

The current situation of construction & demolition waste management in China

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Abstract—The large quantity of construction & demolition waste (C&DW) with rapid urbanization, growth of economy and population, has placed great burden on the finite landfill space and environment since the early 1980s. This paper outlines the trend of C&DW generation and waste composition, as well as describes current status of waste management in China. The current recycling is restricted to those high scrap value recycling materials like steel; other non-profitable materials like aggregates will be sent to C&D landfills. Mixed collection, manual separation and simple landfill without collection system of leachate and odour are broadly applied in China. Then, some suggestions are given for improving the C&DW management: (1) Perfecting the polluter-pays system; (2) Specialization of C&DW collection method; (3) Encouragement of new recycling technologies and mature technology imported; (4) Implementing an integrated disposal method; (5) Establishment of regulations and improvement of supervision structure; (6) Enhancing environmental awareness.

Keywords—Construction&demolition waste; waste management; China

I. INTRODUCTION

The Chinese government has made a clear commitment to achieve a minimum of 15.5 m² of living space per person by 2010[1]. To achieve this goal, since the early 1980s, China advocated a massive housing development and heavy infrastructure construction schedule. The large quantity of C&DW has placed great burden on finite landfill space and environment. Dumping untreated waste under the pavement may cause a lot of troubles like corrosion of underground device. Dumping on landfills may cause soil and groundwater pollution. From a broad point of view, C&DW is not only a simple environmental problem, but also has a negative impact on the health and hygiene of scavengers and workers.

II. C&DW IN CHINA

A. Sources and classification of C&DW

The ministry of construction of the P. R. China issued a guideline, entitled “Regulations for construction waste management in cities” in 2005. In this regulation, C&DW is defined as: “The soil, material and others are discarded and generated by any kinds of construction activities, including the

development, rehabilitation, refurbishment of construction projects.” According to current categories and reality, sources of C&DW are defined in Fig 1. Waste from illegal activities, infrastructural waste and soil clearing aren’t considered here because of unavailable data to be estimated.

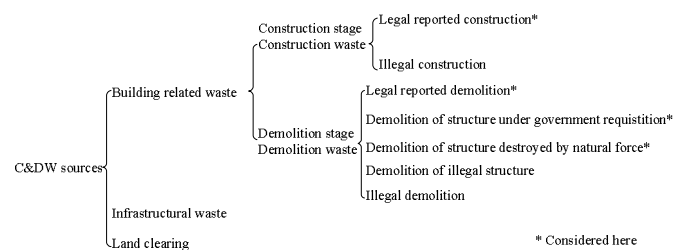


Figure 1. C&DW by source in China [3]

B. Generation and characteristics of C&DW

The direct statistic of quantities of C&DW generated is quite difficult, since construction or demolition companies are not obliged to record and report the qualitative and quantitative characteristics of waste. Estimating the quantities of C&DW is through the following data relevant to the building activity and the number of demolition licenses: (1) floor area of building [4]; (2) floor area of demolition [5]; (3) construction waste per m² of floor area, 0.0106 ton/m² [6]; (4) demolition waste per m² of floor area, 1.2 ton/m² [7].

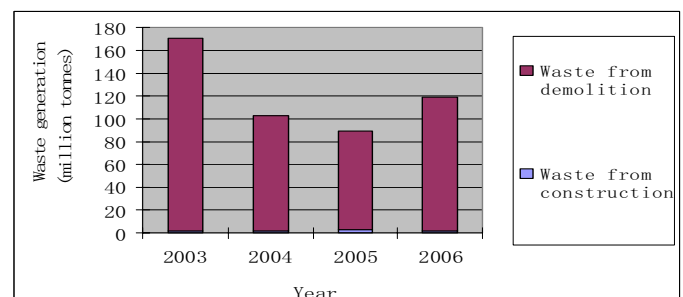


Figure 2. Estimation of the quantity of C&DW generation in China

As shown in Fig 2, the estimated quantity of C&DW gradually decreased from 2003 to 2005, mainly because the amount of demolition wastes decrease. The regulation

published in 2003 limited the floor area of demolition by means of demolition licenses to slow down the overspeed development of real estate. Even though, it maintained about 90 million tons in 2005 and the average amount of C&DW was about 120 million tons in that four years. In the long term, the quantity of waste will keep large level, in the case of increase in population and economy.

