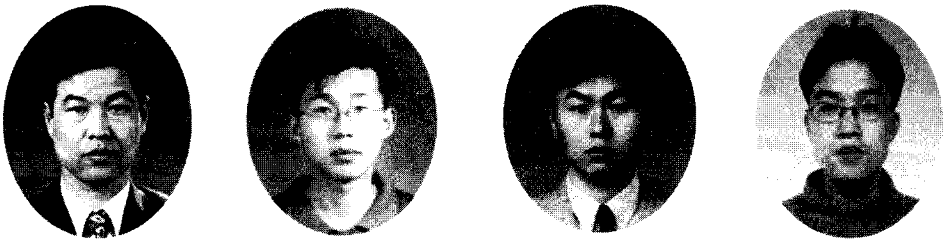
Strength Characteristics of Unsaturated Polyester Resin Mortar using Recycled Fine Aggregates



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ABSTRACT

The purpose of this research is to investigate the utilization of recycled fine aggregates as a material to apply to a building finished walls or as a decorating material in combination with a polymer. The strengths of two resin mortars using recycled fine aggregates and natural fine aggregates was made. In order to improve the workability and the strength of the resin mortar with recycled fine aggregates, partial replacement of recycled fine aggregates with natural ones was made with the application of various type of fillers. The results, it show that the compressive strength and flexural strength of resin mortar using the recycled fine aggregates were about 70% to 100% of those of resin mortar using natural fine aggregates. It was enough to assure the utilization of the recycled fine aggregates as a material for the production of resin mortar. From the result of partial replacement of recycled fine aggregates with natural ones, the compressive strength was increased from 5% to 15% and the flexural strength was much as 5% to 20% as a result of 70% substitution. It was also found that the use of garnet powder shows a similar tendency in the compressive strength and slag powder does in the flexural strength and tensile strength.

Keywords : recycled fine aggregates, unsaturated polyester resin, slag, fly-ash, garnet powder, compressive strength, flexural strength, tensile strength

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1. INTRODUCTION

Most waste concrete lumps generated from a process of demolishing building are buried in the ground, and some of them are crushed and utilized as recycled aggregates. Recycled aggregates have not been practically utilized as concrete aggregates because of its poor quality, but have been limitedly used as a base coarse material for road.

This study investigates the effectiveness of recycling aggregates for building's finishing or decoration with additional use of polymer and has an objective to find the strength characteristics of resin mortar associated with mixing ratio of recycled aggregate and natural fine aggregate, types of filler and volume ratio. This study also intends to improve the quality of recycling aggregates by adding an excellent polyester resin for the improvement of durability, anti-corrosiveness, and strength.

In general, the polymer concrete shows various characteristics according to the type of polymer, the amount of diluent, catalyst, a shrinkage-reducing agent, types of filler and aggregates, fineness modulus and maximum size of aggregate. Therefore, this study aims at investigating the strength characteristics of mortar through parametric study of types of aggregates, volume ratio of filler to binder and types of filler.

2. MATERIALS

2.1 Unsaturated Polyester Resin

Binder for mortar was unsaturated polyester resin, together combined with styrene monomer (SM) as a diluent, methylethyketon peroxide (MEKPO) as an initiat or and cobalt octoate (CoOc) as an accelerator. The properties of unsaturated polyester resin are shown in Table 1.

Table 1 Properties of unsaturated polyester resin used

Specific gravity at 25℃	Viscosity (at 25℃,ps)	Acid value	Styrene Content (%)
1.12	3±30%	23±4	38

2.2 Filler

In this study, blast furnace slag in Kwang-Yang was used for filler. And, garnet powder, which is industrial by-products produced in Young-Joo, and fly-ash produced in Bo-Ryung, were used to make mortar and compare with that using slag powder.

Table 2 Physical properties of fillers

Type of filler	Specific gravity	Blain's specific surface(㎠/g)
Slag	2.88	4,400
Garnet	4.01	13,950
Fly-ash	2.22	3,500

2.3 Aggregates

The recycled fine aggregate(R.S) and the natural fine aggregate(N.S) were used in this study. Recycled fine aggregates were produced from small crusher specially manufactured for this study, and the compressive strength of crushed concrete was from 200 to 300kgf/㎠

According to the result of preliminary experiment, it was impossible to compare strengths of R.S mortar with that of N.S mortar because of the loss of workability associated with much dust attached to

