PERFORMANCE ASSESSMENT OF ACI, ACII AND ACIII ADHESIVE MORTARS FOR COATING SYSTEMS

AVALIAÇÃO DE DESEMPENHO DE ARGAMASSAS COLANTES AC I, AC II E AC III PARA SISTEMAS DE REVESTIMENTO

EVALUACIÓN DEL DESEMPEÑO DE MORTEROS ADHESIVOS AC I, AC II Y AC III PARA SISTEMAS DE REVESTIMIENTO

Betina Pituco[1]
Valentina Candela-Rengifo[1]
Gihad Mohamad[1]
Alexandre Silva de Vargas[1]
José Pedro Marquezan de Oliveira[2]

[1] PPGECAM - Programa de Pós-graduação em Engenharia Civil e Ambiental, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brasil
[2] Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brasil

Correspondence to: pitucobetina@gmail.com

Abstract: This study analyzes and compares the performance of three types of adhesive mortars from the same manufacturer: ACI, ACII, and ACIII, focusing on their physical-mechanical properties. After particle size analysis, the mortars were prepared under the same conditions and evaluated in the fresh state (slip, spreadability, and density) and in the hardened state (pull-off strength, tensile strength, compressive strength, and elastic modulus). The main objective was to

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identify and characterize performance differences between the mortar types. The results showed no significant differences in the fresh state. In the hardened state, mechanical properties varied inversely with mortar particle size. This detailed analysis contributes to a better understanding of material behavior and guides the selection of adhesive mortars according to designer requirements, promoting coating durability, reduced rework and material waste, and lower economic and environmental impacts.

Keywords: Adhesive mortar; characterization; mechanical strength; adhesion, durability.

Resumo: Este estudo analisa e compara o desempenho de três tipos de argamassas colantes de um mesmo fabricante: ACI, ACII e ACIII, focando em suas propriedades físico-mecânicas. Após a avaliação granulométrica, as argamassas foram preparadas sob as mesmas condições e avaliadas em estado fresco (deslizamento, espalhamento e densidade) e em estado endurecido (arrancamento, resistência à tração, resistência à compressão e módulo elástico). O objetivo principal foi identificar e caracterizar as diferenças de desempenho entre os tipos de argamassa. Os resultados mostraram que, no estado fresco, não houve diferenças significativas entre as argamassas. Em estado endurecido, as propriedades mecânicas apresentaram variações que se relacionam inversamente com a granulometria das argamassas. A análise detalhada contribui para uma melhor compreensão do comportamento dos materiais e orienta a seleção de argamassas colantes em função das exigências do projetista, favorecendo a durabilidade dos revestimentos, a redução de retrabalhos e desperdício de materiais, e menores impactos econômicos e ambientais.

Palavras-chave: Argamassa colante; caracterização; resistência mecânica; aderência, durabilidade.

Resumen: Este estudio analiza y compara el rendimiento de tres tipos de morteros adhesivos del mismo fabricante: ACI, ACII y ACIII, centrándose en sus propiedades físico-mecánicas. Tras la evaluación granulométrica, los morteros se prepararon bajo las mismas condiciones y se evaluaron en estado fresco (deslizamiento, trabajabilidad y densidad) y en estado endurecido (resistencia al arrancamiento, resistencia a la tracción, resistencia a la compresión y módulo elástico). El objetivo principal fue identificar y caracterizar las diferencias de rendimiento entre los tipos de mortero. Los resultados mostraron que en estado fresco no hubo diferencias significativas. En estado endurecido, las propiedades mecánicas

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variaron inversamente con la granulometría de los morteros. Este análisis detallado contribuye a una mejor comprensión del comportamiento de los materiales y orienta la selección de morteros adhesivos según los requisitos del proyectista, promoviendo la durabilidad de los revestimientos, la reducción de retrabajos y desperdicio de materiales, y menores impactos económicos y ambientales.

Palabras clave: Madera laminada encolada; refuerzo con polímeros reforzados con fibras; Método de los Elementos Finitos

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1 INTRODUCTION

The demand for ensuring minimum performance requirements in building systems has steadily increased in recent decades, driven by advances in construction technologies and the growing need for durability and service-life reliability (Silva *et al.*, 2020). In ceramic cladding systems, the occurrence of pathological manifestations, particularly ceramic tile detachment, remains a recurring concern and has intensified over the last decades due to changes in materials and application techniques (Wetzel *et al.*, 2010).

