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Mechanical performance of inorganic polymer-based mortars with glass fibre reinforced polymer bars

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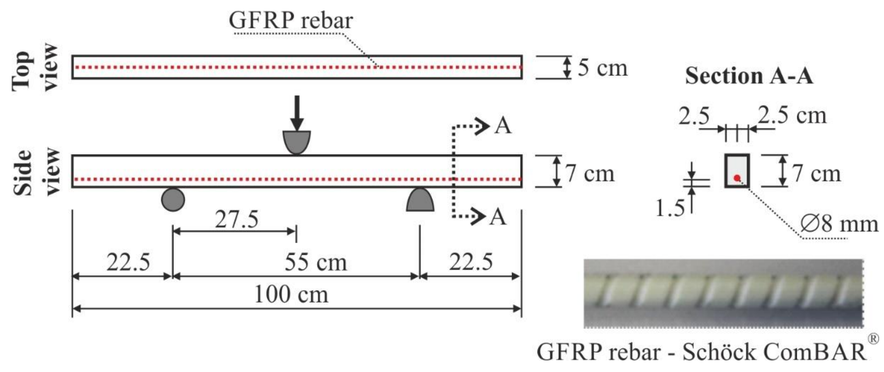
Introduction

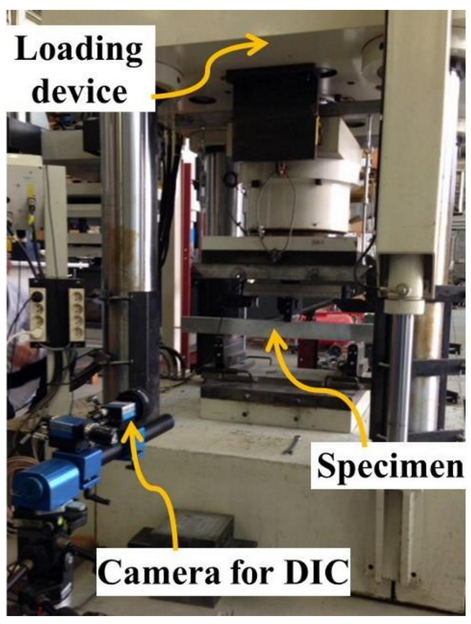
The aim of the study is the preliminary evaluation of the mechanical interaction between an inorganic polymer (IP) mortar made by alkali activated fayalite slag (FS) and the embedded glass fibre reinforced polymer (GFRP) bars used for reinforcement, defining the bearing capacity of the dual system under flexural loading. Ordinary Portland Cement (OPC) beam reinforced with same GFRP bar has been adopted for comparison.

Materials and methods

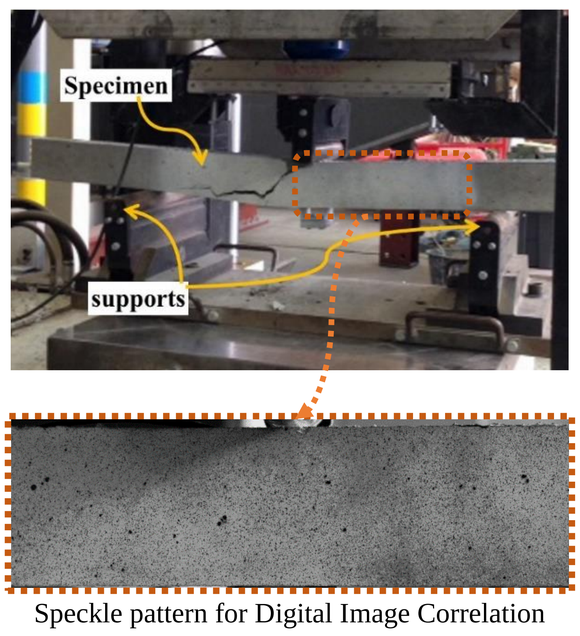
- Four mortar specimens, reinforced with an unidirectional E-glass fibre reinforced polymer (GFRP) bar of diameter 8mm, were tested in a three points bending setup after 33 days of curing at 25ºC and 90% relative humidity.
- Digital image correlation technique (DIC) was used to track the 2D full-field displacement and to calculate the strain developed.



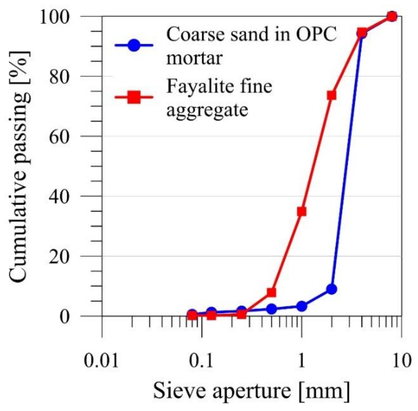
Dimension of reinforced beam specimens and 3-point bending set-up



