COMPARATIVE STUDY OF GLASS POWDER AS TERNARY BLEND ON ASR FOR RECYCLED GLASS MORTAR

Shibaura Institute of Technology Student Member ○Ludmila Soares Carneiro
Shibaura Institute of Technology Regular Member Takeshi IYODA

1. INTRODUCTION

The alkalis and silica reaction that happens in a cement environment (concrete, mortar and so on) is a problem for structures. In order to decrease the possibility of the ASR to happen, a low alkali cement can be used or the aggregate has to be choose carefully. The use of supplementary cementitious material (SCM) can also help to control ASR (Mehta, 2008). The most common materials used in combination with ordinary Portland cement (OPC) to decrease ASR are fly ash (FA) and ground granulated blast furnace slag (GGBFS), however recently glass powder (GP) has also been studied. The glass when used in fine particles (around 0.75μm) can contribute to the reduction of the expansion. In this study, seven mixes were cast following ASTM C1567 to evaluate the effectiveness of the glass powder used as ternary blend with FA and GGBFS. The GGBFS and FA as binary blends were also cast for comparison parameter of of ASR mitigation. This study objective is to observe the glass powder effectiveness of decreasing ASR when used alone and together with other SCM materials. It has also as a specific goal to promote the use of recycled materials in construction for sustainability purposes.

2. EXPERIMENTAL OUTLINES

2.1 Materials

The materials used in this study were OPC, GP, glass aggregate (reactive aggregate), GGBFS, FA and tap water. The glass aggregate and Powder (75μm) were from Fujino Kogyou Ltd. and Ordinary Portland cement from Taiheiyo Cement Corporation (NaOeq = 0.62%). The particle size of glass sand was graded as specified on ASTM C1567. The Chemical composition of glass can be seen at Table 1.

Table 1. Glass chemical composition

Content wt%	SiO_2	CaO	Na_2O	K_2O	Al_2O_3	Fe_2O_3	MgO	Na_2Oeq
Glass (Powder/ Aggregate)	69.27	20.98	4.61	1.87	1.83	0.46	0.25	5.84

2.2 Mix Designs and Testing Methods

The material mix proportions established one part of binder for 2.25 parts of graded aggregate and water-binder ratio of 0.47 (ASTM C1567). Glass powder, GGBSF and FA were used substituting OPC in mass as shown at table 2. The values were chosen based in the literature for the most effective use of FA (30%) and GGBFS (70%) (Afshinnia, 2015). The Glass powder 50% were choose based on the previous study from the author. The mixes 2, 5 and 6 have the same amount of OPC (50%). The mix 7 have high content of GGBFS (50%) in combination with GP (20%). The mixes were named according to percentage of substitution (For example: BFS25GP25 = GGBFS 25% Glass Powder 25%).

Table 2. Mix designs

	SCM	CEMENT (G)	GLASS POWDER (G)	BSF (G)	FA (G)
1	REF	440	0	0	0
2	GP50	220	220	0	0
3	BFS70	132	0	308	0
4	FA30	308	0	0	132
5	BSF25GP25	220	110	110	0
6	FA25GP25	220	110	0	110
7	BSF50GP20	132	88	220	0

The procedures for mixing, cast and test the samples followed the ASTM C1567. According with the standard, the water and cement are placed inside the bowl first and after the sand is added slowly. The total mix process takes 4 minutes. The curing is divided in 3 situations. The first 24 hours the samples stay inside the molds (20°C and RH60%). After that, they are demolded and transferred to a recipient with tap water. This recipient with the samples have to be kept at 80°C for 24 hours. The last curing condition consists to change the tap water by NaOH solution (40g of NaOH/l) at 80°C. The next readings were taken at 5, 7, 10 and 16 days from casting.

Keywords: Alkali-Silica Reaction, Glass powder, Ground Granulated Blast Furnace Slag, Fly Ash, Sustainability.
Contact address: Shibaura Institute of Technology (9F Room 09R-32) 3-7-5, Koto-ku, Tokyo, 135-8548 Japan, Tel: +81-03-5859-8356 – me19103@shibaura-it.ac.jp

3. RESULTS AND DISCUSSION

3.1 Alkali-Silica Reaction

The result shows at Figure 1 that, for all mixes with SCM, the expansions were smaller than 0.1%, so they were considered innocuous for ASR when compared with the reference mix design (REF = 100% OPC).

