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Research situation of recycled coarse aggregate concrete at china and abroad

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ABSTRACT
This paper mainly expounds the recycled aggregate concrete and its related concepts, the background and research significance of recycled coarse aggregate concrete, and focuses on the research status and development trend of recycled concrete technology at china and abroad.

Keywords: *Recycled coarse aggregate concrete; At home and abroad. The comparative study.*
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INTRODUCTION

With the acceleration of the world's urbanization process, a large number of old buildings (structures) are demolished, transformed or abandoned every year, resulting in the annual construction waste accounted for about 40% of the industrial solid waste, of which the waste concrete is the largest proportion of construction waste emissions[1] .

According to the relevant statistics, Japan, the United States each year to waste 30 million tons of concrete; The European Union's waste concrete has grown from 55 million tons in the 1980s to about 160 million tons today. In Germany, the demolition of old buildings generates about 13 million tons of waste concrete every year[2] ; China produces about 50 million tons of construction waste every year, of which about 40% is waste concrete, so China will add 20 million tons of waste concrete every year[3] .

How to dispose of these abandoned concrete has become a difficult problem concerned by all countries in the world. If such a large amount of abandoned concrete is simply piled up near the roads, rivers, farmland and gullies in the suburbs of the city, or the traditional digging and burying treatment, it will not only occupy a large amount of increasingly valuable land resources, but also bring unpredictable secondary pollution to the land and groundwater. It is obvious that the simple disposal method of traditional discarding or digging and burying cannot meet the requirements of environmental protection and social sustainable development.

At the same time, with the emergence of a large number of new buildings (structures) every year, sand and stone aggregate, which accounts for more than 70% of concrete, also brings great ecological environmental pressure to the natural environment[4] . Long-term sand and stone mining has caused a series of serious ecological environment destruction, such as vegetation destruction, mountain landslide, riverbed diversion of aggregate site, and has produced serious negative social effects. On the other hand, natural sand and stone are non-renewable resources, and their formation often takes a long geological time. If the exploitation of natural sand and stone is not controlled now, with the rapid development of social economy, the increase of new buildings (structures), the amount of concrete is increasing, the future will inevitably cause a shortage of natural sand and stone[5] . The lack of sand and stone will eventually cause a bottleneck of social and economic development and seriously affect the sustainable and healthy development of social and economic.

The recycling of waste concrete has become an urgent problem in today's society. Due to the composition of waste concrete is mainly of sand and gravel aggregate, if this part can be sand aggregate recycling use, such not only can save a lot of natural sand and gravel aggregate, protect the ecological environment of natural sand the original site, but also can solve the waste concrete due to pile up, buried land resource waste and environmental pollution problem. Therefore, recycling of waste concrete is regarded as one of the important ways to develop green concrete, which has good social, economic and environmental benefits, and is of great practical significance to build a conservation-oriented sustainable development society. The research on the performance of recycled concrete has also become an important research direction in the field of concrete research. Based on the research on the performance of recycled concrete in China at the present stage, there are still many problems that need to be further discussed, the research of this topic is proposed.

SIGNIFICANCE OF RESEARCH ON RECLAIMED COARSE AGGREGATE CONCRETE

In the past two decades, most countries in the world have adjusted the way of economic growth to match the sustainable development of society. One of the most important work is to promote the development of green buildings and reduce the high consumption of energy and resources by building products. The emergence and development of recycled concrete technology well reflects this concept. The application of recycled concrete has important theoretical significance and practical value for the construction of a conservation-oriented sustainable development society[6] , which is embodied in the following three aspects.

The application of recycled concrete is conducive to ecological environment protection

As mentioned above, the amount of abandoned concrete increases rapidly with the development of social economy, and the traditional disposal of abandoned concrete poses a great threat to the ecological environment around the city. At the same time, new buildings (structures) and need a large number of mining natural sand and stone used as coarse aggregate, so on the original site of natural sand and stone has brought huge ecological damage. If waste concrete can be used to replace part or all of the natural aggregate (mainly coarse aggregate) through crushing, cleaning and other processing procedures, it will greatly protect the ecological environment both around the city and the original site of natural sand and stone.

