Universidade do Minho
Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

EXPERIMENTAL CHARACTERIZATION OF COMMERCIALLY AVAILABLE GROUTS FOR USE IN MASONRY STRUCTURES

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KEYWORDS
Grouts, masonry, strengthening, injection.

EXTENDED ABSTRACT

Conservation of historic masonry structures should preserve its historic nature as well as ensure its structural stability. The condition of a structure and the extent of deterioration determine the type of repair needed. It is important that the selected strategy maintains the existing aesthetic quality of the masonry, as well as its structural integrity, both during and after the intervention.
Cement and lime-based grouting is a well-know repair and conservation method. This intervention technique can be durable and mechanically efficient whilst preserving the historical nature of the structure. The selection of an injection grout for a repair should be based on both the physical and chemical properties of the deteriorated mortar. Compatibility between the existing medium (masonry and mortar) and the repair material is a major factor in the success of the intervention. Furthermore, other parameters such as rheology, injectability and the stability of repair grouts should be considered to ensure the effectiveness of grout injection, (Perret et al., 2003). In fact, to be adequately injected into masonry, the grout should comply with a set of requirements, regarding its rheological, physical, chemical and mechanical properties.
The work present in this paper was developed under the PhD thesis entitled "Experimental analysis of cement and lime grouts for use in masonry structures" and its main objective was to assess the physical, injectability and bond strength characteristics of commercially available grouts.
Several laboratory tests were conducted to determine the fresh and hardened properties (physical and mechanical) of four commercially available (CA) grouts used to repair masonry, considering namely: flow time; bleeding; segregation and compressive strength. The first three parameters were evaluated mixing water at temperatures of 10 º C and 30 ° C. The time taken for one liter of grout to pass through the Marsh cone was measured. The compressive strength was evaluated after 28, 90, 180 and 360 days of curing time.
The injection grouts were evaluated also in terms of injectability and penetration. The injectability of the grout is influenced not only by its intrinsic properties, but also by its compatibility with the masonry to be repaired, (Laefer et al., 1996).With this purpose, the CA grouts were injected into transparent cylindrical plexiglas moulds of 150mm diameter and 300mm height. The moulds were filled with different stones types and sizes, in order to reproduce typical Portuguese masonry walls.
The four different CA grouts were injected, with a pressure of 1,5bar using a "pressure pot". The time for the grout to reach the top of the cylinder was measured. This time is important to define the rate of injectability of the grout, (Binda et al., 2003). The specimens were cured after de-molding at 20ºC and 90% of R.H. At 28 and 90 days of curing, uniaxial compression tests were performed with displacement control together with indirect tensile tests or "Brazilian tests". The tested cylinders were subject to visual inspection after failure in order to study the penetration of the grout, as in other studies (Binda, 2003, Valluzi 2000, Laefer, 1996).
Within the present work, the mechanism of bond was studied in composite grout/stone specimens as the shear bond strength of the grout-stone interface is the main property affecting the behavior of grouted walls. The tensile strength of the interface between grout and the stone, required the preparation of composite specimens with the four CA grouts available and three different stones: Limestone, shale and yellow granite. The moisture content of the stones also varied. The tests were performed with dry, moist and saturated stones. The specimens were prepared with the help of a

Semana da Escola de Engenharia
October 24 - 27, 2011

transparent film stuck to the stone, which served as a mould. The grout was placed with a syringe, and a week before the test a circular metal plate adapted for the tensile test equipment was glued with an epoxy. Tensile tests at the age of 28 and 90 days are being performed.

MAIN RESULTS AND CONCLUSIONS

The investigation of the four commercially available grouts revealed significant variations in the measurements of described properties.
The rheological behavior of the grouts is significantly affected by the temperature variation (T=10ºC and T=30ºC). One of CA grouts presents a very high flow time, which, according with some authors (Shannag et al., 2002) is not preferred for injection purposes. Regarding compression tests, it was observed that the same CA grout mentioned above shows values of compressive strength relatively low (1,5MPa at 28 days) compared to other products (between 12-22 MPa at 28 days).
The penetration capacity of the four CA grouts is also affected by the type of stone. The time required for filling pieces filled with shale or limestone is less than in the case of yellow granite. Expected values, due the fact granite be more rough than the other stones.
For two of the CA grouts the compressive strength and modulus of elasticity, showed low values (below 7 MPa and 6GPa, respectively) for the three types of stone. The other two CA grouts present higher values for the three types of stone (between 14 and 25 MPa for compressive strength and about 17GPa for modulus of elasticity).
Finally, in bond strength tests it was found that one of four CA grout has satisfactory values at 28 days of age (around 0,8MPa) for the three types of stone. For the other CA grouts, in some cases, it was not possible to perform the test, because the specimen in the de-molding process released itself. It occurred for the sample with one of the grouts which curiously presents the highest compressive strength. Although this part of the study is still in progress, the experimental results obtained from bond strength tests allow us to conclude that many factors influence the bond strength of the grouts, like moisture percentage among others, and consequently the effectiveness of the injection. The bonding capacity of the grouts is perhaps the main property affecting the behavior of grouts walls and for this reason should be a larger study.

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