EVALUATION OF THE INFLUENCE OF THE SUBSTRATE LAYER/ ADHESIVE MORTAR /CERAMIC TILE PRODUCT ON THE PERFORMANCE OF THE CERAMIC COVERING

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Among the main pathologies verified in ceramic tile systems, the occurrence of detachments is one of the most worrying, since it jeopardizes the safety of residents, in addition to aesthetic aspects and compromising habitability. The detachment of ceramic tiles can occur with the detachment of ceramics due to adhesive rupture at the ceramic tile/adhesive mortar, adhesive mortar/plaster, plaster/roughcast and roughcast/substrate interfaces or due to cohesive rupture within any of these layers.

In this sense, it is essential to evaluate the interactions between the layers that constitute the ceramic tile system in order to understand the adhesion mechanisms and the possibilities of increasing the resistance of the interfaces. It thus becomes necessary to evaluate other properties of the adhesive mortar (resistance to shearing and flexibility), as well as its behavior over time depending on the demands to which the covering will be exposed throughout its useful life.

The objective of this work was to evaluate the ceramic tile system in small prototypes through the comparative analysis of the performance in function of the type of ceramic tile (water absorption group and moisture expansion), type of adhesive mortar, failures of bonding, preparation base and substrate. For this, different adhesive mortars were characterized according to the Brazilian standard, ABNT NBR 14081-1, as well as the properties of flexibility and shear resistance, which are not yet specified by the Brazilian standard, but are specified by some international standards.

After the characterization of the adhesive mortars, prototypes of ceramic tiles composed of different types of ceramics laid with different types of adhesive mortars, using a standard substrate, were prepared. These prototypes were subjected to heating and cooling cycles and wetting and drying cycles so as to subject them to different stresses and promote accelerated aging. After carrying out these cycles, the loss of adhesion strength of each prototype was evaluated in order to correlate the type and properties of the adhesive mortars, and the properties of the ceramic tiles with the loss of performance over time.

Failures in the laying of ceramic tiles favor loss of adherence and, consequently, loss of performance during the lifetime of the ceramic tile system.

Therefore, after carrying out this study, it is recommended that ceramic tile designers begin to specify the properties of the adhesive mortar, regardless of its classification, as a function of the properties of the ceramic tile (water absorption, moisture expansion), deformation of the base and the demands to which the covering will be subjected (thermal gradients). It is recommended that the deformation capacity of the adhesive mortar be specified, that is, its flexibility, according to the criteria of ISO 13007. And also, to adopt the shear resistance parameters of the ANSI 118.4 and ANSI 118.15 standards, which have resistance criteria to the different shear forces depending on the water absorption of the ceramic tile. It is recommended that the laying procedures according to ABNT NBR 13753, 13754 and 13755 be followed.

1. INTRODUCTION

A collection of data obtained from 44 pathology assessments of ceramic covering tiles from 1998 to 2003 (MANSUR et al., 2006a) showed that detachment of ceramic tiles occurred in 95% of buildings and indicated that in 81% of cases it was observed that the detachment of the tiles occurred at the ceramic tile/adhesive mortar interface. Percentages of occurrences close to these have also been presented by some studies carried out to analyze stresses in ceramic tile systems. (ABREU et al., 2004; SARAIVA et al., 2001) identified that this interface is the region of the tile system most subjected to shear stresses, when thermal effects and hygroscopic expansion of the ceramic tiles are considered, as can be observed in Figure 1.

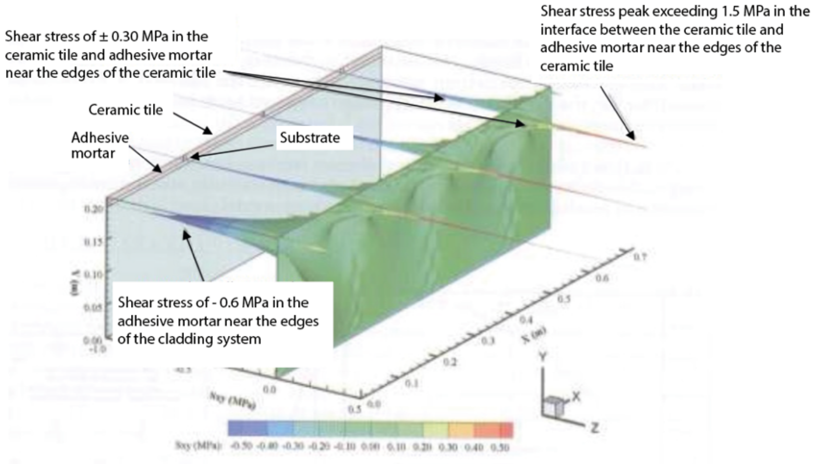


Figure 1 *- Shear Stresses (Sxy) in a ceramic tile system due to 0.1 mm/m of expansion of the ceramic tile (Abreu et al, 2004).*

