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Environmental Pollution Hazards of Urban Construction Wastes and Related Resource Recycling Measures: A Case Study in Central China

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ABSTRACT

Urban construction production increases significantly in China because of the continuous speed and large scale of urbanization. Accordingly, environmental pollution caused by construction waste intensifies. With the growing significance of ecological civilization construction, urban development projects are under pressure to apply energy-saving and environmentally friendly methods. Recycling of construction waste resources can effectively reduce the environmental pollution of such wastes, thereby achieving sustainable urban development. To further analyse environmental pollution hazards caused by urban construction wastes, construction waste resource recycling measures were proposed. A case study based on central China was conducted and extensive studies on construction waste recycling in the context of developed territories (Europe and America) were reviewed. Environmental pollution damage caused by urban construction wastes was also identified. Then, the environmental pollution status generated by urban construction wastes was analysed and the causes of urban waste recycling barriers were summarized. Finally, measures for urban construction waste recycling were proposed. Results show that America, Japan, and Germany have achieved high construction waste recycling rates. Environmental pollution hazards from urban construction waste are manifested by large-scale occupation of land resources, resulting in intensifying domestic water, soil, and air pollution. High waste production and low comprehensive utilization rate of construction waste caused by urban construction scale are two aspects of current urban construction waste pollution. The main causes of the low recycling rate of urban construction wastes involve a lack of supporting laws and regulations as well as industrial policies, low market shares of construction-waste recycling products, poor coordination of key nodes in the industrial chain, and low benefits of recycling products. Research conclusions provide good references for improving the overall development level of urban construction recycling, facilitating continuous development of construction waste recycling industrialization, and formulating construction waste recycling policies and development plans in other regions in China.

INTRODUCTION

With rapid economic and social developments, people place progressively higher requirements on living standard and quality. Original buildings cannot meet the desire for higher-quality houses. Recently, the urban construction scale increasingly grew due to accelerating urbanization, as manifested by the continuous proliferation of new engineering constructions, reconstructions, expanding constructions, and demolitions. These activities incessantly produce abundant construction wastes and generate considerable ecological pressure on the environment. As an important pillar of national economic development, the construction industry plays an important role in facilitating such development through urbanization. However, construction projects in China are frequently built, expanded, remade, and dismantled because of the short designed service life, poor quality, inadequate foresight in urban planning, and flawed industrial policies. Consequently, construction waste production and emissions grow steadily.

Central China covers six adjacent provinces: Shanxi, Henan, Anhui, Hubei, Jiangxi, and Hunan. As a region that witnesses rapid economic and social development, central China has an urbanization level that has continued increasing in recent years. Its urban construction scale has expanded and the total output value of its construction industry has soared annually (Table 1). Meanwhile, the gradual improvement of living standards has prompted people to place higher requirements on residential conditions. The continuous increase of per-capita living space and luxury living environment and decoration has not only stimulated tremendous construction supply but also intensified the great consumption of natural resources by buildings and caused a relative shortage of various resources. Dismantling buildings at the end of their designed service lives will produce abundant construction wastes that will cause environmental pollution and fill many dumping areas. Therefore, given the limited natural resources, meeting the growing living demands of people while preventing excessive consumption of natural resources and unwarranted production of construction

wastes is necessary. Effective means to relieve environmental pollution caused by construction wastes include implementing resource recycling and accelerating production reduction, recycling, and harmless management of such wastes.

