# EVALUATION OF CHANGE IN THE SURFACE APPEARANCE OF GLAZED CERAMIC TILES DUE TO ABRASIVE WEAR: COMPARISON BETWEEN THE ISO 10545-7:1996 VISUAL ANALYSIS AND MEASUREMENT OF COLOUR DIFFERENCE (CIELab VALUES)

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The aim of this study has been to investigate different types of glazed ceramic tiles, tested in accordance with the ISO 10545-7:1996 - Resistance to surface abrasion. The subsequent evaluation of testing was carried out visually in accordance with ceramic tile classification regarding change of the surface appearance.

The methodology of the testing is questionable given that it depends on the evaluation criteria used by the analyst. Therefore, there have been many discussions in relation to the best method of classifying ceramic tiles according to their resistance to surface abrasion, also known as the PEI method. A comparison is made in this study between the use of CIELab measurements, through a reflectance spectrophotometer.

A comparison is made in this study between the qualitative method (visual, through comparison of parts that have suffered abrasion and those that have not) and the quantitative method (CIELab chromatic coordinate values and the detection of small differences in colour ΔE in a Konica Minolta reflectance spectrophotometer – model CM-2600d, configured with D56 lighting, observation at 10º and including gloss).

The wear was carried out following the ISO 10545-7:1996 methodology. Intermediary trial cycles were also carried out according to the proposals made for this process. Values L, a, b, (CIELAB) were determined and the ΔE values were calculated using a non-tested reference test piece with the aim of determining value ranges where it was possible to see the wear. The ΔL, Δa, Δb, and ΔE values appear in the cycles where the wear visually manifests itself and in the cycles immediately before the wear appears visually (Table 1). Glazed examples in eight different colours were selected for the tests (chromatic coordinates L*, a*, b* in Judds): white (L=91.65/ a=0.40/ b=0.96), blue (L=28.88/ a=7.35/ b=-21.05), red (L=39.59/ a=35.87/ b=18.51), black (L=27.25/ a=0.40/ b=-0.10), yellow (L=69.47/a=20.86/ b=66.67), green (L=35.05/ a=-8.62/ b=9.05), light grey (L=78.01/ a=0.06/ b=0.27) and dark grey (L=47.29/ a=0.03/ b=-2.79).

| SAMPLE | NUMBER OF CYCLES | | ΔL (Judds) (A)/(B) | Δa (Judds) (A)/(B) | Δb (Judds) (A)/(B) | ΔE (Judds) (A)/(B) |
|---|---|---|---|---|---|---|
| | NON-VISIBLE WEAR (A) | VISIBLE WEAR (B) | | | | |
| White | Non-visible wear to 15000 cycles | | | | | |
| Blue | 55 | 60 | -0,42/ 0,52 | 0,21/ -0,22 | -0,18/ 0,40 | 0,52/ 0,69 |
| Red | 75 | 80 | 0,14/ 0,37 | -0,81/ -1,06 | -0,61/ -0,89 | 1,03/ 1,44 |
| Black | 50 | 55 | 0,55/ 0,44 | -0,02/ -0,02 | -0,09/ -0,05 | 0,56/ 0,44 |
| Yellow | 800 | 875 | -0,08/ -0,48 | -0,77/ 1,27 | -6,27/ -7,11 | 6,32/ 7,25 |
| Green | 50 | 60 | 0,17/ 0,33 | -0,01/ 0,36 | -0,03/ -0,26 | 0,38/ 0,55 |
| Light grey | 1000 | 1060 | 0,44/ 0,44 | 0,01/ -0,02 | -0,06/ -0,08 | 0,45/ 0,46 |
| Dark grey | 150 | 175 | 0,66/ 0,84 | -0,06/ -0,07 | -0,01/ -0,06 | 0,67/ 0,85 |

*Table 1. Previous cycles and cycle in which a change in appearance is observed, values of ΔL, Δa, Δb, and ΔE.*

The analysis of the results in Table 1 shows that wear is observed in different cycles according to the initial colour of the surfaces. Considering the variation of colour obtained on the tested surface (ΔE), in a lower cycle to the one where wear was observed, the conclusion can be drawn that the perceptible variations in the visual analysis are different according to the colour of the batch sample. For example, a black sample, with a ΔE of about 0.5 Judds already allows the possibility of visual identification of wear. However, it was not sufficient for a yellow sample with a ΔE of 6.0 Judds, to observe the same kind of wear.

The results indicate that the higher values in parameter b lead to a higher tolerance to appearance change derived from abrasive wear. Wear was not visually detected in the white glaze until 15000 cycles (this corresponds with a ΔE of 0.51 ± 0.07 Judds). Figure 1 shows the evolution of ΔE in glaze surfaces of different colours according to the increase of wear cycles.