Felixberger (2006) mathematically demonstrates that the shear stresses between the substrate and the ceramic tile are a function of the reactive movement between the base and the ceramic tile (εu), the specification modulus (EFi), the dimensions (lFi; bFi) of the ceramic tiles, the shear modulus (Gki) and the thickness (dki) of the adhesive mortar, according to the following formula:

$$\tau_{KI\text{-}max}(l_{FI}, b_{FI}) = \varepsilon_U * \sqrt{\frac{E_{FI} * d_{FI} * G_{KI}}{d_{KI}}} * \tanh\sqrt{\frac{(l_{FI}^2 + b_{FI}^2) * G_{KI}}{d_{KI} * d_{FI} * E_{FI}}}$$

That said, it is noted that larger tiles will cause greater shear stresses between the ceramic tile and the base (Figure 2), requiring an adhesive mortar with greater flexibility, that is, a lower shear modulus (Figure 3). Analyzing Figure 2, Felixberger (2006) highlights that for tiles with dimensions above (40x40) cm, shear stresses do not tend to increase, reaching a limit value of 0.62 MPa. Figure 3 indicates the maximum dimensions of the ceramic tiles depending on the shear modulus of the adhesive mortar so that a maximum shear stress equal to 0.5 MPa occurs. It should be noted that for a tile with dimensions equal to (20x20) cm, an adhesive mortar with a shear modulus twice as small is required as for a ceramic tile with dimensions equal to (10x10) cm. Therefore, the flexibility of the adhesive mortar must be higher to avoid cracks or pathological problems of detachment for larger tiles.

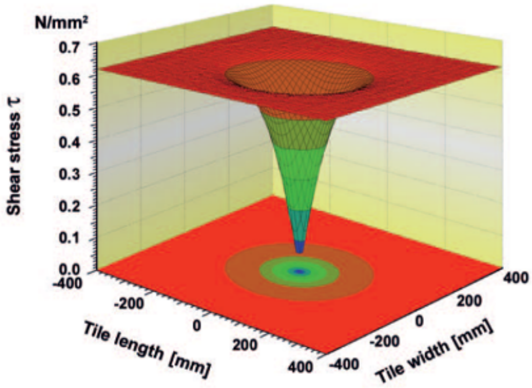


Figure 2 *– Maximum shear stress at the edges of ceramic tiles depending on the dimensions of the ceramic tiles (Felixberger, 2006).*

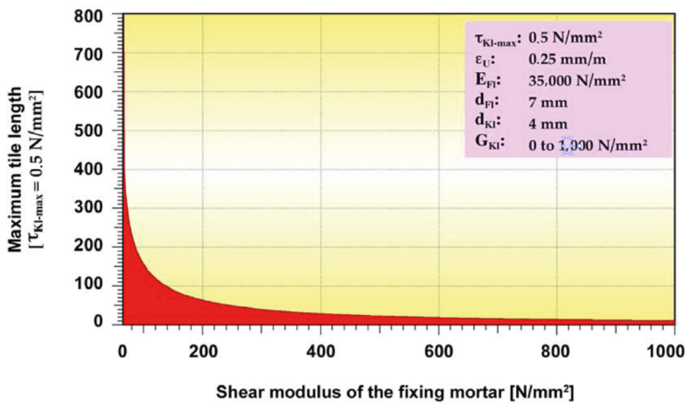


Figure 3 *– Required values for the shear modulus of the adhesive mortar depending on the dimensions of the ceramic tiles*

In this sense, it is essential to evaluate the interactions between the layers that make up the ceramic tile system to understand the adhesion mechanisms and the possibilities of increasing interface resistance. Therefore, it is necessary to evaluate other properties of the adhesive mortar (shear resistance and flexibility), as well as its behavior over time depending on the stresses to which the tile will be exposed throughout its useful life.

The objective of this work was to evaluate the ceramic tile system in small prototypes through comparative analysis of performance depending on the type of ceramic tile (water absorption group and moisture expansion), type of adhesive mortar, bonding failures, preparation of the base and substrate.

2. MATERIALS AND METHODS

To evaluate the influence of the characteristics of adhesive mortars on the performance of the ceramic tiles, 9 national adhesive mortars and 5 adhesive mortars from a manufacturer were selected as shown in Table 1.

The adhesive mortars were characterized in accordance with ABNT NBR 14181, that is, the adhesion strength of the mortars was determined during normal conditions, water immersion and air-circulating oven (this condition only for ACII and ACIII adhesive mortars) and open time. The adhesion resistance test methodology for normal conditions, water immersion and air-circulating oven is specified by the ABNT NBR 14081-4 standard. For this, the adhesive mortars are mixed in the laboratory under controlled conditions of temperature (23ºC ± 2ºC), humidity (60% ± 2%) and wind (≤0.15m/ s) with a defined water/mortar ratio and maturation time by the manufacturer.

