

# Paving Materials and Engineering Applications of Permeable Pavement

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**Abstract:** The stability of roads in cities directly affects the safety of traffic and transportation. In the process of pavement laying, relevant personnel should use permeable paving materials in the process of construction. Based on the analysis of road drainage requirements, traditional paving materials have relatively poor water permeability, which leads to ponding problems during road use<sup>[1]</sup>. Within this frame of reference, beginning with the characteristics of permeable paving materials, this paper makes an in-depth exploration on practical application measures.

**Keywords:** Permeable pavement; Paving materials; Engineering application; Porosity

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## 1. Introduction

The construction of permeable pavement has many benefits, among which the most noticeable are the reduction of ponding on road surface, night reflection prevention, vehicle noise reduction, surface temperature and humidity adjustment, as well as the alleviation of urban heat island effect. In order to improve the construction quality of permeable pavement, employees should actively take optimization measures to improve the paving efficiency in a comprehensive manner and contribute to urban road safety as well as optimal construction.

## 2. Properties of permeable paving materials

### 2.1. Relationship between strength and porosity

In the process of exploring the properties of breathable water-based paving materials, workers must fully comprehend the relationship between strength and porosity. Based on the analysis of several results, the strength of various permeable paving materials is related to their porosity. On the whole, the relationship between porosity and material strength shows an inverse relationship; that is, the lower the porosity, the higher the strength of the material. However, in regard to the influence of the actual value of material porosity, unreasonably low porosity will affect the material's water permeability. Therefore, in the application of paving materials for pavement construction, relevant personnel need to fully understand the construction requirements, the porosity and permeability of the materials, and other related factors, so as to select appropriate paving materials that have high adaptability for pavement construction.

Specifically, different types of permeable paving materials have different strengths. Taking permeable asphalt mixture, permeable cement concrete, and permeable pavement bricks as examples, pervious asphalt mixture itself has high porosity, which means that the shear strength of the material is relatively low. This

property makes it difficult for the pervious pavement constructed with pervious asphalt mixture as the primary material to maintain its integrity when enduring sharp turns or brakes by heavy-duty vehicles. Permeable asphalt mixture is not suitable for heavy-duty vehicle traffic roads. On the other hand, permeable cement concrete has relatively more pores, and its tensile strength is lower than that of ordinary concrete in the process of pavement laying. From the analysis of specific index values, the porosity of permeable cement concrete is between 15% and 30%, its 28-day compressive strength is about 10 to 20 MPa, and its flexural strength is in the range of 2.5 to 4 MPa. The strength of permeable pavement bricks is affected by the manufacturing process; moreover, different types of permeable pavement bricks have great differences in strength. The overall strength of concrete permeable pavement bricks is low, whereas porous concrete permeable pavement bricks can reach a high level of strength with the support of good manufacturing technology.

## **2.2. Weather resistance**

In addition to pavement strength and water permeability, permeable pavement also needs to have good stability to ensure that the pavement can ensure road safety in case of bad weather. In the context of permeable pavement, weather resistance can be reflected from two angles: temperature and precipitation.

While planning the use of permeable materials based on temperature, it is important to note that permeable pavements are more prone to frost heave effect than ordinary roads in low temperature<sup>[2]</sup>. From the aspect of essential difference, ordinary permeable pavement bricks will be damaged due to their low density, strength, and frost resistance, which will lead to the destruction of pavement integrity and eventually jeopardizing the safety of users. For permeable asphalt mixture, low temperature will cause it to crack. In contrast, permeable cement concrete ensures the connection between the interior and the outside of the pavement at low temperature with the support of high porosity. Therefore, even if the moisture contained in the pavement is frost heaved due to low temperature, it will not leave much impact to the pavement. In general, the use of permeable cement concrete materials has more advantages in low temperature resistance. Under high temperature, permeable asphalt mixture will expand due to its poor stability. Therefore, the use of permeable asphalt mixture is not conducive to ensuring the stability of pavement under high temperature. The performances of permeable cement concrete and permeable pavement bricks do not easily change under high temperature conditions. Therefore, in the context of a high temperature weather, the construction personnel should select either permeable cement concrete or permeable pavement bricks for pavement construction according to the construction needs.

When selecting materials to be used for pavement construction in combination with precipitation, relevant personnel should select materials that have less impact from environmental humidity. Specifically, when permeable cement concrete is exposed to an environment with high humidity, its strength will not be greatly affected, and even in the later stage, the high humidity will help to improve its efficiency. In the application of permeable asphalt mixture, high-intensity precipitation or high environmental humidity will affect the viscosity of asphalt materials, resulting in pavement problems. When paving in areas with large precipitation or high environmental humidity, workers should give priority to permeable cement concrete materials for construction.

