DRIVING FACTORS FOR CONSTRUCTION WASTE MINIMIZATION: EMPIRICAL STUDIES IN HONG KONG AND SHENZHEN

Zezhou Wu,[1]* Ann T.W. Yu,[2] Hao Wang,[3] Yigang Wei[4] and Xiaosen Huo[5]

ABSTRACT

Effective waste management is an important aspect of green building development. However, a number of studies find that construction waste minimization actions are not satisfactorily performed in practice. Thus, it is of significance to identify the driving factors that influence construction practitioners' waste minimization behavior. This paper aims to explore the driving factors by comparing the affecting factors and construction waste minimization behavior between Hong Kong and Shenzhen. Firstly, through a comprehensive literature review, potential affecting factors were categorized into five groups: background information variables, construction waste minimization intentions, economic viability, governmental supervision, and project constraints. Based on the identified factors, a questionnaire was initially designed and then refined through a focus group meeting with three experienced experts. A total of 166 questionnaires were collected and non-parametric tests (Mann-Whitney U Test and Kruskal-Wallis Test) were conducted to investigate the underlying driving factors. Results revealed that background information variables play insignificant roles in construction waste minimization. Compared with other affecting factors (i.e., waste minimization intentions, governmental supervision, project constraints), economic viability is the most important driving factor that determines construction waste minimization. Results suggested that local governments should make policies that increase practitioners' profit, rather than just increasing their intentions or regulating waste management behavior.

KEYWORDS

driving factor, construction waste minimization, economic viability, Hong Kong, Shenzhen.

1. Assistant Professor, Sino-Australia Joint Research Center in BIM and Smart Construction, Shenzhen University, Shenzhen, China. Email: wuzezhou@szu.edu.cn (*Corresponding author)

2. Associate Professor, Department of Building and Real Estate, The Hong Kong Polytechnic University, Kowloon, Hong Kong. Email: bsannyu@polyu.edu.hk

3. Associate Professor, School of Management Science and Engineering, Central University of Finance and Economics, Beijing, China. Email: hao.wang@cufe.edu.cn

4. Assistant Professor, School of Economics and Management, Beihang University, Beijing, China. Email: weiyg@buaa.edu.cn

5. Assistant Professor, School of Economics and Management, Chongqing Jiaotong University, Chongqing, China. Email: huoxiaosen1025@foxmail.com

1. INTRODUCTION

During the implementation of construction activities, waste is unavoidably generated due to design change, inappropriate material storage, lack of environmental protection awareness, etc. (Ajayi et al., 2017; Ling et al., 2013; Poon et al., 2004). To promote the development of green building, effective waste minimization is required (Laquatra and Pierce, 2009; Wu et al., 2016b). Thus, it is necessary for practitioners to adopt appropriate measures to minimize waste generation at construction sites.

The generation of construction waste is enormous in both Hong Kong and Shenzhen. According to a report published by the Hong Kong Environmental Protection Department (HKEPD), non-inert construction waste that is disposed at landfills was 3,942 tons per day in 2014, increasing 9.8% compared with the disposal rate in 2013 (HKEPD, 2015). Meanwhile, the amount of inert construction materials that are sent to the public fill reception facilities was 34,400 tons per day in 2014 (HKEPD, 2015). In Shenzhen, the minimization of construction waste is not optimistic as well. Lu et al. (2017) estimated that wasted construction materials in Shenzhen was about 1.13 billion tons in 2014; however, the recycling rate was no more than 10%, and the majority was simply landfilled or even illegally dumped.

In recent years, the minimization of construction waste has received widespread attention from both academia and local authorities (Duan et al., 2015; Wu et al., 2014). Waste materials from construction development can be treated as resources at wrong places; they can be reused/recycled after proper treatment. For instance, Pongiglione and Calderini (2014) conducted a case study to demonstrate a steel reuse approach, results showed that reusing wasted steel could not only save new steel but also reduce CO_2 generation. Duan and Poon (2014) claimed that recycled aggregates can be used to produce concrete which has properties as good as the one produced using natural aggregates. In addition to material saving and environmental protection, recycling wasted construction materials can also bring economic profits to the recyclers (Brown et al., 2011). Considering that landfill space is running out in many regions, it is a necessity to save materials at construction sites and minimize waste discharge at landfills (Onyango et al., 2012; Park and Tucker, 2017; Sterner, 2008). Consequently, implementing construction waste minimization in practice is of significant importance.

