

Major Factors Affecting Waste Generation on Construction Sites in Iran

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Abstract

Construction and demolition (C&D) waste account for a large share of total solid waste sent to the environment. As a result, effective C&D waste management has been treated as one of the available avenues towards sustainable development. Yet, C&D waste management within the Iranian construction industry has been literally overlooked by investigators. As one of the first studies in Iran, the main causes of generating C&D waste on construction projects have been identified through a review of literature. Afterwards, the list has been subjected to the scrutiny of 101 experts in the field deploying a questionnaire survey. The findings revealed that important causes of C&D waste generation on construction sites were all associated with lack of skills and experience of construction workers and lack of awareness of the concept of waste and values of construction materials. No discrepancy in terms of causes of waste generation was observed among different tiers of construction companies in the Iranian construction industry. The paper concludes with providing a number of guidelines to address the issues as identified for Iran and other developing countries suffering from the same problems.

Keywords: C&D waste, waste generation, construction project, sites, Iran.

Introduction

Iran is facing serious issues in terms of the large amounts of C&D waste generated in construction activities. According to TWMO (2014), the amount of annually C&D waste generated in Tehran amounted to around 23 million tons during the period 2013-2014 from which only a small fraction was recycled and the rest was disposed in landfills. Such large amounts of solid waste pose a wide range of environmental predicaments for Iran. Particularly, because pollutants are not identified and properly treated before disposal in landfills as postulated by Ghazinoory (2005).

As the first step to resolve the issue in any country, the main causes of C&D waste generation on construction projects should be identified as indicated by Poon (2007). Developed countries have devoted considerable effort to discover the such causes, yet developing countries are still lagging behind in identifying the main sources of waste generation as postulated by Yuan and Shen (2011). In line with such an insight, review of the literature reveals a clear lack of research within the Iranian context on identifying the sources of waste. In essence very few studies e.g. (Saghafi and Teshnizi, 2011; Najafpoor and Jamali-Behnam, 2014; Meibodi et al., 2015) have been conducted on C&D waste management in Iran while for the most part they have focused on particular issues related to

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waste management and have not attempted to discover the sources of waste generation. In fact, no explicit body of knowledge is available to provide an insight into the major reasons behind C&D waste generation on construction projects in Iran. As the first study in its kind in Iran, here is an attempt made to discover and unearth the major sources of C&D waste generation within the Iranian construction industry.

Literature review

All the waste generated during the construction, renovation and demolition activity (excavation, construct building, cleaning the sites, demolition activities, road jobs, renovation the building, etc...) fall within the category of C&D Waste (Shen *et al.*, 2004). C&D waste exposes serious issues in different countries. As an example, the amount of C&D waste generated in the USA is 136 million ton per year in the year 2006 while merely 20% to 30% was recycled. China generates the 29% of the whole municipality solid waste in the world from which around 40% falls within the category of C&D waste (Yuan and Shen, 2011). In the Middle East in Kuwait, 15 to 30 percent of solid waste is produced through construction activities and more than 90% of this is recycled as pointed out by Kartam *et al.* (2004). The strategies for C&D waste management can be considered according to C&D waste pyramid (see Figure 1) according to which the lowest environmental impacts belong to strategies that pursue reducing C&D waste generation. The amount of waste generated on-site is of great salience in terms of addressing the problems associated with C&D waste in view of the fact that around 10%-30% of construction materials might be wasted as announced by Chen *et al.* (2002).

