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Use of agglomerated geopolymer pellets as a partial replacement for reactive aggregates to mitigate Alkali Silica Reaction (ASR)

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Introduction

- An average of 375,000 tons of waste glass fibers is landfilled each year in the US [1].
- ASR = Alkalis in pore solution + reactive silica from aggregate + moisture = expansive ASR gel that leads to cracks in concrete.
- Previous research has shown ground glass fibers (GGF) to be an effective SCM to mitigate ASR [2,3]. Nevertheless, using SCMs, in general, could delay the strength development and setting time.
- Additionally, GGF has also been found to be very an effective precursor for geopolymer concrete [4].
- Another research showed that the extent of ASR reaction was lower in geopolymer concrete than in Portland cement concrete [5].

Research Hypotheses

The investigated hypothesis here is: if a partially geopolymerized pellets were used in combination with reactive aggregate, there would be a competing reaction between ASR and geopolymerization processes, and the latter most likely will dominate; which could lead to the reduction or the elimination of the ASR-related damages.

Objective of the study

The objective of this study is to evaluate the effectiveness of using GGF-based geopolymer pellets (GGFGPs) as a partial replacement of highly reactive aggregates to mitigate ASR.

Research Methodology

PHASE 1	• **Prepare the GGFGPs**
PHASE 2	• **Test the reactivity of GGFGPs.**
PHASE 3	• **Test the ASR mitigation performance for the GGFGPs.**

Materials and Methods

- Ground Glass Fibers (GGF) from PPG Inc. (Shelby, NC) used as the precursor for geopolymerized pellets.

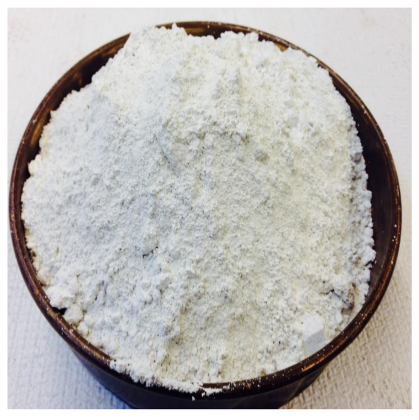

Figure1: The ground glass fibers GGF [2]

Figure 2: The GGFGPs

- **Alkali activator solution**: NaOH pellets were used to prepare an 8N solution.
- Crushed aggregate from Placitas gravel pit, NM and Jobe sand were used as reactive aggregate.

As for the test method, the accelerated mortar bar test (ASTM C1260) was followed to evaluate the ASR potential of GGFGPs and the reactive aggregates, independently as well as in combination.

Experimental Program

- **Preparation of GGFGPs:**

Disk Pelletizer was used. A few trials were run to determine the appropriate settings to create the pellets. Disc rotation speed of 40 RPM and a 45° inclination angle were used. After GGFGPs were made, they were cured at

Figure 3: the Disc Pelletizer

- **Test Reactivity of GGFGPs**

The GGFGPs were crushed to meet the gradation requirements of ASTM C1260, then the mortar bars were prepared and tested for ASR.

- **Test Potential for ASR for combinations of reactive aggregate and GGFGPs**

GGFGP replacement levels of 25%, 50%, and 75% were tested with both NM crushed aggregate and Jobe sand. The amount of water absorbed by the GGFGPs was added for each mixture.

Results and Discussion

- Ability of GGF to mitigate ASR when used as a SCM with Placitas Aggregate [1]

