DETERMINATION OF CRAZING RESISTANCE FOR CERAMIC TILES

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1. INTRODUCTION

The ceramic tile system is composed of a set of elements and components, such as the base, the intermediate layers and the ceramic. The ceramic tiling, in turn, is composed of the ceramic tile, adhesive mortar and grout. Based on the existence of movement stresses, retraction and prone forces of traditional ceramic tiling systems, ceramic tiles must withstand the expected forces of the assembly without suffering hidden defects and vices.

Ceramic detachment is caused by loss of adhesion or failures at the interface of ceramic tiles with the substrate, which can happen for several reasons, most of which occur during the useful life of the buildings. The pathologies that cause ceramic detachment may be related to constructive failures, setting joints, mortar layer thickness, moisture expansion, efflorescence, crazing, cracks, fissures, inadequate laying and the quality of the ceramic material.

According to the ISO 10545-11[1] standard, crazing consists of hairline cracks limited to the glazed surface of the ceramic tile. Crazing occurs when glazes are subjected to tensile stress, since brittle materials have much lower tensile strength than compressive strength, which can occur during the manufacture or use of ceramic tiles. These variations are simulated aggressively and accelerated in the test method using an autoclave for conformity assessment.

Although crazing in glazed ceramic tiles has been widely studied and is currently a well-known, controlled and mastered phenomenon, changes in production processes, in the characteristics of construction systems and in testing standards require that this pathology be studied in view of the new specificities.

The objective of this study is to analyze the determination of crazing resistance in ceramic tiles, evaluating the effects of the test method, the water absorption groups of the products, the ceramic body/engobe/glaze fit, the expansion due to moisture and the crystalline and non-crystalline phases present.

2. MATERIALS AND METHODS

Ceramic tiles from three water absorption groups (BIa, BIII and BIIb), without history and with history of crazing, available from national manufacturers will be used; and samples of the ceramic body, engobe and glaze used in the manufacture of these tiles.

The samples were coded, separated, prepared with the standardization of the cuts in the necessary dimensions, and sent for tests to determine water absorption, moisture expansion and crazing resistance. They were also characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The ceramic body, engobe and glaze samples were evaluated by means of linear thermal expansion and expansion curve fit.

3. RESULTS AND DISCUSSION

Table 1 contains the results for the water absorption, moisture expansion and crazing resistance tests (without reheating, after reheating at 300 °C and after reheating at 500 °C) for the ceramic tiles samples being evaluated. All results comply with the tolerances established in the ISO 13006[2] standard for the respective product types. Therefore, for the remaining analyses, the results obtained for two samples selected from the total number of samples received, type BIIb, with and without a history of crazing are presented: EAG2B2 and EAG4B1, respectively, for comparison.

Sample	Group	History	Water Absorption (%)	Moisture Expansion (mm/m)	Crazing Resistance		
					No reheating	Reheating at 300 °C	Reheating at 500 °C
EAG5A1	BIa	No	0.3	0.01	No	No	No
EAG1B2	BIIb	Yes	7.9	0.30	No	No	No
EAG2B2	BIIb	Yes	7.1	0.34	No	No	No
EAG7B2	BIIb	Yes	8.2	0.14	No	No	No
EAG3B1	BIIb	No	7.4	0.15	No	No	No
EAG4B1	BIIb	No	5.5	0.11	No	No	No
EAG6C1	BIII	No	18.6	0.02	No	No	No

***Table 1** - Test results.*

Table 2 contains the information obtained from X-ray diffraction and scanning electron microscopy for the two samples. Despite not showing crazing or significant differences in composition after the tests without reheating, with reheating at 300 °C and reheating at 500 °C, cracks appeared both on the surface and in the cross-section of the samples.

Sample	Group	History	Condition	XRD	SEM	
					Surface	Section
EAG2B2	BIIb	Yes	No reheating	No significant difference in composition with the change in the reheating process	No cracks	With cracks
			Reheating at 300 °C		No cracks	No cracks
			Reheating at 500 °C		Cracks close to the cut	Cracks in the glaze and engobe
EAG4B1	BIIb	No	No reheating	No significant difference in composition with the change in the reheating process	With cracks	With cracks
			Reheating at 300 °C		With cracks	No cracks
			Reheating at 500 °C		Few cracks	With cracks

Table 2 - *Results XRD and SEM.*

The cracks on the surface close to the cut of the samples may have originated at the time of preparation, since the samples did not show crazing. Cracks in engobe and glaze are cracks that spread towards the surface, which could possibly lead to crazing during the use of these products.

Table 3 shows the values of the linear thermal expansion coefficients (α) of the ceramic body, glaze and engobe for samples EAG2B2 and EAG4B1, and the values of the glaze fit temperature (Ta) obtained by superimposing the expansion curves of the engobe and the ceramic body. It is noted that the glaze in both samples is under the action of compression forces ($\Delta C<0$).

Sample	α ceramic body	α engobe	α glaze	Ta (ºC)	ΔC
EAG2B2	75.0	80.7	58.7	697	-1.34
EAG4B1	66.5	53.2	56.2	712	-1.17

Table 3 - *Results of expansion tests.*

4. CONCLUSIONS

The results obtained in the study, so far, indicate the need to repeat the crazing determination test for as many cycles as necessary for it to occur in the samples. It will thus be possible to correlate the propagation of cracks with the number of cycles necessary for crazing to occur, with porosity and with the amount of crystalline and non-crystalline phases present in the samples.

5. REFERENCES

[1] ISO 10545-11 (1994), Ceramic tiles - Part 11: Determination of crazing resistance for glazed tiles.
[2] ISO 13006 (2018), Ceramic tiles - Definitions, classification, characteristics and marking.