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Research on a Sustainable evaluation system for Construction Waste Recycling management

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Reconmatic

汇报提纲

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PART 1
研究背景

The background of the study

1. Definition of Construction Waste

➢ Construction Waste

In recent years, a large amount of construction waste has been generated, due to the rapid progress of urbanisation. However, the rate of construction waste recycling or reuse in China is still quite low, currently less than 10%. At the same time, throughout the process of recycling and reuse, there are many issues such as high energy consumption, high costs, secondary environmental pollution, poor performance of recycled products, difficulties in promotion, immature technology, irregular production by comprehensive recycling companies, and incomplete policies, regulations, and standards. In response to the above issues, this study explores the sustainable construction waste recycle management system, in alignment with relevant national policies.

At present, the definition of construction waste varies from country to country, and here we choose the Chinese national standard Design Standards for Construction Waste Recycling Plants (GBT51322-2018): solid waste generated in the construction of new buildings, extensions, modifications and demolition of all kinds of buildings, structures, pipelines, networks and other projects and decorative works.

2. Characteristics of Construction Waste

➢ Large Quantity

According to data from the construction industry, for every 1 square meter of new construction, an estimated 0.3 tons of construction waste is produced. For residential renovations, an estimated 0.1 tons of construction waste is produced per square meter, and for every 1 square meter demolished, 1.3 tons of construction waste is generated.

➢ High Utilization Value

Although construction waste is large in quantity and complex in composition, much of the waste can be reused and holds considerable utilisation value. According to the data from the Qianzhan Industry Research Institute, recycling 100 million tons of construction waste can reduce land occupation by 15,000 acres, generate an additional 8.46 billion yuan in output value, and reduce CO_2 emissions by 1.3 million tons.

➢ Complex Composition

Due to the diversity of infrastructure projects, fast updates in construction and demolition cycles, and the large scale of projects in China, the sources of construction waste are extensive, and the waste composition is complex and diverse. Different sources of construction waste show significant differences in their composition.

➢ Hazards

In recent years, China has promoted the recycling of construction waste to reduce open-air storage and landfills because the open-air piling and simple landfilling of construction waste poses significant risks. These include occupying land, polluting water, air, and soil, and negatively affecting the appearance of the city and public health.

PART 2
国外研究现状

Current national and international research status

Current Research Status Abroad

The urbanisation of western developed countries started early and to a high degree, more than 20 years earlier than that of China as a whole. So the research on resource utilisation of construction waste started earlier, and in developed countries in Europe, led by Germany, and in America, is relatively mature. International research on the whole process evaluation system of sustainable and recyclable construction waste mainly exists in the following aspects.

Technology

- Image Analysis Method
- Alkali-activated cement technology
- Recycled Concrete Aggregates

Economy

- Cost-benefit approach
- Recycling of construction waste
- System Dynamics

Management

- U.S. Green Building
- LEED
- Recycling Management Simulation Model

Industrialisation development and environment

- Envelopment Analysis
- Life Cycle Assessment
- Material Flow Analysis

Policy and Legislation

- Resource Utilisation of Construction Waste
- Construction Waste Management

1. Technology

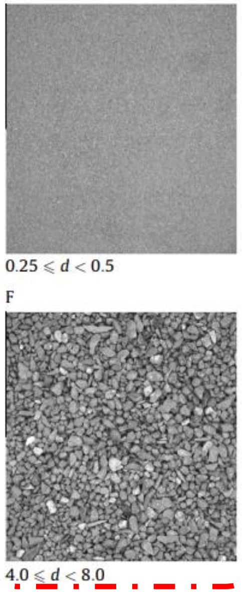
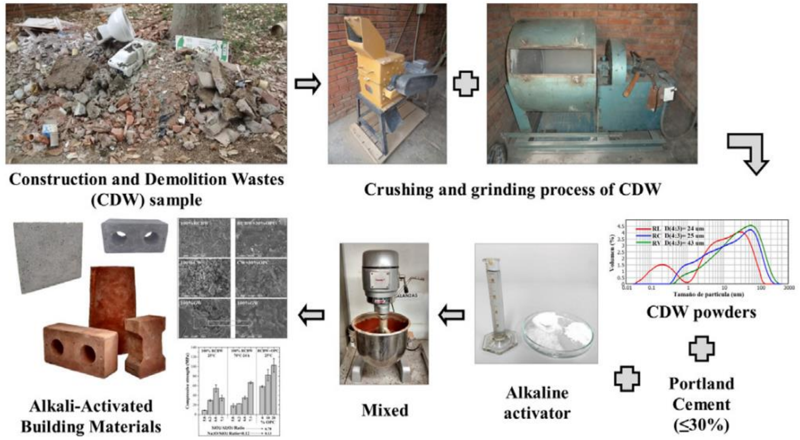


Image Analysis Method

Maria and other experts used the "Image Analysis Method" to analyze the particle size distribution of recycled aggregates in construction waste. This method was applied in recycled material plants and showed an 85% similarity to the results obtained from manual screening, confirming the feasibility of using image analysis in production lines for recycled materials.

