The Role of Cooperative Management Mode of Prefabricated Buildings According to Building Information Modeling in the Recycle Management of Construction Waste

Qiong Tang

Qujing Normal University, Qujing Yunnan province, 655011, China

Abstract. In order to realize the comprehensive utilization of construction waste resources, in this research, firstly, the definition, classification, generation way, and harm to the environment of construction waste are analyzed, and the importance of scientific and effective recycle management of construction waste is pointed out. Then combining building information modeling (BIM) technology with prefabricated building management, a BIM-based prefabricated building collaborative management model is proposed and applied to the recycle management of construction waste. The results show that the cooperative management mode enables the construction waste to be classified scientifically and improves the accuracy and efficiency of recycle management of construction waste, and achieve comprehensive utilization of construction waste resources. Therefore, through the application of the actual management platform, the collaborative management model of prefabricated building based on BIM technology effectively achieves the construction waste recycling management, reduces the disposal cost of construction waste, decreases the pollution of construction waste to the environment, and takes the road of sustainable development.

Keywords: BIM technology; Prefabricated building; Collaborative management; Construction waste; Recycle.

1. Introduction

Since the reform and opening up, China's national economy has developed rapidly. China is taking the road of urbanization of large-scale expansion, large-scale reconstruction, large-scale demolition, and large-scale construction. At the same time, the generation and emission of urban waste are also growing rapidly, among which construction waste accounts for 30%~40% of the total urban waste [1, 2]. According to rough statistics from relevant departments, the amount of construction waste generated and discharged in China each year is more than 100 million tons, and the total amount of construction waste generated in other forms will reach hundreds of millions of tons. By 2020, the area of new buildings in China is about 30 billion square meters, and the amount of construction waste generated from this is bound to be an astonishing number [3, 4].

With the improvement of social civilization, people's living standards are also improving rapidly. Harmony between human beings and the environment has become a hot topic nowadays. As the main source of urban waste, the core of sustainable development is to recycle the construction waste and realize its transformation from waste to treasure. Therefore, how to realize comprehensive utilization of construction waste has become a universal concern of all countries in the world. It is an inevitable trend for the construction industry to enhance informatization capacity construction, and the emergence of BIM technology just solves the current development needs. BIM technology integrates various information of various stages and participants in the whole life of construction waste recycling management, and has great potential in the process of construction waste recycling management [5, 6, 7]. As a green new product of the construction industry, prefabricated buildings fit well with the national sustainable development strategy. Its construction process borrows the assembly line manufacturing model of parts and components from industry and manufacturing industry, improves the traditional and backward management model, effectively reduces resource and energy consumption, and forms considerable economic and environmental benefits [8].

In this research, BIM technology is introduced into the construction process of prefabricated buildings in view of the difficulties in recycling management of construction waste in China's building construction. A new construction management model of prefabricated buildings based on BIM technology is designed, that is, the collaborative management model of prefabricated buildings

based on BIM technology. It is expected to form an information attribute database through BIM technology, integrate a large amount of construction waste information, and simulate the effect of the optimal treatment scheme. In addition, it is hoped that this collaborative management mode can be used to efficiently manage construction waste in construction, reduce the disposal cost of construction waste, decrease the pollution of construction waste to the environment, realize comprehensive utilization of construction waste resources, and take the road of sustainable development.

2. Methodology

2.1 Classification of Construction Waste

The composition of construction waste is influenced by the nature of building materials, building structures, and construction activities, and its sources are wide and its composition is complex. The composition of construction waste produced by buildings with different structural types is basically the same, but the composition content is different. The composition of construction waste in construction sites with different structural forms and the amount of garbage generated per unit building area are shown in table 1.