In order to promote construction waste minimization in practice, it is necessary to understand the driving factors of practitioners' waste management behavior. To date, there have been a number of studies on investigating the affecting factors of practitioners' construction waste minimization behavior in different regions (Lu and Yuan, 2010; Peng et al., 2018; Tam and Lu, 2016; Udawatta et al., 2015a). However, existing studies were conducted focusing on only one specific region, no attempt has been made to explore the underlying driving factors through comparison of two regions. In order to bridge this research gap, this paper empirically investigates the construction waste minimization situations in Hong Kong and Shenzhen. The two regions were selected because the generation of construction waste is enormous in both cities; meanwhile, they are close to each other yet in different contexts. The comparison can investigate if there is difference in terms of construction practitioners' waste minimization behavior, and its potential affecting factors between the two regions. It is expected that the comparison may reflect more insightful reasons of implementing construction waste minimization practices.

The following sections present the potential affecting factors identified from a thorough literature review. Then, the research methodology used in this study is explained. Based on the collected data, non-parametric tests are employed to analyze the differences between Hong

Kong and Shenzhen. Discussions of the derived results are further provided based on interviews with professionals. These findings can serve as valuable references for local government to adopt proper strategies for construction waste minimization.

2. LITERATURE REVIEW

Exploring driving factors is essential for an in-depth understanding of particular phenomena (Hong et al., 2017; Liang et al., 2016; Williams et al., 2010). Previous studies have been conducted to investigate the affecting factors of construction waste minimization behavior (Lu and Yuan, 2011; Palanta et al., 2018; Udawatta et al., 2018). Based on a comprehensive literature review, the affecting factors can be categorized into five groups, namely background information variables, waste minimization intentions, economic viability, governmental supervision, and project constraints.

The background information of practitioners may influence the implementation of waste minimization behavior. For example, Lee and Paik (2011) found that demographic variables could affect respondents' household waste management behavior. In terms of construction waste management, Lingard et al. (2000) stated that managerial staff had a less positive perception of construction waste management than site workers because they focused more on cost, time and quality objectives. Tam et al. (2007) investigated the relationship between on-site waste generation amount and project types, revealing that different construction project types had different levels of waste generation. Begum et al. (2009) claimed that contractors' behavior tended to differ based on their company sizes, construction-related education and experiences of employees.

Construction practitioners' waste minimization intentions may influence their waste management behavior. For example, Li et al. (2015) revealed that designers' attitudes towards waste management had positive and significant effects on their behavior of waste minimization design. According to the study conducted by Kulatunga et al. (2006), the construction project practitioners were found to pay little effort on maintaining positive intentions towards waste minimization. Furthermore, Osmani et al. (2008) claimed that changing designers' current intentions was a significant hurdle to overcome to achieve better waste minimization design. This argument was echoed by Yuan et al. (2011), noting that weak awareness was a significant obstacle for improving the performance of waste management. The research findings revealed by Udawatta et al. (2015b) suggested that attitudinal approaches as well as technologies need to be improved to achieve waste minimization. Two recent studies conducted by Liu et al. (2018) and Yuan et al. (2018) also confirmed the importance of behavioral intentions on actual waste management behavior.

Economic viability is regarded as a critical factor that influences practitioners' waste minimization behavior as gaining profits is a main objective for practitioners to participate in a construction project. Begum et al. (2009) and Al-Sari et al. (2012) found that contractors' involvement in waste management practices was mostly driven by economic considerations. Crocker and Lehmann (2013) also asserted that financial rewards were commonly used in the behavioral change approaches. Through an investigation of nineteen potential factors influencing effective waste minimization, Wang et al. (2014) revealed that economic incentive was one of the top critical factors. Oliveira Neto et al. (2017) claimed that economic performance influences the selection of waste processing technologies. The importance of economic viability was also recognized by many other studies (Colomer Mendoza et al., 2017; Ding et al., 2018; Duran et al., 2006; Jin et al., 2017; Lehmann, 2011; Marrero et al., 2017).

Government supervision, sometimes, exerts a more significant influence in practitioners' waste management behavior. For example, Poon et al. (2001) found that construction practitioners in Hong Kong were reluctant to carry out on-site waste sorting even in when a tipping fee is imposed. This statement was supported by Yu et al. (2013). In their research, it was found that the implementation of the disposal charging scheme had little positive effect on motivating subcontractors to improve their construction waste management behavior. Though it is generally regarded that increasing a waste disposal fee has a positive influence in decreasing waste generation (Hao et al., 2008; Tam, 2008), Poon et al. (2001) claimed that legislation and contractual requirements could be more effective to facilitate the full implementation of effective construction waste management. Manowong (2012) and Yuan (2013) asserted that relevant policies and regulations could enhance the implementation of waste minimization. Wu et al. (2016a) further stated that government should take the responsibility of demolition waste management.

