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Mixing Ratio Design and Experimental Studies of High-Performance Porous Concrete Strength

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According to the principle of the accumulation of aggregate and particle interference theory, mixing design method, experimental research and analysis through an analysis of the use of pervious concrete aggregate gradation test. They were established aggregate gradation and aggregate porosity unit volume aggregate number of particles, the regression equation between the aggregate surface area. Based on pervious concrete mix design features in-depth analysis of the relationship between the parameters and principles of performance and mechanical properties of porous concrete between the constituent materials; and selecting suitable raw materials, optimizing pervious concrete material, permeable to determine the best ratio of concrete; Finally, life cycle environmental assessment system, ordinary concrete, pervious concrete and pervious concrete high performance environment coordination of the evaluation carried out. Through this high-performance pervious concrete mix design and study the life cycle environmental evaluation system, we draw some important conclusions of the study, to promote engineering applications pervious concrete has a certain reference value.

1. Introduction

Pervious concrete is a particular gradation of cement, water, aggregates, additives, admixtures, and inorganic pigments eco-concrete having a continuous gap in a specific mix prepared from a special process (Sun, 2015). The apparent density is generally: 1600-2100kg / m3,28d compressive strength: 10b30MPa, flexural strength: 2-6MPa, permeability coefficient: 0.5 ~ 20mm / s. Compared with ordinary concrete, permeable concrete with permeable, breathable, clean water, sound absorption, protection of groundwater resources, alleviate the urban heat island effect and improve the ecological environment of soil and many other excellent performance (Lignos and Ricci, 2013). High-performance pervious concrete, that is, except the ordinary pervious concrete has the permeable, breathable, clean water, sound absorption, excellent performance, it also has a high strength, high crack resistance, high wear resistance, high corrosion resistance and other properties more perfect pervious concrete (Kheni and Pucinotti, 2015). Based on this, to carry out high-performance water-permeable concrete technology development, improve the high performance pervious concrete mix design method and quality control system, improve the urban ecological environment, the protection of groundwater resources and other aspects of great significance (Sun and Lu, 2015).

According to the principle of the accumulation of aggregate and particle interference theory, mixing design method, experimental research and analysis through an analysis of the use of pervious concrete aggregate gradation test. Pervious concrete is a closed hole with more non-porous concrete. Pervious concrete is aggregate, cement, additives and water from mixing through a specific process of porous concrete (Zeng, 2013). it does not contain fine aggregate, coarse aggregate coated thin layer bonded to each other to form a slurry honeycomb cavities uniformly distributed, containing a large proportion of its internal penetration of the pores (Zhang, 2012). It has a breathable, permeable and light weight, reduce environmental impact as concrete, pervious concrete research and development of more and more attention. Pervious concrete pavement is a pavement that meets the performance, but also to coordinate symbiosis with the natural environment for human comfort pavement structure dysprosium packaging material living environment.

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2. The basic concept of pervious concrete

2.1 Performance of the status of work

There is no uniform method of evaluation and fresh pervious concrete workability. Because the porous concrete is dry concrete, slump approaches zero, not suitable for traditional slump detection n3 (Xiong and Darbhanzi, 2014). In the experiment, researchers jump tables with pervious concrete test method to evaluate the fluidity of its work, but the effect is not ideal. With further research, and evaluation of new methods have been proposed, the use of multi-factor orthogonal experiment, the regression equation evaluation of surplus pulp ratio:

$$\delta = 38.9 - 0.834V_{CA} + 6.34\times10^{-4}C + 34.63W/C + 51.2S_P;(R = 0.23) \quad (1)$$

Among them:

δ-Surplus slurry mass ratio (%)

V_{CA}-Aggregate porosity (%)

C-The amount of cement (g/m^3)

S_p-Sand ratio(%)

W/C-Water cement ratio

In theory the accumulation of aggregate or aggregate terms, domestic experts and scholars have done a lot of theoretical work, and has made some achievements (Zhu, 2012). Since the aggregate particles irregularities and Priorities diversity, research and analysis is not easy, it is generally in the application of particle packing theory analysis need to establish a model ball heap of concrete aggregate gradation, to analyze the different particle size of each sphere arrangement with the way the relationship between the accumulation of porosity. Sphere model:

$$V_{\text{Interspace}} = 1 - \sum_{\text{n=1}}^{\text{m}} V_{\text{n(Sphere)}} = 1 - m\cdot\frac{4\pi r^3}{3} \quad (2)$$

Non-diameter sphere model:

$$\begin{aligned} V_{\text{Interspace}} &= 1 - \sum_{\text{n=1}}^{\text{m}} V_{\text{n(Sphere)}} \\ &= 1 - \sum_{n->+\infty} [n^3\cdot\frac{4\pi R^3}{3} + (n-1)^3\cdot\frac{4\pi r^3}{3}] \end{aligned} \quad (3)$$

