EQUIVALENT WEAR RESISTANCE: A NEW WAY TO ASSESS ABRASIVE WEAR RESISTANCE OF CERAMIC TILES

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ABSTRACT

The evaluation of abrasion resistance for ceramic tiles of the glazed type is accomplished through the PEI abrasion test. The PEI method however, presents some problems due to its subjectivity, since it is strongly dependent on the visual accuracy of the evaluator. Besides, the results may be influenced by the colour and patterns applied to the ceramics. The results of the PEI abrasion test applied to five ceramic samples showed no difference among these pieces, however when the microabrasion test was conducted on the same ceramic samples, the results showed that a difference existed among them. The results were performed with the abrasives silicon carbide and alumina.

KEY WORDS: Ceramic, PEI and microabrasion

INTRODUCTION

The evaluation of the wear resistance of coated ceramics is performed by the PEI method[1]. The PEI method however shows strong subjectivity, as it depends of the visual accuracy of the observer and is influenced by the colour and patterns of the tile. That fact is used by industry to give their products high PEI classifications.

Some attempts have been made to substitute the PEI method, but without success.

Barbera et al.[2] suggest a method based on measurement of the accepted limit of variation of the surface properties after the material has begun to show signs of surface deterioration as result of the abrasion. This method, however, also raises the issue of subjectivity by virtue of the accepted limit also being subjective.

Escardino et al.[3] in turn found a linear relation among parameters of the variation of the gloss curves and Ra roughness parameter as a function of the cycles of the PEI abrasion test. The results were obtained on homogeneous glazes. Gonçalves R.A. et al.[4] applying the same experimental procedures on commercial ceramics did not find any correlation among the same parameters.

OBJECTIVE

The objective of this work is to present a curve of the wear coefficients of the Mohs standard minerals as a function of their hardness. Through this curve, the Mohs standard minerals equivalent wear resistance can be obtained, allowing an index to be found that can contribute to classifying ceramic tile wear resistance without subjective measurements.

EXPERIMENTAL PROCEDURE

Slabs of the Mohs standards minerals (gypsum, calcite, fluorite, apatite, orthoclase, quartz, topaz, and corundum) were subjected to microabrasion tests using a Calowear microabrasion tester[5]. The Calowear microabrasion test consists of making a ball roll, under a falling watery dispersion of abrasive, over the surface of the object being studied, as can be seen schematically in Figure 1.

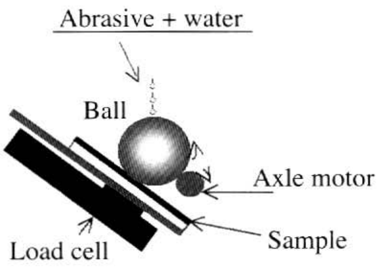


Figure 1. Schematic representation of the Calowear microabrasion test.

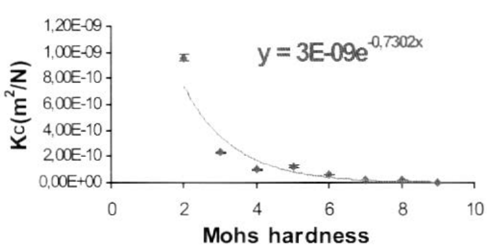
A cap is generated on the surface of the sample. The coefficient of wear K_C can be found from equation 1, where b is the diameter of the cap, L the slide distance, F_N the normal force applied and d the diameter of the ball. An ASTM 52100 steel ball was used, with diameter of 20 mm The configuration was adjusted to a normal force of 0.16N and the abrasives used were silicon carbide and alumina with a grain size of 1000 mesh and 5μm respectively and concentration of 0.75 g/ml (watery dispersion). The generated caps of wear were measured using an image analyzer coupled to a metallographic bank

$$K_C = \frac{\pi \cdot b^4}{32 \cdot L \cdot F_N \cdot d} \quad [1]$$

RESULTS AND DISCUSSION

With the values found of the wear coefficients of the Mohs scale standard minerals, plots were made of the wear coefficients as a function of Mohs hardness, for the silicon carbide and alumina, as shown in Figure 2.