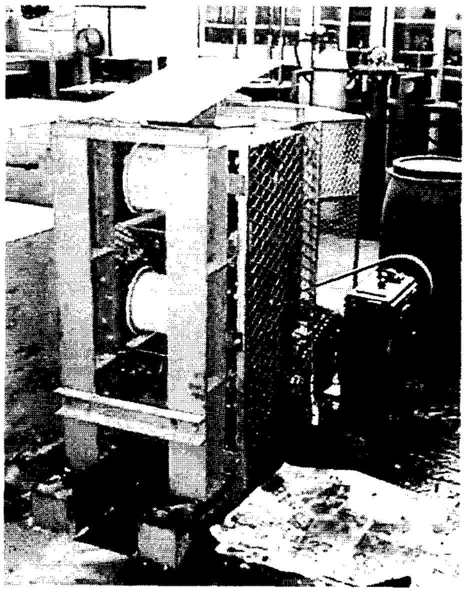


Fig.1 View of Small Crusher

surface of R.S. Therefore, the R.S had not to be used until the dust is washed out.

The physical properties of aggregates are shown in Table 3. The configuration of the small crasher used is shown in Fig.1.

Table 3 Physical properties of aggregate.

Type	Size (mm)	Specific gravity	F.M	Absorptivity (%)
R.S	0.15~4.75	2.45	2.90	4.20
N.S	≤4.75	2.57	2.58	1.69

R.S : Recycled fine aggregates
N.S : Natural fine aggregates

3. EXPERIMENTAL PROGRAM

3.1.Mix Proportions of Resin Mortar

Strengths of resin mortar using the recycled fine aggregate(R.S) with those using natural fine aggregate(N.S) were compared at first. It was estimated the strength characteristics respectively according to the substitutional ratio of natural fine aggregates and of filler type to promote the strength of resin mortar. The experimental mixing proportion was planned to acquire optimum workability and filling capability of resin mortar mixed with the recycled fine aggregate. The mixing proportion plan of this experiment is shown in Table 4, 5 and 6.

Table 4 Mix proportion of mortar (series-I)

Type of sand	Filler-binder ratio (vol%)	MIix proportion (vol%)		
		Polyester	Slag	R.S (N.S)
R.S N.S	15	38.3	6.8	55
	20	36.0	9.0	
	25	33.8	11.3	
	30	31.5	13.5	
	35	29.3	15.8	
	40	27.0	18.0	
	15	34.0	6.0	60
	20	32.0	8.0	
	25	30.0	10.0	
	30	28.0	12.0	
	35	26.0	14.0	
	40	24.0	16	
	15	29.8	5.3	65
	20	28.0	7.0	
	25	26.3	8.8	
	30	24.5	10.5	

Table 5 Mix proportion of mortar (series-II)

N.S /(R.S +N.S) (vol%)	Filler-binder ratio (vol%)	MIix proportion(vol%)		
		Polyester	Slag	Sand
0, 30, 50, 70, 100	20	36.0	9.0	55
	25	33.8	11.3	
	30	31.5	13.5	
	35	29.3	15.8	

Table 6 Mix proportion of mortar (series-III)

Type of Filler	Filler-binder ratio (vol%)	Mix proportion(vol%)		
		Polyester	Filler	R.S
Slag Garnet Fly-ash	15	38.3	6.8	55
	20	36.0	9.0	
	25	33.8	11.3	
	30	31.5	13.5	
	35	29.3	15.8	

3.2 Fabrication and Curing of Specimen

The specimen were manufactured according to KS F 2419 (Method of Making Polyester Resin Concrete Specimen). Size of specimen for the measurement of compressive and flexural strength were 40×40×160mm, those for tensile strength were ϕ50×100mm.

Specimens had been cured in the curing room for 7 days keeping the temperature of 20℃ and humidity of 50±5%.

3.3 Strength Test Method

Compressive, flexural and splitting tensile strength tests were performed in accordance with the KS F 2481 (Method of Test for Compressive Strength of Polyester Resin Concrete), KS F 2482 (Method of Test for Flexural Strength of Polyester Resin Concrete), and KS F 2480 (Method of Test for Tensile Strength of Polyester Resin Concrete).

4. TEST RESULTS AND DISCUSSION

4.1 Workability of Resin Mortar

It is known that the workability of resin mortar mixed with N.S is better than that of resin mortar mixed with R.S. It may be due to the weak mortar sticked to R.S. In case that mixing volume of aggregate is 65%, the workability of resin mortar using R.S was decreased significantly in compare with resin mortar using N.S.