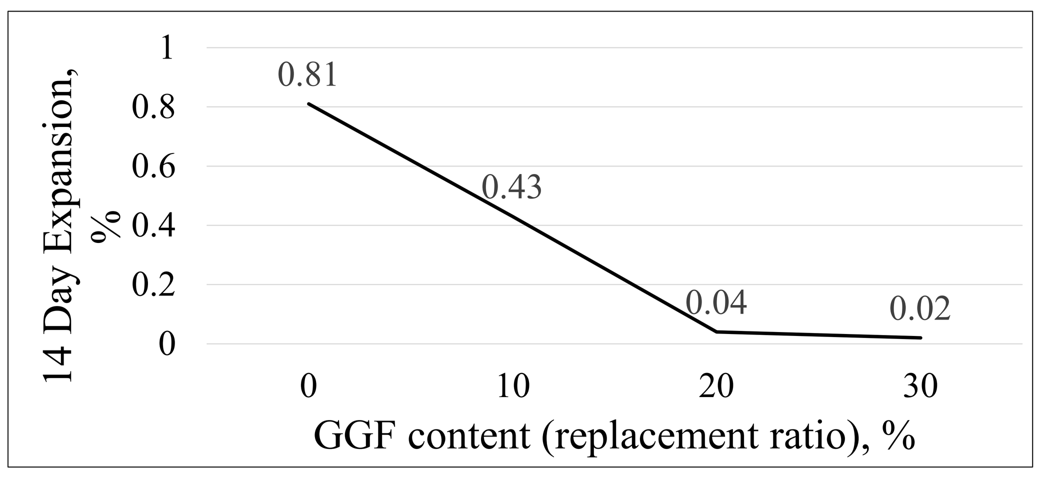

Figure 4: 14-day expansion when GGF introduced as pozzolan

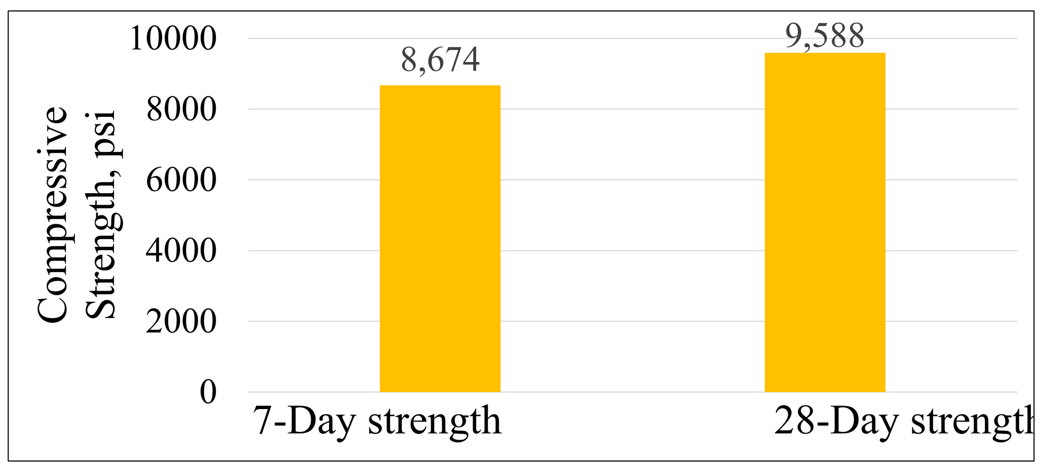

Figure 5: Compressive strength for GGF-based geopolymer mortar

- The properties of the produced GGFGPs:

Table 1: Physical Properties of GGFGPs

Specific Gravity	**1.75**
Absorption Ratio,%	**15%**
Rodded Unit weight, pcf	**69.3**

- Testing the reactivity of GGFGPs:

