METHOD OF MEASURING DIMENSIONAL CHARACTERISTICS OF CERAMIC TILES: THREE-DIMENSIONAL ARM VERSUS DATAPLUCOMETER - PART 01

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1. INTRODUCTION

In recent years, the worldwide sector of ceramic tile manufacturers has shown a tendency to produce large format products, which is a challenge for companies and laboratories to control their dimensional characteristics.

The standard ISO 10545-2 of 2018 defines the test methodology to determine the dimensional characteristics of ceramic tiles, where it establishes the use of a measuring table with 6 comparator clocks, 3 support pins and 3 side pins. However large format tiles subjected to this method tend to present unreliable results due to deformations that the tile suffers when supported on the 3 pins.

The objective of this work is to evaluate if the measurement system using the three-dimensional arm presents acceptable variations to determine the dimensional characteristics of ceramic tiles and if there is compatibility of the results with the measurement system currently used, the dataplucometer.

2. MATERIALS AND METHODS

For the development of this work, a set of 6 samples was selected of typologies BIa and BIIb in the formats: (15x60) cm, (45x45) cm and (60x60) cm. The specimens were measured 10 times in each measurement system, from which 5 values were selected, discarding scattered values, to calculate the normalized error. For each characteristic, the percentage of compatible measurements between the measurement systems (MS's) was calculated.

Repeatability and Reproducibility (RR) calculations, RR percentage calculation (99.74% probability of deviation within normal distribution - see figure 1), type A and B measurement uncertainty calculation[1] were performed in MS's: dataplucometer and Faro Arm. For these calculations we used a sample of type BIIb in the format (45x45) cm, which was measured 10 times by 3 technicians in each MS. We also calculated the percentage RR deviations, type B (Ums) and combined (Uc) uncertainties on the standard tolerance value for each characteristic to complement the %RR assessment.

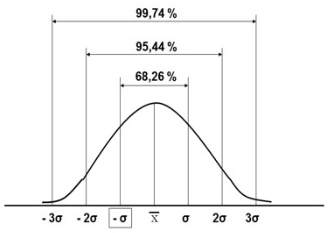

Figura 1. *Gaussian (or Normal) Distribution Curve*

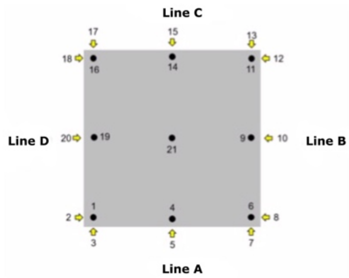

Figura 2 *Points Collection Model*

The Faro Arm measurement system is based on the collection of 21 points (Figure 2), 9 surface and 12 side for the construction of dimensional characteristics. Characteristics created based on side points: size is constructed by the spacing of points collected at the vertices of parallel lines; orthogonality by moving away from the opposite point of the X axis in Y; side straightness by offsetting the center point on the Y-axis in X. Characteristics created on the basis of surface points: central curvature by offsetting the center point from the reference plane in Z; side curvature by distancing the center point of each side from the reference plane in Z; warp by offsetting the point at each vertex from the reference plane at Z.

The reference plane was created in 2 models: deviation from the mean plane (MP - uses all surface points collected to build the plan) and deviation from the 3-point plane (3P - uses the same principle as the dataplucometer, 3 points to form a plan).

Wedges were used on the vertices of the tiles to prevent the movement of the pieces during the points collection.

3. RESULTS AND DISCUSSION

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

Method	Features	RR (mm)	%RR[1)]	RR/T (%)	U_{MS}[2)] (mm)	U_c[3)] (mm)	U_{MS}/T (%)	U_c/T (%)	MP[4)5)]	3P[4)6)]
Dataplucometer	**Size**	0.135	40.5%	7%	0.010	0.274	1%	14%	86%	
Faro Arm		0.209	62.6%	10%	0.003	0.422	0%	21%		
Dataplucometer	**Orthogonality**	0.078	23.3%	4%	0.010	0.158	1%	8%	100%	
Faro Arm		0.206	61.9%	10%	0.003	0.416	0%	21%		
Dataplucometer	**Side straightness**	0.028	11.2%	1%	0.010	0.058	1%	3%	92%	
Faro Arm		0.070	28.0%	4%	0.003	0.141	0%	7%		
Dataplucometer	**Central curvature**	0.065	19.5%	3%	0.010	0.131	1%	7%	67%	33%
Faro Arm		0.060	18.1%	3%	0.003	0.122	0%	6%		
Dataplucometer	**Side curvature**	0.059	17.7%	3%	0.010	0.120	1%	6%	8%	38%
Faro Arm		0.042	12.6%	2%	0.003	0.085	0%	4%		
Dataplucometer	**Warp**	0.076	22.8%	4%	0.010	0.154	1%	8%	25%	42%
Faro Arm		0.087	26.0%	4%	0.007	0.176	0%	9%		
1) %RR = (6*RR/T) *100% - T = Tolerance										
2) U_{MS} (mm/m) - Measurement uncertainty Type B										
3) U_C (mm/m) - Measurement uncertainty combined Type A and B										
4) Compatibility Rating by Normalized Error / 5) Average plan / 6) 3-point-based plan										

Table 1. *Results of RR calculation, measurement uncertainty and compatibility.*

As recommended by the MSA Manual[2], a measurement system may be considered acceptable for some applications if it has %RR ratios below 30%.

The characteristic "size" presented a high %RR index, but the deviation of RR / T, Ums / T and Uc / T are in acceptable standards. The compatibility index is satisfactory, but the proposed MS uses a spherical tip that generally provides results inferior to the current MS.

The "orthogonality" characteristic presented a high % RR index, but the RR / T, Ums / T and Uc / T deviations are in acceptable standards. The compatibility index is satisfactory.

The characteristic "side straightness" presented %RR, RR / T, Ums / T and Uc / T index in acceptable standards. The compatibility index is satisfactory.

The planar characteristics (warping, central and side curvature) presented indices of %RR, RR / T, Ums / T and Uc / T in acceptable standards. However, the compatibility indices are not satisfactory. This result was expected since the proposed MS performs the measurement with the workbench supported part and uses a different measurement principle (middle plane).

The central curvature characteristic showed incompatibility only in the formats (60x60) cm of both groups, it is believed that this difference is due to the deformation that the plate suffers when supported by the 3 support pins of the current MS. This confirmation will be made in the second stage of the study which provides for tile scanning and comparison with the results of both MS's.

4. CONCLUSIONS

The measurement system using the three-dimensional arm does not show compatibility in all dimensional characteristics, making its adoption unfeasible without further study of influence factors and improvements to reduce %RR indexes in the characteristics: size, orthogonality and side straightness. These investigations and improvements together with the evaluation of smaller and larger format tiles will be performed in the second stage of this study. At the end of the second stage we intend to propose a substitute methodology to the current MS defined in ISO 10545-2[3].

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. Manual de Referência, 4ª ed. AIAG, 2010

[3] [3] ISO 10545-02 (2018), Ceramic tiles Part 2: Determination of dimension