ANALYSIS OF MOISTURE EXPANSION MEASURING SYSTEMS AVAILABLE IN ISO 10545-10

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1. INTRODUCTION

Moisture expansion is a physical property of ceramic tiles, usually with negligible values and low impact on the building system.

ISO 10545 Part 10, 1995, defines the test methodology for determining accelerated moisture expansion where it establishes the use of a measuring table with a minimum resolution device of 0.01 mm and specimens may be cut in formats greater than or equal to (35x100) mm. ISO 10545-10 also does not define: the type of measuring equipment, the standard of the table with sample support system, among other factors that can generate divergences of results.

The objective of this work is to validate the applicability of the possible Measurement Systems (MSs) foreseen in the current version of the standard, through Repeatability and Reproducibility (RR) analysis and uncertainties of type A and B measurements.

2. MATERIALS AND METHODS

For the development of this work, a set of 13 samples of different types was selected: 4 BIa (J, K, L and M) products, 1 BIIa (I) product, 5 BIIb (A, B, C, D and E) products and 3 BIII products (F, G and H), from which specimens were taken from the center of each ceramic tile and cut to a size of (35X100) mm. The specimens were tested by three technicians, following all procedures described in the standard (ISO 10545-10), alternating only the MSs. Sample average and standard deviation were calculated for graphical comparison of outcome variables.

Repeatability and Reproducibility (RR) calculations, RR percentage calculation (99.73% probability of deviation within normal distribution - see Figure 1), calculation of type A and B measurement uncertainty were performed for MSs: caliper and dataplucometer with resolution of 0.01 mm and by 2 measuring devices with resolution of 0.001 mm and 0.0005 mm. For these calculations a sample from group BIIa (sample I) was used, which was measured 10 times by 3 technicians in each MS. The percentages of RR deviations, type B (Ums) and combined (Uc) uncertainties on the tolerance value (0.6 mm / m) were also calculated to complement the %RR assessment.

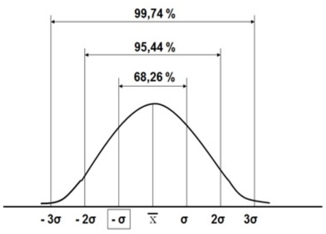

Figure 1. *Gaussian (or Normal) Distribution*

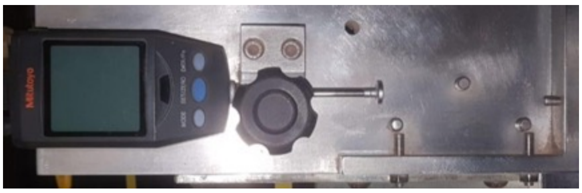

Figure 2. *Measuring Device*

The measuring devices consist of 3 non-collinear pins to support the pieces forming a perfect plane according to spatial geometry (Z axis), 2 lateral pins fixing the length (Y axis) and 1 lateral pin fixing the width (X axis), locking the alignment so that the tile does not move and the measurement always occurs at the same points (see Figure 2).

3. RESULTS AND DISCUSSION

The results obtained from the studies are shown in Figure 3 and Table 1.

