depth of carbonization can't be measured, so its carbonization resistance was very good, the ability of impermeability was more than P40, after 200 times cycles of freezing and thawing, its strength lost only by less 25%, and its weight didn't change. Its original slump was about 20±2cm, and was 17cm two hours later, and the alkali resistance was very great.

Professor Feng Naiqian and Yan Peiyu in tsinghua think that the crack directly affect the permeability, which is related the durability and life-span, and the reason of crack is due to the plastic shrinkage before final set and temperature difference because of heat of hydration.

Professor Zhang Xiong in Tongji university is studying intelligent concrete — emulate self-curing concrete including self-diagnosis, self-tuning, self-adaptive, self-recovery and self-repairing.

4. Conclusion

In the research of HPC, the important is the study of all kinds of mineral ultra-pulverized power, such as ultra-pulverized slag, ultra-pulverized phosphorus, ultra-pulverized zeolite and ultra-pulverized FA etc, which are regarded as the sixth component. These power can decrease the quantity of cement, reduce cost, benefit environment by use of industry waste and make construction easy by improving workability of concrete, they also can improve performance of physics, chemistry and mechanics and make concrete waterproof, compensate shrinkage, shielding, conduct, in addition they make it possible to produce intelligent concrete, such as self-navigation, self-diagnose, self-regulating damp, self-controlling temperature, self-repairing, self-flexing. One reason of these is that there is less hydrated crystal of cement because waste replaces some of cement, then cement can hydrate very well and plays its role well, the other is that more power cam improve the density of concrete and plays its special roles. The sixth component is very useful and worth to study. But we must notice many problems of complicated construction technics, some deleterious component in admixture and the matching with cement, so some further research must be carried on.

The direction of high strength should be HPC, especially GHPC. High performance stands for high strength, but also good workability and durability. It is very inspired that UHPC will be made into moulds built up with metal polymer, which shows that the application range of HPC expand greatly. But while we focus on the development of technique and economic benefit, we should pay more attention to Green Cause. Portland cement and normal cement both are not continual material, however, GHPC can save cement and concrete, which make concrete a continual material. To expand the range of application, the lower level of strength of GHPC may be fixed at about 30MPa temporarily, at the same time we must strengthen of scientific research, increase variety of it, make best use of superiority of high performance to save cement and concrete by diminishing section area because of its high strength and high impermeability, or prolonging its life, to decrease energy cost, material cost during produce and transportation because of its high durability and to decrease degree of destroying environment. China is a country, which produces most cement, so it is more stringent to enlarge produce and application of GHPC than other countries, and the effect will also be more obvious.

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STUDY ON SPRAYED CONCRETE MODIFIED BY WASTE RESIDUE

1. Introduction

Currently sprayed concrete is still one of important supporting ways among underground projects. In recent 50 years, this technology has being developed, but one problem---low strength-has not been solved at all. On the site, the actual strength is only between 10MPa and 15MPa ,compared with the designed ,it is too low, which may influence safe production in mining. To solve them, we must enhance management, in addition, one more effective way is to improve concrete strength by adding waste residue.

2. Raw material and experiments

2.1. Raw, material

Test result of sprayed concrete

	C : S : G : W : SM : H1 : FA (SF*、GG**)	fcu1 MPa	fcu3 MPa	fcu28 MPa	t1	t2
	1.00:2.00:2.00:0.50:0.00:0.03:0.00	14.9	23.6	28.9	8′ 40″	14′ 00″
No	1.00:2.00:1.50:0.45:0.00:0.03:0.00	15.3	24.9	33.4	6′ 50″	11′ 30″
J1	0.85:1.86:1.50:0.37:0.01:0.03:0.23	24.6	35.2	49.3	11′ 10″	18′ 20″
J4	0.85:1.86:1.50:0.37:0.01:0.03:0.23**	24.5	36.5	48.8	10′ 50″	18′ 30″
J5	0.90:2.00:1.50:0.37:0.01:0.03:0.10*	28.7	39.4	55.0	11′ 50″	18′ 50″