Project constraints are very common in practical construction projects and may influence the implementation of waste minimization practices. Shah Ali et al. (2009) conducted a questionnaire survey in Malaysia and found that time and cost issues were the main problems in refurbishment projects. Li and Yang (2014) further asserted that constrained site spaces and limited access to building information were the main barriers to waste minimization in retrofit projects. In addition to the limited site spaces, Su et al. (2012) argued that labor resource availability and a constrained time schedule were also common project constraints. In the research conducted by Wang et al. (2010), manpower, market for recycled materials, site space, and sorting equipment were identified as the key factors influencing the adoption of on-site sorting. Recently, it has been a trend that newly built buildings are required to apply for green building certificates, waste minimization is also an essential component during the assessment, thus waste minimization can be improved by promoting green building assessment (Doan et al., 2017; Lehmann et al., 2013; Wu et al., 2016b).

Through the above literature review, it can be found that the driving factors may vary in different regions due to specific regional contexts. The existing studies mainly investigated the influencing factors focusing on one specific region; there is a lack of comparison studies for different regions with different contexts. Therefore, this study attempts to compare the construction waste management situations in Hong Kong and Shenzhen, expecting that the comparison may reflect more insightful reasons to implement construction waste minimization practices. Detailed instruments for the investigation are developed based on the potential identified influencing factors and the process of instrument development is described in Section 3.

3. RESEARCH METHODOLOGY

The research methods used in this study involved a combination of literature review, focus group meeting, questionnaire survey and interviews with experienced professionals. A literature review was employed to preliminary identify potential influencing factors and to design an initial questionnaire, then a focus group meeting was conducted to refine the questionnaire and to formulate a formal questionnaire. A questionnaire survey was employed to investigate the differences of construction practitioners' waste minimization behavior and relevant affecting factors between Hong Kong and Shenzhen. After completing the non-parametric tests, interviews with experienced professionals were conducted to discuss the derived results.

3.1 Questionnaire design and data collection

Based on the literature review, an initial questionnaire which measures potential affecting factors was designed. A focus group meeting was further conducted to confirm the affecting factors and to formulate the measurement scales for the subsequent formal questionnaire surveys. Three participants, including one academic researcher whose research field is construction waste management, and two experienced practitioners who have been engaging in construction waste management for more than five years, were invited to participate in the focus group meeting. They were invited because they have sufficient experience in construction waste management. Through the focus group meeting, improvement was made by adding and deleting instruments. In addition, the wording of the instruments was also revised to make them more understandable for practitioners.

In the formal questionnaire, respondents' background variables include the following: job category, work experience, gender, level of education, number of participated projects, project type, contract sum, and number of on-site staff. The developed measurement scales for the affecting factors and waste minimization behavior are shown in Table 1.

A Likert scale was adopted to measure the numeric factors. Five optional responses include "strongly disagree," "disagree," "neutral," "agree," and "strongly agree," with ranking values from 1 to 5 respectively. The third question in the measurement scales of behavioral intention was designed using reverse wording, giving a reverse meaning compared to the other three questions. The purpose of using reverse wording was to test the reliability of the collected responses.

The target population of the questionnaire survey involved construction practitioners in both Hong Kong and Shenzhen. During the data collection process, a "snowball sampling" strategy was employed because of its efficiency and cost effectiveness (Sambasivan and Soon, 2007). In Shenzhen, a total of 132 responses were collected from practitioners, of which 125 responses were valid. In Hong Kong, the collected responses were 46, of which 41 were valid. After statistical analysis, five professionals, who participated in the questionnaire survey and left their contact information were invited to attend face-to-face individual interviews for discussion of the derived results. The background information of the interviewees is presented in Table 2.

3.2 Statistical analysis

A non-parametric test was employed as the statistical analysis technique in this study to evaluate whether there are statistically significant differences between Hong Kong and Shenzhen. Non-parametric techniques were undertaken because, compared with parametric tests, non-parametric tests do not make assumptions about the underlying population distribution, and they are ideal for the data measured by nominal and ordinal scales (Pallant, 2007; Yu et al., 2008). Two non-parametric techniques, the Mann-Whitney U Test and Kruskal-Wallis Test, were used. The former tests the differences between two independent groups, while the latter allows comparison of more than just two groups.

In a Mann-Whitney U Test, the null hypothesis is no significant difference exists between the two independent groups. The corresponding parametric alternative is an Independent-samples T-test. The calculated Z value and probability value (i.e., p-value) are usually used to interpret the analysis results. If the p-value is less than 0.05, the null hypothesis is rejected, which means a significant statistical difference exists between the two groups.

Similar with Mann-Whitney U Test, the null hypothesis of Kruskal-Wallis Test is that there no significant difference exists between the tested three or more independent groups. The corresponding parametric alternative is One-way Between-groups Analysis of Variance. The

TABLE 1. Measure scales of affecting factors.