In series-Ⅱ performed to compensate the loss of workability and strengths by the R.S, the workability was improved with increasing the substitutional ratio of N.S. In series-Ⅲ, the workability was improved in order of slag, fly ash, and garnet powder. This reason seems to be surface texture and fineness of powder.

The test specimens of resin mortar using R.S and N.S are shown in Fig.2.

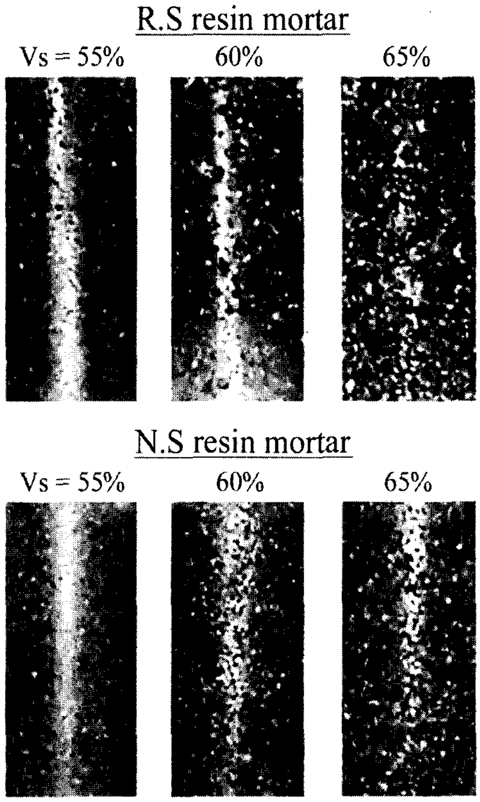
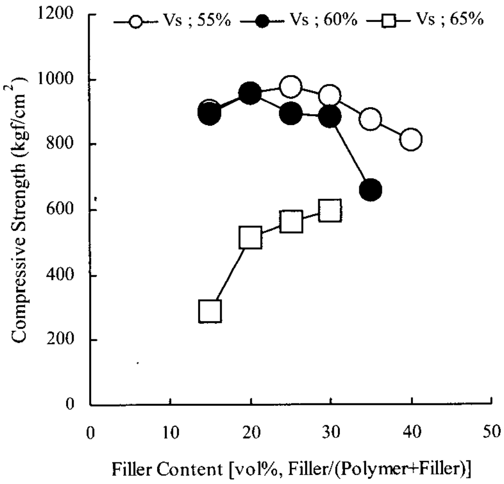


Fig.2 Figure of mortar specimen

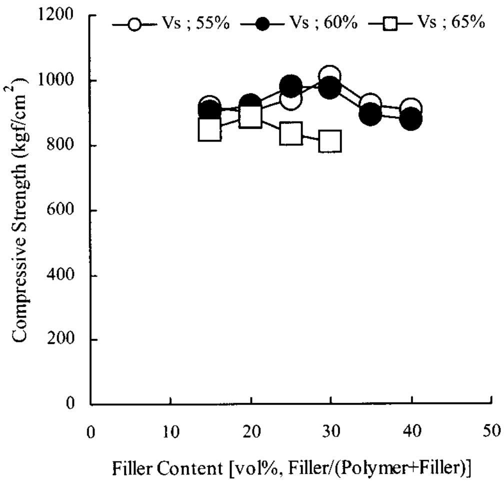
4.2 Strength Characteristics of Resin Mortar Using Recycled Fine Aggregates (series Ⅰ)

Fig.3 shows the effect of filler content, types of aggregates and volume of aggregate on the compressive strength. The compressive strength of R.S mortar showed 34% to 106% against N.S mortar. However, R.S mortar had almost similar strength when volume of fine aggregates was ranged from 55% to 60%. It is shown that the maximum volume of R.S was 60%. On the other hand, compressive strength of resin mortar increased with increasing filler content, and maximum strength of R.S mortar and N.S mortar obtained in the filler contents of 25% and 30%, respectively.