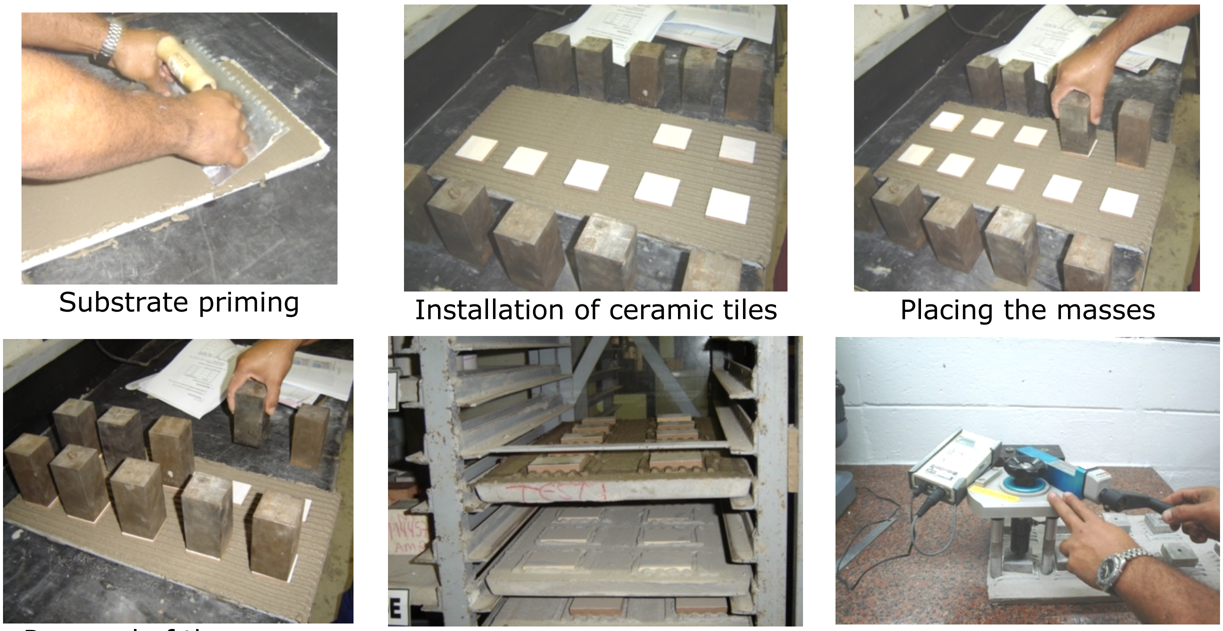
After preparing the adhesive mortar, it is applied to a standard concrete substrate with dimensions equal to (500x250) mm using a 6 mm notched trowel. After opening the adhesive mortar ribbons on the standard substrate, wait 5 minutes for the application of 10 ceramic tiles with dimensions equal to (50x50) mm and water absorption varying between 3% and 5%. The ceramic tiles are spaced 5 cm apart. After 30 seconds of placing the ceramic tile on the ribbons, a 2 kg mass is applied to these ceramic tiles for 30 seconds, in order to promote the crushing of the ribs. Subsequently, the substrates are placed in normal laboratory conditions (temperature between 23ºC ± 2ºC and humidity between 60% ± 4%). Substrates for the determination of adhesion strength remain in these conditions for 28 days, while substrates for water immersion and air-circulating oven remain in these conditions for 7 days and 14 days, respectively. After 7 days of molding, the water immersion curing substrates are immersed in a tank with water at a temperature of 23ºC ± 2ºC, remaining in this environment until 28 days have passed. After 14 days of molding, the adhesion strength substrates are placed in an air-circulating oven at a temperature of 70ºC ± 2ºC, remaining in this environment until 28 days have passed. At 28 days, the adhesion strength test is carried out. Figure 4 illustrates these procedures.

To evaluate the flexibility of adhesive mortars, the procedure specified by the ISO 13007 standard was used, in which thin tiles of adhesive mortar with dimensions equal to (300x45x3) mm double supported were tested for flexion, determining the maximum deflection (vertical displacement) in the middle from the gap. Figure 5 shows the steps of the flexibility test.

Manufacturer	Type of Mortar	Name in Study	Specification
A	AC I	ACI A	Adhesive mortar for internal use
A	AC II	ACII A	Adhesive mortar for internal and external use
A	AC III	ACIII A	Adhesive mortar for internal and external use
B	AC I	ACI B	Interior Adhesive Mortar
B	AC II	ACII B	Special Mortar - Interiors - Exteriors - Covering
B	AC III	ACIII B	Special Superflexible Mortar
C	AC I	ACI C	Gray mortar for Internal use
C	AC II	ACII C	Gray mortar for Internal use
C	AC III	ACIII C	Gray flexible mortar
E	C 1	ACII E	Gray
F	C 1T	ACII F	Gray mortar (Internal and external)
G	C 2	ACIII G	Gray mortar (Internal and external)
H	C 2 TE	ACIII H	Gray mortar (Internal and external)
I	C 2 TE S1	ACIII I	Maxi gray mortar (Internal and external)

Table 1 *– Tested adhesive mortars.*

To carry out the shear test of the adhesive mortar, the procedure of the ASTM C482/14 technical standard was adopted, which consists of laying a ceramic tile displaced on one of the faces of a cubic substrate with the same dimension as 50 mm. After curing, a compression force is applied to the ceramic tile in order to apply a shear stress to the surface of the adhesive mortar. Figure 6 shows the steps for carrying out the shear test.



