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Influence of Supplementary Cementitious Materials on the concrete – spacer interface

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INTRODUCTION

The application of spacers in the construction industry is crucial and has been a common practice since the introduction of reinforced concrete. Spacers or chairs are used in order to allow for the required concrete cover but their effect on the concrete itself and its resulting properties has not been thoroughly studied yet. This project aims to study the influence of the inclusion of spacers in concrete samples that have mixes of Supplementary Cementitious materials such as fly ash, silica fume and slag i.e. GGBS. W/c ratio used was 0.4, an aggregate fraction of 70% with a minimum size of aggregate equal to 10mm.The samples used were created using the following mixes:

- Set C1 = Portland cement I + 8% Silica Fume
- Set C2 = Portland cement I + 30% Fly Ash
- Set C3 = Portland cement I + 60% Slag

EXPERIMENTAL PROCEDURE

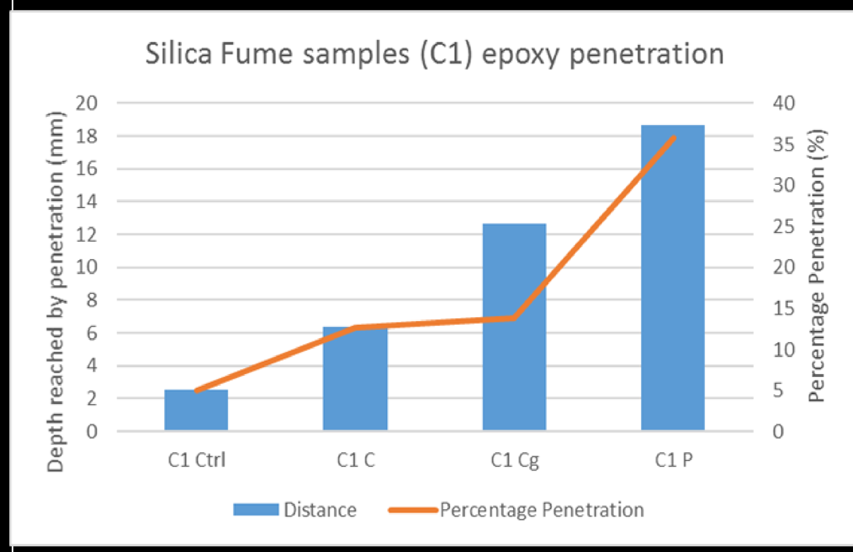
For each of the three sets four samples were created, containing a cementitious, ground cementitious, plastic or no spacer. The samples were kept in conditioning chambers of a constant relative humidity of 70% for approximately 3 months until their mass stabilised and then were prepared for epoxy impregnation.

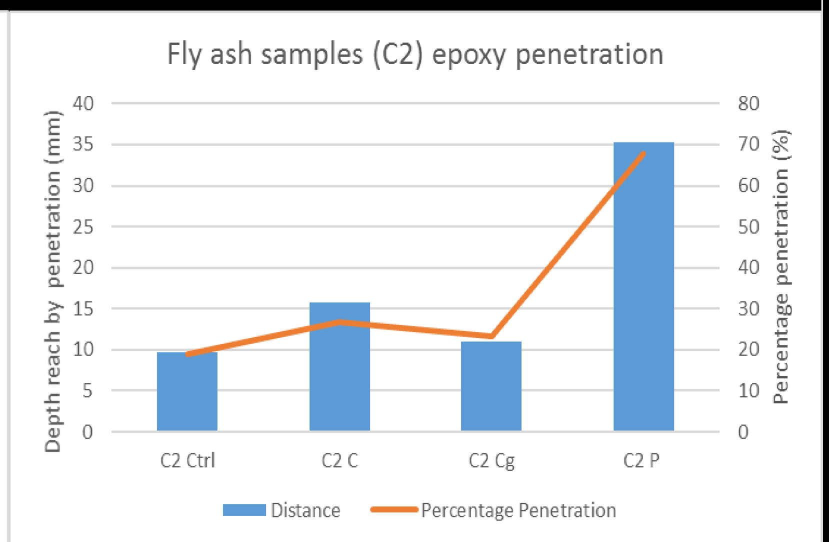
Struer's epoxy resin was used with a ratio of epoxy to hardener to toluene equal to 25:3:5%. The samples were placed in a pressure chamber set at 2.5 bars for 22 hours to accommodate for the penetration.. The samples were then sectioned in half and after drying each side was imaged under ultraviolet lighting after common noise reduction techniques were used, such as sonic bath in acetone and compressed air.

Following this, further sectioning of the fly ash samples into 20mm x 40mm x 8mm blocks was carried out, which were required for Backscattered Electron microscopy. The cementitious spacer was also studied using the BSE microscope for comparability and to provide further insight on its microstructure and properties.