(A)



(B)

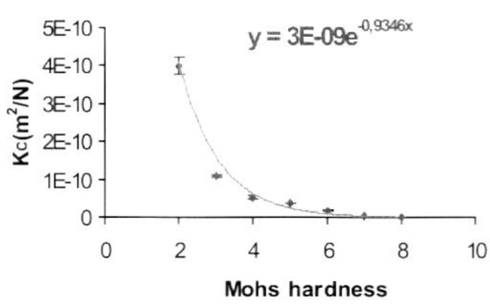


Figure 2. Curves of the variation of the wear coefficients as a function of the hardness of the Mohs standard minerals. Results obtained for the abrasive silicon carbide (graph A) and alumina (graph B).

The transformation of these curves in straight lines, Figure 3, gave Equations 2 (for silicon carbide) and 3 (for alumina), which enable obtaining the equivalent coefficient of wear for the Mohs standard minerals (K_E) for any materials when the respective K_C are known.

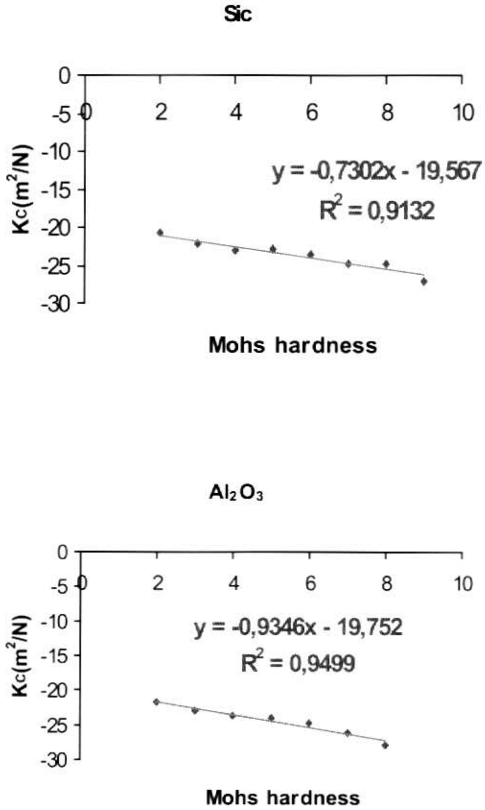


Figure 3. Linear correlation between the wear coefficient and hardness of the standard minerals.

$$K_E = \frac{-[\ln(K_C) + 19{,}57]}{0{,}73} \qquad \text{(for SiC)} \qquad [2]$$

$$K_E = \frac{-[\ln(K_C) + 19{,}75]}{0{,}93} \qquad \text{(for } Al_2O_3\text{)} \qquad [3]$$

In order to demonstrate the application of this process, the wear coefficients of five ceramic tiles were measured. With these values, using Equations 2 and 3, the respective equivalent wear coefficients were found. These results are shown on Table 1. Each result represents the average of nine values. The table also shows their respective PEI classification and Mohs hardness.

Samples	A	B	C	D	E
Class. PEI	III	III	III	III	III
Mohs hardness	5	4	5	4	6
K_E (m^2/N) SiC	6.55 ± 0.06	6.66 ± 0.11	6.76 ± 0.14	6.72 ± 0.12	6.58 ± 0.20
K_E (m^2/N) Al_2O_3	6.84 ± 0.10	6.76 ± 0.10	6.88 ± 0.12	6.82 ± 0.27	6.78 ± 0.11

Table 1. Equivalent wear resistance for the abrasives silicon carbide and alumina.

The coefficients of relative wear of the ceramics A, B, C, D and E present a better wear performance when compared with the standard minerals with the same Mohs hardness. With the Calowear microabrasion tests, the numerical values show that these ceramics have performance equivalents to the minerals of hardness 6.55, 6.66, 6.76, 6.72 and 6.58 when tested with silicon carbide and equivalent to the minerals of hardness 6.84, 6.76, 6.88, 6.82 and 6.78 when tested with alumina. On the order hand, when alumina is used, the values are higher than those obtained with silicon carbide. This occurs because the abrasive power of alumina is lower than that of silicon carbide.

It is also observed that the results show no relation with the respective PEI classification and Mohs hardness.

CONCLUSIONS

1 – The PEI abrasion test did not show any sensitivity for distinguishing the abrasive behaviour of the ceramic samples subjected to testing.

2 - The PEI classifications did not show any relation to the Mohs hardness.

3 - The evaluation methods for the abrasion resistance through the equivalent wear coefficient obtained by means of the microabrasion test have proven to be more effective in distinguishing the wear resistance of the samples tested.

4 - The equivalent wear coefficient may be used as an indicator of the resistance to wear, with the advantage that it is not subjective and, in addition, to represent a reference to the wear resistance for the Mohs hardness standard.

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