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Research on permeable concrete road construction technology and quality inspection

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Abstract: *At present, China's society is in a stage of rapid development, and with it, the construction of urbanisation is constantly being adjusted and strengthened, with sponge cities as an important part of urban construction, which have a very important role in reducing flooding, saving water resources and adjusting water ecosystems. Permeable concrete roads are used in a variety of ways in the construction of sponge cities, playing an irreplaceable role that should be handled with care. This paper first introduces the structural composition of two types of permeable concrete roads, then describes the construction technology and quality inspection of permeable concrete roads, and finally makes reasonable suggestions on the design of permeable concrete roads.*

Keywords: *permeable concrete roads, construction technology, quality testing*

1. Preface

Today, permeable concrete roads are an important part of sponge city construction. Their important role includes facilitating the operation of urban drainage systems, effectively reducing the amount of water on urban road surfaces, effectively protecting road foundations, and making traffic movement safer and more comfortable. This type of road design includes both monolithic permeable concrete roads and permeable concrete roads with edge strips. Both are three-layer structures, with different materials used for the base, middle and surface layers, and the influence of a variety of external factors. In the construction of sponge cities, the design of permeable concrete roads should keep pace with the times, strictly follow the engineering design requirements, strive to control the quality of the road and give full play to the role of such roads.

2. Project Overview

In 2018, a domestic enterprise built a permeable concrete road in a sponge city in Suining City, and worked out the patented technology of overall permeable concrete road and side belt permeable concrete road, which has roughly 25 million yuan of capital investment. The total length of the road is about 20,000m, with an average width of 6.5m, of which the width of the motorway is 5m and the width of the pavement is 1.5m. After the road is completed, there is almost no water on the road, runoff is effectively controlled, the roadbed is effectively protected, and the safety and comfort of driving is improved.

3. Permeable concrete road structure composition and construction technology

The term "integral permeable" refers to the overall permeability of the road surface. The overall permeable concrete road is divided into a motorway and a footpath, where the motorway is divided into three layers from top to bottom [1], 1 layer for the road surface layer, consisting of 120mm permeable concrete; 2 layers for the road sub-base layer, consisting of 200mm coarse aggregate permeable concrete; 3 layers for the road base layer, consisting of 500-800mm clay sandstone. The pavement is also divided into three layers from top to bottom, 1 layer for the road surface layer, composed of 120mm pervious concrete; 2 layers for the road sub-base layer, composed of 20mm coarse sand levelling layer; 3 layers for the road base layer, composed of 400mm gravel layer. The so-called "edge with permeable" refers to the road surface layer edge with permeable. Side with permeable concrete road divided into motorway and footpath, which is divided into three layers from top to bottom of the motorway, 1 layer for the road surface layer, divided into two parts, the left side by 100mm asphalt

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concrete, the right side by 100mm permeable concrete; 2 layer for the road sub-base layer, composed of 200mm water stability layer; 3 layer for the road base, composed of 500-800mm clay gravel. The pavement is also divided into three layers from top to bottom. 1 layer is the road surface layer, composed of 120mm permeable concrete; 2 layers are the road sub-base layer, composed of 20mm coarse sand levelling layer; 3 layers are the road base layer, composed of 400mm gravel layer.

3.1 Integral pervious concrete road considerations

(1) Integral permeable concrete roads are not to be used on expressways, trunk roads, secondary roads and other heavy traffic sections.

(2) The overall permeable concrete road shall be designed in tandem with the pavement and other rainwater dissipation spaces, and the dimensions and elevations of the dissipation spaces shall be taken in conjunction with the main body of the road.

(3) An impermeable layer such as clay gravel shall be provided beneath the permeable concrete surface.

(4) The final disposal space is determined according to the actual situation and can be a pavement, roadside greenery, central divider, etc.

(5) The thickness of the surface layer of fine aggregate permeable concrete is not less than 120mm and the thickness of coarse aggregate permeable concrete is not less than 200mm.

(6) The width of the inflow channel is not less than 30mm and the depth is not less than 30mm.

