



Geopolymers in cultural heritage: their application in azulejo conservation

Catarina F. M. Geraldès

Laboratório Nacional de Engenharia Civil, Avenida do Brasil 101, 1700-066 Lisbon, Portugal.

Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia - UNL, Quinta da Torre, Campus Universitário, 2829-516 Caparica, Portugal; cgeraldes14@gmail.com

Augusta M. Lima

Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia - UNL, Quinta da Torre, Campus Universitário, 2829-516 Caparica, Portugal; arl@fct.unl.pt

J. Delgado-Rodrigues

Laboratório Nacional de Engenharia Civil, Avenida do Brasil 101, 1700-066 Lisbon, Portugal;

João Manuel Mimoso

Laboratório Nacional de Engenharia Civil, Avenida do Brasil 101, 1700-066 Lisbon, Portugal; jmimoso@lnec.pt

Sílvia R. M. Pereira

Laboratório Nacional de Engenharia Civil, Avenida do Brasil 101, 1700-066 Lisbon, Portugal; spereira@lnec.pt

SUMMARY: Currently, the restoration materials used to fill gaps in architectural historic azulejos (e.g. lime or organic resin pastes) present relevant drawbacks in terms of compatibility, efficacy or durability. The current solutions are not able to fully protect the azulejos resulting in further deterioration. Geopolymers can be a potential solution for azulejo lacunae infill given the chemical-mineralogical similitude, durability and versatile range of physical properties that may be obtained through the manipulation of their formulation and curing conditions. This communication presents and discusses the viability of the use of geopolymeric pastes to fill lacunae in azulejos or to act as “cold” cast ceramic tile surrogates reproducing missing azulejo fragments. The formulation of geopolymers (type and concentration of activators, aluminosilicate source and water content) and curing conditions was optimized. The need for post-curing treatments (desalination) was also taken into consideration in view of the purpose of their application: the restoration of outdoor architectural historic azulejos, which are exposed to adverse environmental conditions. The possible advantages and disadvantages of the use of geopolymers in the conservation of azulejos is also discussed.

KEY-WORDS: Geopolymers; azulejos; conservation; restoration, lacunae infill



RESUMO: Os materiais de restauro actualmente utilizados para preencher lacunas em azulejos históricos inseridos na arquitectura (por exemplo cal ou pastas de resinas orgânicas) demonstram ao longo do tempo, sinais de falta de compatibilidade, eficiência e durabilidade (Figura 1). As soluções actuais são incapazes de proteger totalmente os azulejos, expondo-os a uma crescente deterioração. Devido à sua semelhança química-mineralógica, possível durabilidade e poderem ser formulados de modo a possuírem uma gama versátil de propriedades físicas [1,2], os geopolímeros apresentam grande potencial para o preenchimento de lacunas em azulejos (Figura 2).

Nesta comunicação é apresentada e discutida a viabilidade do uso de pastas geopoliméricas para preenchimento de lacunas em azulejos bem como para produzir fragmentos de azulejos em falta. A formulação dos geopolímeros (tipo de activadores e concentração, fonte de aluminossilicatos, teor de água) e as condições de cura foram optimizadas. A necessidade de procedimentos pós-cura como a dessalinização, foi também levada em conta tendo em consideração a finalidade da sua aplicação: o restauro de azulejos históricos em integração arquitectónica, principalmente quando expostos a condições ambientais adversas.

Serão também discutidas as possíveis vantagens e desvantagens do uso de geopolímeros na conservação e restauro de azulejos.

GEPOLYMERS IN HERITAGE RESTORATION

Geopolymers present chemical-mineralogical similitude, durability and versatile range of physical properties that makes them highly promising for the conservation of azulejos. Principally when compared with the most commonly used materials (e.g. lime or organic resin pastes) which present issues of lack of compatibility, efficiency or durability (Figure 1). Geopolymer pastes were formulated by varying the aluminosilicate source (several types of metakaolins), activating solution (NaOH, KOH), curing temperature and usage of other additives (CaOH, and Na/K silicates). The first screening of efficiency of the geopolymer pastes was done by a visual observation of the pastes. The better performing ones were characterized through different techniques (MIP, open porosity, water vapour permeability, adhesion strength by pull-off, mechanical strength by bending tests, FTIR and XRD). As can be seen in figure 2, were some images of the samples used in different tests to characterize the geopolymers are displayed. The bending resistance showed lower bending strength for the geopolymer pastes obtained than historic azulejos but a higher bending resistance than the most common inorganic materials used in restoration of azulejos. The adherence of geopolymer pastes to the biscuit, which is one of the most challenging problems of the most currently used inorganic materials in restoration of azulejos, demonstrated a higher adhesion strength, indicating that these new pastes can overcome the usual problem of lack of adhesion. The results obtained in our study demonstrate that the geopolymers pastes are materials with high potential to be used as lacunae infill pastes in azulejos conservation. Further research will still be performed to attest their adequacy for this purpose.



Figure 1. Lacunae infill treatments with issues of lack of compatibility, efficiency or durability. Palácio Fronteira, Lisbon, 2012. Photos by S. Pereira



Figure 2. Geopolymer pastes and examples of some tests performed to characterize them. a) Visual observation of the pastes, b) Mechanical strength test (bending), and c) Samples for adhesion strength test (pull-off). Photos by C. Geraldes.

ACKNOWLEDGEMENTS

Project CerAzul: Research and development of materials and methods for the conservation of historic azulejos (PTDC/CTM-CER/119085/2010)

BIBLIOGRAPHIC REFERENCES

- 1 GUO, W., Wu, G., Wang, J. et al., *Preparation and performance of geopolymers*. Journal of Wuhan University of Technology-Mater. Sci. Ed., Vol. 23, 2008, pp. 326-330.
- 2 MUÑIZ-VILLARREAL, M.S., Manzano-Ramírez, A., Sampieri-Bulbarela, S. et al - *The effect of temperature on the geopolymerization process of a metakaolin-based geopolymer*. Materials Letters, Vol 65, 2011, pp - 995-998.