Table 1. Quantity and composition of construction waste (unit: %)

Garbage composition	Construction waste composition ratio			The proportion of the main components of construction waste to the amount of material purchased
	Brick structure	Framework	Frame-shear wall structure	
Broken brick	30~50	15~30	10~20	3~12
Concrete	8~15	15~30	15~35	5~10
mortar	8~15	10~20	10~20	1~4
Pile head	——	8~15	8~20	5~15
Roofing material	2~5	2~5	2~5	——
Packaging material	5~15	5~20	10~20	3~8
Steel	1~5	2~8	2~8	2~8
Wood	1~5	1~5	1~5	5~10
Other	10~20	10~20	10~20	——
Total	100	100	100	——
Garbage production(kg/m^2)	50~200	45~150	40~150	——

As can be observed from table 1, the components of construction waste include broken brick, concrete, mortar, pile head, roofing materials, packaging materials, steel, and wood, etc. Construction sites with different structural forms have slightly different proportions of waste, and the amount of waste varies due to different construction management methods.

The classification of construction waste and the utilization of the recyclable part can not only reduce the pollution of construction waste, but also save resources. The United States divides the classification and treatment of construction waste into three levels, as shown in figure 1 [9]. Through scientific and reasonable classification of construction waste in western developed countries, the recycling cost is effectively reduced and the recycling efficiency is improved.
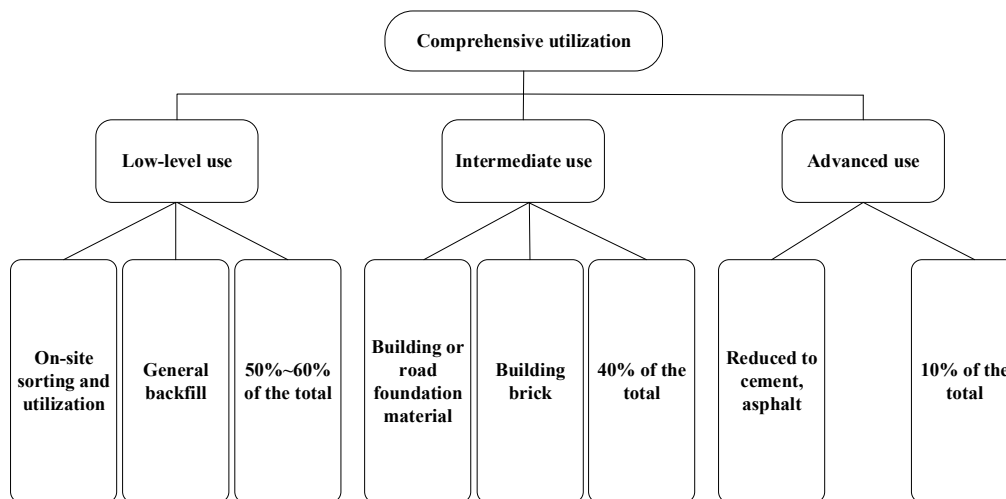
Figure 1. Classification processing of construction waste in American

China has insufficient understanding of construction waste, a late start, and a low classification. Construction waste can be divided into four categories according to whether it can be recycled: inorganic non-metallic renewable building solid waste, organic renewable solid waste, metal construction solid waste and waste materials, as shown in table 2. At present, due to the small number of professional sorting personnel and low classification level of construction waste in China, most of the waste that can be recycled is not recycled [10].

Table 2. Classification and treatment of building construction waste

Category	Characteristic substance	Research focus
Inorganic non-metallic renewable building waste	Waste concrete, waste mortar, waste sand, waste brick, waste asphalt concrete, lime soil, waste plaster, waste stone, etc.	Recycling of relevant technical standards, policy protection, etc.
Organic renewable waste	Waste plastic, waste paper, waste wood, waste formwork, etc.	The recycling mechanism of waste materials at the source, the market recycling of waste materials at the source
Metal construction solid waste	Scrap steel, scrap steel frame	
Waste goods	Old wire, doors and windows, various pipelines, wood, etc. Establish market recycling mechanism	Establish a market recycling mechanism

2.2 Current Situation of Construction Waste Disposal

Construction waste disposal has attracted the attention of countries all over the world, and foreign research on the recycling and reuse of construction waste has been carried out for many years. In developed countries, the recycling rate of construction waste has reached 80% to 90%. For example, in Japan, the recycling rate of construction waste is as high as 97%. Throughout some foreign research results, the main measures are to establish sound laws and regulations and advocate the control of the amount of construction waste from the beginning of construction design until the completion of the building.

