enough space to segregate waste on site as a main barrier to implementing waste management. Interviewee I further added that contamination usually can occur when all waste is put into one bin without separating waste on site.

4.2 Findings of questionnaire survey

4.2.1 Descriptive statistics of barriers to implementing waste management practices

The ranking results of all barriers to implementing waste management practices are shown in Table 3.

It can be clearly seen from Table 3 that all of the 20 identified barriers have a mean value of greater than 3.00. This indicates that respondents believed that these barriers are all critical to construction waste management.

Some interesting comments were made by respondents. One respondent highlighted that, currently, contractors aim to minimise waste generation to reduce costs incurred in buying

TABLE 3. Ranking of barriers to implementing waste management practices.

Code	Mean	SD	Ranking
B1	4.12	.816	1
B2	4.04	.800	2
B3	3.88	.972	3
B4	3.82	.932	4
B5	3.80	.896	5
B6	3.79	.889	6
B7	3.79	.889	6
B8	3.74	.935	8
B9	3.66	1.030	9
B10	3.65	.922	10
B11	3.64	.975	11
B12	3.64	1.088	12
B13	3.63	.860	13
B14	3.50	1.014	14
B15	3.45	1.013	15
B16	3.43	1.130	16
B17	3.41	.972	17
B18	3.38	.997	18
B19	3.30	.974	19
B20	3.30	1.105	20

additional materials and the cost of waste disposal. However, they mentioned that, due to the one-off nature of construction projects and factors such as human error, waste reduction could be improved further in construction projects. Another respondent commented on limited site space and highlighted that materials such as concrete, sand and other heavy raw materials which make up over 75% of the waste stream, are normally sorted using materials recovery facilities 'off site in a single skip bin'. They revealed that source separation has been carried out as on-site waste separation has been tried and failed in the past owing to the lack of educational initiatives for site teams as well as time restrictions.

TABLE 4. Structure and pattern coefficients: barriers to implementing waste management practices.

Barriers to implementing waste management practices	Factor			
	1	2	3	4
Resistance to change	.826 (.753*)			
Attitudes and behaviours towards waste management practices	.770 (.721*)			
Fragmented nature of the construction industry	.593			
Short-term profit-driven nature of the construction industry		.727 (.670*)		
Unique nature of construction projects		.590 (.595*)		
Intense competitiveness		.581 (.577*)		
Higher cost and lack of financial incentives for implementing construction waste management		.566		
Confrontational relationships among construction project participants	.557	.560		
Traditionally, waste management is not a priority in construction project management		.559		
Traditional procurement methods and conventional practices				
Lack of awareness of ways to improve construction waste management			.840 (787*)	
Inadequate experience and knowledge on waste management			.727 (.691*)	
Lack of commitment or responsibility for waste management from stakeholders	.525		.526	
Poor coordination				
Limited site space				
Absence of a proper market for waste materials and construction waste products		.535		-.735 (-.662*)
Reluctance to use recycled materials				-.617 (-.583*)
Insufficient industrial performance standards and regulations on waste management				-.586 (-.609*)
Lack of advanced technology to deal with waste				-.583 (-.559*)
Lack of effective construction and demolition (C&D) waste management methods				-.535
Initial eigenvalues	6.439	1.889	1.475	1.426
% of variance (cumulative % = 56.146)	32.197	9.445	7.373	7.131
Cronbach's alpha	.808	.787	.758	.745

Note: *pattern coefficients

4.2.2 Identifying the underlying factors of barriers to implementing waste management practices

Principal-axis factoring (PAF) was conducted on 20 items with oblique rotation (direct oblimin). No variable had all correlations less than 0.3 and all MSAs were greater than 0.5. Parallel analysis (PA) was then conducted by using the 'rawpar' program with PAF and raw data permutation for the 20 variables. This identified the existence of four factors. Principal-axis factoring (PAF) was then conducted for 20 items with oblique rotation (direct oblimin) to extract five factors. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis; KMO = 0.802 ('meritorious' according to Williams et al. (2012)]) and all KMO values for individual items were > 0.702, which is above the acceptable limit of 0.5. Bartlett's test of sphericity X2 (190) = 833.196, ρ = 0.000, indicating that correlations between items were sufficiently large for principal-axis factoring (PAF). Table 4 outlines the factor analysis for implementing waste management practices and shows various items that load on specific factors.