Alkali-Activated Cement Technology

Robayo and colleagues analyzed the use of construction waste (such as concrete, bricks, and glass waste) to create alkali-activated cement. Tests on the compressive strength of cement blocks demonstrated that this technology could be used for manufacturing building materials such as bricks and boards.



Recycled Concrete Aggregates

Sabai and his team conducted extensive experiments, proving that recycled concrete aggregates meet standard strength requirements, making it technically feasible for use in construction.

2. Economy

Cost-Benefit Analysis

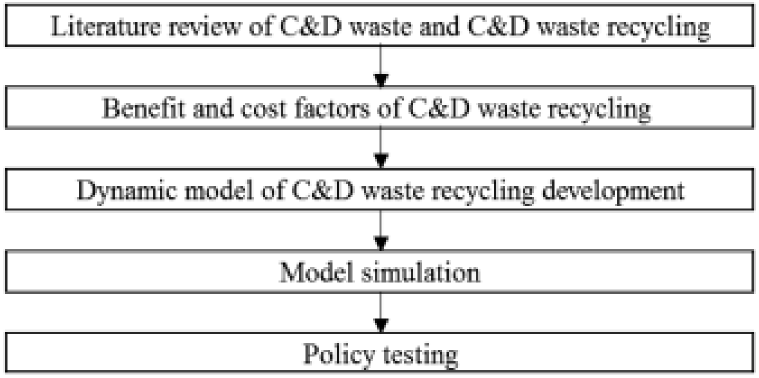
Tam applied a cost-benefit analysis to compare the resource utilization of recycled concrete with traditional waste disposal methods. The research data showed that using recycled concrete materials can generate positive net economic benefits.

Recycling of Construction Waste

Ajayi and colleagues found, through numerous theoretical and practical case studies, that the recycling of construction waste is often underestimated in terms of cost. However, recycling can provide significant economic returns.

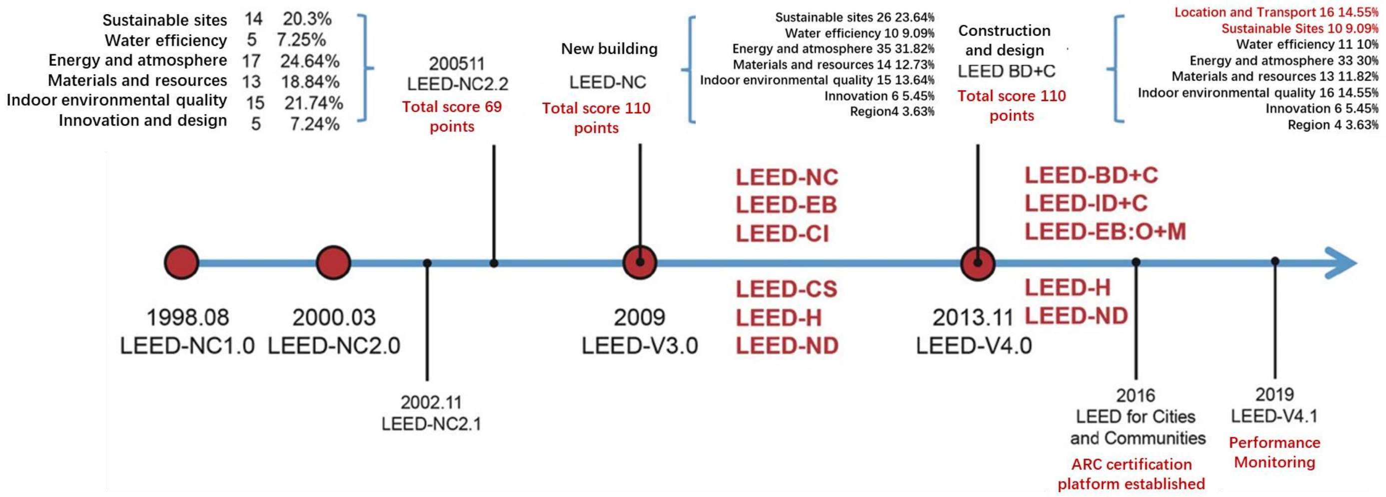
System Dynamics Technology

Doan and his team used a system dynamics technology to establish a model analyzing the costs and benefits of construction waste recycling projects in Bangkok, Thailand. Their analysis demonstrated the economic feasibility of the recycling plan.