The application of recycled concrete is conducive to the construction of a resource-saving society

The accumulation and burial of waste concrete and the mining of natural sand and stone will greatly consume land, minerals and water resources. And these resources are non-renewable resources, once used up, will have a huge negative impact on the society. According to relevant data statistics, due to construction land, mineral resources excavation, waste stacking and burial, resulting in China's arable land area in the past 20 years net reduction of more than 15 million mu; Every year, more than 7 billion tons of non-renewable resources such as sand, clay, lime and steel will be consumed because of new buildings (structures)[7] . China is also short of water resources, more than 600 cities are facing the embarrassment of water shortage, and the trend of water shortage is still expanding. These are always reminding us that we must do everything possible to save energy of these non-renewable resources. The recycling of waste concrete can greatly save land, mineral resources and even water resources, which is also in line with the requirements of the energy-saving social construction vigorously carried out in China at the present stage.

The application of recycled concrete is conducive to energy saving

Building energy consumption accounts for more than 1/4 of the total social energy consumption. Every year, China needs at least 200 million tons of standard coal for the production energy consumption of building materials, which shows the importance of energy saving in the construction field[8]. Xu Kuangdi, an academician of the Chinese Academy of Engineering, once called on: "Human survival and development are inseparable from the precious resources endowed by nature. It is an urgent task to vigorously promote the recovery and reuse of resources, as well as an important content and inevitable choice to achieve sustainable development." The popularization of recycled concrete technology is beneficial to the society's energy saving and emission reduction, which is an important measure to reduce building energy consumption.

At present, most of the existing theoretical achievements in China focus on theoretical research, which is not operable. Or simply study one or several aspects of recycled concrete. This topic will focus on the actual situation in China, starting from the basic performance of recycled concrete research, on the basis of analyzing the factors affecting the performance of recycled concrete, improve the test program, and finally find out the realization path of high-performance recycled concrete. This will play a positive supplementary role in improving the theoretical research of high-performance recycled concrete in China, and has a certain theoretical significance and research value.

PRODUCTION PROCESS OF ORDINARY RECYCLED AGGREGATE

Production process of recycled aggregate in Japan

The most common production process of recycled coarse aggregate in Japan can be roughly divided into three steps: the first step is the crushing process. The discarded concrete blocks with a diameter of 40mm are broken through the jaw crusher, and the crushed waste concrete is sent to the eccentric rotating equipment through the conveyor belt. The second step is the grinding process, the jaw crusher crushing completed chunk of concrete through the eccentric rotary grinding equipment for further grinding, the diameter of the concrete test block grinding to 25mm below, transported to the vibrating screen through the conveyor belt. The third step is the vibrating screening process, through the 5mm aperture of the vibrating screen will be transmitted to the concrete fragments screen is divided into 5 ~ 25mm and 5mm two groups, 5 ~ 25mm is the regeneration of coarse aggregate. Through this production process, The recycled coarse aggregate can meet the requirements of Japanese Industry Standard (JIS) and Japanese Architectural Standard Specification (JASS).

Russian recycled aggregate production process

The production process of the most common recycled aggregate in Russia is improved compared with that in Japan,

which is mainly reflected in the first, the magnet separator and separation platform are added to separate the metal, wood, plastic and other sundry objects that may exist in the waste concrete; Second, the single screen screen machine into a double screen screen machine, so that the particle size of recycled aggregate can be further distinguished into 5 ~ 10mm small particle size, 10 ~ 20mm medium particle size and 20 ~ 40mm large particle size, so that the grading of recycled aggregate is more in line with the needs of the project. As a result of these changes, the production process is much more complex than that of Japan, often resulting in a large investment in equipment.

4. PRODUCTION PROCESS OF HIGH-PERFORMANCE RECYCLED AGGREGATE

The recycled aggregate obtained by the above two production processes can meet the performance requirements of general recycled concrete. However, in order to obtain high performance recycled concrete, the waste cement mortar on the surface of recycled coarse aggregate needs to be stripped and removed, and the corresponding production process needs to be further improved. At present, there are two main modification methods of reclaimed aggregate. One is to remove the old cement mortar attached to the surface of reclaimed aggregate by mechanical means, which is generally called mechanical strengthening method. The other method is to strengthen the recycled aggregate by soaking it with chemical reagents, which is called chemical strengthening method.

