CAUSES OF DELAYED CURVATURE IN INSTALLED PORCELAIN STONEWARE

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1. INTRODUCTION

Production of porcelain stoneware has grown in the last few decades, as well as the demand for large-sized products (larger than 60 x 60 cm²). Particularly for larger tiles, obtaining satisfactory flatness is a huge challenge. The possible development of delayed curvatures due to the relaxation of stresses after the piece leaves the kiln makes this task even more difficult. If after a period of time the tile's flatness is adequate, the product is deemed ready for sale. However, there are reports of cases in which curvatures develop after the product has been installed, which leads to tiles becoming detached. In addition, it has been observed that products from the same production batch that were kept (not installed) remain flat. In these circumstances, given present understanding of the causes of delayed curvature, a possible explanation is that the top face and the underside of the tiles have suffered different expansion rates due to differences in microstructure. The aim of this paper was to check the validity of this hypothesis.

2. MATERIALS AND METHODS

Pieces of the product were selected which presented curvature after installation and pieces of the same product (same batch) not installed which did not present any curvature. Samples of these pieces were extracted and were cut in half, on a parallel plane to the surface. Subsequently, the cut pieces were classified in relation to their composition of the RIR-Rietveld phases, porosity and water absorption. The assessment of the porosity was carried out using the Archimedes method. Water absorption measurements were taken in a vacuum chamber, in accordance with the procedure described in ASTM C373 standard. A thermodilatometer was used to assess moisture expansion in severe hydration conditions: 10 h exposure to a steam atmosphere in an autoclave, at a pressire of 5 atm.

3. RESULTS AND DISCUSSION

	Uninstalled porcelain stoneware			Installed porcelain stoneware		
Phases (%)	Non-crystalline	Quartz	Mullite	Non-crystalline	Quartz	Mullite
Underside	56	34	10	57	34	9
Top face	63	29	8	63	28	9

Table 1. *Composition of the phases of the top face and underside of the pieces assessed*

The results show considerable differences in the crystalline phases between the top face and underside of a single plate. There are a greater proportion of vitreous (non-crystalline) phases and less quartz content in the top face than in the underside. This result can indicate that the top face of the samples is subjected to more effective thermal treatment, resulting in greater formation of vitreous phases.

Characteristics	Uninstalled porcelain stoneware		Installed porcelain stoneware	
	Underside	Top face	Underside	Top face
Water absorption (%)	0.16 ± 0.01	0.10 ± 0.01	0.10 ± 0.02	0.08 ± 0.02
Open porosity (%)	0.36 ± 0.03	0.23 ± 0.04	0.23 ± 0.04	0.19 ± 0.05
Closed porosity (%)	11.3 ± 0.2	11.7 ± 0.1	11.9 ± 0.1	12.2 ± 0.1
Total porosity (%)	11.7 ± 0.2	12.0 ± 0.1	12.2 ± 0.1	12.4 ± 0.1

Table 2. *Water absorption and porosity of the faces of the pieces assessed*

The results of the analysis of water absorption and porosity confirm the heterogeneity outlined above by the phase quantification tests. In general, it was noted that there are more elevated open porosities in the undersides of the plates, whilst in the top faces there is an increase in closed porosity. These results confirm that the top faces of the plates are in more advanced stages of sintering than the undersides.

The assessment of moisture expansion delivered zero moisture expansion for both sides of the installed porcelain stoneware. However, the moisture expansion measurements for the samples of the two sides of the non-installed porcelain stoneware were interrupted due to the rupture of the test bodies during heating. This indicates that, although these pieces have very low moisture expansion, severe hydration was sufficient to generate stresses in the bodies of the test pieces up to the point of causing them to break during the subsequent heating in the dilatometer. This suggest that contact of the piece with humidity, due to the expansion differential of the two sides, may generate stresses which may be responsible for developing curvatures in the piece.

4. CONCLUSIONS

The curvatures observed in the installed pieces of the samples of installed porcelain stoneware appear to be associated with the heterogeneity observed between the two sides of the product. Said heterogeneity was established by the quantitative analysis of the phases and by the water absorption and porosity analyses performed on the top face and underside of the piece, which indicate that the former is at more advanced stages of sintering. During settling, the presence of humidity from the mortar (and eventually the atmosphere) in contact with the underside of the product probably promotes its differential expansion, causing stresses that may produce the curvatures noted in the installed products, and which lead to their becoming detached.

5. BIBLIOGRAPHICAL REFERENCES

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