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TECHNICAL APPLICATION OF READY MIXED CONCRETE SLUDGE WATER TO CEMENT MATRIX

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ABSTRACT

A by-product, waste sludge water produced from ready mixed concrete(remicon) factories may affect our environmental contamination if it is discharged without proper waste disposal. In Korea, all waste sludge water has been recycled in the way of mixing water of remicon, but the quality of the concrete then produced can be deteriorated, so it might cause slump loss or irregular compressive strength. In this study, waste sludge water is divided into two parts, remicon sludge and residual water in order to make it's property more stable. Then, the remicon sludge and high-alkaline residual water were used as admixture and alkali activator respectively. In this paper we research about quality of with remicon sludge and residual water and performed the fundamental properties of cement matrix mixed with remicon sludge and residual water.

KEYWORDS: Waste sludge water; Remicon sludge; Residual water; Latent hydraulic property, Alkali activator, GGBF Slag

1. INTRODUCTION

Remicon sludge water is an industrial waste generally produced by washing following things; remicon which is sent back, mixer truck, drum and batch plant. As 109 million tons of remicon were made in Korea in 2000, quantities of the sludge water concomitantly produced were around 23 million tons. If the sludge water, irrefutably an industrial waste, is discharged without taking proper measures, it can cause severe environmental contamination and destroy our balanced ecosystem. Thus, the remicon factories have traditionally neutralized it with chemicals such as SO_4 before they discharge it, or have some waste disposal company process the brought-in materials. However, due to the increase of the expense for disposal in Korea, remicon factories have chosen the alternate way of recycling the sludge water as mixing water. In that case, as the varying remicon-output per day, the concentration of solid powder in sludge water would not be constant, so that adjusted mixture should be followed. If such is the case, the values of compressive strength would be inconsistent, and problems such as increase of quality deviation or deteriorated workability can occur.

In this study, waste sludge water is divided into two parts, remicon sludge and residual water. Then, the sludge is used as an admixture in concrete through drying and grinding processes, and high-alkalinic residual water is used as an alkali activator which accelerates latent hydraulic property of ground granulated blast furnace slag. The mentioned processes illustrated high probability of economical production of high-quality concrete.

2. MATERIALS

2.1 Cementent and Mineral Admixtures

Ordinary Portland Cement (OPC), Ground Granulated Blast Furnace Slag(SG) and Dried Grounded Sludge(DGS) were prepared. The chemical composition and physical properties of materials are shown in Table 1.

2.2 Mixing Water

Residual water(RW) is obtained after extracting only the clean water at the top of the sedimentation tank. In Table 2, the ingredients and chemical characteristics of residual water and tap water(W) are shown.

2.3 Aggregates

River sand as a fine aggregate and crushed stone as a coarse aggregate were used. The physical properties of these aggregates are shown in Table 3.

2.4 Chemical Admixture

The main component of the AE water reducing agent(AEWR) was lignin sulfonate composites. The chemical composition and physical properties of the chemical admixture are shown in table 4.

Table 1. The chemical composition and physical properties of materials

Items / Types	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	SO_3 (%)	Specific gravity	Ig. loss (%)	Specific surface area (cm^2/g)
OPC	20.68	5.16	3.02	62.42	4.71	2.42	3.15	1.36	3,438
SG	31.93	13.27	0.26	42.73	6.53	3.11	2.94	0.21	4,559
DGS	39.73	13.33	5.11	36.92	2.64	2.41	2.30	18.49	4,300

Table 2. The chemical characteristics of residual water and tap water

Items / Types	pH	Cl^- (ppm)	Na^+ (ppm)	K^+ (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)
Residual water	12.8	82.7	123	22.7	1,200	0.02
Tap water	7.45	11.1	7.08	0.15	24.9	5.40

Table 3. The physical properties of the aggregates

Items / Types	G_{max} (mm)	Specific gravity	Absorption (%)	Fineness modulus	Unit weight (kg/m^3)	Percentage of solids (%)
Fine aggregate	-	2.60	1.20	2.50	1,620	62.3
Coarse aggregate	25	2.63	0.80	6.31	1,410	53.6

