Discussion on Classification System of Construction Waste in China

Liang Wang and Chenggang Xi
RIOH High Science and Technology Group, Beijing, China
Email: 263065093@qq.com

Abstract. With the continuous recommendation of the urbanization process in China, the production of construction waste is also increasing. At present, the utilization of construction waste resources in China is relatively low, mostly landfilling disposal. The environmental problems caused by landfill disposal are becoming more and more serious, but also a great waste of resources. Fine classification of construction waste source is the premise and key to promote the precise management and control of construction waste. This paper makes a thorough investigation and literature analysis on the classification methods of construction waste in developed countries abroad and the Post-disposal modes brought by classification. Based on the current situation and existing problems of classification of construction waste in China, six first-level classification and 28 second-level classification are proposed. The results of construction waste and the feasibility of the results are discussed and analyzed in order to provide reference for the classification of buildings in China.

1. Background
With the continuous deepening of reform and opening up, China’s urbanization has developed rapidly and construction has continued to advance. The accompanying construction waste has also increased. At present, the amount of construction waste in China has accounted for 30% to 40% of urban waste [1]. At present, China’s construction waste disposal methods are mainly landfills and the level of resource utilization is low. Nearly 90% of construction waste is land filled in landfills [2]. With the increasing emissions, waste of resources, the ensuing environmental problems have become increasingly serious. Therefore, the detailed classification of construction waste and the identification of its environmental hazards are the premise and key to improving the accurate management and disposal of construction waste in China. The developed countries’ classification of construction waste started earlier and was more detailed. For example, the European Union has carefully classified construction waste, including the first and second classification of construction waste, and separate classification of harmful construction waste. Its total classification reaches more than 40 kinds [3]; Japan attaches great importance to the recycling of construction waste, and regards construction waste as “construction by-products”. According to the environmental attributes of different construction waste, construction waste is divided into: general waste, safe industrial waste (it can be safely landfilled), managed industrial waste (unsafe landfill), and specially managed waste (environmentally harmful), with a total classification of more than 20 types [4]. At present, the classification and planning of construction waste in China is still in its infancy, and the occurrence and composition of construction waste presents its own characteristics. Therefore, the refined classification of construction waste is the first task to achieve accurate control of construction waste in China. Based on the status of construction waste control and classification in China, this paper studies the composition and
characteristics of construction waste in China, and classifies construction waste with the goal of resource utilization, providing a theoretical basis for the accurate management and control of construction waste in China.

2. China’s Construction Waste Classification Status and Existing Problems

The refined classification of construction waste is the premise and basis for achieving full resource utilization of construction waste and planning for disposal. According to the “Technical Standard for Construction Waste Disposal” (2019) issued by the Ministry of Housing and Urban-Rural Development [3], the construction waste is classified into the following five types according to the source, namely engineering slag, engineering mud, engineering waste, demolition waste and decoration waste, etc.. At the same time, some scholars have proposed classification according to the composition of construction waste, which can be divided into waste soil, concrete blocks, waste mortar, etc. according to availability classification; it can be divided into inorganic non-metal renewable building solid waste and organic renewable solid waste. Solid wastes and wastes of metal buildings; according to their physical and chemical properties, they can be divided into inert construction waste and non-inert construction waste [5-9]. See table 1 for specific classification and composition of construction waste.

At present, the classification methods for construction waste in China are mostly concentrated on the source classification, but these classifications are mostly focused on how many types will be generated, and the direction of resource utilization, etc.; how to clearly guide the classification of construction waste sources to serve construction. The precise management and control of garbage and subsequent resource disposal still need to be improved [10].

3. Construction Waste Classification System for Precise Control

3.1. Connotation of Construction Waste Classification for Precise Management

At present, with regard to the management and control of construction waste, domestic construction waste authorities generally adopt the source classification method for statistics on construction waste occurrence and disposal. However, from the perspective of the disposal of construction waste, it has dual attributes: one is the pollution property, and the random disposal and landfill of construction waste will bring water, air pollution and hidden dangers; the second is the resource property, construction Garbage may be waste for the source engineering, but it may be resources for other projects. This is the “construction waste is a misplaced resource” that is generally considered abroad and often mentioned by domestic experts. Traditional construction waste disposal methods are mainly landfills. This method undoubtedly amplifies the pollution properties of construction waste, and ignores its resource properties, leading to environmental damage and pollution.

