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Reuse of building demolition waste mainly based on recycled aggregates-a review

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ABSTRACT
The rapid development of urbanization has led to a lot of building demolition waste, most of them are dug and buried, causing pollution in the region and affecting the integrity of the environment. This article summarizes the experience of predecessors and provides a series of systematic summaries on the reuse direction of construction waste mainly composed of recycled aggregates. Research has been done to elaborate that the mechanical properties of different recycled aggregates vary greatly, and most recycled aggregates have distinct differences in mechanical properties compared to natural aggregates. Compared with natural aggregates, recycled aggregates have some defects such as high water absorption, high porosity, high water absorption, and more cracks. And the processing of recycled aggregates can effectively narrow this gap. Various literature reviews have shown that adding fibers to crushed red brick aggregates can significantly improve the strength of recycled brick concrete. It has also been observed that recycled concrete containing crushed rubber has greater ductility than recycled concrete without crushed rubber, making it widely applicable to structures that can withstand earthquakes.

KEYWORDS
Construction and demolition waste; Recycled aggregates; Mechanical properties of aggregates; Load-bearing capacity

1 Introduction

Nowadays, with the slogan of environmental protection gradually taking root in people's hearts, governments of various countries have also begun to vigorously implement new environmental protection measures. However, in the construction industry, there is still a lot of building demolition waste that has not been recycled, causing a huge burden on the environment. According to data from 2018, construction and demolition waste (CDW) accounted for 35% of all waste generated in the European Union[1]. Since the beginning of the 21st century, China's economic level has grown rapidly, the construction industry has been revitalized, the scale of urban construction has expanded significantly, and the population has grown rapidly. At the same time, the construction waste generated during the construction process in the construction industry has reached a point where people are at a loss. The issue of handling construction waste is increasingly attracting attention from the construction industry. However, since the lack of strong policy support, as of 2019, the recycling rate of construction demolition waste (CDW) in China is less than 5%[2]. China's construction demolition waste is generally disposed of through direct landfill, which will directly lead to pollution of land, air, rivers, groundwater, etc. within the region, and also harm nearby biological communities. The sources and types of construction and demolition waste are diverse, leading to varying qualities of recycled aggregates[3]. The secondary utilization of recycled aggregates has become the primary issue in the construction industry.

Construction and demolition waste is generated in almost all activities of building construction, such as the construction of bridges. These residues are composed of all kinds of materials, including various components of the building and other materials used during the construction process[4], such as concrete, metal, glass, sand, plastic, etc.

The general mode of waste classification for construction and demolition is shown in Figure 1.

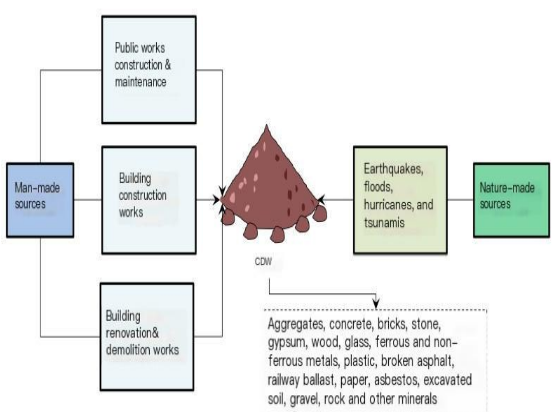

Figure 1 [5]

Studies have shown that recycled fine aggregates have a good application in the construction industry [6], and recycled fine aggregates are also a good substitute for sand. And people's research on recycling coarse aggregates needs to be more in-depth than their research on recycling fine aggregates.

Recycled coarse aggregates have a relatively high water absorption rate. However, the high water absorption rate of aggregates can have a huge negative impact on the stability of building structures, such as reducing the compressive strength of concrete [7]. In the process of concrete production, directly mixing recycled coarse aggregates into the concrete will significantly reduce the fluidity of the concrete [8]. The properties of recycled aggregates mainly depend on their sources.

Although recycled aggregates have some shortcomings compared to natural aggregates in many aspects, there is still ample room for utilization.

It has been found that the stiffness of recycled concrete aggregates increases with the increase of load cycles under low moisture content conditions, high-dimensional pressure, and vertical confining pressure, and has good prospects as pavement materials[9]. Gomez Meiride B et al. proposed the feasibility of using recycled aggregates in asphalt mixtures [10]. In the study by Rahardjo H et al., the application of dual capillary barriers with recycled aggregates in landfill cover has been proven to effectively prevent rainwater from infiltrating into the landfill, thereby avoiding pollution of the surrounding environment by waste leachate [11].

This review aims to improve the application of building demolition waste, mainly consist of recycled aggregates, in construction projects, and maximize the utilization of building recycling waste as much as possible. At the same time, this article will focus on the recycling of coarse and fine aggregates, and compare their respective advantages and disadvantages, composition, mechanical properties, applicable scenarios, etc., and make recommendations for the current management of recycled aggregates.

2 Recycled aggregates：mechanical properties and Composition

2.1 The Structure of Recycled Aggregates

The composition of recycled aggregates is closely related to their own sources, and different building materials can affect the ratio between different components of recycled aggregates. For example, firing bricks is the main building material in some countries, while in other countries and regions, building materials are mainly brick, stone, and wood[12].

