Durability and service life of structural lightweight aggregate concrete produced with different types of cementitious materials

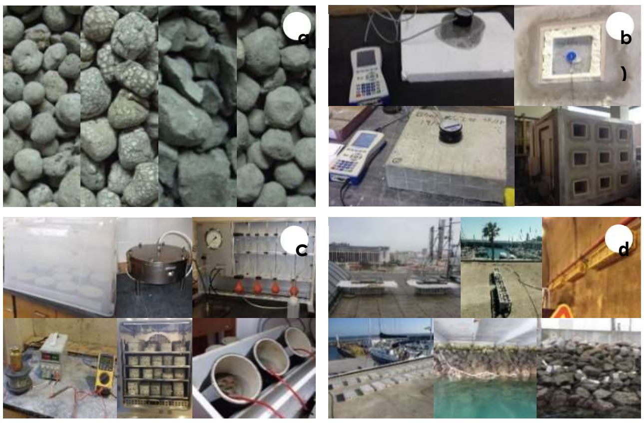
Summary

In the last decades, with the technological evolution of high performance concrete and with the increasing durability and energy efficiency demands, research was intensified in the structural lightweight aggregate concrete (SLWAC) domain. However, there are still numerous uncertainties in its characterization and performance, namely durability, service life and thermal performance areas. Thus, the present study's aim was to characterize the durability and thermal performance of SLWAC. To that end, an extensive experimental campaign was carried out, comprising the production and characterization of concrete mixtures with four types of lightweight aggregate with distinct porosities, nine types and volumes of binder and four water/binder ratios, covering an extensive range of SLWAC with resistance classes between LC8/9 and LC55/60 and density classes between D1,6 and D2,0, which increased the validity of this study. Overall, more than 7500 samples were tested in this study. SLWAC's durability was characterized through the main transport properties of concrete structures, namely capillary absorption, oxygen permeability, electrical resistivity, as well as carbonation and chloride penetration resistance, based on laboratory testing and on real environmental exposure. The influence of SLWAC's main composition parameters was assessed, namely the type of aggregate, type of binder and water/binder ratio, as well as testing age and exposure environment.

The proposal of a biphasic model to characterize SLWAC's carbonation behaviour is worth mentioning. The relation between SLWAC's durability and its main physical and mechanical properties were analysed. SLWAC's main deterioration mechanisms were modelled according to the main durability standardization and their semi-probabilistic and probabilistic service life analysis were performed, for different XS and XC environments. Furthermore, new abacuses were suggested for carbonation and chloride induced corrosion service life and new composition limits were recommended for SLWAC, taking into account different types of aggregate and binder, and practice guidelines were defined for SLWAC subjected to different exposure environments. Finally, SLWAC's thermal performance was characterized. New thermal conductivity measurement methods were suggested for lightweight aggregates and a model to estimate SLWAC's thermal conductivity was proposed. Moreover, SLWAC's potential for thermal bridge reduction and improvement of the energy performance of buildings was assessed. In conclusion, the present study has contributed to widening the current understanding of SLWAC, building confidence in its utilization, which combines the advantage of weight reduction and better thermal performance with the durability requirements established for this study.

Keywords

Structural lightweight aggregate concrete, durability, environmental exposure, semi-probabilistic and probabilistic service life, thermal performance.



Overview of the experimental campaign: a) different types of LWA; b) thermal characterization; c) durability characterization; d) different environmental exposure conditions.

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Period

2015-2019

Funding

FCT scholarship (SFRH/BD/100397/2014)