Table 4. The chemical composition and physical properties of the AEWR

Items / Types	Component	Specific gravity	Characteristic	Standard dosage (C x %)
AEWR	Lignin sulfonate composites	1.245 ±0.005	Dark brown	0.2 – 0.5

3. MIXTURE

3.1 Cement Mortar

The mortar mixtures, in which SG is replaced with cement 50% and from 0, 3, 6, 9 and 12% remicon sludge is respectively mixed at the same time, are mixed. In addition, the mortar specimens, and residual water is mixed at the rate of 0, 25, 50, 75, and 100% at the same time, are mixed. Then flow values are tested, and compressive strength is also measured at the age of 3, 7, and 28 days. Classifications of the mortar mixtures are shown in table 5

3.2 Concrete

In concrete mixtures, design strength was 300kgf/cm^2 and target slump was 15±1.5cm. The concrete specimens, in which SG is replaced with cement at the rate of 50%, and residual water is respectively mixed at the rate of 0, 50 and 100% of water at the same time, are mixed. Then compressive strength values are measured at the age of 3, 7, and 28 days. Classifications of the concrete mixtures are shown in table 6

Table 5. Mix proportion of mortar

Items / Types	Ratio of SG	Dosage of RS & RW (%)
Mixing RS	SG 0	RS 0, 3, 6, 9, 12
	SG 50	
Mixing RW	SG 0	RW 0, 50, 100
	SG 50	

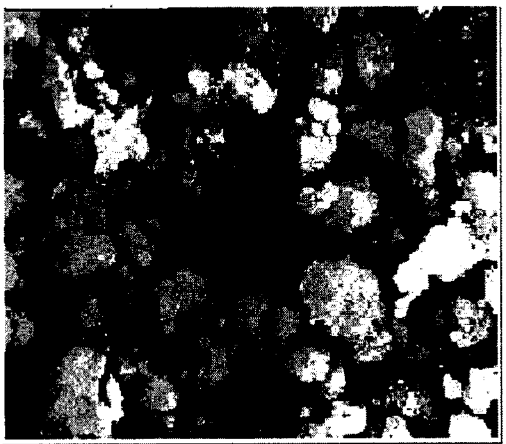
Table 6. Mix proportion of concrete

Types \ Items	W/B (%)	S/a (%)	Unit Weight (kg/m³)							
			W	C	SG	DGS	RW	S	G	AEWR
OPC	50	46	175	350	0	0	0	800	963	C x 0.3%
SG50	σ	σ	175	175	175	0	0	795	959	σ
SG50 DGS 3	σ	σ	175	175	175	10.5	0	784.5	959	σ
SG50 DGS 6	σ	σ	175	175	175	21	0	774	959	σ
SG50 RW50	σ	σ	87.5	175	175	0	87.5	795	959	σ
SG50 RW100	σ	σ	0	175	175	0	175	795	959	σ

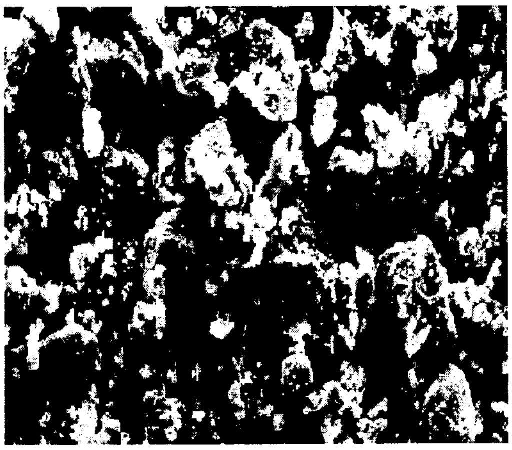
4. RESULTS AND DICUSSION

4.1 Characteristics of DGS and Residual Water

The particle shapes of DGS and OPC are compared in images in the scanned photomicrographs from electron microscope. They are shown in figure 1.