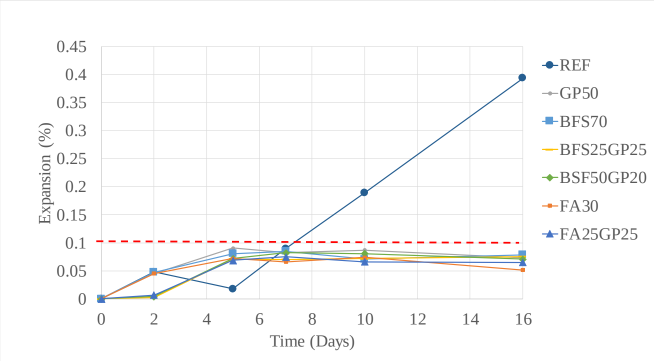

Fig. 1 ASR expansion all results

As we look at the results of SCM closely, the most effective result are FA30, FA25GP25, BFS50GP20, GP50, BFS25GP25 and BFS70 (Figure 2). Some factors have to be considered such as SCM characteristics and amount of alkalis available from the cement. Between the GP, FA and GGBFS alone, the FA showed the most effective result, followed by the GP and GGBFS. However, glass powder 50% do not present a high compressive and bending strength so GGBFS is commonly used as an option in order to decrease ASR and keep the strength. The results for the mixes with the same amount of OPC, and consequently same amount of alkalis coming from the cement, showed the most effective result for the mix of FA25GP25, followed by GP50 and BFS25GP25. The FA decrease the pH of the pore solution and its pozzolanic properties helps to decrease porosity of the samples making the surface denser (Du &Tan, 2012).

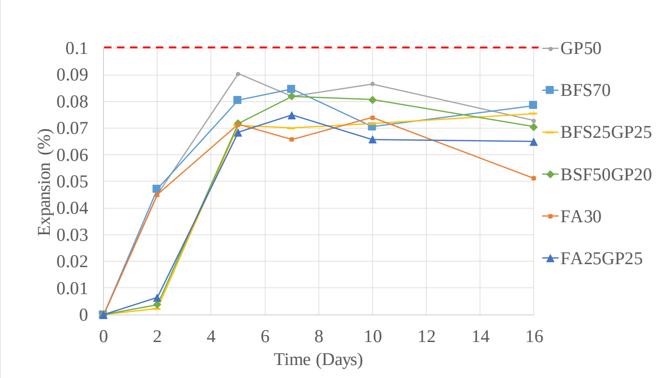

Fig. 2 ASR expansion for all SCM

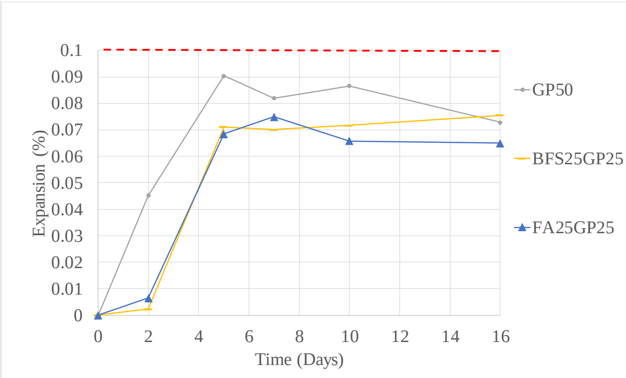

Fig. 3 ASR expansion OPC 50%

4. CONCLUSIONS

The experiments showed that the difference in expansion between the samples did not present a huge variation. All SCM are under the dangerous expansion of 0.1%. However, Between the combinations of GP and other SCM, the FA25GP25 had more effective result for ternary blend.

As specific conclusions:

- The most effective combination of SCM and GP was FA 25% and GP 25%;
- The GP can be used to mitigate ASR alone or as ternary blend and obtain similar results of expansion as commonly used SCM alone (FA, GGBFS), however strength index evaluation is necessary to give more support to the use of the material.

ACKNOWLEDGMENT

The author acknowledges the support of Fujino Kogyo CO. Ltda., Shibaura Institute of Technology (SIT) and the Ministry of Education, Culture, Sports, Science, and Technology of Japan (MEXT).

REFERENCES

Mehta, Povindar Kumar; Monteiro, Paulo Jose Melaragno; Mehta, P. H. Concreto, Microestrutura, Propriedades E Materiais. 2008.

Du, Hongjian, and Kiang Hwee Tan. "Use of waste glass as sand in mortar: Part II–Alkali–silica reaction and mitigation methods." Cement and Concrete Composites 35.1 (2013): 118-126.

Afshinnia, Kaveh, and Prasada Rao Rangaraju. "Efficiency of ternary blends containing fine glass powder in mitigating alkali–silica reaction." Construction and Building Materials 100 (2015): 234-245.