

CERAMIC TILE SURFACE MODIFICATION WITH TETRAETHYL ORTHOSILICATE: IMPLICATIONS IN BOND STRENGTH BETWEEN PORTLAND CEMENT MORTAR AND MODIFIED CERAMIC TILE

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1. INTRODUCTION

Adhesion between tiles and mortars is of paramount importance to the overall stability of ceramic tile systems. The interfaces between ceramic tiles and Portland cement mortar are derived from several physical and chemical phenomena that take place during their formation. Hence, despite being investigated for several decades, these interfaces are yet to be entirely understood mostly due to their complexity. In order to improve bond strength at the tile/mortar interface, the purpose of this study was to promote a new chemical functionalization of ceramic tile surfaces by modifying them with tetraethyl orthosilicate (TEOS) in order to enhance the interfacial adhesion with Portland cement mortar.

2. EXPERIMENTAL PROCEDURE

Pull-off tests were carried out in order to characterize the system after curing under controlled laboratory conditions, water immersion and heat aging (Table 1). The reference mortar was a Brazilian type ACI (usually, cement, aggregates, and thickener), which requires 0.5 N/mm² under laboratory conditions and water immersion (no requirements for heat aging condition), and the aim was to achieve C1 class type specifications, according to EN 12004 (ACII class in Brazilian standards) with tile surface modification and removal of the latex polymer from the mortar formulation, which would be attractive from an economic point of view.

Curing condition	Features
Laboratory curing	Tensile adhesion strength after 28 days at temperature ((23±2)°C) and relative humidity ((60±5)% conditions (standard climate)
Water immersion	Tensile adhesion strength after 7 days standard climate and 20 days water immersion
Heat aging	Tensile adhesion strength after 14 days standard climate and 14 days at (70±2)°C

Table 1: Summary of curing conditions.

3. RESULTS AND DISCUSSION

Figure 1 shows the influence of the surface modification on the bond strength and the comparison of bond strength results obtained from the ACI-TEOS modified tile with ACI and ACII unmodified tile systems due to the presence of TEOS alkoxysilane. Statistical analysis of the bond strength results indicates a significant increase in adhesion for the tile modified with TEOS (90% confidence) compared to that of the unmodified tile with ACI and ACII mortars under heat aging and water immersion storage conditions.

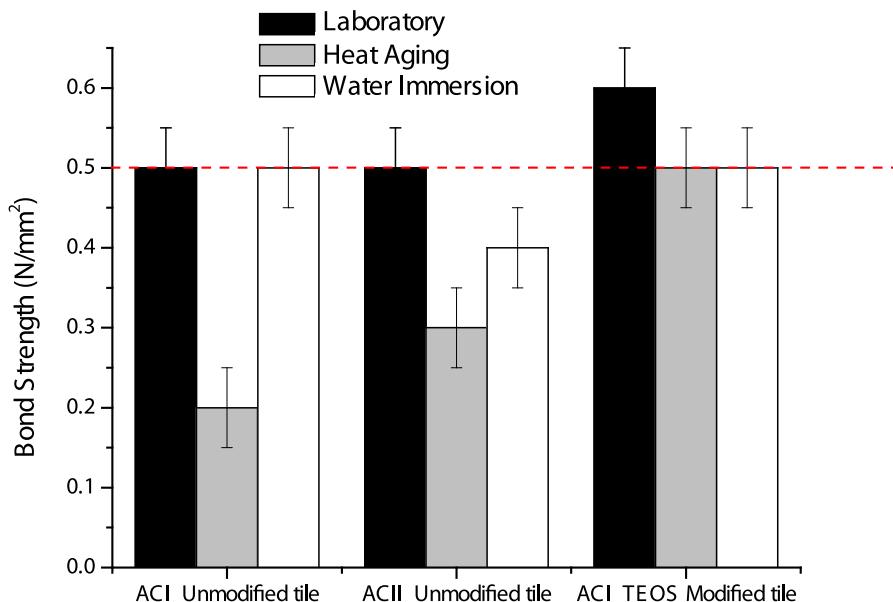


Figure 1: Bond strength results of ACI and ACII mortars with unmodified tiles and of ACI with TEOS modified tiles.