Recent studies have reinforced the importance of evaluating adhesive mortar performance to better understand adhesion mechanisms and failure modes in ceramic coating systems, especially under mechanical loading and practical application conditions (Ferreira *et al.*, 2023; Salustio *et al.*, 2022). In addition, recent experimental and review-based investigations highlight the strong influence of formulation parameters, particle size distribution, and polymer modification on bond strength and slip behavior in modern tile adhesives (Dvorkin *et al.*, 2022; Neves, 2021).

Regarding execution techniques, field evaluation of mortar workability is often performed empirically, as the applicator determines consistency based on sensory perception (Kudo; Cardoso; Pileggi, 2013). This practice may lead to variability in the water content used during mixing, directly affecting the interaction between the fresh mortar and the substrate (Kudo, 2012). Such variability can significantly influence adhesion performance and mechanical behavior after hardening.

From the material perspective, adhesive mortar performance depends on complex interactions between cementitious components, aggregates, and polymer modifiers. These interactions directly affect the development of mechanical strength and adhesion in ceramic coatings (Regert, 2009). Several factors influence interfacial resistance, including ceramic tile absorption, cement composition, polymer content, application procedures, and water-to-cement ratio (Wetzel *et al.*, 2010). Multiple mechanisms act simultaneously to promote adhesion, making it difficult to isolate the contribution of each parameter. More recent studies also indicate that curing conditions and microstructural development significantly affect shrinkage behavior and bond strength in polymer-modified mortars (Dvorkin *et al.*, 2022; Liao *et al.*, 2021).

A ceramic cladding system is generally composed of three main layers: substrate, adhesive mortar, and ceramic tiles. Although typically classified as a non-structural system, differential movements between layers may induce stress concentrations capable of compromising adhesion performance (Andiç; Ramyar; Korkut, 2005). Consequently, understanding the physical and mechanical behavior of adhesive mortars is essential to improving the reliability of coating systems.

According to ABNT NBR 13755 (Associação Brasileira de Normas Técnicas, 2017), adhesive mortar is defined as an industrialized dry product which, when mixed with water, forms a plastic and adhesive mass suitable for bonding ceramic materials to substrates. These mortars are composed primarily of binders, aggregates, and chemical additives that modify properties in both fresh and hardened states (Kudo; Cardoso; Pileggi, 2013). Among the most used additives are cellulose ethers and polymer modifiers, which influence workability, cohesion, adhesion strength, deformability, and durability (Costa *et al.*, 2013; Jenni *et al.*, 2006).

Recent literature emphasizes that properties such as particle size distribution, fresh-state rheology, density, and mechanical strength are strongly interconnected and directly affect adhesion performance in cement-based mortars (Ferreira *et al.*, 2023; Salustio *et al.*, 2022). Therefore, combined evaluation of fresh and hardened properties is essential to better understand mortar performance.

Admixtures are specifically designed to stabilize and improve properties such as mechanical strength, impermeability, and resistance to environmental exposure (Gado, 2022). Tests such as Flow Table (fresh state) and tensile and compressive strength (hardened state) are among the most widely used methods for mortar characterization (Lima *et al.*, 2022). Additionally, according to NBR 14081 (Associação Brasileira de Normas Técnicas, 2012), pull-off and slip tests are applied to evaluate mechanical resistance and performance of industrialized adhesive mortars under service conditions.

Proper evaluation of the physical and mechanical performance of adhesive mortars contributes to improved specification of ceramic cladding systems, helping to reduce pathological manifestations such as tile detachment (Lima *et al.*, 2022; Salustio *et al.*, 2022). This performance-based approach is also associated with increased service life and reduction of material waste and maintenance interventions, contributing to more sustainable construction practices.

Therefore, this study aims to evaluate the physical and mechanical properties of industrialized adhesive mortars classified as ACI, ACII, and ACIII in both fresh and hardened states. The experimental program includes Flow Table, slip, density, pull-off strength, ultrasonic pulse velocity, tensile strength, and compressive strength tests.

2 MATERIALS AND METHODS

This section describes the materials used in the experimental program and methods employed to evaluate the physical and mechanical performance of the adhesive mortars ACI, ACII, and ACIII. The characterization includes raw material analysis and tests conducted in fresh and hardened states, following the guidelines of Brazilian technical standards. The procedures were designed to ensure reproducibility and to allow a comparative analysis of the mortars under controlled conditions.