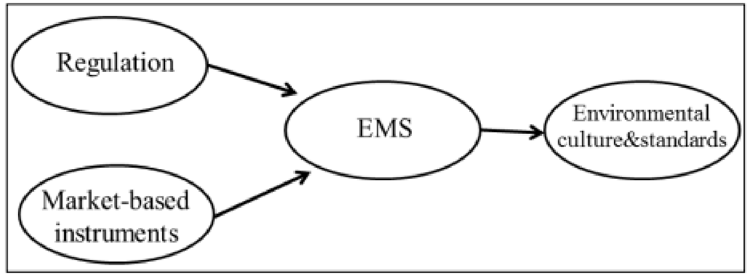


3. Management

LEED Green Building Evaluation System in the USA



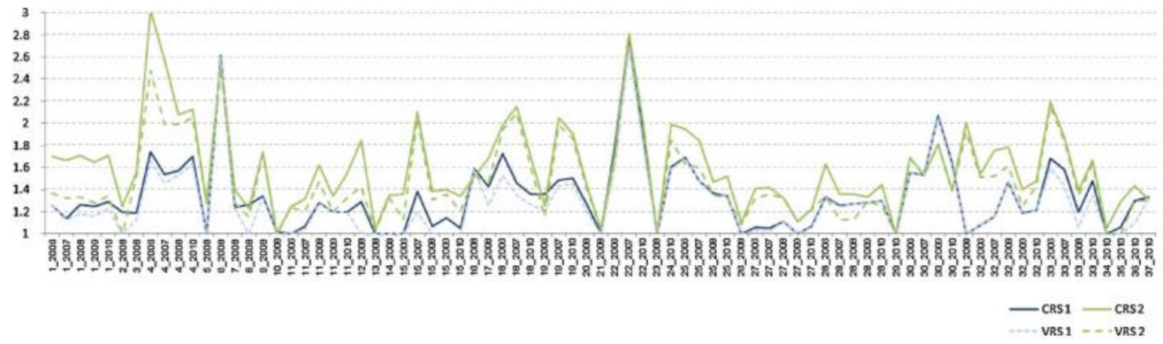
The U.S. Green Building Rating System LEED (Leadership in Energy and Environmental Design) is a system for evaluating the performance of buildings and communities in terms of environmental sustainability. LEED was developed by the U.S. Green Building Council (USGBC) to promote the adoption of greener design and construction standards in the building industry. The LEED rating system covers a wide range of areas, including energy use, environmentally friendly materials, and indoor environmental quality. Specific contents include: 1. certification level, 2. evaluation category, 3. evaluation area, 4. point system, 5. update and certificate version. Professor M.A from Canada studied and analysed the policies and laws and regulations on building waste in Japan and Germany, and put forward the proposal of applying the LEED standard and green evaluation standard of the U.S. green building evaluation system to the management of building waste resources.



Recycling Management Simulation Model

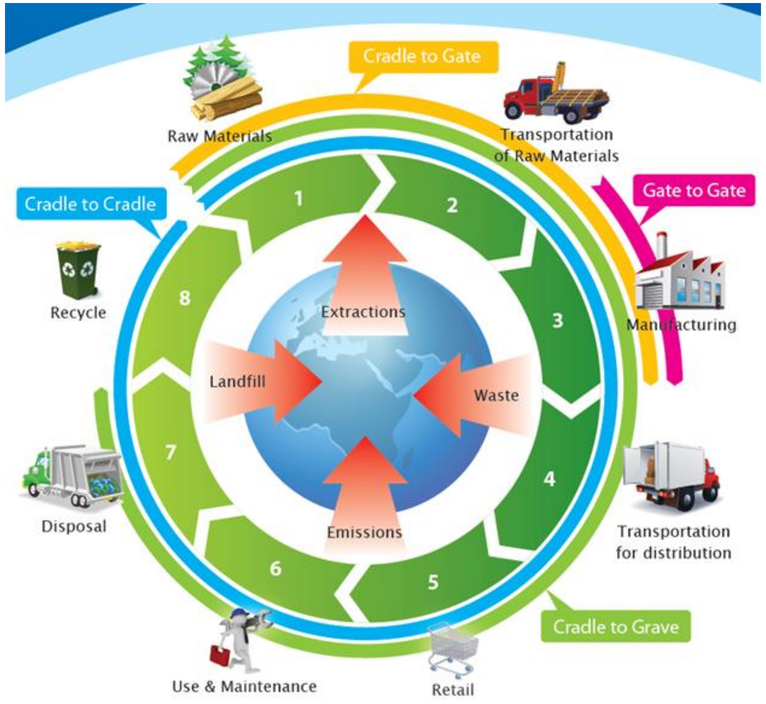
Calvo and his team addressed the issue of informal landfill sites in their country by encouraging businesses to increase the recycling of construction waste. They implemented tax penalties and economic incentives and built a recycling management simulation model to analyze the impact of government measures on businesses involved in recycling construction waste.

