The 6th International Symposium on East Asian Resources Recycling Technology
October 23 - 25, 2001, Gyeongju (慶州), Korea
ISBN: 89-952527-0-7 93530

Fundamental Properties of Concrete Using the Ground Calcium Slurry Carbonate

Han-Young Moon, Ho-Seop Jung, Doo-Sun Choi

1) Dept. of Civil Engineering, Hanyang University, KOREA
2) Dept. of Civil Engineering, Hanyang University, KOREA
3) Dept. of Civil Engineering, Hanyang University, KOREA

Nowadays, according to the trend of a high performance of concrete structure, the research results have been announced for the purpose to make the high quality. With this respect, we began research to use the Ground Calcium slurry Carbonate (GCC) to a concrete admixtures which ground the limestone until about 1.5㎛. In this paper, we examined the quality of GCC to fine out the value in use as the concrete admixtures. And mechanical properties of concrete using cement blended with GCC, silica fume and mixed two were investigated. It was result from this study that air contents of concrete replaced with GCC were constant regardless of replacement ratio, but the more GCC it had the use of, the less slump was measured. Especially 10% GCC concrete had a good result of compressive strength. In case of mixture with GCC and silica fume, the workability and compressive strength don't seem to be any problems. In the scope of this study it was indicated that the most reasonable replacement with GCC was 10% of cement weight as concrete admixture.

1. INTRODUCTION

Recently, we emphasize and are interested in high strength and high performance concrete, so these concrete have been widely used in civil engineering [1, 2]. To make the concrete of the high quality, the much kind of mineral and chemical admixtures have been developed. Among these by-products, silica fume (SF), ground granulated blast furnace slag (GGBS) and fly ash were representatively mineral admixtures. Many researchers are studying to use these materials for high quality concrete [3, 4].
JDC (Japan Development Corporation) developed a high fluidity and high strength concrete, which ensured high workability and strength at the same time with inorganic chemistry - F Corporation [5]. It was large developed workability as the some adds the Ground Calcium Carbonate (GCC) ultra particle slurry.
The GCC, ultra particle, were verified that it can be easily mixed at a cement particle interval in slurry and can be attained effect of development of workability of concrete as the some adds because the GCC existence to scattered at the particle of the individual situation to be become independent.
In this paper, the aim is a study on the using the GCC as concrete admixture materials. We fixed water-binder ratio by 35%, and changed the replacement ratio of GCC and silica fume to the by 0, 5, 10, and 15% of cement weight, respectively. So we found out fundamental properties of matter according to the replacement ratio of the mortar and then serve also because we find out the senior relation of Silica fume with GCC, did the total amounts of GCC and silica fume to the by 10% of a cement weight.
The alternate material of the silica fume utilizes the GCC as a concrete admixture in this research. We changed each mixing rate to 5 kinds to 10:0, 7:3, 5:5, 3:7, and 0:10, respectively and considered about fundamental properties of matter such as the flow value, air content and compressive strength of the mortar.

2. Experiment / Modeling

2.1 Materials

(1) Cement: Ordinary Portland Cement (OPC) as specified in KS L 5201(Portland cement) was used in all concrete mixtures. Its physical properties and chemical compositions are given in Table 1.
(2) Aggregates: The coarse aggregate was crushed limestone with a nominal maximum size of 20.0mm. Its specific gravity and absorption are 2.62, 0.82 respectively. And we are used both natural sand and crushed sand which specific gravity 2.59, fineness modulus 2.17 and specific gravity 2.6, fineness modulus 3.18, respectively. They mixed to modify fineness modulus by 2.80. Its physical properties of the coarse and fine aggregates are given table 2.

Table 1 Physical properties and chemical composition of OPC

Density (g/cm^3)	Specific surface area (cm^2/g)	Setting time (hr : min)		Compressive strength (MPa)		
		Initial set.	Final set.	3d	7d	28d
3.15	3,280	3 : 41	6 : 01	22.6	31.6	38.7
Chemical composition (%)						
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	I g. loss
21.7	5.7	3.2	63.1	2.8	2.2	1.3

Table 2 Physical properties of aggregates

	G_{max} (mm)	Specific gravity	Absorption	F.M
Fine aggregate	-	2.60	1.2	2.8
Coarse aggregate	20	2.62	0.8	7.3

(3) Superplasticizer (SP): Malialim A–20 that a comercially available poly carbonic acid base superplastcizer was used by 1.8% of a cement weight. Table 3 showed that general properties of it.

