

# Review of Research Progress on Rubber Concrete

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**Abstract:** As an environmentally friendly material, rubber concrete has attracted widespread attention from researchers around the world due to its lightweight, superior ductility, strong impact resistance, thermal insulation and sound insulation, especially in the utilization of waste tires. Produces significant economic and environmental value. In recent years, research on the mechanical properties of this material has been in-depth, revealing that although the replacement of traditional aggregates by rubber may lead to a decrease in the strength of concrete, scientific means, such as aggregate surface modification to enhance the bonding strength with the cement matrix, or adjust The ratio of water to cement in the mixture can effectively make up for this deficiency. In addition, the low water absorption and lightweight structure of rubber concrete itself complies with the application standards of lightweight aggregates, further confirming that converting waste rubber into building materials is not only feasible in theory, but also an effective strategy in practice.

**Keywords:** rubber concrete; impact resistance; water absorption; ductility.

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## 1. Overview of Rubber Concrete

Facing the sharp increase in tire consumption caused by the rapid expansion of the automobile industry, the effective processing and resource utilization of waste rubber tires has become a major environmental issue that needs to be solved urgently around the world. Improper disposal of waste tires will pose a major threat to the natural environment. Therefore, exploring ways to reduce pollution and waste has become the focus of the industry and society. Existing treatment strategies include renovation, creative reuse, pyrolytic transformation, and physical crushing. Although retreading tires can restore part of their use value, their durability and safety issues cause concerns; although creative reuse can turn waste into treasure, it can only digest a small amount of used tires; pyrolysis technology efficiently produces fuel oil and carbon black, but it is accompanied by high energy consumption, safety risks and potential pollution; the rubber powder generated after physical crushing is widely used in industrial raw materials, shoe manufacturing and construction materials, especially through deepening processing to strengthen plastics and pave runways, etc., which is significant. Promotes resource recycling and value regeneration. In this context, in view of the safety hazards of tire retreading, rubber powder prepared by recycling technology stands out. It not only maximizes the value of tire resources in a closed-loop system, but also ensures environmental friendliness through physical methods without chemical additions, demonstrating its application in civil engineering. The vast economic and ecological value of its application in the field of road construction has strongly promoted the tire industry to move towards circular economy and sustainable development.

In the 1980s, American scholar Ahmad pioneered the development of rubber concrete. By integrating waste tire rubber as aggregate into the concrete manufacturing process, it marked the birth of an innovative and environmentally friendly composite material. Compared with standard concrete, rubber concrete has shown significant advantages in reducing the weight of the structure, improving crack resistance and impact resistance, and enhancing energy absorption and ductility. It has opened up a new low-carbon and environmentally friendly way for the resource utilization

of waste tires. path. With the prosperity of the construction industry, research results on rubber concrete have become increasingly fruitful around the world, highlighting its important position and potential in the innovation of modern building materials.

The process of integrating waste rubber into concrete is mainly divided into two categories: substitution method and external mixing method. Among them, the substitution method, as a mature and widely recognized technology by the academic community, has become a mainstream research direction by replacing sand and gravel in equal amounts or simultaneously replacing sand and gravel in a specific ratio. In contrast, the external admixture method adds rubber particles directly to the concrete mixture. The properties of rubber particles, including their dosage, size, shape, roughness and surface treatment, are key factors affecting the performance of rubber concrete, and the dosage and particle size of rubber are basic and core research considerations. Due to the large differences in experimental designs, current research has not yet constructed a complete theoretical framework for rubber concrete, resulting in limited application cases in actual projects. This article comprehensively analyzes the latest developments in rubber concrete research at home and abroad, aiming to provide comprehensive reference information and guidance for in-depth exploration in this field.

## 2. Mechanical Properties

### 2.1. Basic mechanical properties

The matrix mechanical properties of concrete are the core criteria for evaluating the quality of its material, which reflects the resistance characteristics of concrete when it is subjected to external loads. In recent years, many researchers have extensively explored the basic mechanical properties of rubber concrete, conducting in-depth analysis through a variety of perspectives and methods, aiming to comprehensively understand its behavior under stress conditions. As early as 1996, Toutanji et al[1] found that adding different volume amounts of rubber particles to concrete would lead to a decrease in its compressive and flexural strength, and the decrease in compressive strength

was approximately twice that of the flexural strength. Rubber concrete exhibits ductile failure characteristics in flexural resistance, with significant displacement before fracture, showing higher toughness than ordinary concrete. By 2004, Xiong Jie et al[2] replaced the coarse aggregate in concrete with four particle sizes and three dosages, and conducted compression tests in accordance with ASTM and ordinary concrete mechanical properties test method standards, and found that rubber concrete has better resistance to The compressive strength decreases as the rubber content increases, but the strength does not decrease as the rubber particle size increases. In 2020, Zhang Jun et al[3] studied the size effect and rubber replacement rate of rubber concrete specimens. The results showed that the larger the rubber concrete specimen volume, the better the integrity after damage; in the rubber replacement rate When the sample size remains unchanged, the smaller the specimen size, the higher the compressive strength, and as the rubber substitution rate increases, the influence of specimen size on the compressive strength of rubber concrete decreases. In the same year, Hu Yanli et al[4] conducted a pure shear test study on rubber concrete with a rubber replacement rate. The test found that as the rubber replacement rate continued to increase, the failure section of the rubber concrete became more irregular, and at the same time, the rubber particles fell off. The quantity increases, and the shear strength shows a gradually decreasing trend. In 2022, Fu Qian et al[5] used an orthogonal design method to conduct experiments by regulating factors such as water-binder ratio, rubber replacement rate, particle size, and fly ash replacement rate, and used the range method to analyze the sensitivity of mechanical properties. , it was finally determined that the rubber substitution rate is one of the most sensitive factors affecting the mechanical properties of concrete. During the same period, Han Chenyue et al[6] conducted uniaxial compression tests and energy characteristics research on rubber concrete with different strain rates. The research results showed that during the compression process of rubber concrete, energy was first converted into and stored in large amounts as elastic energy, and then the dissipated energy conversion rate gradually increased, causing a large number of micro-cracks on the surface of the specimen, which ultimately led to the rapid release of elastic energy and a significant increase in the dissipated energy conversion rate, thereby inducing overall damage to the specimen.