4. Industrial Development and Environmental Aspects



Envelopment Analysis Method

Envelopment Analysis (EA) is a technique used for time series data analysis and anomaly detection. It is mainly used to analyse the envelope of data to help identify potential problems, anomalies or trends in the data. Rui Cunha et al. studied and analysed the current situation of the Portuguese waste-building material resource extraction industry with the help of Envelopment Analysis and concluded that the governmental policy orientation is an important factor influencing the development of the industry.



Life Cycle Assessment - LCA

Life Cycle Assessment (LCA) is a systematic approach to assessing the environmental impacts of a product, process or service throughout its life cycle. LCA aims to quantify and analyse the total environmental impact of a product or service at each stage, from raw material acquisition, production, and use, to disposal. This approach not only focuses on the environmental impacts of a single stage, but also considers the combined effects of all stages, helping to make more environmentally friendly decisions. Dahlbo et al. comprehensively evaluated and analysed the economic and environmental impacts of a construction waste management system in Finland by means of a life-cycle assessment and a material flow analysis, and concluded that mixed waste is the most effective for increasing the utilisation rate of construction waste resources.

5. Policy and Legislation Aspects

Recycling and Repurposing of Construction Waste

The United States, Japan and the European Union have done a better job in the resource utilisation of construction waste, especially Germany, which has formulated a series of policies and regulations. The United States for the implementation of construction waste reduction, resource, harmless, industrial management, and the development of the Solid Waste Disposal Act, the Superfund Act, the Pollution Prevention Act, etc. Since the 1960s, Japan has formulated norms for 'recycled building materials use,' the 'Construction Waste Recycling Promotion Act,' 'Waste Disposal Act' and other laws to promote the development of the resourceful use of construction waste. In Germany, the reuse of construction waste began earlier, with the enactment of the Waste Disposal Act in 1972, and its level of technological development is also ahead of the rest of the world.

Year	Policy and Regulation Documents	Year	Policy and Regulation Documents
1975	"Waste Framework Directive"	1999	"Landfill Directive"
2000	"Waste Catalogue"	2011	"European Resource Efficiency Roadmap"
2014	"Enhancing Resource Efficiency in the Construction Sector" and "Towards a Circular Economy: Zero Waste Plan"	2015	"European Circular Economy Action Plan"
2016	"Draft EU Construction Waste Management"	2018	"Waste Classification Technical Guidelines"

Construction Waste Management Regulations

The European Union has a higher level of legal effectiveness in construction waste management than its member states and the European Economic Area. Representative policies, regulations and documents on construction waste management in the EU are shown in the table to the left.

PART 3
国内研究体系

Progress of project work

Current Research Status in China

In comparison to developed countries, China's research on a sustainable evaluation system for construction ware recycling management system began relatively late. The related theoretical system is still under development, and the current research mainly focuses on the following aspects:

Life Cycle Assessment Theory - LCA

Building Environmental Performance Analysis System - BEPAS

Environmental impact assessment system for solid waste management in construction projects (based on LCA and BEPAS)

Green Building Evaluation System - LEED

Life-Cycle Assessment，(LCA)

Product Life Cycle Assessment (LCA) officially appeared in 1990, but the idea has been around since the 1960s. Product life-cycle assessment is a methodology for evaluating the environmental factors and potential environmental impacts associated with a product or service. It identifies the environmental impacts associated with the inputs and outputs of a system by compiling an inventory of those inputs and outputs, and then analyses the inventory and the environmental impacts present in order to guide the development and application of the product.