Table 3 Physical properties of superplasticizer

Main component	Polycarbonic acid based compound
Appearance	Dark brown liquid
Solid content	20%
Specific gravity	1.04 ± 0.02
pH	2.5 ± 1.0

(4) GCC (Ground Calcium Carbonate): Ground calcium carbonate that had been made by crushed is wet process was used. It is slurry with 1.5μm average particle size.

2.2 Experiment Methods

Slump, air contents, compressive strength and split tensile strength test of concrete were according to KS F 2402 (Testing method for slump of Portland cement concrete), KS F 2421 (Method of test for air content of fresh concrete by the pressure method), KS F 2403 (Method of making and curing concrete specimens), 2405 (Method of test for compressive strength of concrete) and KS F 2423 (Method of test for splitting tensile strength of concrete).

2.3 Mix Proportion

It changed that the water-binder ratio is 30, 35 and 40%, maximum size of coarse aggregate is 20mm in all batches. GCC and silica fume blended to 5, 10 and 15% of binder weight and those admixtures blended to 10% of binder at the same time. The proportion of the concrete mixtures is summarized in Table 4.

Table 4 Concrete mix proportions

Items / Types	G_{max}	W/C (%)	Air (%)	Slump (cm)	S/a	Unit weight (kg/m^3)					
						W	C	S	G	GCC	SF
OPC30	20	30	2 ± 0.5	16 ± 2	39	165	550	645	1,028	0	0
OPC35	20	35	2 ± 0.5	16 ± 2	39	165	471	670	1,068	0	0
OPC40	20	40	2 ± 0.5	16 ± 2	39	165	413	689	1,098	0	0
G5W35	20	35	2 ± 0.5	16 ± 2	39	165	473	660	1,054	23.6	0
G10W30	20	30	2 ± 0.5	16 ± 2	39	165	550	625	996	55.0	0
G10W35	20	35	2 ± 0.5	16 ± 2	39	165	471	651	1,043	47.1	0
G10W40	20	40	2 ± 0.5	16 ± 2	39	165	413	674	1,073	41.3	0
G15W35	20	35	2 ± 0.5	16 ± 2	39	165	471	644	1,027	70.1	0
S5W35	20	35	2 ± 0.5	16 ± 2	39	165	471	659	1,050	0	23.6
S10W30	20	30	2 ± 0.5	16 ± 2	39	165	550	618	986	0	55.0
S10W35	20	35	2 ± 0.5	16 ± 2	39	165	471	647	1,032	0	47.1
S10W40	20	40	2 ± 0.5	16 ± 2	39	165	413	669	1,066	0	41.3
S15W35	20	35	2 ± 0.5	16 ± 2	39	165	471	636	1,014	0	70.7
G7S3	20	35	2 ± 0.5	16 ± 2	39	165	471	651	1,038	33.0	14.1
G5S5	20	35	2 ± 0.5	16 ± 2	39	165	471	650	1,037	23.6	23.6
G3S7	20	35	2 ± 0.5	16 ± 2	39	165	471	649	1,035	14.1	33.0

* sp : binder * 1.8%

3. Results and Discussion

3.1 Physical properties of Ground Calcium Carbonate Slurry

The carbonic acid calcium is the material that the Ca^{2+} ion is combined with the CO_3^{2-} ion as the $CaCO_3$. The carbonic acid calcium exists among them to the gel phase. So, the peak is not discovered in XRD analysis [8].

Crystal form of carbonic acid calcium classified as the calcite, aragonite and vaterite. The most stable form is calcite and the unstable is vaterite. If not exist water on normal temperature and pressure, vaterite and aragonite are not changed to calcite. But aragonite and vaterite are changed by endothermic reaction at about at 500℃, and by

endothermic reaction exothermic reaction at about 470℃, respectively.
In this paper, result from the using GCC that crushed to be wet process; solid content is 75%. The other physical properties are given in Table 5.

Table 5 Physical properties of Ground Calcium Carbonate

Solid content (%)	≥75
Whiteness (%)	≥94
Viscosity (cps) (B-type, 60 rpm)	≤200
pH	10 ±0.5
Specific gravity	2.74

X-ray diffraction analysis of GCC, which dry powdered, and particle distribution of GCC slurry are shown in fig 1 and fig 2. We can know if we see them, XRD main peak located around 30 degree so main component is calcite. And it was ultra powder by average of particle size was 1.5㎛.