Fig.4 shows the effect of filler content, aggregates type and aggregates volume on the flexural strength of resin mortar. Similar to above result, the compressive strength of R.S mortar showed 66% to 103% against N.S mortar, and it has almost similar strength when volume of fine aggregates was ranged from 55% to 60%. The optimum percentage of filler to

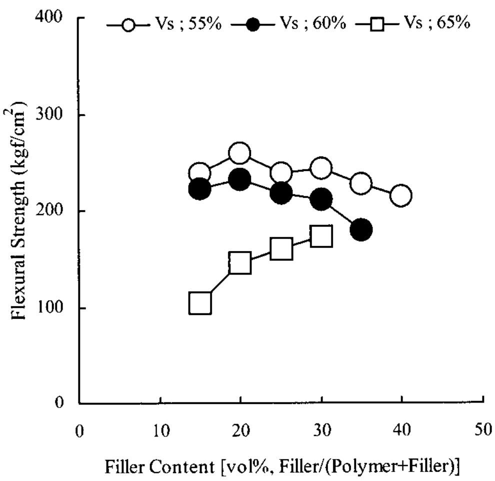


(a) Resin mortar using R.S

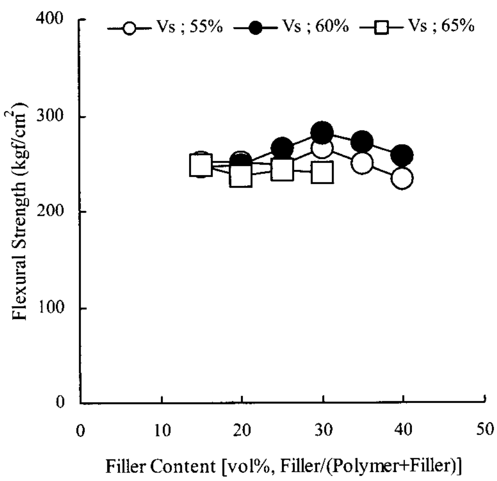


(b) Resin mortar using N.S

Fig.3 Effect of filler content, types of aggregate and volume of aggregates on compressive strength of resin mortar

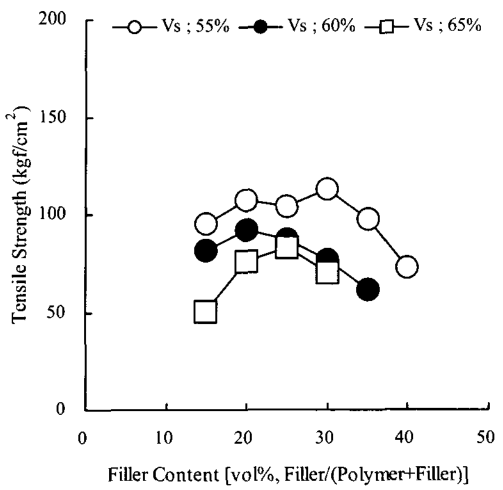


(a) Resin mortar using R.S

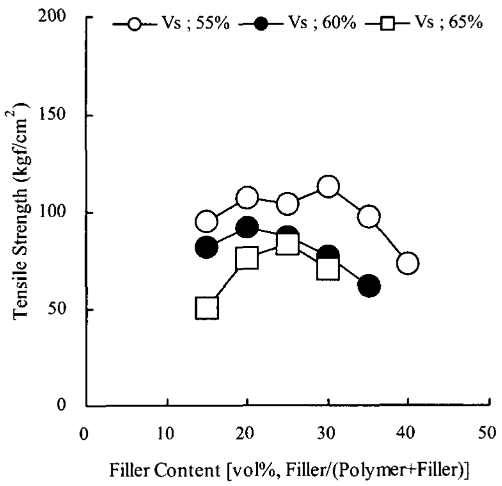


(b) Resin mortar using N.S

Fig.4 Effect of filler content, types of aggregate and volume of aggregates on flexural strength of resin mortar



(a) Resin mortar using R.S



(b) Resin mortar using N.S

Fig.5 Effect of filler content, types of aggregates and volume of aggregate on tensile strength of resin mortar

binder volume was similar to the result mentioned above. The flexural strength ratio (0.26-0.30) to compressive strength was higher than that of cement mortar.

The result of tensile strengths in resin mortar are showed in Fig.5. The tensile strengths of resin mortar increased with increasing filler content, and maximum strength of R.S mortar and N.S mortar obtained in the filler content of 25% and 30%. The maximum strength of R.S mortar was same as that of N.S mortar.

From the above-mentioned results, it is obvious that recycled fine aggregates can be used as the aggregate of resin mortar when dust was washed out.

