MODELLING THE STRESS-STRAIN BEHAVIOUR OF CERAMIC TILE COVERINGS INSTALLED WITH DOUBLE-FACE ADHESIVE SHEETS

Otávio Luiz do Nascimento[1]; Alexandra A. Piscitelli Mansur[1]; Herman Sander Mansur[1]

(1) Federal University of Minas Gerais, Brazil

1. INTRODUCTION

Ceramic tile systems comprise several layers of different materials directly connected by physical and chemical interactions. Due to these microstructural linkages, every movement at any layer is transferred to the others, resulting in a complex state of stresses and strains. The stress–strain values depend on the physical and chemical features of each layer, including thickness, Young's modulus and yield stress, and failure limits.

For ceramic tiles installed with double-face adhesive sheets, an innovative product for ceramic tile installation available in the Brazilian market, the study of this stress–strain state is crucial to establishing the bond strength stability limits of this new system. In view of the characteristics of this installation product, the thermal effects, ceramic tile moisture expansion, and structural substrate movement (thermal, creep, shrinkage, load accumulation, etc) will be the mayor causes of differential stresses between layers. Failure occurs when the stress–strain values are higher than the strength limits of the materials and interfaces. In this sense, this work presents the results of a study based on the Finite Element Method in order to determine the tensions that develop in the interface between tile and adhesive under thermal stresses, in comparison with those that develop in the dry-set mortar installation system.

2. EXPERIMENTAL PROCEDURE

A reduced model consisting of five tiles 10 cm x 10 cm with 5 mm thickness (Figure 1) was considered. Both dry-set mortar (5 mm) and adhesive sheets (3 mm) were considered as installation systems. A concrete slab (25 mm) was the substrate for tile installation. All relevant properties for tiles, mortar and concrete were drawn from the literature, while the mechanical properties for the adhesive sheets were measured (Table 1). The stress-strain values were determined considering tiles installed with the adhesive sheets and dry-set mortar. The models were subjected to a temperature difference of 40°C. The presence of a perimeter expansion joint was also considered.

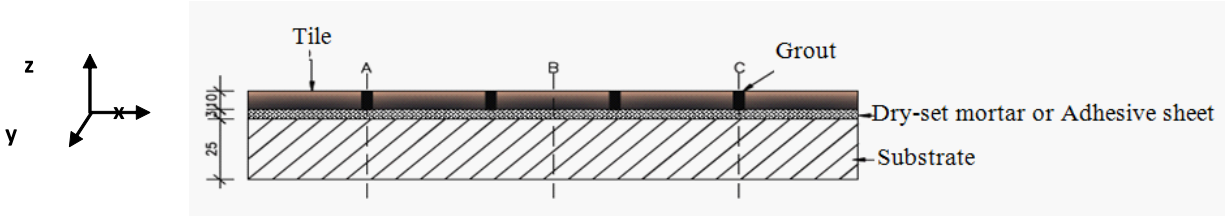

Figure 1 – Schematic representation of the ceramic system under evaluation showing the three selected cross-sections (A, B and C) to evaluate the tensions under thermal stress.

Component	Density (kgf/ dm³)	Thickness (mm)	Tension resistance (MPa)	Young's modulus (GPa)	Poisson coefficient
Dry-set mortar	1.69	5.0	0.70	7.50	0.2
Adhesive sheet	0.45	3.0	0.14	0.05	1.0
Tile	2.70	6.0	-	49.0	0.2
Concrete substrate	2.55	20.0	-	4.5	0.2
Grout	2.45	5.0	-	8.5	0.2

Table 1 – Properties of the ceramic tile system components.

3. RESULTS AND DISCUSSION

The results revealed that the shear stresses at the tile/adhesive interface decreased significantly when the adhesive sheet was used instead of dry-set mortar (Figures 2 and 3) due to the lower Young elastic modulus of this material.

