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Effect of Crumb Rubber on the Fresh Properties of Mortar and Concrete

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ABSTRACT

The importance of the performance of concrete cannot be neglected since it is the early indicator of its physical and mechanical properties. It became more important when material with different physical properties than normal material such as rubber tire was used as concrete constituent. This paper presented apart of research result conducted on mortar and concrete with crumb rubber. Crumb rubber was replaced at 10%, 15% and 20% as sand replacement by volume. In addition, ordinary Portland cement was added to silica fume at 10% and 15% by weight. The properties measured in this study are air content and workability test. As for workability, superplasticizers were constantly used at 1% dosage for all mortar mixture, and 0.5% to 0.7% for concrete mixture. The air content was set at 4% to 6% and mortar flow test was conducted on a steel plate, shocked 15 times in 15 seconds and concrete slump test was carried out using slump cone equipment. Pressure method was used to measure air content. All mixes were done in a controlled room temperature. Results showed that when CR was added in the mixture segregation was observed in mortar requiring a high dose of superplasticizer to be added to improve the workability while air-modifying agent was used to reduce the mortar air content. In concrete mixture, low dosage of superplasticizers was required for workability and air-entrained agent was injected into the mixture to increase the air content between 4%-6%.

Keywords: Air content, concrete slump, crumb rubber, mortar flow

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INTRODUCTION

Utilization of waste tire rubber as concrete material has been widely studied since 1990's. Waste tire rubber is a soft material with specific gravity ranging between 0.6 g/cm3 to 1.3 g/cm3 that contributes to low strength of concrete when used as concrete constituent. Nehdi (2001) in his discussion stated that rubber may be viewed as voids in concrete mix and gave weak bonding between rubber particles and cement paste. It was reported that although no air-entrained is used in the mixture, higher air content was measure compared to control mixture made with air-entrained agent. This may due to the non-polar nature of rubber particles and its ability to entrap air on jagged surface texture.

Meanwhile, workability performance reported by Bigzonni (2006) on tire waste rubber utilized in self-compacting concrete showed good slump flow and pass in the presence of obstacle. Erhan (2009) pointed out that the V-tunnels flow time increase gradually with the increasing of crumb rubber. But, when fly ash was added, it resulted in a steady decrease of V-funnel flow in comparison with the mixture without fly ash. However, there was agreement that in concrete, slump was decreased by increasing rubber content to the total aggregate volume (Topçu, 2010). In this paper, result of concrete and mortar fresh properties is reported from research on rubberized concrete conducted in Concrete Engineering Lab, Kyushu University.

MATERIALS AND METHODS

In this research, waste tire rubber was classified as crumb rubber, CR which is a by-product produced from used vehicle tires received from recycle plant without undergoing any washing procedure. The size of the CR was combination of 1 mm to 3 mm with density of 1.17 g/cm^3, used as sand replacement. Ordinary Portland cement (OPC) and silica fume (SF) acted as binder, where a selected percentage SF was added to cement. Sea sand passing 5 mm sieve with water absorption of less than 3.5% as stated in *JSCE Standard Specification for Concrete Structures, 2007* was used as fine aggregate. Meanwhile, crushed stone with 20 mm maximum size was used as coarse aggregate. All aggregate were prepared under saturated surface dry condition. Details of the material physical properties are presented in Table 1.

Mix Proportion

Table 2 and Table 3 shows the mix proportion of mortar and concrete respectively. Control parameter was the air content ranging between 4% to 6%. After several trial mixes, superplasticizers for workability was constantly used at 1% dosage for mortar and 0.5% to 0.7% dosage for concrete. Suitable chemical admixture was then decided to achieve target air content. Mortar flow test was conducted on a steel plate and shocked 15 times in 15 seconds. Concrete slump was measured using slump cone. Meanwhile, air content data was collected using pressure method. Mixing was done in a controlled room temperature at 200C according to JIS R 5201-1997 Physical Testing Method for Cement.

Table 1
Physical properties of materials

Component	Physical properties	
Ordinary Portland Cement	Density, g/cm^3	3.16
Silica fume	Density, g/cm3	2.20
Crumb Rubber	Density, g/cm^3	1.17
Fine Aggregate	Density, g/cm^3 (SSD condition)	2.58
	Water absorption (%)	1.72
	Fineness modulus	2.77
Coarse Aggregate	Density, g/cm^3	2.91
Ether-based polycarboxylate superplasticizer	Density, g/cm^3 at 20°C	1.07
Air entraining agent	Density, g/cm^3	1.04
Air-modifying agent	Density, g/cm^3	1.00

Table 2
Mix proportion of mortar

Series	CR/ (S+CR)	SF/C	w/c	Water	Cement	Silica Fume	Sand	Crumb Rubber	Chemical Admixture
	(Vol %)	(%)		W	C	SF	S	CR	
Control	0	0	0.35	217	619	-	1514	-	1.0
0CR - 10SF	0	10				62	1442	-	1.0
0CR - 15SF	0	15				93	1406	-	1.0
10CR - 10SF	10	0				-	1364	69	1.0
10CR - 10SF	10	10				62	1292	69	1.0
10CR - 15SF	10	15				93	1255	69	1.0

Table 3
Mix proportion of concrete

Description	CR/ (S+CR)	SF/C	w/c	Water	Cement	Silica Fume	Fine Aggregrate	Crumb Rubber	Coarse Aggregate		Chemical Admixture
				W	C	SF	S	CR	G1	G2	
	(Vol %)	(%)				kg/m^3					%
Control	0	0	0.35	160	457	0.0	741	0	608	405	0.5
10CR - 0SF	10	0					667	34			0.5
15CR - 0SF	15	0					629	50			0.7
20CR - 0SF	20	0					594	67			0.7
10CR - 10SF	10	10	0.35	160	457	46	613	34	608	405	0.7
15CR - 10SF	15	10					575	50			0.7
20CR - 10SF	20	10					540	67			0.7

RESULTS AND DISCUSSION

The main difference between mortar mix design and concrete mix design is the amount of chemical admixture that is added to control the air content. In this study air-entrained agent and air-modifying agent was introduced to control the air content. The purpose of the air-entrained agent is to increase the air content. In contrast in the case of the mixture air-modifying agent is used to decrease the amount of the air content.