2.1 Materials

Three types of industrialized adhesive mortars, AC I, AC II, and AC III, were used, according to the classification of NBR 14081 (Associação Brasileira de Normas Técnicas, 2012), from the same manufacturer, justified as follows:

1. **Variable control:** Using mortars from the same manufacturer minimizes variations in the quality of basic inputs that can influence product performance. This ensures that the differences observed in the

study are mainly due to the inherent characteristics of each mortar type and not to variations in material quality between different manufacturers (Neville, 1981).

2. **Consistency in the production process:** A single producer generally maintains uniform processes and quality standards, ensuring greater consistency in the manufacturing process and a more accurate and fair assessment of the differences between mortars (Mehta; Monteiro, 2001).
3. **Reduction of comparison bias:** Comparing products from different companies can introduce biases due to differences in formulations and production technologies. Working with a single supplier eliminates these biases and allows the study to focus on evaluating the properties and performance of each mortar type under controlled and comparable conditions (Callister; Rethwisch, 2016).

NBR 14081 (Associação Brasileira de Normas Técnicas, 2012) recommends that AC I mortar be used for indoor environments, with typical mechanical and hygrothermal solicitations. ACII and ACIII mortars can also be used in outdoor environments, as they allow for the absorption of greater efforts, being subject to cyclic variations in temperature and humidity, as well as wind action. The main difference between them is adhesion capacity, where ACIII has a higher capacity than AC II (Associação Brasileira de Normas Técnicas, 2012).

The standard substrate used was supplied by ABCP (Lot E=16) and has the dimensions recommended by NBR 14081-2 (Associação Brasileira de Normas Técnicas, 2012), being 250 × 500 × 20 mm (width × length × thickness). The water absorption required by the standard is less than 0.5 cm^3 in a four-hour interval, and the substrate used met the requirement with an absorption of 0.3 cm^3. The surface adhesion required by the standard is a minimum of 2.0 MPa, and the tested lot presented a surface adhesion greater than 2.5 MPa, also complying with the standard.

2.2 Methods

Standardized tests to assess the properties of adhesive mortars at different stages were adopted as a methodological approach. Raw materials were characterized through particle size distribution and FTIR spectroscopy. Mortars were prepared under controlled conditions and evaluated in the fresh state through density, slip, and consistency index tests. Mechanical properties such as pull-off strength, flexural strength, compressive strength, and elastic modulus were determined in the hardened state. Statistical analyses were also performed to support the interpretation of the results.

2.2.1 Characterization of Raw Materials

Tests for particle size distribution and Fourier Transform Infrared (FTIR) spectroscopy (ASTM E 1252-98, 2021) were performed. For the former, the fineness modulus, maximum size, and nominal maximum size of the ACI, ACII, and ACIII adhesive mortars were determined, following the specifications of ASTM C136 (American Society for Testing and Materials, 2019) for fine aggregates. For the latter test, an identification of functional groups was carried out to understand the chemical composition of the mortars, following ASTM E1252 (ASTM International, 2021).

2.2.2 Mortar Preparation

The mortar samples were prepared in a mechanical mixer, Solotest brand, model C2 with a 5L capacity and a metal paddle, which rotates on its own axis and describes a planetary movement around the axis of the tub, these movements being in opposite directions. Table 1 shows the paddle speeds in the mixer.

Table 1 – Mixer paddle speed

Speed	Rotation around the axis (rpm)	Planetary movement (rpm)
Baixa	140 ± 5	62 ± 5

Source: NBR 14081-2 (Associação Brasileira de Normas Técnicas, 2012)

2.2.3 Fresh state

The preparation of the adhesive mortars was carried out according to the procedure described in item 6 of standard NBR 14081-2 (Associação Brasileira de Normas Técnicas, 2012). The amount of material and water was dosed according to Table 2. The amount of water used was due to the climatic conditions on the day of mixing (average temperature of 15 ºC and humidity close to 100%), where the proportional amount indicated by the manufacturer was separated into 10 parts. Mixing began at low speed, for 30 s, with 5 parts of the total amount of water, and 4 more parts were added until reaching a suitable consistency. Then, the edges were scraped, and the mixture was rehomogenized for 60 s at low speed. After maturation (covered with a damp cloth for 15 min, as indicated by the manufacturer), the mixer was turned on at low speed for another 15 s.