The results indicated that the reference mortar (Brazilian type ACI with unmodified tiles) fulfilled the requirements for its class: 0.5 N/mm² under laboratory conditions and water immersion (no requirements for heat aging condition). In contrast, the Brazilian type ACII with unmodified tiles (control mortar) did not meet the specifications required by the Brazilian standards regarding heat aging and water immersion.

Ceramic tiles modified with TEOS installed with ACI mortar met the Brazilian requirements for the ACII type, which are the same as those of the C1 class type specifications according to EN 12004, regarding laboratory conditions, heat aging, and water immersion.

The enhanced bond strength is believed to be related to the development of a continuous interface between the modified ceramic tile and the Portland cement mortar by covalent bonds between alkoxy-derived and calcium silicate hydrates (C-S-H), which are likely to occur to some extent, increasing bond strength, as may be observed in Figure 2. Minet *et al.* (2006) and Franceschini *et al.* (2007) have shown the incorporation of alkoxy silanes in calcium silicate hydrates in alkaline media at room temperature without disrupting the C-S-H inorganic framework.

4. CONCLUSIONS

The bond strength results revealed that, even after heat aging and water immersion curing, the system TEOS-modified tile/mortar meets the C1 requirements while the ACII Brazilian mortar, which was used as a control, did not meet the specifications required by the standards. The new system costs were also competitive. A reduction of about 50% and 90% in costs was calculated for tiles installed in a single and a double layer, respectively.

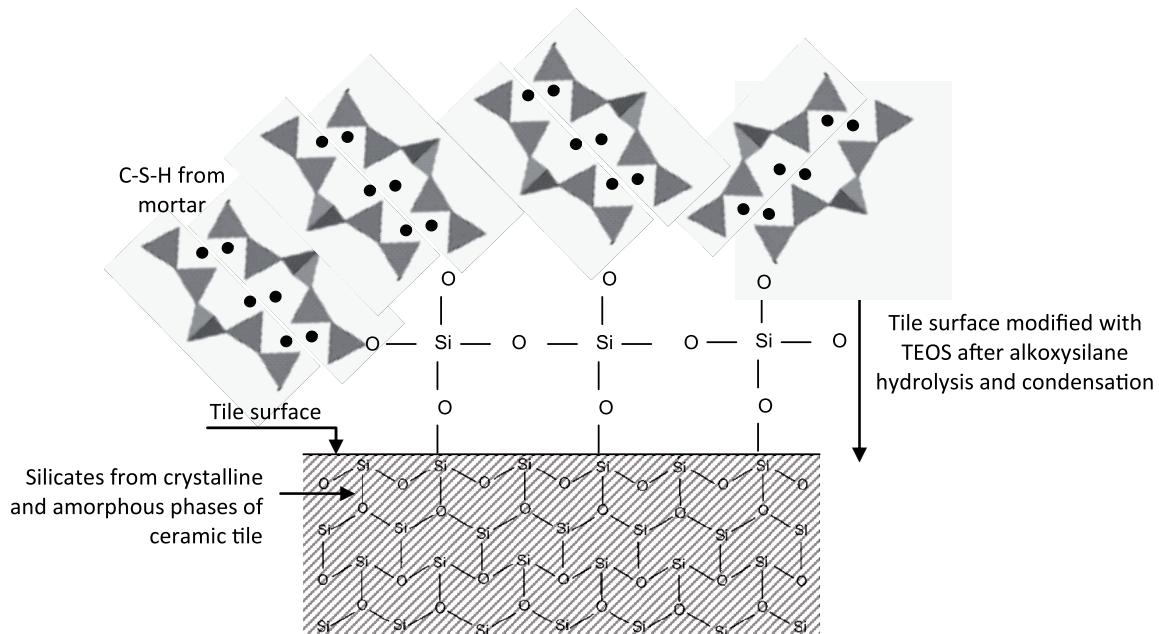


Figure 2: Schematic representation of Portland cement mortar/TEOS modified ceramic tile interaction model.

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