

# *Research Summary and Application Prospect of Permeable Concrete*

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**Abstract:** Permeable concrete, as an environment-friendly building material, has great application potential in urban construction and ecological environment protection. This paper aims at comprehensively discussing the performance of permeable concrete, its policy environment and market prospect. In order to achieve this goal, the article adopts a variety of research methods. In the process of research, the basic properties of permeable concrete are systematically evaluated, including its permeability, mechanical properties, durability and other key indicators. At the same time, the article also discusses the current national and local policies, industry standards, market demand and development trend related to permeable concrete. The research results show that permeable concrete has good application effect in many fields, which is of great significance to solve urban waterlogging and improve the quality of ecological environment. At the same time, with the continuous promotion of policies and the continuous growth of market demand, the application prospect of permeable concrete is very broad.

## **1. Introduction**

With the acceleration of global urbanization, the problem of urban drainage has become increasingly prominent [1]. Traditional hardened floors, such as asphalt roads and cement roads, hinder the natural infiltration of rainwater, resulting in a large number of rainwater can not be effectively discharged in a short time, thus causing serious problems such as urban waterlogging and road water accumulation [2]. This not only affects urban traffic and residents' life, but also poses a challenge to urban infrastructure [3]. At the same time, the importance of ecological environment protection has been paid more and more attention. The traditional urban construction method often ignores the ecological balance, which leads to the waste of water resources, the deterioration of water environment and the destruction of ecological system [4]. Therefore, how to protect the ecological environment in the process of urbanization has become an urgent problem.

In this context, pervious concrete as a new type of environmental protection building materials came into being [5]. It has good water permeability, and can simulate the hydrological cycle of natural soil, so that rainwater can quickly seep through its surface, thus effectively relieving the urban drainage pressure and improving the urban water environment [6]. The study of permeable concrete has an important influence on urban water cycle. By promoting the natural infiltration of rainwater, permeable concrete can replenish groundwater and maintain the balance of urban water

resources [7]. In addition, it can effectively reduce rainwater runoff and reduce the load of urban drainage system, thus avoiding or reducing the occurrence of urban waterlogging and other disasters.

## **2. Basic concepts and characteristics of permeable concrete**

### **2.1. The definition of permeable concrete**

Permeable concrete is a special concrete material, which is mainly composed of aggregate, cement, water and additives in a certain proportion [8]. Among them, the choice of aggregate is particularly critical, and coarse aggregate with single gradation or discontinuous gradation is usually used to ensure the porosity in concrete. Cement, as a cementing material, is responsible for closely bonding aggregates together. Water and additives are used to adjust the consistency and hardening properties of concrete.

The structural feature of permeable concrete is that there are a large number of communicating pores in it. These pores are formed by special molding methods in the construction process, which makes the concrete have good water permeability while maintaining a certain strength [9]. When rainwater touches the surface of permeable concrete, it can quickly penetrate into the ground through these pores, thus simulating the hydrological cycle of natural soil.

### **2.2. Main characteristics of permeable concrete**

**Permeability:** One of the remarkable characteristics of permeable concrete is its excellent permeability. Through the design and control of internal pores, permeable concrete can realize the rapid infiltration of rainwater, effectively reduce surface runoff and reduce the pressure of urban drainage system. At the same time, it can promote the recharge of groundwater and maintain the balance of urban water resources.

**Strength and durability:** Although there are a lot of pores in permeable concrete, it can still maintain good strength and durability through reasonable proportioning and molding technology. This enables permeable concrete to bear certain traffic load and environmental erosion, and ensures its stable performance in the long-term use process.

**Eco-environmental protection:** As an environmentally friendly building material, permeable concrete has obvious eco-environmental protection. It can not only reduce the damage to the ecological environment caused by urban hardening, but also provide a habitat for living things and promote the protection of biodiversity. In addition, the carbon emission of permeable concrete in the process of production and use is low, which is in line with the development concept of green and low carbon.

### **2.3. Comparison with traditional concrete**

Compared with traditional concrete, permeable concrete has obvious differences in performance [10]. First of all, in terms of water permeability, traditional concrete has almost no water permeability, while permeable concrete can realize rapid infiltration of rainwater. Secondly, in terms of strength and durability, although the strength of permeable concrete is slightly lower than that of traditional concrete, it can still meet the requirements of most projects through reasonable design and construction. Finally, in the aspect of eco-environmental, traditional concrete has great damage to the environment, while permeable concrete has obvious environmental advantages.

Due to the differences in performance, permeable concrete and traditional concrete are also different in application scenarios. Traditional concrete is mainly used in projects that need to bear

heavy loads and require strict durability, such as bridges and high-rise buildings. Permeable concrete is more suitable for urban roads, sidewalks, squares and other places that need good drainage performance and ecological environment protection, as shown in Figure 1.