Based on the analysis of the pollution and resource type of construction waste, this article believes that the precise management and control of construction waste is, in short, “reasonably processing the pollution properties of resources on the premise of maximizing the resource properties”. That is to say, according to the environmental properties of construction waste generated during construction, the maximum comprehensive utilization of resources should be realized first, and the waste that cannot be recycled should also be most reasonably digested and treated according to its environmental properties (fill in Burial, incineration, etc.). Therefore, for the classification of construction waste oriented to precise control, the two attributes of construction waste are also used as the starting point to achieve maximum resource utilization and reasonable environmental disposal.

3.2. Construction Waste Classification Principles for Precise Management

For the complex field of precise management of construction waste, the classification of construction waste is particularly important for the formulation and monitoring of management policies and the coordinated processing of related departments. Therefore, the classification of construction waste for precise management must first be easy to understand. Promote consensus that the classification of
construction waste is oriented to precise management and control, so the classification results must not only meet the statistics and monitoring of on-site collection and construction waste management departments, but also promote a unified understanding, which is conducive to the coordination and communication of all parties in the construction waste disposal; The second is based on practical and practical classification, which is classified according to the characteristics of the source and composition of different construction waste, so as to avoid the confusion and complexity of the on-site classification; finally, to maximize the use of resources and dispose of conditions and environments. The most reasonable premise is to use resources as the guide, identify different types of construction waste, and use the environmental properties of construction waste as indicators to achieve the harmless treatment of construction waste.

| Category name | Classification and composition |
|---------------|--------------------------------|
| “Technical Standards for Construction Waste Disposal” (2019) | 1. Engineering slag: including spoil generated during the foundation excavation of various buildings, structures, pipe networks, etc.; 2. Engineering mud: including drilling pile foundation construction, underground continuous wall construction, mud-water shield construction, horizontal directional drilling and mud-water jacking; 3. Engineering waste: including waste materials generated during the construction of various buildings and structures; 4. Demolition garbage: including waste materials generated during the demolition of various buildings and structures; 5. Decoration garbage: Waste generated during the decoration of a house. |
| Source of construction waste | 1. Foundation pit spoil (surface soil and deep soil); 2. Demolition wastes such as roads and buildings (asphalt concrete, concrete, old bricks and cement products, broken blocks, tiles, stone, waste steel bars, various waste decorative materials, building components, abandoned pipelines and wires, plastic, waste wood, Lime soil, etc.); 3. Construction waste (waste sand stone, waste mortar, waste concrete, broken blocks, waste wood, waste metal, waste building materials packaging, etc.); 4. Decoration waste (demolition waste and old decoration materials, old building demolition and waste soil, building material waste, decoration waste, waste packaging, etc.); 5. Waste of building materials (waste materials, substandard products, etc. generated during the production and distribution of building materials). |
| Rubbish source | 1. Spoil; 2. concrete block; 3. waste concrete; 4. waste mortar; 5. asphalt concrete fragments; 6. waste brick; 7. waste sand stone; 8. waste wood; 9. waste plastic and waste paper; 10. Gypsum and waste mortar; 11. Metals such as waste steel bars; 12. Waste packaging. |
| Composition | 1. Inorganic non-metal renewable building solid waste; 2. Organic renewable solid waste; 3. Metal building solid waste; 4. Waste and used items. |
| Availability | 1. Inert construction waste (waste concrete, waste stone, waste asphalt, waste bricks, engineering muck, etc.); 2. Non-inert construction waste ((1) general solid waste; (2) toxic and hazardous solid waste). (1) General solid waste: scrap metal, waste wood, waste paper, waste polymer, construction sludge; (2) Toxic and hazardous solid waste: asbestos waste, waste organic solvents, chemically treated wood, lead paint, mercury waste, etc. |
| Physical and chemical properties | 1. Spills; 2. concrete block; 3. waste concrete; 4. waste mortar; 5. asphalt concrete fragments; 6. waste brick; 7. waste sand stone; 8. waste wood; 9. waste plastic and waste paper; 10. Gypsum and waste mortar; 11. Metals such as waste steel bars; 12. Waste packaging. |
3.3. Construction Waste Classification and Results Analysis for Precise Management

