Journal of Architectural Research and Development, 2022, Volume 6, Issue 6
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Application of Construction Waste Recycled Material Processing in Road Engineering

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Abstract: In order to promote the recycling of construction waste in China and reduce the cost of road engineering materials, this paper expounds on the technical indexes, road performance, durability, and the impact on the compressive strength of road engineering of construction waste recycled materials based on the analysis of the processing technology of construction waste recycled materials to provide reference for future research.

Keywords: Construction waste; Road engineering; Material regeneration

Online publication: November 21, 2022

1. Introduction

The number of road projects and buildings continues to increase with the development of urban construction in China, and the amount of garbage generated by the construction industry is also gradually increasing, highlighting the importance of garbage treatment methods. If the large amount of garbage is not handled properly, it will have a negative impact on people's life and on urban economic development. The hazards caused by construction waste are described below.

Firstly, construction projects involve long and complex processes, resulting in a large amount of construction waste. This kind of construction waste is disposed at will, or moved to other places for landfill or incineration, which is very likely to cause dust, corner waste, etc., which will affect the urban spirit and urban green landscape, and cause certain damage to green belts. If construction waste is piled in the outdoors without proper landfills, the land will collapse over time and affect people's lives. Secondly, when garbage accumulates near ditches and tunnels, the flood discharge of surface drainage, and the regulation and water storage capacity of water body will be affected, causing water pollution. Thirdly, transporting construction waste to other treatment plants is costly due to the need for manpower, resources, and also the long travel distance. Fourthly, domestic construction waste mostly consists of polymers that are difficult to decompose and contain toxic heavy metals. Therefore, when these toxic substances penetrate into the soil and are difficult to dissolve, it will affect the soil quality. When these harmful metals enter the surface water, the groundwater will also be polluted. Besides, when the toxic gas produced by these construction wastes volatilizes into the atmosphere, causing the surrounding air to become turbid and the air quality deteriorates [1-6]. Therefore, it is necessary to make full use of construction waste, apply it to road engineering, and realize a win-win cooperation between road engineering and construction.

2. Construction waste processing technology

2.1. Waste concrete treatment

The treatment technology of construction waste and waste concrete is relatively systematic and comprehensive. Unwanted materials, iron bar, plastic, and wood are removed from the concrete, and the recycled aggregate are screened and graded from grade 0 to grade 4. It is a system for recycling 0mm-40mm relatively waste concrete. The primary crushing and secondary crushing of concrete blocks are carried out by a jaw crusher and screened by double-layer screen efficiently. The primary selection adopts 5mm and 40mm screens to separate the aggregate into three particle sizes of 0-5mm, 5-40mm and more than 40mm, of which the aggregate of more than 40mm enters the secondary crushing and primary selection cycle. The aggregate with particle size of 5-40mm enters the secondary sieve, which further divides the aggregate into three particle sizes of 5-10mm, 10-20mm, and 20-40mm with mesh of 10mm and 20mm.This treatment method is most suitable for waste cement concrete. The sundries can be separated using the density difference of wood and the magnetic difference between concrete and reinforcement steel. However, this treatment technology is not suitable for construction waste mixed with bricks and concrete blocks, and the separation of sundries is not thorough, which cannot solve the problem of dust [7].

2.2. Drying, sorting and grading

A chargeable heating and drying device is adopted for drying and sorting after primary separation. After heating and drying, secondary grinding and sorting can be carried out to obtain recycled materials with better quality. It can increase and improve the surface activity of the aggregate. The secondary crushing adopts drum-type or ball mill roller. After drying 300 times, the cement stone with damaged outer layer of aggregate is stripped to obtain higher strength aggregate [8]. The purpose of this method is to remove the metal in the waste concrete and reduce the particle size of the waste concrete to a certain extent, which is different from the existing separation methods. The process is complex and the treatment cost is high, and it is only suitable for the recovery and treatment of waste concrete.

2.3. Rotary drum dryer

In the process of construction waste treatment, drying and roller compaction are adopted. Firstly, the materials are roughly selected through manual sorting. Then a rotary drum dryer is used for sorting, drying and rolling, and finally discharge of waste [9].

