Preparation method of epoxy resin sand based permeable material

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Abstract. The sand was pretreated in different ways, and the epoxy resin was selected as the cementing material to prepare the epoxy resin sand based permeable material. This kind of modification and treatment of permeable materials can obtain more superior performance and more widely used permeable materials, which provides a material basis for the construction of sponge city.

1. Introduction
In order to accelerate the construction of sponge City, improve the connotation quality of the city, improve the quality of new urbanization, meet the needs of human and better life, and promote the harmonious development of human and nature, the general office of the State Council issued the guidance on promoting the construction of sponge city in 2015. It puts forward clear requirements for sponge city construction planning, implementation, operation and maintenance. The document especially emphasizes that on the basis of the original natural ecology, we should further play the role of human intervention, implement source emission reduction, process control and system governance, and effectively improve the maximum effect of sponge city construction. It is pointed out that sponge road and square construction should be actively promoted, and the use of permeable pavement should be further expanded. As new permeable paving materials, permeable brick and permeable concrete have been constantly innovating in sponge city construction and application of permeable paving products, optimizing process and forming a variety of permeable paving products and technology to meet the needs of various regions in China. Because of its high permeability, high compressive strength and low cost, the market prospect of epoxy resin sand based permeable brick is very broad. The main raw materials of epoxy resin sand based permeable brick are desert aeolian sand and epoxy resin, which are modified by coupling agent, limestone powder and quartzite powder, so as to obtain sand based permeable brick with higher wear resistance, anti clogging and cost performance.

2. Raw material

2.1. Sand
In almost all the experimental research of sand based permeable brick, the aeolian sand in desert is selected. The main consideration is low moisture content, high porosity, good permeability and low cost. Wang pingping 1(1) of Dalian University of technology has made detailed comparative test and
characterization on the properties of aeolian sand and dry sand in his research. It shows that the moisture content of aeolian sand is 0.29%, mud content is 5.58%, apparent density is 2637 kg/m$^3$, porosity is 36.3%. Compared with dry sand, the performance of the sand is more superior. In another study conducted by this scholar $^{[2]}$, the dried aeolian sand was selected. After analysis, it was found that the size of the dried aeolian sand was 0.3-0.6mm, and it was mostly spherical, with apparent density of 2637 kg/m$^3$, accumulation density of 1719 kg/m$^3$, porosity of 35%, mud content less than 0.04%, water content less than 0.2%. The results show that the dry and wet strength of the sand after drying has increased to some extent.

| properties       | Types of sand                     |
|------------------|-----------------------------------|
| Moisture content | aeolian sand 0.29% | air dried sand <0.2% |
| Sediment percentage | 5.58% | <0.04% |
| Apparent density | 2637 kg/m$^3$ | 2637 kg/m$^3$ |
| porosity         | 36.3% | 35% |

2.2. Epoxy resin
The epoxy resin selected by Wang Pingping $^{[1-2]}$ and others, component A is bisphenol epoxy resin, component B is amine curing agent, blue transparent liquid. The epoxy resin selected by Zhang Jianqiang $^{[3]}$ and others in their research is 8515A / B, in which component A is hydrophilic modified epoxy resin, colorless and transparent liquid. Group B is amine curing agent, light yellow transparent liquid. The research of both scholars shows that the 24-hour curing strength of epoxy resin can reach 80% of the maximum value at room temperature. The epoxy resin selected in the study by Qin Shengyi $^{[4]}$ and others is CYD-128 (industrial grade) produced by Sinopec Baling Petrochemical Company.

2.3. Filler
Zhang Jianqiang and others $^{[3]}$ used limestone powder as filler. The density was 2.67g/cm$^3$, the specific surface area was 550m$^2$ / kg, and the content of calcium carbonate was more than 96%. Wang Pingping et al. Used 200 mesh refined quartz powder as filler.

| properties                 | Types of limestone powder          |
|---------------------------|------------------------------------|
| density                   | 2.67g/cm$^3$                       |
| specific surface area     | 550m$^2$ / kg                      |
| content of calcium carbonate | >96%                              |

2.4. Curing agent
Some scholars $^{[4]}$ selected IPDA curing agent. The curing agents used by Wang Pingping $^{[1]}$ include slow drying curing agent GCC137 and fast drying curing agent GCC134, in which the slow curing agent GCC137 is modified isophorone diamine. The curing agent selected by Qin Shengyi et al. $^{[4]}$ in their research is industrial alicyclic amine modified curing agent.

2.5. Other solid wastes
In order to make full use of solid waste, the waste commonly used in the production of permeable brick mainly includes the treated construction waste, ceramic waste, tailings waste, industrial waste, and biomass waste. The comprehensive utilization of the waste materials not only reflects the comprehensive utilization of resources to a large extent, but also greatly reduces the production cost of permeable brick, increases the activity of cementitious materials in permeable brick, optimizes the comprehensive performance of permeable brick, and is widely used.
3. preparation method

In the study of the properties of epoxy sand based permeable brick, Zhang Jianqiang et al. [3] in the study of the properties of epoxy resin sand based permeable brick, the modified epoxy resin a component and limestone powder of certain quality are mixed quickly for a certain time, and then mixed with the curing agent of B component of the modified epoxy resin according to the mass ratio of 4:1. Under the action of coupling agent, after mixing for a certain time, a certain quality of sand is added. The resin coated sand mixture was obtained by mixing and forming. Weigh a certain quality of mixture, pour into the mold under certain molding pressure, the specimen is formed, and the mold is naturally cured. Wang Pingping and others put the epoxy resin in a m(componentA): m(component B) =100:30 in the planetary mortar mixer and mix it evenly. Then, the wind-based sand is added to the mixed epoxy resin after drying, and then it is mixed evenly, and then it is put into the mold, vibrated and formed. After 24 hours, the mold is demoulded and dried and cured in the room. The above two ways and the preparation methods of the permeable bricks are all used in advanced AB mixing, and then mixed with sand, and the sample is dried and molded under the pressure or tamping.

