A Study of Using Construction Waste and Recyclable Materials in Modern Landscape Design

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Abstract. By examining the recycling of construction waste in the city construction including both architecture and landscape, this paper aims at exploring a recyclable manner of making use of the construction waste in the landscape design. This paper sorts out types of usable construction wastes and outlines approach, including green recycling and planting. It is hoped that this paper can help to provide a frame of reference for the landscape design.

1. Introduction
The Chinese urbanization has processed into a new phase of rapid growth. The construction of the city also enters a new era of comprehensive development requiring multidisciplinary cooperation, including urban planning, urban design, architecture design, and landscape design. There will be, inevitably, a substantial amount of construction waste left as a byproduct of such urbanization. In China, the most common way to deal with waste is to bury them in the city outskirt, resulting in landfill sites. Apparently, such treatment not only takes up our limited land resources but also brings unavoidable damage to the earth. Thus, some proposals are presented to mitigate such damage. One of the most efficient ways is to make use of the construction waste and seek its recycling possibility for the city landscape constriction, such as shaping terrains, paving roads, covering plants, and so force, which can be an ecological approach to consume the city waste.

2. Construction Waste
Construction waste is part of the urban solid waste. It often refers to the waste such as spoil, dumped material, and other waste generated from municipal constructions, such as building, renovating, expanding, and demolishing. Construction waste can be categorized into different types. According to the phase of generation, waste can be categorized into two main types as construction waste and demolition waste. On the basis of generate source, it can be listed as: land excavation, road excavation, building demolition, building construction, and building materials. In China, construction waste mainly composed of clay, grit, sand, brick, concrete, asphalt, plastics, metal, bamboo, and so forth.

3. The Use of Construction Waste in Municipal Development
The academic research on construction waste and recycled materials in the field of highway engineering has made a significant achievement. Among these advanced studies, some of hypothesis have been further substantiated in the real-life cases, showcasing the possibility for other disciplines. In the city construction nowadays, demolition waste like abandoned building materials are exclusively used for road construction. It tells the fact that, as a building material, the construction waste is capable to meet the current building regulation. These discarded materials such as concrete, brick, tile, stone, and lime-fly ash, have a strong capability of strength, and most of them are made up of the...
high-quality ingredient, closer to the road construction. It therefore, indicates the technical feasibility of using the demolition waste. In the case of path construction in landscape design, the requirement of load and strengthen is, definitely, much lower than the highway and road. Hence, the use of construction waste in the highway and the road case can server as a technical support.

4. The Use of Construction Waste in Architecture and Landscape
The use of abandoned materials in modern construction are mainly divided into two cases: the in-situ recycling building material and the recyclable building material. The following text will further elaborate in detail.

4.1. In-situ Recycling Building Material
In some cases, abandoned materials are efficiently reused to preserve the historical and cultural value. In the rapid urban development, many building materials, including bricks and tile, are discarded into waste from demolition. These old bricks and tiles used to be part of the building, expressing a historical sense of collective memory. The recycling of discarded materials is not only a remembrance and a tribute to traditional culture, but also a symbol enriching the history and showing a continuity. For example, in the Xiangshan campus of CAA (China Academy of Art), the abandoned bricks and tiles were used to retell the old story.

4.2. Recycled Building Materials Industry
The technology of recycled building materials gains a great speed of development. The recycled building materials generated from industrial and architectural waste has been industrialized. For example, discarded concrete and bricks can be used to produce recycled bricks, concrete, and other materials. The strength of EcoX concrete, a concrete composed recycled materials, is as strong as reinforced concrete. The exposed structure with various colors demonstrating a beautiful appearance. This material has an excellent property of waterproof that can be used in kitchen and bathroom. [3]

5. Construction Waste in Landscape design
In the west, the use of construction waste in landscape design has gained a great achievement. The recycled materials in the garden design can mainly be categorized into two types of temporary landscapes structure and abandoned land remolding.

5.1. Temporary Landscape Construction
The Landscape Art Exposition can be a perfect case for elaboration. It is known that often, such Exposition would be in the form of an exhibition showing artwork for a short period. The construction or structure for holding the exposition usually built for temporary instead of permanent. Therefore, the use of recyclable building materials is a perfect choice since they can be reused in another occasion, before or after any event. In this specific case, the temporality of the exposition plays a decisive role in the use of the recyclable materials. [4]

5.2. The Reconstruction of the Abandoned Land
Since post-industrial era, landscape architects began to take up the role of reconstructing the city landscape. Construction waste becomes part of such process. They are, effectively, recycled into a new building material and used for construction. Architecturally, these reused materials give a sign of respect to nature and the city.