2.4. Concise processing technology

Concise treatment technology adopts broad and simple treatment methods to treat construction waste according to crushing, magnetic separation, air separation, screening, and other processes. This series of processes adopts common methods such as gravity separation, magnetic separation, air separation, and vibration screening to realize the treatment and classification of construction waste. Due to the low labor cost in China and the difficulty in handling large materials of mechanical equipment, the construction waste are screened by manual sorting in the early stage to eliminate large materials and materials that are not suitable for reprocessing. The impact crusher can efficiently crush bulk materials small particles with an even force. Through preliminary investigation and research, it is found that the construction waste not only contains light impurities such as waste wood and plastics, but also contains iron materials such as short and thick iron bars and fine iron wires. The crushed materials are transported to the air separation equipment through the lower conveyor belt, and light materials are removed based on difference in densities to obtain pure recycled materials. At the same time, a magnetic separation device is installed between the impact crusher and the wind power separator to remove impurities such as iron powder and iron bar [10].

2.5. Water washing and dust removal process

The vibrating screen dust removal process can remove part of the soil before crushing, but the cleanliness requirements of aggregate on cement concrete pavement and asphalt pavement are high, so it is difficult to meet the requirements for vibrating screen dust removal. The spray dust removal system only avoids the release of dust in the production process. For the aggregate requiring special cleanliness, after the selection is completed, mud and other impurities affecting strength can be removed by washing, and relatively pure recycled products can be obtained. The recycled aggregate produced can be set according to their respective drying process [11].

3. Application of construction waste recycled materials in road engineering

3.1. Technical indicators of construction waste recycled materials

Table 1. Technical indexes of recycled materials of construction waste

Project	Needle and flake content (%)	Crushing value (%)	Concrete block content (%)	Dopant content (%)
Basic level	≦ 20	≦ 45	≧ 40	≦ 0.1
Subbase	≦ 22	≦48	≧ 30	≦ 0.1

The control range of specific index content is shown in **Table 1**. Among them, the needle and flake content is used to reflect the final generation quality of construction waste recycled materials; the higher the quality is, the better the road performance of recycled materials, and the better the screening of recycled materials. The crushing value affects the compressive strength of construction waste recycled materials; the higher the crushing value, the higher the compressive strength. Recycled materials with different crushing values are mixed with aggregates, and the final compressive strength of the mixture is affected by recycled materials; the content of concrete block affects the mechanical properties of recycled materials. Mechanical properties are one of the indicators affecting the compressive strength and crushing value. They have a significant impact on the utilization of recycled materials, the quality of road engineering mixture, and the final quality of road engineering. The amount of impurities has the most obvious impact on the quality of road engineering, which can seriously affect the construction quality of road engineering. Besides, the reinforcement steel and sawdust contained in recycled materials also have a significant impact on the performance of the mixture, which needs to be strictly controlled.

3.2. Road performance of recycled mixture

3.2.1. Mechanical properties

(1) When the composition of the mixture is the same, the strength of cement-stabilized recycled mixture increases with the increase of cement input.

(2) The strength of cement-stabilized recycled mixture increases nonlinearly with time; the fastest increase occurs during the 0th to 7th day, the slowest increase occurs during the 7th to 28th day; the strength increase from the 28th to the 90th day is negligible.

(3) The unconstrained compressive strength of cement-stabilized recycled mixture decreases with the increase of recycled aggregate content. This is because the crushing value of construction waste recycled material itself is higher than that of new aggregate and its strength is low. In addition, the low adhesion of construction waste recycling materials to cement particles further reduces the strength of the mixture.

(4) The infinite compressive strength of cement stabilized construction waste recycling mixture meets the requirements of highway substrate.

3.2.2. Stability

With the increase of the content of construction waste recycled material, the antifreeze performance of cement-stabilized recycled mixture decreases, because the recycled aggregate of construction waste itself is a porous material. The higher the absorption rate, the more the strength decreases after the same freeze-thaw cycle, while the strength of recycled material is lower than that of the aggregate. The porosity and strength are lower and more vulnerable to external influence and damage after freezing and thawing. Therefore, the higher the content of recycled aggregate, the lower the compressive strength after the same number of freeze-thaw cycles. In general, the freezing stability coefficient of cement-stabilized construction waste recycling mixture is basically the same and has good freezing stability [12].

3.2.3. Dry shrinkage performance

The greater the amount of recycled material, the greater the dry shrinkage coefficient of the mixture. This is because the absorption rate of recycled material itself is greater than that of natural aggregate, resulting in higher dry shrinkage coefficient. Therefore, the early maintenance of cement-stabilized construction waste recycling mixture is crucial [13].

3.3. Durability of recycled aggregate concrete

3.3.1. Cold resistance of recycled aggregate concrete

(1) Regardless of the type of aggregate, the quality of concrete specimens increases positively and the quality improves continuously. Besides, the drought resistance of recycled aggregate concrete increases gradually, and the concrete recycled aggregate containing brick has the highest drought resistance.