The classification of construction waste should not only meet the needs of the industry authority’s management and control level, but also facilitate the classification of on-site sources. Therefore, the classification method in this paper uses the dual classification scheme combined classification method, that is, the secondary classification scheme is adopted, and according to the characteristics of construction waste, statistical classification is the main classification type of construction waste. Under each main classification type, it is subdivided according to different material composition and resource utilization methods, and coding of various types of construction waste is helpful to construction waste management departments and all parties. Form consensus. This paper divides the main classification of construction waste into 6 first-class categories and 28 second-class categories. The construction waste classification results are shown in Table 2.

Table 2. Classification system of construction waste in China.

| Code  | Construction waste category                                      | Contains content                                                                 |
|-------|-----------------------------------------------------------------|----------------------------------------------------------------------------------|
| CW 01 | Concrete, brick, stone                                         |                                                                                  |
| CW 01 01 | High grade waste concrete (block)                               | C20 and above concrete                                                          |
| CW 01 02 | Low grade waste concrete (block)                                | Less than C20 waste concrete blocks, spilled concrete, unidentifiable labelled concrete, and high and low labelled concrete mixture |
| CW 01 03 | The entire waste brick and tile                                 | Demolition of complete bricks and tiles                                          |
| CW 01 04 | Broken brick, tile                                             | Broken bricks, broken tiles, mixtures of whole bricks and broken tiles           |
| CW 01 05 | Hard rock                                                      | Rocks with saturated uniaxial ultimate compressive strength greater than 30 MPa, including excavated waste rock and demolition waste rock |
| CW 01 06 | Soft rock                                                      | Rock with saturated uniaxial ultimate compressive strength less than 30 MPa, or a mixture of hard and soft rocks, including excavated waste rock and demolition waste rock Waste ceramic tiles from demolition, ceramics and waste ceramic tiles from construction, etc. |
| CW 01 07 | Waste ceramic tile                                             | Waste ceramic tiles from demolition, ceramics and waste ceramic tiles from construction, etc. |
| CW 01 08 | Mixture of concrete, brick, stone, tile                        | Contains more than two of the four species                                       |
| CW 01 09 | Concrete, bricks, stones and their mixtures containing pollution and harmful substances | Those who have been polluted or contain harmful substances shall not be classified into the above eight categories, and shall be uniformly classified into this category. |
| CW 02 | Dregs                                                          |                                                                                  |
| CW 02 01 | Shield soil                                                    | Paste muck produced by tunnel shield construction                                |
| CW 02 02 | Mud                                                            | Mud from bridge foundation, tunnel mud-water balance shield, etc.                |
| Code   | Description                                                                                           | Characteristics                                                                                   |
|--------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| CW 02 03 | Cultivated soil                                                                                       | Fertile topsoil in agricultural land such as green land                                           |
| CW 02 04 | Excavation earthwork containing sand and stone                                                        | Undisturbed excavated soil with sand and stone content greater than 20%                           |
| CW 02 05 | Muck                                                                                                  | Excavated soil, miscellaneous filling soil with sand and stone content below 20%, slag mixture mixed with CW01 (content not exceeding 30%), waste mortar |
| CW 02 06 | Low pollution sludge                                                                                  | Sludge from dredging, etc.                                                                       |
| CW 02 07 | Highly polluted or harmful muck                                                                       | Various types of muck or muck mixture containing high pollution and harmful substances, cannot be classified into the above six categories |
| CW 03   | Asphalt concrete                                                                                      |                                                                                                  |
| CW 03 01 | Asphalt concrete containing coal tar                                                                  |                                                                                                  |
| CW 03 02 | Asphalt concrete                                                                                      | Asphalt concrete and materials without coal tar                                                   |
| CW 04   | waste metals                                                                                          |                                                                                                  |
| CW 04 01 | Scrap metal                                                                                            | Waste steel bars, steel scraps, etc.                                                              |
| CW 04 02 | Other scrap metal                                                                                      | Non-steel, non-heavy metal, non-polluting metal                                                   |
| CW 04 03 | Harmful and polluting scrap metal                                                                    | Heavy metals, contaminated or scrap containing hazardous materials                                |
| CW 05   | Thermal insulation, waterproofing and other building materials                                       |                                                                                                  |
| CW 05 01 | Asbestos-containing building materials                                                                |                                                                                                  |
| CW 05 02 | Building materials containing other harmful substances                                                | Contains general building materials mixed with hazardous building materials                       |
| CW 05 03 | General building materials                                                                            | Free of asbestos and other harmful substances                                                     |
| CW 06   | Other construction waste                                                                             |                                                                                                  |
| CW 06 01 | Shattered glass                                                                                        |                                                                                                  |
| CW 06 02 | Waste wood                                                                                            |                                                                                                  |
| CW 06 03 | Waste plastic                                                                                        |                                                                                                  |
| CW 06 04 | Waste packaging materials                                                                             |                                                                                                  |

