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An empirical study of perceptions towards construction and demolition waste recycling and reuse in China

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ABSTRACT

This study was designed to investigate the recent movement and current stage of China's construction and demolition (C&D) waste recycling and reuse. Specifically, the research aimed to provide the big picture of recent C&D waste diversion practice in China, as well as to offer insights from Chinese field practitioners' perceptions towards benefits, challenges, and recommendations of C&D recycling and reuse. This research was conducted based on a review of existing practice and a holistic approach by collecting feedback of professionals from multiple disciplines through a questionnaire-based survey. Totally 77 valid responses were received from 592 questionnaires sent. Both quantitative data and qualitative information implied that China was still at the early stage of recycling C&D wastes. Lack of client demands was identified as one of the main difficulties in C&D waste diversion. The study revealed that engineers and consultants had a more positive perception on promoting industrial training in C&D waste recycling, while construction management professionals held more conservative opinion on it. It was also found that gaining experience in C&D waste recycling and reuse would offer professionals more positive perception on the quality of products containing recycled contents. It was further implied that although governmental supervision had a high impact on China's current C&D waste management practice, the economic viability should eventually dominate the C&D waste diversion.

1. Introduction

Construction and demolition (C&D) waste was defined as a mixture of surplus materials generated from construction, renovation, and demolition activities, for example, site clearance, land excavation and roadwork, and demolition (Shen et al., 2004). It accounts for around 40% of total urban waste in mainland China (China Strategic Alliance of Technological Innovation for Construction Waste Recycling Industry or CSATICWRI, 2014), 26% of total solid waste in the U.S. (U.S. EPA, 2009), and 34% of all industrial waste within Europe (Eurostat, 2016). The construction industry in China is continuing its considerable growth, and billions of tonnes of C&D waste have been produced in recent years due to the large-scale urbanization programs (Duan and Li, 2016). The enormous amount of C&D waste generated in China over the past decades has caused severe damage to the environment (Lu and Yuan, 2010; Wu et al., 2016). Duan and Li (2016) used, Shenzhen, one of China's most developed municipalities as the example, showing that

84% of C&D waste were landfilled in recent years far exceeding the local landfill capacity. It was further stated by Duan and Li (2016) that over half of C&D waste in Shenzhen was disposed to unlicensed landfill sites or by dumping. The urgency in reducing C&D waste to decrease the pressure on landfills and to enhance waste diversion has driven the movement towards the environmental sustainability from both government and industry perspectives in mainland China.

Wu et al. (2016) found that in China, government played an important role in guiding and promoting contractor's behavior in C&D waste management. Several researchers (e.g., Zhao et al., 2008; Zhao et al., 2010; Wu et al., 2016) proposed that besides governmental policy, economic instruments (e.g., tax and subsidy for fostering the recycling industry), and economic viability in terms of business profitability also influenced C&D recycling practice. Technical issues with recycling C&D wastes such as quality of recycled concrete aggregates and their applications were also evaluated in the studies of Li (2008) and Li (2009). Lu and Yuan (2010) suggested the importance of having

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the active participation of all stakeholders (e.g., government, clients, contractors, and suppliers, etc.) in C&D waste management. Nevertheless, lack of communication and coordination among parties was identified by Domingo and Luo (2017) as one of the major barriers. It was further identified by Saez et al. (2013) that limited comprehensive strategies have been studied in effective waste management and individual attitudes towards the C&D waste management evaluation could vary. Whether multiple parties involved in the C&D waste diversion share consistent views on this subject could impact the effectiveness in communication, as the C&D waste management requires team effort in recruiting participants from different disciplines. The other concern was whether the prior project experience would affect professionals' perceptions on C&D waste management.

Research gaps could be identified from a review of these existing studies (e.g., Zhao et al., 2010; Saez et al., 2013; Wang et al., 2014; Domingo and Luo, 2017) in that: 1) there is still limited research on investigating the overall experience of recycling and reusing C&D waste crossing regions in China; 2) there has been insufficient feedback on policy and economy related issues from practitioners and stakeholders who are directly involved in the C&D waste treatment; 3) limited studies have addressed the question regarding the influence of professionals' occupation and prior experience on their perceptions, which could further impact their behavior on C&D waste treatment.