Four factors were extracted, explaining 56.15% of the total variance. The first factor (three items) was labelled as 'rigidity of construction practices' consisting of 'resistance to change', 'attitudes and behaviours towards waste management practices' and the 'fragmented nature of the construction industry'. The second factor (six items) was labelled as 'construction project characteristics' consisting of 'short-term profit-driven nature of the construction industry', 'unique nature of construction projects', 'intense competitiveness', 'higher cost and lack of financial incentives for implementing construction waste management', 'confrontational relationships among construction project participants' and 'traditionally, waste management is not a priority in construction project management'. The third factor (three items) was labelled as 'awareness, experience and commitment' consisting of 'lack of awareness of ways to improve construction waste management', 'inadequate experience and knowledge of waste management' and 'lack of commitment or responsibility for waste management from stakeholders'. The fourth factor (five items) was labelled as the 'nascent nature of waste management', consisting of 'absence of a proper market for waste materials and construction waste products', 'reluctance to use recycled materials', 'insufficient industrial performance standards and regulations on waste management', 'lack of advanced technology to deal with waste', and 'lack of effective construction and demolition (C&D) waste management methods'.

4.3 DISCUSSION

The barriers to implementing waste management practices in construction projects were identified from a literature review, the preliminary interviews and Charrette exercise as shown in Table 3. These factors are ranked according to the results of the questionnaire survey. Similarly, the research findings suggest that practitioners in the construction industry have a good understanding of barriers to implementing waste management practices in construction projects.

4.3.1 Critical barriers to implementing waste management practices in construction projects

According to the results of the questionnaire survey, all 20 barriers have mean values above 3.00, thus indicating that all barriers are critical in waste management practices in Australia. Out of these 20 barriers, 'resistance to change' and 'attitudes and behaviour towards waste management practices' have mean values above 4.00, which indicates they are even more critical barriers to implementing waste management practices in construction projects. 'Higher cost and lack of financial incentives for construction waste management', 'attitudes and behaviour towards waste management practices' and the 'short-term profit-driven nature of the construction industry' were the three main barriers identified from the preliminary interviews. Moreover, Yuan et al. (2011) identified a list of major obstacles to improving the performance of construction waste management in China and found similar barriers but in a different order of priority. This is arguably due to cultural differences between China and Australia as those differences could affect behaviours and work practices in the construction project environment.

4.3.2 Rigidity of construction practices

According to the results of this study, 'resistance to change', 'attitudes and behaviours of construction practitioners' and 'lack of commitment or responsibility for waste management' are identified as barriers to implementing waste management practices in construction projects. Thus, these results highlighted the predominant nature of human related barriers to implementing waste management practices in construction projects. Schein (2010) highlighted the resistance to change, which accompanies attempts to change the behaviours of people. This is consistent with understanding of people as 'creatures of habit' (Hodgson, 2004). Yuan et al. (2011), in their research, also identified 'traditional construction culture and behaviour' as a barrier to implementing waste management practices.

4.3.3 Construction project characteristics

'Higher cost and lack of financial incentives for construction waste management' was ranked eighth, according to the results of the questionnaire survey. The results of the preliminary interviews identified cost as a main barrier to implementing waste management practices in construction projects. The preliminary interviewees highlighted that better waste management practices are associated with costs and that a client's commitment always depends on the cost-saving abilities of such actions. They also pointed out that contractors have limited ability to encourage clients and designers to implement waste management practices as most construction project arrangements are price-driven. These findings further support the idea that construction practitioners are focused on profit maximisation rather than on reducing the environmental impacts of construction actions (Wong and Yip, 2004, Yuan and Shen, 2011). The preliminary interviewees highlighted that there is no major incentive for contractors to implement waste management practices, as clients pay for waste disposal. Yuan et al. (2011), in their research, also identified that 'contractors lack economic incentives to carry out waste management in construction' and 'construction and demolition waste management would result in higher project cost' considering the barriers to implementing waste management practices. Another important finding from the preliminary interviews was that, even though contractors are responsible for waste management, most of the time, contractors' ability to influence waste management is determined by the design or documentation and dependent upon project characteristics. Furthermore, time restrictions, controversial relationships, layered arrangements, competitiveness and the unique and fragmented nature of construction projects all act as barriers to implementing waste management practices in construction projects.

4.3.4 Awareness, experience and commitment

Lack of awareness of ways to improve construction waste management', 'inadequate experience and knowledge of waste management' and 'lack of commitment or responsibility for waste management from stakeholders' were identified as barriers to implementing waste management practices in construction projects. Yuan et al. (2011) identified a similar ranking for 'operatives' weak awareness about construction and demolition waste reduction' (ranked fourth) and 'clients' weak awareness about construction and demolition waste management' (ranked fifth) in their study. Despite some similarities between this study and Yuan et al. (2011), there are some differences in the ranking order of critical barriers to implementing waste management practices. This highlights the importance of conducting *context based* studies on barriers to implementing waste management practices.