Table 2 – Mix formulation

Mortar	Manufacturer's indication		Proportional		Used	
	Kg	L	Kg	L	Kg	L
ACI	20	4,6	2,5	0,575	2,5	0,5175
ACII	20	4,6	2,5	0,575	2,5	0,5175
ACIII	20	5,6	2,5	0,7	2,5	0,63

Source: Author

2.2.4 Density

The density test was performed according to NBR 13278 (Associação Brasileira de Normas Técnicas, 2005a). Immediately after preparing the mortar as described in item 2.2.2, three layers of mortar of approximately equal height were added to a container of known volume and weight. As each layer was added, 20 blows were applied with a metal spatula along the perimeter of the mortar to reduce existing voids. After tamping, the container was dropped three times from a height of approximately 3,00 cm, and subsequently, the mortar was struck off with a sawing motion. Finally, the container was weighed, and the weights for each mortar type were recorded.

2.2.5 Slip

The slip test followed the parameters guided by NBR 14081-5 (Associação Brasileira de Normas Técnicas, 2012). After 15 minutes of preparation, the standard substrate was primed using the smooth side of the trowel. Then, new portions of mortar were applied, and ridges with an average height of 5 mm were formed in the vertical direction of the substrate using the notched side of the trowel.

After 2 minutes from application, the measuring ruler was set up, and 3 ceramic plates (100 × 100 mm and absorption $\leq 0.5\%$) were positioned so that they touched the measuring ruler and were approximately 25 mm apart from each other. The standard weight was placed on the plates for 30 s, and the marker ruler was carefully removed, where the 6 initial measurements (Li) were taken. The standard substrate was positioned vertically, where it remained for 20 minutes. After this time, measurements were taken again at the 6 initial positions, obtaining the final measurements (Lf) away from the marker ruler.

2.2.6 Consistency index test

On a clean and dry Flow Table, a truncated conical mold was placed according to standard NBR 13276 (Associação Brasileira de Normas Técnicas, 2016). This standard is used for rendering and masonry mortars. However, the objective was to evaluate the consistency of the adhesive mortars and compare this index with spread and slip.

After mortar preparation, a 15-minute wait was observed as specified by the supplier, and the mold was filled in three layers of similar thickness, applying 15, 10, and 5 blows with the metal spatula respectively, finalizing this step by striking off the top surface flush with the mold wall. The mold was removed vertically, and the handle was cranked 30 times in an average time of 30 s. Four diameter measurements were recorded for each mortar.

2.3 Hardened state

For characterization in the hardened state, ten tests were performed to determine tensile strength (Associação Brasileira de Normas Técnicas, 2012), four tests to determine flexural strength, and eight tests to determine compressive strength (Associação Brasileira de Normas Técnicas, 2005b), and four tests for elastic modulus (Associação Brasileira de Normas Técnicas, 2021).

2.3.1 Determination of tensile strength

The test to determine tensile strength, also called the pull-off test, followed the parameters guided by NBR 14081-4 (Associação Brasileira de Normas Técnicas, 2012). After 15 minutes of preparation, the standard substrate was primed using the smooth side of the trowel. Then, new portions of mortar were applied, and ridges with an average height of 5 mm were formed in the longitudinal direction of the substrate using the notched side of the trowel.

After 5 minutes, 10 ceramic plates (50 × 50 mm and water absorption 4 ± 1%) were positioned, spaced at least 50 mm from each other and 25 mm from the edge of the substrate. They were loaded with the standard mass of 2 kg for 30 s, and then excess mortar was removed from the sides. The molded assemblies remained in a horizontal position for 28 days in a conditioned room (temperature of $20 \pm 2,0$ °C and relative humidity of $50 \pm 5,0\%$).

72 hours before the test, metal pieces for pull-off by simple tension were glued using a two-component epoxy adhesive. The test was performed by manual tension, applying a load at a uniform speed of (250 ± 50) N/s until rupture. The load and type of rupture were recorded for each of the 10 pieces.

2.3.2 Flexural and compressive strength

Tensile and compressive strength tests were performed for the characterization of the adhesive mortar, as indicated in NBR 13279 (Associação Brasileira de Normas Técnicas, 2005b). This standard is used for rendering and masonry mortars. However, the objective was to evaluate the strength of the adhesive mortars and compare this index with the sample density. With the same mortar mix, four rectangular specimens of 4 × 4 × 16 cm were molded and compacted for each mortar type.