Affecting factor	Measurement scales
Waste minimization intention	I intend to take actions to avoid construction waste generation.
	I intend to take actions to reuse or recycle construction waste.
	I intend to see the inappropriate dumping of construction waste.
	I intend to attend trainings on construction waste minimization.
Governmental supervision	The government has complete and clear regulations on construction waste management.
	The government has particular department(s) for construction waste management.
	The government has a comprehensive supervision system for construction waste management.
	The government imposes strict punishment to illegal construction waste dumping.
Economic viability	On-site construction waste management can reduce construction cost.
	Decreasing construction waste can save construction cost.
	Effective construction waste management can bring benefits to the company.
	The current fee for discharging construction waste is high.
	The government has attractive policies to encourage minimizing construction waste.
Project constraints	The project has enough workers for effective construction waste management.
	The project has enough money for effective construction waste management.
	The project has enough time for effective construction waste management.
	The project has enough space for effective construction waste management.
	The project has enough equipment for effective construction waste management.
	The current construction waste recycling market is mature.
Behavior	I used to minimize construction waste through appropriate on-site management.
	I used to minimize construction waste through appropriate material procurement.
	I used to minimize construction waste through advanced construction technologies.
	I used to minimize construction waste through on-site sorting.
	I used to directly reuse construction waste in my project.
	I used to recycle construction waste in my project.
	I used to minimize construction waste through other measures in my project.

TABLE 2. Profile of the interviewees.

Interviewee	1	2	3	4	5
Job category	Construction engineering	Quantity survey	Construction engineering	Project management	Project management
Working experience	0–5 years	6–10 years	6–10 years	Over 15 years	6–10 years
Gender	Male	Male	Male	Male	Male
Level of education	Postgraduate	Bachelor	Bachelor	Bachelor	Bachelor
Number of participated projects	1–5	6–10	6–10	11–20	6–10
Project type	Residential building	Public works	Residential building	Residential building	Commercial building
Number of on-site staff	More than 200	More than 200	101–200	More than 200	More than 200

Chi-Square value, the degrees of freedom, and the significance level are the main indicators for interpreting the outputs. If the significance level is less than 0.05, the null hypothesis is rejected and there are significant differences among these groups.

4. RESULTS AND DISCUSSION

4.1 Influence of personal background variables

The non-parametric test results of personal background information variables to waste minimization behavior are presented in Table 3. In the eight background variables, the variable of "Gender" has two groups (i.e., male and female), thus Mann-Whitney U Test was selected as the analysis method. The other background variables have more than three groups; as a result, the Kruskal-Wallis Test was employed for the analysis.

From Table 3, it can be seen that all significance levels of the non-parametric tests are larger than 0.05. It can be concluded that the background variables have no significant influence in implementing construction waste minimization in both Hong Kong and Shenzhen. This research finding is different from the arguments of Begum et al. (2009) who claimed that company size, education level of employees, and work experiences critically influence waste minimization behavior in Malaysia. The research findings in this study revealed that the background variables, in both Hong Kong and Shenzhen, play an insignificant role in determining practitioners' waste minimization behavior.

4.2 Comparison of affecting factors

The affecting factors and construction waste minimization behavior in Hong Kong and Shenzhen were compared using non-parametric tests. The Mann-Whitney U Test was selected

TABLE 3. Non-parametric tests of background information variables.

Variable	p-value	
	Shenzhen	Hong Kong
Job category	0.278	0.700
Experience	0.257	0.576
Gender	0.058	0.357
Education	0.480	0.505
Project number	0.856	0.648
Project type	0.199	0.975
Contract sum	0.051	0.576
Staff number	0.301	0.709

as the analysis method because there are two groups compared, i.e., Hong Kong and Shenzhen. The results of the non-parametric tests are shown in Table 4. From Table 4, it can be seen that the affecting factors in Hong Kong and Shenzhen are significantly different at the significance level of 0.05, which means the levels of affecting factors in Hong Kong and Shenzhen are different. The means of waste minimization intentions, governmental supervision, and project constraints in Shenzhen were greater than Hong Kong, whilst the mean of economic viability of Shenzhen was lower. The levels of construction waste minimization behavior in the two regions were also different at the significance level of 0.1. The mean of construction waste minimization behavior in Shenzhen was lower than Hong Kong, which indicates that the practitioners in Hong Kong perform better construction waste minimization in practice than the practitioners in Shenzhen.

In terms of the behavioral intentions of construction waste minimization, the practitioners from both Shenzhen and Hong Kong showed positive willingness. The mean values of behavioral intentions in both regions exceeded 3.7, illustrating that the construction practitioners in the two regions were willing to adopt effective construction waste minimization measures from their individual perspectives. However, the practical construction waste minimization performance in both regions were regarded as not satisfactory; the mean values of behavior were just 2.696 and 2.902, respectively, both less than a neutral score (i.e., 3.0). This means that behavioral intentions do not have a positive influence in practical implementation. This research finding is opposite to the conclusions from many existing research studies (e.g., Begum et al. (2009) and Osmani et al. (2008). This brings to mind the proverb: "*the road to hell is paved with good intentions*." In the construction industry of Hong Kong and Shenzhen, the practitioners' construction waste minimization behavior was not improved because of their good intentions. During the following-up interviews, an interviewee said that though they have a willingness to reduce construction waste generation, there are many other aspects that they should pay more attention to. For example, if the project is required to be completed in a limited period, they would deemphasize construction waste minimization and focus more on how to shorten the construction period.