4.3.5 Nascent nature of waste management

According to the results of the questionnaire survey, project managers believed that even though most recyclable waste is recovered from construction waste, compared to the total waste generated in construction projects, the majority of construction waste is still not recovered. The results of this study indicated that there is *resistance to the reuse and use of recycled materials* in construction projects, a view which is also supported byWong and Yip (2004). The lack of availability of recyclers and lack of a proper market for recycled products also act as barriers to implementing waste management practices. According to Yuan et al. (2011), 'lack of a well-developed waste recycling market' was ranked as the first obstacle to implementing waste management practices. As highlighted by the preliminary interviewees, the effective use of recycled materials in construction projects is associated with difficulties due to some quality issues. In support of this view, two respondents of the questionnaire survey pointed out that recycled materials do not always meet the specification standards and therefore cannot be used. However, according to the interviewees, materials which have financial returns are easily recycled.

In addition, the lack of space in which to segregate waste on site and the lack of advanced technology, act as barriers to implementing waste management in construction projects. Yuan et al. (2011) also identified that the lack of effective construction and demolition (C&D) waste management methods and limited site space were obstacles. Not having enough space for waste sorting is also one of the key limiting factors in construction waste management, as identified from the preliminary interviews. 'Insufficient industrial performance standards and regulation on waste management' was ranked 19th in this study, while in Yuan et al.'s (2011) study, 'insufficient regulation support' was ranked second. As identified by Private Building Certifier A, there is also no provision for waste management in the BCA/NCC in terms of enforcement or as a review policy.

There are four underlying factors, extracted from the factor analysis, relating to barriers to implementing waste management practices in construction projects: rigidity of construction practices; construction project characteristics; awareness, experience and commitment; and the nascent nature of waste management. These findings will be very useful for practitioners and policy makers to make changes in their current practices to enhance the waste management practices in construction projects in Australia. Construction project characteristics and the nature of stakeholders involved in construction projects could be considered in developing/enhancing waste strategies.

The results of this study identified that both technical and human factors acted as critical barriers to enhancing waste management performance. Thus, measures should be introduced to address both technical and human related issues. In particular, human related measures such as education and motivation of stakeholders should be in place to improve waste management practices.

5. CONCLUSIONS

This article has given an account of and considered the reasons for the multiple barriers to implementing CWM practices in Australia to promote waste reduction. The findings are rigorous due to the use of multiple methods in the data collection such as interviews and the questionnaire survey, which were supported by findings of a charrette. The empirical evidence suggests that it is necessary to concentrate on the persistence of traditions, rigidity of construction practices and construction project characteristics when implementing waste management practices in construction projects. At the same time, it is necessary to enhance awareness, experience and commitment of construction stakeholders with regards to waste management practices. This study provides additional evidence with respect to the nascent nature of waste management as project managers still believe that the absence of a proper market for waste materials and construction waste products; reluctance to use recycled materials; insufficient industrial performance standards and regulation of waste management; lack of advanced technology to deal with waste; and lack of effective construction and demolition waste management methods act as barriers to implementing waste management practices. More notably, these findings emphasize the importance of changing cultural values with regard to the prioritising of economic growth over environmental concerns. These findings highlight the importance of addressing the identified barriers to implementing waste management practices, especially the human related barriers.

Necessary actions should be taken by the government and professional institutions in the construction industry to overcome these barriers to promote waste management practices in Australian construction projects. The government and the construction industry could introduce new waste management programmes and financial incentives to enhance the awareness and experience and commitment of construction stakeholders to promote waste management practices. Similarly, it is necessary to promote the use of recycled materials in construction projects through these new programmes. These suggestions were further supported by Udawatta et al. (2015) study that suggested improving the economic viability of waste management by introducing measures such as tax reductions and strategic guidelines for waste management.

This article focuses only on CWM practices in commercial building projects due to the abundance of such projects and also to avoid complexities which may arise when simultaneously evaluating commercial building and residential projects. Similarly, only project managers were targeted in the questionnaire survey, as it was determined that project managers have a vital involvement in the construction project environment. Further research on this topic needs to be undertaken to identify how these barriers can be varied with different stakeholder categories, different project types and different countries. Similarly, future research could further explore the most relevant sociological and anthropological approaches to overcoming cultural and behavioural barriers and improving the implementation of waste management practices in construction projects.

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