At present, most of the disposal methods of construction waste in China still adopt the traditional open-air stacking or landfill. This method not only occupies a large area of land, but also most materials in construction waste are difficult to biodegrade, and there are heavy metal elements harmful to organisms. These wastes are buried in the ground, which will cause groundwater pollution, surface subsidence, and subsidence in the landfill area, and the soil structure is seriously damaged. Traditional construction waste disposal has caused a series of ecological and environmental problems. Reasonable treatment and scientific use of construction waste mainly start from the following three directions: reduction, resource, and harmless.

The comprehensive utilization of construction waste is a huge system, which not only involves the collection, transportation, treatment, and reuse of construction waste, but also is affected by the planning, construction, health, and other administrative departments. Therefore, only by building a continuous management chain with the participation and coordination of various departments, can a closed recycling management system of construction waste be formed and the comprehensive utilization of construction waste be realized. It is difficult to deal with construction waste only by enterprise behavior and market operation in the early stage, so strong support from the government must be introduced. China needs to learn from the successful experience of foreign countries to make construction waste recycling into industrial operation, as shown in figure 2. Only the government, the enterprise and the market can complement each other, the recycling of construction waste can achieve the highest efficiency.
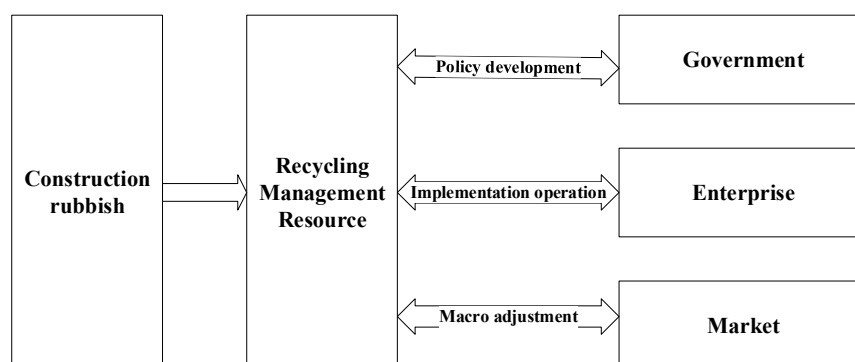

Figure 2. Relationship between various construction waste resources

3. Results and Discussion

3.1 Cooperative Management Mode of Prefabricated Buildings

BIM technology mainly uses 3d digital design and engineering software to combine into a visual digital building model. It can realize the data sharing and collaborative work of all participants in the whole life cycle of the building based on the model, and effectively improve the information interaction ability in the project implementation process and the informatization level of the construction industry.

Prefabricated buildings are made by transferring a lot of site work in the traditional construction method to the factory, processing and manufacturing building components and accessories in the factory, transporting them to the construction site, and installing them on the construction site through effective connection. The advantages of prefabricated buildings include short construction period, high construction efficiency, less construction waste, high project quality and environmental protection. However, the application of prefabricated buildings increases the construction links and information in the construction process. With the increase of the construction link, the information transmission decays and the accuracy rate declines, which will inevitably increase the errors in the construction management process.

In this study, BIM technology is introduced into the construction process of prefabricated buildings to form a collaborative management mode of prefabricated buildings based on BIM technology. With the help of the collaborative management platform, construction waste classification and recycling management can be effectively coordinated to eliminate the information island effect in the process of construction waste recycling management and improve management efficiency. The system provides collaborative management, information confirmation, parts management, and other functions, and an API interface for participating in the docking of some information of the enterprise's internal management system, applies the model from the design stage to the whole process of construction waste recycling management, such as generation, collection, transfer, allocation, classification treatment, and redistribution of construction waste. For the basic information data of construction waste required in the operation process, such as: physical and chemical properties of

