Study on the Characteristics and Reduction Measures of Construction Waste Generated in Subway Engineering

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Abstract. In the process of urban modernization and rapid construction, the construction and reconstruction of large-scale construction projects such as subways, underground pipe corridors, and housing construction facilities are accompanied by a large amount of construction waste. A huge amount of construction waste not only occupies a large number of land resources, but also affects air quality, pollutes waters, destroys city appearance and environmental sanitation, and has potential safety hazards. In the long run, it also affects urban development space and shortens the city life cycle. At present, there are many shortcomings in China's policy management, classification and measurement, reduction technology, transportation recovery, recycling and other aspects of construction waste. Especially from the source, there is a lack of research on the source characteristics of construction waste, which makes the quantitative quantification of various construction wastes impossible to achieve construction, accurate management, and control of waste. This study takes the urban subway construction project as the research object, through the field investigation, literature review and other methods, analyses the classification and source of underground construction waste by the project unit construction process as the framework, and analyses the corresponding construction waste according to the investigation and data collection. The reduction measures implemented.

1. Background
In recent years, with the rapid development and expansion of cities, the urban population has expanded rapidly, causing severe traffic pressure. The urban subway construction project has become the main measure to ease traffic pressure within the city, which has brought great convenience to people's travel. At the same time, the construction of such large-scale infrastructure has also generated a large amount of construction waste, which has seriously affected the ecological environment. It is estimated that an underground tunnel with a length of 1 km and a diameter of 6 m will produce about 68,000 cubic meters of construction waste. Taking the development of subway planning as an example, in the next 5 to 10 years, the construction mileage of China’s subways will increase by more than 4,000 kilometres, and it is estimated that about 2.7 billion cubic meters of construction waste will be produced [1]. At present, China lacks effective treatment measures for construction waste. Leading to a large amount of construction waste, the resource utilization rate is less than 10% [2]. Therefore, if the problem of construction waste
control is not handled well, it will aggravate the shortage of construction resources and environmental problems in China, and even seriously affect the construction of ecological civilization in China.

2. Domestic and Foreign Research

2.1. Foreign Research

Developed countries such as the United States and Japan have formulated relevant laws and standards on waste resource reuse, resource conservation and recycling, and integrated waste management in the 1970s. These regulations propose a strategy for controlling and reducing construction waste output from the source, specifying the management methods for building materials classification, promoting renewable resources, the obligations of various responsible entities, and the marketization and industrialization of recycled products. And under the effective macro-legal means and micro-technical means in these years, developed countries can basically implement zero discharge of construction waste treatment, and the recovery rate can reach over 97% [3].

2.2. Domestic Research

2.2.1. Legal Standard. With the rapid development of China’s economy in recent years, the government’s requirements for environmental protection are increasing, and a series of laws and regulations, special plans and preferential policies have been formulated in the construction of waste recycling. The regulations implemented at this stage mainly include the Municipal Solid Waste Treatment Law, the Solid Waste Pollution Prevention and Control Law, the Urban Construction Waste and Engineering Waste Management Regulations, the Construction Waste Treatment Technical Specifications, and the Urban Construction Waste Management [4]. Regulations, etc., have played a very good role in promoting the comprehensive utilization of waste, but the enforceability is poor, the subject of responsibility is not clear, and there is no effective supervision system and rewards and punishments.

2.2.2. Reduction and Resource Utilization. The resource utilization rate of construction waste in China is low, and most of the construction waste is untreated and directly transported to the open air for land dumping or landfill. According to the “Circular Development Leading Action”, China has set a target of 13% of urban construction waste recycling rate by 2020 [5]. At present, China is carrying out pilot work on construction waste management, selecting 11 cities to strengthen the reduction and control of construction waste sources [6], researching green construction technology systems with low environmental impact and efficient use of resources, improving the recycling of construction waste, and formulating policies for the promotion and application of recycled products.

In short, compared with the development of foreign countries, China’s construction waste disposal technology started late, technology and management are not mature, did not form a relatively complete industrial chain and management system, the recycling technology is not mature, the law and supervision are not enough, etc. These are the problems faced by the disposal of construction waste in China.

3. Subway Engineering Case

Dongfeng Station is the fourth station of Zhengzhou Subway Station 3 and is replaced with the “T” type of Tongle Station of Zhengzhou Subway Station 8. It is located at the intersection of Nanyang Road and Dongfeng Road, along with the Nanyang-Road setting. Dongfeng Road Station is an underground two-story island platform station with a total length of 228.8 meters, a standard section width of 23.1 m and a platform width of 14 m, and 4 entrances and exits. The standard section foundation pit adopts open excavation construction, adopting bored pile inner support; the transfer node is constructed by cover
digging method, and the support system adopts underground continuous wall inner support. The main structure of the station is a two-story three-span rectangular frame structure, and the transfer node is a three-story underground structure.