Substrate priming | Installation of ceramic tiles | Placing the masses

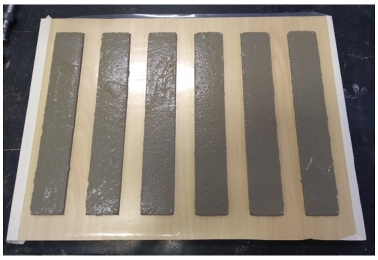
Removal of the masses | Curing | Adhesion resistance

Figure 4 *– Procedure for carrying out the adhesion and open time test.*

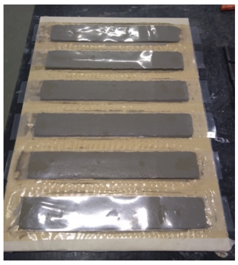
After characterizing the adhesive mortars and analyzing the results obtained, the mortars that would be used in the accelerated aging tests were selected. To carry out the thermal shock tests, 6 adhesive mortars specified for external use were selected out of those that showed the best results in adhesion resistance and different flexibility behaviors (ACII C, ACIII A, ACIII G, AC III I – see Table 2). To carry out the wetting and drying cycle tests, 4 adhesive mortars were selected, one exclusively for internal use and the others for internal and external use (ACI C, ACII C, ACIII A and ACIII B). In parallel with the selection of adhesive mortars, it was necessary to determine the ceramic tiles that would also be used to manufacture the test specimens for the thermal shock and wetting and drying tests. For this, the properties of the ceramic tiles characterized in phase 1 of the study were analyzed, for which the CRC Laboratory was responsible. From the analysis of this report, it was defined which ceramic tiles would be used in the test specimens for the thermal shock test: glazed porcelain tile (PE01), BIIa ceramic tile, porcelain tablet (PP01), extruded ceramic tile (A101). For the preparation of test specimens for the wetting and drying cycles test, the following were defined: an extruded porous ceramic tile (AIII), a pressed porous ceramic tile (BIII) and three semi-porous ceramic tiles (BIIb 12, BIIb 04, BIIb 02 and BIII 2). The evaluated products are presented in Table 2.

External use (Heat Cycles and Thermal Shock)		Internal use (Wetting and Drying Cycles)	
Ceramic Tile	Adhesive Mortar	Ceramic Tile	Adhesive Mortar
PE 01	ACII C	A III	ACI C
PP 01	ACIII A	BIIb 12	ACII C
A101	ACIII G	BIIb 04	ACIII A
BIIa	ACIII I Dosed mortar Adhesive	BIIb 02	ACIII B Dosed mortar 1 Dosed mortar 2 Adhesive

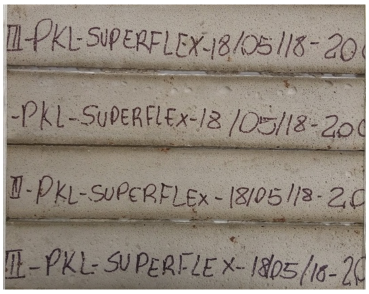
***Table 2**- Ceramic tiles and adhesive mortars selected for the study.*



Molding of test specimens



Curing of the specimens



Test specimens before testing

Flexibility test

***Figure 5** – Flexibility test steps.*

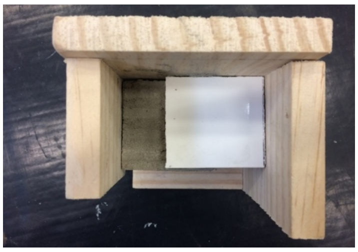
To prepare the test specimens for thermal shock tests and wetting and drying cycles, standard concrete substrates with dimensions equal to (50x25) cm were used. For laying, the ceramic tiles, with the exception of the porcelain tiles, were cut into dimensions of (10x10) cm with 1 mm setting joints. After installation, grouting was carried out using a cementitious grout mortar or elastomeric sealant (simulating the situation without grout). Finally, to restrict the movement of the covering, strips of ceramic tiles were glued with epoxy to the edges of the substrates. Figure 7 shows photos of the simulation of setting failures (gluing adhesives to the back of the tiles) and the molded prototypes.

After molding and curing the prototypes, they were subjected to thermal shock or wetting and drying cycles (Figure 8). Thermal shock cycles were carried out by heating the prototype's covering until it reached a surface temperature of 80ºC, which was maintained for 1 hour.

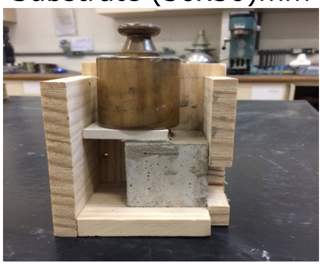
After this time, water was sprayed on the surface of the covering, in order to simulate rain and promote rapid cooling of the surface to a temperature of 25ºC, which was maintained for 5 minutes. After this time, the cycle was restarted, repeating it 10 and 50 times. The wetting and drying cycles were carried out by spraying water on the surface of the covering for two hours and then interrupting the wetting for 4 hours. After this time, the cycle was restarted, repeating it 50 times.

After the end of the thermal shock or wetting and drying cycles, adhesion strength tests were carried out on the prototypes that were subjected to aging cycles and on those that were not subjected, in order to compare the loss of adhesion resistance promoted by thermal shock and wetting and drying cycles.