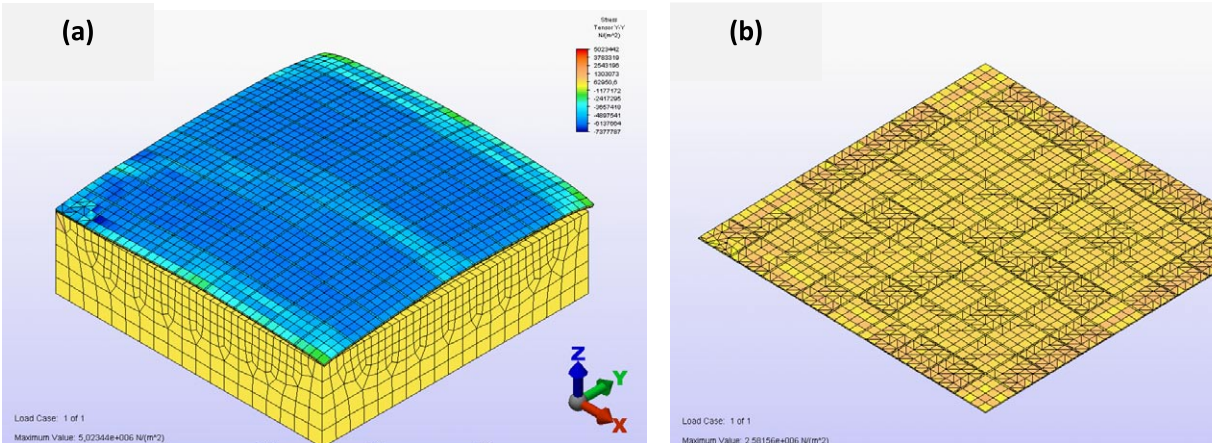

Figure 2 – Shear stresses due to thermal variation of 40ºC for the studied ceramic tile system considering (a) dry-set mortar and (b) adhesive sheet.

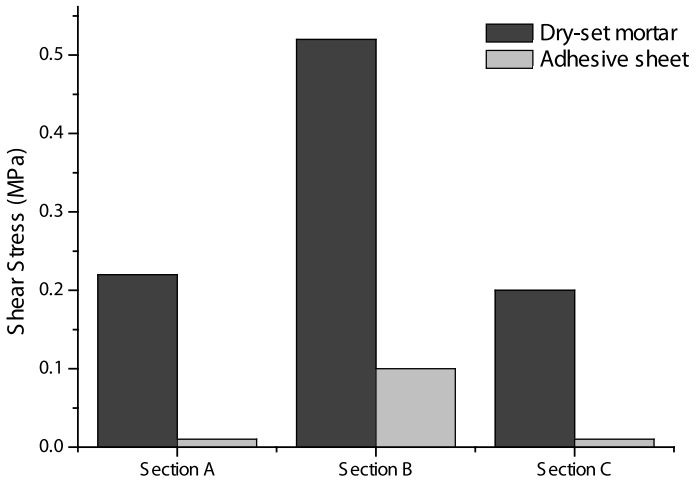

Figure 3 – Shear stresses in the cross-sections under evaluation.

The calculations showed that the displacement of the tiles (in the z direction) were greater in dry-set mortar systems (about 0.06 mm) than in the adhesive sheet systems (about 0.002 mm) (Figure 4).

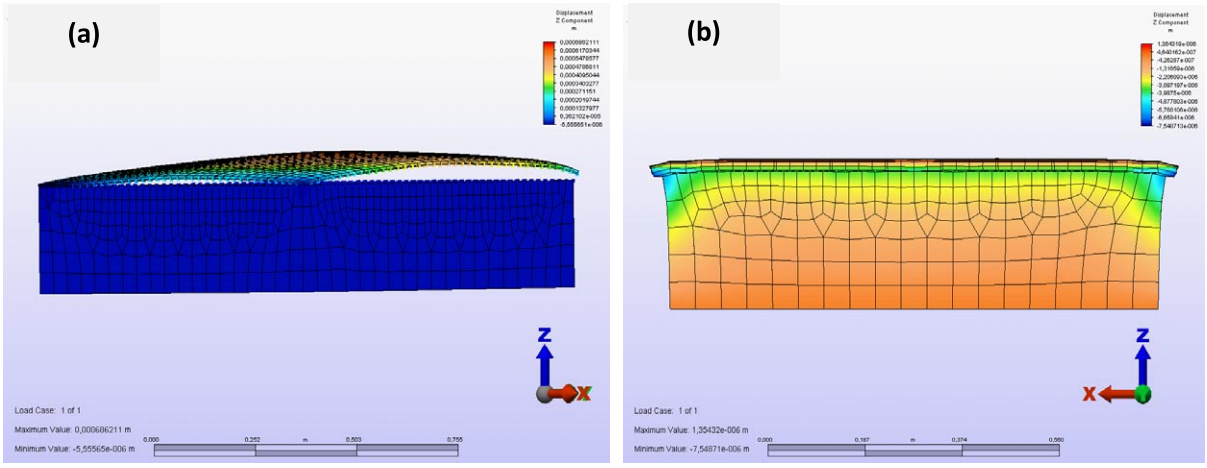

Figure 4 – Displacement of tiles due to the thermal variation of 40ºC calculated for tiles installed with (a) dry-set mortar and (b) adhesive sheet.

4. CONCLUSIONS

The calculated values enabled it to be established that the recommended bond strength limits or the innovative ceramic tile installation method could be lower than the specifications for mortar systems.

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