III-62 On lime-stabilized fly ashes by X-ray microanalyzer in relation to strength development

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INTRODUCTION

An attempt was made on utilizing fly ash, which chemical compositions are shown in Table 1. Lime (L) and lime mixed with chemical additives (G) were used as stabilizers. The q_u test and SEM-EDX analysis were performed to clarify strength-imparting mechanism due to so-called Ettringite, Monosulphate, and C-S-H phases. The results show that microstructures changed as strength was developing, and that stabilized fly ash may be used as material for constructing subgrade, subbase,etc.

TABLE 1 Chemical compositions of fly ash used

oxide	SiO_2	Al_2O_3	CaO	TiO_2	K_2O	Na_2O	Fe_2O_3	MgO	SO_3
(%)	49.3	22.0	5.40	1.23	1.20	2.01	4.40	1.10	0.70

SAMPLE CONDITIONS

The samples were made by adding stabilizers into fly ash; only lime-fly ash (FL) and lime added with Carbonated-Aluminium Salt - fly ash (FG). Mix ratio of L and G to fly ash was 20:80. Treated water content was 60% of total weight (see ref.1 for more details).

COMPOSITIONAL ANALYSIS BY X-RAY MICROANALYZER

The failed sample obtained from q_u test was performed with a HORIBA X-ray microanalyzer. Peak element ratio (PER) and surface area ratio (SAR), defined as ratios of intensities of each constitutive element to Ca on **specific section** and **entire viewing surface** respectively, are proposed as two significant ratios.

RESULTS AND DISCUSSION

It has been accepted that C-S-H product cured at ordinary tempt. has a Si/Ca ratio of 0.5-0.7. Based on the results obtained from line analysis, predicted ratios corresponding to dominant reaction products are then proposed in Table 2. PER of higher value (generally larger than 1.5) was found in unreacted zone or particle. A notch-like distribution of PER across a section (see Fig.1) can refer to weak section or weak seam, resulting in a low

TABLE 2 Predicted element ratios of reaction products

REACTION PRODUCT	CHEMICAL FORMULAR	ELEMENT RATIO FROM FORMULAR	ELEMENT RATIO PREDICTED FROM EDX
C-S-H groups	$3CaO \cdot 2SiO_2 \cdot 3H_2O$	Si/Ca = 0.66	Si/Ca = 0.50-0.70
Ettringite and	$3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$	Al/Ca = 0.33, S/Ca = 0.50	Al/Ca = 0.20-0.30, S/Ca = 0.10-0.50
Monosulphate groups	$3CaO \cdot Al_2O_3 \cdot CaSO_4 \cdot 12H_2O$	Al/Ca = 0.50, S/Ca = 0.25	
Calcium carboaluminate	$3CaO \cdot Al_2O_3 \cdot CaCO_3 \cdot 12H_2O$	Al/Ca = 0.25	Al/Ca = 0.25-0.35
Calcium carbonate	$CaCO_3$		Si/Ca < 0.50
Calcium hydroxide	$Ca(OH)_2$		Al/Ca < 0.20
Calcium sulphate	$CaSO_4$		S/Ca < 0.10

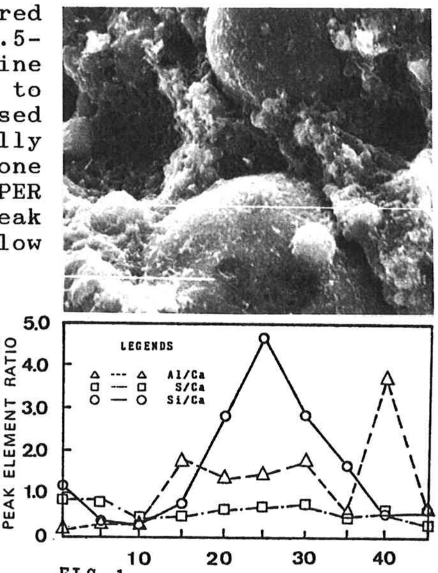

FIG.1 SEM-EDX analysis and PER distributions of FG sample observed at 3 days (X2000)

stability but large deformation. However, it was apparent that PER tended to reduce its value into the ranges of predicted PER (Table 2) as curing periods increased (see Fig.2). SAR can also represent rigidity of microsection as the value had a prone to fall into predicted PER ranges (see Table 3). For only lime -fly ash, neither the PER nor SAR tended to incline into the predicted ranges though curing time increased (see Fig.3). The strength characteristic curves of two mixtures are given in Fig.4. It is apparent that fly ash mixed with G may even be used as base course material, and thus small amount of chemical additives added into lime could improve hardening characteristic of fly ash.

