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INFLUENCE OF SUPPLEMENTARY CEMENTITIOUS MATERIALS ON TRANSPORT PROPERTIES OF CONCRETE CONTAINING REINFORCEMENT SPACERS

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INTRODUCTION

The influence of supplementary cementitious materials (SCMs), namely silica fume (SF), fly ash (FA), ground granulate blast-furnace slag (GGBS), on the transport properties of concrete containing reinforcement spacers was investigated in this study. Oxygen diffusivity, oxygen permeability, water sorptivity, accessible porosity, and electrical conductivity were assessed in order to quantify the effects of different SCM materials on transport properties of concrete.

SPACERS

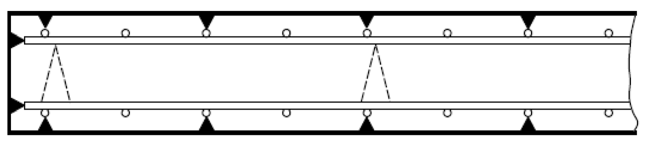

Figure 1. ▲ Side View of Spacer (BS7974-1:2001)

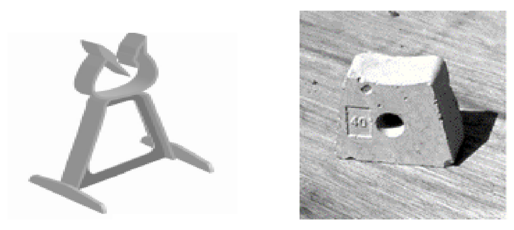

Figure 2. Plastic and Cementitious Spacer (BS7974-1:2001)

The British Standard defines reinforcement spacer as a component which is placed to maintain cover between reinforcement and formwork or blinding and which provides cover or support for reinforcement. Three types of spacers were used in this project: 1. Plastic spacers 2. Cementitious spacers 3. Cementitious spacers with grounded surface

SUPPLEMENTARY CEMENTITIOUS MATERIALS

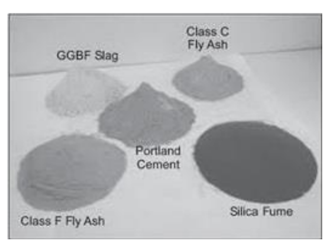

Figure 3. SCM Powders

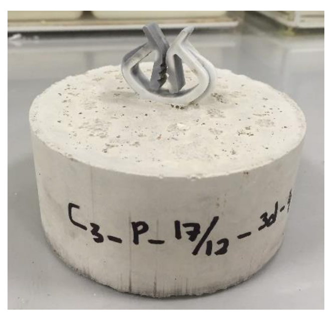

Figure 4. Test Sample

SCMs are pozzolanic materials that consist predominantly of silica and alumina, and are able to combine with portlandite ($Ca(OH)_2$) and water to produce new reaction products exhibiting a binding character (Mertens *et al,* 2009).

Use of SCMs has numerous environmental advantages: reduced disposal and better utilization of industrial waste, reduced use of raw materials, reduced green-house gas emissions and reduced energy use from the production of ordinary Portland cement.

SAMPLE PREPARATION

Sample Type	Concrete		
Water/Cement Ratio	0.40		
Binder System	CEM I + 8% Silica fume	CEM I + 30% fly ash	CEM I + 60% GGBS
Curing age	3 days or 28 days		
Conditioning	20°C, 75% Relative Humidity		