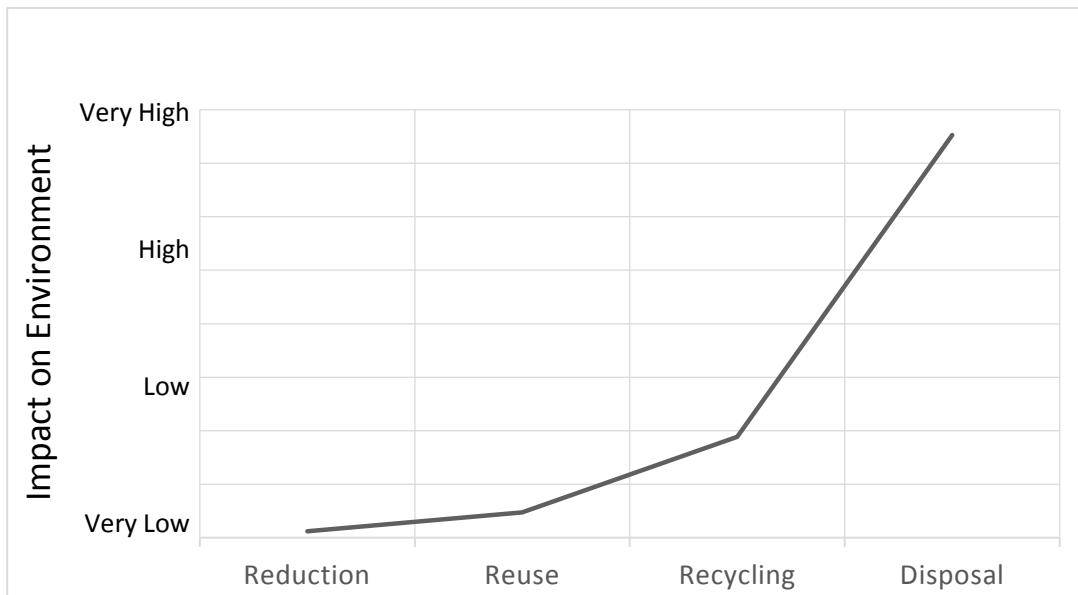


Figure 1. C&D waste management strategies impacts on the environment

As a result, investigating the main causes of waste generation on construction projects have become an active field of research in different countries (Yean Yng Ling and Song Anh Nguyen, 2013). The findings of a number of noteworthy investigations in this regards are briefly illustrated in Table 1.

Table 1. The causes of C&D waste generation on construction site

No.	Causes of C&D waste generation on-site
1	Lack of skills and experience of construction workers
2	Lack of skills and experience of demolition contractors
3	Wasteful use of materials in construction activities
4	Inappropriate methods for loading and shipment of building materials from suppliers to sites
5	Inappropriate methods for handling and shipment of building materials on-site
6	Frequent demolitions due to reworks and change of orders
7	Prevalence of traditional methods of construction
8	Inappropriate packaging of building materials and components
9	Inappropriate inventory of building materials and components
11	Low quality of buildings components and materials

Sources: (Teo and Loosemore, 2001; Ekanayake and Ofori, 2004; Poon, 2007; Oyedele *et al.*, 2013; Yean Yng Ling and Song Anh Nguyen, 2013)

In general, findings of previous studies bring to light that different sets of factors are the main sources of waste generation for different nations due to the specific idiosyncrasies of the construction industry (Yean Yng Ling and Song Anh Nguyen, 2013). This includes dissimilarities between environmental regulations and behavior of construction practitioners. Even more, Teo and Loosemore (2001) stated that behaviors to waste generation might be different in different organizations in one country. Therefore, due to lack of previous studies on waste generation minimization, Iran deserves its own research study in view of its unique socio-economic, political and technological conditions. This has been the driving force behind this study as described below.

Methodology

The questionnaire for the study was divided into three main categories comprising (1) demographics of respondent, (2) five questions for evaluation of the current state of waste management on construction projects (3) eleven factors (identified from the literature) to elucidate the perceptions of respondents regarding the main sources of waste generation on construction sites. This is regarding the level of influence of each factor in impeding implementation of an effective waste management regime in the country. The questionnaire was designed based on a five-point Likert rating scale comprising effect levels of very high=5, high=4, moderate=3, low=2, and very low=1. The developed questionnaire was pilot tested by sending it to three project managers. Feedback obtained was incorporated into the questionnaire prior to delivering the survey to the population of interest.

The target population included various types of contractors involving in all kinds of construction activities in Tehran. According to the formal classification of contractors currently in place in Iran, construction companies active in government projects are classified into 5 tiers. Those in tier 1 are the most large-sized and are allowed to undertake projects with the biggest budgets (Ghoddousi and Hosseini, 2012) while companies in tier 5 are usually newly-established companies that carry out small projects. Apart from these 5

tiers, some firms are involving in construction of small residential dwellings and dealing with the private sector. The target population covered both private sector companies and those clarified in 5 tiers as described above. Invitations were sent out to 350 companies in October 2014 and 125 responses were received by February 2015. Inspection of returned questionnaires resulted in considering 101 properly-completed questionnaires manifesting a response rate of around 28 percent.

As Iran's capital, Tehran with the population of over 10 million (almost 15% of total population in Iran) is the largest city in the country and among the most populated capitals in the world. Due to the concentration of a wide range of socio-economic opportunities, many construction professionals with different expertise and from other regions of the country migrate to Tehran to seek for construction positions. Thus, Tehran was regarded as a representative of a pool of a wide range of construction professionals with various expertise as argued by Ghoddousi *et al.* (2014).