DGS particles



OPC particles

Figure 1. SEM of DGS and OPC (x 2000)

Figure 1. shows the particle shapes of DGS similar to those of OPC, minute and comparatively bigger particles are mixed. The bigger particles can be guessed as a part of fine aggregate remained in the DGS. X-ray diffraction pattern of DGS is shown in figure 2.

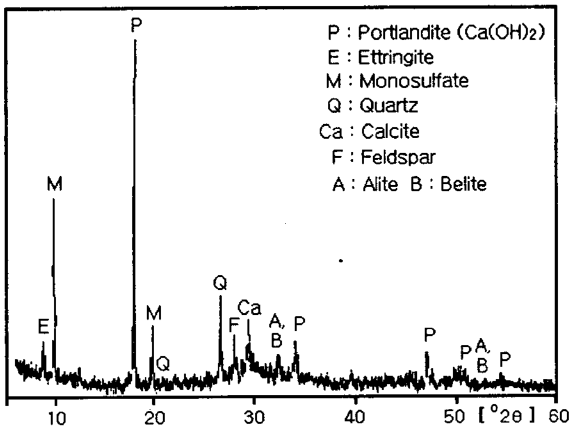


Figure 2 XRD patterns of DGS

Figure 2. shows main peak of $Ca(OH)_2$ hydrates and coexistence of both ettringite and monosulfate indicating hydration is in some measure proceeded. Moreover, both of the alite and belite indicate the possibility of additional reaction as remicon sludge starts hydration again. The peaks of quarts and feldspar mean fine grains from fine aggregate still remain in the DGS.

Table 2. shows contents of Ca^{2+} ions are the most plentiful of all components in residual water, and the next most abundant ions are Na^{+} and Cl^{-} which is from the sea sand in mixing remicon. Besides, lots of basic ions like Ca^{2+}, Na^{+}, and Mg^{2+}, make its high alkali of pH 11 ~ 13.

4.2 Properties of Cement matrices using DGS

Experimental results of mortar and concrete mixed DGS were presented in figure 3,4. figure 3 shows that compressive strength of mortar with elapsed ages. Figure 4 was the result of concrete. From the figures compressive strength of all mixtures of cement matrices was increased in proportion to the mixing ratio of DGS.

The reasons are, first of all, main component DGS is $Ca(OH)_2$ which can accelerate latent hydraulic property of SG when hydration is processed, so early age strength can be improved. The second reason would be that grinding process in ball mills might have exposed the unhydrates of DGS powder, and thus additional hydration by them can increase the strength. Third, as a result of grinding, the size of sludge powders became smaller, so they act as a filler which fill up the space in-between cement matrices.