Table 1. Sample Composition, Curing and Conditioning Regime

OXYGEN DIFFUSIVITY

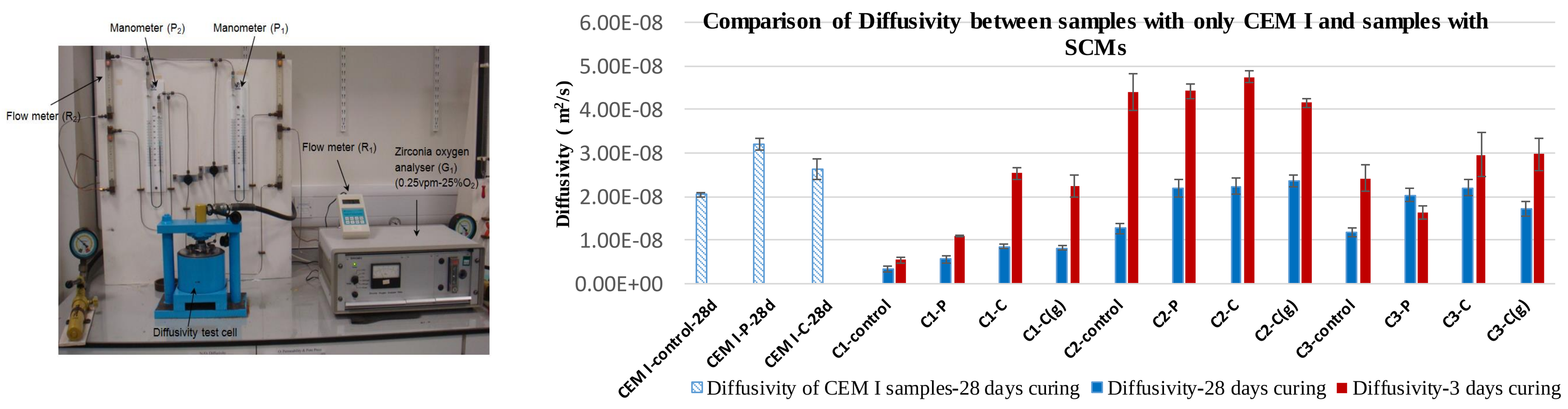

Figure 5. Diffusivity Test Apparatus and Results

Two streams of oxygen and nitrogen with equal pressure were applied on two opposite sides of the sample. Oxygen diffusivity was measured by measuring oxygen concentration in the nitrogen stream by using the zirconia oxygen analyser.

It can be seen from the graph that adding SCMs can reduce the oxygen diffusivity but this only happened in 28 days curing samples. The average diffusivity in the three different mixes spans up to one order of magnitude: Silica fume reduced the oxygen by the most extent due to its extreme fineness of particles. Samples with fly ash have the highest oxygen diffusivity because fly ash react later than other SCMs.

OXYGEN PERMEABILITY

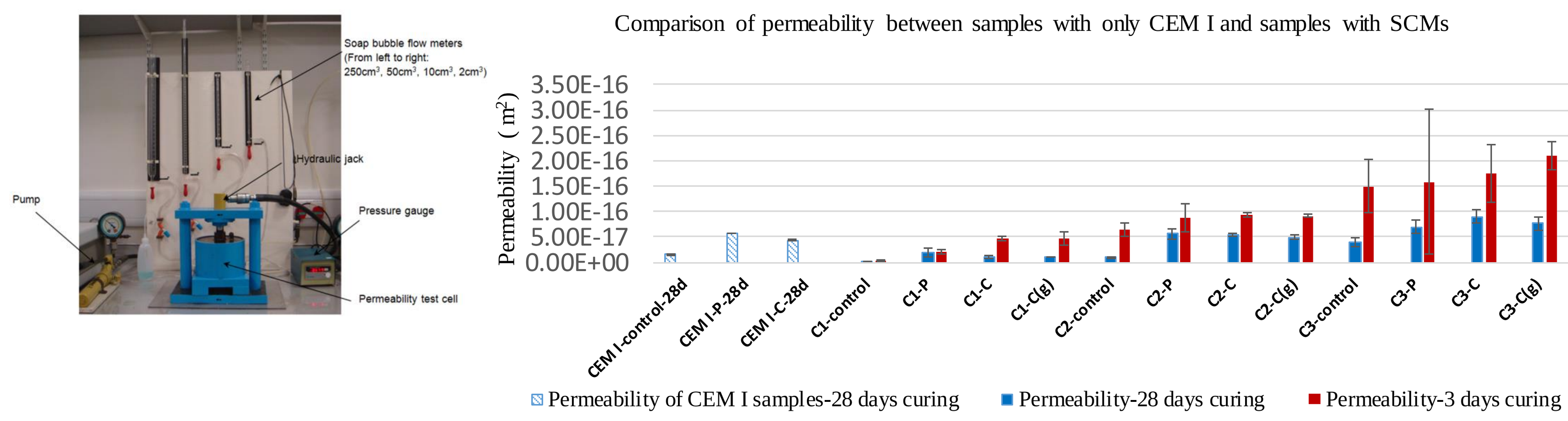

Figure 6. Permeability Test Apparatus and Results

Oxygen permeability was measured by applying a pressure gradient of 0.50, 1.50 and 2.50 bar above atmospheric pressure on one side of the concrete sample.

It was found that adding SCMs did not reduce the oxygen permeability. This was caused by the large scale of increase of interfacial transition zone due to the presence of spacers induces more microcracking, and this cannot be compensated by SCMs, especially when some SCMs like GGBS is potential to induce more cracking. Other transport properties like diffusivity and water sorptivity are not as affected as permeability, since they are less sensitive to microcracking (Wong *et al*, 2009).