1. Fly-ash

Fly-ash is the solid wastes of combustion of coal collected from the flue pipe of boiler ,whose composition and mineral makeup vary with the kind of coal, burning condition and collecting ways, its primary chemical composition are SiO_2, Al_2O_3 and other oxides, respective content is about as follows: S 40%~60%, Al 20%~35%, C 0.8%~7%, MgO 0.5%~2%, F 2%~12%, K_2O 0.5%~2%, Na_2O 0.01%~1%, Loss 0.5%~15%. In the mineral composition, there is more than half of vitreous body. Through XRD, we can see the main minerals : α $-SiO_2$、β $-SiO_2$、β $-C_2S$、γ $-Al_2O_3$ and so on. Fly-ash doesn't hardened in water under normal temperature. In view of the convenience of transportation, we use the fly-ash of power plant in town Zou.

2.1.2. Gangue

A kind of waste residue during mining or collecting coal, the chemical composition is as follows: S 40% ~ 65%, Al 15% ~ 35%, C 1% ~ 7%, Mg 15 ~ 4%, F2% ~ 9%, R_2O 1% ~ 2.5%, Loss2% ~ 17%, there are many

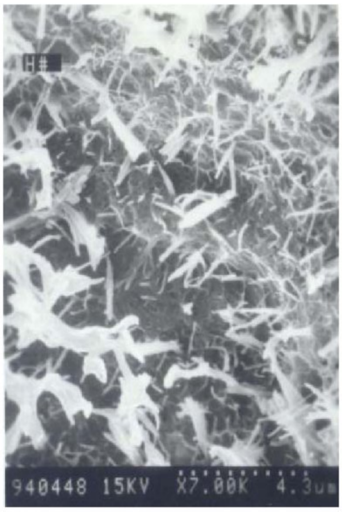

Fig.1. Structure of cement stone with FA(1)

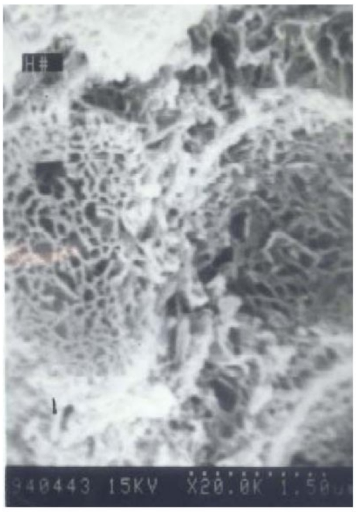

Fig.2. Structure of cement stone with FA(2)

Fig.3. Structure of cement stone with GG(3)

Fig.4. Structure of cement stone with GG(4)

Fig.5. Structure of cement stone with GG(5)

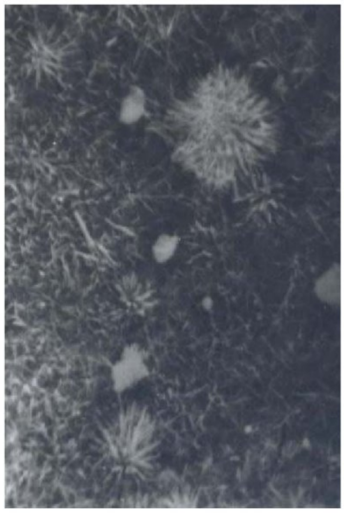

Fig.6. Structure of cement stone with SF(6)

kinds of minerals as shown in the analysis of lithofacies, such as quartz, fildspar, yellow iron ore, clay mineral, organic substance, gibbsite and so on. In this test, we used the gangue of local mine.

2.1.3. Silicon fume

Waste residue, ashen power, under SEM, it is regularly spheric and the particle distribution varies widely, the average diameter is about 0.1μ m, the specific surface is 19600 m^2/Kg ,and the main chemical composition is S. In addition, there are a little of A, F, C. Silicon fume used was of the iron alloy plant in city Tianjin.

