Reaction between carbonaceous rocks and water glass.

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Abstract: In this paper attempt was made to develop a new cementitious material at low temperature. Three kinds of carbonaceous rock of different chemical composition have been used. Ground carbonaceous rock, especial of low calcium content, was discovered to react with the altered technical grade water glass at a temperature of 40 . Strength of the paste cured for 7 days reached 32.64MPa and 14days was 40.49MPa. The products were observed by SEM. These results indicate that carbonaceous rock mixed with water glass can produce a new perspective cementitious material at appropriate conditions.
Key words: carbonaceous rock; water glass;

1 INTRODUCTION

The manufacture of cement is expensive due to the high energy consumption as well as the cost of raw materials. Limestone is one of the majority natural resources in the earth and plays a major role in cement industry. It will have many benefits if limestone can be used as cementitious material directly without being calcined at high temperature, both to economy and environmental protection. However, at ambient temperature, it is very difficult to produce such cementation materials as hydration calcite silicate by limestone, for limestone can not dissolve in alkaline solution.

The ASTM C150 standard specification for Portland cement now permits the cement to contain up to 5% of ground limestone. Several investigators have observed that limestone participates in the clinker hydration reactions rather than being an inert filler[1,2,3]. When studying mechanisms of Alkali Silicate Reaction, a deleterious reaction between alkali and aggregates in concrete, Wen [4] found that alkali silicate solution can erode crystal of $Ca(OH)_2$ at certain ratio of sodium to silicate, and the product was just hydration calcite silicate. Those investigations threw light on how to activate the chemical reacti vity between limestone and water glass. In this paper, experiments proved the possibility of reaction between lcarbonaceous rocks and water glass.

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Ground carbonaceous rocks , especial with low calcium content, was discovered to react with the altered technical grade water glass at about 40 . The strength of the paste was substantially high, which indicates that carbonaceous rocks mixed with water glass can produce a new perspective cementitious material at appropriate conditions.

2. EXPERIMENTAL PROCEDURE

2.1. Raw materials

Three kinds of carbonaceous rocks were obtained from Guangdong province. The chemical analysis of the carbonaceous rock is shown in Table 1.

Table 1 Chemical analysis of carbonaceous rock (wt.%)

rock	**Oxides**					
	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
A	41.13	2.98	0.71	0.36	52.95	0.72
B	37.10	10.42	0.77	2.17	46.4	1.73
C	44.19	0.83	0.87	0.24	32.55	19.17

X-ray diffraction studies indicated that the main crystalline material present in rock A was calcite, while rock B contained calcite, quartz and clay. As far as rock C is concerned, dolomite was the predominant mineral while calcite was minority . The scientific classification of the three types of rocks is as follows:A: is limestone, B: is siliceous limestone, and C: is dolomitic limestone.
The water glass (40 wt.% active) used in lab experiments were technical grade materials . Based on chemical analysis of the water glass, the weight ratio of silica (SiO_2) to sodium oxide (Na_2O) was found to be 3.15:1.

2.2 Preparation and methods

One of the most important methods to excitated the reaction between carbonaceous rock and water glass was to alter the property of water glass, which was made by adding NaOH in water glass. The molar ration of silica (SiO_2) to sodium oxide (Na_2O) in modified water glass was ajusted to be a certain value. Carbonaceous rock powder was made in a porcelain ball mill using porcelain balls of different sizes for 0.5h to ensure 70% of the granule sizes were less than 20μm. Carbonaceous rock powder were mixed with modified water glass, cast in a cubic mould of internal dimensions 2×2×2 cm^3, cured for 24h in a humidity chamber at 90% R.H. and constant temperature (40±°C), then demoulded and cured under the same conditions for 7 and 28 days. The broken specimens from the determination of compressive strength were then transformed to vacuum desiccation chest to be dried. The reaction products were studied by the classical techniques, namely SEM (scanning electron microscope,) to investigate the mechanism of the reaction.