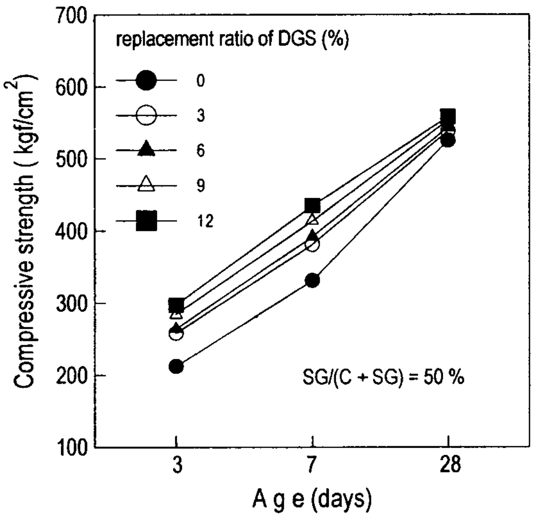


Figure 3 Compressive strength of mortar using DGS

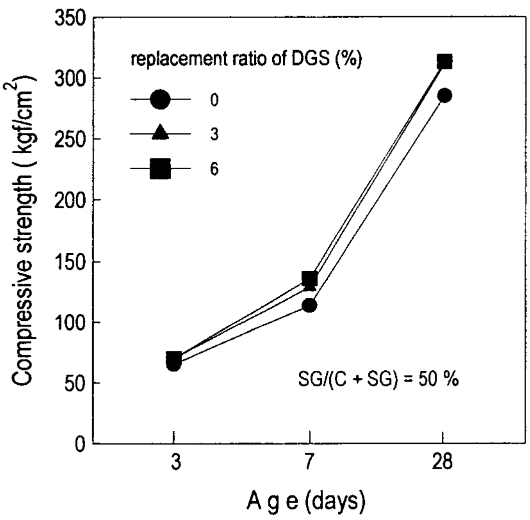


Figure 4 Compressive strength of concrete using DGS

4.3 Properties of Cement matrices using RW

Compressive strength values of cement matrices mixed with residual water are shown in figure 5,6.

From the figures we knows that the cement matrices mixed with RW were superior in compressive strength to those mixed with only water, and figures shows compressive strength was increased according to the amount of RW.

This tendency of concrete mixed with RW is due to high alkali over pH12 and plentiful $Ca(OH)_2$ of RW, which can accelerate latent hydraulic property of SG when hydration is proceeded.

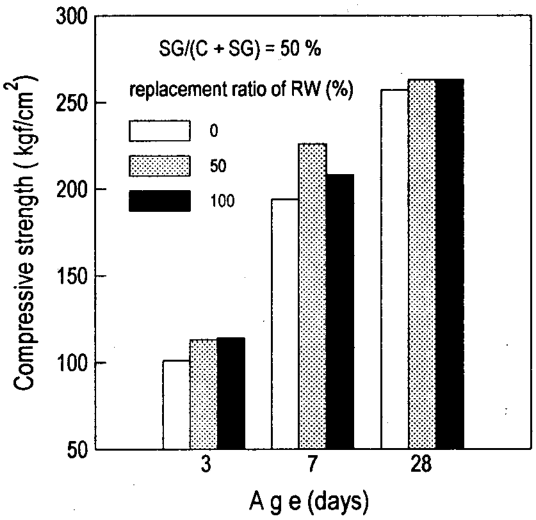


Figure 5 Compressive strength of mortar using RW

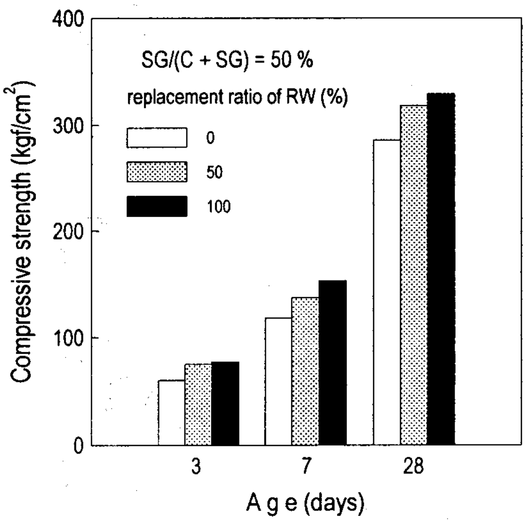


Figure 6 Compressive strength of concrete using RW

5. CONCLUSIONS

- From the results compressive strength of all mixtures of cement matrices was increased when mixing DGS. The reasons are, it can be accelerate the latent hydraulic property of SG, has a possibility of additional hydration by the exposed unhydrates and has a role of filler which fill up the void of cement matrices

- In the case of mixing residual water in cement matrices, compressive strength values are improved at all ages, because of RW has a plentiful of $Ca(OH)_2$ so high-alkalinic residual water is used as an alkali activator which can accelerates latent hydraulic property of SG.

- As a result of this study, remicon sludge and residual water are not any more materials occurring environmental problems or disposal expenses but materials that can be used both effectively and economically in cement matrices mixed with SG.

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