This study targets on investigating the current movement and practice of C&D waste recycling and reuse in China. The objectives of this empirical study are: 1) to gain the overall picture of more recent changes in China's governmental policy and industry practice towards sustainable treatments of C&D waste; 2) to study benefits and difficulties related to C&D waste recycling and reuse from the perspectives of professionals within relevant fields; 3) to explore whether practitioners' perceptions towards C&D waste management related items would be dependent on their occupations or prior experience; and) to provide suggestions on enhancing the existing practice of C&D waste diversion based on the responses received from the questionnaire survey. Survey participants from this study consisted of practitioners or researchers from multiple relevant fields (e.g., material supplier, construction management, and engineering consultants). The following sections of this paper include: 1) background information regarding benefits, barriers, and recommendations in C&D waste recycling and reuse in Section 2.2) a description of research methodology in Section 3 involving a review of China's C&D waste diversion practice in terms of both quantitative data summary and qualitative policy change, as well as a questionnaire-based survey to collect insights from professionals involved in C&D waste treatment; 3) results and discussion in Section 4 with subgroup tests conducted to determine whether the perceptions on C&D waste recycling and reuse would be affected by survey participants' occupations or their prior experience.; 4) summary from findings in Section 5 providing information on whether stakeholders and practitioners from various disciplines, either with or without relevant experience, would share the consistent views on C&D waste management related issues.; and 5) conclusion in Section 6. The findings from this study serve as insights to stakeholders including governmental authorities, especially those from developing countries, on the current practice and trend of C&D waste management in China, as well as provide directions on sustainable treatment of C&D waste in developing or populous regions.

2. Background

2.1. Benefits of recycling and reusing C&D waste

Numerous studies (e.g., Li, 2008; Marzouk and Azab, 2014; Vieira and Pereira, 2015) have recognized several benefits of recycling and reusing C&D waste. These benefits are summarized below:

- Reusing of materials on-site and saving natural resources (Poon and

Chan, 2007; Rao et al., 2007; Tam, 2008a; Zhao et al., 2010; Sabai et al., 2013; Duan et al., 2013; Huang et al., 2013; Vieira and Pereira, 2015);

- Decreasing the needs on landfill spaces (Hsiao et al., 2002; Poon and Chan, 2007; Marzouk and Azab, 2014);
- Saving energy and reducing greenhouse gas emissions (Huang et al., 2013; Marzouk and Azab, 2014);
- Reducing health-related risks associated with landfilled C&D wastes (Marzouk and Azab, 2014);
- Coping with governmental strategy or industry standard to achieve environmental sustainability (Fatta et al., 2003; Li, 2008).

It can be indicated that the recycling and reuse of C&D wastes could generate environmental, social, and economic benefits. For example, recycling programs can save landfill charge and build the social sustainability image (Doan and Chinda, 2016), and construction companies could benefit from reduced waste by lower costs to purchase virgin materials (Bossink and Brouwers, 1996).

2.2. Difficulties and challenges in recycling and reusing

Despite the widely recognized benefits, the sustainable management of C&D waste are facing these difficulties and challenges, including:

- Lack of waste-processing facilities or companies (Melo et al., 2011; Domingo and Luo, 2017; Jia et al., 2017);
- Insufficient relevant policies, regulations, and acts (Chung and Lo, 2003; Fatta et al., 2003; Rao et al., 2007; Domingo and Luo, 2017);
- Poor communication and coordination among parties involved (Domingo and Luo, 2017);
- Lack of economic feasibility and viability in recycling and reusing C&D wastes, for example, when the cost of recycling and reuse exceeding the recycled waste value, or when landfilling tipping charge was lower for direct disposal (Zhao et al., 2008; Zhao et al., 2010);
- Poor qualities of recycled products and their limited applications (Rao et al., 2007; Li, 2009; Zhao et al., 2010; Sabai et al., 2013; Duan and Poon, 2014);
- Reluctance or cultural resistance to implement C&D waste diversion (Saez et al., 2013; Esa et al., 2016), for example, illegal dumping still occurring worldwide (Poon et al., 2001; Conceição Leite et al., 2011; Melo et al., 2011).

It should be noticed that some benefits verse challenges within C&D waste diversion remain inconsistent among different studies. For example, Zhao et al. (2008) and Zhao et al. (2010) were backed by Gull (2011)'s study that incurred labor cost when extracting waste materials and the cost of using extra admixture in the recycled product could downplay the economic benefit of recycling and reusing C&D wastes. In contrast, Tam (2008b)'s case study showed that reusing recycled C&D materials could be more cost effective compared to landfilling them. Therefore, further studies might be needed to determine the effects of multiple parameters (e.g., desired quality of recycled products) in the economic viability of C&D waste diversion.

2.3. Recommendations on improving C&D waste recycling and reusing

Existing studies have provided recommendations in enhancing the effective C&D waste management; these strategies and suggestions include:

- Applying economic instruments, such as tax incentive, penalty and subsidy mechanism (Zhao et al., 2008; Zhao et al., 2010; Marzouk and Azab, 2014; Wang et al., 2014; Jia et al., 2017);
- Governmental initiatives to increase C&D waste diversion activities, for example, a landfill ban for unsorted wastes, policies

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