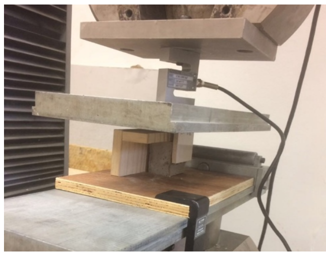
Substrate (50x50)mm



Ceramic tile installation



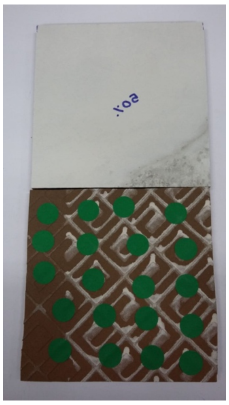
Application of weight to crush the ribs



Compression shear test

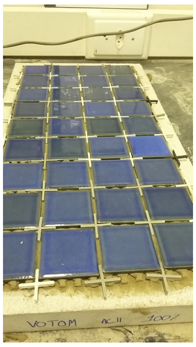
Figure 6 *- Steps of the Adhesive Mortar Shear test.*

Tile without setting failure simulation – 100% filling of under tile



Tile with simulation of 50% setting failure – 50% filling of under tile

Tile with simulation of 25% setting failure – 75% filling of under tile



Prototype covered with porcelain tiles and ACII mortar and without setting failure – no restrictions

Prototype covered with porcelain tiles and ACIII mortar with 25% setting failure and with elastomeric grout

Prototype covered with porcelain tiles and ACIII mortar with 25% setting failure and with elastomeric grout – with restriction

Figure 7– *Simulation of setting failures and prototypes for thermal shock and wetting and drying cycles.*

Figure 8- *Thermal shock chamber with the prototypes.*

3. RESULTS AND DISCUSSIONS

Table 3 presents the adhesion resistance results of these adhesive mortars according to ABNT NBR 14081, the transverse deformation (shear) according to ISO 13007-2 and the shear resistance results according to the ASTM C482/14 methodology.

Mortar	Adhesion Strength (MPa)				Flexibility (mm)	Shear (MPa)
	Open Time	Adhesive strength	Adhesive strength/ water immersion	Adhesive strength/ elevated temperature		
ACI – A	0.89	0.83	0.69	-	1.21	1.44
ACI – B	0.87	1.01	0.63	-	1.14	-
ACI - C	0.67	0.74	0.39	-	0.47	-
ACI - D	0.44	0.53	0.33	-	-	-
ACII - A	0.83	1.18	0.83	0.25	1.34	1.53
ACII - B	0.75	1.22	0.86	0.47	1.47	-
ACII - C	0.81	1.03	0.83	0.39	1.32	0.75
ACII - D	0.91	1.59	0.80	1.04	-	-
ACII - E	0.67	0.75	0.29	0.45	0.42	-
ACII - F	0.42	0.72	0.65	0.02	0.83	-
ACIII - A	0.82	1.61	1.53	0.73	1.59	2.55
ACIII - B	1.41	1.7	1.32	1.33	1.54	-
ACIII - C	0.49	0.74	1.1	0.26	1.15	1.86
ACIII - D	1.11	1.87	1.31	1.22	-	-
ACIII - G	1.03	1.22	1	0.74	1.1	-
ACIII - H	1.41	1.6	1.22	1.29	1.23	-
ACIII - I	1.64	1.79	1	1.37	1.48	2.59

Table 3 *- Average results for adhesive mortars.*

Table 4 presents the average results of the characterization of adhesive mortars according to the tests specified by the technical standards for covering mortar, ABNT NBR 13279/05 and ABNT NBR 15630/09. Although these tests are standardized only for covering mortars, they were carried out to characterize the adhesive mortars with the aim of characterizing them and verifying the correlation between these properties and the subsequent performance of the adhesive mortars.

Mortar	Compression Resistance (MPa)	Tensile load (MPa)	Modulus of Distortion (GPa)
ACI – A	12.1	4.63	9.19
ACI – B	11.43	4.12	9.51
ACI - C	4.68	2.44	5.96
ACI - D	3.13	1.79	6
ACII - A	13.43	4.51	9.29
ACII - B	14.7	4.86	12.11
ACII - C	13.15	5.31	10.17
ACII - D	12.84	4.88	10.63
ACII - E	4.18	1.83	4.47
ACII - F	8.3	2.51	6.3
ACIII - A	15.89	6.73	11.21
ACIII - B	15.4	6.56	11.11
ACIII - C	11.52	4.85	12.34
ACIII - D	11.61	5.95	9.24
ACIII - G	10.99	4.67	5.64
ACIII - H	12.33	4.8	8.03
ACIII - I	14.78	5.11	6.88

Table 4 *- Average results for adhesive mortars.*

Analyzing the data obtained in the adhesive mortar characterization tests, the following was found:

- Mortars with the same classification as the Brazilian standard have very different adhesion strengths, even when meeting standard parameters, indicating that manufacturers can use different percentages of cement and polymers in their composition, which will present different performance in practice.
- Mortars with the same classification as the Brazilian standard have very different flexibility, including Type AC II mortars being more flexible than ACIII mortars, indicating that some ACIII mortars are more rigid than some ACII adhesive mortars, and may present lower performance throughout their useful life in the covering.
- A lack of correlation between adhesion strength in different types of curing with the compressive strength, compression resistance, modulus of deformation and flexibility of adhesive mortars.
- No correlation between shear resistance and flexibility of the adhesive mortar.

