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Effect of Preparation Technology on Properties of Cellular Concrete

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Abstract: The volume method is used to calculate the mix ratio of porous concrete. According to the special structure of porous concrete, the influence of different mixing technology, forming technology and curing technology on the performance of concrete is analyzed. The test results show that the coating method is more suitable for mixing porous concrete than the single feed method. Appropriate vibration and pressure can increase the strength of porous concrete. Under the condition of suitable temperature, the moisture curing effect of covering geotextile is roughly the same as that of standard curing, which has a practical reference for the preparation and site construction of porous concrete.

Keywords: Cellular concrete, Paste-coating method, Stir, Moulding, Conserve.

1. Introduction

Concrete is an important building material in our country, the kind and function of concrete gradually become diversified with the development of engineering construction. Porous concrete[1-3] is a new type of concrete material, which has continuous irregular pore structure, light weight and relatively strong, so it is widely used, mainly used in permeable pavement and green slope protection engineering construction.

Ordinary concrete preparation process includes mixing, molding and maintenance, in order to ensure the quality of the project, China has developed a series of national standards and industry standards, and porous concrete in the selection of raw materials and ordinary concrete has a certain difference, in order to ensure its unique pore structure, generally choose a single graded particle size of aggregate, The difference in composition and structure determines the special technology must be used in the preparation process of porous concrete[4]. At present, China has not promulgated the specification and standard of porous concrete preparation technology, so the influence of different preparation technology on the performance of porous concrete was studied in this paper.

2. Raw Materials and Mix Ratio Design

2.1. Raw materials

Cement: P·O42.5 ordinary Portland cement produced by Yanxin Holdings is selected, with the performance parameters shown in Table 1; the various technical indexes are in line with the standards set in GB175-2007 Common Portland Cement.

Table 1. Physical Properties of the Cement

Density (m^2/kg)	SSA (m^2/kg)	Water requirement of normal consistency %	Soundness	Setting time (min)		Bending strength (Mpa)		Compressive strength (MPa)	
				Initial setting	Final setting	3d	28d	3d	28d
3020	380	28.6	Up to standard	245	304	4.9	8.8	24.4	60.2

Coarse aggregate: two kinds of gravels of single sizes are selected, with their respective size at 16.0-19.0mm and 19.0-26.5mm, and the various parameters are shown in Table 2; the technical indexes of the gravels are all in line with the standards set in JGJ52-2006 Standard for Technical Requirements and Test Method of Sand and Crushed Stone (or gravel) for Ordinary Concrete.

Table 2. Properties of Coarse Aggregate

Size (mm)	Apparent density (kg/m^3)	Packing density (kg/m^3)	Close packing density (kg/m^3)	Clay lump content (%)	Flat & Elongated Particles (%)	Crushing index (%)	Void fraction (%)
16.0~19.0	2645	1453	1573	0.4	6	10.8	40
19.0~26.5	2630	1407	1556	0.5	7	11.3	41

Admixtures: the polycarboxylic aciol super plasticizer produced by Hongxiang Building Additive & Admixture Factory in Laiyang City is selected, with water-reducing rate at 35% and various technical indexes in line with the standards set in GB/8076-2008 Concrete Admixtures.

Mixing water: ordinary tap water

2.2. Mix proportion design

The volume method[5] was used to design the mix ratio. The water-cement ratio was 0.3 and the target porosity was 25%. The calculation method is shown in formula (1) :

$$\frac{M_g}{\rho_g}+\frac{M_c}{\rho_c}+\frac{M_w}{\rho_w}+P=1 \quad (1)$$

In the formulas, M_g coarse aggregate amount per cubic meter, kg; M_c cement dosage per cubic meter, kg; M_w amount of mixed water per cubic meter, kg; M_z amount of mineral admixture per cubic meter, kg; ρ_g coarse aggregate apparent density, kg/m^3; ρ_c apparent density of cement, kg/m^3; ρ_w density of water, kg/m^3; P target porosity, %.

1) To determine the amount of coarse aggregate, calculate according to formula (2) :

$$M_g=\alpha\cdot\rho_G \quad (2)$$

In the formulas, M_g coarse aggregate amount per cubic meter, kg; α correction coefficient, 0.98; ρ_G coarse aggregate packed density,kg/m^3.

2) To determine the amount of cement and mixing water, calculate according to formula (3) and (4) :

$$M_c=\frac{V_j}{R_{\frac{W}{B}}+\frac{1000}{\rho_C}} \quad (3)$$

$$M_w=M_c\cdot R_{\frac{W}{B}} \quad (4)$$

In the formulas, V_j cement slurry volume, L/m^3; M_c cement dosage per cubic meter, kg/m^3; M_w amount of mixed water per cubic meter, kg/m^3; $R_{\frac{W}{B}}$ water-binder ratio, ρ_C cement apparent density, kg/m^3.

After calculation, the mix ratio of porous concrete is shown in Table 3.