The grading curve closer parabola, the greater the density. Expression is:

$$p = 0.5\times\left(\frac{d}{D}\right) \quad (4)$$

Where:
p - aggregate (diameter d) by percentage, %;
D - as aggregate maximum particle size, mm.
The calculation formula shown in Equation 5, can be used to calculate the continuous gradation and gap-graded. Since the pervious concrete skeleton unique pore structure, generally carried out using a single particle aggregate mix design, so that the theory can be used in pervious concrete mix design gradation analysis.

$$t = \left[\left(\frac{\varphi_0}{\varphi_a}\right)^{\frac{1}{3}} - 1\right]\cdot D \quad (5)$$

Among them:

t -Former grain size particles pitch

D -Former grain size particles size

Φ_0-Secondary particle theory solid ratio

Φ_a-Primary particle diameter practical solid volume ratio

2.2 Pervious concrete action to protect groundwater resources

The common feature is permeable ground precipitation can penetrate the lower part of the soil seepage path through communication hole, it impervious pavement and drainage are different (see Figure 1), and thus for the protection of groundwater resources play a positive role.

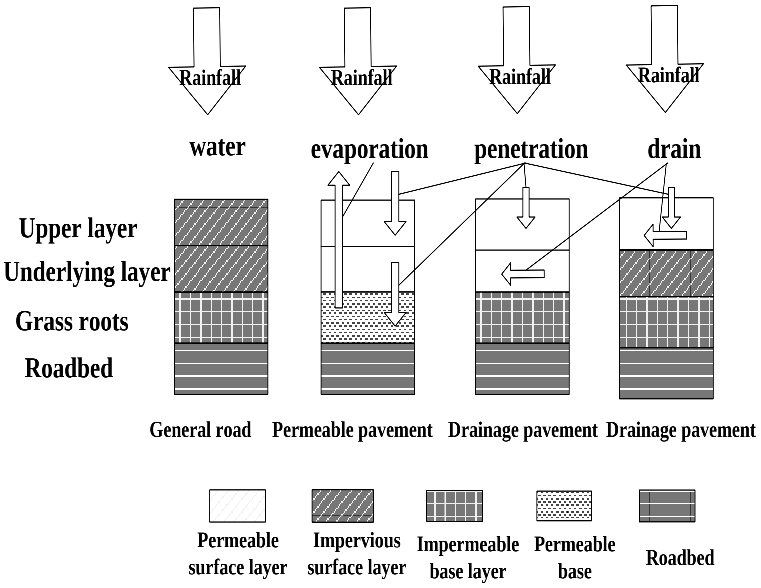

Figure 1: Schematic diagram of water impermeable pavement and pavement

Permeable paving both good water permeability and moisture resistance, taking into account both human activity requirements for hardening the ground, but also through its own performance close to the ecological advantages of natural grass and the soil surface to reduce the city's face hardened destruction of nature degree, permeable paving the following plants, animals and microbes living space are effectively protected, reflecting the requirements of sustainable development of natural biological environment. Thus well it reflects the "symbiosis with the environment," the concept of sustainable development.

3. Experiments and results

3.1 Pervious concrete mix design method

Different from ordinary concrete, pervious concrete mix design, the first consideration is the porosity (fill in the amount of pulp). Generally aggregate slurry was wrapped, no more water flows out of the mud appropriate common methods Quality Law, volume method and the surface method.

$$1m^3\ Quality\ Concrete\ stone\ for\ m_g = 1493 \times 98\% = 1463.14kg/m^3 \tag{6}$$

$$V_{\text{cement+water}} = V - P = 44.73\% - 15\% = 29.73\% = 297.3ml \tag{7}$$

Which is

$$\frac{m_c}{\rho_c} + \frac{m_w}{\rho_w} = 297.3 \tag{8}$$

There

$$\frac{m_c}{3.1} + \frac{m_w}{1.0} = 297.3 \tag{9}$$

Were taken w / c = 0.20, 0.25, 0.30, 0.35, 0.40, 0.45 amount of material available are shown in Table 1. Similarly, you can get the target porosity of 20% compared with 25% in Table 1.

Table 1: Mix a porosity of 20% compared with 25%

Aims P	w/c	0.20	0.25	0.30	0.35	0.40	0.45
15%		524	613	345	435	611	354
		115	135	163	166	134	141
	G/C	2.53	2.92	4.92	2.45	4.24	2.24
		1452					
20%		523	376	354	387	764	536
		97	65	33	224	258	143
	G/C	3.58	2.82	2.26	1.52	4.29	2.29
		1452					
25%		/	348	897	476	335	/
		/	97	68	84	108	/
	G/C	/	3.53	5.26	3.99	5.28	/
		1452					

3.2 Analysis of experimental results

Different sizes of aggregate particles in the preparation of pervious concrete, the role differently. Just play a large particle size aggregate skeleton supporting role, mainly from the small particle aggregate filling compacting effect. Therefore, it is necessary to state pervious concrete aggregate bulk porosity was tested. Aggregate gradation can be drawn with pervious concrete aggregate bulk porosity state relationship, the specific equation is:

$$y_{\text{Bulk porosity}} = 52.8723 \cdot x_a + 232.2316 \cdot x_b - 521.1346 \cdot x_a x_b + 534.7232 \cdot x_a x_c - 234.5281 \cdot x_b x_c + 482.0723 \cdot x_a x_b x_c \tag{10}$$

Established its pervious concrete porosity A, B, C three components regression equation proportional relations hip is extremely significant. In addition, it can be seen from Figure 2, points distributed substantially on a straig ht line, but also shows the regression equation was better.