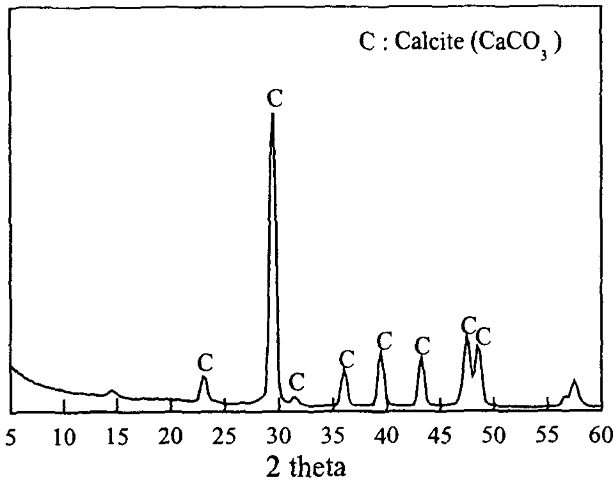

Fig 1 XRD of Ground Calcium Carbonate

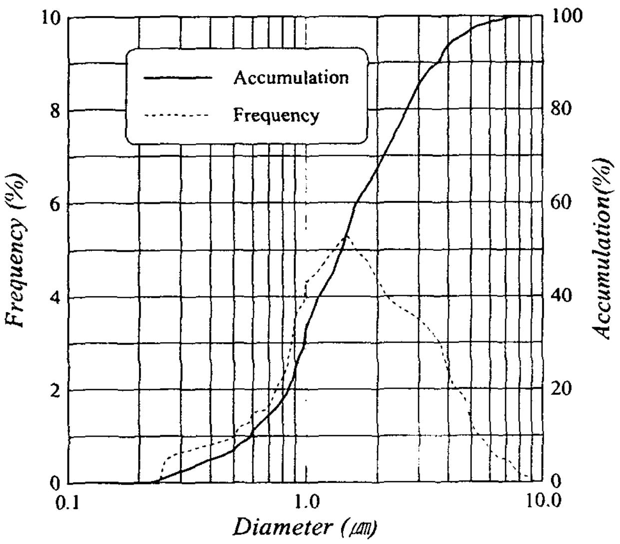

Fig 2 Distribution curve of Ground Calcium Carbonate

3.2 Fundamental properties of concrete using the Ground Calcium Carbonate Slurry

We experimented to find out the characteristic to use GCC as the concrete materials. First of all, if it was fixed to water-binder ratio by 0.35, relationship between slump value and air contents of concrete according to replacement ratio of GCC and silica fume is shown in fig 3 and fig 4, respectively.
Result from this study showed that air contents of concretes were constant regardless of replacement of GCC as less than 2% and slump value of concretes, which is 14 ~ 18cm, were decreased with replacement of it, in fig 3. But, in fig 4, slump value of silica fume concrete was increasingly up to 10% of replacement of silica fume, and reduced after than. According to the replacement ratio, air content was increased with replacement of silica fume.

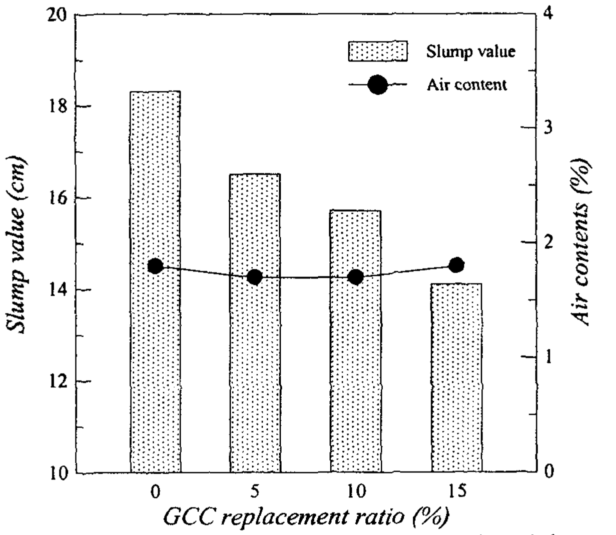

Fig 3 Relationship between GCC replacement ratio and slump value, air contents of concrete

