6 Development of Self-Compacting Premix GRC

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SUMMARY: Premix GRC is widely used in the world including USA, Europe and Japan. Productivity of premix GRC is decisive factor for cost reduction and quality constancy. The most important property for the productivity of premix GRC is the flowability of GRC mortar without any materials separations.

Self-Compacting Concrete (SCC) was developed in 1989 and then SCC has been increasing in Japan. Self-Compacting premix GRC (SC-GRC) is one of the most difficult mortal to flow for its big aspect ratio of glass fiber. We have developed new SC-GRC which was taken the glass fiber into consideration. We propose 4 kinds of SC-GRC using different admixture and show their properties.

Keywords: GRC, Self compact, polymer, methylcellulose, thickener, Air-entraining and high-range water-reducing admixture

INTRODUCTION

Premix GRC is widely used in the world including USA, Europe and Japan. Productivity of premix GRC is decisive factor for cost reduction and quality constancy. The most important property for the productivity of premix GRC is the flowability of GRC mortar without any materials separations.

Over ten years ago we developed high performance glass fiber chopped strands for high fluidity premix GRC[1)]. The new fiber gave high fluidity to premix GRC.

Self-Compacting Concrete (SCC) was developed in 1989 and then SCC has been increasing in Japan. Self-Compacting premix GRC (SC-GRC) is one of the most difficult mortal to flow for its big aspect ratio of glass fiber. We have developed new SC-GRC in combination with the high performance glass fiber. We propose 4 kinds of SC-GRC using different admixture and show their properties.

EXPERIMENT METHOD

Materials

Table 1 shows materials which were used in this paper. Separation reduction type water-reducing admixture (SRHR) has functions of water-reducer, separation reduction and antifoaming. High performance thickener (HPTH) includes 2 kinds of surfactant and these surfactants meat in the mortar electrostatically during mixing and para-polymer generated from their surfactants make

mortar high viscosity.

Table 1 Materials

Cement	ordinary Portland cement
Aggregate	Silica sand No.6
Additive	Silicafume (particle size 0.1~0.2 μm)
Admixture	Air-entraining and high-range water-reducing admixture (AEHR) Separation reduction type water-reducing admixture (SRHR) Powdered acrylic polymer (PAP) Methylcellulose (MC) High performance thickener (HPTH) Antifoaming agent (AFA)
Glass fiber (GF)	ACS13PH-901X, ACS19PH-901X, ACS25PH-901X

Mix proportions

Mix proportions are shown in Table 2.

Table 2 Materials (part)

No.	1	2	3	4	5
Cement	100				
Silica sand	100				
Water	30	28~31	30		
Silicafume	5				
AEHR	1.5		1.4	1.0	0.7
SRHR		1.0			
PAP			1.0		
MC				0.02	
HPTH					0.3
AFA			0.05	0.05	0.05
GF	3.0 wt% against mortar				

Mixing and casting

Five-litter Omni mixer was used for mixing GRC mortar.

Figure 1 shows mixing flow chart of this experiment. Additive was mixed with water before casting mixer. PAP and MC were mixed with silica sand before casting mixer. Mixed GRC mortar was cast into plane mold for test pieces.