C&DW contains broken concrete (foundations, slabs, floors, etc.), bricks and masonry, wood and other materials such as dry wall, glass, insulation, roofing, wire, and pipe. There are no available data about national proportion of C&DW composition. However, it is obvious that inert materials (concrete, brick, mortar) accounting for more than 50% of total C&DW by weight is demonstrated by following three main factors affecting the characteristics of C&DW [8]: (1) Utilization type (e.g., residential, Table I); (2) Activity being performed (e.g., construction, renovation, Table II); (3) Structure type (e.g., frame structure, Table III).

TABLE I. COMPOSITION OF DEMOLITION WASTE BY THE TYPES OF BUILDINGS IN SHANGDONG PROVINCE [9]

Type of construction	Component and proportion of waste (%)
Residential building	Bricks and tiles (about 80%), wood, glass, lime, soil
Commercial building	Concrete (50% -60%), metal, bricks, plastic, etc.

TABLE II. COMPOSITION OF C&DW IN WUHU CITY [10]

Type of activity	Component and proportion of waste (%)
Renovation & demolition	Brick & tile (48%), concrete (45%), wood (1%), glass (0.64%), plastic (0.34%), metal, porcelain, soil.
Construction	Concrete+sand+brick+stone (70%), metal, soil, plastic, wood, paint.

TABLE III. COMPOSITION OF CONSTRUCTION WASTE IN BUILDING SITES OF DIFFERENT STRUCTURAL STYLES IN CHINA [6]

Component	Proportion (%)		
	Brick-concrete structure	Frame structure	Frame-shear wall structure
Brick	35-50	15-30	10-20
Mortar	8-15	10-20	10-20
Concrete	8-15	15-30	15-35
Piling head	-	8-15	8-20
Packaging	5-15	5-20	10-15
Roofing material	2-5	2-5	2-5
Steel	1-5	2-8	2-8
Wood	1-5	1-5	1-5
Other	10-20	10-20	10-20
Total	100	100	100

C. Management of C&DW in China

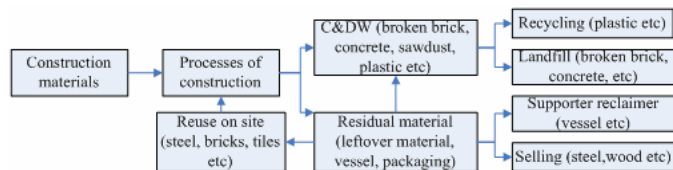


Figure 3. Construction waste flow on site in Beijing [11]

The current status of C&DW in China is absent of network for the collection and utilization of the materials. The recycling chain is easily broken and dependent on the willingness of the

contractors. More specifically, still a lot of materials, such as concrete, brick, mortar are not recycled.

Fig. 3 and Fig. 4 give a descriptive outline of waste flow on the construction site. The waste with high profitable like steel are piled up on construction site for recycling or reuse. Other mixed wastes are thrown everywhere or lobbied into landfill. According to certain route and time permitted by Municipal Administration Commission, C&DW is carried into certain landfilling sites by qualified transportation companies. Most of inert materials which occupy more than 50% of total amount will flow into the landfill. It's noted that most of landfill without collection system of leachate and odour still are permitted to accept mixed waste with hazardous decoration waste.

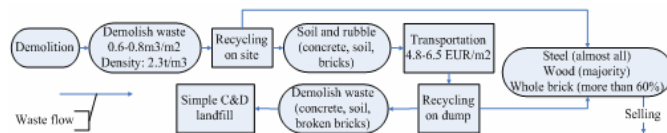


Figure 4. Diagram of demolition waste management in Beijing [11]

C&D landfill is the most popular disposal approach for C&DW. The locations of C&D landfill include the bottomlands, wild lands and pits of quarries. For example, there are more than 300 C&D landfills around Beijing. With urban areas expand and amount of waste disposal increase, C&D landfills space surrounding cities gradually decrease. New C&D landfills far away from the urban centre, lead to the increase in transportation fee.