TABLE 3 SAR of FG sample at various curing days

ELEMENT RATIO	SURFACE AREA RATIO			
	3 DAYS	7 DAYS	28 DAYS	90 DAYS
Al/Ca	0.37	0.22	0.24	0.24
S/Ca	0.38	0.12	<0.1	0.18
Si/Ca	0.75	0.51	0.25	0.54

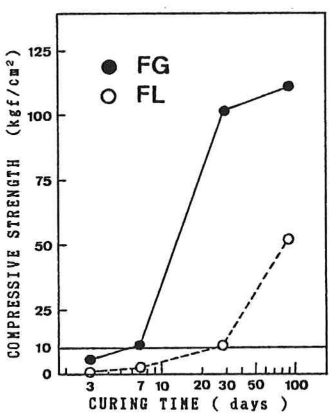

FIG.4 Strength-characteristic curves of stabilized fly ash

CONCLUSION

1) PER and SAR may be used as indicators for strength test for stabilized soil in the future. The test can be assumed to be a non-destructive testing method since it requires only a few specimen for analysis.

2) A knowledge of PER associated with SAR can elucidate reaction mechanism, including strength-imparting mechanisms of stabilized soil.

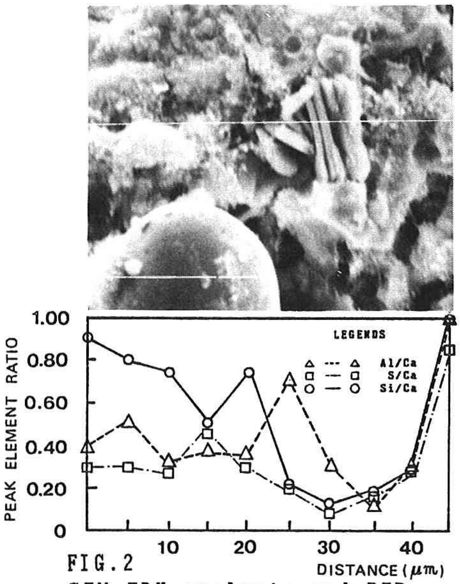

FIG.2 SEM-EDX analysis and PER distributions of FG sample observed at 90 days (X2000)

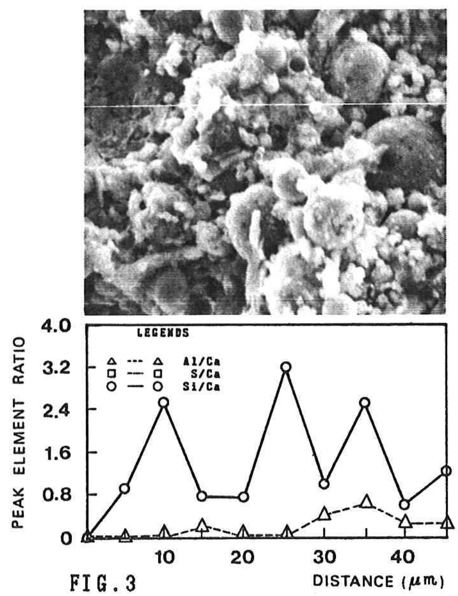

FIG.3 SEM-EDX analysis and PER distribution of FL sample observed at 90 days (X2000)

REFERENCE

1) KAMON, M. et al (1987);"The utilization of various waste materials by cement hardening", Review of The 41st General Meeting, Technical Session, CAJ, pp.84-87.