Figure 9 shows the adhesion resistance of the ceramic covering composed of AIa, BIIa, PE01 and PP ceramic tiles depending on the type of adhesive mortar, the setting failure percentage (0%, 25% and 50%) and the number of thermal shock cycles (0, 10, and 50). Analyzing this figure, it can be seen that the mortar that presented the best performance, whether in adhesive strength or after thermal shock cycles, with and without the presence of setting failures was the AC III-I adhesive mortar. This mortar was the one that presented the best adhesion strength, as well as greatest flexibility and shear resistance. In addition, this mortar exhibited excellent adhesive behavior, also showing a small variation in adhesion strength depending on thermal shock cycles. Also from Figure 9, it can be seen that the coverings, with the exception of that laid with AC II – C mortar, regardless of the number of thermal shock cycles and the percentage of laying failures, presented adhesion strength greater than 0.3 MPa.

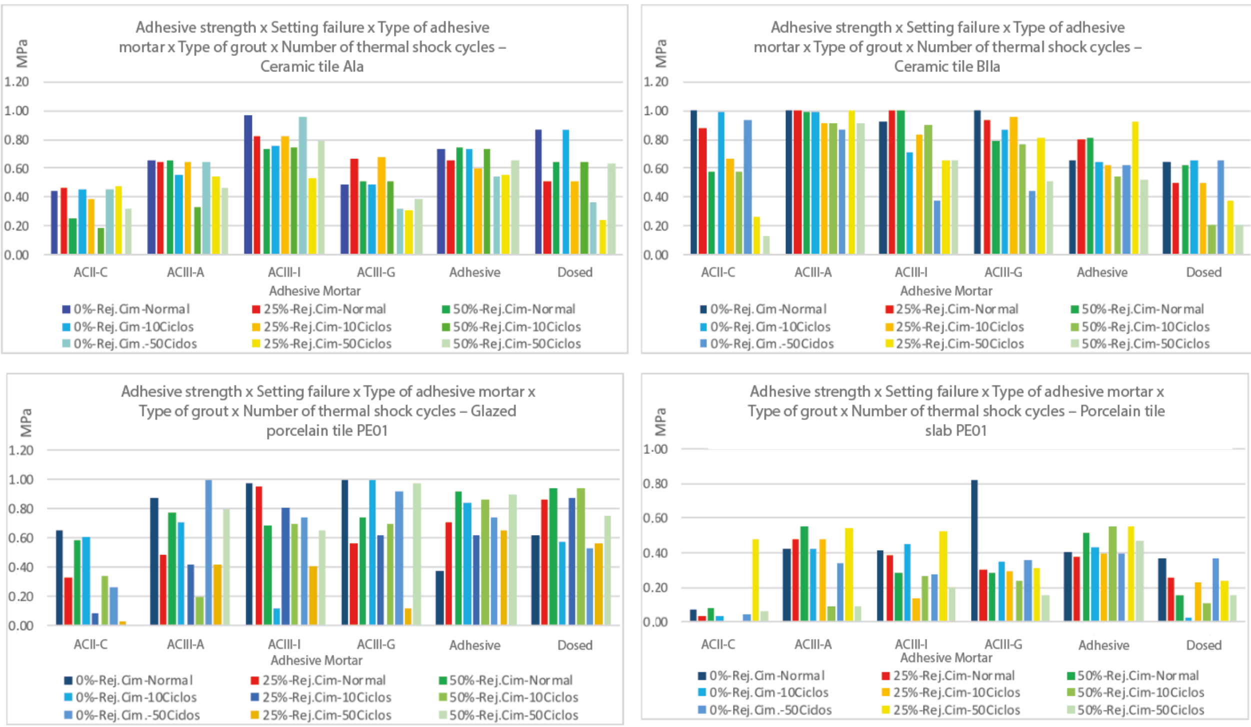


Figure 9 - *Adhesion Strength depending on the type of adhesive mortar, percentage of coverage under the tile and number of thermal shock cycles for AIa, BIIa, PE01 and PP tiles.*

Analyzing Figure 9, it is observed that:

- **AIa product:** the mortar that showed the best performance, whether during adhesion curing or after thermal shock cycles, with and without the presence of installation failures was the AC III-I adhesive mortar. This mortar was the one that presented the best adhesion strength, as well as greater flexibility and shear resistance. In addition, this mortar exhibited excellent adhesive behavior, also showing a small variation in adhesion strength depending on thermal shock cycles. It is noted that the coverings, with the exception of that laid with AC II – C mortar, regardless of the number of thermal shock cycles and the percentage of laying failures, presented adhesion strength greater than 0.3 MPa.
- **PE01 product:** the negative influence of the number of cycles and the percentage of setting failures on the adhesion strength of the covering is noted. It is noted that the presence of setting flaws significantly affected the adhesion strength of the ACII-C adhesive mortar. For this type of ceramic tile, it is noted that the adhesive mortars that showed the best behavior were the mortars ACIII-I, ACIII-G and Adhesive.
- **PP product:** the negative influence of the number of cycles and the percentage of setting failures on the adhesion strength of the covering is noted. It is noted that for this type of ceramic tile, the ACII-C mortar did not present satisfactory adhesion resistance even before being subjected to thermal shock cycles. The presence of 25% of adhesion failures significantly affected the adhesion strength in relation to the covering without adhesion failure. The covering with 50% setting failure presented similar bond strength to the covering with 25% setting failure. For this type of ceramic tile, it is noted that the adhesive mortars that showed the best behavior were the mortars ACIII-A, ACIII-I, ACIII-G and Adhesive.

