STUDY ON THE INFLUENCE OF ABRASIVE POWDER ON WEAR MECHANISMS

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1. INTRODUCTION

Since 1996, the international standards on ceramic tiles have considered two test methods of determining resistance to abrasion, described in standards ISO 10545-7[1] and ISO 10545-6[2], applicable to glazed and unglazed tiles, respectively. Both methods use corundum as abrasive, which produces a much higher level of wear than that generated in actual product use and, in their assessment, the methods do not include all the surface changes (e.g. change of gloss) that can actually be observed, penalizing dark-coloured matt surfaces in respect of light-coloured glossy ones.

This work is part of a joint initiative of the Spanish and Italian delegations in standardization committee ISO/TC 189 Ceramic tiles, which aims to advance in the development of a new method of evaluating the wear resistance of ceramic flooring, seeking to overcome the constraints of current standard test methods.

2. EXPERIMENTAL

To assess the influence of the characteristics of the abrasive on the wear process, three materials with increasing hardness (feldspar, quartz, and fused alumina) were selected and sieved below 200 microns (Figure 1). The wear tests were carried out with the same tester as that described in standard ISO 10545-7, however, replacing the abrasive load of steel balls and water with a cylindrical abrasion device (Figure 2), with three 4S rubber support points distributed symmetrically at angles of 120°, as described in UNE 138001:2008 IN[3]. Wear intensity was determined by measuring gloss change at 60° after the tests.

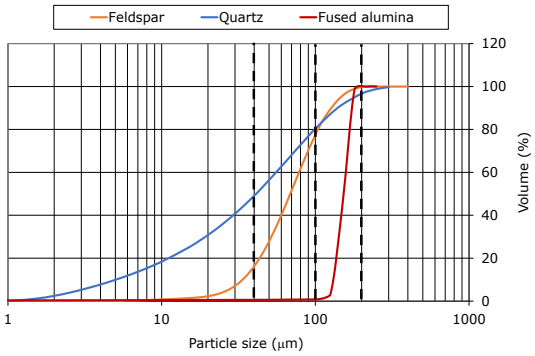

***Figure 1**. Particle size distribution*

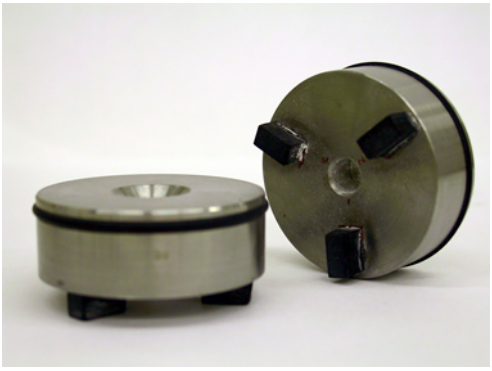

***Figure 2.** Abrasion device*

2.1 INFLUENCE OF ABRASIVE PARTICLE SIZE AND HARDNESS

Wear tests were carried out on float glass plates with the three types of abrasive and different particle size fractions of these abrasives, using 0.1 g for a wear stage of 300 revolutions. As Figure 3 shows, the loss of gloss became greater as abrasive particle size increased, the fraction below 40 microns hardly contributing to the wear process. In addition, abrasive hardness was also found to have a significant influence, gloss loss being noticeably lower for feldspar (Mohs hardness 6/6.5), though its mean particle size was larger than that of quartz.

As float glass hardness is much lower than that of ceramic materials, additional tests were conducted on unglazed polished porcelain tile (Figure 4), which confirmed that quartz generated a level of wear about 10 times greater than that of feldspar. The influence of the metred amount of abrasive as a function of the number of revolutions was also analysed, it being verified that the cumulative wear stages (0.5g/500r) with feldspar on the same test piece produced the same loss of gloss as direct stages with a cumulative metred amount of abrasive up to the same number of revolutions (same ratio of 0.5g for each 500r).

With a view to assessing the influence of particle size on glossy ceramic surfaces, tests were conducted using a feldspar with a particle size distribution between 100 and 300 microns, in direct stages with the same metring ratio. Comparison of the results of both feldspars confirmed that increasing particle size to 300 microns only raised gloss loss by about 22%, without achieving the gloss losses generated by quartz, which suggests that the influence of abrasive hardness was greater than that of particle size in this particle size distribution range.

