Study on Estimation Method of New Construction Waste

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Abstract. With the rapid development of construction industry and the large discharge of construction waste, there are many environmental problems. In order to formulate and implement the strategy of reducing management at the project level, it is necessary to estimate the amount of construction waste production accurately. Based on two methods, the building area method and the BIM method are used to estimate the amount of construction waste generated by a new residence, and a comparative model is established. According to the results, the method based on BIM can accurately estimate the amount of residential construction waste, improve the management level of residential construction waste and reduce environmental pollution.

1. Introduction

Construction industry is the pillar industry of our national economy, which plays an important role in economic growth and employment absorption. The construction industry is not a resource-saving and environment-friendly industry. Construction activities will produce a large amount of construction waste. It is expected that the national construction waste production will exceed 3 billion tons in 2020, which will have a great adverse impact on the environment. The construction waste contains waste metals, waste polymers and a small amount of lead paint and mercury-containing waste [1], resulting in reduction of soil quality [2]; construction waste contains materials such as asphalt, gypsum and paint, which pollute the water source, which will decompose into harmful and irritant gases such as sulfides, ammonia and pollute the of air quality [3].

The research on the production of construction waste mainly from two aspects, on the one hand to predict the regional (national or urban) production of construction waste, the other is to estimate the production of building waste. the grey model [4], multivariate linear regression model [5] and ARIMA model [6] are used to predict the main models of construction waste production in the future regions, different models are different in prediction accuracy and calculation mode. Katz [7] using field sampling, Chooi by collecting the size and quantity of different types of construction waste disposal vehicles, Documenting the amount of garbage generated high - rise buildings [8], Calculate the construction waste discharge index. Lam put forward that construction waste production is based on the bill of quantities estimate, to establish a method for estimating the amount of construction waste, such as ceramic tile, inner wall latex paint and formwork, Three multi-storey houses in Hong Kong, Getting a square metre of building produces 0.6 cubic metres of construction waste, and verify the accuracy of the data [9]. BIM is also used to produce construction waste, Kim proposed a BIM - based framework, The framework estimates construction waste at an early stage of design, for effective and simplified planning, handling
and management of construction waste [10].

Building area method and BIM method are used to estimate the amount of construction waste generated by new buildings. BIM can digitize and parameterize buildings, and can accurately estimate the amount of construction waste produced in a short time. It is of great significance to estimate construction waste.

2. BIM-based estimation model for new buildings

By consulting the literature, the traditional method of estimating the production of new construction waste usually introduces a concept of "construction waste generation index". POON, in estimating the total amount of new construction waste generation, a new concept "construction waste generation index" is introduced, that is, the average output of construction waste per unit building area (GAF) [11]. On-site sampling of 10 new residential construction sites in Israel was Katz to produce 0.2 cubic metres of construction waste per square metre for the entire residential project based on the amount of construction waste collected and its composition [7].

According to the literature, there is little use BIM estimate project construction waste in China. Cheng extract the information of building material composition and volume by BIM model, predict the amount of construction waste produced by demolition or reconstruction, and provide the basis for calculating the waste disposal fee in Hong Kong [12]. Guerra refer to the material balance method put forward by relevant scholars, that is, the amount of construction waste discharge is the difference between the amount of material purchased and the actual amount used in construction, and the quantity of waste concrete, brick and block in the construction process is calculated by using the BIM to calculate the material quantity and purchase list and the purchase list [13]. This model uses the actual construction waste production index, the reference [14] method, based on the BIM to derive the list of building materials, calculate the total amount of new construction waste, the calculation formula is

\[ W = \sum_{i=1}^{n} C_i \times Q \]  

(1)

The W represents the total amount of new construction waste, the \( t;C_i \) represents the consumption of the main building materials, and the \( t;Q \) represents the target and kg/t. of the main building materials waste.

The composition of construction waste has different definitions in different regions and scholars. Shenzhen's Technical Specification for Emission reduction of Construction waste shows that the basic composition of construction waste produced by buildings with different use functions is roughly the same, mainly composed of concrete, brick and block, mortar, metal and wood (see Table 1).

| Construction type       | concrete | brick and block | mortar | metal | wood | other | WA   |
|-------------------------|----------|-----------------|--------|-------|------|-------|------|
| Residential buildings   | 18.7     | 1.8             | 1.3    | 4.0   | 7.8  | 3.4   | 37.0 |
| Commercial buildings    | 18.0     | 1.8             | 1.2    | 4.5   | 5.7  | 2.8   | 34.0 |
| Public buildings        | 18.0     | 2.2             | 2.1    | 3.0   | 6.3  | 3.4   | 35.0 |
| Industrial buildings    | 17.4     | 1.2             | 1.2    | 2.6   | 5.6  | 3.0   | 31.0 |

