

1 **Construction and Demolition Waste Management on**
2 **Construction Sites in Kazakhstan**

3 Abid Nadeem¹, Altynay Khamatova¹, Md Aslam Hossain¹, and Hau Yan Leung²

4 ¹ Nazarbayev University, Nur-Sultan 010000, Kazakhstan

5 ² Hong Kong College of Technology, Hong Kong

6 abid.nadeem@nu.edu.kz

7 **Abstract.** The rapid development of the construction industry in Kazakhstan has
8 led to the formation of construction and demolition (C&D) waste which
9 significantly affects the environment. C&D waste contains hazardous materials
10 in significant quantities which have an adverse effect on the public health and the
11 environment. It is essential to reduce C&D waste. This paper focuses on the
12 determination of appropriate C&D waste management strategies. C&D waste
13 minimization techniques such as reducing, reusing, recycling, bioremediation,
14 composting, and incineration were identified and explored through the literature
15 review. A questionnaire survey was conducted to investigate current C&D waste
16 management practices on construction sites in Kazakhstan. The questionnaire
17 survey was sent to 270 respondents in 11 companies in different cities of
18 Kazakhstan. The response rate of the questionnaire was about 93%. It was found
19 that recycling was the most appropriate method for waste minimization on
20 construction sites in Kazakhstan. The information which came from the
21 questionnaire survey helped to understand how to apply the recycling
22 methodology on construction sites with benefits and drawbacks. Consequently,
23 after identifying a proper waste minimization method, it is necessary to prepare
24 an adequate site waste management plan.

25 **Keywords:** Waste Management, Construction and Demolition Waste,
26 Kazakhstan.

27 **1 Introduction**

28 Construction and Demolition (C&D) waste is represented as a "wide" term which
29 includes waste coming from construction, demolition, excavation, road planning, and
30 maintenance activities [1]. C&D waste are divided into inert and non-inert materials.
31 The inert materials like concrete and subsoil have substances which hardly react under
32 the chemical conditions while non-inert materials can react with other substances when
33 used or disposed. Some of the C&D waste are illegally disposed in natural drainages
34 with water, which is detrimental for the environment and public health [2]. It is essential
35 to determine a sustainable method for the management of C&D waste.

36 Waste optimization is the objective of the waste management to minimize waste
37 disposal from a construction site. This approach gives an opportunity to significantly
38 reduce the cost of the project related to material and landfill resources [3].

39 This study examines construction waste management methods to achieve waste
40 optimization. The main approaches to dispose of construction waste are reducing,
41 reusing, and recycling. Additional methodologies like composting, bioremediation and
42 incineration are also discussed. The key objectives of this paper are (1) to evaluate
43 construction waste management methods and identify their benefits and drawbacks;
44 and (2) to determine the most advantageous construction waste management method.

45 **2 Literature Review**

46 Construction and Demolition (C&D) waste arises from construction, renovation and
47 demolition activities [4]. Generation of C&D waste is attributed throughout the
48 lifecycle of the construction project and can be divided into several source categories
49 like design, contracting, transportation, procurement, on-site management and
50 planning, material handling, site operations, residual and others [5-7]. These categories
51 and the reasons for waste generation are given in Table 1.

52 The strategies for C&D waste management are eliminating waste, reducing, reusing,
53 recycling, bioremediation, composting and incineration [8]. Reducing construction
54 waste is performed by continuously using materials. This methodology helps to
55 significantly reduce any waste disposal in construction [9]. Waste can be reduced by
56 transportation of resources in small capacities as this will reduce packaging wastes [10].
57 Minimizing the waste is also applicable to minimizing wastes in the processes and the
58 minimization of toxic wastes on site.

59 Reusing the construction-based waste is to recover material to its initial form by
60 using it again. The main purpose of the reusing methodology is the transportation of
61 materials from one to another application in an eco-friendly way. It is a preferable
62 method to achieve optimization of waste products on the site after the reduction. This
63 methodology significantly reduces expenses for construction materials.