The main steps in product life-cycle assessment are: definition of the objectives and scope of the study; inventory analysis; life-cycle impact assessment; conclusions and assessment for improvement.

Application of product life cycle assessment in solid waste management

Product life cycle assessment can also be used in solid waste management, and such application is described by Yang et al. This provides a systematic and holistic view of solid waste management, in which all operational activities (processes) of the municipal solid waste management system are studied as a whole, from raw material acquisition, product manufacturing, and waste generation to waste collection, recycling, incineration, composting, landfilling and other processes. Using the life cycle assessment methodology, the whole process of solid waste management can be divided into the following two phases: one is from product design to waste generation; the other is from waste generation to final disposal of waste, the specific process diagram is shown in the figure below.

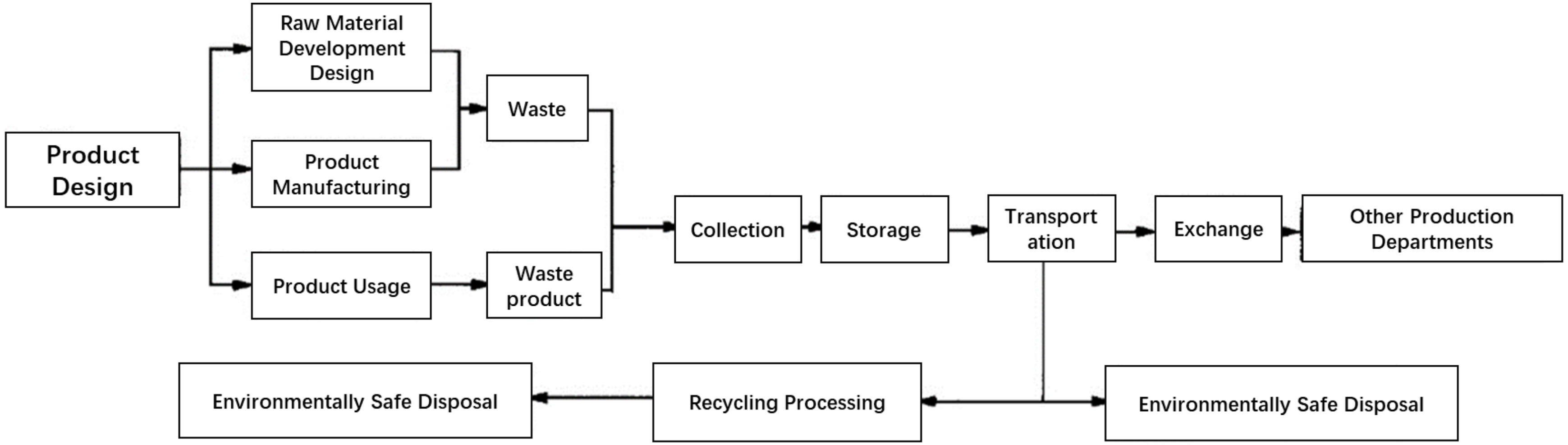
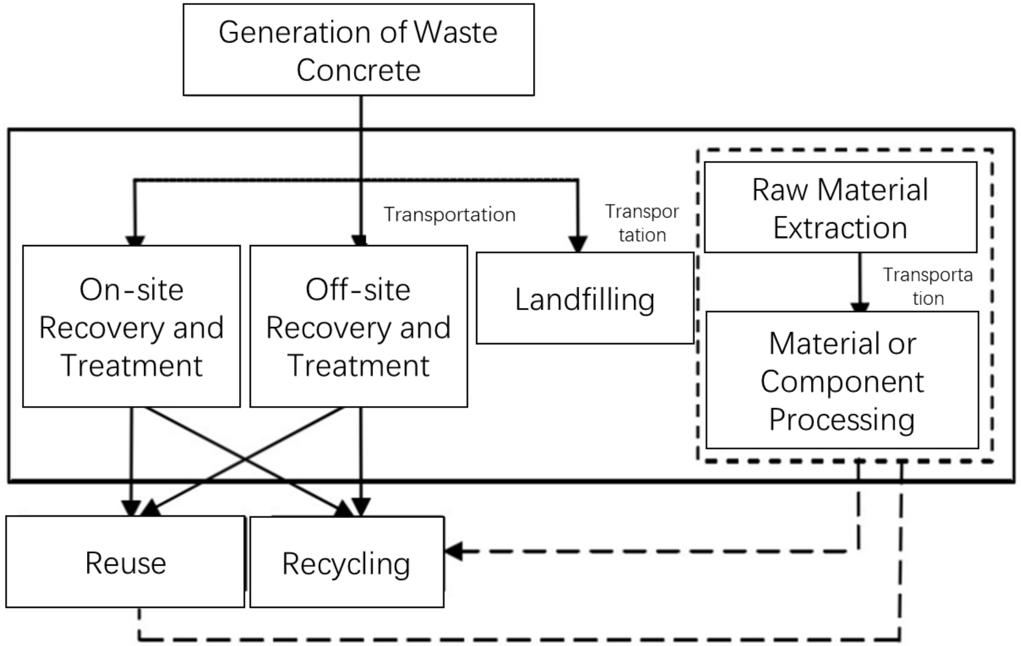