3. RESULTS AND DISCUSSION

The compressive strength values of the hardened carbonaceous rock-water glass pastes are given in Table 2. The results indicate that the compressive strength of all hardened pastes increases continuously with curing time. This is mainly due to the continual formation of reaction products which always deposit inside the available pore structure leading to a decrease in the total porosity. Moreover, the pastes containing rock C give the highest strength than those of the other two. The compressive strength at 7 days reached 32.64MPa, 28 days increased to 40.48MPa. All the evidences proved that carbonaceous rock have reacted with water glass and the products had substantially high cementitious strength.

Table 2 Compressive strength of the carbonaceous rock –water glass paste (MPa)

Curing time (days)	rock A	rock B	rock C
7	7.59	22.35	32.64
14	10.32	30.65	40.48

Fig. 1 shows the unreacted carbonaceous rock grain s. Fig 2 to 4 represents the SEM micrographs of the specimens of carbonaceous rock reacted with water glass up to 7 days. The SEM pictures depict an interesting body of evidence. Fig. 2 shows rock A with water glass. It is clear that few products appear intersperse the original mineral, indicating low levels of the reaction between carbonaceous rock and water glass.

Fig. 3 shows rock B with water glass. Plenty of short-stick particles can be observed spreading around in the specimen, which means carbonaceous rock of low calcite could react with water glass to a high extent. The particle size is below 1μm.

The morphology of the reaction products in fig.4 is markedly different from those of in Fig.2 and 3.Noticeable changes is loss of surface relief and have an almost honeycomb pattern, indicating a dissolution or erosion of the constituent grains. In addition to this, there are amorphism products and a reduction in the particle size.

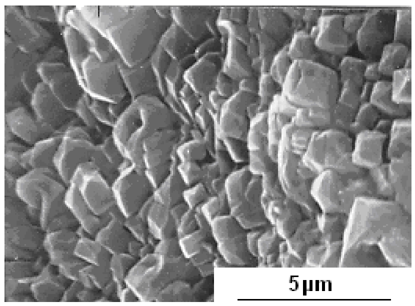

Fig.1 limestone grains

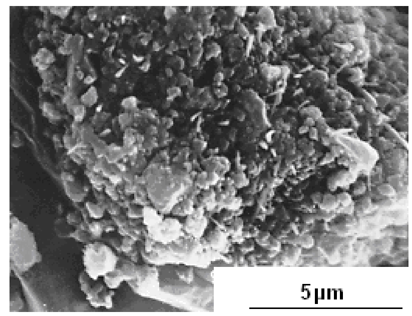

Fig.2 SEM micrographs of the specimens of rock A reacted with water glass curing up to 7 days.

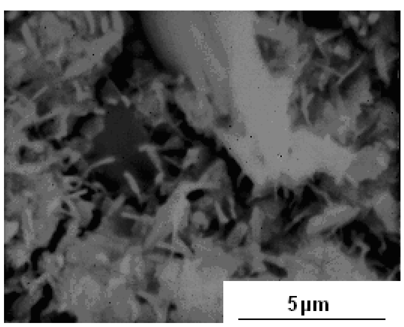

Fig.3 SEM micrographs of the specimens of rock B reacted with water glass curing up to 7 days.

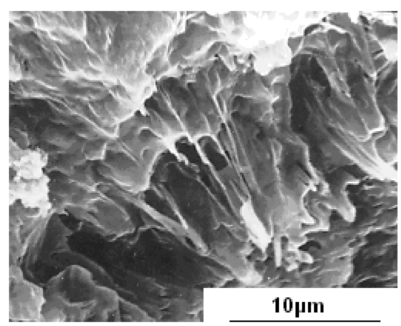

Fig.4 SEM micrographs of the specimens of rock C reacted with water glass curing up to 7 days.

4. CONCLUSIONS

(1) Carbonaceous rock powder could reaction with modified water glass at low temperature and produce cementitious products.

(2) The content of $CaCO_3$ in carbonaceous rock is one of the prime factors specific to the reactivity of carbonaceous rock with modified water glass. Carbonaceous rock of lower calcite content exhibits stronger chemical reaction and cementation strength. This may be a prospective way to use low quality carbonaceous rock.

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