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EFFECT OF LINSEED OIL ON THE MECHANICAL PROPERTIES OF LIME MORTARS

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Abstract: *Linseed oil was commonly used in former times as an additive for mortars to improve hydrophobicity. However, linseed oil has also an important role on the mechanical behaviour of mortars that is strongly dependent on the type of binder. The effect of linseed oil addition in 1.5% by the weight of the binder was studied in two different mortar mixtures: air lime mortar and air lime-metakaolin mortar. The degree and the order of carbonation and hydration reactions were studied by thermogravimetric analysis and flexural and compressive strength were evaluated along curing time: 14, 28, 60 and 90 days. The results point out that carbonation process was slightly improved by the addition of linseed oil whereas the hydraulic effect of the pozzolana metakaolin was reduced. However, it is the lower capillarity coefficient, which involves a water intake reduction that may be reported as the main factor improving the mechanical behaviour of lime with linseed oil mortar exposed to freeze-thaw cycles and hence, its durability in wet and freezing conditions.*

Keywords: ***Linseed oil, lime, metakaolin, mechanical strength, hydrophobic effect.***

The scientific interest on mortars based in traditional formulations is that they show great compatibility with ancient building materials. However, lime mortars with compositions similar to ancient mortars have presented durability problems when exposed to weathering agents (Veiga, 2003).

Since liquid transport is one of the key factors influencing durability (Roels, 2000) additives which grant hydrophobic properties to mortars have become of great interest to the scientific community (Blachnik, 2001; Stolz, 2007; Izaguirre et al., 2010). The design of lime mortars with oil additives has the main goal of ensuring a degree of internal hydrophobicity and, consequently, lessen the damage from salt and frost. However, data from literature show that addition of oils to lime mortars reduces their mechanical strength by partially inhibiting carbonation reactions (Oliveira & Santiago, 1992; Sá, 2002; Veiga, 2003). Other studies indicate significant compressive strength increment (Rovnaníková, 2002; Sá 2005; Ventolà et al., 2011).

Linseed oil was one of the main lipid additives used for mortars formulation in former times according to ancient treatises e.g. Vitruvius, Pliny, Palladio. However, there is lack of information about the formulation technique.

Owing to the proved influence of oils on the mechanical properties and durability of mortars the aim of this paper is to study the variation of the mechanical behavior in hardened lime-based mortars (lime and lime with metakaolin) with 1.5%-w/w linseed oil (to the weight of binder) and to relate it with resistance to freeze-thaw cycles.

Although previous research studies outlined that oil addition to lime mortars decreases their mechanical strength by restraining carbonation, the results obtained in the present study show the contrary. This is possibly due to a combination of different factors, particularly the chemical composition of the oil, the type of binder and the amount of oil added. In the present study it is highlighted that porosity and carbonation rate have low influence on the mechanical performance of mortars with oil 90 days of age. The strength modification (Fig. 1) may be rather assigned to formation of insoluble calcium salts of fatty acids that are well bounded in the mortar structure improving strength in lime mortar and decreasing it in lime-metakaolin. Porosity results are very

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similar between reference mortars and mortars with oil (33%±1.3) but the capillary coefficients are relevantly different: oil addition to lime mortar promoted a coefficient reduction of approximately 82% and on lime-metakaolin mortar 57%. The extremely slow capillary absorption rate of mortars with oil compared to the reference may be assigned to the hydrophobic effect of the oil that grants higher contact angle of water on the hydrophobic mortars surface and inhibits water penetration into the voids.

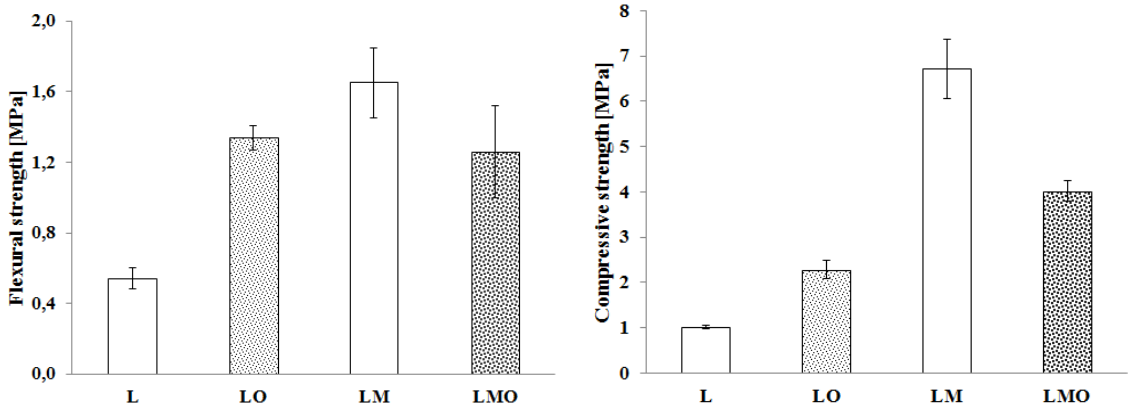

Fig. 1: Graphics of flexural and compressive strength of 90 days of age mortar specimens (the values correspond to the average of 5 samples ± standard deviation). Mortar codes: L: lime; LO: lime+oil; LM: lime+metakaolin; LMO: Lime+metakaolin+oil.

Improved durability of lime mortar with oil addition has been confirmed by testing their freeze-thaw resistance: lime mortar was destroyed after 1 cycle whereas lime with oil endured 10 cycles after which exhibited moderate degradation but mechanical strength significantly decreased. Mechanical strength and porosity are important indirect parameters to assess mortars durability. In the case of oil addition to lime based mortars the results indicate that the modification of the chemical composition of the mortar can have greater significance for the mortar durability by hindering water intake, thus lessening related problems. The lower capillarity coefficient may be pointed as the main factor improving the performance of lime mortar with oil exposed to freeze-thaw cycles and hence, its durability. Further research developments focused on the chemistry of the processes will certainly contribute to clarify the questions on mortar strength and durability raised by the results reported.

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