After seven days, the specimens were demolded and remained curing under laboratory conditions for a total of 28 days. The flexural and compressive strength tests were performed on a universal testing machine (Instron brand, model 3400) with a loading speed of 50 ± 10 N/s until rupture and 500 ± 50 N/s until rupture, respectively.

2.3.3 Elastic modulus

The dynamic and static modulus of elasticity was determined for each of the mortars using the pulse excitation technique, specified by NBR 8522-1 (Associação Brasileira de Normas Técnicas, 2021). The prismatic specimens (4 × 4 × 16 cm) were tested with the Sonelastic equipment, which consists of software, an ADAC signal digitizer, a CA-DP acoustic pickup, and a portable pulser, to determine the dynamic modulus of elasticity of the material and, finally, estimate the static modulus of elasticity using Equation 1 (Alves l. b. o., 2022).

$$E_{ci} = 0.107 \cdot E_{dc}^{1,4} \cdot \rho^{-1} \tag{1}$$

The input values correspond to density (ρ) in kg/m^3 and dynamic modulus of elasticity (E_{cd}) in Pa.

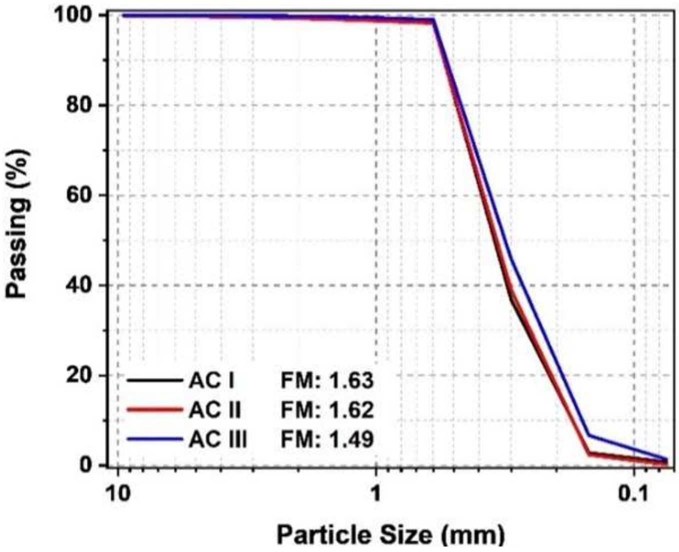
3 RESULTS AND DISCUSSION

This section presents and discusses the main results obtained from the experimental characterization of the ACI, ACII, and ACIII adhesive mortars. The findings are organized according to the state of the material—fresh and hardened—and are interpreted considering the existing literature. Emphasis is given to the influence of particle size distribution, density, and additives on the mechanical performance of the mortars. Statistical analyses complement the discussion by identifying significant differences among the mortar types.

3.1 Characterization of Raw Materials

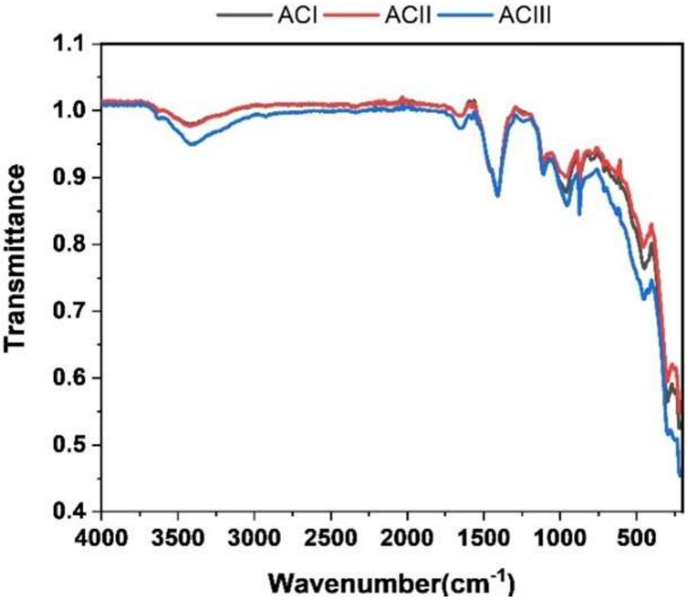
Figure 1 shows the particle size distribution (PSD) curves for each of the mortars analyzed in this study. The fineness modulus (FM) for mortars AC I, AC II, and AC III was 1.63, 1.62, and 1.49, respectively. The maximum size (MS) was determined only for AC I, as it was the only sample where 100% of the particles passed through the mesh sieve; therefore, the maximum size for this sample was 3/8" (9.525 mm). The nominal maximum size (NMS) was also determined for each mortar, and it was found that AC I, AC II, and AC III presented an NMS of No. 30 (0.600 mm). The results confirm that AC III presents the finest particles, while AC I shows the coarsest distribution, as illustrated in Figure 1.