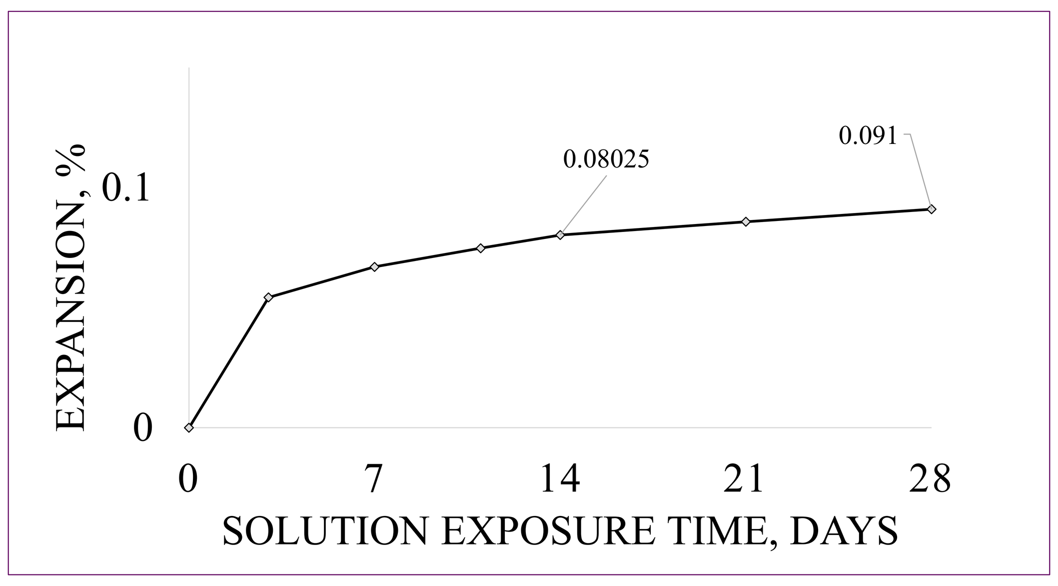

Figure 6: Expansion due to ASR for GGFGPs as fine aggregate

- The ASR performance of combinations of GGFGPs and reactive aggregate:

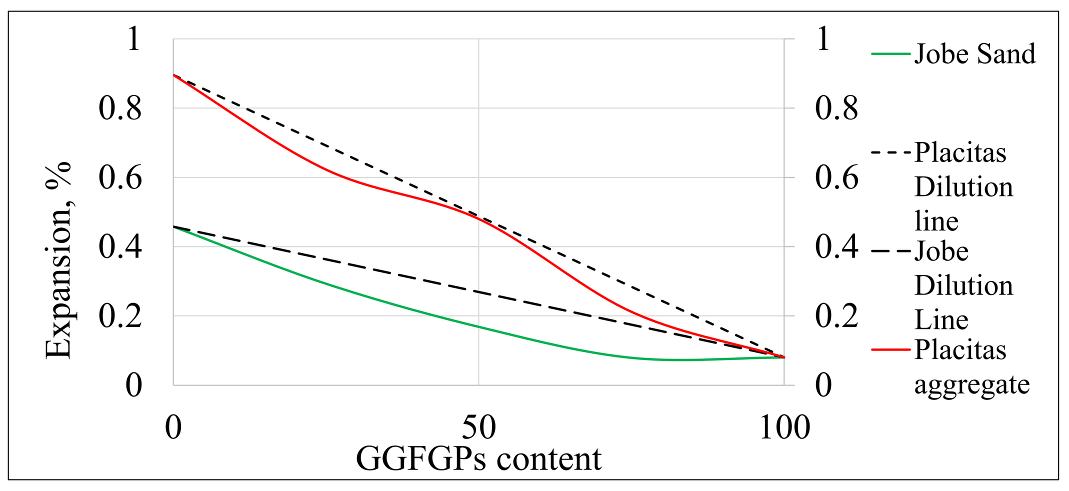

Figure 7: ASR test results for Combinations of reactive aggregate and GGFGPs

- Looking at Figure 4, it clearly shows the benefit of using GGF as pozzolan to partially replace cement in terms of ASR mitigation. A replacement ratio of 20% or higher was sufficient to yield a 14-day expansion less than the 0.1% limit specified by ASTM C1260.
- Figure 5 shows how effective GGF is in producing geopolymer that is activated only by NaOH solution.
- Reviewing table 1, the specific gravity and rodded UW of GGFGPs is about 30% less than the average natural normal-weight aggregate's. Also, the produced GGFGPs have high absorption ratio which makes it necessary to add the absorbed water when mortar is prepared.
- Figure 6 shows that although GGF is glass, which in itself is very reactive, the performance of the produced pellets was acceptable in terms of ASR related expansion.
- Investigating the pessimum ratio, results indicated that at 80% GGFGP content, the maximum expansion was still less than 0.1%.

