Classification, Treatment and Disposal of Construction and Demolition (C&D) Waste at Source: A Case of China

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Abstract

With the rapid economic development in China, the construction industry is developing at a significant pace. The construction and demolition activities have become ubiquitous, which caused a lot of C&D waste, also brought great pressure to the city's environmental protection work. Therefore, how to deal with C&D waste rationally has become an important problem to be solved urgently. This paper departs from the problem of C&D waste treatment, based on the field investigation combined with literature collection, and it is found that there is a large gap between China and the West in the field classification of C&D waste. The research regard this as the starting point, and has expounded classifying and recycling of C&D waste at construction site. Through the contrastive analysis of C&D waste disposition in developed countries, it presents a reference method for the reduction of the construction waste at source.

Key words

C&D waste; Classification; Construction site; Reduction.

1. Introduction

At present, in China, the awareness of construction and demolition (C&D) waste treatment has been preliminarily formed, and the government has increasingly control over C&D waste generate from construction projects. Although there are some relevant policies and regulations has been issued, some breakthroughs have been broken in the C&D waste treatment, there are still many problems. At the end of 2016, the urbanization rate of China was 57.35%, 1.25 percentage points higher than that at the end of 2015 (CNBS, 2017)[1]. With the increasing urbanization rate in China, the generation of C&D waste is also increasing. According to the estimation of the National Development and Reform Commission, the annual generation of C&D waste in China has exceeded 1 billion tonnes (Bt) (NDRC, 2014) [2]. According to statistics of scholars from administrative departments and investigation and research samples, it is concluded that from 2013 to 2016, about 2.36 Bt C&D waste were produced in China annually, and its generation accounted for an increasing proportion of the total generation of municipal solid waste (MSW). However, the existing disposal mode of C&D waste in China is mainly based on extensive landfill, which not only occupies land, wastes precious land resources, but also causes pollution problems to the natural environment. This disposal mode has been unable to adapt to the sustainable development requirements of modern society. There is a big gap between the recycling level of C&D waste in China and developed countries and regions in Europe and North America. In order to achieve the goal of green construction, the recycling of C&D waste should be given priority. In the treatment of C&D waste, the reduction at source should be considered first. The waste should be classified on the construction site and treated to the maximum extent with the help of modern recycling technology and put them into the construction project to achieve a material recycling.

2. C&D waste disposal status in foreign countries

There is still a big gap between China and developed countries in Europe and North America in C&D waste recycling technology and disposal methods. At present, the recycling rate of C&D waste in Europe, America, Japan and other countries has reached over 70%, while the recycling rate of C&D waste in China is only 5% (NDRC, 2013)[2]. Japan has the most refined regulations on the division of C&D waste in the world, with more than 20 categories, and its recycling rate of C&D waste has reached over 96% (MLIT, 2012)[3]. The United States is the first to legislate to regulate the disposal of C&D waste (Solid Waste Disposal Act, 1965). Germany is the first country in the world to recycle a large amount of C&D waste.

The recycling of C&D waste in developed countries usually takes two forms: First is in the construction site to form the waste reprocessing process; Second, specialized comprehensive processing plants for waste reprocessing. The first form cannot use high-productivity equipment to get clean and graded products, some demolition and construction site close to residential, the crusher cannot work continuously; Second form has to be equipped with the means of transport, the factory equipped with high-power crushing and screening equipment, deep processing and remove impurities can be convenient to produce the various types of recycling materials, compared with the processing factory, there is a greater advantage in the construction site, not only achieve the goal of the C&D waste reduction, also save a lot of cost of building materials' transportation (Sun, 2015)[4]. There are many classification dustbins or signs of C&D waste at construction sites in Europe and the United States (Figure 1), considering the transport process can cause some dust pollution, the most concrete and brick waste will be crushed as recycled aggregates according to the classification of particle size on the construction site and put them into the construction activities.

Source: Chlara Francavilla, 2013; Hideko Yonetani, 2013.
Figure 1. The dustbins of C&D waste in America and Japan

In general, in the treatment of C&D waste, we should try to reduce the generation at the source. However, the current literature research in China still lacks analysis on the source classification and on-site reuse of C&D waste. Based on the relevant research in some developed countries and regions in Europe and the United States, this paper will propose a suitable C&D waste source reduction treatment scheme and technology for China.

3. On-site classification of C&D waste

In a construction site, C&D waste mainly consists of brick, concrete, stone, wood, metal, asphalt and other mixture waste. In order to reduce the waste at source, on-site classified collection and storage of C&D waste should be carried out to improve the efficiency of utilization. Figure 1 illustrates the whole utilization process of C&D waste. It can be seen from figure 2 that there are two main closed cycles in the process of C&D waste treatment, namely construction site→ generate→ classify→ stack→ on-site treatment→construction site; Construction site→ generate→classify stack→ recycling station treatment→construction site. In order to reduce the amount of landfill and the consumption of C&D waste, reducing at the source and improving the efficiency of recycling rate are

the main ways. The treatment of C&D waste in circulation is mainly divided into two modes: on-site treatment and recycling station treatment. No matter which mode is adopted for treatment, it should be classified at the source to improve the recycling efficiency.