EARLIER STUDIES

With respect to environmental pollution hazards of construction wastes and their recycling, theoretical and practical studies on construction wastes have been conducted in several developed countries. Such countries currently possess rich experiences in construction waste recycling. Aside from abundant fundamental studies about the source, classification, and production of construction wastes, developed countries have also generated mature management methods and processing technologies and equipment, with significant processing outcomes. Gluzhge proposed the concept of "construction waste recycling" for the first time and then studied the basic performances of recycled concrete (Gluzhge 1946). Peng et al. believed that dumping charges soared due to the shortage of refuse landfills and the increasing concerns of supervision organizations and the public. Recycling mechanisms and processing strategies for different categories of construction wastes were also introduced (Peng et al. 1997). Faniran et al. advocated for the maximum reduction of wastes during the construction process (Faniran et al. 1998). Shen et al. introduced environmental management in construction engineering in Hong Kong. Results demonstrated that a Hong Kong contractor should provide assistance in allocating company resources effectively to adjust environmental management policies (Shen et al. 2002). Kartam et al. investigated the environmental management method for the construction and demolition wastes in Kuwait and concluded that all major participants in the construction industry (including owners, designers, contractors, and building managers) were subjects of construction waste management (Kartam et al. 2004). Duran et al. constructed an economic feasibility evaluation model for construction and demolition waste recycling in Ireland and analysed the viability of construction waste recycling (Duran et al. 2006). Begum et al. examined the reuse and recycle of construction waste materials in Malaysia through a cost–benefit analysis method (Begum et al. 2006). Kofoworola et al. estimated the production of construction wastes in Thailand and proposed construction waste management measures (Kofoworola et al. 2009). Ortiz et al. believed that resource utilization could maximize the construction waste values and minimize the environmental impact of construction wastes by considering environmental performance and transportation conditions (Ortiz et al. 2010). Chong et al. discussed the transportation energy consumption for construction waste recycling and the actual recycling rates of projects to help designers better estimate the energy and recycling performances of construction materials (Chong et al. 2010). Osmani analysed new environmental processing requirements on construction wastes in the United Kingdom in response to technological reform and public pressure; he argued that minimizing environmental pollution from construction wastes was the main responsibility of the construction industry (Osmani 2012). Using original data from two practical construction sites and secondary data from the literature, Hossain et al. conducted a comprehensive assessment of the construction waste management (CWM) system by life cycle evaluation (Hossain et al. 2017). Esa analysed the overall construction and demolition waste management mode in Malaysia and found that CWM is a fundamental element for sustainable construction and construction management (Esa 2017). Ding et al. believed that CWM in design and construction stages is important in waste reduction throughout the construction process (Ding et al. 2018). Li et al. conducted an empirical study based on data collected in Shenzhen using the planning behaviour and structural equation models (Li et al. 2018). Existing literature indicates that America, Japan, and Germany achieved high construction-waste recycling rates and their governments paid considerable attention to construction wastes. Strict laws and effective management methods minimized the production of construction wastes. Due to recycling technologies and positive governance, the construction waste recycling rates in these

Table 1: Total output of construction wastes in central China from 2007 to 2016. unit: Hundred million Yuan. (Data source: National Bureau of Statistics of China, http://data.stats.gov.cn/index.htm).

Province	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Shanxi	1060.7	1355.4	1826.1	2143.5	2324.9	2668.2	3034.4	3103.5	2931.3	3318.5
Anhui	1517.0	1854.6	2239.6	2865.0	3597.3	4230.4	4965.5	5482.9	5695.9	6047.3
Jiangxi	786.1	1032.9	1323.2	1690.0	2095.5	2789.6	3470.0	4122.6	4602.5	5179.0
Henan	2151.7	2824.1	3596.5	4400.6	5279.4	6009.1	7003.2	7911.9	8047.7	8808.0
Hubei	2110.8	2605.1	3421.9	4345.2	5586.5	7043.4	8465.3	10059.6	10592.9	11862.4
Hunan	1828.8	2115.4	2507.4	3161.7	3915.0	4407.9	5283.8	6021.0	6630.8	7304.2

countries surpassed 90%. Developed countries with advanced experiences have turned construction waste recycling into an industry; maximized the roles of governments, enterprises, and markets; and applied mature and strict recycling technologies. In this study, the status of construction waste recycling and environmental pollution hazards caused by construction wastes in central China is analysed, focusing on construction waste recycling measures to optimize construction waste recycling. Research conclusions are beneficial for the sustainable development of the construction industry and the green development in the new urbanization process.