TABLE 4. Non-parametric tests of affecting factors and construction waste minimization behavior.

Affecting factor	Mean		Difference	Z	p-value
	Shenzhen	Hong Kong			
Waste minimization intention	4.048	3.781	0.268	–2.696	0.007
Governmental supervision	3.551	3.144	0.407	–3.416	0.001
Economic viability	2.535	3.061	–0.526	–5.126	0.000
Project constraints	3.597	2.720	0.877	–6.489	0.000
Behavior	2.696	2.902	–0.207	–1.745	0.081

Hong Kong and Shenzhen both have regulations guiding practitioners' construction waste minimization behavior. However, the practitioners' perceived governmental supervision in Shenzhen is better than Hong Kong, getting a mean score of 3.551. This finding is a little surprising. In Hong Kong, construction waste minimization has been attracted attention from the government since the 1990s. A website was specifically established by the Environmental Protection Department (EPD) for introducing construction waste minimization measures and publishing construction waste statistics (EPD, 2015). Meanwhile, a disposal charging scheme has been implemented in order to achieve construction waste minimization (Hao et al., 2008; Lu and Tam, 2013). Thus, it is generally regarded that governmental supervision in Hong Kong is better than Shenzhen. According to an interviewee from Hong Kong, the possible reason may be that construction waste management regulations have been implemented in Hong Kong for a long period without any improvement; therefore, the practitioners have already got used to the existing requirements. In other words, the existing regulations have few effects on improving the practitioners' perceptions towards construction waste minimization improvement. Nevertheless, as the local government in Shenzhen have been paying increasing attention to sustainable development in the construction industry, practitioners perceive an increasing governmental supervisory role for construction waste minimization.

Despite the better perceived behavioral intentions and governmental supervision, the economic viability of construction waste minimization in Shenzhen is lower than Hong Kong. Economic viability involves two aspects: cost and profit. According to the charging scheme in Hong Kong, it takes HK$71, HK$175 and HK$200 for each ton of waste disposal at public fill reception facilities, sorting facilities, and landfills respectively. In Shenzhen, the waste disposal charging fee varies greatly from region to region, ranging from 2 yuan/ton (1 yuan = 1.16 HK$) in Beijing and Shanghai to 70 yuan/ton in Jiangxi and Hubei province (Yuan and Wang, 2014). Through this comparison, it can be easily concluded that the cost of waste disposal in Shenzhen is much less than in Hong Kong. In addition, the recycling market in Hong Kong is better than Shenzhen. In Hong Kong, the list of recycled construction materials and products are presented on the official website of EPD, and the information of recyclers, such as acceptable waste types, locations, is presented for selecting a recycler. Thus, the economic viability of construction waste minimization in Hong Kong is better than Shenzhen.

The level of perceived project constraints (i.e., 2.72) in Hong Kong is lower than the normal level of 3.00. This indicates that project constraints, such as lack of enough workers or space, may be factors that hinder the implementation of construction waste minimization. However, practitioners from Shenzhen seem to be more optimistic about project conditions than Hong Kong practitioners, with a mean value of 3.597. These findings are not difficult to explain. In Hong Kong, there are many construction activities based on existing, developed projects. The work space at such construction sites is usually limited; there might be not enough place to store and sort generated waste. However, projects in Shenzhen are usually newly developed projects which involve several development phases. It is rare that space limitation is a problem. In addition, the labor cost for a single experienced worker in Hong Kong is much higher than Shenzhen, which also caused the perception of project constraints.

In terms of construction waste minimization behavior, contractors from both Hong Kong and Shenzhen regarded it as insufficient. According to the statistical analysis results, practitioners in Hong Kong perform relatively better than Shenzhen at the significance level of 0.1. Overall, the practitioners in Shenzhen have advantages in implementing waste minimization management from the aspects of behavioral intentions, governmental supervision, and project constraints; however, the economic viability of conducting construction waste minimization is not as good as Hong Kong. The only weakness (i.e., economic viability) leads to the lower performance of construction waste management. Thus, it can be concluded that, compared with other affecting factors, economic viability is the most significant factor determining practitioners' waste minimization behavior. Supported by Wu et al. (2017), it is found that the factor of behavioral intentions does not play a determinant role in waste minimization behavior.

5. CONCLUSIONS

Understanding the affecting factors is essential for implementing effective construction waste minimization. This study compared the affecting factors between Hong Kong and Shenzhen in order to provide insightful reference for the promotion of effective waste minimization management.