Figure 1 Mixing flow chart

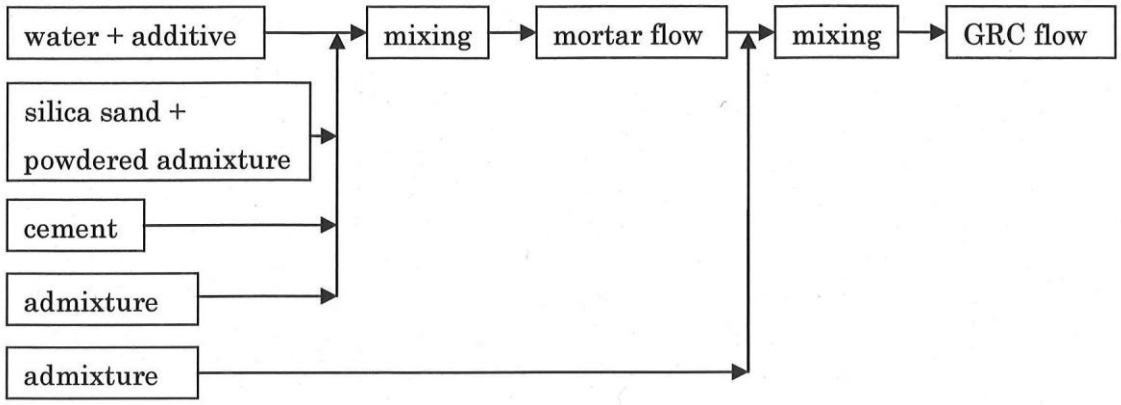


Figure 1 Mixing flow chart

Bending strength

LOP and MOR were measured by the bending test prescribed by the Japan GRC Association, test conditions of which are shown in Table 3. Specimens for the bending test were remolded at the age of one day and stored in a curing room at 20°C, 60% relative humidity (RH) until the age of 28 days.

Table 3 Bending test conditions

Dimensions of specimen (mm)	Bending span (mm)	Test speed (mm/min)	Loading method
275 X 50 X 15	225	2	3-point

Mortar flow value

The left figure in Figure 2 shows the test method for fresh mortar flowability. A flow cylinder of 55 mm in diameter and 50 mm high was placed on a plate. It was filled with fresh mortar and then pulled straight up and the fresh mortar flowed on the plate. The diameter of the fresh mortar was measured as a mortar flow value.

GRC flow value

The right figure in Figure 2 shows the test method for fresh GRC mortar flowability. A GRC flow value of fresh GRC mortar (including glass fiber) was measured by flow test of the physical testing method for cement provided in JIS A 5201. A flow cone of 70 mm upper diameter, 100 mm lower diameter and 70 mm high was placed on a flow table. It was filled with fresh GRC mortar and

pulled straight up. The diameter of flowed GRC mortar was measured as a GRC flow value.

Figure 2 Test methods for flowability

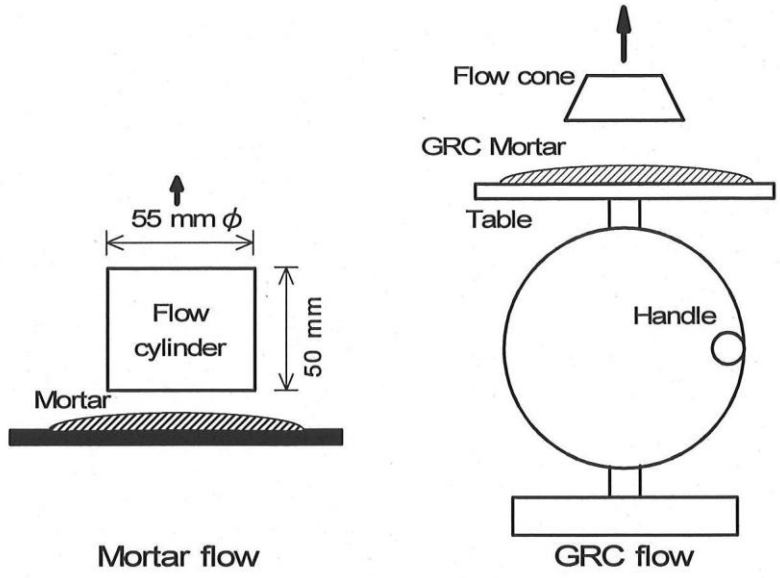


Figure 2 Test methods for flowability

Self-compactivity

Self-compactivity was defined as height difference in Figure 3. Four kg GRC mortar was cast into vinyl tube whose inside diameter is 30 mm and length is 3 m.