3.2 Considerations for Permeable Concrete Roads in Sidebands

The basic set-up of the permeable concrete road with side-strip: the permeable concrete with a width of 1m is built at the place where the motorway and the pavement meet, and the water channel is set on the outside of the side-strip, and the gravel infiltration zone is set at the base of the road under the pavement, connecting the gravel infiltration zone set under the pavement and the permeable concrete set on the motorway through the perforated paving stones, so that the rainwater falling on the motorway can be discharged to the permeable side-strip through the ground slope, and then discharged into the gravel infiltration zone under the road through the perforated paving stones. This allows rainwater falling on the carriageway to be discharged through the slope of the ground to the permeable edge zone and then through the perforated kerbstone holes into the gravel infiltration zone under the road.

(1) Permeable concrete roads with edge strips may not be used for heavy traffic sections such as expressways and trunk roads.

(2) Sidebelt permeable concrete roads shall be designed in tandem with pavements and other rainwater dissipation spaces, and the dimensions and elevations of the dissipation spaces shall be taken in conjunction with the main body of the road.

(3) A water stabilisation layer shall be provided beneath the permeable concrete surface.The cross slope of pervious concrete is not less than 1%.

(4) The final disposal space is determined according to the actual situation and can be a pavement, roadside greenery, central divider, etc.

(5) The thickness of the permeable concrete in the edge band is not less than 100mm.

(6) The width of the inflow channel is not less than 30mm and the depth is not less than 30mm.The diameter of the inflow hole is not less than 100mm.

3.3 Technical points for permeable concrete roads

3.3.1 Control of the surface slope of the clay-sandstone rolled layer

As a road subgrade for motorways, the clay-sandstone rolled layer has the important function of increasing the bearing capacity of the shallow layer of the foundation set below the foundation grade, reducing the settlement of the road to a certain extent and accelerating the rate of foundation drainage consolidation. Controlling the slope of the surface ensures the overall stability of the road and effectively improves the overall road surface slope, thus allowing water to flow in the desired direction.

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3.3.2 Installation of a gravel infiltration zone under the pavement

A gravel infiltration zone is a layer of gravel set at a suitable location within the road, which serves to dissipate rainwater runoff in situ, purify it and store some of it.

3.3.3 Use of a porous brick machine to connect the permeable concrete on the moving carriageway to the gravel infiltration zone under the pavement

The use of porous bricks to connect the gravel infiltration zone set under the pavement with the permeable concrete set on the motorway enables a close connection between the motorway and the pavement and allows water from the motorway to flow into the gravel infiltration zone under the pavement.

3.3.4 Installation of permeable blind pipes in the gravel infiltration zone, connected to the municipal stormwater pipes

The blind permeable pipe is set within the gravel infiltration zone and is connected to the municipal rainwater pipe, which can bring the water seeping down to the road base into the municipal rainwater pipe for timely discharge. In this project, the blind permeable pipes are DN200 longitudinal blind permeable pipes and DN100 transverse blind permeable pipes.

3.3.5 Installation of inflow channels on the outside of permeable concrete edge strips

Diversion channels are long, narrow, deep channels installed on the side of the road to collect, channel and drain water from the road to prevent siltation and flooding. For this project, it was designed to measure 30mm× 30mm.

3.3.6 Control of paving stone opening elevations

The perforated paving stones play a role in connecting the motorway to the pavement in the side-strip permeable concrete road and their elevation should be level with the surface height of the pavement.

3.3.7 Controlling the setting elevation of porous bricks

The porous blocks serve as a link between the motorway and the pavement in the overall permeable concrete road and their elevation should be level with the surface height of the pavement.

4. Permeable concrete road quality inspection

4.1 Integral permeable concrete road design requirements

The construction of both the base and surface layers of the overall permeable concrete pavement should be included in the process supervision and completion acceptance, and the surface layer should be concealed and accepted at the base before laying.

(1) The overall permeable concrete pavement's own permeability, slip resistance, wear resistance, block shape, colour and strength shall meet the design requirements and conform to the provisions of the Technical Specification for Permeable Cement Pavement (CJJ/T135).

(2) The overall permeable concrete pavement base meets the design requirements.

