Research on resource consumption of construction industry in Xining based on material flow analysis

Huihui Zhang\textsuperscript{1}, Haifa Jia\textsuperscript{1, 2*}, Chengying Li\textsuperscript{1, 2} and Chengkui Liu\textsuperscript{3, 4}

\textsuperscript{1} College of Civil Engineering, Qinghai University, Xining, Qinghai, 810016, China
\textsuperscript{2} Qinghai Provincial Key Laboratory of Energy-saving Building Materials and Engineering Safety, Xining, Qinghai, 810016, China
\textsuperscript{3} Qinghai Building and Materials Research Co., Ltd., Xining, Qinghai, 810016, China
\textsuperscript{4} The Key Lab of Plateau Building and Eco-community in Qinghai, Xining, Qinghai, 810016, China

*Corresponding author’s e-mail: jiahf2014@qhu.edu.cn

Abstract. Qinghai Province is a very fragile area of ecological environment. While paying attention to economic development, we should pay more attention to the change trend of ecological environment. According to the urban statistical yearbook, the energy consumption of construction industry accounts for a large proportion of urban energy consumption. In the concept of sustainable development, we should pay attention to the problem of resource consumption and environmental pressure of urban construction industry. This paper takes Xining construction industry as the research object, based on the material flow analysis method, analyzes the material flow of newly built and demolished buildings in Xining city from 2011 to 2015, and reveals the material consumption status of Xining construction activities and the pressure on the environment.

1. Introduction

During the Twelfth Five-Year Plan, the area of newly built buildings in Xining City has increased from $742 \times 10^4 \text{m}^2$ in 2011 to $751 \times 10^4 \text{m}^2$ in 2015 \cite{1}. Facing the rapid development of the construction industry, it is necessary to balance the relationship between economic development and the environment. Every year, resources are obtained from the natural environment to build new buildings, and at the same time some dilapidated houses are demolished, and a lot of waste is discharged to the environment. Therefore, it is of great significance to explore the relationship between resource consumption in the construction industry and environmental pressure.

From the national level, Chen Xiaoshu et al. \cite{2} earlier estimated the total material demand of China from 1989 to 1996, and then estimated the total material input and total material output of China from 1985 to 1997 \cite{3}. At the regional level, Xu Yijian et al. \cite{4} made a preliminary analysis on the economic growth mode of Guiyang city by using the material flow analysis tool. Zhang Yinbo et al. \cite{5-6} analyzed the different influences of population, economy, technology and other factors on material input and output in Guangdong Province from a micro perspective. At the level of industrial economic system, Ma Zhong, Chen Xiaoshu et al. \cite{7-8} studied the material and energy metabolism and environmental impact of cement industry. Liu Zheng et al. \cite{9-11} carried out quantitative analysis on the whole life cycle of phosphorus resource industry.
This paper takes Xining construction industry as the research object. Based on the material flow analysis method, this paper analyzes the material flow of newly built and demolished buildings in Xining city from 2011 to 2015. This paper provides some basic quantitative analysis results for the formulation of regional (city) social, economic and environmental sustainable development planning and the optimization and adjustment of industrial structure. It is of great significance to promote the sustainable development of the region.

2. Material flow analysis of construction activities in Xining City

2.1. Framework analysis.
The main task of this study is to study the material transfer in Xining construction activities, that is, material input and waste output. Based on the material flow analysis framework of EU, this paper analyzes the material flow of construction activities. The building materials studied include: steel, cement, glass, aluminum, wood, stone and sand. The consumption of these seven building materials accounts for the vast majority of the total consumption of building materials.

2.2. System boundary
Spatial boundary: including the entire administrative region of Xining city. From 2011 to 2015, the area of Xining City remained the same. Time boundary: the selected time range is the 12th Five Year Plan period (2011-2015). The GDP of Xining City in 2015 increased by 1.48 times compared with that in 2011. The analysis of this time period has strong pertinence: compare the existing resource consumption during the 12th Five Year Plan period with the results of material flow analysis, improve the material flow analysis method of construction industry, and predict the future city Prepare for resource consumption.

| years | 2011 | 2012 | 2013 | 2014 | 2015 |
|-------|------|------|------|------|------|
| Gross product (Billion) | 760  | 838  | 968  | 1066 | 1132 |

The material flow analysis system of construction activities in Xining city includes the newly-built and demolished residences from 2011 to 2015. The system boundary is shown in Figure 1. The material flow analysis of energy consumption is not considered in this study, and the energy consumption is assumed to be 0.

2.2.1. New residential buildings.
Material consumption includes: construction materials input during construction, fuel oil required for transportation of building materials to construction site, power consumption during construction (mechanical power and lighting), energy consumption of field equipment (crane, etc.). The output mainly includes: emissions in the process of building materials mining and processing, construction waste and pollution gas emissions from transport vehicles. This study only considers the material consumption of construction materials and the output of construction waste.

2.2.2. Demolished residential buildings.
Buildings are usually demolished at the end of their life cycle. At this stage, most of them consume energy. The main energy input includes: the energy consumed by demolishing buildings and the energy consumed by transporting solid waste. Outputs include: solid waste and environmental emissions during transportation.