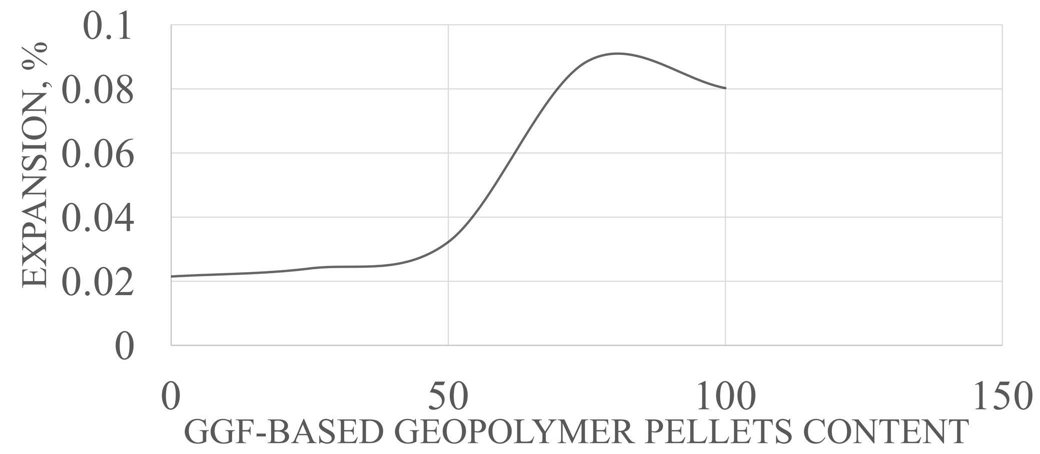

Figure 8: Pessimum Ratio for GGFGP at 14 days

- HOWEVER, when GGFGPs tested in combinations with reactive aggregate, as figure 7 indicates, the effect on ASR expansion was a little lower than the **dilution effect.** The reason might have been that the pellets may have geopolymerized sufficiently that they may have not absorbed alkali from pore solution as readily.

To-Date Conclusion

- So far, the use of GGFGPs has not been proved to be effective to mitigate ASR. Unlike when the GGF was introduced as a SCM where ASR-related damages were extensively reduced at 20% replacement or higher.

Future Scope

- The Reactivity of GGFGPs will be further investigated by running ASTM C227.
- Microstructural analysis.
- Optimization of the GGFGPs quality.
- Further investigation of ASR performance for concrete by running ASTM C1293 or AASHTO TP110

Literature cited

- Hemmings, R. Process for Converting Waste Glass Fiber into Value-dded Products. DOE Report No. DE-FG36-03GO13015. Albacem, LLC, Peoria, Ill., 2005
- Rangaraju, P. R., et al. "Properties and Performance of Ground Glass Fiber as a Pozzolan in Portland Cement Concrete." International Concrete Sustainability Conference, Washington, DC. 2016.
- Rashidian-Dezfouli, Hassan, Kaveh Afshinnia, and Prasada Rao Rangaraju. "Efficiency of Ground Glass Fiber as a cementitious material, in mitigation of alkali-silica reaction of glass aggregates in mortars and concrete." Journal of Building Engineering 15 (2018): 171-180.
- Rashidian-Dezfouli, H., and P. R. Rangaraju. "Comparison of strength and durability characteristics of a geopolymer produced from fly ash, ground glass fiber and glass powder." Materiales de Construcción 67.328 (2017): 136.
- Kupwade-Patil, Kunal, and Erez Allouche. "Effect of alkali silica reaction (ASR) in geopolymer concrete." World of Coal Ash (WOCA) conference. 2011.

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