Below are graphs of the variation in adhesion resistance as a function of the wetting and drying cycles, the number of setting failures (0%, 25% and 50%), the type of adhesive mortar (ACI-C, ACII-C, ACII-A, ACIII-B, ACII-Dosed, ACI-Dosed) for coverings with ceramic tiles BIIb12, BIIb4, BIIb2, BIII2 and AIII (Figure 10).

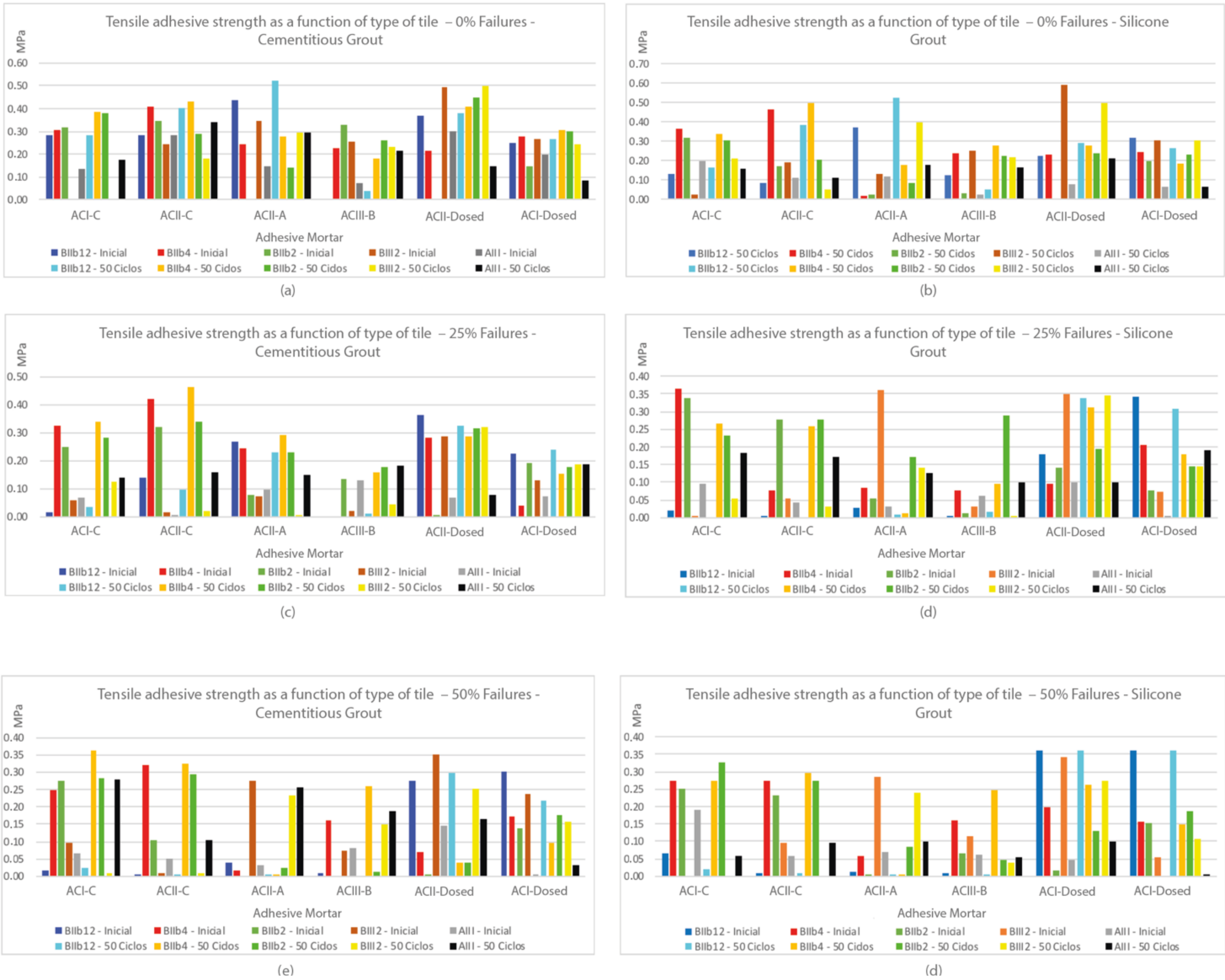


***Figure 10**: Graphs of the variation in adhesion resistance depending on the wetting and drying cycles, number of setting failures (0%, 25% and 50%), type of adhesive mortar (ACI-C, ACII- C, ACII-A, ACIII-B, ACII-Dosed, ACI-Dosed) for coverings with ceramic tiles BIIb12, BIIb4, BIIb2, BIII2 and AIII.*

Analyzing Figure 10(a) reveals that adhesive mortar ACIII-B was the one with the worst adhesion resistance to initial tensile loading, as well as after 50 wetting and drying cycles, for most types of laid ceramic tiles without the presence of faults. The BIII ceramic tile showed zero initial adhesion resistance to the ACI-C adhesive mortar. The mortars that showed the best behavior in relation to initial and final adhesion strength were adhesive mortar ACII-C and ACII-Dosed. It is noted that the behavior of the adhesive mortar varied depending on the ceramic tile.