Figure 3 Test method of self-compactivity

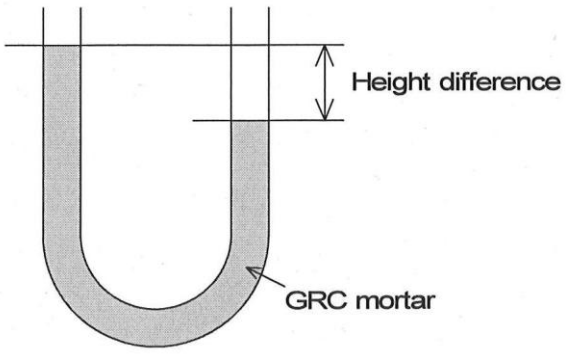


Figure 3 Test method of self-compactivity

RESULTS

Separation reduction type water-reducing admixture

As separation reduction type water-reducing admixture (SRHR) has function of both water-reducer and separation reduction, flowability was adjusted by W/C. In case of ACS19PH-901X mortar flow and GRC flow are shown in Figure 4 and GRC bending strengths are shown in Figure 5. W/C range from 0.28 to 0.31. From Figure 4 and Figure 5 it is found that time when W/C is 0.30 is most suitable. Figure 6 shows relationship between glass fiber length and flow value when W/C is 0.30. Figure 7 shows relationship between glass fiber length and bending strength in the same W/C as Figure 6. Glass fiber length affects GRC flow greatly. Shorter glass fiber is better for SC- GRC. To achieve SC-GRC ACS13PH-901X is the best glass fiber.

Figure 8 shows GRC bending strength at the age of 1, 14 and 28 days.

Figure 4 Relationship between W/C and flow value (SRHR)

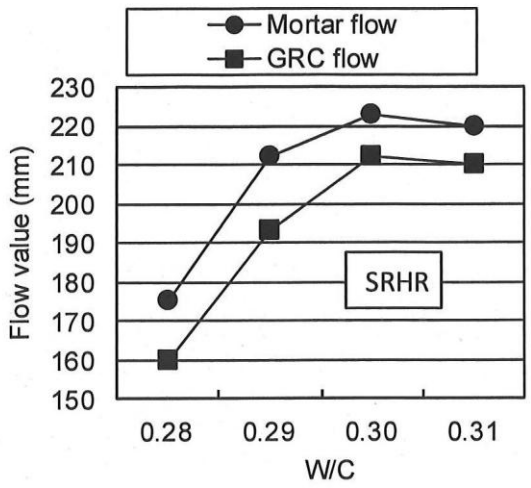


Figure 4 Relationship between W/C and flow value (SRHR)

Figure 5 Bending strength (SRHR)

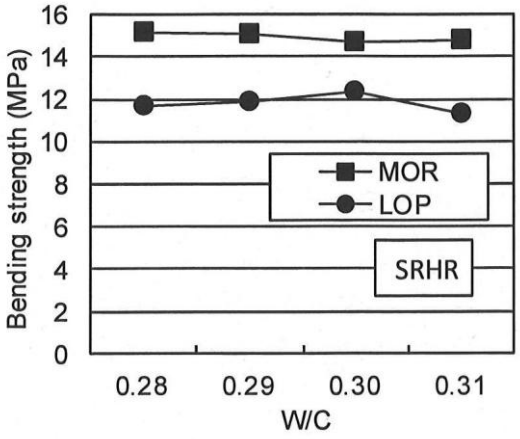


Figure 5 Bending strength (SRHR)