ENVIRONMENTAL POLLUTION HAZARDS CAUSED BY URBAN CONSTRUCTION WASTES

With the rapid urbanization in central China, the construction industry enters a high-speed development stage. Accordingly, abundant construction wastes are produced. However, the construction waste recycling rate in this region is low. Construction wastes are often processed simply by piling up, dumping, and combustion. These methods not only waste natural resources but also cause many hazards.

Large-scale occupation of land resources: Abundant construction wastes produced by new construction projects and old building demolitions will occupy extensive land areas, which is the main risk posed by such wastes. Construction waste will increase to a peak stage, and thus directly intensify human-land conflicts in the urbanization process and decrease land utilization. Cultivated lands and roads surrounding residential areas, houses, and cities are decreasing continuously, thereby influencing the basic life of human beings.

Domestic water pollution: Waste concrete blocks and waste mortar contain calcium silicate and calcium hydroxide. After rainwater penetration and immersion, percolation water becomes strongly alkaline. Immersion of waste metals in rainwater introduces a large amount of heavy metal ions in the percolation water. Construction wastes also contain sulphate ions, and rinsing them with rainwater produces acidic percolation water. After exposure to different weather conditions, construction wastes produce harmful substances, resulting in pH imbalance of percolation water or other forms of pollution. Such percolation water penetrates underground through rainwater immersion and dilution, thereby causing serious pollution of both surface water and underground water and directly or indirectly influencing and threatening water resources needed by humans and organisms for survival.

Soil degradation: Land in direct contract with construction waste and soil is the direct victim of such waste. Construction wastes and polluted percolating water changes the physical structure and chemical properties of soils, further causing soil degradation. With external influences, excessive impurities and harmful matter are introduced into soils and are difficult to remove, thus reducing soil productivity.

Intensifying air pollution: Air pollutants such as dust and sand are generated when construction wastes are transported to suburbs for piling up and dumping. After rainwater erosion, sun exposure, weathering, and closure processing of construction wastes, some organic matters decompose and generate toxic and harmful gases. Combustion of some flammable substances produces unsafe substances or small particles that float in the air for a prolonged time. After long-term piling, some substances in the mixed construction wastes generate bacteria accompanied by dust.

STATUS OF ENVIRONMENTAL POLLUTION CAUSED BY URBAN CONSTRUCTION WASTES IN CENTRAL CHINA

Excessive waste production at large urban construction scale: The rapid economic development in central China has generated a sizeable urban construction scale that has expanded quickly in recent years. Residential construction areas have increased annually (Fig. 1). Substantial total construction waste volume has been produced by demolition and new construction activities. The major construction waste is earth-rock, which is often piled up randomly without any tarpaulin covering or anti-wind and anti-dust nets. This situation increases the production of dust in cities. Over a long period, abundant construction wastes have become primarily distributed in main urban areas with large-scale demolitions. Many provinces have disregarded construction waste processing. No special construction waste processing or utilization sites have been developed. A uniform, perfect construction waste management method and standard processing location is lacking. Construction wastes in six provinces in central China are mostly abandoned and buried; they are transported to suburbs or rural areas or dumped randomly in urban areas.

Low comprehensive utilization of construction wastes: Owing to the absence of comprehensive utilization technologies, the total energy consumption in the construction industry in central China has increased year by year (Fig. 2). Construction wastes in this region mainly entail those with high added value, such as reinforcing steel bars and waste metals. The rest of the wastes are abandoned. In addition, relevant regulations are insufficient and no detailed regulation exists on waste processing. Thus, most enterprises use minimal means to process construction wastes. At present, no laws prohibit enterprises from dumping reusable con-