2.3. Data sources of Xining logistics analysis
Through searching Xining statistical yearbook, the consumption of building materials in Xining city from 2011 to 2015 is obtained, as shown in Table 2.
Table 2. Consumption of building materials in Xining City from 2011 to 2015.

| years | Steel (t) | cement (t) | Aluminum (t) | glass (t) | total (t) |
|-------|-----------|------------|--------------|-----------|-----------|
| 2011  | 576225    | 2592316    | 24237        | 8444      | 3201222   |
| 2012  | 761755    | 2656535    | 44541        | 5489      | 3468321   |
| 2013  | 647809    | 2366750    | 56069        | 5476      | 3076103   |
| 2014  | 865972    | 3170140    | 67208        | 10240     | 4113559   |
| 2015  | 541591    | 2153159    | 132015       | 8697      | 2835462   |

According to the research results of Gao Yunfu [1], it can be concluded that the area of newly-built and demolished buildings and the amount of solid waste generated from newly-built and demolished buildings in Xining city from 2011 to 2015 are shown in Table 3 and table 4.

Table 3. 2011-2015 New Construction Waste Generation.

| years | construction area (m²) | Concrete (kg/m²) | Bricks and blocks (kg/m²) | mortar (kg/m²) | glass (kg/m²) | Ceramic or tile (kg/m²) | other (kg/m²) | total (t/m²) | total (10⁴t) |
|-------|------------------------|-------------------|---------------------------|----------------|---------------|------------------------|---------------|--------------|--------------|
| 2011  | 7418094                | 127811206         | 20470332                  | 17741786       | 14836187      | 2225428               | 296724        | 183382       | 136034232    |
| 2012  | 7141804                | 123146742         | 19477680                  | 16838600       | 14836187      | 2142541               | 285672        | 176175       | 125820616    |
| 2013  | 5945676                | 15986105          | 102421188                 | 13863084       | 11891353      | 1783703               | 237827        | 146183       | 86915833     |
| 2014  | 8901195                | 24344037          | 18741966                  | 21014966       | 17802389      | 2670358               | 356047        | 219489       | 195371792    |
| 2015  | 7511178                | 20704548          | 17841542                  | 15022355       | 2253353       | 139244547             |              |              |              |

Table 4. 2011-2015 Demolition of construction waste generated.

| years | construction area (m²) | Concrete (kg/m²) | Bricks and blocks (kg/m²) | mortar (kg/m²) | glass (kg/m²) | Ceramic or tile (kg/m²) | other (kg/m²) | total (t/m²) | total (10⁴t) |
|-------|------------------------|-------------------|---------------------------|----------------|---------------|------------------------|---------------|--------------|--------------|
| 2011  | 1044894                | 2688995703        | 6078766494                | 1147417379     | 9514580       | 316901033             | 47124389      | 197542538    | 1847740722   |
| 2012  | 3198450                | 9275724467        | 1547103743                | 316901033      | 7726874       | 279300961             | 71023261      | 1890552     | 18869407    |
| 2013  | 1054600               | 1985315950        | 316901033                | 3451378        | 65701557      | 19897034915           | 829347551     | 10530621    | 105517150   |

2.4. statistical results of material flow

The direct material input caused by construction activities includes three parts: construction material input, fossil fuel input and air input; the waste discharged to the environment includes solid waste, carbon dioxide and pollution gas, and the solid waste includes the waste and construction waste generated from the mining and processing of building materials. The data collected are analyzed as follows.

Taking 2011 as an example, Xining City has a newly built building area of 742*10⁴m² and a demolished building area of 105*10⁴m². In 2011, the construction material input was 320.122×10⁴t; in 2011, the construction waste was 333576770*10⁴t.
The difference between material input and output is the increase of material storage, that is, the quality of material stored in buildings, that is, how much material exists in the economic system in the form of housing.
3. Conclusion
Based on the material flow analysis of Xining construction industry, this paper obtains some data of material input and material output from 2011 to 2015. It shows that part of the construction industry in Xining city resource consumption, the pressure on the environment and the relationship between resource input and pollutant emissions. This is to prepare for predicting the material consumption of future construction activities and the potential pressure on the environment. According to the law of conservation of mass, it can be inferred that a large amount of energy is needed in the acquisition stage of building materials. To reduce the environmental impact of building materials, on the one hand, building materials can be reasonably allocated in the design. However, since the demand for building materials per unit building area is basically unchanged, it is important to improve the production process of building materials to reduce the emission to the environment; on the other hand, strengthen the construction The recycling of garbage will also reduce the amount of material input to a certain extent, thus reducing the impact on the environment. Construction activities promote industrial development with high input and high consumption of materials. In order to maintain the sustainable development of the city, how to reduce the input of resources and the emission of pollutants is one of the focuses of future research. The material flow analysis in this paper does not include energy consumption, but also needs more detailed and reliable statistics of building energy consumption, building materials, construction waste and so on Data to support this study.

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