Figure 6 Relationship between glass fiber length and flow value

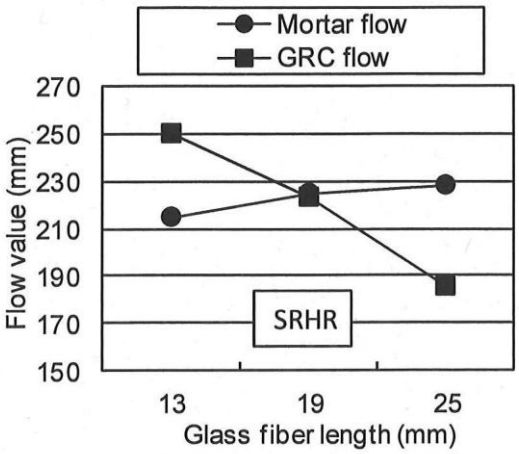


Figure 6 Relationship between glass fiber length and flow value

Figure 7 Relationship glass fiber length and bending strength

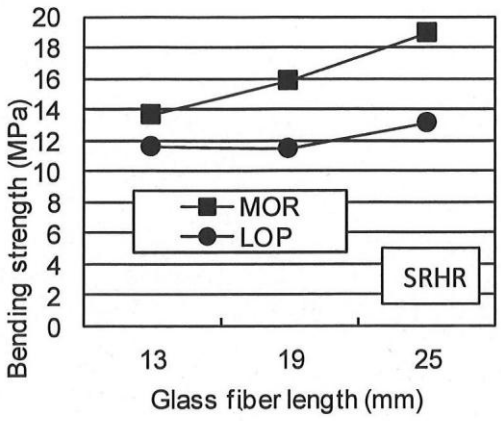


Figure 7 Relationship glass fiber length and bending strength

Figure 8 Bending strength at aged 1, 14 and 28 days

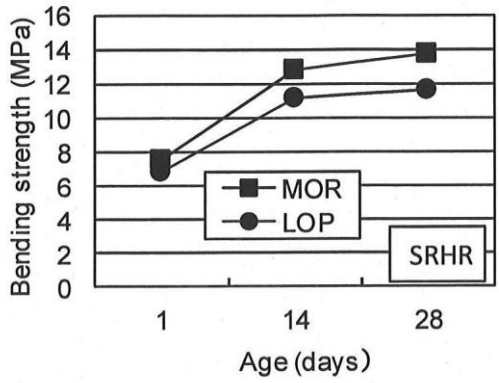


Figure 8 Bending strength at aged 1, 14 and 28 days

Other admixture

When other admixtures were examined, following conditions were fixed;

Glass fiber: ACS13PH-901X

W/C: 0.30

Figure 9 shows flow value with various mix proportions. Each mortar flow value was adjust around 200mm because if it is more than 220mm GRC mortar tends to separate and if it is less than 180mm self-compactivity is poorer. Although each mortar flow value was the almost same, each GRC flow value was different. Self-compactivity is shown in Figure 10. Smaller self-compactivity value means better self-compactivity. No. 1 mix proportions is high fluidity premix GRC[1)]. 4 kind of newly developed mix proportions as SC-GRC have superior self-compactivity than No.1 high fluidity premix GRC. Admixtures using No. 2 to No.5 mix proportions also give thixotropic to GRC mortar. It seems that these viscosity properties of GRC are more suitable for SC-GRC than that

using silicafume.

Figure 11 shows air-dried specific gravity and

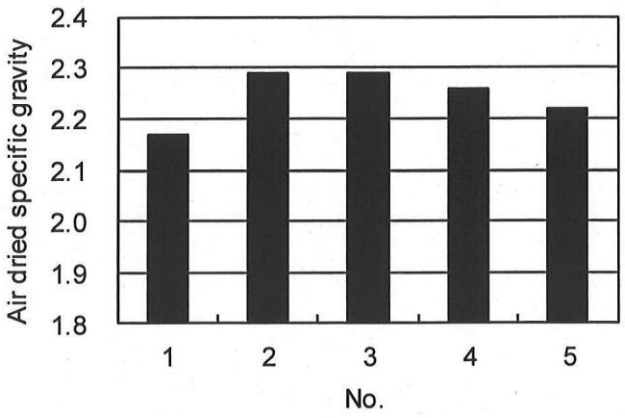


Figure 11 Air dried specific gravity with various mix proportions

Figure 12 shows bending strength with various mix proportions. Antifoaming agent is added to No. 3 to 5 for reduction air content in the GRC. If it is not added, air content increase 10% and bending strength does not reach good enough. Bending strength of No.3 using APA was very high

