Comparative study of sulfate attack resistance of carbonated calcium silicates and plain Portland cement mortars

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Objective

- To compare the expansion and microstructural changes (chemical alterations) in the carbonated calcium silicate (Solidia Cement™) based mortars and ordinary Portland cement (OPC) mortars after 18 months of exposure to sulfate solutions.

Materials and Experimental Methods

- Mortar prisms (1x1x1.5 in.) made of Solidia Cement™ (SC) and OPC (Type I) cast according to modified ASTM C109
- Exposure solutions: - 0.35M Na₂SO₄ - 0.35M MgSO₄ - de-ionized water
- Exposure time and length change measurements procedure according to ASTM C1012;
- A 1 x 1 x 1 inch cube specimens removed from mortar beam at the end of exposure period (i.e. after 18 months) were used for SEM study;
- Powdered mortar samples were used for thermal analysis study.

Test results

- SC matrix
  - No cracking and no chemical alteration of the matrix upon exposure to Na₂SO₄ solution;
  - No traces of Na₂SO₄ found in the matrix (except for some sulfate precipitates);

- OPC matrix
  - Mortar specimens immersed in sodium sulfate solution showed severe cracking and disintegration upon ~9 months of exposure;
  - Layered deposits of large gypsum crystals in the ITZ and in the paste;
  - Deposits of secondary ettringite in the matrix of OPC specimens.

Microscopic analysis results

- SC matrix
  - No observable microstructural or chemical changes.

- OPC matrix
  - Microcracks over the entire cross section of the specimen;
  - Surface double-layer consisting of brucite and gypsum (Fig. 5, d);
  - Transformation of CSH into deteriorative MSH close to the surface double-layer (Fig. 5, e);
  - Deposits of gypsum layers parallel to the exposed surfaces, both in the matrix and at the ITZ (Fig. 5, f);
  - Formation of secondary ettringite.

Conclusions

- After 18 months of exposure the carbonated Solidia Cement mortar bar specimens did not reach the critical point of expansion (maximum expansion observed was ~33% of the critical expansion);
- A chemical reaction between carbonated SC-L system and magnesium sulfate resulted in decalcification of the matrix, formation of gypsum and incorporation of Mg²⁺ ions into the structure of silica.
- Exposure of the same matrix to sodium sulfate solution did not result in any observable microstructural or chemical changes.