General overview of test set-up



Speckle pattern for Digital Image Correlation



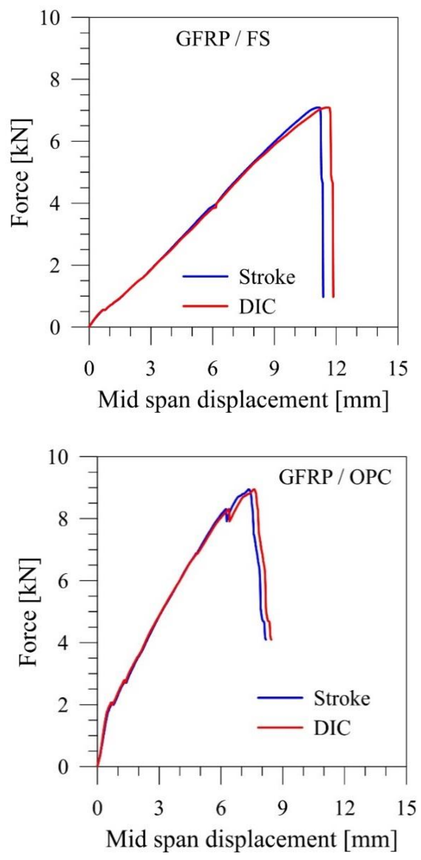
Particle size distribution of fine aggregates in mortar specimens.

FS mortar mixture		OPC mortar mixture	
Material	Weight [%]	Material	Weight [%]
Fayalite aggregates	64.3	Cement	22.7
Finely milled fayalite	27.3	Coarse sand	47.5
Activating solution SiO2/K2O= 1.6 molar, H2O/K2O= 14.9 molar	8.4	Fine sand	20.8
		Water	9.0

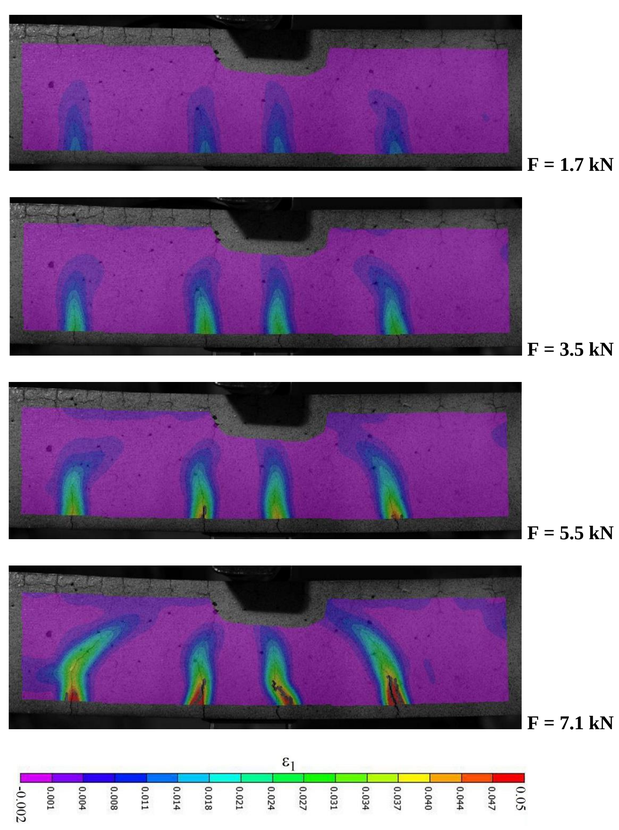
Mortar mixture proportions expressed as weight [%]

Results

- Qualitative analysis of failure modes showed a typical shear failure of the beams.
- Clear similarities in the interaction between OPC mortar and GFRP rebars, and between FS mortar and GFRP rebars during bending were corroborated by the strain field analysis.
- For the reinforced OPC-mortar specimen the maximum load was 38% higher than that obtained for FS specimens.
- The difference is motivated by the high compressive strength obtained for the OPC mortar (almost 72MPa in contrast to 45MPa for the FS).



Bending test of reinforced beams. Force vs. mid span displacement measured by the stroke and DIC



Map of the maximum principal strain field developed during 3-point bending test using DIC analysis on a reinforced FS-mortar specimen

Failure mode of GFRP-reinforced beams: OPC mortar (above) and FS mortar (below)

Conclusions

- FS mortars presented flexural strength values high enough to be considered suitable for certain structural applications. Optimization of alkali activator dosage, compositional mixture and curing method can improve the mechanical characteristics even further.
- Load bearing behaviour and strain field developed by FS mortars reinforced with GFRP bars proved to be analogous to that established for traditional Portland mortars reinforced in the same way.
- This finding opens the possibility for the application of current known structural design principles to this new composite IP-GFRP system.
- The potential of fayalite slag as mortar for IP-GFRP reinforced elements is confirmed and encourages further research.

Acknowledgements

This research would have not been possible without the collaboration of Prof. Lucie Vandewalle and colleagues from Reyntjens Laboratory, at the Department of Civil Engineering, KU Leuven.