Diagram of the whole process of solid waste management

Application research

In terms of application research, Gong Zhiqi et al. used the life cycle assessment method to account for the environmental impacts of four types of concrete waste recycled aggregate reuse, recycled raw material utilisation, base fill utilisation and landfill. Among them, the LCA method adopts the 'mid-point method' to calculate the life-cycle environmental impact status, and converts the results of the life-cycle impact status into a single environmental impact score expressed in monetary value through the concept of social willingness to pay. The results show that, under the premise of material substitution, the use of recycled aggregates from concrete waste has the lowest environmental impact and best reflects the resource value of concrete waste.



System boundaries for life cycle assessment of waste concrete

Conclusion

Life-cycle assessment can theoretically provide the best methods and approaches for waste management. Using the principles of life-cycle assessment, the whole process of solid waste management can be achieved by improving the legal and regulatory system, accelerating the process of market development, implementing the mortgage-return system, adopting economic incentives, promoting the producer responsibility system, strengthening publicity and education, and opening up a wide range of financing channels, among other specific measures. Specifically, to different regions and industries, and according to their own characteristics, choose different management methods. But no matter which method is adopted, it should not violate the basic law of the product life cycle and should follow the principle of consistency and optimisation. The means adopted should not conflict with the existing management means, legal means and environmental policies, so as to achieve the best environmental, economic and social benefits.

Building Environmental Performance Analysis System (BEPAS)

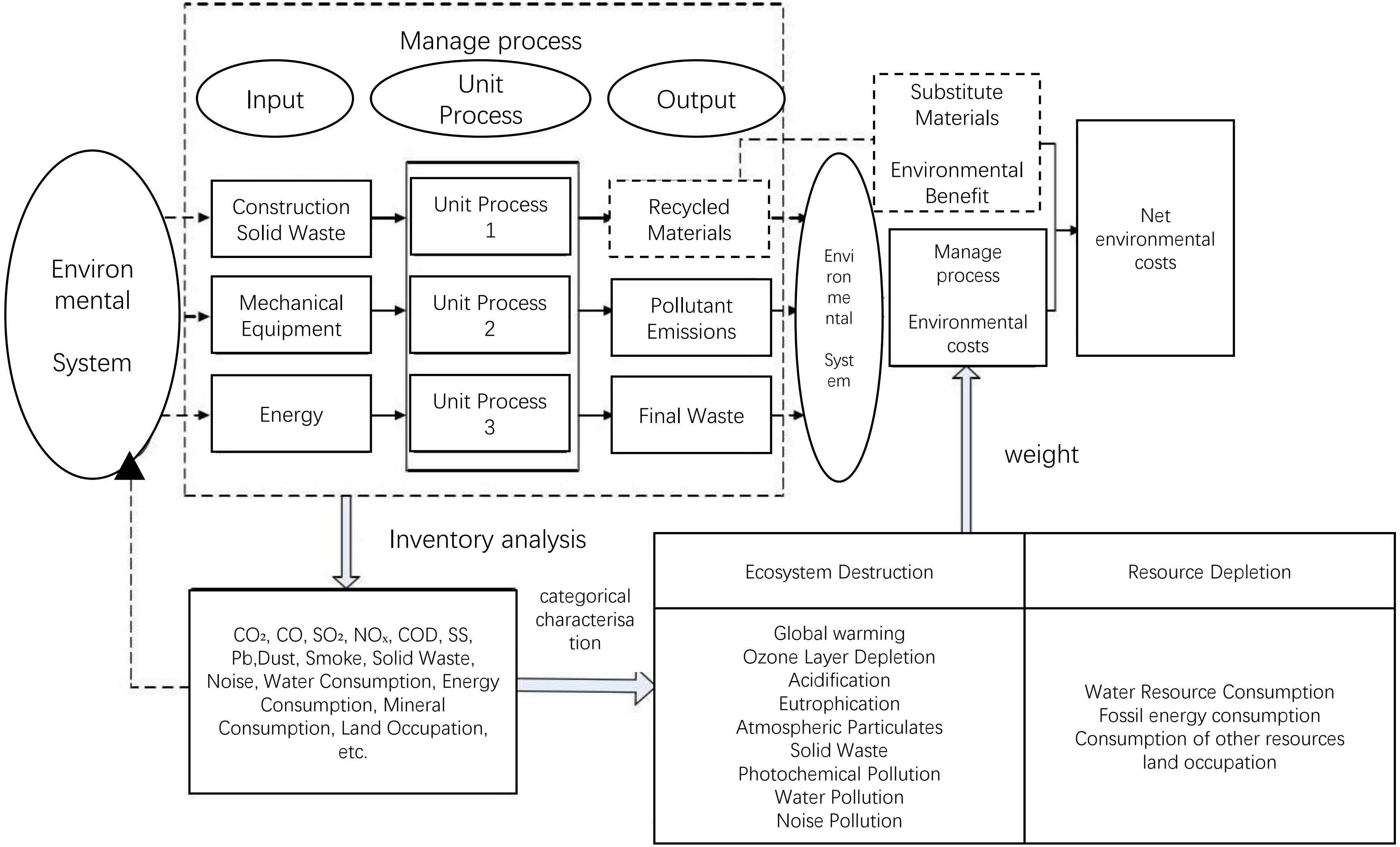
In the field of construction engineering, Zhang Wisdom, Li Xiaodong and others have done more in-depth research and established the 'Building Environmental Performance Analysis System (BEPAS)', which divides construction engineering into four evaluation systems: development of building materials, construction process, use and maintenance, and solid waste management.