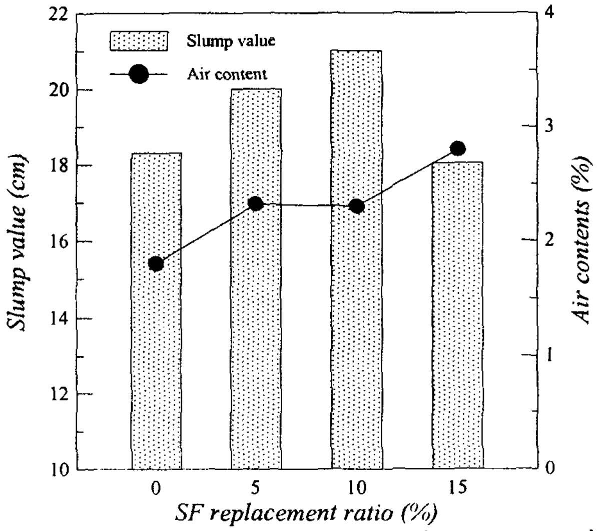

Fig 4 Relationship between silica fume replacement ratio and slump value, air contents of concrete

We considered also the result about the compressive strength with replacement of GCC and silica fume. The results are shown in fig. 5 and fig. 6. We can know from these figures, compressive strength of concrete was expressed most value, about 68Mpa, at the 10% of GCC

replacement ratio, increased up to 10% of replacement of silica fume, and reduced over that ratio.
The compressive strength expressed almost similar tendency as a GCC replacement ratio increased. From results of experiment, we confirmed a best-suited replacement ratio of GCC exists.

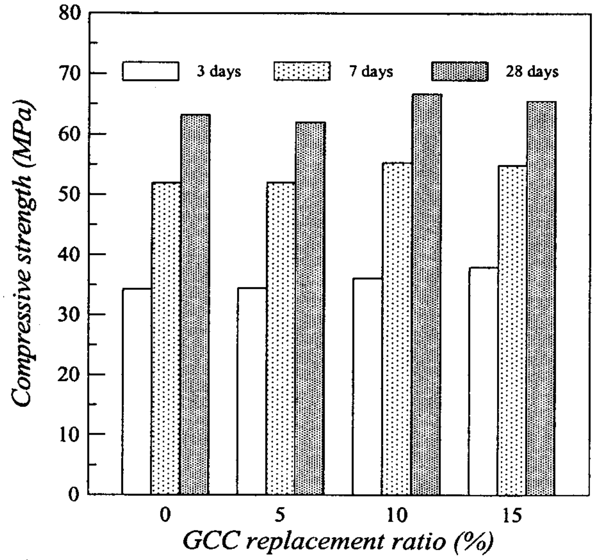

Fig 5 Compressive strength according to GCC replacement ratio

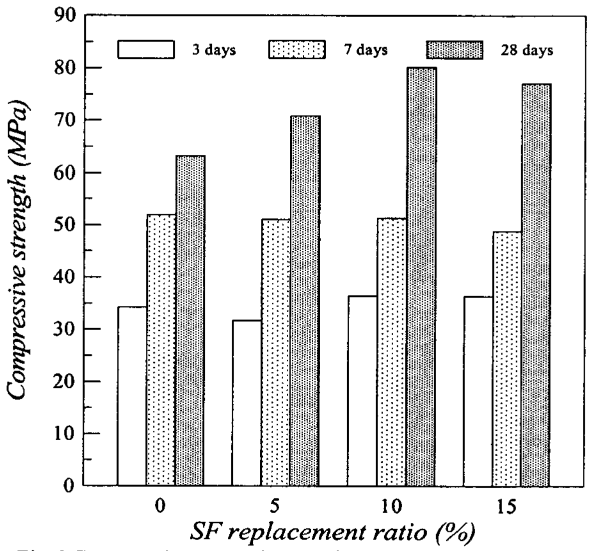

Fig 6 Compressive strength according to SF replacement ratio

The next is split tensile strength according to the replacement ratio and compressive strength ratio according to the water-binder ratio. Those results are shown in fig 7 and fig 8, respectively. At the fig 7, split tensile strengths are increased up to 10% of GCC and silica fume replacement ratio, but reduced over that replacement ratio of GCC and continuously increase over that of silica fume. Fig 8 was shown compressive strength ratio of OPC, GCC and SF concrete. The control concrete is OPC concrete that made by water-binder ratio 30%, 35% and 40% respectively. As we can see, regardless water-binder ratio, compressive strength ratio of GCC concrete is lager than OPC concrete but smaller than SF concrete. Result from this study, we known that using the GCC as concrete admixture 10% of replacement ratio