4.3 Strength Characteristics Associated with Mixing Ratio of Recycled Fine Aggregate. (series II)

In order to improve workability and strength of mortar using R.S, N.S was replaced partially with R.S. Fig.6 shows the effect of filler content and the substitutional ratio of N.S on the compressive strengths of resin mortar. The compressive strengths of resin mortar increased with increasing substitutional ratio of N.S, and maximum strength of resin mortar obtained in ith substitutional ratio of 70%. The maximum strength of resin mortar was about 105% to 115% of that with

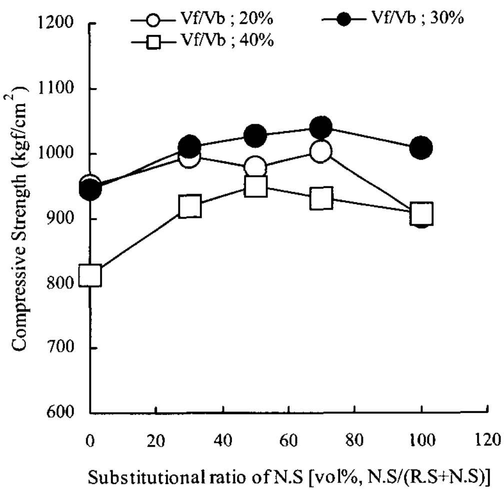


Fig.6 Effect of replacement of N.S on compressive strength of resin mortar

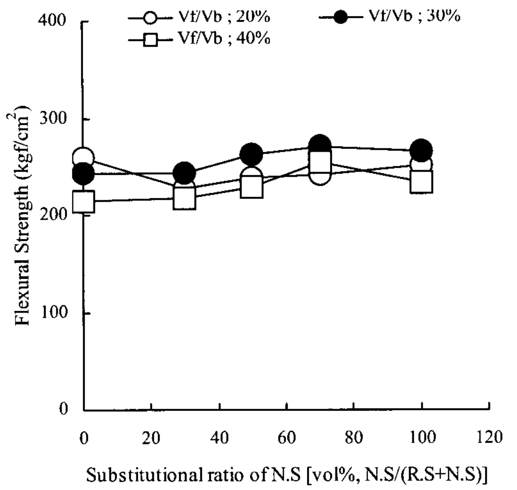


Fig.7 Effect of replacement of N.S on flexural strength of resin mortar

substitutional ratio of 0%. On the other hand, optimum percentage of filler to binder volume for excellent compressive strength was 30%.

Fig.6 shows the effect of filler content and the substitutional ratio of N.S on the flexural strengths of resin mortar. Similarly to the results of compressive strength, flexural strength was slightly increased as substitutional ratio increased, and maximum strength of resin mortar obtained in substitutional ratio of 70% and filler content of 30%.

Fig.8 shows the effect of filler content and the substitutional ratio of N.S on the tensile strengths of resin mortar. The tensile strength of resin mortar tended to decrease with increasing substitutional ratio of N.S.

From the above-mentioned results, optimum substitutional ratio of N.S was 70%, and replacement of N.S was more effective on compressive strength rather than on other strengths.

4.4 Effect of Filler Types on Strength Characteristics (series III)

The characteristics of compressive strength according to typess of fill are shown in Fig.9. Generally, the compressive strength of resin mortars reached maximum with the filler content