(3) The thickness of the permeable cement concrete surface layer shall conform to the design requirements.

(4) The dimensions of the inflow channel are in accordance with the design requirements and the width is not less than 30mm and the depth is not less than 30mm.

4.2 Permeable concrete road design requirements for edge strips

The construction of both the base and surface layers of permeable concrete pavement in the sidebelt should be included in the process supervision and completion acceptance, and the surface layer should be concealed and accepted at the base before laying.

(1) The permeability, slip resistance, wear resistance, block shape, colour and strength of the edgebanded permeable concrete pavement shall meet the design requirements and conform to the provisions of the Technical Specification for Permeable Cement Pavements (CJJ/T135).

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(2) The thickness of the permeable concrete surface layer in the edge band shall conform to the design requirements.

(3) The size of the inflow channel meets the design requirements, and the width is not less than 30mm and the depth is not less than 30mm

(4) The diameter of the inflow hole is in accordance with the design requirements, and not less than 100mm

Permeable concrete should be rolled with special rolling tools, compacted by small rollers or low frequency flat vibrators, not high frequency vibrators to avoid slurrying of permeable concrete and affecting the permeability of the concrete

4.3 Permeable concrete road design requirements

(1) When permeable concrete pavements are used in shallow foundation areas in old urban areas, a water barrier shall be provided.

(2) Depending on the load-bearing requirements, the base and roadbed should be adjusted and the load-bearing capacity should be accounted for.

(3) Permeable concrete paving is not suitable when the water table or impermeable layer is less than 1.0m deep.

(4) Pervious concrete should not be used in areas with serious runoff pollution; farmers' markets, fresh markets, building materials markets, snack streets and other areas prone to ground blockage should not be used.

(5) When pervious concrete is set on the basement roof slab, it shall meet the load-bearing capacity and waterproofing requirements of the roof slab under full saturated water conditions.

(6) The permeable concrete surface should be sloped towards the rainwater collection outlet, and the slope should be 1%-1.5%.

(7) A high strength grade slag silicate cement with an effective porosity of greater than 10% shall be used.

(8) The thickness of pervious concrete for pavements should be greater than or equal to 80mm, the thickness of pervious concrete for car parks should be in the range of 120mm-150mm, and the thickness of pervious concrete for fire escapes should be greater than or equal to 180mm. In special cases, to increase the strength of pervious concrete, reinforcement can be added or the thickness increased.

(9) The design of permeable concrete pavement shall comply with the relevant provisions of the Technical Specification for Permeable Cement Concrete Pavement (CJJ/T135).

4.4 Basic testing items for permeable concrete road quality

The permeable concrete road structure is complex and involves a wide range of materials and technologies, which need to be tested during and after construction to meet design requirements. The basic items of road quality testing include pavement slope, compressive strength, width, permeability and so on. In the road testing, for each basic project, it is necessary to set the margin of error allowed, and to determine whether the indicators of the road are within this range.

4.5 Compressive strength testing methods for permeable concrete roads

The same method of testing the compressive strength of ordinary concrete is used internationally today to determine permeable concrete.

Firstly, there is a clear linear relationship between the compressive strength and the apparent density of the pervious concrete specimens, regardless of their shape, i.e. the compressive strength gradually increases as the apparent density of the pervious concrete increases; secondly, when comparing two different shapes of specimens: cubic and core, the compressive strength of the cubic specimen is higher than that of the core specimen under the same conditions of apparent density, and the deviation between the two specimens becomes larger as the apparent density decreases (the error is about 4-6 MPa). In addition, the correlation coefficient (compressive strength versus apparent density) between

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the two specimens is observed to decrease from 0.9101 to 0.7845 for the cubic specimen.

Test method for the compressive strength of permeable concrete roads. (1) Five groups of pervious concrete specimens with the same raw materials and mix ratios but with different levels of compaction (controlling the apparent density within the theoretical value of ±100 kg/m3) were made. (2) After 28 minutes of forming the pervious concrete specimens, the compressive strength of each group of specimens is accurately measured so that a corresponding curve indicating the relationship between compressive strength and apparent density can be made and an accurate formula can be fitted. (3) Samples are taken from the corresponding permeable concrete roads and formed into cylinders, and the specimens are tested to a constant water content to calculate the apparent density, the presumed value of which is chosen to calculate the compressive strength from the apparent density in the compressive strength-apparent density fitted curve equation.