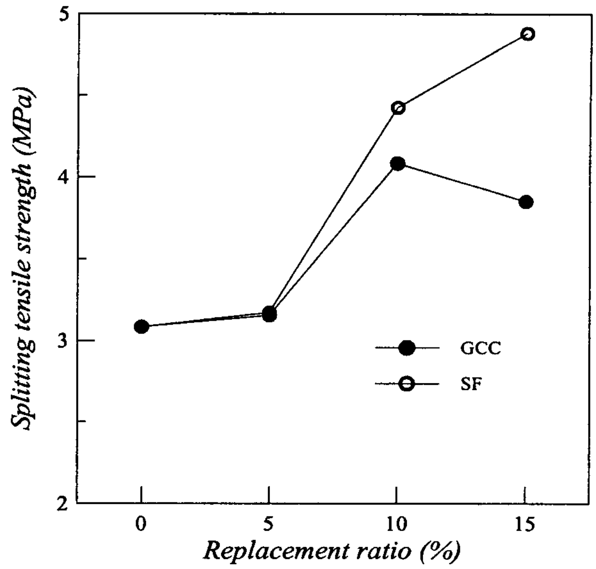

Fig 7 Splitting tensile strength according to replacement ratio

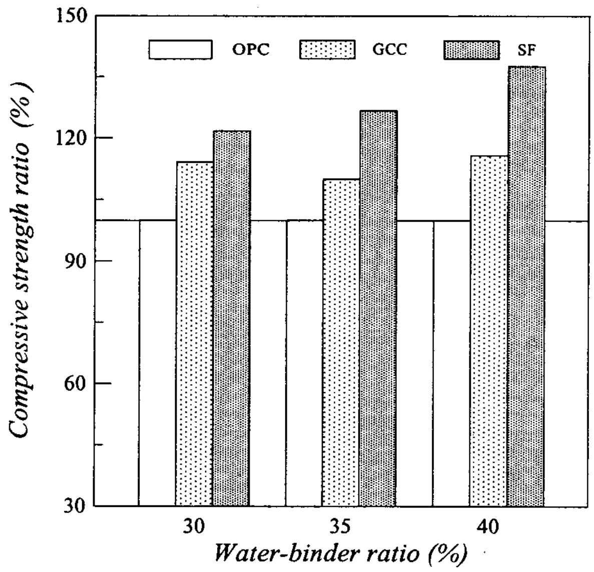

Fig 8 Compressive strength ratio according to the water-binder ratio

3.3 Characteristic of the concrete using the Ground Calcium Carbonate Slurry and silica fume at the same time

From now, we considered with respect to ground calcium carbonate and silica fume were blended to concrete at the same time. We fixed water-binder ratio to 35%, the variable did ground calcium carbonate and silica fume to the 5 level. The results are shown in fig 9 and fig 10.
When used at the same time GCC and silica fume 10% of weight of cement, the interrelationship according to the replacement ratio does not exist in the slump value and air contents. But the strengths grew bigger as many silica fumes treated and was there in the compressive strength and splitting tensile strength. The reasons are because silica fume has latency hydraulicity and pozzolanic material. But GCC is chemically stabilized to the compared with the silica fume.