3.3.1. Analysis of Classification Results of Concrete, Brick, and Stone Construction Waste. Concrete, brick, stone and other construction waste as the main component of the building structure, its production is large, accounting for about 60% of all construction waste, while its material composition is relatively stable, and has a certain strength, has a certain recycling value. According to its strength, it can be used as building materials directly or after reprocessing; its own environmental property is basically harmless, but it does not exclude the contact and mixing with toxic and harmful substances, so it is necessary to identify the harmful mixture.

According to the recyclable characteristics and environmental attributes of construction waste such as concrete, brick and stone, this paper divides it into 9 secondary classifications, including: high grade concrete, low grade concrete, whole waste brick, tile, broken, brick and tile, hard rock, soft rock, waste ceramic tile, concrete, brick, stone, tile mixture and concrete, brick, stone containing pollution and harmful substances class and their mixture, etc. The specific classification is analyzed as follows: (1) high grade concrete: generally, the strength of cement concrete above C20 is high, and its recycled...
use can be processed into C20 concrete aggregate, which can be used for building structure; (2) low grade concrete: the strength of low grade or mixed concrete is low, which can be used as recycled brick aggregate or backfill after processing; (3) whole waste brick and tile: the whole brick and tile sorted in the demolition process can be directly imported recycling; (4) broken and brick and tile: for the broken brick and tile and their mixture produced in the demolition process, they do not have sorting value, but mainly carry out mixed recycling processing, use as backfill, or bury; (5) hard rock: hard rock produced in the project construction (rock with saturated uniaxial ultimate compressive strength greater than 30 MPa), can be directly used as high-grade aggregate Use; (6) soft rock: Soft rock (rock with saturated uniaxial ultimate compressive strength less than 30 MPa) and its mixture are poor in strength, which can be processed as low-grade aggregate or stacked after mixed recycling; (7) waste ceramic tiles: waste ceramic tiles, ceramics, etc. produced in demolition process, are usually recycled as raw materials; (8) concrete, brick, stone ceramic tile mixture: this kind of mixture mainly refers to four or more of the first seven kinds of construction wastes, which have no further subdivision value and are harmless to the environment. It can be collected and buried in a unified way; (9) concrete, brick, stone and their mixture containing pollution and harmful substances: this kind of mixture of construction wastes pollutes the environment no matter how much and how strong whether it is good or bad, it shall be treated separately.

3.3.2. Analysis of Classification Results of Mucky Construction Waste. This paper classifies the source of muck, the different manifestations of muck, and the direction of later disposal and utilization. It is divided into 7 secondary classifications, and the muck that may cause environmental pollution is classified separately. The specific classification can be seen from figure 2 for details.