BEPAS is formed on the basis of the general theoretical framework of life cycle assessment, taking into account the characteristics of production and use of building products and their constituents. It includes the following three main modules: (1) Evaluation scope determination module. This module is mainly used to determine the system boundary of the evaluation object and the life cycle stage. (2) Input-output inventory analysis module based on unit process. Inventory analysis is the abstraction and generalisation stage of the material and energy flows of the life cycle process. (3) Environmental impact assessment module. This module is the core part of BEPAS and can be subdivided into categorical characterisation sub-module and weighted assessment sub-module.

Environmental Impact Assessment System for Solid Waste Management in Construction Projects

Based on the LCA theory and the BEPAS system, and according to the life cycle characteristics of construction solid waste, Wang Dichun et al. constructed an environmental impact assessment system for construction solid waste management. The basic evaluation scope of the system includes two major parts, namely, the environmental impact of the waste treatment process and the environmental impact of recycled materials. The environmental impacts of the management process include the environmental impacts generated by the three main units of construction solid waste transport from the place of generation to the regeneration (or treatment) site, the regeneration process and the final landfill of waste, which cause adverse consequences to the environment and are regarded as the ‘environmental costs’; the environmental impacts of the regenerated materials are based on the production stage of the alternative materials, i.e. mining, transport and production. The environmental impacts of recycled materials are calculated based on the environmental impacts of the physicalisation phase of the alternative materials, i.e. the extraction, transport and production unit processes, which are positive and are considered as ‘environmental benefits’. The total environmental impact of construction solid waste management can be referred to as the ‘net environmental cost’, which is equal to the environmental cost of the construction solid waste management process minus the environmental benefits of the production phase of the alternative materials. A negative net environmental cost indicates a positive environmental impact of construction solid waste management, while a positive value indicates a negative environmental impact.

Environmental Impact Assessment System for Solid Waste Management in Construction Projects