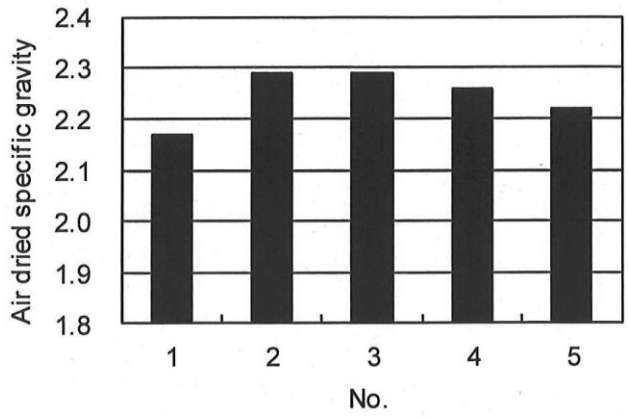


Figure 11 Air dried specific gravity with various mix proportions

as shown in
Figure 12.

Figure 9 Flow value with various mix proportions

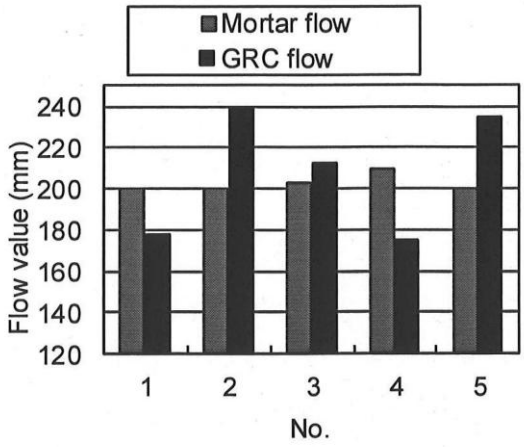


Figure 9 Flow value with various mix proportions

Figure 10 Self-compactivity with various mix proportions

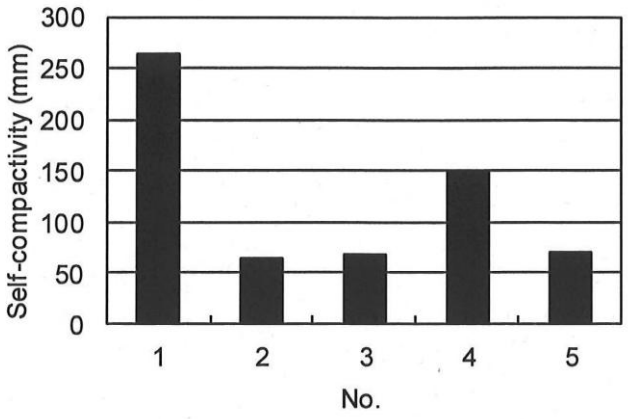


Figure 10 Sefl-compactivity with various mix proportions

Figure 11 Air dried specific gravity with various mix proportions

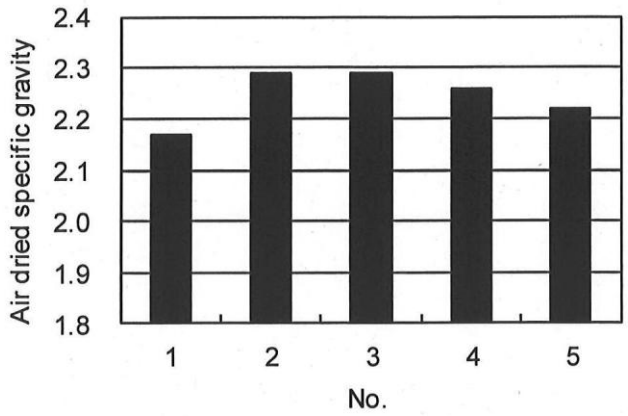


Figure 11 Air dried specific gravity with various mix proportions

Figure 12 Bending strength with various mix proportions

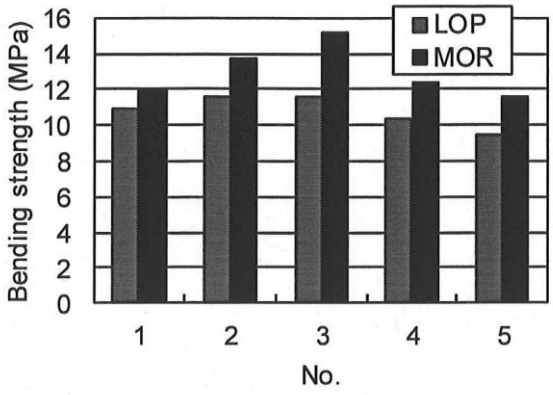
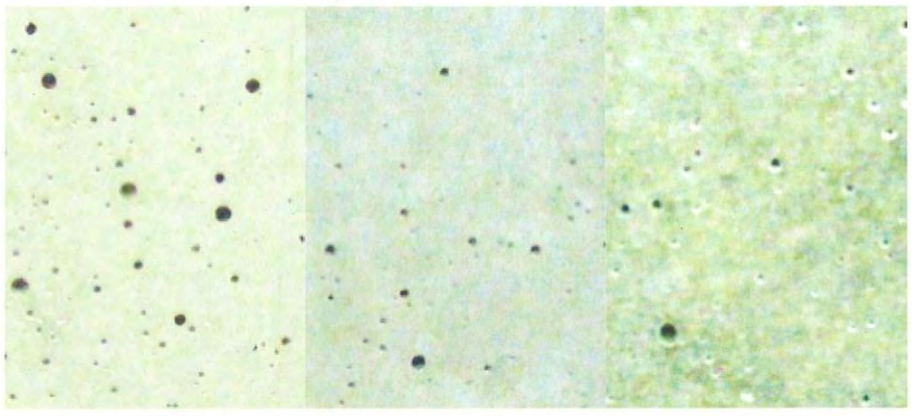


Figure 12 Bending strength with various mix proportions

Surface appearance

Figure 13 shows surface appearance of test pieces. No. 5 is used High performance thickener. This thickener includes 2 kinds of surfactant and these