RELATION BETWEEN IMPACT RESISTANCE AND SCRATCH HARDNESS OF CERAMIC GLAZES (IN GLAZED TILES) AND GLAZE-BODY FIT

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1. INTRODUCTION

It has been empirically found that the same glaze exhibits variations in mechanical behaviour when its conditions of fit with the body to which it has been applied change, either because the thermal treatment to which the glazed tile was subjected was modified or because the difference between the glaze coefficient of expansion and that of the underlying body was altered.

2. EXPERIMENTAL PROCEDURE

Three pairs of tiles were selected. Each pair was coated with a different glaze (A, B and C). The ones coated with glazes A and B had a different body and were fired in kilns with different heat-treatment cycles. The tiles coated with glaze C had been manufactured industrially and had been observed to exhibit different mechanical behaviour: the behaviour of the tiles referenced 1 was worse than that of the tiles referenced 2. To study the glaze-body fit of the samples, the Steger method was used with a stress tester programmed according to the following heat-treatment cycle: 1) Heating to a peak temperature of 750°C at a rate of 5°C/min. 2) 1 min residence at peak temperature. 3) Cooling to room temperature at a rate of 5°C/min.

To study the mechanical behaviour of the test glazes and compare this with the results obtained on the Steger tester, glaze scratch hardness and impact resistance were determined. Scratch hardness was determined by measuring the minimum load required to produce a scratch (Q_R) and to produce chipping (Q_D). This test was conducted on a scratch tester using a Rockwell C indenter. Various scratches were made at constant loading on the sample surfaces, progressively raising the load in 1N steps. The minimum applied load was 1 N. The classification was performed on the topographical map of the resulting scratches. Impact resistance was determined by means of a system developed at ITC, which enables a parameter E_α to be determined, which is representative of the energy absorbed by the material and used to produce microcracks, which on growing give rise to chipping or cracking. Plotting the values of this parameter versus impact energy yields a curved line. The impact energy at which this line leaves the x-axis indicates the formation of the first cracks. On the other hand, the rate of growth of parameter $E\alpha$ indicates the crack propagation rate.

3. RESULTS AND DISCUSSION

Table 1 lists the values found for parameters Q_R and Q_D. In the first place it can be observed that the values of both parameters are lower in tile 1 than in tile 2 for the same glaze, the difference being much more noticeable in parameter Q_D. This fact indicates that the scratch hardness of a glaze can vary according to the body onto which the glaze has been applied and to the firing conditions used.