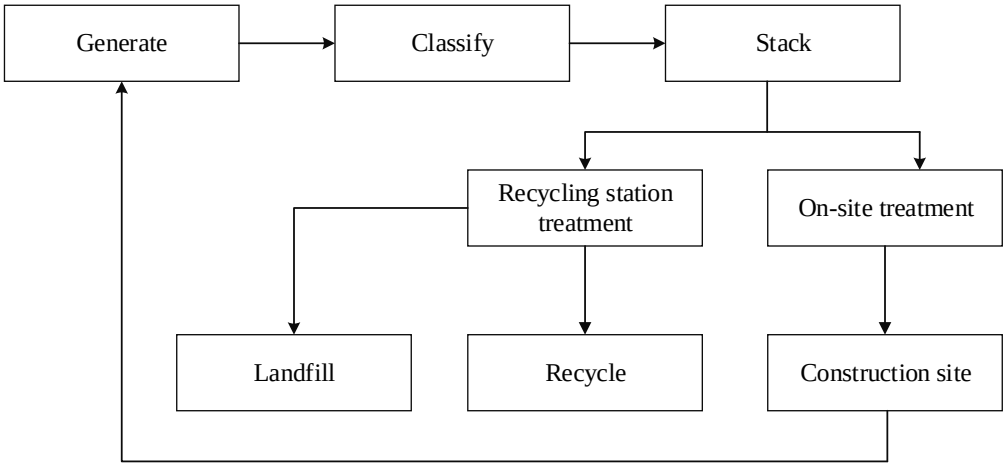

Figure 2. The utilization process of C&D waste

As shown in figure 3, there are three main patterns of recycling C&D waste in China.

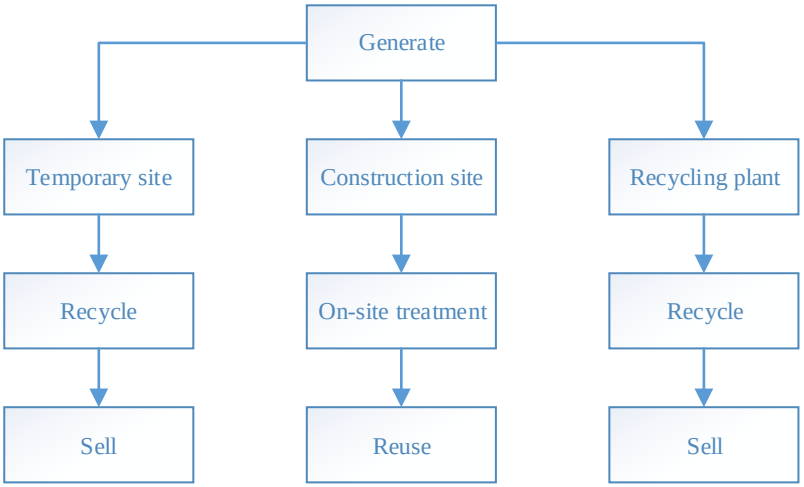

Figure 3. C&D waste reuse pattern

3.1 General C&D waste

General C&D waste materials refer to C&D waste without toxic ingredients. In general construction projects, this kind of waste accounts for more than half of the total waste, and it is the main component of C&D waste in China. Moreover, most of this C&D waste can be recycled and treated at the construction site, including concrete, asphalt, metal, wood, etc. (see table 1 for details). Generally, according to the different components of C&D waste, the general waste materials could be put in different dustbins of C&D waste in the construction site. However, considering the difference between the construction site environment and the construction project's scale, most construction management parties are unable to carry out fine sorting and stacking of C&D waste on the site. In order to maximize the C&D waste recycling rate on site and reduce the proportion of C&D waste transportation, regardless of the project's scale and management level, the minimum guarantee to achieve this goal is to separate and reuse the maximum proportion of concrete waste on site.

3.2 Hazardous C&D waste

Hazardous C&D waste materials refer to C&D waste with a certain proportion of toxic ingredients, which is mainly found in some decoration materials. Examples include asbestos in insulation materials and mercury in fluorescent lamps (see table 2). Hazardous C&D waste cannot be treated on

site, and it needs to be transported to the professional recycling plant for harmless treatment under protective measures.

