Design and realization of the supervision system for the harmless treatment of building waste based on LCA

Lanyun Chen¹, Shuanglei Wu²* and Quanwei Zhao³

¹ School of Architectural Engineering, Jinhua Polytechnic, Jinhua, Zhejiang, 321017, China
² School of Materials Science and Engineering, Zhejiang University, Zhejiang, 310007, China
³ School of Architectural Engineering, Jinhua Polytechnic, Jinhua, Zhejiang, 321017, China

*Corresponding author e-mail: wushuanglei@zju.edu.cn
*Corresponding author ORCID: https://orcid.org/0000-0001-6805-3879

Abstract. With the acceleration of our country's urbanization and the continuous enrichment of people's material life, it is necessary to improve the construction of urban functions. Therefore, it should demolish and rebuild existing buildings to improve the original scattered, chaotic, and poor environment, resulting in a large amount of construction waste. At present, most of the construction waste has not undergone any treatment and is disposed of in open-air storage or landfill. This treatment method not only takes up a lot of arable land and construction funds, but also increases environmental pollution, causing increasingly unbearable pressure on the social environment. For this reason, it is essential to design a monitoring system for the harmless treatment of building waste from the perspective of a long-term life cycle. The purpose of this article is to study the harmless treatment of building waste and the real-time supervision of waste. In this paper, the field survey method and questionnaire survey method are used to investigate and respond to on-site construction waste. Experimental research results show that the design of the supervision system for the harmless treatment of building waste is supported by the state, society, enterprises and citizens. Among them, the treatment of concrete in the waste is the first place, because its proportion in the waste reaches 47.8%. In order to protect the environment and follow the path of sustainable development, it is imperative to treat wastes in a harmless manner.

1. Introduction

At present, the treatment of construction waste resources in our country is still in its infancy. First, the corresponding mandatory laws and regulations have not been promulgated at the national level. Second, the relevant subjects of construction waste management lack the awareness of recycling. As a result, the resource utilization of construction waste has not reached the ideal state. Due to the pursuit of the principle of maximizing corporate profits, in many areas based on the principle of lowest disposal cost, the construction unit chooses to transport the generated construction waste to the suburbs for direct landfill or illegal landfill treatment nearby. Limited by land, technology and capital, the processing technology of resource-based enterprises is not yet fully mature, and the scale of production cannot meet the current increasing amount of construction waste. Therefore, we must
properly dispose of the construction waste generated during the construction process, and increase the proportion of construction waste recycling. The supervision system for the harmless treatment of construction waste has been further improved, which is of great significance to the effective management of construction waste and the promotion of the recycling of construction waste.

There are many researches on the LCA-based supervision system for the harmless treatment of building waste. For example, Bertrand A proposed that the energy lost to the environment can be recovered through the waste water heat recovery system in the building. In addition, the potential and relevance of waste water heat recovery have not been quantified as a function of the number of specific residents and households, end use, and building type and age [1]. A Domínguez introduced the use of waste from the construction and demolition industry to produce valuable glass materials. These materials are produced through a one-step process at moderate temperature after simple adjustment of the chemical composition of the waste, to help achieve sustainable development [2]. Zambrana believes that, at the city level, most of the generation of municipal solid waste and construction demolition waste is related to the life cycle of buildings. He proposed an assessment method based on the life cycle assessment method to analyze the environmental performance of construction waste management strategies in different life cycles in tertiary buildings. During the use phase of the building, minimize waste and avoid landfilling at least 10% of construction and demolition waste [3].

Based on the design of the LCA-based harmless treatment of building waste supervision system, this article mainly starts from the life cycle to understand the basic framework of life cycle assessment, and then according to some basic conditions of construction waste, combined with the relevant theories of LCA to prevent waste. Some experimental studies have been made on the design of the supervision and management of chemical treatment.

2. LCA-Based Harmless Treatment of Building Waste

2.1. Basic Framework of Life Cycle Assessment
LCA includes four contents: target and scope determination, inventory analysis, impact rating and result analysis [4].

(1) Determination of objectives and scope: The first step in life cycle assessment is to clarify the purpose of the research, and then determine the system functions, functional units, system boundaries, environmental impact types, data requirements, assumptions, etc.