III. PROBLEMS AND PERSPECTIVES

A. Problems & reasons

1) Lack of a suitable C&DW collection system

Mixed collection will enhance recycling cost and affect quality of recycling materials. On the one hand, large and advanced equipments to efficiently separate mixed waste must drive recycling cost increase. On the other hand, impurity caused by mixed waste incurs no quality assurance of recycled materials. Manual separation and outdated equipments also influence efficiency of collection. In addition, contractors consider environmental management as a non-profitable activity. Investigation on construction site in Shenzhen and Hong Kong found: 90% of the respondents think they have no relationship with waste management, compared to 10% of the respondents think strengthening waste management is very significant [13].

2) Lack of a suitable C&DW recycling approach

The recycling is restricted to those high scrap value recycling materials like steel, whereas other non-profitable will be sent to C&D landfills directly. The current recycling will speed the depletion of relevant resources and the saturation of limited landfill space. Several bottlenecks in recycling market have been identified:

a) *Market of potential demand for recycled materials:* unestablished, since there are few available recycling equipments and manufactures to produce recycled materials.

b) *The related regulations and legislations:* Regulations implemented by government are too liberal. If regulated by non-mandatory schemes, waste producer is reluctant to implement the high-investment environmental management.

c) *Recyclers:* The recycling market lacks a central and stable medium like recycling centre. The recycled materials are still difficult to be accepted by manufacturers with the consideration of non-quality assurance from waste pickers.

d) *Investment:* In current recycling market, it is difficult to afford the high investment costs on facilities, equipments, land and labour. Changes or ordination in legislation and technical regulation might make the recovery process more expensive. These dynamics make it difficult for the investors to find the right timing and the right level for investments.

e) *Unspecific standards on recycled materials:* The resources reservation, construction waste minimization from "Construction Law" and "Urban construction waste management" and other regulations are guideline. How to implement them is not involve in laws. For example, using recycled C&DW refers to standardized utilization of original building materials.

f) *Economic feasibility:* According to "Commodity Prices issued documents" in some cities, disposal fees of urban C&DW only are 0.2-0.5 EUR/ton excluding transportation. The cost of recycled waste through the collection, sorting, crushing, etc is higher than landfill cost. Moreover, low price of resources with low resource tax in China incur that recycled materials prices are higher than the original materials.

3) *Pollution by simple landfill sites and illegal dumping*

Because in these simple landfills (without collection system of leachate and odour) only a negligible quantity of leachate is treated before being discharged into the groundwater, this situation will devalue the nearby land, pollute the water, land and air as well as endanger the health of people. For instance, chromated copper arsenate (CCA)-treated wood containing a lot of hazardous substances such as chromium and lead, can contribute to toxic and ecotoxic impact on groundwater and soil [13]. Hydrogen sulfide (H₂S) as a principal odorous component from C&D landfills enormously contributes to acidification of environment.

Due to no compulsive regulation about collection of leachate and odour from C&D landfill as well as deficient investment on landfill, pollution from landfill is more and more serious with waste quantity increase. Furthermore, Because of high supervision cost of government and soft punishment of illegal dumping, frequent dumping happens, which punishment is from 500 EUR to 5000 EUR for enterprise and below 20 EUR for individual in regulation "urban construction & demolition waste administration" promulgated by Ministry of Construction in 2005.

B. *Perspectives*

In the future, to meet the needs of an integrated C&DW management system, the following aspects should be improved:

1) *Perfecting the polluter-pays system*

Low disposal fees should be increased with reference to external cost from loss of land and health caused by landfill. Furthermore, addition of disposal fee can not only drive waste flow into recycling system, but also achieve waste prevention. To effectively execute pays system, the supervision of waste transportation systems and punishment on illegal dumping should be improved for preventing illegal dumping. For instance, the specific trucks with Global positioning system (GPS) are easily managed in Guangzhou.

2) *Specialization of C&DW collection method*

Waste sorting and mechanical pre-treatment on site should be broadly spread. Waste sorting shortens the waste chains, because secondary collecting and sorting are omitted through waste pickers or recycling plants. By means of pre-treatment, reduced volume of rubble allows for fewer loads and less transport cost. Small volume of waste can effectively take advantage of space of loader and prevent recyclers pay extra cost to reduce volume for disposal requirement in diameter. Moreover, a part of concrete and brick can be used as backfill for construction on the spot by pre-treatment.