3.1. Source and Characteristics of Waste Generation

According to the investigation of the construction site, the units and processes for the construction waste of the works of Dongfeng Station are shown in table 1. The differences in construction waste in each construction process are compared and analysed [7]. It is concluded that construction waste is mainly constructed with engineering waste in the whole period of underground construction. Engineering waste, engineering mud, and waste steel are the main ones, accounting for more than 99%. The waste wood and waste paint barrels are rarely generated, and the characteristics are disordered, but the chemical composition is complex and requires precise control at the construction site. After the completion of the project, due to the high recycling value of the waste steel, the construction party will establish a temporary storage yard to recover the discarded steel bars. After recycling, such materials will be reprocessed into materials to be recycled [8]. The waste wood is mainly generated when the wooden formwork is worn out, and the amount generated on the construction site is small. The earthwork backfilling will use some of the engineering waste to backfill, but the backfill volume of the engineering dregs is not equal to the volume of the backfilling part, or a part of the muck is used to burn environmentally-friendly bricks, sand-fired recycled bricks, etc., but the amount of use is not large enough. Consumption, so the last remaining construction waste produced the largest amount of engineering waste, accounting for more than 70% of the total construction waste. Abandoned concrete blocks and mud account for about 20% of the total construction waste. The best disposal method for the garbage is generally on-site utilization, or it can be used as a concrete reuse aggregate bypassing the test indicators.

3.2. Garbage Generation Control and Analysis

Based on the analysis of the source and characteristics of construction waste, further analyse the influence of construction waste and the precise disposal factors, and summarize the main factors that affect the construction and control of construction waste are the lack of existing national standards, extensive management, resource-based technology, insufficient industrial support, and weak construction site management. China’s current standard norms lack accurate classification of construction waste, resulting in construction waste not being on-site classification, increasing the cost of sorting and disposal, affecting the efficiency of construction waste resource utilization [9]; at the same time, China has not established a statistical reporting system for construction waste. There is a lack of scientific methods to predict construction waste indicators, resulting in a lack of accurate statistics on the total amount of construction waste generated and the amount of construction waste generated each year. It is impossible to achieve precise control; the government often ignores the construction waste disposal plan in the near-term planning, resulting in the lack of superior planning. The amount of construction waste generated during construction is affected by factors such as construction scale, design basis, construction technology and construction level, and the concept of construction workers. The source characteristics of waste are unclear, and the characteristics of space-time evolution are unclear. As a result, the utilization of construction waste resources is insufficient, and the remaining construction waste is too large.

4. Reduction Measures

According to the investigation of the research on the implementation of construction waste recycling and demonstration projects at home and abroad, the existing major contradictions propose several reduction measures.
Table 1. Dongfeng Subway project produces waste components and source records.

| Construction process          | engineering dregs | waste concrete | engineering mud | waste packaging | scrap steel | waste wood | waste plastic | others |
|-------------------------------|------------------|----------------|----------------|----------------|-------------|------------|--------------|--------|
| **Demolition project**        |                  |                |                |                |             |            |              |        |
| Transplanting trees           | -                | -              | -              | -              | -           | -          | -            | -      |
| Demolition of road surface,  | ◎                | -              | -              | -              | -           | -          | -            | -      |
| base layer, masonry structure, |                  |                |                |                |             |            |              |        |
| levelling site, etc.          |                  |                |                |                |             |            |              |        |
| Construction access road      | -                | ◎              | -              | -              | ◎           | -          | -            | -      |
| construction                   |                  |                |                |                |             |            |              |        |
| Remove the pipe               | -                | -              | -              | -              | -           | -          | -            | ◎      |
| **Interval support**          |                  |                |                |                |             |            |              |        |
| Bored pile construction       | ◎                | ◎              | ◎              | -              | ◎           | -          | -            | -      |
| Ground wall construction      | ◎                | ◎              | ◎              | -              | -           | -          | -            | -      |
| Foundation pit excavation     | -                | -              | -              | -              | -           | -          | -            | ◎      |
| Grouting                       | -                | ◎              | -              | -              | -           | -          | -            | -      |
| **Lining engineering**        |                  |                |                |                |             |            |              |        |
| Lining concrete               | -                | ◎              | -              | -              | -           | -          | -            | -      |
| Drain pipe                    | -                | -              | -              | -              | -           | -          | -            | ◎      |
| **Shield tunnelling**         |                  |                |                |                |             |            |              |        |
| Shield excavation             | ◎                | -              | -              | -              | -           | -          | -            | -      |
| Lining grouting               | -                | ◎              | -              | -              | -           | -          | -            | -      |
| Precast reinforced concrete segments | - | - | - | - | - | - | - | - |
| **Underground structure**      |                  |                |                |                |             |            |              |        |
| engineering                   |                  |                |                |                |             |            |              |        |
| Concrete column               | -                |◎              | -              | -              | ◎           | -          | -            | -      |
| Concrete foundation beam      | -                |◎              | -              | -              | ◎           | -          | -            | -      |
| Concrete wall                 | -                |◎              | -              | -              | ◎           | -          | -            | -      |
| Concrete wall bottom plate,   | -                |◎              | -              | -              | ◎           | -          | -            | -      |
| middle layer plate, platform  |                  |                |                |                |             |            |              |        |
| plate                         |                  |                |                |                |             |            |              |        |
| Coil waterproof               | -                | -              | -              | -              | -           | -          | -            | ◎      |
| Film waterproof               | -                | -              | -              | -              | -           | -          | -            | ◎      |
| Rigid waterproof layer        | -                | -              | -              | -              | -           | -          | -            | ◎      |

Note: ◎ a lot, many; ◯ small amount; - nothing.