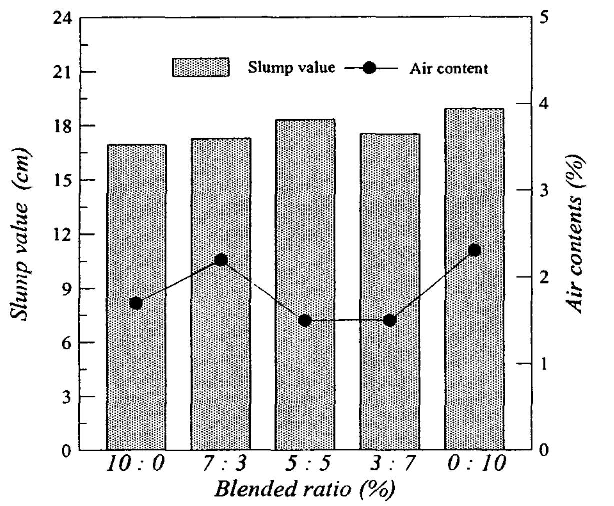

Fig 9 Relationship between blended ratio and slump value and air content

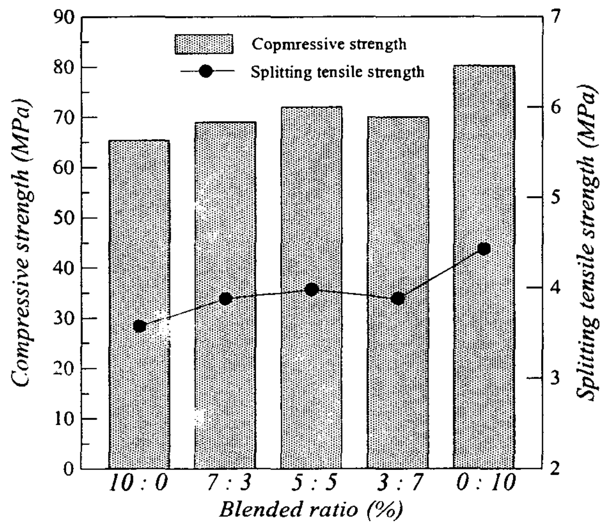

Fig 10 Relationship between replacement ratio and compressive strength and splitting tensile strength

4. Conclusion

As research to use the ground calcium carbonate to a concrete material, we got the conclusion following.
(1) Result form the using GCC which crushed to be wet process, it was showed that solid content is 75%, pH value 10 ±0.5, specific gravity is 2.74 and average particle size is 1.5㎛.
(2) Results from this study showed that air contents of concrete was constant regardless of replacement of GCC as about 2% and slump of fresh concrete were decreased with replacement of it.
(3) In this paper, it showed that compressive strength ratio of GCC concrete is lager than OPC concrete but smaller than silica fume concrete regardless of water-binder ratio.
(4) This study indicated the most optimum replacement of ground calcium carbonate was 10% of weight of cement as concrete admixture.

References

[1] Alireza Mokhtarzadeh and Catherine French, "Mechanical Properties of High Strength Concrete with Consideration for Precast Applications", ACI Materials Journal, March-April, 2000, pp. 136~147

[2] Tarun R. Naik, Shiw S. Singh and Mohammad M. Hossain, "Properties of High Performance Concrete Systems Incorporating Large Amounts of High-lime Fly-ash", Construction and Building Materials, Vol. 9, No. 4, 1995, pp. 195~204

[3] Michal R. Petrou, et al, " Influence of Mortar Rheology on Aggregate Settlement", ACI Materials Journal, July -August, 2000, pp. 479~ 485

[4] W. Huang, "Properties of Cement-Fly Ash Grout Admixed with Bentonite, Silica Fume, or Organic Fiber", Cement and Concrete Research, Vol 27(2), 1997, pp. 369~380

[5] Y. Xi, D. D. Siemer, B. E. Scheetz, "Strength Development, Hydration Reaction and Pore Structure of Autoclaved Slag Cement with Added Silica Fume", Cement and Concrete Research, Vol 27(1), 1997, pp. 75~82

[6] Nagataki Shigeyosi, et al, "A Study on the Characterization of Silica Fume and the Evaluation of Properties of Concrete Containing Silica Fume", JSCE, No 520, Vol 28, 1995, pp. 87~98

[7] Moon Han-Young, Jung Ho-Seop, Choi, Doo-Sun, "Fundamental properties of Mortar Using the Ground Calcium Slurry Carbonate", Hanyang Univ. Journal of the Construction Research Institute. Vol . 7, 2001, pp. 19 ~26

[8] Korea Britannica Online, "The Calcite" http://dcluxc.britannica.co.kr/bol/topic.asp?article_id=b09b0428a

[9] Haruya Sawara and Tadashi Yamamura, "Concrete properties Which Contain Heavy Calcium Slurry Carbonate Crushed be Wet Process", Proceedings of the Japan Concrete Institute, vol. 22, No.2, 2000. pp. 37~42

[10] K. E. Hassan, J. G. Cabrera, R. S. Maliehe, "The Effect of Mineral Admixtures on the Properties of High-performance Concrete", Cement & Concrete Composites, Vol. 22, 2000, pp. 267~271

[11] Shunsuke hanehara, Kazuo Yamada, "Interaction Between Cement and Chemical Admixture from the Point of Cement Hydration", Absorption Behavior of Admixture, and Paste Rheology, Cement and Concrete Research, Vol 29, 1995, pp. 1159~1165

[12] Wei-Hsing Huang, "Improving the Properties of Cement-Fly Ash Grout Using Fiber and Superplasticizer", Cement and Concrete Research, Vol 31, 2001, pp. 1033~1041

[13] Y. Xu, Y. L. Wong, C. S. Poon and M. Anson, "Impact of High Temperature on PFA Concrete", Cement and Concrete Research, Vol 31, 2001, pp. 1065-1073