## 2.2. Dynamic mechanical properties

In terms of research on dynamic mechanical properties, when rubber concrete faces strong effects exerted in a short period of time such as earthquakes and impact loads, its impact resistance and damping properties have become the core indicators for evaluating its performance. For example, in 1997, Topçu[7] mixed rubber particles of two different sizes into concrete and conducted collision and impact tests, confirming that rubber concrete is more suitable for scenes that have no load-bearing function but require impact resistance. In 2012, Atahan et al[8] found through dynamic drop weight testing that the incorporation of rubber significantly improved the impact resistance and energy consumption capacity of rubber concrete. When rubber replaced 20% to 40% of fine aggregate, the rubber concrete's The impact resistance is improved, but if the rubber replacement rate exceeds 60%, the impact resistance will be reduced. In 2022, Eltayeb et al[9] found that as the amount of

rubber increases, the impact resistance and damping ratio of rubber concrete also increase simultaneously. When the rubber content is 17% and 47.8%, the damping ratio of rubber concrete is respectively higher than that of ordinary rubber concrete. Concrete improved by 21.1% and 17.3%.

## 2.3. Modification treatment

Incorporating rubber powder into concrete will reduce the strength of the concrete. In order to enhance the mechanical strength of rubber concrete, domestic and foreign scholars have adopted a series of modification measures to rubber powder. In 2012, Ossola et al[10] found that ultraviolet pretreatment of rubber particles can improve the interface bonding with cement aggregates; the flexural strength of concrete mixed with 15% modified rubber only dropped by 6%, while that of unmodified rubber dropped by 21 %. In 2019, Abd-Elaal et al[11] studied the effect of 200°C heat-treated rubber on the properties of concrete. Through SEM observation, it was found that the properties of rubber concrete after heat treatment were improved. When the rubber content is 20% and the particle size is 40 mesh, the heat-treated rubber restores 60.3% of the compressive strength. . In 2020, Copetti et al[12] studied the effect of NaOH pretreatment rubber particles and silica fume on the microstructure of concrete. Research results show that rubber causes a reduction in porosity, while the effect of pretreatment is not obvious.

## 2.4. Under the influence of environment

The performance of rubberized concrete can be challenging in special circumstances. In view of this, in 2012, Xu Jinhua et al[13] studied the durability of rubber concrete under freeze-thaw cycles. Tests have shown that adding an appropriate amount of rubber can improve its frost resistance, especially the rubber powder dosage of 5% to 10% and the particle size  $\leq 0.27\text{mm}$  has the best effect, but excessive amounts will reduce the frost resistance. In 2019, Záleská et al[14] studied the dry volume heat capacity, humidity transfer and thermal conductivity of rubber concrete in high temperature environments, revealing that increasing the rubber content will improve the water vapor transmission performance of concrete and reduce the thermal conductivity, but in Performance changes significantly at 400°C. Mousavimehr et al[15] analyzed the stress-strain characteristics of concrete containing rubber powder at high temperatures and established a set of prediction models. This model is consistent with the test results and proves that temperature increase has a significant impact on the physical and mechanical properties of concrete. Saberian et al[16] studied the mechanical properties of recycled concrete mixed with rubber powder at high temperature and found that the specimen with 1% rubber powder had the best performance at high temperature. The melting of rubber powder helps to enhance the strength and reduce the porosity, while the pores The rate shows a trend of first increasing and then decreasing with temperature changes. In 2022, Long Yifei et al[17] studied the dynamic mechanical properties of rubber concrete under different freeze-thaw cycles and impact air pressure through ultrasonic testing and SHPB tests. They found that freeze-thaw cycles would lead to increased damage, reduced longitudinal wave speed, and with subsequent As the strain rate increases, the peak stress, ultimate strain, dynamic strength enhancement factor (DIF) and absorbed energy of concrete increase, showing a strain rate effect.

### 3. Conclusion

The fusion of rubber particles improves the mechanical properties of concrete. By optimizing stress distribution and enhancing the ability to resist impact and vibration, it exhibits the characteristics of high damping and low elastic modulus. It also has excellent thermal insulation, water resistance, permeability resistance and chlorine resistance. The ion erosion performance brings an environmentally friendly and sustainable new concrete to the field of building materials. Although rubber concrete has excellent performance in terms of toughness, deformation recovery and resistance to environmental damage, the loss of its basic mechanical strength has become a major obstacle to engineering applications. At present, although research has made significant progress, the comprehensive development of rubber concrete still needs to overcome many difficulties, including but not limited to structural response under dynamic and cyclic loading, cost-effective rubber modification technology, and in-depth exploration of the relationship between various mechanical strengths. The mechanism of interaction, these are indispensable scientific research directions to promote the widespread application of this material.

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