COMPARATIVE ANALYSIS OF SLIP RESISTANCE ASSESSMENT METHODS

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1. INTRODUCTION

Slip resistance is one of the characteristics included in Mandate M/119 "Floorings" of the Construction Products Directive (CPD 89/106), as a requirement for the CE marking in ceramic tiles intended for flooring, although it will only be required when applicable regulations exist in the importing country. Although the work done in the European Committee for Standardization (CEN) has been directed toward the adoption of a single valid test method for every type of material, the difficulty of establishing the necessary agreements, both on a national level and among the representatives of the different countries involved, augurs a long transition period before having a harmonised European method. Till that time comes, the Spanish floor tile manufacturers will be forced to verify the slip resistance of their products according to the methods laid down in the different national regulations of the importing countries.

2. EXPERIMENTAL

To assess the equivalence among the four methods set out in the international (ISO/DIS 10545-17) and European (prEN 13552) draft standards, measurements have been conducted of the wet coefficient of friction on an extensive series of ceramic floor tiles, with surface characteristic ranging from polished tiles to materials with high roughness. Since slip resistance is not an intrinsic material property, but depends highly on the state of the surface (impregnation, intermediate vehicle, pollutants), it was decided to unify testing conditions for all the methods as detailed in Table 1, with a view to eliminating elements of error foreign to the testing equipment.

Test method	Type of slider	IRHD hardness	Surface
Self-propelling slider (Tortus® apparatus)	4S smooth rubber	96±2	Saturation with distilled water + surfactant
Static slider (horizontal dynamometer)			
Friction pendulum (TRRL)			
Ramp	Commercial footwear with smooth rubber sole	55±5	

Table 1.

Furthermore, in the case of the ramp method (based on standard DIN 51130), the standard safety boots were replaced by commercial footwear with a flat rubber sole, on considering the actual conditions of use of the footwear proposed by the standard not to be very representative.

3. RESULTS

Figure 1 presents a comparative plot of the values of the wet static coefficient of friction versus the results of the dynamic coefficient of friction found with the Tortus apparatus.

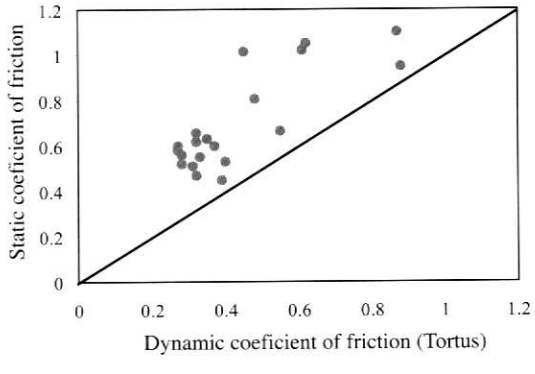

Figure 1. Static/dynamic comparison (Tortus).

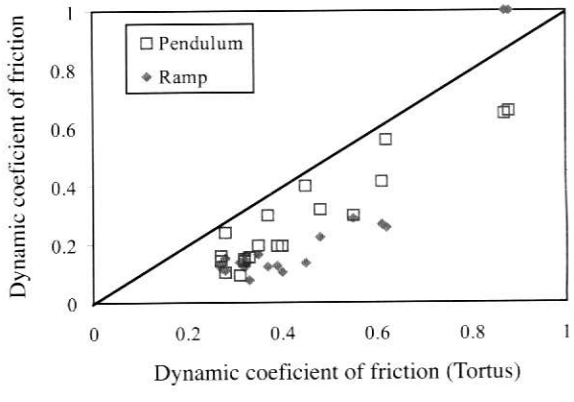

Figure 2. Comparison between dynamic methods.

Comparison of the resulting values confirms that the static coefficient of friction always exhibits higher values, as well as greater scatter. This is because the friction mechanisms under the two conditions are quite different, so that it is impossible to establish a correlation between the two parameters.

