

# Research on Resource Recycling Technology of Construction Waste

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**Abstract.** Based on the current situation and research progress of construction waste, the paper analyzes the composition of construction waste and put forward six main stages of the recycling of construction waste: Preliminary Sorting, Clear the Soil, Three broken, Shape and Strengthen, Aggregate Screening, Deep Processing and Application. Furthermore, it's showed that construction waste can be applied to the recycled concrete, the recycled mortar, the recycled brick and pavement layers and sub-grade of road engineering. Finally, according to the current research situation, the countermeasures and suggestions for the effective recycling of construction waste are proposed.

## 1. Introduction

With the rapid development of China's economy, a large number of construction waste appeared and increased rapidly. According to the relevant information, China's annual construction waste output was 40 million t in 2016. The number of construction waste had accounted for 30% to 40% of total municipal waste in China<sup>[1-3]</sup>. Such a large number of construction waste, not only caused great waste of resources, but also seriously affected the ecological environment and people's lives. At present, China's construction waste disposal methods remain at the level of backfill, reclamation, reclamation<sup>[4-6]</sup>. With the development of ecological civilization and circular economy, higher requirement of the construction waste comprehensive utilization is proposed.

Construction waste refers to some waste generated during the construction, maintenance, and dismantling of buildings, including waste concrete block, asphalt concrete block, waste residue, broken brick, metal, bamboo wood, and other packaging materials. Among them, concrete, broken brick, mortar accounted for about 80% of the total. Sorted by the attribution area, construction waste mainly includes old buildings disposal waste, foundation excavation waste, road excavation waste and decorative waste.

Author introduction: Dong Xu(1984-), born in Shandong Province, engaged in road and traffic research.



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Figure1 Disposal of Construction Waste

## 2. Composition of Construction Waste

In general, the main components of construction waste are concrete and broken brick. But according to different types of the architectural structure, the proportion is different. As shown in Table 1, broken brick component of the brick and concrete structure accounted for 30% to 50% of the total waste, while concrete component of the frame structure accounted for 15% to 30% of the total waste.

Table.1 Composition of construction waste

| Component Composition          | Concrete and brick structure (%) | Frame structure (%) |
|--------------------------------|----------------------------------|---------------------|
| Concrete                       | 8~15                             | 15~30               |
| Mortar                         | 8~15                             | 10~20               |
| Broken brick                   | 30~50                            | 15~30               |
| Pile head                      | —                                | 8~15                |
| Packaging materials            | 5~15                             | 5~20                |
| Roofing materials              | 2~5                              | 2~5                 |
| Steel                          | 1~5                              | 2~8                 |
| Wood                           | 1~5                              | 1~5                 |
| Other (ceramic, glass, gypsum) | 10~20                            | 10~20               |
| Garbage generation             | 50~200                           | 45~150              |

## 3. Six main Stage of Construction Waste Resource Recycling

Through related analysis of construction waste and on-site investigation, the following six stages are put forward mainly.

### 3.1 Preliminary Sorting

Construction waste resource is complex and the composition is diverse. The first step is to classify the different construction waste, which is mainly classified into three categories.

(1) construction waste that can be used for processing recycled products, which are the main production materials;

(2) construction waste that can be directly recycled, not needed to re-process;

(3) non-renewable waste. For example, some construction waste from hospitals, chemical plants, or other construction waste containing radioactive, toxic and hazardous substances.

### 3.2 Clear the Soil

Construction waste in the process of demolition and excavation, will mix a lot of waste soil. These waste soil has a great impact on the aggregate strength, and mud content indicator, so it should be cleared. At this stage, vibration feeder is used commonly.

### 3.3 Three broken

Crushing process is divided into three broken(rough broken, middle broken, fine broken).

#### (1) First broken(rough broken)

The primary broken is mainly to break up large pieces of construction waste into particles, which is less than 31.5 mm. Rough broken particles are thicker, and needle-like particles are more, which is not suitable to use directly. Rough broken needs to break large pieces of construction waste, usually using jaw crusher.