At present, there are two common ways of mechanical strengthening method: one is through the regeneration of aggregate under the action of mechanical equipment, high-speed friction, mutual impact to remove the waste cement mortar adhesion on the aggregate surface, because of mutual impact can also remove the large edges and corners on the regeneration of aggregate; Second, the relatively rotating metal conical lining board with rough surface can be used to repeatedly roll, rub, rub and vibrate the reclaimed coarse aggregate, so as to peel the waste cement mortar from the reclaimed coarse aggregate surface.

Chemical strengthening method is to use chemical polymer, cement admixture and other chemical reagents to soak the reclaimed aggregate, so that the waste cement mortar is stripped from the reclaimed aggregate surface layer, so as to achieve the purpose of strengthening the reclaimed aggregate strength. This aspect is not suitable for processing and regenerating coarse aggregate in large quantities, and the effect of pure chemical strengthening method is not very obvious, so this method is not widely used.

Shima recycled aggregate production process

Shima et al. proposed a set of modified reclaimed aggregate production process based on mechanical and chemical strengthening methods, which can not only get high-quality reclaimed coarse aggregate, but also get reclaimed fine aggregate with particle size less than 5mm.

The biggest difference between this production process and the Japanese and Russian processes mentioned above is the addition of a hot air filling heating device and a mechanical roller of about 300 degrees Celsius. Through high temperature (about 300°), the surface waste cement mortar of reclaimed aggregate becomes fragile, and then through the mechanical rolling of the next process, the purpose of completely removing waste cement mortar is achieved, so that the strength of reclaimed aggregate is improved, so as to obtain modified high-quality reclaimed aggregate. Through a lot of engineering practice, the mechanical properties and durability of the recycled aggregate produced by this production process are similar to that of the natural sand aggregate, and the purpose of high performance is achieved.

The performance change of reclaimed aggregate is not obvious between 200 and 400° at high temperature. Therefore, if the heating temperature is not easy to reach 300°, the heating temperature of 200° is also cost-effective.

Production process of recycled aggregate processed by wet treatment

A building materials enterprise in The Netherlands has put forward a set of production technology for processing recycled aggregate with wet treatment method. The biggest unique feature of this treatment method is that it adds the production process of washing recycled aggregate with water before screening the recycled aggregate after grinding. This process can not only reduce the production of dust screening time, but also wash the dirt, debris and other impurities attached to the surface layer of reclaimed aggregate, so as to improve the quality of reclaimed aggregate, so as to achieve the purpose of high performance.

Shima reclaimed aggregate production process and wet processing reclaimed aggregate production process although can effectively remove the old cement mortar attached to the reclaimed aggregate concrete surface layer, grinding reclaimed aggregate larger edges and corners, reduce the existence of various small impurities in the reclaimed aggregate. However, the production process of these two sets of production technology is relatively complex, and the input of equipment is also large, which may not be suitable for the actual needs of China's current economic society.

RESEARCH ON PROPERTIES OF RECYCLED AGGREGATE

Many studies at home and abroad have found that the water absorption rate of reclaimed aggregate is much larger than that of natural aggregate. The water absorption rate of reclaimed coarse aggregate is 2-3 times that of the same grade, and the water absorption rate of reclaimed fine aggregate is even larger. Experimental research conducted by Roumiana Zaharieva, Salomon M.Levy, Hou Jingpeng [9] found that the reasons for this phenomenon are as follows: In the process of crushing, rolling, washing, screening and other processing processes, the internal structure of waste concrete will be damaged to varying degrees, resulting in a large number of fine cracks and greatly increased porosity. At the same time, the water absorption rate of reclaimed aggregate is significantly higher than that of natural aggregate because the surface of reclaimed aggregate will adhere to the old cement mortar, and the surface shape is irregular and there are many prominent edges and corners.

Li Jiabin, Zhang Xuebing and other scholars found through research that the water absorption rate of recycled aggregate could be more than 95% in the first half hour, and the water absorption rate was the fastest in the first ten minutes, then gradually slowed down until saturation.