64 Recycling is a prominent strategy in solid waste management that is more
65 environmentally friendly and beneficial. It is known that the construction industry
66 meets major difficulties while searching for a place to secure waste disposals. In fact,
67 annual construction-related-waste reaches approximately 20-30 kg/m³ in the USA.
68 These figures are more clearly presented when converting them to 500 kg/person per
69 year [8]. The disposal of C&D waste requires large landfill sites, which are increasingly
70 becoming limited in supply nowadays. For recycling, it is necessary to determine
71 materials which are recyclable and then to prepare a cost analysis for recycling
72 procedure. After that, it is essential to develop a waste utilization plan for a construction
73 site and add it in the contractual agreement [2].

74 Composting is the decomposition of organic materials into small particles with the
75 help of microorganisms like bacteria and fungi. In composting process, the debris is
76 disposed in a landfill, the organic matter is reused and then, recycled for soil

77 amendment. This kind of product enriches the soil structure [11]. The composting
78 process accelerates the natural waste disintegration process.

79 **Table 1.** C&D waste source and reasons for generating

Sources of the waste	Reasons of waste generation
Design	Alteration in design
	Complicated design details
	Design errors
	Improper specifications
	Specifying low quality materials
	Lack of coordination and communication
	Lack of information about alternative products
Contractual	Mistakes in the contract documents
	Incomplete contract documents
Transportation	Losses during transportation
	Problems with access to transport to construction site
	Inadequate protective tools during unloading
	Unsuitable methods of unloading
Procurement	Purchasing materials not meeting specifications
	Over-ordering materials
	Errors from the supplier
On-site management and planning	Absence of on-site waste management plan
	Inadequate planning of materials for needed quantity
	Lack of on-site monitoring and control
	Missing the deadlines of giving a report regarding product data
	Lack of supervision
Material handling	Transportation of materials from storage to the final destination
	Improper material handling
Material storage	Inadequate material storage place which causes the damage
	Unsuitable storage procedures
	Storage place is far away from the point of application
Site operation	Collection of materials which are not used
	Hardware malfunction
	Application of wrong materials
	Lack of time
	Poor quality of work
Residual	Remaining waste from the preparation of material
	Waste from cutting materials in an uneconomic way
	Packaging waste

80 Bioremediation has a similar approach like composting techniques. It also naturally
81 degrades construction pollution with the help of small living organisms. This process
82 helps to disintegrate wood-based construction debris in different ways. To prepare an
83 appropriate substance for bioremediation, mixed shredded chipboard, medium density
84 fiber, hardboard, and melamine serve as nutrient components of the process. The
85 outcome of the process generally reveals good results by enhancing the quality of the
86 ground [12].

87 In the incineration process, the organic matter after achieving the required ignition
 88 temperature and reacting with oxygen starts to compost [13]. The main purpose of the
 89 incineration is to treat C&D waste by diminishing its quantity and toxicity. In other
 90 words, incineration helps to eliminate hazardous materials in construction-related
 91 waste. Furthermore, this technology of waste optimization produces energy and
 92 recovers minerals that are secured in debris.

93 In view of this brief literature review, this paper helps to understand each waste
 94 management methodology and their specifications to assess the applicability of all these
 95 activities on the construction site.

96 **3 Methodology**

97 To achieve the target of the research objectives, a questionnaire survey was conducted
 98 among native companies in different parts of Kazakhstan. The majority of the
 99 companies were located in Astana. The questionnaire survey helped to identify the most
 100 applicable C&D waste management strategy on the construction sites in Kazakhstan.
 101 Eleven companies participated in the questionnaire survey. A five-degree Likert scale
 102 to questions in the survey was adopted. Five-degree Likert scale was aggregated by
 103 using the relative importance index (RII). It is calculated for each of the indicators and
 104 ranked accordingly. The RII is given by equation 1.

$$105 \quad RII = \sum_{i=1}^N \frac{W_i \times X_i}{5 \times N} \quad (1)$$

106 Where W_i = weighting as assigned on Likert's scale by each respondent in a range from
 107 1 to 5, where 1 = very low, to 5 = very high, i = index of response category $i = 5, 4, 3,$
 108 $2,$ and $1,$ X_i = frequency of the i^{th} response, N = total number in the sample.

109 The relative importance index gives an opportunity to analyze information from the
 110 questionnaire survey. In addition, this questionnaire survey includes data about
 111 company profile and its waste management strategies.