#### (2) Second broken(middle broken)

The second broken is the re-processing of the recycled aggregate of less than 31.5 mm, which produces a more reasonable recycled aggregate. Second broken mainly produces 5mm-25mm recycled coarse aggregate. At this stage, hammer crusher or counter-crusher is choosed commonly.

#### (3) Third broken(fine broken)

The third broken is to produce recycled fine aggregate of less than 5mm. Vertical impact crusher is used at this stage mainly. After crushing, the aggregate is mostly hexagonal polygonal.

#### (4) Re-collection during crushing (magnetic separation)

In the initial sorting process, some concrete waste contains steel and iron material inside. After third broken process, magnetic separation equipment can be used to re-collect.

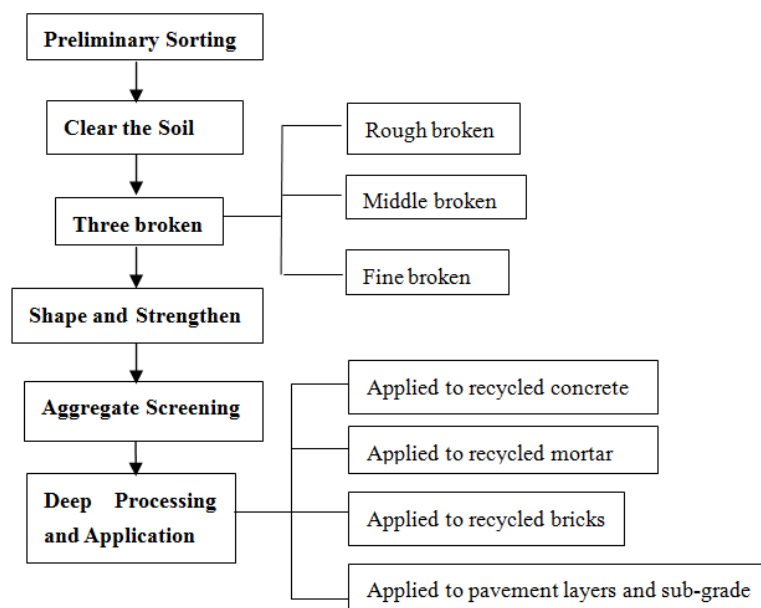


Figure.2 Six main Stage of Construction Waste Resource Recycling

### 3.4 Shape and Strengthen

After three broken of the recycled concrete and mortar, there are so many flacks and cracks inside, affecting workability indicator and strength indicator.

Shape and Strengthen method includes chemical strengthening and mechanical strengthening mainly. Mechanical strengthening method generally uses grinding process to make granular shape more round, to reduce the sheet shape and improve the use performance. Comparison of indicators before and after Shape and Strengthen is shown in Table 2. Chemical strengthening method is to

improve aggregate strength through the chemical reaction method, such as by adding fly ash to improve the workability of mortar and so on.

Table.2 Comparison of Aggregate Indicators before and after Shape and Strengthen

| Project             | Fine aggregate    |                 |                  | Coarse aggregate  |                 |                  |
|---------------------|-------------------|-----------------|------------------|-------------------|-----------------|------------------|
|                     | Natural Aggregate | Simple Crushing | granular Shaping | Natural Aggregate | Simple Crushing | granular Shaping |
| Bulk density        | 1645              | 1245            | 1475             | 1345              | 1155            | 1315             |
| Dense density       | 1755              | 1385            | 1585             | 1495              | 1375            | 1545             |
| Porosity            | 2.72              | 2.51            | 2.56             | 2.71              | 2.62            | 2.67             |
| Water absorption    | 0.88              | 7.9             | 6.9              | 1.4               | 4.8             | 3.1              |
| Crushing index      |                   |                 |                  | 5.7               | 14.9            | 8.7              |
| Needle-like content |                   |                 |                  | 6.6               | 5.3             | 1.8              |