Table 4 provides information of chemical admixture used in rubberized mortar and Table 5 shows the rubberized concrete. The absentees of crushed stones in rubberized mortar provides very high air content despite the absence of air-entrained agent during trial mix. The amount of air reached almost 15% for mix with CR even without air-entrained agent. In order to overcome this problem air-modifying agent with 1.0% dosage was used to reduce the amount of air content in mortar. However, when the same mixture series of 10% CR without SF was conducted in the concrete mix, contrast behaviour was observed in comparison with 10% CR in mortar mix. Rubberized concrete produced air content that was lower than mortar mix, thus air-entrained agent was used to increase the air content. The different behaviour that was observed may be due to the high solid content of concrete due to the presence of fine-coarse aggregate mix in concrete as shown in Figure 1. Furthermore when SF was added to the concrete mixture, air content increased rapidly and an air-modifying agent had to be added in order to achieve the targeted level.

With regards to workability, both rubberized mortar and concrete using the same superplasticizer at different dosage level. Rubberized concrete required small amount of superplasticizer compared to mortar mix. Looking back to mix design proportion, mortar using totally fine aggregate as aggregate rather than coarse aggregate used in concrete. Thus, for the same total volume amount, mortar having larger replacement of CR which was 69kg/m^3 compared to concrete which was 34kg/m^3 at 10% sand replacement by volume. Thus, resulting in the low workability of mortar mix, requiring a high dose of superplasticizer.

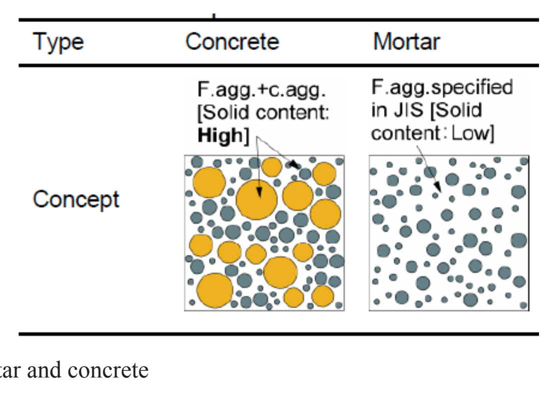

Figure 1. Concept of mortar and concrete

Table 4
Fresh properties of mortar with and without crumb rubber

			Chemical Admixture		Fresh Properties	
Series	CR/(S+CR)	SF/C	Super-plasticizers	Air-modifying agent	Air content	Flow
	(Vol %)	(%)	(%)	(%)	(%)	(mm)
Control	0	0	1.0	1.0	5.2	226
0CR - 10SF	0	10	1.0	1.0	6.9	178
0CR - 15SF	o	15	1.0	1.0	8.0	171
10CR - 0SF	10	0	1.0	1.0	4.2	207
10CR - 10SF	10	10	1.0	1.0	7.8	175
10CR - 10SF	10	15	1.0	1.0	9.0	173

Table 5
Fresh properties of concrete with and without crumb rubber

	Chemical Admixture			Fresh Properties	
Description	Super-plascticisers	Air-entraining agent	Air-modifying agent	Air Content	Slump
	(%)	(%)	(%)	(%)	(mm)
Control	0.5	0.8		4.7	7.0
10CR-0SF	0.5	0.8		5.1	6.0
15CR-0SF	0.7	0.8		4.5	19.5
20CR-0SF	0.7	0.7		4.0	19.5

CONCLUSION

Several conclusions from the above maybe drawn:

1. In mortar mixture, 1% of superplasticizers was used to increase the flow performance of mixture. It decreases slightly when SF was added at 10% and 15% cement replacement.
2. Meanwhile, mortar air content increased with the presence of CR and SF. The rapid increment was controlled using 1% addition air-modifying agent.
3. Contradictory results were noted in concrete mixture; less than 1% superplasticizers was required for workability performance.
4. Concrete mixture with CR showed low air content; to control air content between 4%-6% air-entrained agent was used. However, when SF was added, air content rapidly increased requiring control with air-modifying agent.

Overall, when CR was added in the mixture, mortar showed light segregation and high superplasticizer was added to improve the workability together with air-modifying agent to reduce the ensuing rise in air content. For concrete mixture low dosage of superplasticizers had to be added to improve workability and air-entrained agent injected to increase the air content to between 4%-6%.

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REFERENCES

Nehdi, M., & Ashfaq, K. (2001). Cementitious composites containing recycled tire rubber: An overview of engineering properties and potential applications. *Cement, Concrete and Aggregates, 23*(1). 3-10.

Bignozzi, M. C., & Sandrolini, F. (2006). Tyre rubber waste recycling in self-compacting concrete. *Engineering Applied Science, 36*(4). 735-739.

Guneyisi, E. (2010). Fresh properties of self-compacting rubberized concrete incorporated with fly ash. *Materials and Structures, 43*(8), 1037-1048.

Topcu, U., & Tayfun, I. B. (2010). The role of scrap rubber particles on drying shrinkage and mechanical properties of self-consolidating mortars. *Construction and Building Materials. 24*(7). 1141-1150.

Teranishi, K., & Tanigawa, Y. (2007). Development of mortar structure. *Proceeding of 32nd Conference on Our World in Concrete and Structure*. Singapore.