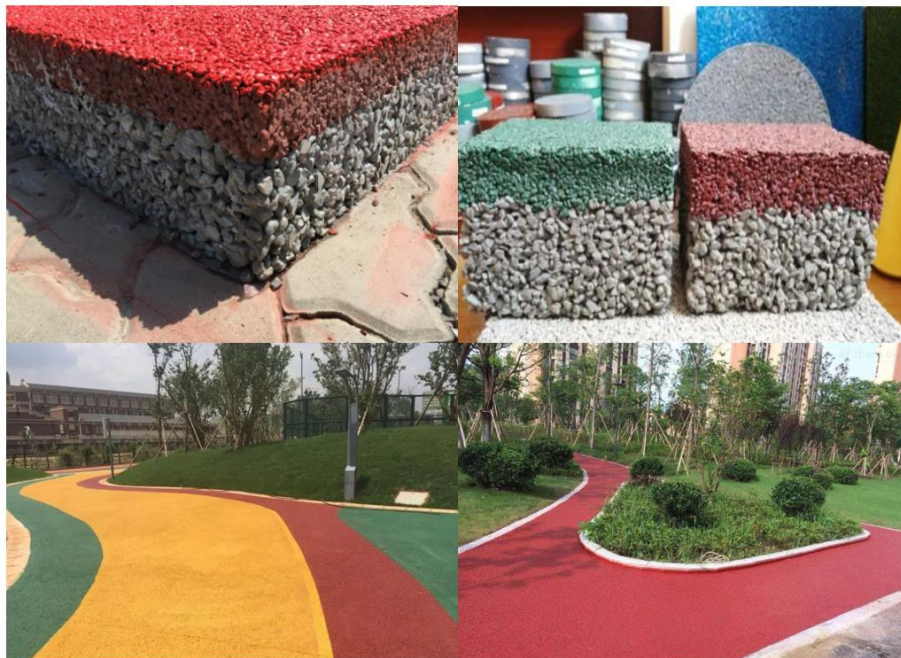


Figure 1: Application of permeable concrete

With the improvement of people's awareness of ecological environment protection and the increasingly serious urban drainage problem, the application prospect of permeable concrete will be broader.

### 3. Research progress of permeable concrete

#### 3.1. Research Status

Internationally, the research on permeable concrete began in 1970s, mainly concentrated in developed areas such as Europe, North America and Japan. Researchers in these countries and regions have accumulated rich experience and technical achievements through a large number of experiments and engineering practices. For example, in terms of raw material selection and mix design, they have developed a variety of permeable concrete materials suitable for different environments and engineering requirements; In terms of preparation technology and equipment, the automatic and intelligent production process is realized, and the production efficiency and quality are improved; In the aspect of performance enhancement technology, the mechanical properties and durability of permeable concrete are significantly improved by adding chemical additives and fiber reinforced materials. The research on permeable concrete in China started late, but it has developed rapidly in recent years. Domestic researchers have made a series of innovations by introducing foreign advanced technology and carrying out localization transformation. For example, in terms of raw materials, industrial waste and construction waste are used to replace some aggregates, which reduces production costs and improves resource utilization; In the aspect of preparation technology, an efficient and environmentally friendly production line suitable for national conditions has been developed; In the aspect of performance improvement, the comprehensive performance of permeable concrete is improved by optimizing the mixture ratio and adding functional materials.

There are some differences in the development trend at home and abroad. Foreign research pays

more attention to the research of basic theory and the application of high-end technology, such as developing new functional materials and studying the mechanism of performance change in complex environment. However, domestic research pays more attention to practicality and economy, such as developing low-cost and high-efficiency production technology and popularizing and applying demonstration projects. These differences reflect the economic and social development level and demand characteristics of different countries and regions.

### 3.2. Research on key technologies

The selection and optimization of raw materials is the key link in the preparation of permeable concrete. Researchers are committed to finding raw materials with stable performance, wide sources and low cost, such as coarse and fine aggregates, cement and additives. At the same time, by optimizing the mixture ratio of raw materials, the performance of permeable concrete can be adjusted and improved. For example, permeable concrete with different porosity, strength and water permeability can be prepared by adjusting parameters such as aggregate gradation, cement dosage and additives.

Preparation technology and equipment are important factors affecting the performance of permeable concrete. Researchers continue to explore and improve the preparation process, such as stirring, molding, curing and other links, in order to improve production efficiency, reduce costs and ensure product quality. At the same time, with the progress of science and technology, new, efficient and environmentally-friendly production equipment is constantly emerging, which provides strong support for the large-scale production and application of permeable concrete.

In order to improve the mechanical properties and durability of permeable concrete, researchers have developed a variety of performance enhancement technologies. For example, adding chemical additives can improve the workability and mechanical properties of concrete; Adding fiber reinforced materials can improve the crack resistance and toughness of concrete; Using surface treatment technology can enhance the wear resistance and freeze-thaw resistance of concrete. The application of these technologies significantly improves the comprehensive performance of permeable concrete and expands its application scope.