Figure 1 – PSD curves of the mortars



Source: Author

Figure 2 – FTIR spectrum for commercial mortars



Source: Author

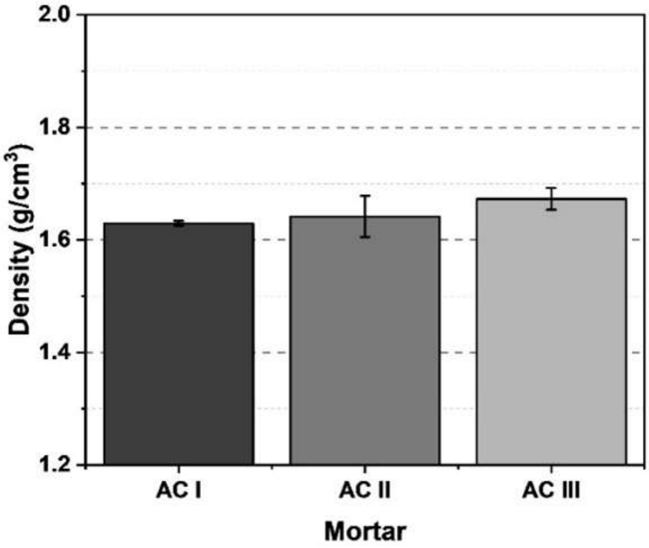
Figure 2 presents the FTIR spectrum of the three classes of commercial mortars studied. In the region of 3500 cm^{-1}–3000 cm^{-1}, a broad absorption associated with the stretching of hydroxyl groups (O–H) is observed, indicating water loss in the samples (Taylor, 1998). In the range of 1700 cm^{-1}–1400 cm^{-1}, carbonated phases ($CaCO_3$) and organic components are identified (Böke *et al.*, 2004; Mollah *et al.*, 2000). A peak around 1650 cm^{-1} may be associated with H–O–H bending vibrations, suggesting the presence of physically adsorbed water or hydrated cement phases. Furthermore, in the range of 1500 cm^{-1}–1420 cm^{-1}, bending vibrations corresponding to carbonates (C–O), mainly calcium carbonate ($CaCO_3$), are recorded (Böke *et al.*, 2004).

In the region of 1200 cm^{-1}–900 cm^{-1}, the presence of asymmetric Si–O bending vibrations, characteristic of silicate structures in C–S–H gel, is reported in the literature (Madejová, 2003; Mollah *et al.*, 2000). In the range of 800 cm^{-1}–600 cm^{-1}, the observed peaks correspond to vibrations of Al–O and Si–O groups, associated with C–A–H phases (calcium aluminate hydrates) or unreacted clinker (C_3A, C_4AF). Finally, in the range between 600 cm^{-1}–400 cm^{-1}, lattice vibrations and metal–oxygen bonds are identified, such as Ca–O and Si–O bending vibrations, as well as signals associated with Fe–O bonds and structural vibrations of residual quartz and/or crystalline phases in the cement matrix (Taylor, 1998).

3.1.1 Fresh State

The fresh state properties of adhesive mortars directly influence application efficiency and initial performance. Figure 3 shows the density results, while Figures 4 and 5 present the consistency index and slip test results.

