CONTRIBUTION TO THE EXPERIMENTAL ANALYSIS OF STRESSES BY TEMPERATURE VARIATION IN CLADDINGS WITH CERAMIC TILES

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1. INTRODUCTION

As discussions in the field of research on external claddings with ceramic tiles show, there are still a number of aspects that have not been satisfactorily resolved such as an inadequate understanding of the intensity and form of the distribution of stresses that arise in tiling interfaces, mainly owing to the great number of variables that influence the state of the stresses.

However, in the technical field there is understanding regarding the origin of the main differential movements that occur in adhered ceramic tilings, which point to the following causes: temperature variations in building facades, hygroscopic variations in the components, deformation of the structure under constant loading (creep), and movements originating by shrinkage of partitions and concrete structures (BOWMAN, 1992; HAYASHI et al. (1993); GOTO et al., 1994; GOLDBERG, 1994; WAGNEUR, 1995; GUAN; ALUM, 1997; GOLDBERG, 1998; MEDEIROS, 1999; ZONGJIN et al., 2000; ABREU, 2001; LNEC, 2003). All these movements, on being restricted, produce a state of stresses in the ceramic tiling layers: compressive or tensile stresses in the layer interfaces; normal stresses to the cladding plane (tension or compression) and shear stresses (LNEC, 2003).

In Brazil, a country with a tropical climate in which temperature variations can potentially become critical for ceramic tiling, few studies are available on the subject. In view of the need for more research on the subject, field work by the authors at construction companies in Sao Paulo has demonstrated that there is a rise in the concentration of tiling detachments during winter periods in which the drop in temperature can generate significant temperature gradients.

In the context of this study, a methodology is presented that is being used in the development of an experimental model for the evaluation of stresses and strains caused by variations in temperature in ceramic facade tilings.

2. METHODOLOGY

In the experimental models on thermal phenomena it is fundamental to analyse how the physical models are simulated that generally use geometries similar to the prototype, and which consider elastic behaviour.

The way temperature variation is simulated in many of the studies and standard test methods is by heating the surface of the test specimen by radiation and/or convection; after a minimum period of time, the test specimen surface is cooled, generally by spraying water, simulating rain.

These approaches are detailed in the CSTC (CSTC, 1980), UEAtc (UEAtc, 1992), standard BS-NF-EN 13687-2 (BSI, 2002) and IPT (IPT, 1998) methods.

The proposed methodology envisages a phase for the determination of the maximum surface temperatures variations of the cladding in the field, by fitting thermocouples (T type) at different points of the facade of a pre-selected building and using a data-logging system (NI) to correlate the values obtained with those of the models reported in the literature, as Figures 1 and 2 show.

The materials used were: industrial mortar for external cladding (as base or substrate), cementitious adhesive of types ACII and ACIII, according to the Brazilian standards, mortar for the tile-to-tile joints, and ceramic tiles of type BII a, according to the water absorption classification. Square test specimens were used, measuring 310 mm x 310 mm x 43 mm, in accordance with Resende (2004).

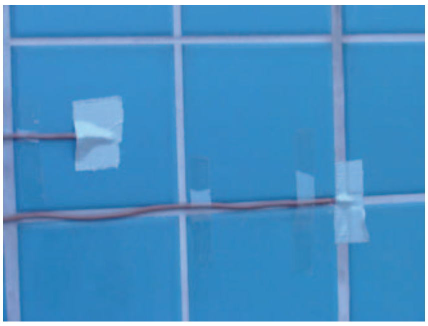


Figure 1. Position of the thermocouples on the building facade.

Figure 2. Temperature data logger, model SCX1300 of National Instruments

For the performance of the preliminary tests with the foregoing test specimens, each specimen was fitted with thermocouples for control of the surface temperature, and electric strain gauge-type extensometers were used to collect the deformation data. The temperature values in this phase were 70°C for the maximum and 20°C for the minimum. Heating was generated as Figure 3 shows with an incandescent lamp of 150 W, and cooling was performed by wetting the surface with water until reaching 20°C. In this phase it was also possible to verify control of the surface temperature with an infrared camera, shown in Figure 4.

Figure 3. Position of the thermocouples and strain gauges in the ceramic test specimen.

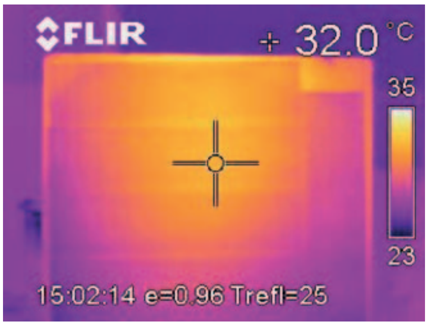
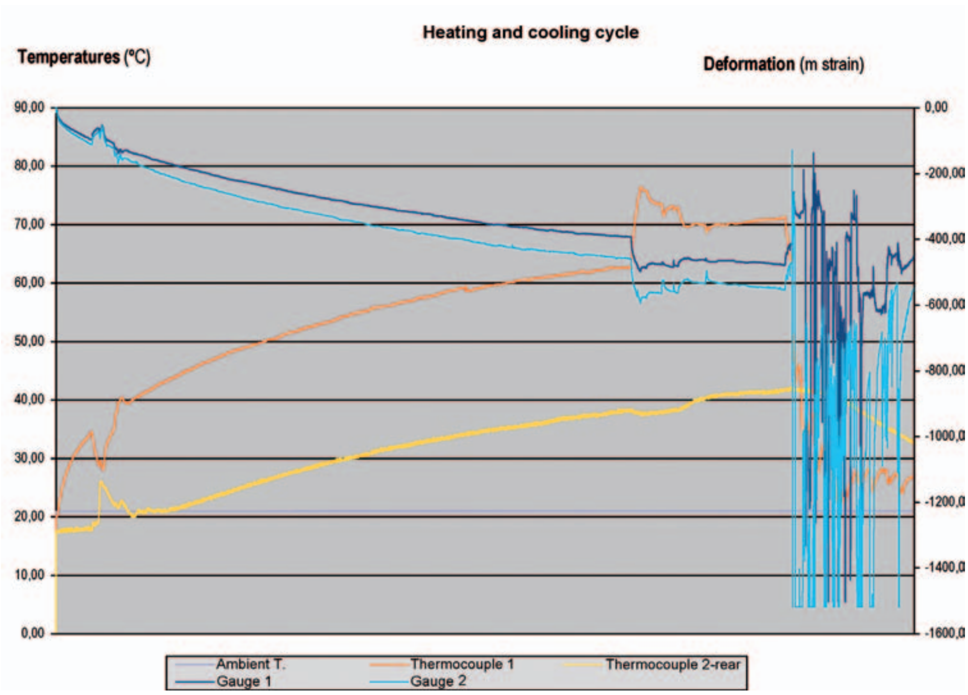


Figure 4. Image taken with an infrared camera during heating of the test specimen surface.

3. RESULTS

The results obtained, shown in Graph 1, do not yet enable drawing numerical conclusions; however they allow providing the test with a degree of sensitivity. For the case of the temperatures, a thermal gradient of 20°C is observed in the tiling between the front and back surface, which reaches a maximum value of almost 30°C. Cooling takes place during the period needed to reach thermal equilibrium. The strain readings (compression) indicate a proportional increase with the rise in temperature, reaching significant values and a strong variability in cooling time.



Graph 1.

4. CONCLUSIONS

The methodology presented has shown that the measurement equipment provides an approximation of the temperature variations and strains in the test specimens that were prepared; however calibration procedures are also necessary for the measurement instruments and control of variables such as relative humidity, so that more detailed studies are required.