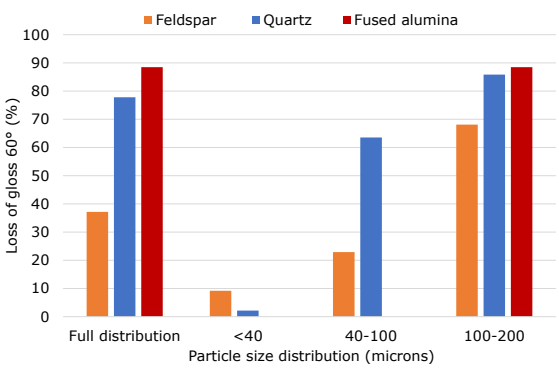

Figure 3. *Tests on float glass*

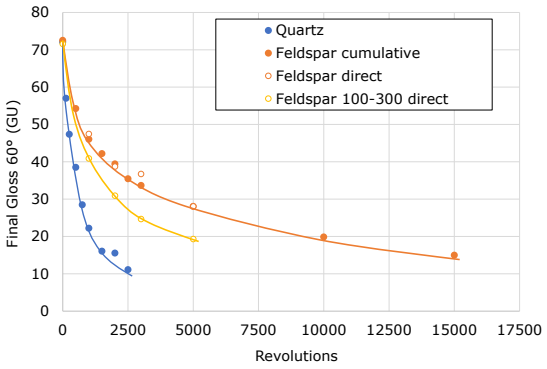

Figure 4. *Tests on BIa polished tile*

2.2 INFLUENCE OF THE AMOUNT OF ABRASIVE

To study the influence of the amount of abrasive used in the test, 6 types of ceramic tiles with a glossy surface finish were selected, as detailed in Table 1. Two series of comparative tests were carried out at two laboratories in Italy and in Spain, for a stage of 1000 revolutions, using two metred amounts of abrasive: 0.1g and 1g, respectively. Figures 5 and 6 show that both laboratories obtained very similar results.

In the tests with a low amount of abrasive, clear differences among the three test abrasives were observed, gloss loss increasing on raising abrasive hardness: on average this was three times higher for quartz than for feldspar, and about 10 times higher for fused alumina. In the tests with a high amount of abrasive, these differences decreased, very similar results being obtained in the tests with quartz and fused alumina, which approximately doubled the gloss loss obtained with feldspar. This was because the evolution of the change in gloss with the level of wear did not exhibit a linear trend, but progressively tended to stabilise as the process advanced, as shown in Figure 4.

Raising the amount of abrasive in the test was further observed to increase the loss of gloss very significantly, doubling the value in the case of quartz and doing so much more markedly in the tests with feldspar.

Sample	Group	Surface finish	Initial gloss (GU)
B	BIa	GL polished	90.4–88.1
D	BIa	GL polished	93.7–89.7
D*	BIa	GL polished	67.3–63.8
F	BIa	GL polished	78.7–75.7
G	BIa	GL smooth	45.0–42.7
L	BIII	GL polished	96.0–94.1

Table 1. *Glossy ceramic tile samples*

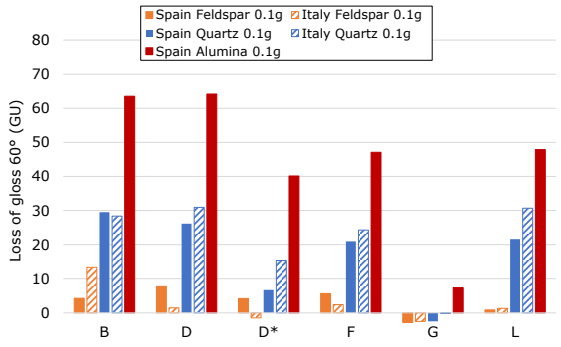

Figure 5. *Tests with a low amount of abrasive*

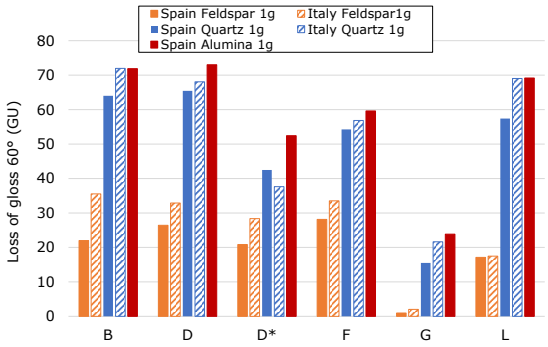

Figure 6*. Tests with a high amount of abrasive*

3. CONCLUSIONS

- The increase in hardness of the abrasive material, the amount of abrasive used, and abrasive particle size distribution contributed to accelerating the wear process on ceramic surfaces. The increase in hardness exhibits the greatest influence.
- The evolution of gloss loss exhibited a decreasing logarithmic trend, with more pronounced changes in the initial stages of abrasion test and progressive stabilization as the process advanced. The first stages of abrasion most notably evidence the influence of the aforementioned variables.
- The increase in amount of abrasive used also contributed very significantly to speeding up the wear process, which would explain the differences observed in actual wear in indoor and outdoor use environments.
- To develop a method of assessing wear resistance, it would be advisable to adapt variables such as abrasive agent hardness and its grain size distribution on the basis of the foreseeable service conditions to which the flooring will be exposed during its service life.

4. REFERENCES

[1] ISO 10545-7:1996 Ceramic tiles — Part 7: Determination of resistance to surface abrasion for glazed tiles.
[2] ISO 10545-6:2010 Ceramic tiles — Part 6: Determination of resistance to deep abrasion for unglazed tiles.
[3] UNE 138001:2008 IN Resistance to wear by pedestrian traffic of ceramic floorings. Recommendations for selection based on intended use.