112 **4 Results & Analysis**

113 The questionnaire survey was implemented among 270 respondents in which 251
 114 provided the answer. The respondents of the questionnaire survey identified themselves
 115 as project managers (12%), civil engineers (18.7%), architects (10%), environmental
 116 engineers (16.7%), site engineers (20.3%), quantity surveyors (11.6%), and others
 117 (10%).

118 By the perspective of the respondents, the problems which affect waste management
 119 are given in Table 2 along with their RII score and RII rank. These problems are
 120 important factors of waste generation on site which gives an idea about how to reduce
 121 overproduction of the C&D waste.

122 According to these calculations, the highest possible value of RII is 5, whereas the
 123 lowest possible value is 1. In accordance with the ranks, it is found that the most
 124 important factors which lead to the formation of the debris on construction site are the

125 over-ordering of material due to lack of coordination and management and the lack of
 126 coordination between design and construction teams. Both factors should be mitigated
 127 at the initial stage of the design. This can be implemented by the application of an
 128 appropriate waste management plan.

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Table 2. Factors affecting the generation of waste

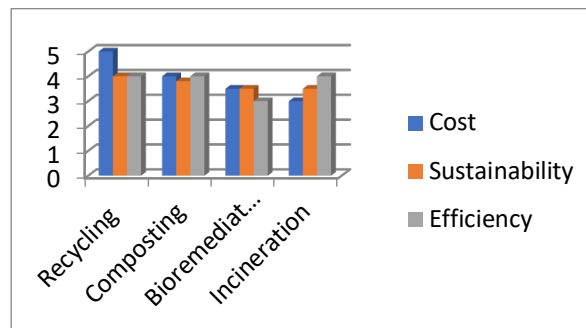
No	Factors	RII	Rank
1	Lack of detailed information on design and specifications	3.41	6
2	Design changes and revisions	3.41	6
3	Lack of coordination between the design and construction team	3.96	1
4	Over-ordering of material due to lack of coordination and management	3.96	1
5	Lack of coordination of supply chain with design and construction team	2.81	13
6	Lack of awareness of on-site personnel on waste prevention	3.63	4
7	Poor workmanship	3.00	11
8	Lack of/poor quality control system	2.23	14
9	Lack of coordination among sub-contractors on site	3.06	10
10	Unskilled labor	1.82	15
11	Poor communication between contractor and sub-contractors	3.56	5
12	Lack of adequate storage	3.28	9
13	Poor skills and knowledge in the handling of the material	3.39	8
14	Lack of material inspection and quality control system for incoming material	2.97	12
15	Damages caused by improper transportation, handling, and storage	3.74	3

130 The waste management plan significantly reduces the quantity of the C&D waste
 131 stream. Referring to the questionnaire survey, the majority of the respondents choose
 132 that, a waste management plan is a helpful tool which reduces the C&D waste. The next
 133 question in the survey was to evaluate the importance of the site waste management
 134 plan on construction waste minimization. The data obtained has shown that nearly 39%
 135 of the respondents believe that the Site Waste Management Plan is a moderately helpful
 136 tool for the minimization of the C&D waste stream at the initial stage, whereas 20%
 137 and 30 % of the respondents highly and very highly agreed with this statement
 138 respectively.

139 Questionnaire survey gives an opportunity to determine proper C&D waste
 140 management strategy which leads to the application of the relevant waste management
 141 plan. The waste management plan initially can be prepared after finding the cause of
 142 the problems. The respondents were also asked about the processes which cause most

143 the C&D waste. Nearly 39% of the respondents believe that material handling and
 144 storage process of the project contribute most towards waste generation on a
 145 construction site followed by on-site construction (32%), planning and design (18%),
 146 and procurement (11%). This can be mitigated by preparation of the successful site
 147 waste management plan applicable to Kazakhstan.