(2) With the increase of the mass of the test piece, water can continuously enter the pores due to the change of size, so as to increase the mass. No obvious damage is found to the test piece with the naked eye. The mass loss of the test piece is less than 5%. After 100 freeze-thaw cycles, the test piece has no obvious damage. The quality change shows that the durability of the concrete meets the standard requirements.

(3) The compressive strength of concrete prepared with natural gravel and recycled aggregate is similar, and the decline rate of compressive strength after freeze-thaw is basically the same. It shows that recycled concrete can replace natural gravel to prepare concrete, and has no obvious effect on the frost resistance of concrete.

(4) The compressive strength of recycled concrete aggregate with brick content of about 30% is lower than that of natural gravel and recycled non-brick aggregate concrete. The mass loss rate after freeze-thaw is small, but the reduction rate of compressive strength is the largest. The internal stiffness of recycled concrete aggregate is uneven after freezing 100 times. During the thawing cycle, due to different elastic modulus, the stress distribution is uneven, resulting in stress concentration. No changes were observed macroscopically, but the defects already exist in the recycled aggregate of concrete, resulting in a significant reduction in compressive strength.

(5) When bricks are used as concrete aggregate alone, the elastic modulus of aggregate is relatively uniform, the temperature change of 100 freeze-thaw cycles is small, the stress distribution is uniform, and there is no stress concentration. There are many internal defects in recycled aggregate, and the decline of compressive strength after freeze-thaw cycle is lower than that of recycled aggregate containing 30% brick for concrete.

3.3.2. Impermeability of recycled concrete

The high permeability of recycled concrete material of construction waste is mainly due to the low density of recycled aggregate, and water can penetrate through recycled aggregate. In road engineering construction, a reasonable location can be selected to apply recycled concrete according to construction requirements.

3.4. Influence law of recycled material content of construction waste on mixture strength

As shown in **Figure 1**, material content has a certain impact on the compressive strength of the mixture when used in road engineering. The specific impact laws are as follows:

Firstly, due to the large crushing value of recycled materials, the strength of recycled materials is lower than that of aggregates. The higher the content of recycled materials in the mixture, the lower the strength of the mixture. The same amount of mixture is used in road engineering. The higher the content of recycled material, the less aggregate in the mixture, and the lower the strength of the mixture. In the mixture, the adhesion between recycled material and cement is low. If the content of recycled material is too high, the strength of the mixture will be reduced again and the compressive strength of road engineering will be affected [14,15].

Secondly, according to the requirements of compressive strength of road engineering construction, the mixture needs to meet the standard of compressive strength of road engineering construction. The compressive strength of subbase and base course is required to be no less than 7.0Mpa. According to the data in **Figure 1**, when the content of recycled material is less than or equal to 40%, the compressive strength of mixture is higher than 7.0Mpa, meeting the needs of road engineering construction [16, 17].