TABLE IV. RECYCLED MATERIALS FOR CONSTRUCTION INDUSTRY [15]

Recycled materials	Uses
Aggregates	Sub-base material for road construction, hardcore for foundation works, base/fill for drainage, aggregate for concrete manufacture and general bulk fill
Asphalt	Aggregate fill and sub-base fill
Glass	Substitute for sand and aggregates as pipe-bedding material, gravel backfill for walls, crushed stone surfacing, backfill and bedding
Plastic	Synthetic materials in form of plastic lumber for landscaping, horticulture and hydraulic engineering

3) *Encouragement of new recycling technologies and mature technology imported*

New technologies of recycling C&DW are being explored. For instance, Logistics Engineering College successfully developed "artificial wood bricks" as pre-embedding device of electricity, water, gas supply [14]. Concerning mature technology, there are many material-recycling schemes recommended by the developed countries (Table IV).

4) *Implementing an integrated disposal method*

The simple landfill should be improved with reference to sanitary landfill with collection system of leachate and odour. The "mono" landfill (for possible future recovery like inert materials) should be widely advocated in future, which the regulation on "mono" landfill has been executed in some developed countries like USA. The advantages are that more space of C&D landfill is left for final waste and the money is earned from sale of recycling materials transported to recycling centre in landfills, as the "mono" landfill acts as temporary stock for recycling.

5) *Establishment of regulation and improvement of supervision structure*

In the legislation and policy sector some regulations and standards must also be promulgated, such as quality standards

for utilization of recycled materials and pollution control standards for C&DW disposal facilities.

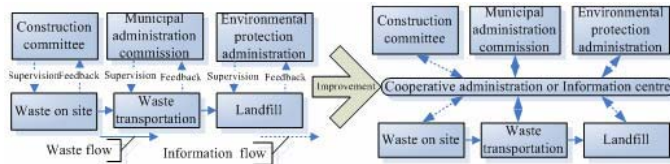


Figure 5. Improvement of supervision structure

In the institutional sector, the institutional reform of C&DW administration and handling comprises: (1) unifying legislative responsibilities of administration by combining the three current responsible governmental agencies into one body at national and local levels (Fig 5); (2) Creating a market mechanism for recycling C&DW by means of economic instruments like tax or subsidy.

Meanwhile, the mature experience from developed countries might be conducted. For example, some guidelines for the use of recycled mineral materials in Germany are shown in Table V [15]

TABLE V. MEASURE RELATED WITH C&D WASTE FROM THE VOLUNTARY AGREEMENT OF 1996

Area of Application	Regulation	Application
Road construction	RAL-RG 501/1	Quality assessment for recycled materials in road construction;
Concrete with recycled aggregates	DIN 4226-100	Recycled aggregates for concrete and mortar;
	DIN 4226	Aggregates for concrete;
	DIN 1045	Concrete and reinforced concrete: dimensioning.

6) Enhancing environmental awareness

C&DW issues have an impact on millions of families, and hence, public participation and support are of vital importance to waste management. Television, radio, newspapers, and other public media can be used for this purpose. In fact, more and more environmental programs and reports are appearing in the public media already. Large-scale public environmental education should be organized through various means and at various levels. Environmental education should begin at an early age and construction sites. It is suggested that elementary schools have environmental education programs periodically, and environmental protection should be a training course for construction employees before work.

IV. CONCLUSION

C&DW management in China need further development. Mixed collection and manual separation result in inefficient recycling and a negative impact on the health and hygiene of these scavengers and workers. There is no efficient and suitable recycling approach. The current recycling market oriented economy incurs high profitable materials like steel are reused or recycled, whereas low profitable materials like concrete are directly transported into the C&D landfills. Simple landfill without collection system of leachate and odour will make the

environmental pollution more serious. In addition, insufficient investment on C&DW management, distempered regulations, outdated technology on waste disposal and resource utilization are also obstacles to regulate waste flow for sustainable development. To improve the C&DW management, this integrated disposal method should include the following: (1) Perfecting the polluter-pays system; (2) Specialization of C&DW collection method; (3) Encouragement of new recycling technologies and mature technology imported; (4) Implementing an integrated disposal method; (5) Establishment of regulation and improvement of supervision structure; (6) Enhancing environmental awareness.

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