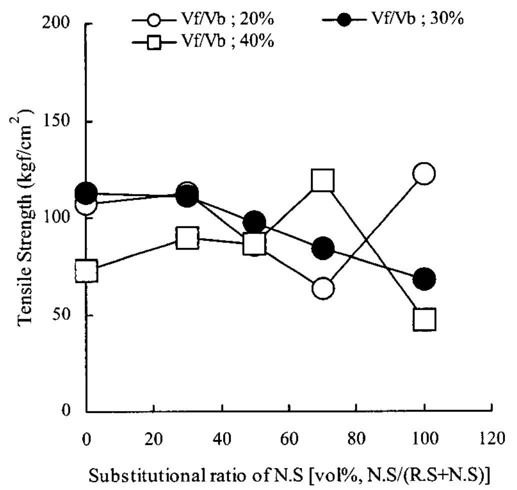


Fig.8 Effect of N.S content on tensile strength of resin mortar

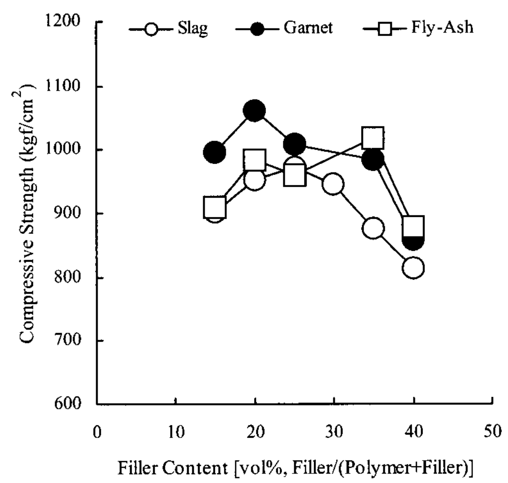


Fig.9 Effect of types of filler on compressive strength of R.S resin mortar

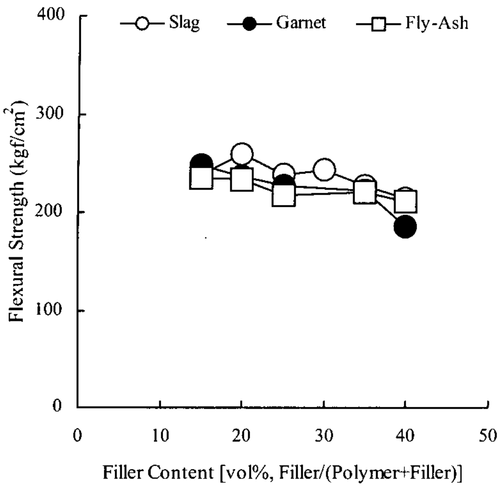


Fig.10 Effect of types of filler on flexural strength of R.S resin mortar

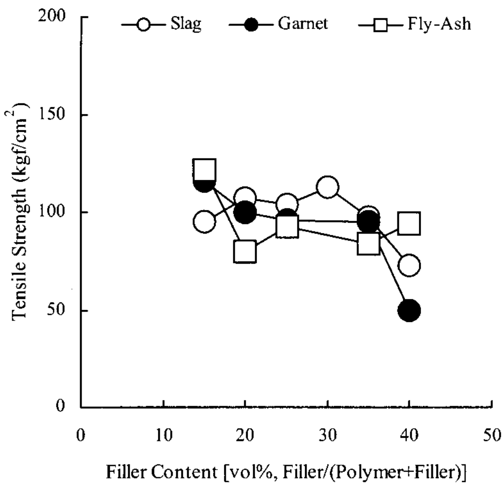


Fig.11 Effect of types of filler on tensile strength of R.S resin mortar

20% to 30%, and then markedly decreased with the filler content of 40%. The compressive strength of resin mortar using garnet powder was higher than that of fly-ash or slag powder. The strength ratio of mortar using fly-ash or slag powder to that using garnet powder was ranged from 0.90 to 1.01. It can be inferred that the garnet powder acted effectively in increasing strength due to micro-filler operation. Therefore, if garnet powder is utilized within adequate range, it is possible to produce the mortar with high compressive strength.

Fig.100 shows the response of flexural strength of resin mortar to different fillers. The flexural strengths of resin mortar were slightly decreased with increasing filler content irrespective of types of filler. However, resin mortar using slag powder showed the maximum strengths at filler content of 20%.

The characteristics of tensile strength in resin mortar are shown in Fig. 11. The tensile strengths of resin mortar using slag powder was reached maximums with the filler content of 30%, and then markedly decreased with the filler content of 40%. However, the tensile strengths of resin mortar using fly-ash or garnet powder was decreased with increasing filler content.

From the above-mentioned results, Garnet powder and slag powder was most effective in compressive strength and in flexural and tensile strength, respectively. Optimum percentage of filler to binder volume was ranged from 20% to 30%.

5. CONCLUSIONS

The strength characteristics of recycled fine aggregates as a constituent of resin mortar were investigate and the results are as followings ;

1. When the dust was washed out, the workability of resin mortar mixed with recycled fine aggregates was improved. Better workability in mortar using natural fine aggregates was showed than in using recycled fine aggregates,

because of mortar fragments sticked to the surface of aggregate. Further study is required to improve workability of resin mortar.

2. R.S mortar had almost similar strength when the volume of fine aggregates was ranged from 55% to 60%. Therefore, it is obvious that the recycled fine aggregates can be used as a constituent for resin mortar when the dust was washed out.
3. It was found that when the recycled fine aggregates were partially replaced by the natural fine aggregates, the compressive and flexural strength of resin mortar were slightly increased but the tensile strength decreased. Thus, most adequate substit- utional ratio of natural fine aggregates to recycled ones was about 70%.
4. Garnet powder and slag powder was most effective in compressive strength and in flexural and tensile strength, respectively. Optimum percentage of filler to total volume was ranged from 20% to 30%.

ACKNOWLEDGMENTS

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