Figure 3 shows: Hold C component (a 9.5 --16mm) content unchanged, with A pervious concrete porosity component (4.75, - 9.5ram.) To reduce the dosage and group B increasing the points (2.36 --- 4.75ram) content showed a decreasing trend. The aggregate packing theory can be extrapolated to maintain constant component C, A component forming the skeleton structure, B component filling wherein the particle interference does not occur, with the reduction of A component constituting the skeleton structure also will reduced, but there are still plenty of space filled by the component B, when B component increases with decreasing a component, and increase free space due to reduced secondary aggregate B, so filling the role of the B component is more obviously, the porosity of pervious concrete showed a decreasing trend.

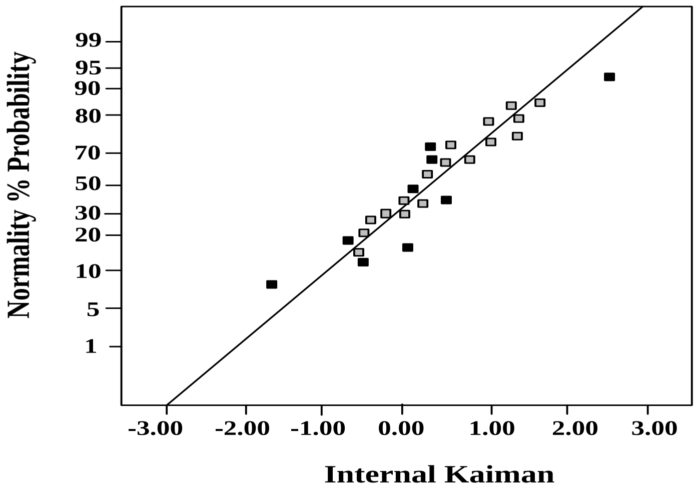

Figure 2: Residual normal probability distribution

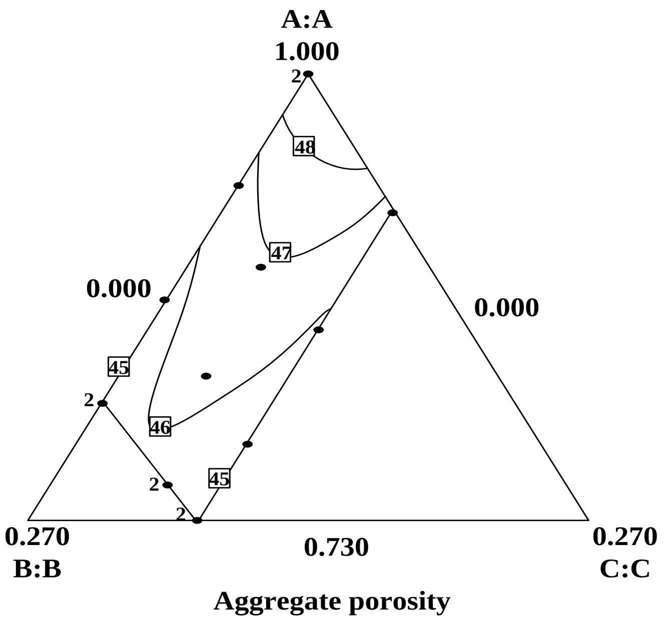

Figure 3: Porosity graphical response surface regression equation

4. Conclusions

Pervious concrete is a particular gradation of cement, water, aggregates, additives, admixtures, and inorganic pigments eco-concrete having a continuous gap in a specific mix prepared from a special process. Based on pervious concrete summarized existing research results, based on pervious concrete mix design features in-depth analysis of the relationship between the parameters and principles of performance and mechanical properties of porous concrete between the constituent materials; and selecting suitable raw materials, optimization of flooding concrete materials to determine the best ratio of porous concrete; Finally, life cycle environmental assessment system, ordinary concrete, pervious concrete and pervious concrete high performance environment coordination of the evaluation carried out. Based on the lack of research progress and application of pervious concrete current status quo exists, this paper presents the concept of high performance of pervious concrete, made of high-performance concrete and effective way of ordinary porous concrete: mainly include increasing the gel strength of materials, increasing the contact point the number of contact points to increase the area and so on.

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