(1) Shield soil: Because the tunnel construction process uses a special construction method, the slag produced by it is similar to toothpaste, and can only be recycled after improved treatment; (2) Mud: Mud will be recycled in engineering construction; It can be reused after being uniformly pressed and solidified. (3) Cultivated soil: This type of soil is mainly produced in the process of surface cleaning. It has good fertility and can be used for engineering greening soil. Therefore, it needs to be stored in a concentrated manner for later special use. (4) Excavation earthwork containing sand and stone: undisturbed soil excavated in the construction of the project. When the content of sand and stone is greater than 20%, the texture is good and suitable for backfilling. (5) Slag: the content of sandstone is less than 20%. Most of the mixed filling soil is a mixture, which has poor strength and needs to be recycled. (6) Low pollution sludge: The sludge generated during the dredging of the project construction usually has a certain low pollution and needs to be tested before being treated; (7) High pollution or harmful Spoil: this type of soil mainly refers to contaminated soil or soil mixed with harmful substances. No matter how much, it needs to be treated separately.

3.3.3. Analysis of Classification Results of Asphalt Concrete Construction Waste. This article is divided into two secondary classifications according to the environmental properties of asphalt concrete. (1) Asphalt concrete containing coal tar: This type of asphalt concrete contains coal tar, which is toxic and requires special recycling treatment. (2) Asphalt concrete: it is different from coal Asphalt concrete other than tar asphalt concrete.

3.3.4. Analysis of Classification Results of Scrap Metal Construction Waste. According to the environmental properties of scrap metal, this paper divides it into three secondary classifications. (1) Scrap steel: This type of scrap steel mainly includes formed waste steel bars, scrap steel scraps, etc., which are easy to recycle and have high value; (2) Other waste metals: It mainly contains some unformed but non-toxic waste metal, including the corners of power cables and pipes, cuttings of plumbing copper pipes, etc., which are of high value and can be specially recycled; (3) hazardous and polluting waste metals: this type of metal They have been exposed to toxic and harmful materials and are environmentally polluting. Therefore, regardless of their value, they are classified separately.
3.3.5. Analysis of Construction Waste Classification Results of Thermal Insulation, Waterproofing and Other Building Materials. In this paper, according to its environmental properties, heat insulation and waterproof materials are divided into three secondary classifications: (1) Construction materials containing asbestos: Asbestos materials are toxic and harmful to the environment and the human body, so they are classified as a separate category; (2) contains other Building materials with harmful substances: Mainly materials containing mixed with other harmful substances, which are classified into one category; (3) General building materials: These materials are non-toxic after testing, and can be directly recycled and classified into one category.

3.3.6. Analysis of Other Construction Waste Classification Results. The other wastes referred to in this article are classified into one category other than the above-mentioned five major types of construction waste. The amount of this kind of waste is relatively small, but it needs to be specially recycled. Other construction waste is divided into four secondary classifications: (1) No pollution to the environment, can be reprocessed into raw materials, which need to be specially recycled, so they are separately classified as a category; (2) waste wood: directly recycled or broken and used, special recycling is required to classify it into a category; (3) Certain environmental pollution, which can be reprocessed into raw materials and need to be specially recycled, so they are counted as a separate category; (4) Waste packaging materials: can be directly recycled and used, with higher recycling value, so they are classified into a category.

4. Conclusion
This paper integrates foreign construction waste classification practices, and combines the current status and problems of construction waste classification in China, with the goal of maximizing the use of construction waste resources and rationalizing the disposal environment; it proposes six primary classifications and 28 secondary classifications. In order to facilitate management and coordinated disposal of various departments, unified coding is carried out. This paper believes that this construction waste classification system table can better reflect the actual occurrence of construction waste in China, and can specifically serve the actual classification and production of construction waste at the source, and can promote the realization of construction waste recycling and harmless treatment.

Acknowledgments
This study was supported by the National Key R&D Program of China (2018YFC0706002).

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