In order to compare the critical slip angle values (α) found in the ramp test with the values of the dynamic coefficient of friction (μ), the assumption is made in a first approximation that the relation $\mu = tg\ \alpha$ holds. As Figure 2 shows, there is no defined correlation between both test methods, with higher values being found with the Tortus apparatus for all the materials, except for the models with a very rough surface (μ>0.8).

Similarly, in spite of presenting a certain alignment, the values found with the friction pendulum are lower than the results with the Tortus apparatus for all the types of tested surfaces.

With regard to the adaptation of the dynamic methods to reproduce actual conditions of use, comparative studies between the values found in the tests and the perception of slip risk estimated by users[1] indicate that the pendulum method exhibits an adequate correlation, while the Tortus apparatus usually generates results that are too optimistic under wet flooring conditions. Keeping in mind that the Tortus apparatus travels approximately 1 meter to determine the dynamic coefficient of friction, the resulting value solely reflects an average for the surface, masking the existence of areas in the piece with lower coefficient of friction values (Figure 3). As the risk of slip falls is associated more closely with the minimum coefficient of friction value than the average for the surface, it would be appropriate to evaluate the results in terms of this value.

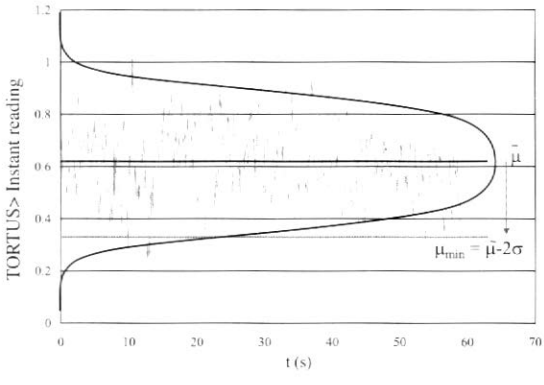

Figure 3. Instant reading with the Tortus apparatus.

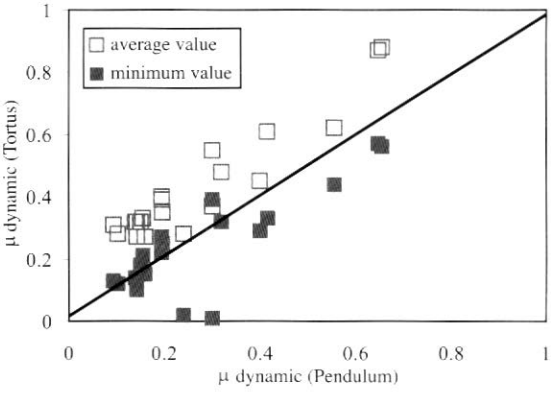

Figure 4. Pendulum/Tortus correlation.

In fact if we analyse the results of the Tortus apparatus on the basis of the minimum value ($\mu_{minimum} = \mu_{average} - 2\sigma$) defined to assure a 95% probability of being exceeded, and we compare these with the results of the friction pendulum (Figure 4), the correlation between both improves across the whole range of values. Departure of these results from the correlation is only found in the case of two floorings with surface profiles. On this type of surface, the apparatus vibrates heavily, which biases the results, producing high standard deviation values.

4. CONCLUSIONS

- The study shows that it is not possible to establish a correlation between the static and dynamic coefficient of friction values, probably due to the differences in the mechanism of friction of both situations.

- Nor has it been possible to establish an adequate correlation between the critical angle values found by means of the ramp method and the results of the dynamic methods, despite carrying out the test under equivalent water impregnation conditions. These

[1] DRAVITZKI, V.K.; POTTER, S.M. The use of the tortus and the pendulum with the 4S rubber for the assessment of slip resistance in the laboratory and the field. J. Test.Eval., 25, 127-134, 1997.

differences could stem from using sliders with rubber of different hardness, or from the simplified interpretation of the critical angle values ($\mu = tg\ \alpha$), which fails to account for the ergonomic aspects of human walking.

- The dynamic methods (Tortus and friction pendulum) exhibit a certain correlation when they are used under equivalent test conditions (intermediate fluid, slider type and hardness, minimum value analysis), although the Tortus apparatus is only appropriate for measuring surfaces with a flat geometry.