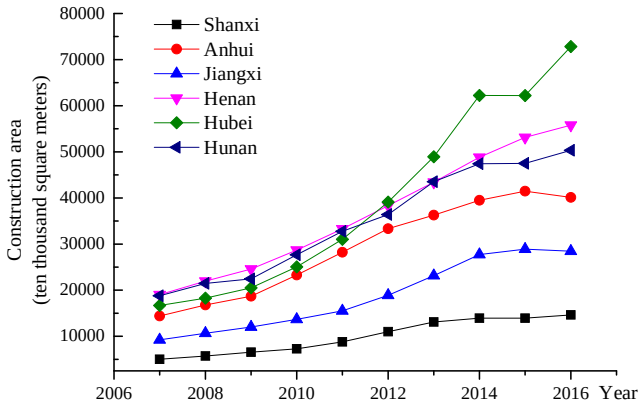

Fig. 1: House construction areas in central China from 2007 to 2016. (Data source: National Bureau of Statistics of China, http://data.stats.gov.cn/index.htm)

struction wastes, and regulations to compel enterprises to perform waste classification are lacking. Moreover, the high cost of waste processing hinders the development of recycling processes for construction waste.

OBSTACLES TO URBAN CONSTRUCTION RECYCLING

Lack of supporting regulations and industrial policies: No practical local finance, taxation support, and other strong incentives exist for enterprises engaged in construction waste recycling despite national preference policies in finance and taxation in relation to construction energy-saving materials. Pioneering enterprises engaged in construction waste recycling are struggling and waiting for the government to implement relevant supporting policies. These enterprises have neither guarantees for investment returns and enterprise development nor a stable supply of raw production materials. Moreover, consumers are concerned about internal product quality and environmental protection issues. All these difficulties require practical policy support. Therefore, facilitating the development of the construction waste recycling industry and formulating the supporting regulations and industrial policies are urgently needed.

Inadequate market consumption of "construction waste" recycling products: Given the concept of "construction waste," two barriers exist against raw material collection and marketing in the construction-waste recycling chain. On the one hand, lack of industrial quality standards means that construction enterprises cannot use recycled bricks made of construction wastes and have high concerns about product quality. On the other hand, consumers are reluctant to use recycled products made of construction wastes for fear that such products contain health-threatening matter.

Poor connections of key nodes in industrial chain: New construction projects are not compelled to use recycled construction materials, so they lack institutional exports of recycled construction materials. Recycled construction materials face difficulty in competing with natural construction materials by depending only on market power. Without compulsory recycling regulations, landfills become the home of construction wastes. Landfills are generally managed by the government, which causes challenges for recycling enterprises to acquire sufficient raw materials. Furthermore, quality standards for recycled products are lacking. Recycled products face problems entering the market in a perfectly justifiable way, and their path to marketization is hindered. No incentives are provided to construction projects that use recycled products positively. Due to the uniqueness of recycled products, they need the government to guide project owners to use products made of construction wastes.

Low benefits of recycled construction products: The marketing price of recycled construction products is often lower than that of natural construction products, which determines the small benefits to enterprises. Therefore, financial subsidies and taxation preferences are needed to motivate more enterprises engaging in this industry. In addition, the raw materials of recycled products and the transportation distance for such products exert economic requirements for processing. During urban construction planning, no land space is reserved for enterprises engaged in construction waste recycling. Enterprises can only construct plants in suburbs, and the increased cost of long transportation distances weakens the product profitability.

MEASURES FOR URBAN CONSTRUCTION WASTE RECYCLING

Perfect the policy system for construction waste recycling: Enhancing the effective development of a compulsory construction waste recycling mechanism through legislation and policy constraints and providing legal guarantees for waste recycling are essential. Moreover, a franchise system of construction waste recycling enterprises should be standardized and the industrial admittance clarified. Improving supervision and guidance over construction-waste recycling enterprises and establishing a standard system of construction waste recycling are also suggested. Furthermore, quality control departments should cooperate with environmental protection and urban construction departments in formulating standards and norms for construction-waste recycling technologies and products, and then apply the outcomes to regulate the market.