In recent year, the use of construction waste in the field of landscape design has been increasingly recognized and applied. Besides, the using of waste in design requires collaborative effort and increased teamwork. Therefore, we can only start from a small-scale project and solve the issue raised during such experimental process. The following text will continue to discuss several approaches about the way to use the construction waste and recycled materials, concerning green recycling and planting.
6. Construction Waste and Recycled Material: Green Recycling and Planting

Recycling construction waste is a perfect method for city development. Theoretically, it is an ideal method to consume the waste and prevent it from occupying our limited land resources. From the perspective of landscaping, it is also a solution proposed by designers in response to the environmental pollution. Such green recycling method becomes widespread, especially in landscape design. Notwithstanding, in the real-life situation, only covering the landfill with green and plant can generate ecological benefits.

As mentioned, a perfect recycling mode would be covering green and plant over the waste. It is proved that the construction waste and recycled material can be an ingredient for planting. The following text will analyze the green recycling and planting for construction waste.

6.1. The Structural Layer of Green Recycling and Planting

As shown in Figure 1, a recycling system built by construction waste, from top to bottom, (14) is a vegetable layer, (13) a soil layer, and (12) a drainage layer. In the drainage layer, it contains two sub-layers named coarse sand layer and grit layer (the coarse sand layer cover of the grit layer). The soil layer produces necessary fertilizer for the planting, while the drainage layer, as its name indicated, can help to drain excess water and ensure the inside soil permeability. The recycling system built by construction waste shown in Figure 1 displays a good layer arrangement and provides a soil environment for planting.

![Figure 1. A Recycling System Built by Construction Waste](image)

6.2. Details of the Structural Layer of Green Recycling and Planting

In the structural later of the recycling system, the raw material of soil layer and the drainage later, containing the coarse sand layer and the grit layer, are all comes from the construction waste and recycled material, details can be found in Table 1.

| Item | Structural Layer | Thickness/Particle-size | Material | Method | Remark |
|------|------------------|-------------------------|----------|--------|--------|
| 14   | vegetable layer  | Herbs and low shrubs    | choosing different plants with species | Detail can be found in Table. 2 |
| 131  | 1st soil layer   | Regeneration Soil for planting by construction waste | Mixed materials of construction waste and other materials |
| 132  | 2nd soil layer   | Soil for reclaimed surface | | |

Table 1. Details of the Structural Layer of Green Recycling and Planting
121 Coarse sand layer 0cm planting soil coarse sand reproduced by construction waste soil Mixture of building waste separation / (grain size) ≤ 2mm

0cm (thickness) 20-30cm / (particle-size) ≤ 2mm

122 Grit layer Gravel layer (thickness) 20-30cm / (particle-size) ≥ 10cm Gravel reproduced by construction waste Gravel of building waste separation / (grain size) ≥ 10cm

11 Construction waste layer Construction waste Mixture of building waste separation / (grain size) ≤ 2mm

Due to the large differences of grain size on construction waste, the construction scheme base on the site conditions ramming

10 Original foundation layer

15 Layer to stabilize the construction waste

6.3. The Use of Construction Waste in Landscape Planting

At present, there are some studies conducted to examine the recycling of sand from the construction waste for landscaping, but they are only limited to the sand that its particle-size is under 5mm. In the real-life situation, only a few available solid can be extracted from the waste, and the process is quite complicated and time-consuming. Also, the composition of the waste is often mixed, and it is hard to arrange them based upon the ideal layer structure discussed in the previous text. This would result in the poor soil permeability and fertilizer, which go against the growth and development.

According to experiment, the sand with particle-size under 2mm from the construction waste can be the essential soil components for planting. Of course, the sand must be mixed with clay and muck soil in a given volume ratio (Table 2). Such prepared mixed soil has a perfect fertilizing structure. The muck soil contains an abundant element for plant growth; the construction waste is added to improve the soil permeability. Therefore, the soil can reach a certain level of stable, providing a sound soil environment for the plant growth.

Table 2. The Component of Soil from Construction Waste

| Composition                         | Proportion (volume ratio) | Component description | Remark                                      |
|-------------------------------------|---------------------------|-----------------------|---------------------------------------------|
| Mixture of building waste separation| 40-60%                    | Thickness ≤ 2mm       | Sorting and sifting of construction waste at the site |
| Clay                                | 30-50%                    | cosmid 50%-85%        |                                             |
| Humus soil                          | 10%                       | pH 5.5-7.0            |                                             |

7. Conclusion

The use of construction waste and recycled building materials can provide a new vitality to the landscape design. It can lead the modern landscape design to a perfect environmental direction in
terms of energy-saving and material-saving. To conclude, the use of construction waste in the modern landscape construction can create a new ecological and recycled environmental system; it helps to demonstrate the future mode of city development.

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