博士論文（要約）

Analysis of material flows associated with building stock for management of demolition waste considering potential hazardousness: A case study of Shanghai

（有害性を考慮した解体廃棄物の管理のための建築物ストックに関わる物質フローの分析:上海を事例として）

GAO Xiaofeng

高 小峰

Since 1978, an unprecedented rapid urbanization process is ongoing in China. The proportion of urban residents in the total population had rose from 18% in 1978 to 59% in 2017. China, as the biggest developing country around the world, the solid waste issue has attracted more and more attention, in particular, the massive quantity of demolition waste generation in recent years. However, the treatment capacity of demolition waste is insufficient. Over 95% was sent to landfills or illegal dumping sites in China. In order to properly manage and plan the demolition waste treatment facilities, the qualitative and quantitative information on the demolition waste projection becomes crucial.

Hence, this dissertation aims to analyze long-term trends of construction materials flow associated with residential & non-residential building stock for the strategic management of demolition waste. The specific research objective are pointed out as follows: (1) to estimate and predict the amount of building stock and the associated construction materials inflow and demolition waste in residential buildings; (2) to estimate stock accumulation and demolition waste in non-residential buildings (including service buildings and industrial buildings); (3) to estimate the hazardous waste flow along with industrial building demolition; (4) to provide the framework of differentiating pollution levels and proposal of treatment pathways for improving demolition waste management.

The dynamic material flow and stock models were developed to explore the quantity of material stocks and demolition waste from residential & non-residential buildings in Shanghai—the largest megacity in China. Moreover, the AutoCAD data integrating experimental data (heavy metals concentration of demolition waste from iron & steel industry) was applied to explore floor area stock, construction material stock, and hazardous demolition waste from industrial buildings: A case of Baosteel.

In this dissertation, the rural–urban land transition was incorporated into residential building material stock and flow analyses to provide a more accurate analysis. The reason are as follows. Notably, there is significant residential buildings stock in rural areas in the past decades, even larger than the urban areas. The rural-urban land use transition, especially the upgrade and redevelopment of original rural areas, is a noted driver of material flows.

In Chapter 3, the current situation and challenges in the C&D waste issue were discussed, and the target city was introduced briefly. The treatment capacity and current C&D waste flow in the whole of China and Shanghai also were presented. However, the current treatment capacity was insufficient. Most of the demolition waste, construction waste & decoration waste were transported to the illegal dumping sites. Then, the development in legislation & regulations of C&D waste management were summarized. Besides, the current economic incentives and supervision, and challenges in C&D waste management also were presented.

In Chapter 4-6, the main outcomes are addressed.

In Chapter 4, the amount of material stocks and demolition waste from residential buildings in Shanghai from 1950 to 2100 were conducted. An enhanced dynamic material flow and stock model that integrates historical rural–urban land transition was applied to this Chapter. The material stocks of residential buildings in Shanghai increased 51-fold from 1950 to 2018, reaching 1200 MMT (million metric tons), and is estimated to be saturated around 2040. Material stocks have experienced a synchronized growth in rural areas, central urban areas, and rural-urban land transition zones (RULT zones) in Shanghai. Until 2040, the RULT zones in Shanghai will be the most significant material repository (62%), followed by central urban areas (20%) and rural areas (18%). The amount of demolition waste, which accounted for 11 MMT in 2018, is expected to peak at 29 MMT in 2060s. This suggests the need for a deliberate investment plan for increasing waste treatment capacity. In addition, the dominant component of demolition waste will shifts from brick to the concrete after 2025. The RULT zones will contribute two-thirds of demolition waste to Shanghai until the 2060s, up from one-third in 1995. If we do not consider the reality of the physical status of buildings in RULT zones, the demolition waste will be underestimated by a maximum of 57% in 2003 in urban areas. The findings on the demolition waste generation trend and the significant contribution of RULT zones can be used as a reference for fast-developing cities in China and other countries.

In Chapter 5, service buildings and industrial buildings were discussed. The dynamic material flow and stock model was applied to explore the amount of material stock and demolition waste from seven types of service buildings in Shanghai from 1950 to 2100. The industrial buildings were decomposed into 14 industrial departments for investigating the hazardous demolition waste from buildings in some specific departments (e.g., Metallurgical industry and Chemical industry).

In Chapter 6, the result of demolition waste in various industrial processes combined with the hazardous substance (such as heavy metals) contents to make a hazardous waste flow analysis. By using the single factor contamination index (SFCI) method, the contamination degree of heavy metals in demolition waste from the different processes of iron & steel industry was classified. In this Chapter, these findings on the potential hazardous demolition waste generation and the contribution of the specific industrial process can be used as a reference for waste management.

In Chapter 7, based on the Chapter 6, the framework of differentiating pollution levels in various industrial sectors was proposed. Then, the strategy of sampling and pollution identification for industrial demolition waste also was provided. Combining with the current treatment pathways of demolition waste in Chapter 3, the future recycling and disposal pathways of demolition waste were proposed. After considering the current recycling capacity and the amount of recyclable demolition waste, the suggestion on increasing of treatment capacity also has been obtained. Finally, the improvement of the supervision on demolition waste was also recommended.