Results derived from non-parametric tests revealed that the performance of waste minimization in Shenzhen was lower than Hong Kong. The background variables, such as job category, gender, education level, did not play important roles in determining practitioners' construction waste minimization behavior in both Hong Kong and Shenzhen. The other four affecting factors (i.e., waste minimization intentions, governmental supervision, economic viability, and project constraints) were significantly different between Hong Kong and Shenzhen. Overall, the affecting factors in Shenzhen got higher scores than the ones in Hong Kong, except economic viability. Given the better performance in Hong Kong, it can be concluded that economic viability is more significant in affecting practitioners' waste minimization behavior.

According to the derived results, it is suggested that rather than attempting to increase practitioners' waste minimization intentions or regulating their waste management behavior, the most efficient measures for local government to promote construction waste minimization should be related to the policies that can increase practitioners' profits. At the industry level, project managers should make a reward mechanism for workers to encourage their material saving behavior.

ACKNOWLEDGMENTS

This study was supported by the Humanities and Social Sciences Grant, Ministry of Education [grant number 17YJCZH191]; Natural Science Foundation of SZU [grant number 2017065]; Guangdong Planning Office of Philosophy and Social Science [grant number GD16YGL07]; Youth Talents Programme of the Central University of Finance and Economics [grant number QYP1711]; Beijing Social Science Foundation [grant number 17GLB030] and Fundamental Research Funds for the Central Universities [grant number QL18012].

REFERENCES

Ajayi, S.O., Oyedele, L.O., Akinade, O.O., Bilal, M., Alaka, H.A., Owolabi, H.A., 2017. Optimising material procurement for construction waste minimization: An exploration of success factors. Sustainable Materials and Technologies 11, 38–46.

Al-Sari, M.I., Al-Khatib, I.A., Avraamides, M., Fatta-Kassinos, D., 2012. A study on the attitudes and behavioural influence of construction waste management in occupied Palestinian territory. Waste Management & Research 30 (2), 122–136.

Begum, R.A., Siwar, C., Pereira, J.J., Jaafar, A.H., 2009. Attitude and behavioral factors in waste management in the construction industry of Malaysia. Resources Conservation and Recycling 53 (6), 321–328.

Brown, T., McEvoy, F., Ward, J., 2011. Aggregates in England—Economic contribution and environmental cost of indigenous supply. Resources Policy 36 (4), 295–303.

Colomer Mendoza, F.J., Esteban Altabella, J., Gallardo Izquierdo, A., 2017. Application of inert wastes in the construction, operation and closure of landfills: Calculation tool. Waste Management 59, 276–285.

Crocker, R., Lehmann, S., 2013. Motivating change: sustainable design and behaviour in the built environment. Routledge.

Ding, Z., Zhu, M., Tam, V.W.Y., Yi, G., Tran, C.N.N., 2018. A system dynamics-based environmental benefit assessment model of construction waste reduction management at the design and construction stages. Journal of Cleaner Production 176, 676–692.

Doan, D.T., Ghaffarianhoseini, A., Naismith, N., Zhang, T., Ghaffarianhoseini, A., Tookey, J., 2017. A critical comparison of green building rating systems. Building and Environment 123 (Supplement C), 243–260.

Duan, H., Wang, J., Huang, Q., 2015. Encouraging the environmentally sound management of C&D waste in China: An integrative review and research agenda. Renewable and Sustainable Energy Reviews 43, 611–620.

Duan, Z.H., Poon, C.S., 2014. Properties of recycled aggregate concrete made with recycled aggregates with different amounts of old adhered mortars. Materials & Design 58, 19–29.

Duran, X., Lenihan, H., O'Regan, B., 2006. A model for assessing the economic viability of construction and demolition waste recycling—the case of Ireland. Resources, Conservation and Recycling 46 (3), 302–320.

EPD, 2015. Introduction to Construction Waste. <http://www.epd.gov.hk/epd/misc/cdm/introduction.htm>.

Hao, J.L., Hills, M.J., Tam, V.W.Y., 2008. The effectiveness of Hong Kong's Construction Waste Disposal Charging Scheme. Waste Management & Research 26 (6), 553–558.

HKEPD, 2015. Monitoring of Solid Waste in Hong Kong. <https://www.wastereduction.gov.hk/sites/default/files/msw2014.pdf>.

Hong, J., Li, C.Z., Shen, Q., Xue, F., Sun, B., Zheng, W., 2017. An Overview of the driving forces behind energy demand in China's construction industry: Evidence from 1990 to 2012. Renewable & Sustainable Energy Reviews 73, 85–94.

Jin, R., Li, B., Zhou, T., Wanatowski, D., Piroozfar, P., 2017. An empirical study of perceptions towards construction and demolition waste recycling and reuse in China. Resources, Conservation and Recycling 126, 86–98.