Results and discussion

Profile of respondents

Participants in the survey came from different positions in Iran's construction industry such as consultants, site supervisors, builders, project managers and member of board of directors etc. Out of the selected participants, almost 50% of the respondents were from construction firms dealing with private sector, while other 50% were registered contractors dealing with governmental construction projects. Furthermore, the sample was deemed adequately knowledgeable of the issues associated with waste management because nearly 78% of respondents had more than 6 years of experience within the Iranian construction industry (Table 2).

Table 2. Contractor's experiences based on their company's role in the industry

Contractor's Tier	Years of experience				Total
	< 5	6 < > 10	11 < > 20	> 21	
Private firms	16 %	16 %	17 %	3 %	51 %
Tier 1	3 %	3 %	8 %	2 %	16 %
Tier 2	1 %	3 %	5 %	4 %	13 %
Tier 3	1 %	2 %	3 %	2 %	8 %
Tier 4	1 %	1 %	2 %	0 %	4 %
Tier 5	0 %	4 %	2 %	2 %	8 %
Total	22 %	28 %	37 %	13 %	100 %

Current state of waste management

To evaluate the current state of waste management in Iran, respondents were asked to indicate their perception regarding the level of priority assigned to waste management on their projects; the level of recycling implementation and the level of waste sent to landfill on a scale from very low to very high as illustrated in Figure 2. This was based on the suggestion put forward by Yean Yng Ling and Song Anh Nguyen (2013), indicating that effectiveness of waste management may be evaluated based on the quantity of waste generated, quantity of waste that were reused and recycled. Additionally, the common perceptions in the Iranian

construction projects regarding the priority of waste were assessed to incorporate the behaviors as an important factor affecting waste management and generation (Teo and Loosemore, 2001).