5. Pervious concrete road construction effect enhancement method

5.1 Actively promote the citation and cultivation of talent

Talent is the key to promote the effectiveness of permeable concrete road construction[1] . Therefore, relevant construction enterprises should focus on the citation and cultivation of talents. First of all, enterprises should improve the entry conditions, especially in terms of management knowledge and professional ethics. This can improve the overall quality of construction staff, so as to improve the management ability of construction work, which in turn can guarantee the quality of the project to a great extent. Secondly, enterprises should try to allocate a certain amount of time for professional staff to study and further improve their professional knowledge and skills, for example, management knowledge, material awareness, quality testing, etc., so as to ensure the smooth progress of engineering construction. Finally, enterprises should set up assessment, reward and punishment mechanisms to evaluate the professional quality and working ability of relevant staff, so as to ensure that they attach importance to their work responsibilities.

5.2 Effective control of construction costs

Construction costs are something that construction companies must take into account, and strict cost control can greatly solve the economic aspects of the problem. First of all, enterprises should do a good job in advance of all aspects of the construction project spending budget, improve the level of cost budget can effectively reduce costs, must be a scientific and reasonable accounting of construction costs, strict planning of each construction needs, such as material costs, material transportation costs, manpower costs and other aspects of the use of funds, to ensure that the limited funds scientifically and reasonably implemented to all aspects of the needs, as far as possible to avoid waste, effectively alleviate or even Avoid the shortage of funds on hand. Secondly, should focus on strengthening the rational regulation on the planning of construction of the building construction programme design, strict and accurate observation of the construction site conditions, aware of the road construction requirements, based on the reality of the construction programme for effective correction, so as to make the construction drawings more accurate and credible, especially in the road construction programme initially proposed after the construction planning should be simulated and predicted in advance, as far as possible to find out the differences between the reality and the programme, and Scientific correction, perfect, as far as possible to design a more reasonable construction program, in order to achieve the overall optimization of the overall quality of engineering construction, effectively reduce its cost input, as far as possible to avoid the phenomenon of wastefulness and other purposes.

5.3 Strengthening the management of the building construction environment

The construction site environment is related to the safety of staff and the quality of construction, therefore, the management of the construction environment should be strengthened. First of all, enterprises should find out the weather conditions and climate characteristics of the construction site before the construction[2] , according to different weather conditions and climate characteristics to make corresponding adjustments, so as to meet the construction needs. For example, during the rainy period construction should do a good job of material flood control, timely observation of irregular changes in the weather, to ensure good response to preventive measures[2] . After the rain has stopped it is necessary to first map the road surface foundation to ensure that the road surface meets the construction conditions. Secondly, the current situation of the construction site should be mapped and focus on its

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reasonable management, the construction safety principles as a code and efforts to implement, to reduce the possibility of accidental outbreaks on site, to further determine the safety and reliability of the construction site. The division of labour can be planned according to the actual situation of the construction site, determine the purpose of management, establish management indicators, strengthen the supervision of site staff, so that the survey, solve the safety hazards of the construction project and other work to do thoroughly, to further ensure that the staff are safe and sound. Finally, a certain amount of time should be taken regularly to train the relevant staff so that they can pay attention to and raise their own awareness of safety precautions, make them aware of the working principle of "safety first", and take the initiative to strengthen the importance of safety responsibilities, so as to ensure the safety of each construction step, and fully enhance the overall construction of the relevant projects.

6. Conclusion

This paper focuses on the structure of two types of pervious concrete roads, the materials that make up each layer of the road, the design requirements of pervious concrete roads, construction specifications and the main application effects of pervious concrete roads. It can be seen from this, pervious concrete road structure complex[3] , high requirements, the state and related construction enterprises need to respond carefully, pay attention to the construction technology of pervious concrete[3] , effectively promote the benign development of China's sponge city, adapt to the concept of environmental protection continues to take root in today's society.

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