2.1.4. Cement

The chemical composition of cement P.O42.5R from plant in city Qufu is: S 20.19% , Al 5.00% , F 4.30% , C 64.11%, Mg 4.20%, Loss 0.38%; f-CaO 0.235%, f_{kh} 0.92%, KH 0.96%, N 2.17%, P 1.16%; C_3S 58.31%, C_2S 13.91%, C_4AF 12.90%, $\overline{S}$ 2.05%。

2.1.5. Admixture

Admixture was used to regulate the setting time, improve viscidity of materials, improve the concrete strength and control shrinking cracks. The effect of the resin high range water reducer and Red-star Ⅰ accelerating admixture is showed in table.

2.1.6. Sand

In the local riversand, mud content is 0.71%, SiO_2>90%, Mx=2.9, $\rho_o^{'}$ =1460Kg/m^3, grading in the zone B.

2.1.7. Stone

The particulate diameter of local lime crushed stone is between 5mmm ~ 10mm , $\rho_o^{'}$ = 1560 Kg/m^3.

2.2. Experiments

The cement's physical mechanics experiment was done according to the standard of current national cement experiments, and the concrete's test is according to the standard of current concrete strength test and the mine laneway construction and check. The equipments and methods used in checking include: XYS - 2 diffraction apparatus under condition of CuKa, 35KV.17Ma,V=2° /mm, TSM - Ⅱ scanning electron microscope to analyze microstructure ,IR and NHR inspection instrument to determine organics, etc. 3. Test result analysis

The fly ash replaced cement by 15%, over coefficient is 0.15, superlurous was to replace the sand .The way to replace cement with gangue is the same as the fly ash, silicon fume replaceds cement by 10% with equal weighth. The strength and setting time of this experiment are showed in table 1 and the microstructure of hydraulic cement material in picture.

Note: The setting time was tested by penetrating resistance instrument.

From table, the setting time of sprayed concrete containing waste residue was longer, but the strength is 1.48 to 1.90 times of that without them. In fact, any of the mixes (J3, J4, J5) will make the strength up to C25.

Picture 1 and 2 are the structure of cement stone with FA, from which we can see that the hardened cement is composed of spiculated crystal AFt and thin slice netted colloid C-S-H which was the hydraulic of FA and where there are obvious many lacunas with the width of 40～650nm. Picture 3, 4, 5 are the structure of that with gangue, in which there are netted and particulate C-S-H, rodlike AFt, continuous slice crystal C_4 (A、F) H_{13} and valve crystal Afm. In picture 6, cement stone with silicon fume is composed of fibre colloid C-S-H distributed averagely, among which there are a little of radiative C-S-H, some inert materials and a little spiculate AFt.

4. Conclusion

(1) Waste residue may modify the cement sprayed concrete effectively. Replaced cement with FA by 15%(K=0.15), added 1% SM, concrete strength may be improved by more than 16MPa, if submitted FA with gangue in the same percent, it would be improved by 15MPa. Replaced cement with silicon by 10%, then by 22MPa.The concrete absolute strength containing any waste residue also increase.

(2) The setting time of concrete will be longer, but this is accepted according to the actual instance.

(3) Because the waste residue was extra-pulverized, the relative amount of power increased, which benefits the bond between materials and decrease rebound.

(4) Microstructure test indicated that, the concrete with waste residue was almost the same as normal concrete in the microstructure in which there are crystal AFt, all sorts of C-S-H and the multiphase system of CH and Afm, the difference between them was in the number of kinds of hydraulic, in the shape, in the growth of crystal and the structure of pores. With the extra-pulverized waste residue and the water-reducer, the concrete structure was densified and strength increased. With the silicon fume, there are more fibriforms C-S-H distributing averagely, which make the strength increase largely.

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