(2) Inventory analysis: The core of inventory analysis is to establish the input and output of the product system expressed in product functional units. Common data collection channels for the inventory include field collection, existing databases, literature data, and government data.

(3) Impact assessment: Life cycle impact assessment has 3 steps. Classification, the results of inventory analysis should distinguish series, parallel, indirect and joint influence issues [5]. Characterization, through the establishment of a model to summarize the results of similar inventories. Weighted assessment, to determine the weight of each environmental impact, so as to summarize into a total environmental impact value.

(4) Interpretation: Analyze the results, form conclusions, explain limitations, make recommendations, and report the results of life cycle interpretation in a transparent manner.

2.2. Information about Construction Waste

(1) Composition: The sources of construction waste mainly come from four types of activities, namely, waste generated from new construction, reconstruction and expansion, demolition and decoration. Take the demolition of buildings as an example to study the composition of waste [6]. At present, most of the demolished buildings are brick-concrete buildings or structures of the last century. Among them, the amount of abandoned bricks and rubble accounts for about 80% of the total waste, and the rest are abandoned muck, waste wood, etc.. With the improvement of construction technology
and residential structure, the waste gradually changes from discarded bricks and rubble to concrete blocks.

(2) Features: our country’s construction waste has the characteristics of complex composition, large quantity, high potential value, and high pollution.

(3) Social impact: The impact on land resources, with the advancement of urbanization, the amount of construction waste will greatly increase [7]. Therefore, the land used for landfill will increase, which will put a huge pressure on the land resources of Jinan; it will affect the air quality of the city. When construction waste is piled up, some of the organic matter decomposes with the emission of toxic gases. Toxic substances are also produced when combustible substances are burned and spread in the air; in transportation, non-enclosed transport vehicles are generally used to generate a large amount of dust and cause serious pollution to the atmosphere; the impact on water resources, when construction waste is used. During landfill treatment, if rainwater soaks the waste mortar and concrete blocks stored in the open air, causing it to flow into river water or seep into the ground, it will pollute the surface and groundwater; it will have an impact on public safety. After investigation, it is found that many cities have not formulated special plans for the stacking of construction waste, and many safety accidents have occurred as a result.

2.3. Grey Forecasting Method
Grey forecasting is a method of forecasting systems with uncertain factors. Grey forecasting refers to the forecasting method in which the forecasting results are not necessarily accurate because the forecasting standards contain certain unknown factors [8]. This paper uses the grey forecasting method to predict the amount of building waste generated.

Calculation steps:
(1) Establish sample data from the amount of construction waste generated in Wuhan from 2011 to 2020, and construct the GM (1, 1) model sample data sequence as shown in formula (1):

\[ Y^{(0)}(l) = \left\{ y^{(0)}(1), y^{(0)}(2), L, y^{(0)}(m) \right\}, \quad (1) \]

Accumulate the sample data sequence of 10 years to obtain:

\[ Y^{(1)}(l) = \left\{ y^{(1)}(1), y^{(1)}(2), L, y^{(1)}(m) \right\}, \quad (2) \]

Ans among them, \( Y^{(i)}(l) = \sum_{i=1}^{m} Y^{(0)}(l), i = 1, 2, L, m \)

(2) Calculate the mean value \( Q \) of the immediate vicinity, the development coefficient \( b \), and the amount of ash effect \( v \). The calculation formula for the mean value \( Q \) of the immediate vicinity is (3):

\[ Q^{(i)}(l) = \frac{y^{(i)}(l) + x^{(i)}(l - 1)}{2} \quad (3) \]

The calculation formula of the development coefficient \( b \) is (4):

\[ b = \frac{1}{m - 1} \sum_{l=2}^{m} \left( y^{(0)}(l) \sum_{i=2}^{m} \left( Q^{(1)}(l) - \sum_{i=2}^{m} y^{(0)}(l) Q^{(1)}(l) \right) \right) \]

\[ \sum_{i=2}^{m} \left( Q^{(1)}(l) \right)^2 - \frac{1}{m - 1} \left( \sum_{i=2}^{m} \sum_{i=2}^{m} Q^{(1)}(l) \right)^2 \]