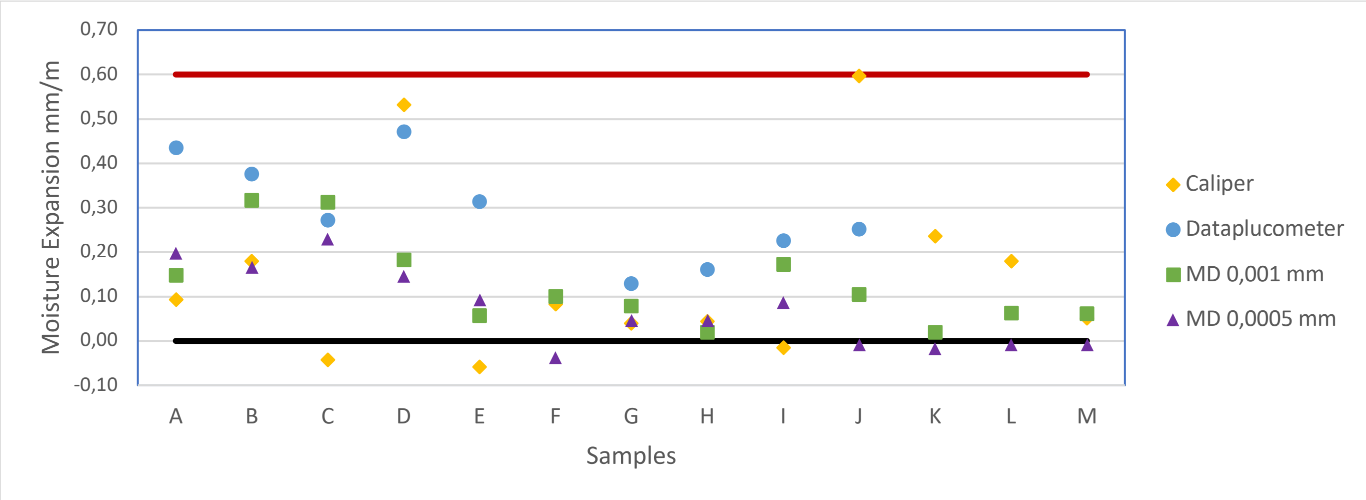

Figure 3. *Moisture expansion by sample typology versus MS*

In MS caliper it was necessary to exclude the measurement result of an operator in samples A, B, C, J, L and M and in MS dataplucometer in samples A, B, C, D, E, H and J, it was also not possible to measure samples F, K, L and M due to the high variability of the results. It is noted that the accuracy of the equipment can influence the results when using different operators.

According to Table 1, the MSs calipers and dataplucometer showed deviations of %RR higher than the limit recommended by the MSA (<30%), the deviations of RR / Tol represent 91% and 209%, respectively. They also had high type B (53% and 28%) and combined (A + B) measurement uncertainty indices, 243% and 770% respectively, which are directly influenced by equipment resolution (0.01 mm) and the variability of measurements (RR), caused by the lack of a suitable fastening system that provides tile alignment on the X, Y and Z axes.

The MSs "measuring devices" equipped with 0.001mm and 0.0005mm resolution comparator clocks had %RR ratios below 30%, RR / Tol deviations representing less than 5%. They also had low type B measurement uncertainty indices (UMS / Tol) for both devices. Such results are obtained by being equipment of higher precision and low variability in the measurement process.

Method	Resolution (mm)	RR (mm/m)	%RR	RR/Tol. (%)	U_{MS} (mm/m)	U_c (mm/m)	U_{MS}/Tol. (%)	U_c/Tol. (%)
Caliper	0.01	0.547	546.9%	91%	0.32	1.46	53%	243%
Dataplucometer	0.01	1.257	1256.6%	209%	0.17	4.62	28%	770%
Measuring device (MD)	0.001	0.022	22.0%	4%	0.06	0.11	10%	18%
Measuring device (MD)	0.0005	0.022	21.8%	4%	0.06	0.07	10%	12%
%RR = (6*RR/Tol) *100%, where the tolerance (Tol) used was 0.6 mm/m.								
U_{MS} (mm/m) - Measurement uncertainty Type B.								
U_C (mm/m) - Combined measurement uncertainty type A and B.								

Table 1. *Results of RR calculations and measurement uncertainties.*

4. CONCLUSIONS

As recommended by the MSA Manual[2], a measurement system may be considered acceptable for some applications if it has %RR ratios below 30%. Only measuring systems with 0.001 mm and 0.0005 mm comparator clocks met the recommended indexes.

Based on the data from this study, it is suggested that ISO 10545-10[3] be revised to include the use of equipment with a minimum resolution of 0.001 mm and the description of a standardized measuring system (as shown in Figure 2), locking the alignment so that the tile does not move and the measurement always occurs at the same points, to ensure the reliability of the results and reproducibility between different laboratories.

5. REFERENCES

[1] ISO GUM (2008), Avaliação de dados de Medição – Guia para a expressão de incerteza de medição, 1ª edição brasileira.

[2] AUTOMOTIVE INDUSTRY ACTION GROUP. Measurement Systems Analysis, MSA. Reference Manual, 4th ed. AIAG, 2010

[3] ISO 10545-10 (1995),isture expansion.