Kulatunga, U., Amaratunga, D., Haigh, R., Rameezdeen, R., 2006. Attitudes and perceptions of construction workforce on construction waste in Sri Lanka. Management of Environmental Quality: An International Journal 17 (1), 57–72.

Laquatra, J., Pierce, M., 2009. Taking construction site waste management to the next level. Journal of Green Building 4 (4), 29–32.

Lee, S., Paik, H.S., 2011. Korean household waste management and recycling behavior. Building and Environment 46 (5), 1159–1166.

Lehmann, S., 2011. Resource recovery and materials flow in the city: zero waste and sustainable consumption as paradigm in urban development. Journal of Green Building 6 (3), 88–105.
Lehmann, S., Zaman, A.U., Devlin, J., 2013. Integrated demand forecasting to support urban planning of low-carbon precincts: The waste scenario. Journal of Green Building 8 (2), 54–70.
Li, J., Tam, V.W.Y., Zuo, J., Zhu, J., 2015. Designers' attitude and behaviour towards construction waste minimization by design: A study in Shenzhen, China. Resources, Conservation and Recycling 105, Part A, 29–35.
Li, M., Yang, J., 2014. Critical factors for waste management in office building retrofit projects in Australia. Resources, Conservation and Recycling 93, 85–98.
Liang, X., Hong, T., Shen, G.Q., 2016. Occupancy data analytics and prediction: A case study. Building and Environment 102, 179–192.
Ling, T.C., Poon, C.S., Wong, H.W., 2013. Management and recycling of waste glass in concrete products: Current situations in Hong Kong. Resources, Conservation and Recycling 70, 25–31.
Lingard, H., Graham, P., Smithers, G., 2000. Employee perceptions of the solid waste management system operating in a large Australian contracting organization: implications for company policy implementation. Construction Management and Economics 18 (4), 383–393.
Liu, J., Gong, E., Wang, D., Lai, X., Zhu, J., 2018. Attitudes and behaviour towards construction waste minimisation: a comparative analysis between China and the USA. Environmental Science and Pollution Research, 1–10.
Lu, W., Tam, V.W.Y., 2013. Construction waste management policies and their effectiveness in Hong Kong: A longitudinal review. Renewable and Sustainable Energy Reviews 23, 214–223.
Lu, W., Webster, C., Peng, Y., Chen, X., Zhang, X., 2017. Estimating and calibrating the amount of building-related construction and demolition waste in urban China. International Journal of Construction Management 17 (1), 13–24.
Lu, W., Yuan, H., 2011. A framework for understanding waste management studies in construction. Waste Management 31 (6), 1252–1260.
Lu, W.S., Yuan, H.P., 2010. Exploring critical success factors for waste management in construction projects of China. Resources Conservation and Recycling 55 (2), 201–208.
Manowong, E., 2012. Investigating factors influencing construction waste management efforts in developing countries: An experience from Thailand. Waste Management & Research 30 (1), 56–71.
Marrero, M., Puerto, M., Rivero-Camacho, C., Freire-Guerrero, A., Solís-Guzmán, J., 2017. Assessing the economic impact and ecological footprint of construction and demolition waste during the urbanization of rural land. Resources, Conservation and Recycling 117, Part B, 160–174.
Oliveira Neto, R., Gastineau, P., Cazacliu, B.G., Le Guen, L., Paranhos, R.S., Petter, C.O., 2017. An economic analysis of the processing technologies in CDW recycling platforms. Waste Management 60 (Supplement C), 277–289.
Onyango, J., McGeough, C., Obonyo, E., 2012. Waste to worth: Evaluation of potential waste heat recovery system within commercial kitchens in Northern Ireland. Journal of Green Building 7 (4), 62–69.
Osmani, M., Glass, J., Price, A.D.F., 2008. Architects' perspectives on construction waste reduction by design. Waste Management 28 (7), 1147–1158.
Palanta, I., Aretoulis, G., Palantas, P., 2018. Facilitating decision making on construction and demolition waste management in Greece through dynamic system modelling. International Journal of Management and Decision Making 17 (2), 199–223.
Pallant, J., 2007. SPSS survival manual: A step-by-step guide to data analysis using SPSS version 15.
Park, J., Tucker, R., 2017. Overcoming barriers to the reuse of construction waste material in Australia: a review of the literature. International Journal of Construction Management 17 (3), 228–237.
Peng, Y., Zhu, X., Zhang, F., Huang, L., Xue, J., Xu, Y., 2018. Farmers' risk perception of concentrated rural settlement development after the 5.12 Sichuan Earthquake. Habitat International 71, 169–176.
Pongiglione, M., Calderini, C., 2014. Material savings through structural steel reuse: A case study in Genoa. Resources, Conservation and Recycling 86, 87–92.
Poon, C.S., Yu, A.T.W., Ng, L.H., 2001. On-site sorting of construction and demolition waste in Hong Kong. Resources, Conservation and Recycling 32 (2), 157–172.
Poon, C.S., Yu, A.T.W., Wong, S.W., Cheung, E., 2004. Management of construction waste in public housing projects in Hong Kong. Construction Management and Economics 22 (7), 675–689.