The calculation formula of ash effect \( v \) is (5):

\[ v = \frac{1}{m - 1} \left[ \sum_{l=2}^{m} \left( y^{(0)}(l) + b \sum_{i=2}^{m} \left( Q^{(1)}(l) \right) \right) \right] \]

Then the whitening model of GM(1,1) is:

\[ c y^{(1)}(h) + b y^{(1)}(h) = v \quad (6) \]

Substitute \( b \) and \( v \) into the GM(1,1) model and transform to obtain the predicted output time of construction waste.
2.4. Theoretical Research on Construction Waste Life Cycle Management

2.4.1. Circular economy theory. The development of circular economy follows the "3R" principle, namely the principle of "reduction", "reuse" and "recycling", as the basic principle of circular economic activities [9]. The reduction of construction waste is to check from the source. This measure is to follow to produce the same products and reduce the consumption of natural resources, thereby reducing environmental pressure. The "reduction" of the source is the most advocable of these three methodologies, and the source cracking mechanism can alleviate the pressure on the entire industrial chain. Based on the consideration of the whole life cycle of the building, the concept of "reduction" must be strengthened at all stages. The recycling of construction waste requires that construction materials can still become other recyclable substances after they have completed their intended functions. The recycling of construction waste generally includes on-site recycling and in-depth recycling of processing companies. For example, earth and stone are used in foundation pits or roadbed engineering landfills, and waste concrete blocks are treated as filling materials for the roadbed base. Transport the construction waste to the resource treatment company, and deep-process it into recycled concrete, recycled lightweight aggregates and new wall materials. The harmlessness of construction waste is the most basic requirement for effective management. After incineration or physical and chemical treatment, harmful substances are removed and their hazards are reduced as much as possible. The harmless treatment of construction waste can help reduce the impact on the natural environment.

2.4.2. Closed-loop mobile industry chain. The closed-loop fluid industry chain has the characteristics of structural attributes, value attributes and stability. The closed-loop and mobile industrial chain changes the structure of the original resource-use unidirectional linear non-circular industrial chain, and extends the original industrial chain to the upstream and downstream as much as possible. The reuse of construction waste can create huge benefits (including economic benefits and environmental benefits). And social benefits), after a long-term resource treatment process, all subjects of the industrial chain can share its value added [10]. Therefore, the circular economy industry chain not only attaches importance to economic benefits and the value-added of the industry chain, but also attaches importance to environmental benefits, so that the industry chain develops better, and the construction waste is maximized to realize resource treatment.

3. Experimental Research on the LCA-Based Supervision System for the Harmless Treatment of Building Waste

3.1. Supervision System Structure
The building waste disposal information supervision platform is based on the urban geographic information platform, comprehensively using database sensor technology, RFID technology, data analysis technology, computer information management and auxiliary technology, etc., to achieve the basic data of the city's building waste management digital collection and preservation, to realize all-round digital monitoring and management of building waste management business, and assist decision-making for the unbiased collection of enterprises, the comprehensive scheduling of collection and transportation units, the operation and management of building waste disposal sites and the environmental sanitation management department, the calculation of funds provides a reliable and credible basis, provides decision-making support for leaders at all levels, and lays a foundation for the management of environmental sanitation management departments to realize informatization supervision [11]. The overall goal of the system is to finally build twelve major subsystems, which are supplemented from the generation, collection and transportation of building waste to disposal, and supplemented by sub-platforms such as decision-making management and citizen participation. The building waste supervision and control system is not an isolated system, but a business application system under the framework of an integrated urban integrated management digital platform. The
supervision information collection system mainly uses GIS collectors, hand held readers, UHF RFID electronic tags, RFID card openers and other data collection equipment to collect real-time data generated during the whole process of construction waste processing.