### 3.3. Research challenges and future directions

Table 1: Future research direction, content and goal of permeable concrete

Research direction	Research contents	Target
Fundamental research	Reveal the internal relationship between microstructure and macro-performance of permeable concrete.	It provides more accurate theoretical guidance for performance optimization and design.
Development of new high performance materials and technologies	Developing new high-performance permeable concrete materials and technologies	Meet the requirements of more complex and demanding engineering environment.
Environmental friendliness and resource conservation	Pay attention to environmental friendliness and resource conservation	Promote the green and low-carbon development of permeable concrete.
Interdisciplinary application	Strengthen the cross-integration with other disciplines	Expand the application scope of permeable concrete in the fields of ecological environment and water resources management.

Although the research and application of permeable concrete has made remarkable progress, it still faces some challenges. For example, the performance of permeable concrete fluctuates greatly,

which is influenced by many factors such as raw materials, preparation technology and environmental conditions; Long-term performance and durability need to be further improved to meet wider engineering requirements; The high production cost limits its popularization and application in some economically underdeveloped areas. For example, Table 1 summarizes the main directions, research contents and corresponding objectives of the future research of permeable concrete.

## **4. Policy environment and market prospect of permeable concrete application**

### **4.1. Relevant policies and standards**

#### National and local policies

With the country's increasing attention to ecological environment protection, permeable concrete, as an environmentally friendly building material, has received extensive attention and support. A series of relevant policies have been issued at the national level to encourage and popularize the application of permeable concrete. For example, the Ministry of Housing and Urban-Rural Development issued the Technical Guide for the Construction of Sponge Cities, which clearly put forward the requirements for promoting the application of permeable concrete and other low-impact development facilities in urban construction. In addition, local governments have formulated corresponding implementation rules and subsidy policies in light of the actual situation, which further promoted the application and development of permeable concrete in local areas.

#### Industry standards and norms

In order to ensure the quality and application effect of permeable concrete, a series of relevant standards and specifications have been formulated at the national and industrial levels. For example, the Technical Specification for Permeable Cement Concrete Pavement specifies the raw materials, mix proportion, preparation technology and construction requirements of pervious concrete in detail, which provides a unified technical standard for the production and application of pervious concrete. In addition, there are related standards such as Permeable Brick and Technical Specification for the Application of Recycled Aggregate Permeable Concrete, which together constitute the standard system of pervious concrete industry.

### **4.2. Market demand analysis**

With the acceleration of urbanization and people's increasing attention to ecological environment protection, the market demand of permeable concrete shows a rapid growth trend. In the fields of urban roads, garden landscapes, public squares, etc., permeable concrete has been widely favored for its unique permeability and eco-environmental advantages. At the same time, with the promotion of national policies and the improvement of industry standards, the application of permeable concrete in municipal engineering, real estate development and other fields has gradually become popular.

Looking into the future, the market potential of permeable concrete is huge. On the one hand, with the increase of global climate change and extreme weather events, urban drainage and waterlogging problems are becoming increasingly serious. As an effective solution, the market demand for permeable concrete will continue to grow. On the other hand, with the improvement of people's living standards and the enhancement of environmental awareness, the requirements for ecological environment and living quality are also constantly improving, and the application of permeable concrete in ecological gardens, green buildings and other fields will be further expanded.

### 4.3. Suggestions on industrial development strategy

In order to promote the sustainable development of permeable concrete industry, it is necessary to strengthen technological innovation and industrial upgrading. On the one hand, through the research and development of new high-performance permeable concrete materials and technologies, the mechanical properties and durability of products are improved to meet a wider range of engineering needs; On the other hand, promote industrial upgrading and intelligent development, improve production efficiency and quality control level, reduce costs and enhance the overall competitiveness of the industry. At the same time, strengthening industrial chain coordination and market expansion is also an important way to promote the development of permeable concrete industry. By integrating upstream and downstream resources, we will build a complete industrial chain and realize the coordinated development and optimal allocation of raw materials, production and construction. At the same time, actively expand market channels and application fields, strengthen cooperation and exchanges with municipal engineering, real estate development and other fields, and promote the application and promotion of permeable concrete in a wider range of fields.

### 5. Conclusions

In this paper, the preparation technology, performance enhancement technology and long-term performance change law of permeable concrete are deeply discussed, which provides theoretical support for the optimal design and application of permeable concrete. Through the systematic study of permeable concrete, we can get the following comprehensive evaluation: permeable concrete has good permeability, which can effectively reduce surface runoff, replenish groundwater and alleviate urban flood problems. At the same time, its unique pore structure provides a good ecological environment and promotes the balance of urban ecosystem. In terms of mechanical properties, although the strength of permeable concrete is lower than that of ordinary concrete, it can still meet the needs of most engineering applications by optimizing the mixture ratio and adding reinforcement materials. In addition, permeable concrete has good durability and freeze-thaw resistance, and can maintain stable performance in harsh environment. In the future, permeable concrete will play an important role in more fields. In urban road construction, permeable concrete will become an important choice to alleviate urban waterlogging and improve road performance. With the increasing attention to ecological environment protection and the continuous progress of science and technology, it is believed that the application prospect of permeable concrete will be broader.

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