Scholar A.K.Padmini found in his study that the water absorption rate of reclaimed aggregate is roughly inversely proportional to the strength of raw concrete, and also found that the water absorption rate of reclaimed aggregate decreases with the increase of aggregate particle size in raw concrete. Analysis of the reasons, there may be the following two main factors: first, the high strength of the original concrete will make the aggregate and mortar tightly bound, when using the original concrete to make recycled coarse aggregate, the aggregate and mortar are not easy to crack; Second, the aggregate particle size of the original concrete is large, so the surface of the recycled coarse aggregate is relatively small, and the recycled aggregate is not easy to adhere to the old cement mortar, so as to reduce the water absorption rate of the recycled aggregate.

Although the primary concrete goes through washing and separation stages during the production of recycled aggregate, the recycled aggregate will inevitably adhere to a certain amount of old cement mortar due to the binding effect of cement mortar and aggregate. This will inevitably affect the water absorption, porosity, apparent density and even gradation of recycled aggregate. The particle size grading of recycled concrete is also related to the strength, use environment, processing technology and many other factors of raw concrete.

Research on basic physical properties of recycled concrete

Because recycled concrete is mixed with a certain proportion of recycled aggregate (mainly coarse aggregate), the porosity of coarse aggregate is larger and the apparent density of coarse aggregate is smaller, so the porosity of recycled concrete is obviously larger than that of matrix concrete, while the density is about 10% smaller. The capillary gap of recycled concrete increases obviously due to the incorporation of recycled aggregate. Scholar ZHANG Jin Xi believes that although these increased pores have no obvious impact on the strength of concrete, they will greatly reduce the durability of concrete.

Research on basic mechanical properties of recycled concrete

Due to the high porosity and water absorption of recycled aggregate, the density of recycled concrete is lower than that of matrix concrete and the porosity is more than that of recycled concrete. As a result, the basic compressive strength, tensile strength and durability of recycled concrete are worse than that of matrix concrete, and its shrinkage and creep are obviously larger than that of matrix concrete.

Nixon, a foreign scholar, found that the compressive strength of recycled concrete is about 20% lower than that of matrix concrete by sorting out relevant foreign research results of recycled concrete. BCSJ, a Japanese scholar, found through experimental data that the compressive strength of recycled concrete is 14% ~ 32% lower than that of matrix concrete, and this decreasing trend increases with the increase of recycled aggregate. Professor Xing Zhenxian from North China Institute of Water Resources and Hydropower, Professor Xiao Jianzhuang from Tongji University and other scholars have also found through experiments that the compressive strength of recycled concrete is about 10% lower than that of matrix concrete under the same conditions.

Foreign scholars Ravindrarajah, Malhotr et al found through experiments that the flexural strength of recycled concrete is significantly lower than that of matrix concrete. Chinese scholars Li Wenxia and others found through systematic research that the flexural strength of recycled aggregate concrete is about 10% lower than that of matrix concrete under the same conditions, and Xiao Jianzhuang found through systematic experimental research that the flexural strength of recycled concrete is not significantly related to the replacement rate of recycled aggregate. Xiao Jianzhuang, Liu Shuhua and other scholars have found through experimental studies that the axial tensile and splitting strength of regenerative concrete is about 20% lower than that of matrix concrete.

Many scholars have found through experimental studies that the elastic modulus of regenerative coagulation is significantly lower than that of matrix concrete. Foreign scholars Frondistou-Yannas and Kakizaki believe that the elastic modulus of recycled concrete is about 30% lower than that of matrix concrete. In China, wang Shaliang, Peng Yulin and other scholars found through experiments that the elastic modulus of recycled concrete will be reduced by about 20%. Analysis of the reason for the reduction of elastic modulus of recycled concrete may be due to the influence of recycled coarse aggregate, because the elastic modulus of recycled coarse aggregate is obviously smaller than that of natural aggregate.

CONCLUSION

Although the research on recycled concrete technology has been carried out in China for more than 20 years, most of the research focuses on the performance of aggregate and the basic mechanical properties of ordinary recycled concrete, and the research on high-performance recycled concrete is very little. Although China has made some achievements in this field, many research conclusions have not reached a unified understanding due to different research methods. Foreign countries have made great achievements in the production technology of recycled coarse aggregate and the research on the characteristics of recycled coarse aggregate. The experience of recycled coarse aggregate production is worth learning from in China.

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