3.2. Existing Situation of the Supervisory System
At present, the traffic control department is not strictly supervising the treatment of transportation and construction waste, which has led to a large number of "black market vehicles" privately transporting construction waste to suburban landfills or throwing them randomly at night [12]. This behavior has an adverse effect on the effective use of construction waste and has a hindering effect on the development of the industrial chain. Relevant government departments should actively play a supervisory role and increase penalties for such violations. The construction unit shall be punished for this kind of behavior and bear joint liability. Only in this way can the employment of "black market cars" be eliminated. Install GPS positioning systems on vehicles with legal transportation qualifications and monitor their transportation status at all times. The secondary pollution of construction waste to the environment can be avoided, and more construction waste can be treated as resources.

3.3. Experimental Process
This article first conducts a field investigation, researches and analyzes the materials and types of construction waste in a city, and then conducts experimental design. For the classification of construction waste, according to the existing supervision technology and expanded monitoring, collect data, and conduct a special building supervision system design. After the system design is completed, it enters the operation and use stage. After a series of tests and related questionnaires, the experimental results were obtained.

4. Experimental Research on Design and Implementation of Building Waste Supervision System
Based on the LCA theory, the disposal of building waste is a big problem that needs to be solved urgently. How to deal with this problem, this article conducted related investigations and studies, carefully analyzed the composition of solid waste after demolished buildings through big data, and analyzed people's views and recognition of the specially designed construction waste supervision system based on the results of the questionnaire.

4.1. Material Analysis of Solid Waste from Building Demolition
From the existing research on the amount of demolition and construction waste, it is not difficult to see that concrete waste, brick/block waste, mortar waste and tile waste account for the largest proportion. As shown in Table 1:

|                | Concrete | Brick/Block | Mortar | Metal | Wood | Ceramic Tile | Other |
|----------------|----------|-------------|--------|-------|------|--------------|-------|
| Mean           | 478      | 222         | 87     | 55    | 32   | 92           | 34    |
| Proportion(%)  | 47.8%    | 22.2%       | 8.7%   | 5.5%  | 3.2% | 9.2%         | 3.4%  |

Table 1. Composition Table of Demolition Construction Waste
Figure 1. Composition of Demolition Construction Waste

It can be seen from Figure 1 that the weight of concrete solid waste is much higher than other wastes, accounting for nearly half of the proportion, while the proportion of wood and other wastes is relatively small, only 3.2%. Therefore, the current focus of the treatment of building waste should be on the concrete body, fully solve the redevelopment and utilization of concrete, and promote the recycling of concrete.

4.2. Feasibility Analysis of Construction Waste Treatment Supervision System

Based on the design of the supervisory system, this article investigates people's views on the supervisory system from the perspective of the supervisory process. As shown in Table 2, people generally hold a difficult view on the supervision of waste disposal. People feel that the monitoring of waste generation is complicated.

Table 2. People's Views on the Regulation of Waste Generation, Collection and Disposal

|                | Generation | Collect and transport | Dispose |
|----------------|------------|-----------------------|---------|
| Easy           | 12%        | 7%                    | 2%      |
| OK             | 10%        | 5%                    | 4%      |
| Complicated    | 7%         | 10%                   | 12%     |
| Difficult      | 3%         | 13%                   | 15%     |

Figure 2. People's Views on the Regulation of Waste Generation, Collection and Disposal

From the pie Figure 2, we can find that 60% of people feel that the design of the supervision system is difficult and complicated, and the most important difficulty lies in how to supervise the waste disposal, collection and transportation process. It can be seen that the design of the building
waste disposal supervision system should focus on the supervision of the disposal process and the collection and transportation process.

5. Conclusion
With the promotion of the concept of green development, in recent years, many scholars have conducted research on the reduction of construction waste from each stage of waste generation. Based on the actual situation, it can be seen that the current situation of construction waste management in our country is not ideal, and the effect of LCA treatment of construction waste in the construction process is still very low. Due to factors such as the complexity of the composition of construction waste, the diversity of treatment methods, and the differences in the level of social development, the construction waste treatment and disposal system is in an unbalanced state. For this reason, the design and implementation of a supervision system for the harmless treatment of building waste based on the LAC theory is indeed necessary. Therefore, this paper studies the main waste materials in the building, and designs a waste disposal supervision system for the building. Based on the above survey, it is found that the research and development of the supervision system can be realized as soon as possible in the context of this information age, thus making a huge contribution to our resources and environment.

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