In another study, Wang Pingping [1-2] used to weigh a certain amount of epoxy resin and curing agent and mix it evenly, and then put wind sediment into the mixer to get the mixed mixture. The forming methods are static pressure forming and vibration forming respectively. Two maintenance methods are also used in the study, one is natural maintenance and the other is the temperature of 20±3. Maintenance of standard box with relative humidity of more than 90%. The results show that different molding and curing methods have a great influence on the performance of epoxy sand based permeable brick.

In the study of Yu Mingkai [4], we weigh a certain quality of quartz sand, pour in epoxy resin for one minute, then add curing agent and mix for 90 seconds, then install mold and press to form, and maintain at 120 °C for 3 hours at high temperature.

The experiment of Luo Fei and others [5] shows that the water cement ratio of sand free permeable concrete should be kept between 0.26 and 0.35, in order to ensure the workability and permeability of permeable concrete. Through the experimental verification, they finally determined that the best water cement ratio of the test is 0.29. When the dosage of epoxy resin is 0, 0.5%, 1%, 2%, 4% and 8% respectively, the cement quality is 408kg and the aggregate quality is 1446kg. Under the premise of ensuring the total water volume is 118.32kg, the quality of emulsion water and mixing water is adjusted in turn. After mixing and molding, the formed sand free permeable concrete specimens were cured for 24-hours with formwork. After removing the formwork, they were cured under standard conditions. The compressive strength and flexural strength were tested at the age of 7 days and 28 days respectively. The freeze-thaw specimens were taken out after curing for 24 days. After some treatment, the effect of epoxy resin on the frost resistance of sand free permeable concrete was evaluated.
Fan Yongtong\cite{6} used wood tar, triethylenetetramine and formaldehyde as raw materials to prepare epoxy resin modifier. The optimal reaction conditions and process parameters were obtained through experiments. Wood tar, triethylenetetramine and formaldehyde reactants were used as modifier, mixed with traditional E50 epoxy resin and ordinary portland cement. The modified epoxy resin is composed of 50~70 parts of epoxy resin, 40~60 parts of triethylene tetramine, 50~30 parts of wood tar and 3~10 parts of formaldehyde solution; The cementitious material is composed of modified epoxy resin and cement. The mass ratio of modified epoxy resin and cement is: modified epoxy resin: Cement = 9:1. In pure epoxy resin pervious concrete, the amount of cementitious material is designed to account for 4%, 6% and 8% of aggregate mass. When the proportion of cementitious material is more than 8%, due to the high fluidity of epoxy resin, the epoxy resin is easy to settle, resulting in the slurry on the bottom surface and the pore blockage on the bottom surface. The modified epoxy resin is more viscous than pure epoxy resin. The percentages of cementitious materials in coarse aggregate of pervious concrete are designed as 4%, 6%, 8%, 10% and 12%.

4. Conclusion

Based on the research of many scholars\cite{7-12}, it is considered that the main factors affecting the performance of epoxy resin sand based permeable brick are closely related to the addition amount of raw materials, addition ratio, mixing time, mixing sequence, molding method, curing method, etc. The main contents are as follows:

The influence of quartz powder addition. A lot of experiments by Wang Pingping and others show that the strength of epoxy mortar increases first, then decreases with the increase of quartz powder, and finally tends to be stable. The reasonable range of quartz powder addition is 2%-4%.

The influence of the addition of epoxy resin. With the increase of epoxy resin, the strength of sand based permeable brick increases. The results show that when the amount of epoxy resin is more than 7%, the compressive strength of sand based permeable brick is higher than 40 MPa because of the excessive amount of epoxy resin, and the strength is much higher than the standard requirement of permeable brick. When the epoxy resin content increased from 3% to 4%, the compressive strength of sand based permeable brick was improved obviously. When the amount of epoxy resin is increased from 4%, the compressive strength of sand based permeable brick increases by about 5MPa every 1% increase. Considering the cost and practical problems, it is suggested that the reasonable range of epoxy resin addition for preparing sand-based permeable brick is 4%-6%.

The effect of coupling agent. The results show that the strength of sand based permeable brick increases first and then decreases with the increase of coupling agent. The best dosage of silane coupling agent and titanate coupling agent is 5%.

The effect of the packing. Limestone powder and nano SiO$_2$ or nano TiO$_2$ can improve the compressive strength of epoxy resin sand based permeable brick. The best addition of limestone powder, nano SiO$_2$ and nano TiO$_2$ is 4%, 2% and 2%, respectively. Among them, the enhancement effect of nano SiO$_2$ is the best.

The influence of the preparation process. Because of the high mud content in the aeolian sand, it is not good for the compressive strength and permeability to directly use the untreated aeolian sand to prepare sand-based permeable brick. The research shows that dry sand is used instead of the aeolian sand directly taken from the desert. The vibration forming and static pressure forming are compared in the research, and the vibration forming technology is better. Under the same amount of epoxy resin, vibration forming technology is more favorable to improve the strength of permeable brick. When the GCC135 content is 5%, the average strength of the whole resin sand based permeable brick prepared by vibration molding is higher than that of the permeable brick prepared by static pressing.

This paper only reviews the preparation of resin sand based permeable brick and its influence on its performance. However, there are insufficient literature resources in the research on durability and cost of sand-based permeable brick, and further research is needed.
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