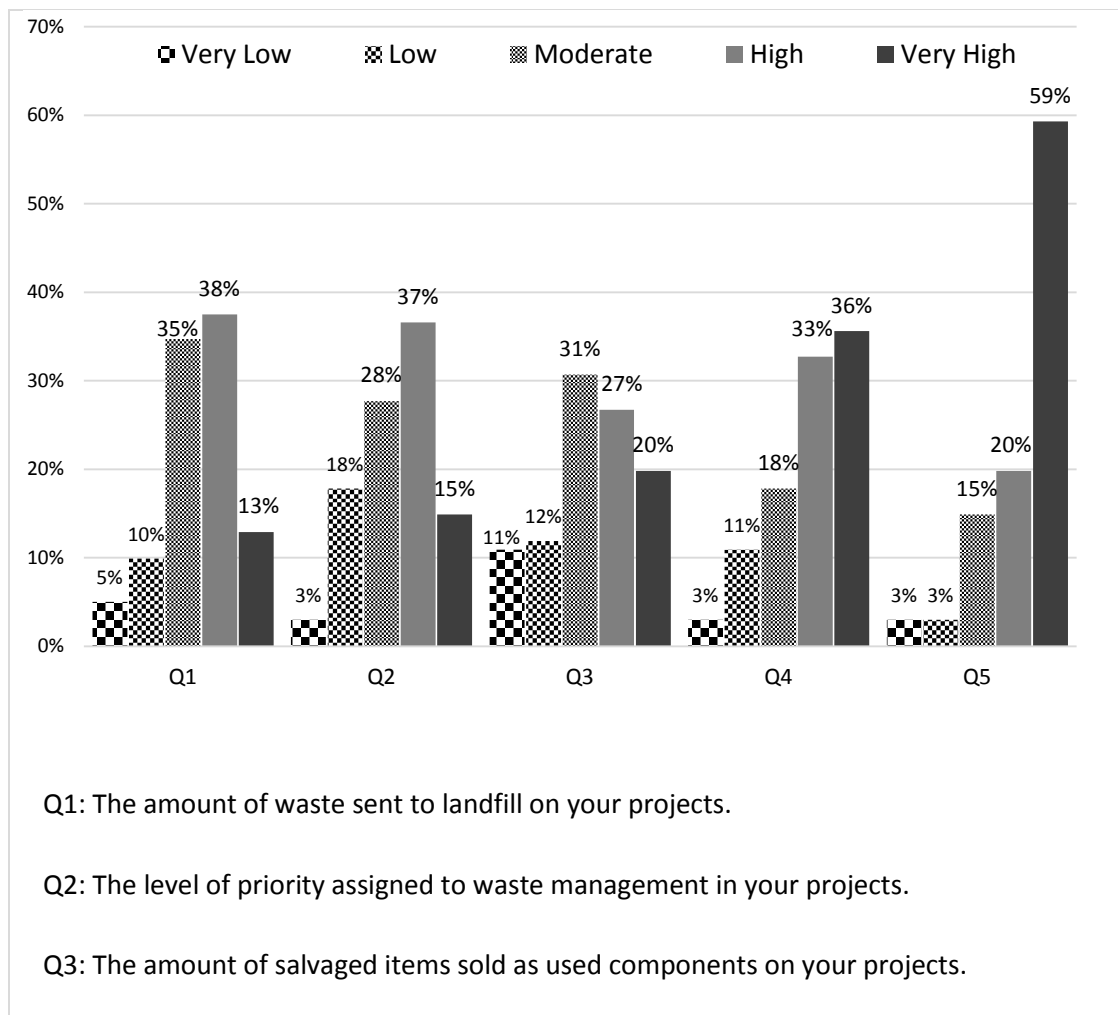


Figure 2. Current state of C&D waste management in Iran

Mostly entirely, respondents indicated that the priority assigned to C&D waste management is moderate or low as illustrated in Figure 2. This reaffirms the observations by Ghazinoory (2005) denoting the lack of attention to construction waste management in Iran. Around 80% percent of respondents (see Figure 2) described the level of recycling on construction projects as very low (60%) and low (20%), which acknowledged the arguments by Saghafi and Teshnizi (2011) regarding low level of recycling C&D waste in Iran. This was echoed judging from the level of waste sent to landfill as illustrated in Figure 2 that was described by around 80% of respondents as very high, high and moderate. One reason for justifying this could be the dire need in developing countries such as Iran for housing and infrastructure projects, which results in a boom in construction activities. As asserted by Yean Yng Ling and Song Anh Nguyen (2013) “the strong demand for construction products leads to a construction boom. One of the typical characteristics of unprecedented construction boom in a developing country is a lack of attention to managing construction waste”. This provides an explanation for the case as observed in Iran.

Major causes of waste generation on construction sites

Table 3 illustrates the most important causes of generating C&D waste on construction sites in Iran alongside the ranking of the causes. The reliability analysis for the 11 factors resulted in the Cronbach's Alpha coefficient value of 0.81. This exceeded the accepted norm of 0.7 according to Nunnally and Bernstein (1994), implying the acceptable reliability of the measurements instrument. These 11 factors were ranked according to the Coefficient of Variation (CV) for each factor illustrated in Table 3. CV defined according to Equation 1 is reflective of the variability in the answers provided by the respondents, hence smaller CVs show higher levels of agreement on the factors as indicated by the respondents (Sheskin, 2007). As a result, CV has been an indication utilised for ranking factors and variables based on perceptions of respondents in construction literature (Ghoddousi and Hosseini, 2012).

$$CV = (Standard\ Deviation)/Mean \quad [Equation\ 1]$$

Table 3. Ranking of the main causes of waste generation on construction sites

Causes	Mean	Std. Deviation	CV	Rank
Lack of knowledge of construction workers	3.87	0.83	0.22	1
Prevalence of traditional methods of construction in Iran	3.62	0.92	0.25	2
Lack of knowledge of demolition contractors	3.55	1.01	0.28	3
Wasteful use of materials on-site	3.55	1.01	0.28	4
Inappropriate packaging	3.29	0.97	0.30	5
Low quality of buildings materials	3.58	1.08	0.30	6
Inappropriate methods for handling on-site	3.34	1.02	0.31	7
Inefficient procurement	3.37	1.07	0.32	8
Inappropriate inventory	3.17	1.04	0.33	9
Inappropriate methods for shipment	3.00	1.08	0.36	10
Frequent demolitions	3.30	1.24	0.38	11

According to Table 3, all of the factors have high impacts in generating waste but the highest impact is due to lack of skills and experience in the Iranian construction industry as reflected in causes ranked the 1st and the 3rd in Table 3. This was similarly the case observed in Vietnam as stated by Yean Yng Ling and Song Anh Nguyen (2013) and is a serious issues for the Iranian construction industry due to lack of skills and awareness of the workforce in the construction sector as highlighted by previous studies in the field e.g. (Tabassi and Bakar, 2009). The strong impacts of lack of skills in the work force and subcontractors (demolition contractors) could be explained by articulating that wasteful practices of construction workers are stemmed from their lack of awareness and training in implementing less wasteful methods of construction. Besides, they are not familiar with appropriate approach for dealing with waste, have wrong perceptions about waste and lack an understanding of the value of construction materials (Ling and Lim, 2002). This explains the reason behind

perceiving wasteful use of materials on sites as the 4th most important reason for waste generation.