Increase government attention to construction waste

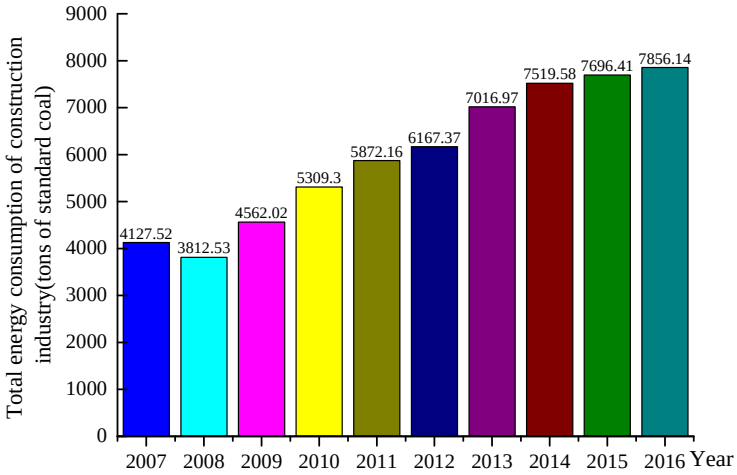

Fig. 2: Total energy consumption in Chinese construction industry from 2007 to 2016. (Data source: National Bureau of Statistics of China, http://data.stats.gov.cn/index.htm)

processing: The government should implement scientific urban planning and avoid large-scale demolition. Unreasonable urban planning will cause excessive building demolitions in the normal design service life, thereby producing abundant wastes and causing serious squandering of resources. The government should provide loans with discounted interests, tax preferences, economic bonuses, and special subsidies to construction-waste recycling enterprises, strengthen the evaluation and supervision of the environmental influences of construction wastes, encourage enterprises to use technological innovations and construction waste recycling technologies through a forcing mechanism, and form the recycling industry. To increase the attention to the environmental influences of construction wastes, organizing environmental influence evaluation professionals to study such influences and formulate the corresponding evaluation standards is advised. In addition, the government should intensify supervision over construction waste processing and facilitate the handling of construction waste recycling by construction enterprises or authorized qualified professional enterprises.

Innovate a construction-waste recycling management mode: Constructing a big data platform and Internet-based management mode of construction waste processing as well as setting up a construction waste recycling management organization are recommended. The local government should establish a detailed waste production and processing report system, build the relevant big-data platform, and create the Internet management mode. Special companies or units should be responsible for construction demolition, waste production, transportation, piling up, and consumption, thereby forming a standard chain-type recycling control and management system.

Improve construction waste-recycling technologies: Innovation of construction waste processing technologies is the technological guarantee to increase waste recycling. Perfecting construction waste recycling technology and product certification are necessary. Such improvements can strengthen the cooperation between scientific research organizations and enterprises to enhance the research and innovation level of construction-waste recycling technologies, such as generating technological developments and the practical study of recycled aggregate production. The government should promote studies on the source "reduction" technologies and pay attention to recycling during building planning design. Regional construction-waste processing plans should be examined according to local economic development level, construction status, and resource endowment conditions, thereby implementing scientific and effective recycling of construction wastes.

Promote industrialization of construction waste recycling: The industrialization of construction waste recycling is a reflection of a systematized and high-level processing of wastes and the inevitable development trend of construction waste recycling. Such industrialization requires the cooperation of "government guidance, social participation and market running." Moreover, this approach can increase the promotion of advanced enterprises and symbol projects in construction-waste recycled products and applications, develop the brand effect, expand social influence, stimulate public participation, and gradually realize the privatization of construction-waste recycling enterprises.

CONCLUSIONS

Rapid national economic development and large-scale modernization construction have caused the construction

industry boom in China. With the large-scale construction of infrastructure and the accelerating urbanization, construction waste production is increased continuously. Promoting resource recycling vigorously is not only a mainstream trend in construction waste processing in the world, but is also the most fundamental and effective way to solve problems related to construction waste.