Table 3. Mix ratio of porous concrete

Size (mm)	Cement (kg/m^3)	Coarse aggregate (kg/m^3)	Mixing water (kg/m^3)	Admixtures (kg/m^3)
16.0~19.0	343	1542	104	3
19.0~26.5	348	1524	104	4

3. Mixing Process Study

There are certain differences in the structure and material composition of porous concrete, which makes it different in the mixing process. Therefore, the paste-coating method[6] is proposed in this paper, and a comparative test is carried out with the one-time feeding method of ordinary concrete. Table 5 describes two mixing methods, and the porosity and compressive strength of concrete test blocks under different mixing methods are measured.

Table 4. Comparative test results of different mixing methods

Mixing method	Size (mm)	Stirring processing	Connected porosity	Total porosity	28d compressive strength (MPa)
all-in method	16.0~19.0	Add all aggregates, cement, admixtures and mixing water at one time and stir for 3min	22.5%	24.6%	9.3
	19.0~26.5		23.7%	26.8%	6.6
paste-coating method	16.0~19.0	1. Stir aggregate and 70% mix water for 1min; 2. Stir 50% cement and water reducing agent for 1min; 3. Stir the remaining cement and mixing water for 1min;	24.4%	26.1%	10.5
	19.0~26.5		26.5%	28.4%	7.9

Note: Vibrating 20s molding, maintenance under standard conditions

As can be seen from Table 5, the total porosity of the porous concrete prepared by the two preparation methods is basically the same, but the connected porosity of the porous concrete test block prepared by the coating method is greater than that by the one-time feeding method, which is favorable to the porous concrete, and the strength of the test block prepared by the coating method is higher.

Through analysis, it is found that when using the one-time feeding method, due to the addition of too much cement at one time, part of the cement slurry and coarse aggregate form clumps, so that other aggregates are not completely wrapped, which not only affects the connected porosity, but also reduces the strength of the test block.

The order of adding is changed in the concrete mixing process. The aggregate and mixing water added first can wet and clean the aggregate surface, which is conducive to better bonding of cement paste. Secondly, porous concrete has a small amount of cement, no fine aggregate, and a large aggregate size, which results in poor slurry fluidity. Adding 50% cement and 70% mixing water first can form a slurry with good fluidity, which can not only avoid crushing of aggregates due to excessive friction, but also make the aggregate surface fully wrapped. Since the surface of the coarse aggregate has been wrapped in a layer of slurry with good fluidity, and finally add the remaining cement and mixing water, under the action of mechanical mixing, it can be uniformly bonded on the surface, and the coarse aggregate fully wrapped in the cement slurry can then contact and bond with each other, which not only ensures the connected porosity, but also improves the strength, this layered

packaging method is also called "shell method".

4. Molding Process Research

On the whole, porous concrete is a structure formed by the accumulation and bonding of coarse aggregate wrapped in cement slurry, and the fluidity is very small, relying on its own weight can not make the concrete achieve a good compactness state, which requires external forces. The commonly used forming methods of concrete are vibration forming and pressing forming. The test adopts the packing method. The newly mixed concrete is divided into three layers into the test mold, and each layer is inserted and rammed 25 times with a metal rammer with a diameter of 16mm.

4.1. Influence of vibration molding on the performance of porous concrete

Vibration molding is to reduce the friction between aggregates through vibration, and then rely on the action of gravity to achieve concrete compaction.

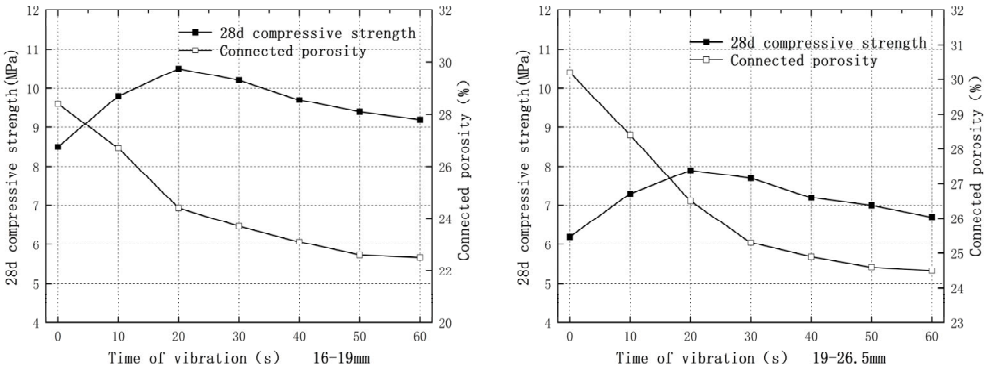

Figure 1. Effect of vibration time on properties of porous concrete

It can be seen from FIG. 1 that the connected porosity of porous concrete gradually decreases with the increase of vibration time. This is because the cement slurry coated with aggregate cannot harden in a short time. Under the action of vibration, the slurry continues to slide downward, reducing the volume of the upper part of the specimen and increasing the volume of the bottom. Thus, the connectivity porosity is reduced. Its strength increases first and then decreases, and reaches the maximum value when the vibration time is 20s. This is because the concrete slurry is gradually densified under the action of vibration, and the occlusion between aggregates is also continuously enhanced. However, with the increase of vibration time, the upper cement slurry gradually decreases, thus reducing the overall strength of the test block.