148 Respondents were also asked about the preferred methods of waste management.
 149 According to the survey results, nearly 60% of the participants believe that recycling is
 150 the desirable waste management methods compared with the other three methods
 151 (disposal 28%, incineration 6%, reducing 4%, and bioremediation/ composting 2%). In
 152 addition, the respondents suggest that that recycling can also save the cost. A histogram
 153 was prepared which distinguished selected C&D waste management methodologies
 154 according to the key factors like cost, environmental impact (sustainability), and
 155 performance (efficiency). The histogram is shown in Fig. 1. It shows that approximately
 156 98% of the respondents believe that recycling is the more cost-desirable C&D waste
 157 optimization way compared to others. 60% responded that the incineration process is
 158 the most expensive and less sustainable than other methodologies. The next desirable
 159 waste minimization methodology after the recycling is composting technique. This
 160 technique has also similar results with recycling, according to sustainability and
 161 efficiency. Nevertheless, nearly 81% of the respondents answered that composting is a
 162 cost-attractive method. This figure is significantly lower than recycling methodology.
 163 Considering, all these features, it can be concluded that the recycling approach of waste
 164 management is the most appropriate and applicable to construction companies in
 165 Kazakhstan.



166

167

Fig.1. Waste optimization methodologies

168 5 Discussion of the Results

169 The application of the waste management plan helps to reduce the capacity of C&D
 170 waste on site. The results of this study show that traditional waste management methods
 171 like reusing and reducing are not very suitable in Kazakhstan. The majority of the
 172 companies apply general waste management approaches like the collection of
 173 construction waste and transportation to the landfills. The disposal of construction
 174 waste, through recycling methods allows construction companies to save money and

175 avoid collection, transfer and other procedures because construction waste such as
176 concrete and brick does not need to be moved. When a building is demolished, a new
177 structure is almost always replaced in its place, and this requires a large amount of
178 rubble for the foundation. Recycling of construction waste, instead of crushed stone,
179 gives crushed brick and concrete obtained during the dismantling of the old structure.
180 A construction company can significantly economize handling and transportation of the
181 C&D waste and there is no need to pay for the placing of the waste stream in landfills
182 since it is treated on a construction site in the waste management area.

183 Recycling of C&D waste gives an opportunity to mitigate an annual rise of the solid
184 debris in the country. This leads to the minimization of harmful impacts on the
185 environment and public health. It is known that the place where construction waste is
186 stored like landfill is not applicable for further land utilization. The results also help to
187 monitor and analyze waste generation history on construction sites.

188 The main challenges during the waste management procedures for contractors are
189 lack of detailed information in design and specification, design changes and revisions,
190 lack of coordination between design and construction team, over-ordering of material
191 due to lack of coordination and management, lack of coordination of supply chain with
192 design and construction team, lack of awareness of on-site personnel on waste
193 prevention, poor workmanship, lack of poor quality control system, lack of
194 coordination among sub-contractors on site, unskilled labor, poor communication
195 among contractor and sub-contractors, lack of adequate storage, poor skills and
196 knowledge for handling of material, lack of material inspection and quality control
197 system for incoming material, damages caused by improper transportation, handling
198 and storage. However, the preparation of the appropriate waste management plan
199 significantly reduces the quantity of the C&D waste stream. The majority of the
200 respondents choose that; a waste management plan is a helpful tool which reduces the
201 C&D waste.

202 **6 Conclusions**

203 According to the research study, it is found that the most convenient and traditional
204 way to reduce C&D waste is recycling approach. Consequently, this paper considered
205 recycling method as a good solution for the given issue. In recent times, recycling is
206 one of the prominent disposal methods of C&D waste in the world.

207 However, this traditional approach is not widely used on the construction site of
208 Kazakhstan. Some limitations have been found during the research study like the lack
209 of information about the C&D waste management status in construction companies in
210 Kazakhstan. Thus, the capacity of the questionnaire survey is limited. On the other
211 hand, approximately 93% of the respondents provided answers. This information was
212 enough to analyze and identify the most applicable waste management strategy.

213 In addition, this study suggests applying a waste management plan which will be
214 efficient to implement recycling operation at the job site and defines its benefits with
215 economic and resource perspectives. The waste management plan will be helpful to
216 avoid overproduction of the C&D waste at the preliminary stage of the project.

217 In Kazakhstan, bioremediation and composting methodologies are not prominent as
218 in the USA and UK. In addition, this kind of technology requires an appropriate facility

219 to conduct the process of minimization of waste. On the other hand, traditional
 220 approaches such as reducing, reusing and recycling have also started to develop in
 221 recent times. In this case, the most desirable strategy is recycling, which becomes
 222 widespread in Kazakhstan now. However, there is a possibility to apply the incineration
 223 process which includes a traditional way of debris optimization.

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