Analyzing Figure 10(c) shows that ACIII-B adhesive mortar was the one that presented, for most types of ceramic tiles laid with 25% of failures, the worst adhesion resistance to initial tensile loading, as well as after 50 wetting and drying cycles. With a 25% presence of failures, only adhesive mortars ACI-C, ACII-C and ACI-Dosed managed to achieve adhesion strength values greater than 0.3 MPa for some type of ceramic tile. It may also be noted that the wetting and drying cycles had little effect on the initial tensile adhesion strength.

Analyzing Figure 10(e) reveals that with 50% presence of failures, only the covering with BIIb4 ceramic tile laid with ACII-C adhesive mortar and the ceramic covering with AIII tile laid with ACII-Dosed adhesive mortar showed adhesion resistance to initial tensile loading greater than or equal to 0.30 MPa. It can also be noted that the wetting and drying cycles did not favor the loss of adhesion strength. Analyzing Figures 10 (b), (d) and (f) shows the same behavior between the covering laid with cementitious grout and the grouting carried out with silicone.

4. CONCLUSIONS

From this study in relation to the performance of adhesive mortars, it was observed that mortars with the same classification as the Brazilian standard have very different adhesion strengths, even when meeting standard parameters, and that adhesive mortars of the same type, but from different manufacturers, will present different performance in practice. It can also be noted that adhesive mortars with a lower classification may present superior performance compared to adhesive mortars with a higher classification according to the Brazilian standard. Regarding the transverse deformation capacity (flexibility), it can be stated that it is an important requirement to be specified for coverings that will be subjected to large deformations (moisture expansions of the ceramic tile, thermal expansion of the covering, deformation of the base). For the mortars evaluated, it was noted that mortars with the same or even lower classification in relation to the classification of the Brazilian standard have very different flexibility and may present lower performance throughout the useful life of the covering for situations that require greater absorption capacity or deformation. Regarding shear resistance, it was noted that it is another necessary parameter to be specified for coverings that will be subjected to large deformations (moisture expansions of the ceramic tile, thermal expansion of the covering, deformation of the base). This requirement is not addressed by the international standard ISO 13007, but only by the ANSI 118.4 and ASTM C482 standards. The ANSI standard began to present shear resistance criteria for adhesive mortars with polymers in 2019, and in 2020 for adhesive mortars with high additives. It will also be a good parameter to differentiate the performance of Brazilian mortars. Regarding the correlations between the properties of adhesive mortars, it is not possible to verify a correlation between adhesion strength, flexibility and shear strength. In commercial adhesive mortars, there was also no correlation between the properties of the adhesive mortar (adhesion strength, flexibility and shear resistance) with compressive strength, flexural tensile strength and deformation modulus. However, with adhesive mortars with a known formulation it was possible to establish a correlation between flexibility and the deformation modulus. The existence of this correlation is an important indication, since the deformation modulus test method is easier to carry out and control. Therefore, it is necessary to advance further in these correlation studies between these two properties in order to establish the criteria for deformation modulus for adhesive mortars to be considered flexible and super-flexible.

During studies evaluating the performance of the covering after thermal shock cycles, it was noted that the property that had the greatest influence on the ceramic tile in relation to adhesion resistance was water absorption in relation to the type of adhesive mortar. During this evaluation it was observed that the adhesive mortars that presented greater flexibility were those that showed less variation in adhesion resistance after thermal shock cycles. However, it was not possible to establish any correlation between the covering performance as a function of ceramic tile moisture expansion, considering the same type of adhesive mortar. This could perhaps be related to the small dimensions of the prototypes. The influence of ceramic tile moisture expansion for the same type of adhesive mortar must be verified in larger prototypes, which will be carried out in the other part of this study.

The wetting and drying cycle tests carried out on small prototypes did not prove to be a good assessment method for aging for ceramic coatings, since there was little loss or even gain in adhesion resistance after the wetting and drying cycles. In this test, it was also noted that some adhesive mortars with a lower classification performed better than some adhesive mortars with a higher classification.

Failures in the laying of ceramic tiles favor loss of adhesion and, consequently, loss of performance during the useful life of the ceramic tile system.

Therefore, after carrying out this study, it is recommended that designers of ceramic tiles begin to specify the properties of the adhesive mortar, regardless of its classification, depending on the properties of the ceramic tile (water absorption, moisture expansion), the deformation of the base and the stresses to which the covering will be subjected (thermal gradients). It is recommended that the deformation capacity of the adhesive mortar be specified, that is, its flexibility, in accordance with the criteria of ISO 13007. And also adopt the shear resistance parameters of the ANSI 118.4 and ANSI 118.15 standards, which have resistance criteria to different shear rates depending on the absorption of the ceramic tile. It is recommended that the laying procedures be followed in accordance with ABNT NBR 13753, 13754 and 13755.

5. REFERENCES

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