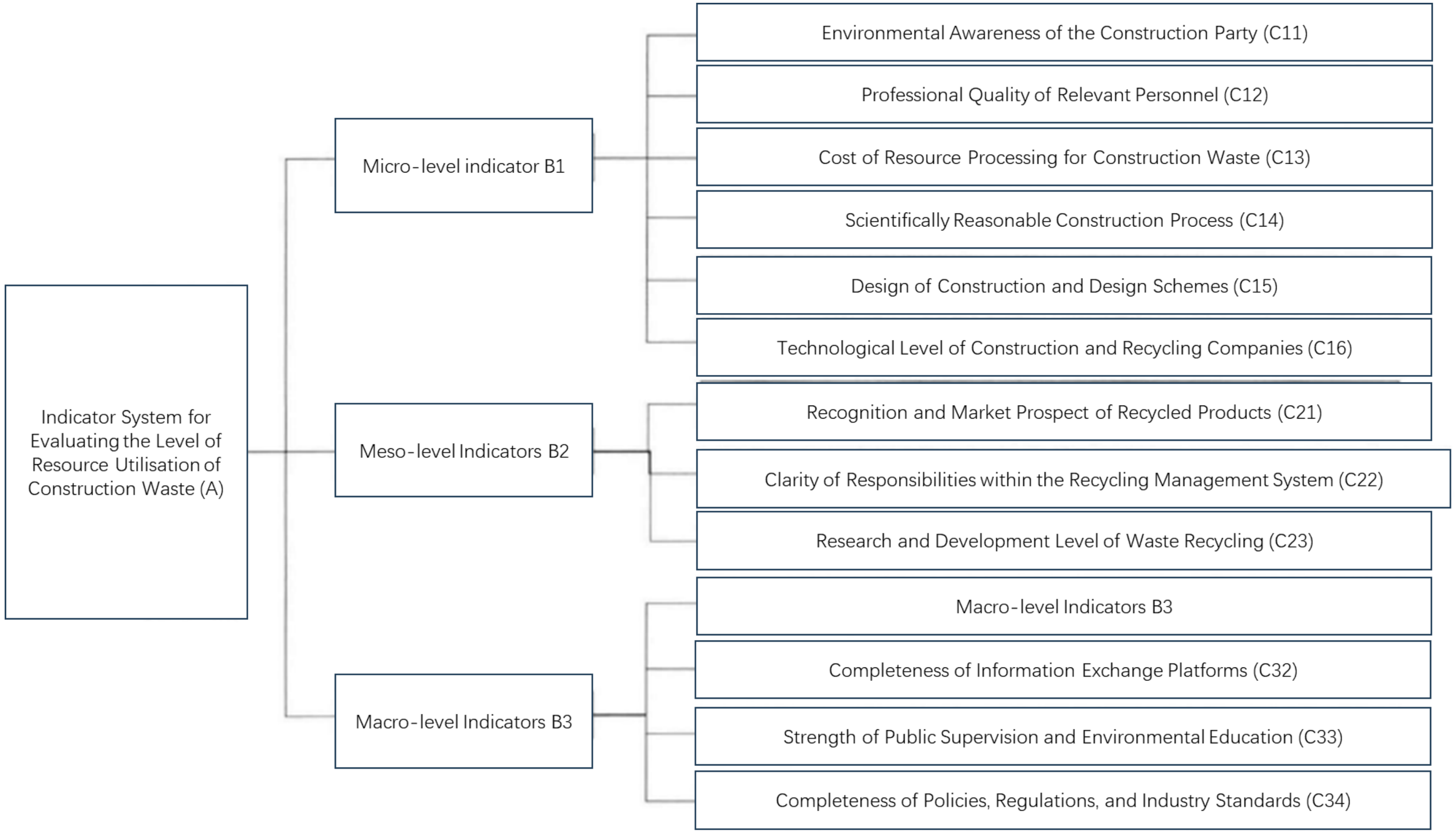


LEED Green Building Evaluation System

LEED (Leadership in Energy and Environmental Design) is a globally recognised green building rating system that promotes the performance of building projects in terms of environmental protection and resource conservation. Developed and maintained by the U.S. Green Building Council (USGBC), the LEED system provides a standardised set of evaluation metrics to measure a building's overall performance in terms of energy efficiency, environmental quality and resource management. For LEED certification, projects are required to implement effective waste management strategies such as waste segregation, recycling, and reduced material use in order to earn points. Such measures not only reduce waste from the building process, but also promote the recycling and support the overall sustainability of the building. In this way, the LEED system promotes effective waste management and optimal use of resources in the construction industry.

Evaluation Indicator System for the Development Level of Construction Waste Resourcing

Based on the research results of the previous researchers, Li Linxuan et al. explored the possibility of resourceful treatment of construction waste at the theoretical and technological levels. They established a corresponding index evaluation system to analyse and study the level of China's construction waste resourcefulness in light of the existing problems of China's construction waste management. For the first time, the influencing factors of construction waste resourcefulness are summarised and collated, and a total of 13 evaluation indicators are collated from three aspects, namely, public foundation, industry development, and macro policy, while the hierarchical analysis method is used to construct a corresponding indicator evaluation system, which provides a scientific tool for research and in-depth analysis of the development status of construction waste resourcefulness.



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