building materials, pollution rate, material cost, data and information of construction waste treatment department, such as types of construction waste recycling, treatment utilization rate, recovery and treatment cost, the relevant information is cross-integrated to form a comprehensive database system, which is conducive to the subentry treatment and transportation deployment of construction waste. In addition, through the construction waste collaborative management system, the average discharge of construction waste, the discharge index of different types of construction waste, and the discharge index of construction waste at different stages of construction can be comprehensively obtained. Therefore, comprehensive and multiple comparisons can be made on construction waste, which can not only improve the reliability of the initial data of the management system, but also be beneficial to the adjustment of construction technology and optimization of construction technology to reduce the generation of construction waste, as shown in figure 3.
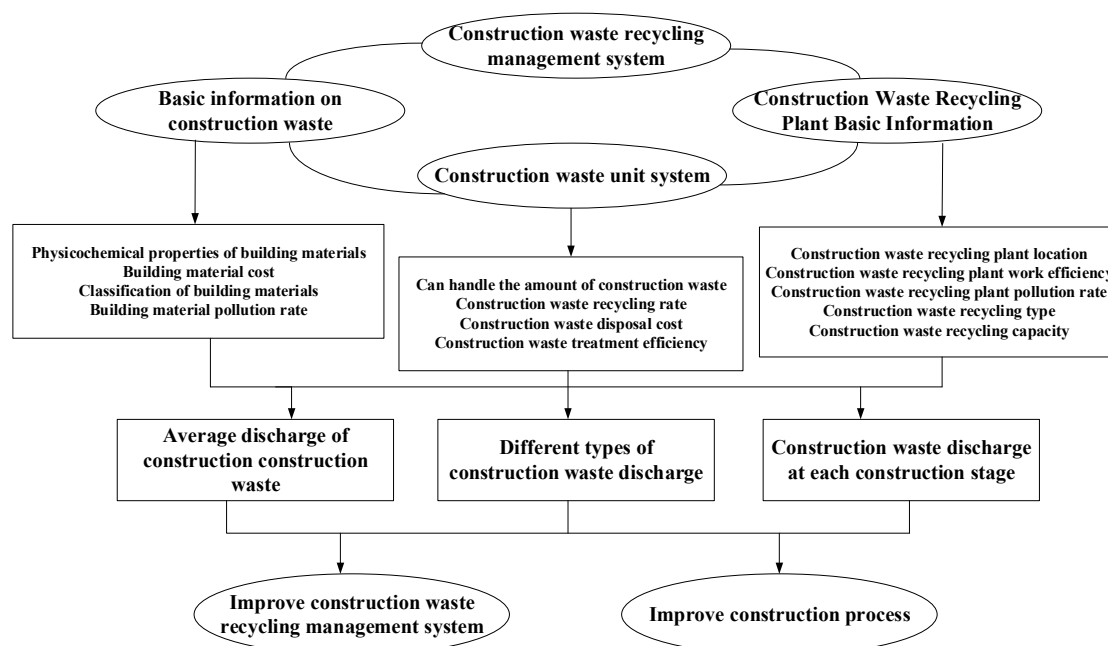

Figure 3. Recycling management system of construction waste

3.2 Application of Construction Waste Recycling Management Platform

Combined with the "3R" (reduce raw materials, reuse, and recycle) mode of sustainable development of resources and energy, comprehensive utilization of construction waste resources can be divided into four links: reuse, remanufacturing, recycling and waste disposal. In the construction waste management network system based on BIM technology, the construction waste collected by the collection point will be transported to the transfer and deployment field, and then tested / classified, disassembled, crushed, cleaned, and separated in the professional classification treatment station. After preliminary treatment, the construction waste that meets the national standards for renewable utilization of construction renewable resources will be sent to the market of construction renewable resources for resale. And the construction waste with reuse value after dismantling and testing will be sent to the formal remanufacturing plant and recycling plant recognized by the state for reprocessing. Finally, the useless construction waste and the waste materials generated in the treatment process will be transported to the waste disposal plant together, which will be buried and incinerated after harmless treatment. The specific flow is shown in figure 4.
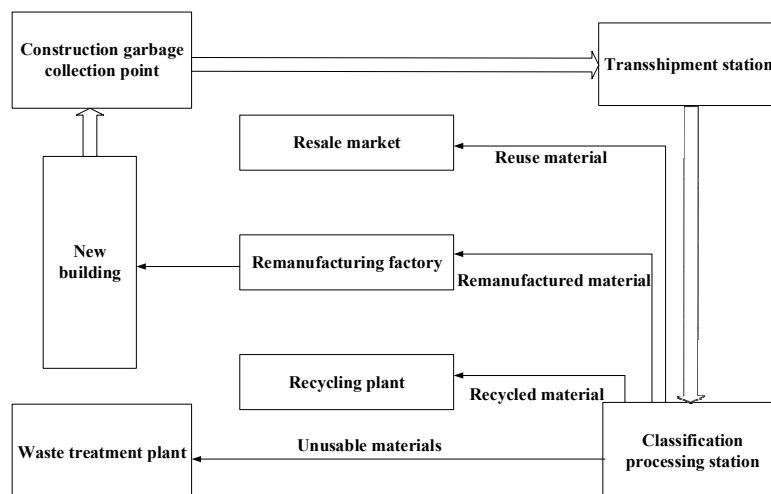
Figure 4. Network diagram of comprehensive utilization of construction waste resources