This study investigated a case in central China. First, existing studies on mature construction waste recycling in developed countries in Europe and America were reviewed. Second, environmental pollution hazards and environmental pollution status caused by urban construction wastes were analysed. Third, barriers to urban construction-waste recycling were summarized. Research results demonstrate that some developed countries (e.g., America, Japan, and Germany) have achieved high construction-waste recycling rates. Environmental pollution hazards caused by urban construction wastes are manifested by the large-scale occupation of land resources and the intensified pollution of domestic water, soil, and air. Currently, considerable construction waste production and low comprehensive utilization are the two major problems caused by such pollution. The low urban construction-waste recycling rate is due to four factors: lack of supporting laws, regulations and industrial policies; low market share of construction-waste recycled products; poor connection of key nodes in the industrial chain; and low benefits of recycled construction products. Finally, five solutions are proposed: (1) perfect the construction-waste recycling policy system, (2) increase government attention to construction waste processing, (3) formulate a construction-waste recycling management mode, (4) improve construction waste recycling technologies, and (5) promote the industrialization of construction waste recycling. In-depth studies should be performed in the future on the benefits of construction waste recycling, applications of construction-waste recycled bricks, optimization of the construction-waste production estimation model, construction-waste recycling mechanisms of developed countries, improvement of laws and regulations for construction-waste recycling, and industrialization of construction waste recycling.

REFERENCES

Begum, R.A., Siwar, C. and Pereira, J.J. et al. 2006. A benefit-cost analysis on the economic feasibility of construction waste minimisation: the case of Malaysia. Resources, Conservation and Recycling, 48(1): 86-98.

Chong, W.K. and Hermreck, C. 2010. Understanding transportation energy and technical metabolism of construction waste recycling. Resources, conservation and recycling, 54(9): 579-590.

Duran, X., Lenihan, H. and O'Regan, B. 2006. A model for assessing the economic viability of construction and demolition waste recycling-the case of Ireland. Resources, Conservation and Recycling, 46(3): 302-320.

Ding, Z., Zhu, M. and Tam, V.W.Y. et al. 2018. A system dynamics-based environmental benefit assessment model of construction waste reduction management at the design and construction stages. Journal of Cleaner Production, 176: 676-692.

Esa, M.R. 2017. Moving towards sustainable construction in Malaysia: a holistic model for construction and demolition (C&D) waste management. Master Degree Thesis of The University of Queensland, Brisbane, Australia.

Faniran, O.O. and Caban, G. 1998. Minimizing waste on construction project sites. Engineering, construction and architectural management, 5(2): 182-188.

Gluzhge, P. 1946. The work of scientific research institute. Gidrotekhnicheskoye Stroitel'stvo, 4: 27-28.

Hossain, M.U., Wu, Z.Z. and Poon, C.S. 2017. Comparative environmental evaluation of construction waste management through different waste sorting systems in Hong Kong. Waste Management, 69: 325-335.

Kartam, N., Al-Mutairi, N. and Al-Ghusain, I. et al. 2004. Environmental management of construction and demolition waste in Kuwait. Waste Management, 24(10): 1049-1059.

Kofoworola, O.F. and Gheewala, S.H. 2009. Estimation of construction waste generation and management in Thailand. Waste Management, 29(2): 731-738.

Li, J., Zuo, J. and Cai, H. et al. 2018. Construction waste reduction behavior of contractor employees: An extended theory of planned behavior model approach. Journal of Cleaner Production, 172: 1399-1408.

Osmani, M. 2012. Construction waste minimization in the UK: current pressures for change and approaches. Procedia-Social and Behavioral Sciences, 40: 37-40.

Ortiz, O., Pasqualino, J.C. and Castells, F. 2010. Environmental performance of construction waste: comparing three scenarios from a case study in Catalonia, Spain. Waste Management, 30(4): 646-654.

Peng, C.L., Scorpio, D.E. and Kibert, C.J. 1997. Strategies for successful construction and demolition waste recycling operations. Construction Management & Economics, 15(1): 49-58.

Shen, L.Y. and Tam, V.W.Y. 2002. Implementation of environmental management in the Hong Kong construction industry. International Journal of Project Management, 20(7): 535-543.