Research status of polymer permeable cement concrete

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Abstract: In this paper, the development of polymer permeable cement concrete is summarized, and the research progress and achievements at home and abroad are introduced. In the end, it summarizes the current development situation and the deficiencies in the research, and makes a prospect for the future development.

1. Summarize

More and more buildings and cement pavement cover the urban ground, greatly reducing the soil, vegetation and other areas, and basically losing the original water storage function of the ground. In recent years, urban waterlogging has become increasingly serious in rainy season, which not only brings great inconvenience to people’s daily life, but also brings serious losses to people’s property [1]. This is mainly because impermeable pavement replaces the original soil and green vegetation in the city. When there is a large amount of rainfall, the drainage system cannot discharge rain water in time, resulting in rain water not being able to penetrate into the soil. Therefore, rain water accumulates on the surface of the city and forms urban waterlogging [2]. Therefore, the concept of “sponge city” is proposed in the hope of alleviating urban waterlogging problems and improving people’s living environment. The emergence of pervious concrete is one of the most important development.

Pervious cement concrete, often referred to as pervious concrete, is composed of a series of connected pores and concrete solid part of the skeleton of porous cement concrete with permeability and water permeability. From the composition of materials, and ordinary concrete, pervious concrete only contains a small amount of fine aggregate or no fine aggregate, to leave the gap between coarse aggregate, cement and aggregate ratio of 1:4 or so.

The research on pervious concrete was carried out earlier in Europe, America, Japan and other developed countries with relatively mature technology. In the late 1970s, in order to solve problems such as “foundation subsidence caused by groundwater extraction”, Japan put forward the “underground reduction policy of rainwater” [3], and started to develop permeable concrete paving. In the United States, pervious concrete is generally referred to as finite-free aggregate concrete. Florida, New Mexico and Utah in the United States have used finite-free aggregate concrete as the pavement material for parking areas [4].

The research on pervious concrete in China started relatively late, which was started by WANG Wuxiang of cement new material institute of China building materials research institute in 1994, mainly studying the preparation, strength and water permeability of pervious concrete [5]. At present, there are many representative applications of pervious concrete in China. In the 2005 north-south changjie road project in Beijing, the sand-free pervious concrete was used. After inspection, the 28d strength reached 15.3MPa, and the pervious coefficient was 1.9cm/s. In 2008, the permeable concrete was successfully applied in the Olympic forest park project, and its strength reached C25, the permeable coefficient was 3.9mm/s, the porosity reached 24%, and the freeze-thaw resistance was more than 50 [6]. In 2009,
pervious concrete was applied in the test section of permeable sidewalk in Shanghai expo park, with 28d compressive strength greater than 22MPa and effective porosity greater than 18%[7]. At present, the development of pervious concrete is relatively mature. However, due to its own problems such as low strength and poor durability, scholars begin to add polymers to pervious concrete to improve its performance, thus producing the concept of polymer pervious cement concrete.

2. Research status of polymer permeable cement concrete abroad

In 1909, L.H.Backland in the United States first used polymer emulsion in Portland cement concrete and applied for patent. The American concrete society (ACI) specially established the research committee of polymer modified cement-based materials [8].

In 1923, Cresson [9] from Britain was the first to use natural rubber latex to insert cement as paving material, and obtained the patent of polymer modified cement concrete. Bond applied for a patent in 1932 to modify cement-based materials with synthetic rubber latex. In 1939, Rodwell also filed a patent for the production of polymers from synthetic resin emulsions for use as modified cement-based materials. Between 1940 and 1950, the number of patents on polymer-modified cement-based materials reached an all-time high, and rubber-modified cement mortar was applied to the floors of Bridges and roads for coating.

Ahmed Ibrahim et al. [10] studied different aggregate particle sizes (4.5mm, 9.5mm, 12.5mm and two-two-50% composite) through practical experiments; Different water-glue ratio; Effect of different cement content on pervious concrete performance. The test shows that the bending strength and compressive strength have the following fitting relationship: \( y = 0.252x + 0.1712 \), where the correlation coefficient \( R^2 \) is 0.68. The compressive strength decreases with the increase of porosity. As density increases, compressive strength increases and porosity decreases. On the other hand, the compressive strength and permeability coefficient are linearly related to the influencing factors.

In May 1975, the first International Conference on Polymer Concrete was held in London, England, jointly organized by the British Concrete Society, the Plastic Association, the Plastic Rubber Association, the American Concrete Association and the National Defense Building Materials and Structural Research and Testing Association. The conference was attended by representatives of 22 countries and 54 papers were published. Polymer concrete was officially used at this meeting. In October 1978, the second International Conference on Polymer Concrete was held in Austin, USA, and ten sessions were held in 2001 [11].

3. Research status of polymer permeable cement concrete in China

Domestic research on polymer permeable cement concrete can be divided into three parts: polymer permeable concrete mix ratio research, polymer permeable concrete molding technology research and polymer permeable concrete construction technology research.

