COMPARISON OF DIMENSIONAL MEASUREMENT SYSTEMS: HORIZONTAL VERSUS INCLINED DATAPLUCOMETER

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1. INTRODUCTION

The system for measuring the dimensional characteristics of ceramic tiles in accordance with ISO 10545-2 evaluates deviations in size, rectangularity, straightness of sides, center curvature, edge curvature and warpage. The measurement occurs by comparing the dimensions of a test ceramic tile with a calibrated standard plate, with the measuring device (dataplucometer) in a horizontal plane. The current measurement system is inadequate to determine the flat characteristics of large format, low-thickness ceramic tiles, as elastic deformation of the piece may occur when supported on the equipment, due to its own weight. This study aims to compare the results of the dimensional characteristics obtained from the horizontal dataplucometer with those of the inclined dataplucometer at 83º, to determine whether elastic deformation can be eliminated/mitigated when performing the inclined measurement.

2. MATERIALS AND METHODS

To evaluate measurement compatibility, a comparative study was carried out between the horizontal (Figure 1) and inclined (Figure 2) methods, using a glass plate with negligible deformation, in dimensions of (300x300x15) mm and (400x400x15) mm. A Measurement Systems Analysis (MSA) study was then conducted, using the inclined method, with a view to evaluating its quality in terms of repeatability and reproducibility (R&R). Finally, a second comparative analysis was conducted between the two methods, using plates previously disqualified in the horizontal method.

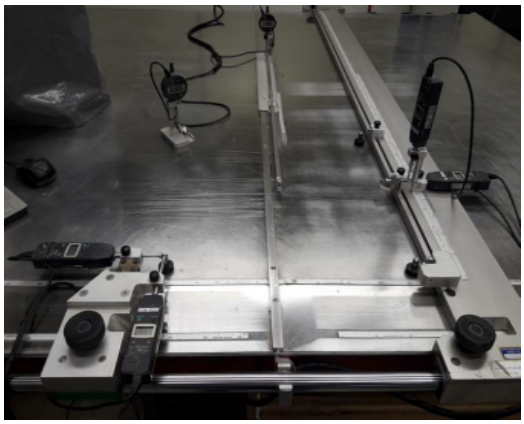

Figure 1 *– Horizontal dataplucometer*

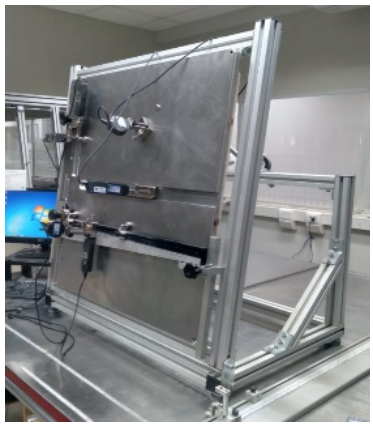

Figure 2*– Inclined dataplucometer*

3. RESULTS AND DISCUSSION

Analyzing the data in Table 1, the difference between the methods is observed to be low, the highest deviation being 0.10 mm, lower than the resolution required by the standard (0.4 mm) [1].

Deviation	Glass plate 300 mm x 300 mm			Glass plate 400 mm x 400 mm		
	Horizontal	Inclined	Difference	Horizontal	Inclined	Difference
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Size	302.90	302.86	0.04	407.48	407.47	0.01
Warpage	-0.12	-0.05	-0.06	-0.11	-0.21	0.10
Center curvature	0.13	0.12	0.01	-0.39	-0.33	-0.06
Edge curvature	0.02	0.03	-0.01	-0.17	-0.19	0.02
Straightness of sides	0.01	0.00	0.01	0.02	0.02	0.00
Rectangularity	0.66	0.66	0.00	-0.06	-0.02	-0.04

Table 1 *– Comparison between measurements on the inclined and horizontal dataplucometer*

In the repeatability and reproducibility (R&R) study to evaluate the quality of the method, the results presented in Table 2 indicate that the R&R deviations for all analyzed characteristics are below 30%, meeting MSA Manual recommendations for acceptability in some applications[2].

R&R study	Deviation pattern (mm)	Study variation (mm)	Variation of study (%)	Tolerance (%)
Size	0.098	0.588	26.52	16.32
Warpage	0.087	0.524	51.40	13.09
Center curvature	0.052	0.314	34.24	7.84
Edge curvature	0.058	0.346	13.59	11.54
Straightness of sides	0.022	0.130	17.35	4.35
Rectangularity	0.023	0.137	5.51	4.56

Table 2 *– Analysis of repeatability and reproducibility (R&R) deviations*

For the comparison of the methods, using the samples that failed the horizontal dataplucometer, the results of the deviations presented in R^2 (%) in Table 3 indicate that there was a strong correlation between the two methods. However, analyzing the Student's t test, the deviations of center curvature, side curvature and warpage, it was possible to prove with 95% confidence that the results obtained in the inclined method are not statistically equal to the results of the horizontal method.

Deviation	Variation	Average (mm)	DP (mm)	R^2 (%)	t-test difference (mm)
Size	Inclined	619.300	0.6150	99.89	0.589
	Horizontal	619.200	0.6090		
Straightness of sides	Inclined	0.4440	0.4005	99.79	0.573
	Horizontal	0.3720	0.4000		
Rectangularity	Inclined	-0.0100	0.7490	98.54	0.891
	Horizontal	-0.0420	0.6870		
Centre curvature	Inclined	1.9770	0.2413	94.68	0.000
	Horizontal	2.7400	0.2498		
Edge curvature	Inclined	0.7940	0.1185	92.59	0.000
	Horizontal	1.1315	0.1490		
Warpage	Inclined	0.0830	0.9970	98.87	0.000
	Horizontal	2.4370	1.1580		

Table 3 *– Analysis of repeatability and reproducibility (R&R) deviations*

4. CONCLUSION

The results obtained in the study indicate that, when the deformation is negligible, as in the case of glass plates, the methods are compatible. In the second stage, the quality of the inclined method in all characteristics was confirmed through the R&R study. In the last stage of the study, the horizontal method proved to be inadequate for evaluation of flat dimensional characteristics, due to the significant interference of the elastic deformation of the ceramic tiles in the results obtained.

5. REFERENCES

[1] ISO 13.006 (2020), Ceramic tiles - Definitions, classification, characteristics, and marking.
[2] AUTOMOTIVE INDUSTRY ACTION GROUP. MSA. Manual de Referência, 4ª ed. AIAG, 2010.