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Deformation Velocity Survey in Mortar and Cement Paste Specimens Subjected to External Aggressive Attacks

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1 Introduction

The durability of concrete depends not only on the composition of the material and its resulting porosity, but also on the environmental conditions. Contact between concrete or cement mortars with water and soils containing sulphates, of a natural, biological origin or deriving from pollution, can activate chemical reactions in the cement paste inducing an expansion and degradation of the concrete. To evaluate the behaviour of the cementitious material subjected to various external aggressive attacks, prismatic samples of cement paste and mortar samples produced with the same binder (Portland cement) were immersed in demineralised water and in various solutions containing 5% and 10% sodium sulphates. Their expansion was monitored over time by a direct length measurement. This paper shows the results achieved in a rather long laboratory investigation and a first hypothesis has been formulated on the possible expansion rate in the first 56 test days and in the following 850 days.

The durability of a concrete structure represents the ability to withstand aggressive environmental stresses, therefore it depends not only on the composition of the material and the resulting porosity, but also on environmental conditions. The different causes of damage to concrete, can be divided into different types depending on whether the aggressive action involves one or more components of the conglomerate (cement paste, aggregate or metallic reinforcement).

In particular, when a concrete structure comes into contact with waters or soils rich in sulphates, a series of complex chemical reactions can occur the sulphates which propagate inside the material and aluminates of cement paste, leading to the formation of leading to the formation of gypsum, secondary ettringite, and in some cases, thaumasite with the consequent expansion and formation of cracks and expulsion of parts of concrete. These phenomena are collected in the general term of the external sulphate attack.

Various researches have been carried out on this subject, many of which were dedicated to the description of sulphate attack from an experimental point of view. There are numerous experimental campaigns carried out on cement paste, mortar and concrete samples, however the results depend strongly on the test conditions, the cement used and the aggregates and their particle size distribution. On this topic there are researches in the literature that for the most part focus on the evaluation of durability and the evolution of damage (Garavaglia *et al.*, 2017, Tedeschi and Garavaglia, 2019, Tedeschi *et al.* 2017).

In this paper, the results of an ongoing experimental campaign are reported, carried out on prismatic samples of cement paste and mortar. An objective of this experimental program is also to highlight the role of the aggregate on the degradation phenomenon, for this reason samples of cement mortar were prepared with two different types of aggregate.

To evaluate the behaviour of the cement material subjected to various external aggressive attacks, laboratory tests were carried out during which cement paste samples (P-CEM), mortar samples with normalised sand (M-nor) and samples of mortar with aggregate (M-agg), were subjected to immersion cycles, thus simulating three different aggressive attacks: from demineralised water, from sodium sulphate at 5% salt concentration and from sodium sulphate at 10% concentration. The expansion was monitored over time by direct length measurements.

The tests were performed in accordance with the UNI EN 12617-4: 2003, but they lasted longer in time in order to verify any changes in behaviour over time.

The results obtained in the 889 days are shown as the variational behaviour of the deformation (shrinkage/expansion) recorded, but also in terms of deformation velocity, variable at each instant of the test process and function of the deformation value recorded.

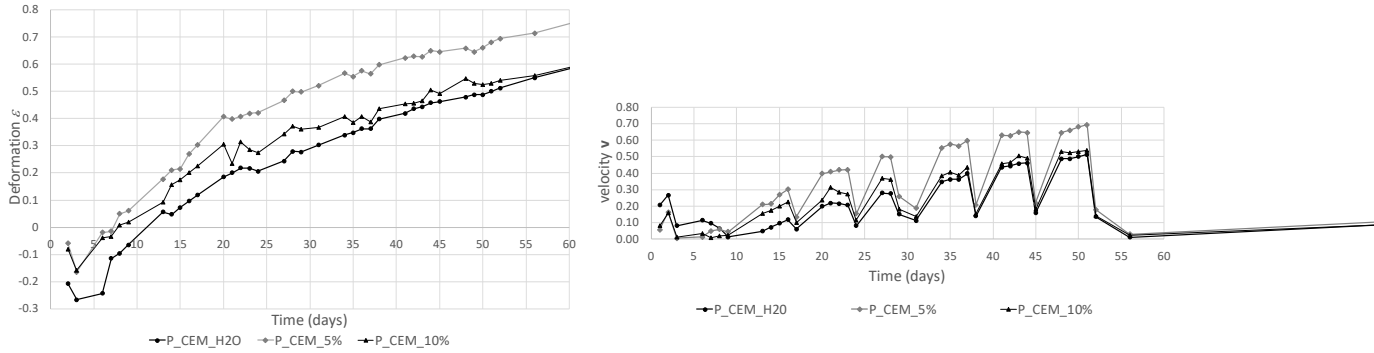

Figure 1. P-CEM mixture. a) Comparison of the variation of deformation in the first 56 days of testing, referring to the three aggressive agents tested and the mixtures; b) Deformation velocity comparison vs. time for the first 56 days of testing referring to the three aggressive agents tested and for the mixtures.

There are not many approaches to this topic in the literature. A similar approach is present in Zhanga *et al*., 2012, which stimulates the authors to continue on this path. Future research developments will be oriented towards probabilistic modelling of the detected behaviours.

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