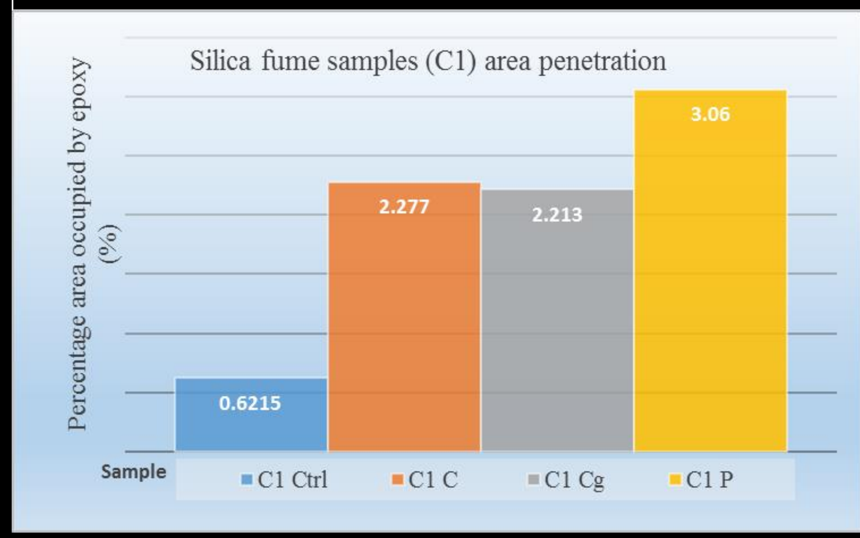
IMAGE ANALYSIS

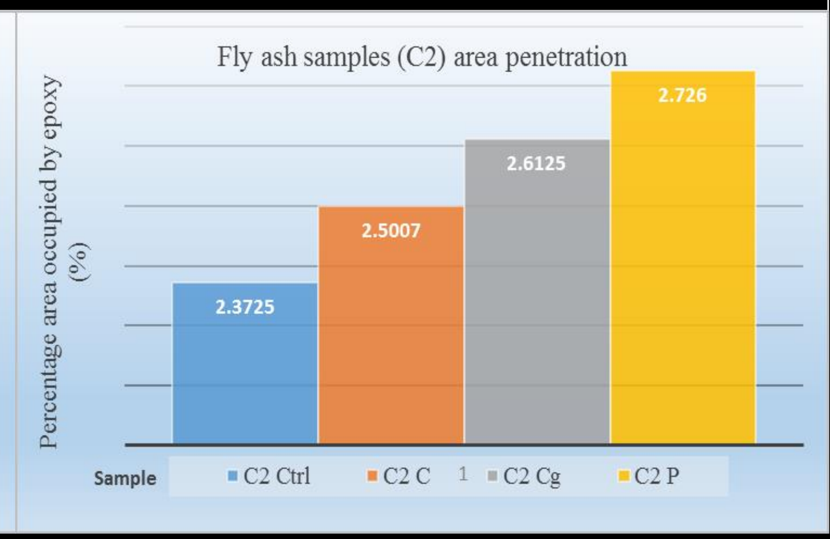
The maximum distance penetrated was recorded using the ultraviolet images and the following results were observed.





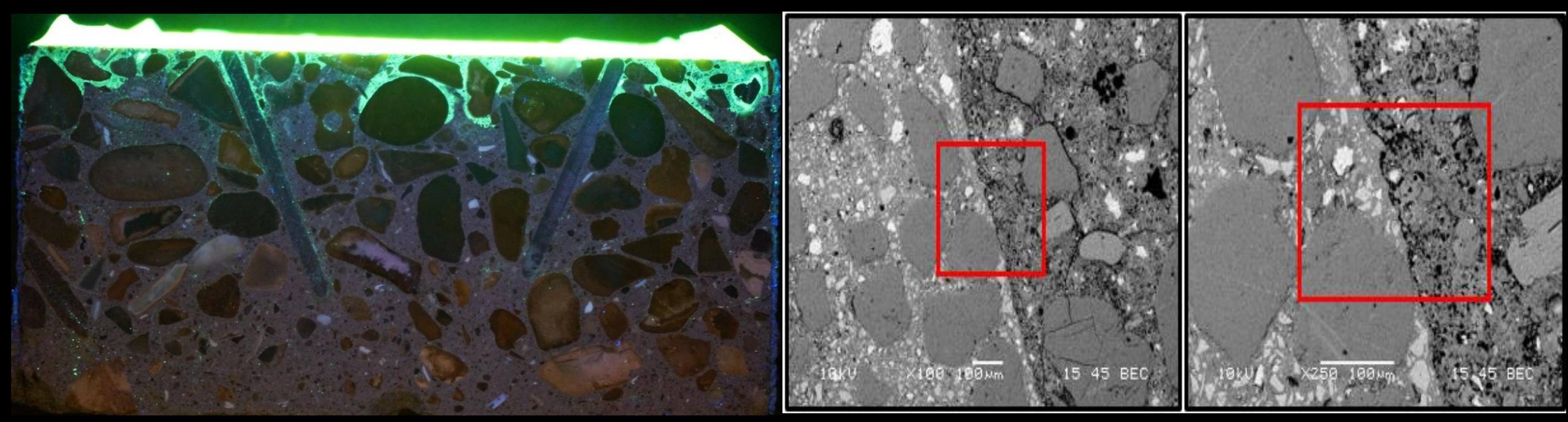
Analysis was carried out using ImageJ. In all cases the plastic spacer accommodated the most penetration along its boundary, reaching a maximum of 67% of the sample height. The images were segmented and thresholded using the fluorescence of the epoxy in order to calculate the fraction of the total volume that is occupied by epoxy.





CONCLUSIONS

The inclusion of spacers led to the increase of mass transport through the specimens. The samples containing plastic spacers, followed by the cementitious spacers showed the highest permeability and tendency to accommodate flow along its boundary. The B.S.E. images also indicated that cement content reduced near the spacer-concrete interface which can be attributed to the 'wall effect' obstructing particle packing in that area. However, grinding of the spacer did not have a noticeable effect on permeability.



Slag samples appeared to be the most dense while For fly ash, as the particles are spherical and in the same size range as Portland cement , it reduced the permeability of concrete. The ground cementitious spacers were observed to have less penetration in the silica fume samples compared to the fly ash samples.

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REFERENCE

Wong, H. S., Buenfeld, N. R. & Head, M. K. (2005) Pore segmentation of cement-based materials from backscattered electron images. *Cement and Concrete Research*