4.1. Establish and Improve the Legal System and Management System
Formulate more reasonable and feasible construction waste recycling laws and regulations as soon as possible, strengthen the restrictions on construction waste discharge, clarify the responsibilities of personnel at all levels, and coordinate the implementation of laws and regulations by various departments; secondly, the government should implement environmental protection and construction waste management measures [10]. Into the bidding system, to achieve the source control of construction waste;
finally, increase social publicity and education, increase supervision and enforcement, and establish a regulatory information platform.

4.2. Increase Scientific Research and Technological Innovation
The high cost of construction waste recycling is a major reason for hindering the recycling of resources. Therefore, the development of construction waste recycling technology has been developed, the recycling rate of construction waste has been improved, and the equipment and equipment suitable for recycling of construction waste in China have been developed. The solution is to solve the problem of resources. At the same time, vigorously promote the use of BIM technology, break the restrictions of the “information gap”, timely grasp the construction design progress, technical issues, etc., to avoid the increase of engineering volume during the construction process due to improper design, and reduce the loss of building materials.

4.3. Refined Design and Construction Management
Fine design can guarantee the quality and durability of buildings, select structural design, building materials and recycled materials that generate less construction waste [11]; Actively promote standardized construction, prefabrication technology, and green construction, which can realize on-site recycling of building materials and reduce pollution on the construction site. Strengthen construction organization management, improve construction workers' awareness of reducing environmental awareness of construction waste, strictly implement construction waste site classification standards, and reduce construction waste generation.

4.4. Strengthen Incentives
Establishing building materials that will use construction waste into green products that are preferentially procured by the government, so that production companies have no worries; introduce more effective policies to increase the proportion of used building materials, and give corresponding preferential policies; The low price of fees and recycled building materials guarantees that they are competitive in the market.

4.5. Strengthen Publicity and Raise Awareness
Raising awareness of resources, not only for builders and designers but also for government and management personnel, is not only conducive to the development of recycling work but also conducive to the promotion of resource-based products, so that the construction waste industry chain continues to grow.

5. Conclusion
The reduction of underground construction waste is solved by the source. The key is to establish sound policies and regulations, effective construction waste design and construction precision management, and improve the efficiency of construction waste resource utilization. At this stage, in order to solve the shortage of resources for the construction of natural sand and gravel aggregates, the state should vigorously promote the policy of sustainable development, support the development of construction waste resources is the general trend; engineering construction waste should be from the whole process information statistics, source characteristics analysis From the source of engineering design, engineering construction, material selection, etc., reduce the amount of construction waste generated and discharged on the construction site, to achieve accurate classification and recycling; further deepen the research and application of construction waste recycling aggregate application technology.

References
[1] Report of Market Research and Investment Forecast Analysis on China Construction and Demolition Waste Disposal Industry (2020-2025).
[2] Wang L, Jiang L, Zhao Y et al. 2019 *Construction Waste Disposal and Resource Utilization* (Beijing: Chemical Industry Press).
[3] Zhao Y, Huang W, Gao X, et al. 2018 *Recycling of Construction Waste Resources* (Beijing: Chemical Industry Press).
[4] Xu Y, Chen J, et al. 2018 *Excerpt of Construction Waste Management and Recycling Policy* (Beijing: China Construction Industry Press).
[5] National Development and Reform Commission 2017 *Circular Development Leading Action*.
[6] General Office of the State Council 2018 "Waste Free City" Pilot Work Program.
[7] *Standard Method of Measurement for Urban Transit Railway Works* GB50861-2013 (Beijing: China Planning Press) pp 30-39.
[8] *Code for Recycling of Construction & Demolition Waste* GB/T50743-2012 (Beijing: China Planning Press).
[9] Zhou W, Chen J and Lu H 2009 *Current Situation and Countermeasures of Construction Waste Recycling in China* (Building Technology) chapter 40 pp 741-744.
[10] Fu X 2015 *Research on the Reducing Management of Construction Waste Based on Green Construction Framework* (Guangdong University of Technology) pp 50-62.
[11] Li J, Zhu J, Cai H, et al. 2014 *Analysis on Influencing Factors of Construction Waste Reduction Behavior of Designers* (Science and Technology Management Research) chapter 14 pp 185-187.