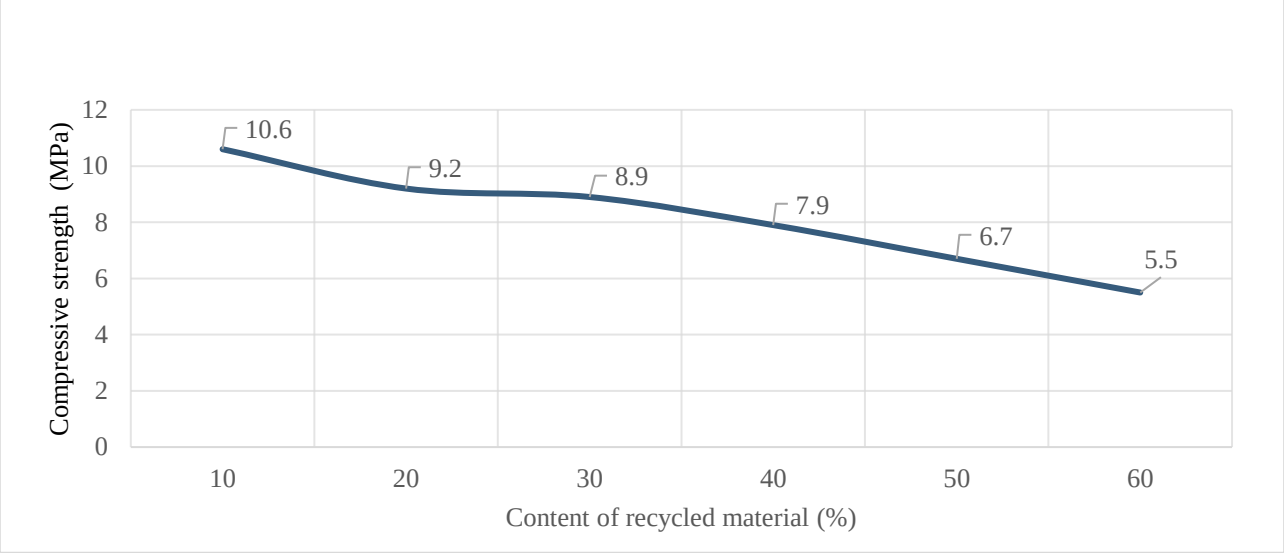

Figure 1. Effect of recycled materials content of construction waste on pressure resistance

4. Conclusion

In short, in China's road engineering construction, the rational application of construction waste recycled materials plays an important role in China's economic development. It can effectively reduce the accumulation of recycled waste, reduce the cost of road engineering construction, and reduce material cost.

Disclosure statement

The author declares no conflict of interest.

References

[1] Zhang Z, Yang J, Wei Z, et al., 2022, Research on The Application of Construction Waste in Expressway. Construction Technology (Chinese and English), 51(04): 46–48 + 61.

[2] Du T, Ma F, Ji L, et al., 2022, Research on the Application of Construction Waste Recycled Brick and Concrete Materials in Roadbed. Transportation Energy Saving and Environmental Protection, 18(01):

73–75 + 87.

[3] Xu S, Liu M, 2021, Research on Application of Construction Waste Recycling Materials in Road Base. Sichuan Building Materials, 47(11): 35–36.

[4] Du H, Wang C, Yu C, et al., 2021, Study on Microstructure of Cement Improved Construction Waste Recycling Materials. Subgrade Engineering, 2021(05): 81–84.

[5] Zhou B, Wang F, Liu J, 2021, Current Situation and Prospect of Urban Construction Waste Recycling and Disposal Policy: A Case Study of Some Cities. Proceedings of Chinese Society for Environmental Science and Technology Annual Conference 2021 — Environmental Engineering Technology Innovation and Application Sub-conference, 525–527.

[6] Lin J, 2021, Study on the Performance of Coarse Aggregate Concrete Recycled from Construction Waste. Jiangxi Building Materials, 2021(09): 38–39 + 42

[7] Wu N, Yue Y, Wu S, et al., 2021, Proportion of New Roadbed Materials Produced by Collaborative Disposal of Sludge from Construction Waste. Architectural Technology, 52(07): 825–827.

[8] Lu J, 2021, Influence of Construction Waste Recycled Fine Powder on Properties of Raw Soil Materials, dissertation, Beijing Architecture University. https://www.doi.org/10.26943/d.cnki.gbjzc.2021.000103

[9] Yu M, Liao, Research on Key Technology of Construction Waste Backfilling Road Base Material. Urban Road Bridges and Flood Control, 2021(04): 30–33 + 38 + 11.

[10] Sun W, 2021, Research on the Effect of Recycled Materials on Reducing Material Loss in Passive Building. Material Protection, 54(03): 195. https://www.doi.org/10.16577/j.cnki.42-1215/tb.2021.03.043

[11] Liu Y, 2021, Research on the Development and Properties of Reclaimed Material Permeable Brick, dissertation, Shandong Agricultural University.

[12] Wu X, 2019, Discussion on the Performance of Construction Waste Recycled Materials as Roadbed Filler. Building Materials and Decoration, 2019(24): 45–46.

[13] Li W, 2019, Preliminary Experimental Study on Aggregate Concrete recycled from Construction Waste. Hubei Agricultural Science, 58(15): 66–67 + 114.

[14] Ma W, Lian Y, Yang G, et al., Research on Recycled Concrete with Organic Fiber Additive from Construction Waste. China Housing Facilities, 2019(07): 16–17.

[15] Yang F, 2019, Application Research of Construction Waste in Highway Engineering. Green Building Materials, 2019(06): 103–104.

[16] Pan Y, Dong X, Liu Q, et al., 2019, Research on Backfilling Construction Technology and Application of Recycled Building Materials. Building Structure, 49(S1): 790–794.

[17] Zhang X, Zhang M, Li Z, 2018, Large-Scale Consolidation Test analysis of Construction Waste Recycling Materials with Proportioning Ratio. Transportation Energy Saving and Environmental Protection, 14(05): 81–84.