Table 1. Classification of non-hazardous C&D waste materials

General C&D waste	Main source	On-site recycling
Concrete waste	Building structure and pavement	Yes
Asphalt waste	Roof, basement waterproofing, expansion joint filling, pavement	Yes
Plastic waste	Plastic pipes, roof slabs, components of doors and windows	No
Metal	Building structure, metal pipes, light structural roofing, components of doors and windows	No
Timber waste	Ceiling, floor, fence, components of doors and window	No
Glazed and non-glazed tiles	Wall and roofing decoration, floor, fill wall	Yes
Plasterboard	Sound insulation, ceiling decoration	Some
Soil	Foundation excavation, green space construction	Yes
Others	Mixed waste	No

Table 2. Classification of hazardous C&D waste materials

Hazardous C&D waste	Main source	On-site recycling
Asbestos	Fireproofing, insulation and heat preservation material	No
Printed-circuit board (PCB)	Household appliances and intelligent building accessory	No
Freon	Household appliance	No
Mercury	Fluorescent lamp	No
Others	Mixed waste	No

Due to the complex process and the professional equipment and technology, the hazardous C&D waste materials need to be transported to the recycling station for processing. However, in order to improve the treatment efficiency, the classification should also be carried out on the construction site, and some coverage measures should be taken in the stacking site to prevent from harmful effects on the construction workers.

4. On-site treatment

At present, the researches on the on-site recycling of C&D waste mainly focus on the concrete waste, glazed and non-glazed tiles, soil and asphalt waste mentioned in section 3. The concrete waste and masonry waste (glazed and non-glazed) have similar characteristics on the composition, and crushing them to recycled aggregate with different particle sizes is the main on-site method, which can be recycled for the project construction. China has formulated the gradation standards for recycled coarse and fine aggregate (see table 3 and 4).

Table 3. Recycled fine aggregate particle size gradation

Square-opening sieve	Cumulative percentage retained (%)		
	First graduation	Second graduation	Third graduation
9.50mm	0	0	0
4.75mm	10～0	10～0	10～0
2.36mm	35～5	25～0	15～0
1.18mm	65～35	50～10	25～0
600μm	85～71	70～41	40～16
300μm	95～80	92～70	85～55
150μm	100～85	100～80	100～75

Source: GB/T 25176-2010 [5]

Note: The actual particle size gradation of the recycled fine aggregate may be slightly higher than the number in table 3 except for 4.75mm and 600μm sieve size, but the total excess shall be less than 5%.

Table 4. Recycled coarse aggregate particle size gradation

Nominal maximum size (mm)		Cumulative percentage retained (%)							
		Side length of square-opening sieve (mm)							
		2.36	4.75	9.50	16.0	19.0	26.5	31.5	37.5
Continuous gradation	5～16	95～100	85～100	30～60	0～10	0			
	5～20	95～100	90～100	40～80	-	0～10	0		
	5～25	95～100	90～100	-	30～70	-	0～5	0	
	5～31.5	95～100	90～100	70～90	-	15～45	-	0～5	0
Single gradation	5～10	95～100	80～100	0～15	0				
	10～20		95～100	85～100		0～15	0		
	16～31.5		95～100		85～100			0～10	0

Source: GB/T25177-2010 [6]

According to the particle size of the recycled aggregate, it can be divided into coarse recycled aggregate and fine recycled aggregate. It can be applied to construction engineering in many aspects. Such as recycled aggregate brick, recycled concrete block, recycled aggregate pervious concrete and recycled aggregate mortar. Recycled aggregate pervious concrete can also be used as pervious pavement material for sponge city construction.

Mobile crusher is mainly used for crushing concrete and brick, and sieving and selection them by particle size. The aggregate produced by the breaking of bricks can be used as the foundation filler for road construction, and the broken materials can replace limestone. Broken bricks can replace low-density concrete aggregate mixed with lightweight concrete and mortar. Figure 4,5 shows different types of crushed brick aggregates. The aggregate obtained from concrete crushing is more widely used. In addition to being used as the mix proportion of a series of concrete and mortar, fine-grained crushed stone concrete also has the drainage characteristics, that is similar to newly excavated rock or gravel can be used as the raw material for the mix proportion of permeable concrete.

Source: EU-ASIA (2006) [7]

Figure 4. The different particle sizes of broken waste concrete materials

Source: EU-ASIA (2006) [7]

Figure 5. The different particle sizes of broken waste brick materials

5. Conclusion and suggestion

Considering the current situation in China, the cost of classification, sorting and treatment of C&D waste is usually higher than that of the new material repurchase. However, recycling of C&D waste can reduce the cost of dumping in landfilling[8]. At the same time, due to the increasing freight, landfill fee and tax burden of all kinds of C&D waste, the reduction at source and on-site recycling of C&D waste is also an important direction for the future development of China's C&D waste management. Sorting is the basis of on-site reuse and recycling of C&D waste, and also an important means to improve recycling efficiency and recovery rate (Wang et al., 2010) [9]. However, there is no unified classification system in China at present. Most of the C&D waste is directly and disorderly piled on the site, and most of it is directly landfill without treatment. The crushing, sieving and other mechanical equipment on the construction site is lower-tech and high failure rate, not smart enough in maintenance, operation and durable. Therefore, it is difficult to ensure the quality of recycled aggregate on site. The above status also limits the construction enterprises to carry out the activities of C&D waste recycling on site. Based on the analysis of the composition of C&D waste on construction sites in China, this paper proposes different on-site disposal and treatment methods for C&D waste in order to reduce the amount of C&D waste at the construction site.

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