WATER SORPTIVITY

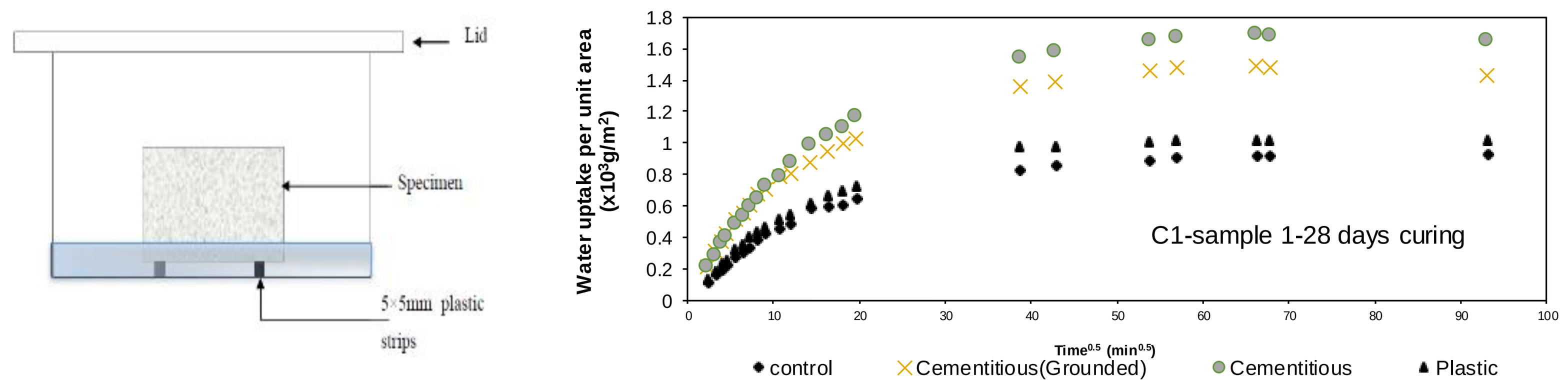

Figure 7. Water Sorptivity Test Apparatus and A Typical Result

The curve of water absorbed vs square root of time showed a bi-linear character. Samples with spacers have larger amount of water uptake than the control samples

VACUUM SATURATION AND POROSITY

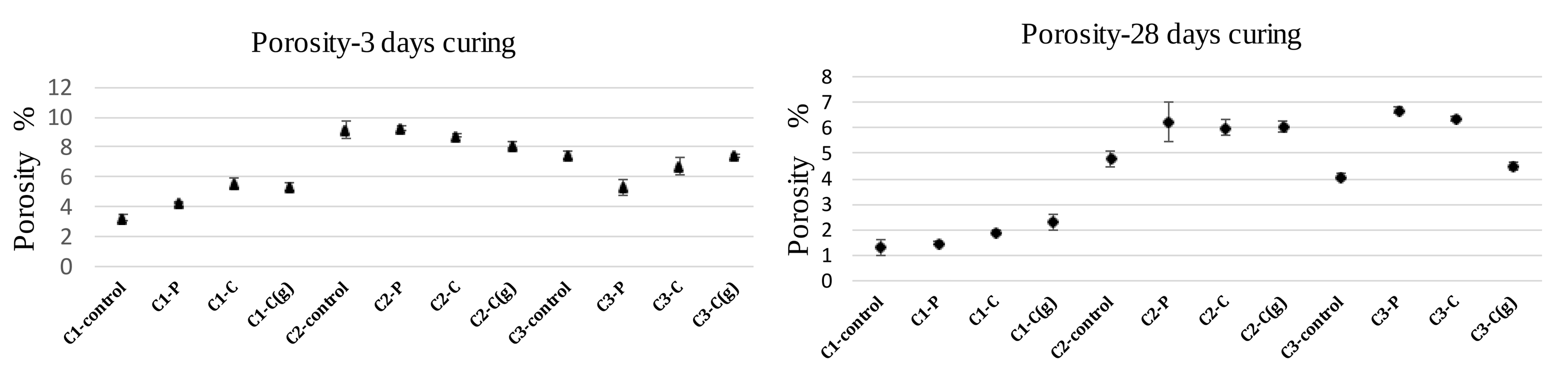

Figure 8. Porosity of Test Samples

Results from vacuum saturation tests showed that samples with fly ash have the highest porosity and samples with spacers have higher porosity than samples with no spacers.

CONCLUSIONS

- Adding SCMs can reduce transport properties of concrete containing spacers.
- The presence of spacers increased the transport properties and cementitious spacers increased it by the most.
- Grounding the surface of spacers can help reduce transport properties of concrete.

ACKNOWLEDGEMENTS

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