surfactants meat in the mortar electrostatically during mixing and para-polymer generated from their surfactants make mortar high viscosity. After casting para-polymer return to an original state and mortar viscosity falls. This change of the chemical structure makes surface appearance good without material separation.

Figure 13 Surface appearance



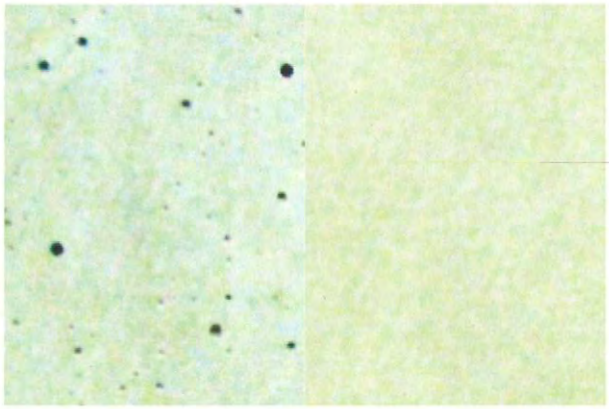


Figure 13 Surface appearance

SUMMARY

(1) SC-GRC is available by using chemical admixture which gives mortar suitable viscosity.

(2) It is easy to be SC-GRC by using SRHR because it has functions of water-reducer, separation reduction and antifoaming water.

(3) Bending strength of SC-GRC using PAP is higher than other SC-GRC.

(4) Surface appearance of SC-GRC using HPTH is better than other SC-GRC because of its unique chemical reaction.

REFERENCE

1) Y. Takeuchi el al. High-fluidity and lightweight premix GRC. Proceedings of International GRC Congress 2001, Dublin, GRCA, 2001