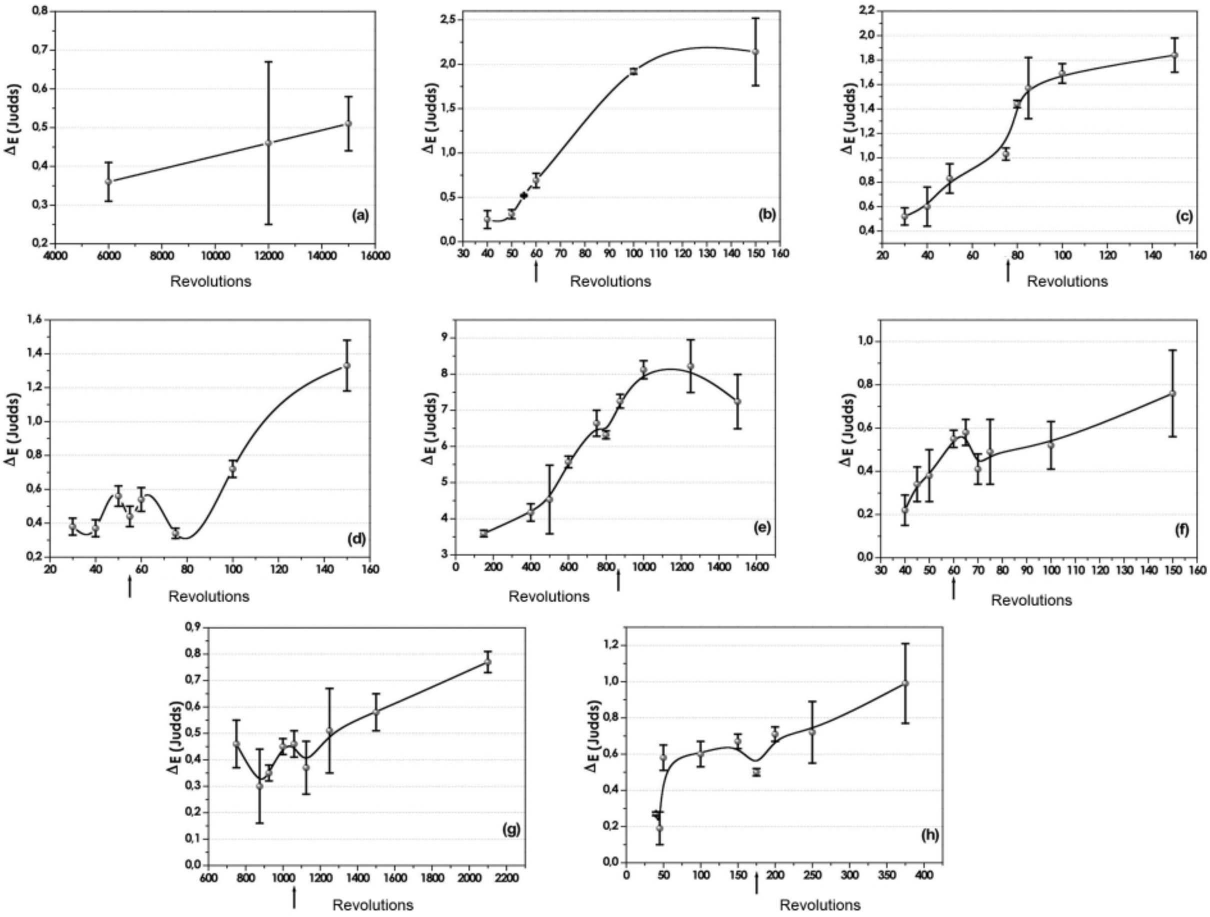


*Figure 1. Evolution of ΔE with cycle variation in the glaze abrasive wear tests: (a) white, (b) blue, (c) red, (d) black, (e) yellow, (f) green, (g) light grey (h) dark grey.*

According to the result obtained (Table 1 and Figure 1) and in accordance with the visual analysis described in the ISO 10545-7:1996 for samples selected for this study, the ΔE values indicate:

- White sample: ΔE values tolerated are higher than 0.5 Judds without the visual manifestation of change in appearance.
- Blue sample: change in appearance for ΔE values between 0.5 and 0.7 Judds.
- Red sample: change in appearance for ΔE values between 1.0 and 1.4 Judds.
- Black sample: change in appearance for ΔE values of about 0.4 Judds.
- Yellow sample: change in appearance for ΔE values of between 6.2 and 7.0 Judds.
- Green sample: change in appearance for ΔE values between 0.3 and 0.5 Judds.

- Light grey: change in appearance for ΔE values of about 0.4 Judds
- Dark grey: change in appearance for ΔE values of between 0.6 and 1.0 Judds.

The results show that the determination of colour differences can be a useful tool in resolving classification doubts for visual evaluation in PEI testing or simply used to forecast resistance to abrasive wear during the lifespan of a glazed surface of a particular colour. In the meantime, in order to make this possible, it is necessary to increase the number of tests and the colours analysed, establishing tolerance limits for ΔE within all the spatial regions of CIELab.

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