The following Figure shows the composition of building demolition waste in Europe. The figure shows that mineral and solid waste account for the vast majority of the waste, reaching 76%. Therefore, this part of the waste dominates the composition of recycled aggregates.

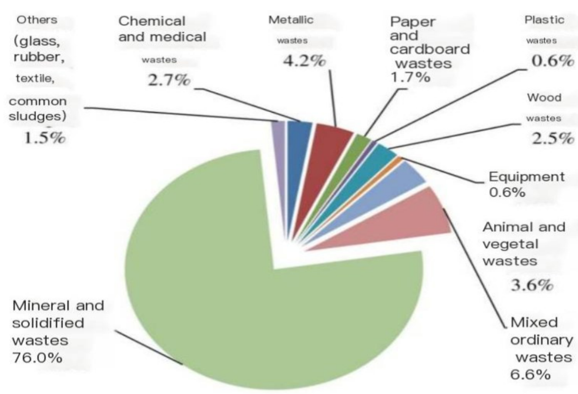

Figure 2 The total amount of waste in the European Union in 2017 [13]

Different recycled coarse aggregates are composed of different materials, so their characteristics are also different. As the water absorption rate increases, the density decreases, which means that the applicability of recycled coarse aggregates for concrete is poorer.

The particle density is a significant difference between fine recycled aggregate and coarse recycled aggregate. The particle density of coarse recycled aggregate is between 2000 and 2500 kg/m3, and the particle density of fine recycled aggregate is between 1800 and 2700 kg/m3 [14-15].

2.2 Properties of recycled aggregates

Coarse aggregate usually refers to aggregates with a particle size greater than 4.75mm [16], and some different types of coarse aggregates are shown in the following figures.

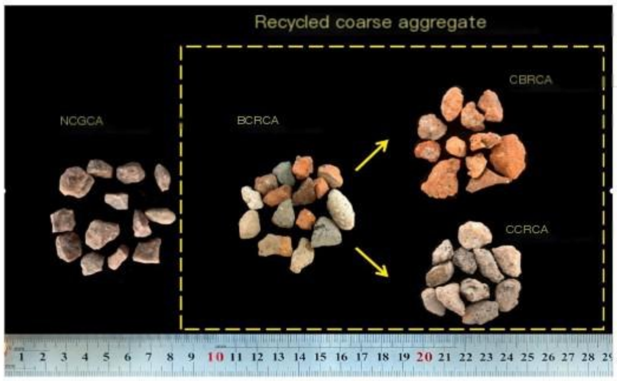

Figure 3 [17]

Figure 4 [4]

Since recycled coarse aggregate has higher porosity, it always has higher water absorption rate than that natural aggregate. The rate of natural aggregates is between 0.5% and 1%, which can often be omitted. The water absorption rate of a material determines its lifespan and durability, and the durability of a material depends on its permeability. High permeability represents its unstable chemical stability [18]. Compared with recycling coarse aggregates, considering cementitious aggregates, the cement mortar content o es is higher than that of coarse aggregates, which leads to a much higher water absorption rate and high heterogeneity of recycled fine aggregates. In addition, pollution may also occur during the recycling process. The obstacle to using fine recycled aggregates in concrete is that the mortar and impurity content of fine recycled aggregates are higher than that of coarse recycled aggregates. In many cases, these problems are often the root cause of workability issues and reduced concrete strength [19].

3 Application of recycled aggregates in construction

In the past few decades, many scholars have conducted numerous experiments to improve the quality of aggregates. For example, grinding [20], ball milling, carbonization [21], freeze-thaw method [22], ultrasonic cleaning, conventional heating, microwave technology, coating and impregnation, etc. Research has found that ball milling and grinding have a higher removal rate for weakly adhered mortar, which can effectively improve the density of recycled aggregates [23]. Some people think that since producing high-quality recycled coarse aggregates is much easier than producing recycled fine aggregates, mechanical grinding methods should be promoted. However, the small cracks that occur in the recycled aggregates caused by this method cannot be ignored [24]. To improve the quality of recycled aggregates, lots of studies have been done.Reserchers find that adding fibers can significantly improves the strength of concrete [25]. Fiberglass has great potential due to its excellent tensile strength and low cost. With the improvement of technology and process, the corrosion resistance of glass fiber is further enhanced[26] [27]. Researchers found that recycled aggregates have higher density and are suitable for coarse and sub base layers of low capacity roads. Recycled aggregates containing cementitious materials can enhance the performance of the layer.

4 Conclusion

This article reviews the types, characteristics, structures, and application scope of recycled aggregates, and provides a comprehensive overview of the current situation of recycled aggregates. Introduced and discussed the differences between recycling coarse aggregates, recycling fine aggregates, and the two. People's concerns about the environment are increasing day by day, but when faced with recycled aggregates, they often choose more familiar natural aggregates. This means that we need to promote legislation, increase investment in scientific research, and gradually transform people's traditional concept of recycling aggregates. The deeper the research on recycled aggregates, the more confident we will be in flexibly applying this material to our production and daily life.

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