Sambasivan, M., Soon, Y.W., 2007. Causes and effects of delays in Malaysian construction industry. International Journal of Project Management 25 (5), 517–526.

Shah Ali, A., Nizam Kamaruzzaman, S., Salleh, H., 2009. The characteristics of refurbishment projects in Malaysia. Facilities 27 (1/2), 56–65.

Sterner, C.S., 2008. Waste and city form: Reconsidering the medieval strategy. Journal of Green Building 3 (3), 69–78.

Su, X., Andoh, A.R., Cai, H., Pan, J., Kandil, A., Said, H.M., 2012. GIS-based dynamic construction site material layout evaluation for building renovation projects. Automation in construction 27, 40–49.

Tam, V.W.-Y., Lu, W., 2016. Construction waste management profiles, practices, and performance: a cross-jurisdictional analysis in four countries. Sustainability 8 (2), 190.

Tam, V.W.Y., 2008. On the effectiveness in implementing a waste-management-plan method in construction. Waste Management 28 (6), 1072–1080.

Tam, V.W.Y., Shen, L.Y., Tam, C.M., 2007. Assessing the levels of material wastage affected by sub-contracting relationships and projects types with their correlations. Building and Environment 42 (3), 1471–1477.

Udawatta, N., Zuo, J., Chiveralls, K., Yuan, H., George, Z., Elmualim, A., 2018. Major factors impeding the implementation of waste management in australian construction projects. Journal of Green Building 13 (3), 101–121.

Udawatta, N., Zuo, J., Chiveralls, K., Zillante, G., 2015a. Attitudinal and behavioural approaches to improving waste management on construction projects in Australia: Benefits and limitations. International Journal of Construction Management 15 (2), 137–147.

Udawatta, N., Zuo, J., Chiveralls, K., Zillante, G., 2015b. Improving waste management in construction projects: An Australian study. Resources, Conservation and Recycling 101, 73–83.

Wang, J.Y., Li, Z., Tam, V.W.Y., 2014. Critical factors in effective construction waste minimization at the design stage: A Shenzhen case study, China. Resources, Conservation and Recycling 82, 1–7.

Wang, J.Y., Yuan, H.P., Kang, X.P., Lu, W.S., 2010. Critical success factors for on-site sorting of construction waste: A China study. Resources, Conservation and Recycling 54 (11), 931–936.

Williams, M.J., Nobe, M.C., Dunbar, B.H., Criswell, M.E., 2010. Acceptance of waste-minimization practices by construction management students. Journal of Green Building 5 (4), 158–175.

Wu, H., Duan, H., Zheng, L., Wang, J., Niu, Y., Zhang, G., 2016a. Demolition waste generation and recycling potentials in a rapidly developing flagship megacity of South China: Prospective scenarios and implications. Construction and Building Materials 113, 1007–1016.

Wu, Z., Shen, L., Yu, A.T.W., Zhang, X., 2016b. A comparative analysis of waste management requirements between five green building rating systems for new residential buildings. Journal of Cleaner Production 112, Part 1, 895–902.

Wu, Z., Yu, A.T.W., Shen, L., 2017. Investigating the determinants of contractor's construction and demolition waste management behavior in Mainland China. Waste Management 60, 290–300.

Wu, Z., Yu, A.T.W., Shen, L., Liu, G., 2014. Quantifying construction and demolition waste: An analytical review. Waste Management 34 (9), 1683–1692.

Yu, A.T.W., Poon, C.S., Wong, A., Yip, R., Jaillon, L., 2013. Impact of Construction Waste Disposal Charging Scheme on work practices at construction sites in Hong Kong. Waste Management 33 (1), 138–146.

Yu, A.T.W., Shen, Q., Kelly, J., Hunter, K., 2008. Comparative study of the variables in construction project briefing/architectural programming. Journal of construction engineering and management 134 (2), 122–138.

Yuan, H., Wu, H., Zuo, J., 2018. Understanding Factors Influencing Project Managers' Behavioral Intentions to Reduce Waste in Construction Projects. Journal of Management in Engineering 34 (6), 04018031.

Yuan, H.P., 2013. A SWOT analysis of successful construction waste management. Journal of Cleaner Production 39, 1–8.

Yuan, H.P., Shen, L.Y., Wang, J.Y., 2011. Major obstacles to improving the performance of waste management in China's construction industry. Facilities 29 (5), 224–242.

Yuan, H.P., Wang, J.Y., 2014. A system dynamics model for determining the waste disposal charging fee in construction. European Journal of Operational Research 237 (3), 988–996.