Li believe that construction waste mainly includes concrete, brick and block, wood formwork, mortar and tile (as shown in Table 2), in which Concrete accounts for up to 43.5% of the total [15]. According to the conclusion of the Li, because most of the materials are purchased in batches, there are few cases where the purchased materials exceed the required amount, so the amount of remaining building materials is not considered, and the utilization rate of engineering residue is high. The amount of engineering residue is not calculated.
Table 2. Production Index of New Residential Construction Waste in Shenzhen

| Material                  | Proportion (%) | Amount purchased | Amount purchased (t) | W(t)   | Consumption (t) | WA (kg/㎡) |
|---------------------------|----------------|------------------|----------------------|--------|-----------------|-------------|
| Concrete                  | 1.0            | 56011㎡           | 134426.4             | 1344.2 | 133082.2        | 17.7        |
| Steel bar brick and block| 3.0            | 10204t            | 10204.0              | 306.1  | 9897.9          | 4.0         |
| Timber formwork           | 5.0            | 6511m³            | 5208.8               | 260.4  | 4948.4          | 3.4         |
| Mortar                    | 80.0           | 60020m³           | 720.2                | 576.1  | 144.1           | 7.6         |
| other                     |                |                   |                      |        |                 |             |
| Total W                   |                |                   | 3096.5               | 40.7   | 100.0           |             |

The generation of construction waste in the construction process is closely related to the type of construction use and the construction technology. The basic components of construction waste produced by buildings with different functions are roughly the same, but the indexes of waste production of various components are different. The waste index of main materials with different functions is shown in Table 3.

Table 3. Index of waste production of construction materials (kg/t)

| Construction type         | Concrete | brick and block | Mortar | Timber formwork | metal | Tile | ... |
|---------------------------|----------|-----------------|--------|-----------------|-------|------|-----|
| Residential buildings     | Q_{11}   | Q_{12}          | Q_{13} | Q_{14}          | Q_{15}| Q_{16}| ... |
| Commercial buildings      | Q_{21}   | Q_{22}          | Q_{23} | Q_{24}          | Q_{25}| Q_{26}| ... |
| Public buildings          | Q_{31}   | Q_{32}          | Q_{33} | Q_{34}          | Q_{35}| Q_{36}| ... |
| Industrial buildings      | Q_{41}   | Q_{42}          | Q_{43} | Q_{44}          | Q_{45}| Q_{46}| ... |

This paper distinguishes the consumption of building materials according to building, the consumption of building materials is distinguished by the following formula, that is

\[ C_i = \{C_{i1}, C_{i2}, C_{i3}, C_{i4}, C_{i5}, ..., C_{in}\} \]

where \( C_i \) represent buildings with different use functions, \( i = 1, 2, 3, 4 \), and \( C_{ij} \) represent the material consumption of buildings with different use functions, such as concrete, reinforcement and formwork.

The total amount of construction waste generated in the new building is shown in the following formula that is

\[ W = \sum_{i=1}^{n} w_i = \sum_{i=1}^{n} (C_i \times Q_{ij}) \]  

3. Building Area Model

The building area method is often used to estimate the amount of construction waste produced, and the new construction waste generated according to the building area is shown in the following formula, that is

\[ WG = \sum_{i=1}^{n} A_i \times (\sum_{j=1}^{m} WA_{ij}) \]

The \( WA_{ij} \) refers to waste output index, kg/m²; The \( A_i \) represents the building area of residential buildings, commercial buildings and public buildings m², as shown in the following...
\[ A_i = \{A_1, A_2, A_3, ..., A_n\} \]  

\( A_1 \) means residential building area, \( m^2 \); \( A_2 \) means commercial building area, \( m^2 \); \( A_3 \) means public building area, \( m^2 \).

According to the Technical Specification for Emission Reduction of Construction Waste issued by the Shenzhen Municipal Bureau of Housing and Urban-Rural Development, 37 kg of construction waste is generated per square metre in residential buildings; Li, based on the principle of quality balance of building materials, an index model of waste generation rate of main building materials is established. Compared with the above data, the results show that the documents and Li published by Shenzhen Housing and Construction Bureau are basically the same. Considering that the data released by Shenzhen Housing Bureau is more authoritative, the data of Shenzhen Housing Bureau are adopted.

4. Model Accuracy Verification

The relative error is used as the index to verify the accuracy of the model in this paper. According to the index shown in the [16] of the literature, \( \leq 20\% \), that is, the accuracy of the model is considered to be good, and the following formula is used to express the accuracy of the model:

\[ \delta_i = \frac{|WG - wg|}{wg} \]  

The \( \delta_i \) is relative error, the \( WG \) is the estimated value of new residential waste, and the \( wg \) is the value of building area method to estimate the amount of new residential waste. If the measurement index \( \leq 20 \), the accuracy of the model is good.

5. Conclusion

This paper establishes the building area method and the BIM method to estimate the new construction waste production model, especially introduces the BIM method to estimate the construction waste model, because the BIM can data and parameterize the building, can accurately estimate the construction waste in a short time, more suitable for estimating the new construction waste production.

The article focuses on the establishment of a BIM method to estimate the amount of construction waste generation model. It is necessary to establish a complete and accurate construction model based on the building completion drawings to obtain the correct engineering quantity list, assist in real-time construction waste generation indicators, and estimate the amount of construction waste generation. Therefore, in actual work, it is necessary to continue to modify and supplement the data to obtain more accurate estimation results.

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