Glaze	Q_R (N)	Q_D (N)
A1	20	23
A2	22	32
B1	25	47
B2	25	58
C1	31	31
C2	32	36

Table 1. *Q_R and Q_D values of the tested glazes.*

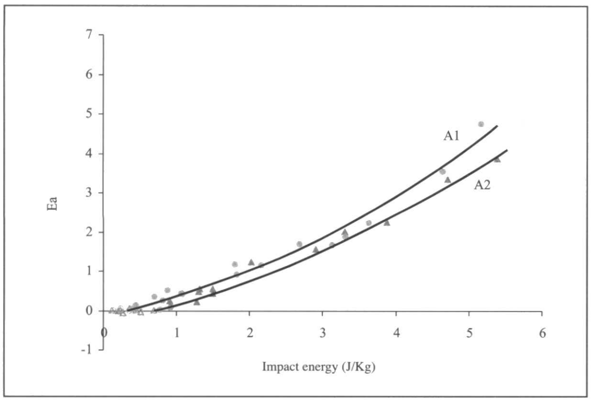

Figure 1. *Impact test results of tiles A1 and A2.*

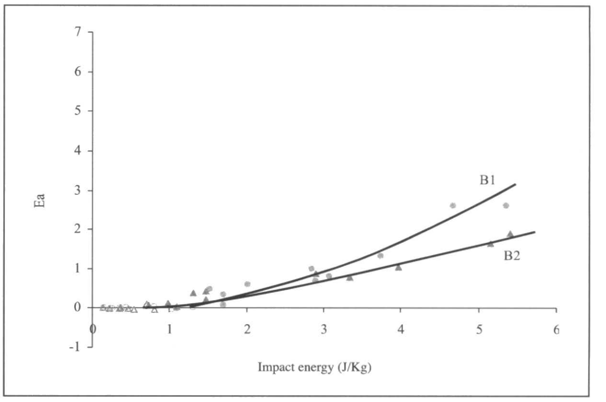

Figure 2. *Impact test results of tiles B1 and B2.*

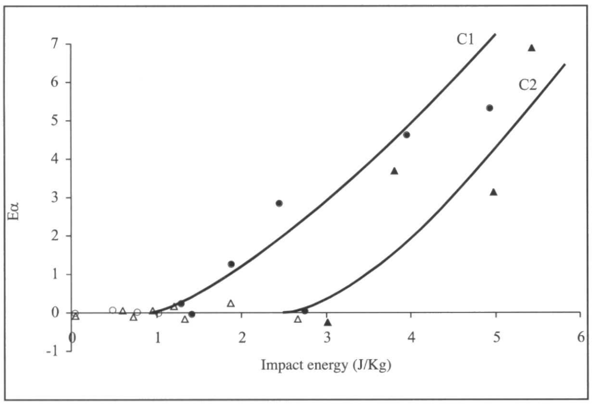

Figure 3. Impact test results of tiles C1 and C2.

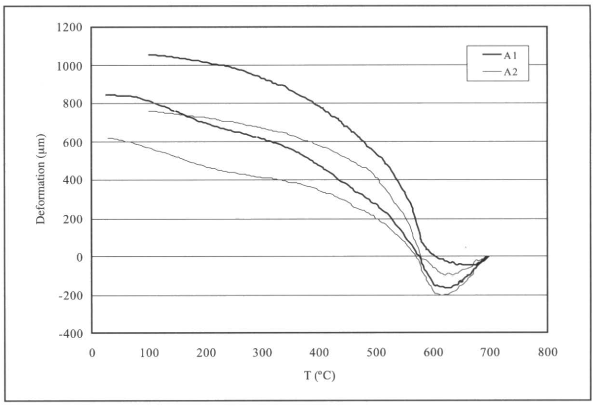

Figure 4. Glaze-body fit of tiles A1 and A2.

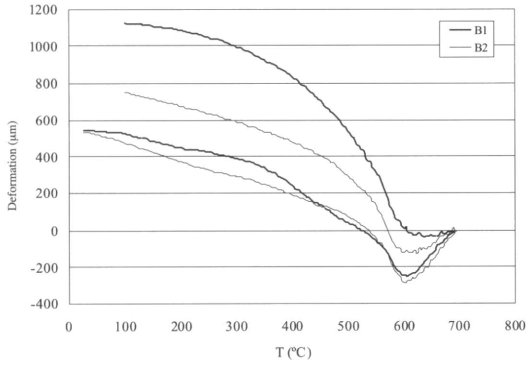

Figure 5. Glaze-body fit of tiles B1 and B2.

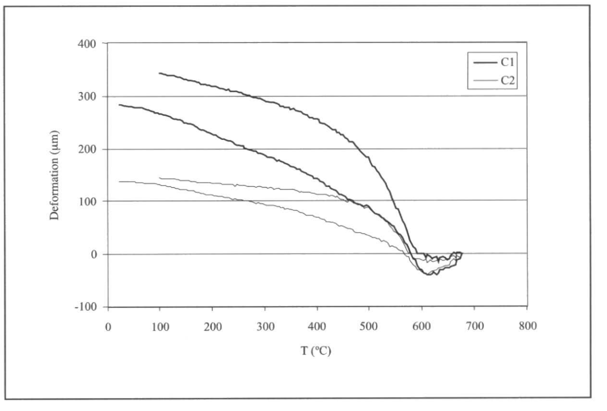

Figure 6. Glaze-body fit of tiles C1 and C2.

The results found in the impact test (Figures 1, 2 and 3) show that the curves corresponding to samples A1, B1 and C1 lie higher than those of A2, B2 and C2, which means that the defects produced by impact propagated more rapidly in the former. It can also be observed that in tile C1, the defect arises at lower impact energies than in C2, a fact also found to a lesser extent in tiles A1 and A2. These findings indicate that the tiles with the lowest scratch hardness also had the lowest impact resistance.

The data obtained in the glaze-body fit tests (Figures 4, 5 and 6) show that the initial stress level in samples A1, B1 and C1 was higher than in the respective paired tile (A2, B2 and C2). This confirms that the existing level of stress in a glaze considerably affects its mechanical properties, as comparing tiles with the same glaze reveals that those with the highest level of stress are the ones that have the lowest scratch hardness and impact resistance.