### 3.5 Aggregate Screening

Screening is to separate different sizes of aggregate through different sieve size. The main machinery for sieving construction waste is fixed sieve, vibrating sieve and drum sieve. Fixed sieve is usually installed before rough broken, to protect machinery and equipment; vibrating sieve is the main screening equipment, which is the most frequently used. The frequency of vibration affects the screening efficiency, and the vibrating sieve should have an inclination angle, preferably  $40^{\circ}\sim 80^{\circ}$ . Roller sieve is a very promising screening device, mainly used for fine sieving.

### 3.6 Deep Processing and Application

#### (1) Applied to recycled concrete

Recycled aggregate concrete consists of recycled coarse aggregate, recycled fine aggregate, cement, water, mineral powder and additive. At this stage, recycled concrete can be widely used in the production of plain concrete or reinforced concrete, not recommended for use in prestressed concrete production.

In the test items, unlike natural sand, the special attention for recycled aggregate is the chloride and mud content. Because some construction waste is placed near the beach, chloride content may be exceeded, which will greatly affect the product performance indicators (such as structural performance, etc.). Otherwise, Natural river sand, is repeatedly washed by the river, its mud content indicator is low. However, mud content indicator of construction waste is often too high, and construction waste needs for deep processing.

#### (2) Applied to recycled mortar

Recycled mortar production does not need to be classified and stored. After second broken, construction waste can be sent back to the third broken and be processed into fine aggregate, which is less than 4.75mm.

#### (3) Applied to recycled brick

Recycled brick mainly includes solid brick and porous brick. The maximum diameter of the aggregate used to produce recycled brick should not be greater than 8 mm.

Production of recycled brick use suppression process. According to whether it is with the role of vibration, molding mode can be divided into static suppression and dynamic suppression. Dynamic suppression process is mainly used, and nominal pressure used is 140t.

#### (4) Applied to pavement layers and subgrade of Road Engineering

According to the characteristic of road construction, the recycled technical feasibility of construction waste in highway engineering is discussed, and the specific technical application requirements are shown in the table 3 below.

Table.3 Technical Requirements for Application of Construction Waste in Road Engineering

| Classification of Application | Technical requirements                                                                                                                                                                         |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Subgrade                      | particle size $\geq 25\text{mm}$ , and $\geq 37.5\text{mm}$ partly, applied to the layers of the subgrade; and according to technical requirements, layered filling and tamping reinforcement; |
| Base                          | particle size between 20mm and 37.5mm, applied to the pavement base and subbase, and in line with each layer's technical requirements;                                                         |
| Asphalt macadam pavement      | particle size between 5mm and 20mm, applied to asphalt crushed base or subbase;                                                                                                                |
| Cement concrete pavement      | particle size $\leq 5\text{mm}$ , applied to cement concrete pavement;                                                                                                                         |

#### 4. Countermeasure Research

Drawing on industrial large-scaled development model of construction waste in the developed countries, China's construction waste recycling technology system is gradually cultivated and built, and the following three aspects of the work should be focused on<sup>[7-8]</sup>.

First of all, the government issues fostering policies. Government should expand the disposal site's approval of construction waste, to promote the development scale of waste. Otherwise, for investment and industrial activities of waste disposal, government should give tax incentives and loan discounts, so as to enhance the self-survival of waste disposal enterprises.

Furthermore, to increase the special technology investment, and break through the key technologies of waste recycling. Special funds and incentive system are established, to encourage universities and research institutes to participate in the development and diffusion of construction waste resource recycling.

Last but not least, to strengthen publicity and education to the public. Through the promotion of education and training, let the whole society understand the importance of construction waste recycling, recognize that construction waste is a useful resource, so as to improve the awareness and enthusiasm of construction waste comprehensive utilization.

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