3.1 Mix ratio studies

YANG Tinghui [5], XUE Lijiao et al. [12] systematically studied the influences of aggregate type, particle size and gradation on the strength and permeability of pervious concrete, and showed that when selecting aggregate type, gravel and cementing material have a larger bonding area than pebble, so the prepared pervious concrete has a higher strength. Gravel is usually selected as aggregate. Different cement labels have a greater impact on the strength of pervious concrete, 52.5R ordinary Portland cement prepared pervious concrete strength is higher than 42.5R ordinary Portland cement, and different cement labels corresponding to the aggregate optimal particle size is different: elected to use 42.5R ordinary Portland cement, gravel should choose 4.75-9.5mm particle size; When 52.5R ordinary Portland cement is used, the strength of permeable concrete with 9.5-16mm gravel is higher.

ZHANG Jinhua, Gao Jianming [13] and others research results show that the addition of polymer, to improve the new mixing performance of concrete and the concrete mixture permeability adhesiveness, and water permeability of concrete compressive strength has increased with the increase of dosage of polymer, but after polymer content more than 15%, the compressive strength increase was not
significant. Considering the economy and technology, the optimal dosage of polymer is between 15% and 20%.

3.2 Molding technology research

WU Dong [14] et al. compared the influences of different molding modes on the performance of permeable concrete. The experimental data show that the strength, permeability and porosity of pervious concrete are affected by the forming mode. Influence law: the vibration forming test block has the phenomenon of slurry sinking, but the accumulation is dense; Manual ramming test blocks are loosely piled up, but have good uniformity, and are easily affected by different forces of the operator; By means of manual insertion and mechanical vibration, the strength and permeability of the test block are improved, and the effect is ideal.

XU Renchong, GUI Miaomiao [15] et al. studied the influence of different molding methods on the performance of permeable concrete. Four molding methods were studied, namely, insert and pound molding, vibration molding, pressure molding and vibration molding. Among the four molding methods, the vibration-compression molding has the highest strength, while the thrust-ramming molding has the lowest strength. The results show that with the increase of vibration time, the strength of pervious concrete increases first and then decreases, and the permeability coefficient decreases gradually. This is because the vibration time is less, the aggregate relies on their own gravity to achieve a more dense state; When the vibration time is long, the upper slurry fills the lower pore, the upper part becomes the weak area of strength, and the lower part becomes the weak area of permeability coefficient. With the increase of forming pressure, the strength of pervious concrete increases first and then decreases. When the pressure is small, the pressure makes the permeable concrete more compact; When the pressure exceeds a certain range, the pressure makes the aggregate fracture, resulting in a decrease in strength.

3.3 Research on construction technology

LIANG Minfeng, ZHANG Zhe, XIONG Jianping [16] and others for the molding of polymer cement concrete and curing process were studied, mainly for the polymer concrete mixing time, feeding way, vibration method and maintenance control factors were analyzed, and concluded that the influence of polymer cement concrete construction of main control factors include feeding mixing method, vibration time, curing conditions, etc., polymer cement concrete exist corresponding optimal maintenance system, on the whole polymer dosage, the greater the standard initial curing days less.

WANG Huibin [17] studied the construction technology of polymer-modified cement concrete pavement, and proposed a series of new and complete construction technologies from construction preparation, back production, transportation to front paving, so as to provide technical support for future construction. The main construction technological process including: preparation, vertical and horizontal seam tag, road cleaning, road closed, interface adhesive of cloth and the polymer mixing, loading, transportation, planting, maintenance etc. Put forward a complete set of construction technology of late, for polymer waterproof concrete practical engineering construction to provide theoretical support.

4. Conclusion

The domestic research status shows that the mechanical properties and water permeability of polymer permeable cement concrete are affected by the mixing ratio, which mainly includes the test factors such as polymer type and dosage, aggregate type and gradation, cement type and dosage, water-binder ratio, molding mode, etc., and it is also influenced by the construction technology of actual engineering. At present, there are some researches on polymer permeable concrete in China, but the researches are shallow and mostly single variables, which fail to form standardized documents. For example, the recommended value of different polymer types and dosage, which molding mode and construction process are more suitable for different polymers, and so on. Therefore, on the basis of the existing research results, this field needs to further analyze the influences of various factors on the porosity,
permeability coefficient, compressive strength, flexural strength and durability of polymer permeable cement concrete.

The polymer permeable cement concrete not only has the advantages of beauty, anti-skid, environmental protection and rapidity, but also improves the mechanical and physical properties of this kind of concrete due to the addition of polymer. At the same time, it provides an effective and feasible scheme for solving the problem of urban waterlogging and constructing sponge city. However, how to optimize the mix ratio of polymer permeable cement concrete, polymer type and amount, molding mode and other different parameters is an urgent problem to be solved.

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