## **3. Application of permeable paving materials in practical engineering**

### **3.1. Permeable asphalt mixture**

From the discussion above, the exploration and research on the practical application of permeable paving materials reveal that permeable asphalt mixture plays an important role in pavement construction. Based on the consideration of the properties of permeable asphalt mixture, the analysis shows that this kind of paving material is suitable for the construction of the wear layer. With this material, the wear resistance

and drainage performance of pavement can be fully guaranteed.

Based on research results and previous excellent construction experiences of high-speed permeable asphalt pavement, permeable asphalt mixture can realize the optimization of pavement drainage and noise reduction by virtue of its properties: a large amount of single particle and coarse aggregate as well as a relatively small amount of fine aggregate and filler. In actual pavement laying, the proportion of coarse aggregate and mineral aggregate in permeable asphalt mixture should be controlled between 10 and 15 mm; controlling the gravel thickness within the range of 5 to 10 mm will ensure the pavement quality to a certain extent. In addition, in order to further strengthen the overall rutting resistance, water damage resistance, and leakage resistance of the pavement paved with permeable asphalt mixture, the constructors should also add nitrate lime and mineral fiber in the paving process to improve the performance of the pavement materials.

### **3.2. Permeable cement concrete**

Permeable cement concrete, commonly known as sand-free macroporous concrete, is a type of macroporous concrete. While using coarse aggregates of a single particle size, it is necessary to strictly control the amount of cement slurry, so that it can reasonably cover the surface of the coarse aggregates without flowing and filling the gaps between them, so as to form large permeable gaps between coarse aggregate particles. Permeable cement concrete does not usually require any sand, but a small amount of sand can be added to improve the strength of the material. Permeable cement concrete can be used for permeable pavements of motor vehicle lanes, non-motor vehicle lanes, and parking lots <sup>[3]</sup>. As an example, permeable concrete pavement is used in the Nanbei Changjie urban road project in Beijing, and each cubic meter of raw material and dosage is 300 kg of 42.5 ordinary silicate cement and 1,400 kg of 10 to 20 and 5 to 10 mm single-grain gravel. It is necessary to strictly control the content of needle-flake particles without adding fine aggregates and to mix a certain proportion of powder binder as well as antifreeze agent for construction during winter. The water consumption is 67 kg. According to the measurement, the permeable cement concrete of the project has a 28-day compressive strength of 15.3 MPa, flexural strength of 3.0 MPa, porosity of 21.5%, and permeability coefficient of 1.9 cm/s; it has high strength and good permeability effect.

### **3.3. Permeable pavement bricks**

The types of permeable pavement bricks that are mainly involved in the material laying process of permeable pavements include concrete permeable pavement bricks, natural sand permeable pavement bricks, and ceramic permeable pavement bricks. Different permeable pavement bricks have different roles in the laying process. Therefore, during permeable pavement construction, the selection of pavement materials should be in consideration of the construction requirements and the characteristics of permeable pavement bricks. Beginning from the analysis of the actual engineering application, the frequency of using concrete permeable pavement bricks and porous concrete permeable pavement bricks is relatively high. Although these two types of permeable pavement bricks involve concrete, there are vast differences in the manufacturing process. The difference between the completed products is mainly reflected in the permeable pores. As there are differences in the manufacturing process, the permeable pores of the two materials are different; the permeable pores of concrete permeable pavement bricks are formed by reserving channel holes in the brick manufacturing process; however, the pores formed in porous concrete pervious pavement bricks are completed in the mixing stage of raw materials, and because the pores of porous concrete pervious pavement bricks are formed under the action of a gas generating agent, the pore size of the completed product is relatively smaller, and the pore distribution is more uniform with a certain continuity.

In general, it is necessary to pay attention to a reasonable selection of permeable pavement bricks in the process of application. With the scientific application of permeable pavement bricks, the water

permeability of the pavement will be improved, so as to effectively convert precipitation into groundwater. At the same time, the use of permeable pavement bricks can improve the flatness of permeable pavements, thus benefitting the current urban construction and development.

#### **4. Conclusion**

Through an in-depth analysis of research contents, it is clear that in the process of urban road construction, it is imperative to strengthen the construction of permeable pavements. In order to achieve high-quality results in the construction of permeable pavements, relevant personnel should select and use appropriate permeable paving materials for the construction of roads. In the construction process, it is important for relevant personnel to fully understand the characteristics of permeable paving materials, so as to carry out scientific and reasonable application according to the characteristics of materials.

#### **Disclosure statement**

The author declares no conflict of interest.

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