4.2. Influence of press forming on properties of porous concrete

Pressing molding is through the pressure to make the aggregate move each other, and then make the concrete to achieve compaction.

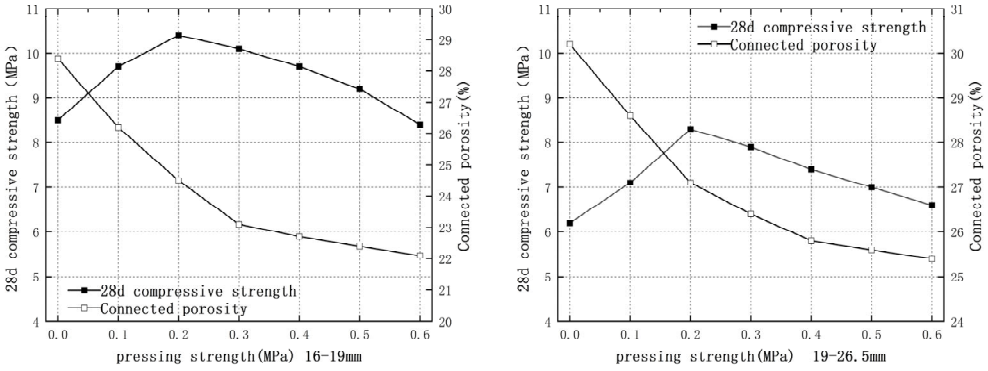

Figure 2. Effect of pressing strength on properties of porous concrete

As can be seen from FIG. 2, with the increasing pressure, the strength of porous concrete increases with the increasing molding pressure within a certain range. When the molding pressure increases to a certain extent, the change in strength is relatively gentle, because the aggregate in the mix has been closely contacted at this time, which is difficult to further compaction. When the pressure exceeds 0.2MPa, the aggregate will be damaged to a certain extent, so the strength of porous concrete reaches the optimal value at this time. With the increase of compression strength, porous concrete becomes dense and its connected porosity decreases gradually, but with the increase of strength, the decline rate slows down gradually and eventually tends to be horizontal.

5. Curing Technology Study

Porous concrete has a special pore structure, and most of the pores are connected pores, so the water is more easily evaporated, so the proper curing method should be studied to ensure the performance of porous concrete. In the laboratory test, the formed test block can be directly put into the standard

curing room together with the test mold, but the construction site obviously can not meet the conditions of the standard curing room, this paper carried out a comparative test. Table 5 lists the different curing methods of porous concrete, and Table 6 shows the influence of different curing methods on the strength of porous concrete.

Table 5. Different curing methods of porous concrete

Curing method	Maintenance content
Standard curing	After the test block is formed, the test mold is put into the standard curing room for 48h, and the mold is removed and continued to be cured in the standard curing room until the required age.
Natural curing	After forming, the mold is removed after 48 hours of natural air curing, and the natural curing is continued to the required age.
Moisture curing	After forming, cover geotextile, wet for 48h, remove the mold, continue to spray water maintenance for 7d, and then natural maintenance.

Table 6. Compressive strength of porous concrete under different curing conditions

Size (mm)	Standard curing		Natural curing		Moisture curing	
	7d	28d	7d	28d	7d	28d
16.0~19.0	8.1	10.5	2.6	4.7	7.6	9.8
19.0~26.5	6.3	7.9	1.9	3.4	5.8	7.4

As can be seen from Table 6, natural curing is very unfavorable to the strength development of porous concrete, its strength is less than 50% of the standard curing, and fine cracks appear at the joints between aggregates, and the bonding effect of slurry cannot be well played, resulting in poor strength of porous concrete. The effect of moisturizing curing is good, which is comparable to that of standard curing, indicating that the humid environment is the main factor to ensure the strength of concrete. Standard curing and moisturizing curing ensure the moisture required for cement hydration, thus guaranteeing the strength of porous concrete. Therefore, moisturizing curing is a very applicable and effective method for porous concrete in practical engineering.

Secondly, the temperature in the curing process is also the main factor affecting the strength of porous concrete, in the moisturizing curing process, the temperature is too high or too low will affect the curing effect, the temperature is too high water evaporation faster, the need for multiple sprinkling water, the temperature is too low will also affect the process of cement hydration reaction, which requires us to fully consider the weather factors in the field construction, Avoid construction in hot and cold weather.

6. Conclusion

(1) Compared with the one-time feeding method, the slurry coating method can wet the aggregate in advance, so that the slurry can effectively cover the surface of the aggregate, and thus improve the strength of porous concrete.

(2) The time of vibration molding should be kept at about 20s, too short time porous concrete can not be better dense, too long time slurry is easy to block the pores, thus affecting the strength and porosity of porous concrete.

(3) When pressing, the pressure should be controlled at about 0.2Mpa, the compaction of porous concrete is poor when the pressure is too low, and the aggregate is easy to be crushed when it is too high, which affects the strength of porous concrete.

(4) When curing porous concrete, attention should be paid to maintaining humidity and temperature. Simple natural curing is unfavorable to strength development, and standard curing and moisturizing curing are better.

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