The difference between construction waste and general renewable resources is that the construction waste is large in production and the discharge method is complicated and concentrated. The entity operation system of construction waste collection management network mainly includes four links, namely, generation collection system, transfer and deployment system, classification and treatment system, and redistribution system. The recycling management system takes the source of construction waste as the collection point and classifies the construction waste on site. Then, according to the capacity status and transportation distance of the surrounding transfer and deployment yard, the construction waste will be transported to the optimal transfer and marshalling yard after comprehensive consideration, and transported outward according to the needs. After the construction waste is transferred to the classification treatment system, the construction waste that is not conducive to the subsequent treatment or does not meet the requirements of the disposal process will be separated. The redistribution system will redistribute the construction waste after simple processing and treatment by sorting treatment stations. The network operation system of construction waste management system is shown in figure 5
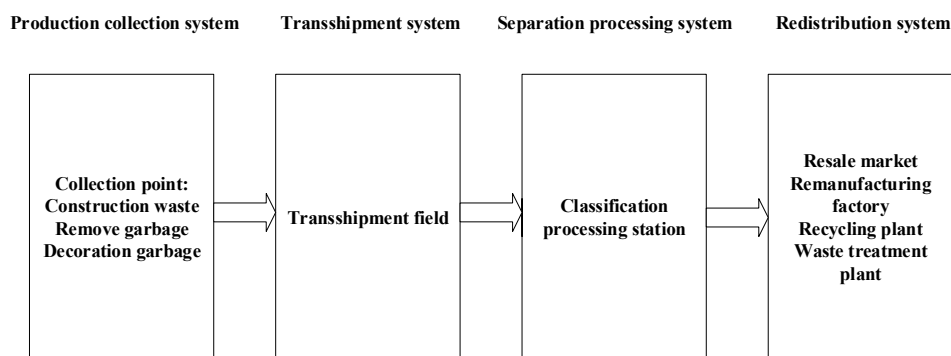
Figure 5. Recycling management network system of construction waste

4. Conclusion

The output of construction waste is increasing and deteriorating year by year, which will cause irreparable damage to China's ecological environment. People have realized the importance of sustainable development and accelerating the construction of ecological civilization. The disposal of construction waste will become more and more standardized, reasonable, and efficient. In this study, BIM technology is used to collect various information of construction waste, and a systematic platform is built by combining the collaborative management mode of fabricated buildings, and the processing process is tracked in real time, so as to design an optimal treatment scheme for construction waste in a timely manner. Through simulation optimization and combined with the

standardized management system, the construction waste is reasonably and effectively processed, and the construction waste resources are fully utilized to promote the informatization, modernization, and scientific development of construction waste recycling management and the development of recycling construction industry, which is of profound significance for promoting sustainable development and ecological civilization construction. However, the construction of China's construction waste recycling management system is still in the exploration stage, and the factors affecting the management of construction waste recycling are wide and complex. The basic data of the research is relatively deficient, which needs to be further enriched and improved. How to make the application of this collaborative management mode popular remains to be further studied. In conclusion, the results of this study can provide a new solution for the recycling management of construction waste.

Acknowledgements

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