Furthermore, the construction industry in Iran is still dominated by traditional methods of construction which are inherently wasteful and unproductive (Ghoddousi and Hosseini, 2012). The same problem is observed in other developing countries 'as inappropriate and traditional construction methods' which lead to generating large amounts of waste (Long *et al.*, 2004). Factors ranked as the 5th, 6th and the 7th causes of waste generation on site are literally the issues with wastage of materials in activities performed on construction sites. These cover damage and spillage, contamination of materials, storage beyond expiry date, over supply, shipment of out of specification materials and items to construction sites (Ekanayake and Ofori, 2004).

Enhancing the level of awareness of construction practitioners of the values of materials and the necessity of reducing waste alongside enforcing more effective supervision on construction sites are remedial solutions suggested to address the abovementioned issues. Factors 8, 9 and 10 are prevalent problems in the construction industry due to the deficiencies of construction supply chain as underlined by Dainty and Brooke (2004). To resolve such problems, the nature of construction supply chain should be revised in order to promote reuse and recycling of leftovers on construction sites. Additionally, all the participants down the supply chain of construction should participate in an integrated effort to minimize waste on construction sites. This includes designers, clients as well as suppliers and contractors (Dainty *et al.*, 2001).

Frequent demolitions due to change of orders and low quality of completed works is a problem within the Iranian construction industry. This was perceived by the respondents as the 11th most important contributor to waste generation on construction sites. In essence, inadequate information, poorly-drafted drawings and specification and vague contracts usually warrant change in design and act as the main contributors to the amount of waste generated on construction sites as pointed out by Yean Yng Ling and Song Anh Nguyen (2013).

The effects of company type

A one-way MANOVA was calculated for examining the effects of role of companies on causes of waste generation on construction sites. In order to investigate the effects of independent variables on a group of related factors, MANOVA becomes relevant, because conducting several univariate tests for each factor ends up in Type I error inflation. That is, many sources of error are contained in case of MANOVA as all the statistical tests are examined at the same time. According to Cronk (2012, p. 87) "multivariate tests look at all dependent variables at once in much the same way that ANOVA looks at all levels of independent variables at once.". Table 4 captures the results of 4 different multivariate tests pertaining different roles of companies. As illustrated in Table 4 (highlighted cells), no significant difference was found among companies with different roles in terms of their level of causes of waste generation on their projects. Thus, difference in role and type of companies does not seem to influence how a company treats waste on construction sites and what factors act as the major causes of waste generation on construction sites. This brings to light that policies for waste treatment and minimizing the amount of waste generated on construction projects could be equally used for different types of companies within the Iranian construction industry.

Table 4. Result of comparing the main causes of waste generation between companies with different roles in the Iranian construction industry (see Table 2)

Multivariate Tests					
Effect	Value	F	Hypothesis df	Error df	Sig.
Pillai's Trace	0.45	0.79	55.00	445.00	0.849
Wilks' Lambda	0.62	0.78	55.00	397.03	0.867
Hotelling's Trace	0.51	0.77	55.00	417.00	0.885
Roy's Largest Root	0.18	1.49	11.00	89.00	0.151

Conclusion

Major causes of waste generation on Iranian construction sites were almost entirely associated with the lack of knowledge and awareness and misperceptions regarding the concept of waste and value of construction materials. Furthermore, inappropriate and traditional methods deployed on Iranian construction sites play a pivotal role in increasing the amount of waste generated. To address these, policy makers should focus on raising the level of awareness in the construction industry regarding different aspects of sustainability with a bias towards waste management principles. This could be pursued by inclusion of sustainability training programs within the subjects of courses that are compulsory for receiving licenses for architects, engineers and other influential players in the Iranian construction industry.

The findings of the study contribute to the field by shedding some light into the nature of causes of waste generation on construction sites in an under-researched context such as Iran. This further establishes the field and provides a foundation for further investigation in the field. Future research studies should focus on discovering the best practices applicable to the Iranian construction industry geared towards changing the current state of treating waste on construction sites and modifying the impacts of the factors identified here as the main sources of waste generation on construction sites.

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