Figure 3 – Density of the mortars in the fresh state



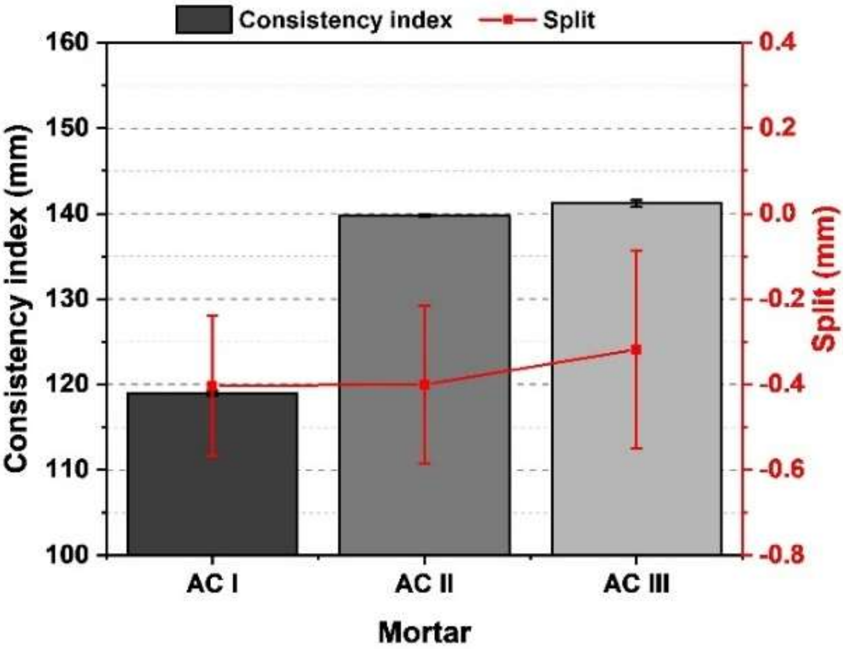
Source: Author

The average density values for mortars AC I, AC II, and AC III were 1.63±0.004 g/cm³, 1.65±0.037 g/cm³, and 1.67±0.019 g/cm³, respectively. The increasing density from AC I to AC III reflects the progressively finer particle size distribution shown in Figure 1. Two mechanisms explain this trend: first, finer particles enable better packing efficiency, reducing interparticle voids and increasing bulk density (Kosmatka; Wilson, 2011; Neville, 2006); second, improved particle arrangement minimizes entrapped air, further contributing to density increase (Ferreira *et al.*, 2023; Mehta; Monteiro, 2001).

Figure 4 – Consistency index of the mortars: a) AC I, b) AC II, and c) AC III

Source: Author

Figure 5 – Results of the consistency index and slip tests



Source: Author

Table 3 – Linear regression analysis for fresh state tests

	Slip		Spread	
	t	p	t	p
Intercept	-2.697	0.017	72.31	<0.001
ACII–AC I	1.064	0.304	8.92	<0.001
ACIII–AC I	0.402	0.693	9.56	<0.001

Source: extracted from Jamovi software.

Although the density values show a clear gradient, statistical analysis (Table 3) indicates that these differences are not significant at the $p < 0.05$ level. This suggests that while particle size influences packing, the formulation similarities among the three mortar types—particularly cement and additive content—maintain comparable fresh state densities.

From a practical perspective, this means that applicators will not perceive substantial differences in mortar weight during mixing and application.

The spread values followed an unexpected pattern: 119.00±3.37 mm for AC I, 139.75±1.71 mm for AC II, and 141.25±4.27 mm for AC III. Based solely on particle size theory, AC III would be expected to show the lowest spread, as finer particles increase interparticle friction and water demand, typically reducing flowability (Mindess; Young; Darwin, 2003). However, the observed increase in spread from AC I to AC III can be attributed to two factors: (1) higher water content used for AC III (0.63 L vs. 0.5175 L for AC I), and (2) higher dosages of polymeric additives in higher-class mortars.

The statistical analysis confirms significant differences in spread between all mortar types ($p < 0.001$), validating that these differences are not due to experimental variability. This indicates that manufacturers intentionally formulate AC II and AC III with enhanced workability to facilitate application.

The slip test results showed average values of -0.403±0.16 mm for AC I, -0.400±0.19 mm for AC II, and -0.318±0.23 mm for AC III. All values comply with NBR 14081 requirements (slip < 2.00 mm) and show no statistical differences among mortar types ($p > 0.05$).

The decoupling of spread and slip behavior is particularly noteworthy. While AC III exhibited higher spread (greater fluidity), it maintained slip performance equivalent to AC I. This is attributed to cellulose ethers and anti-slip agents, which provide thixotropic behavior (Jenni *et al.*, 2006): the mortar flows during application but rapidly regains structure after placement.

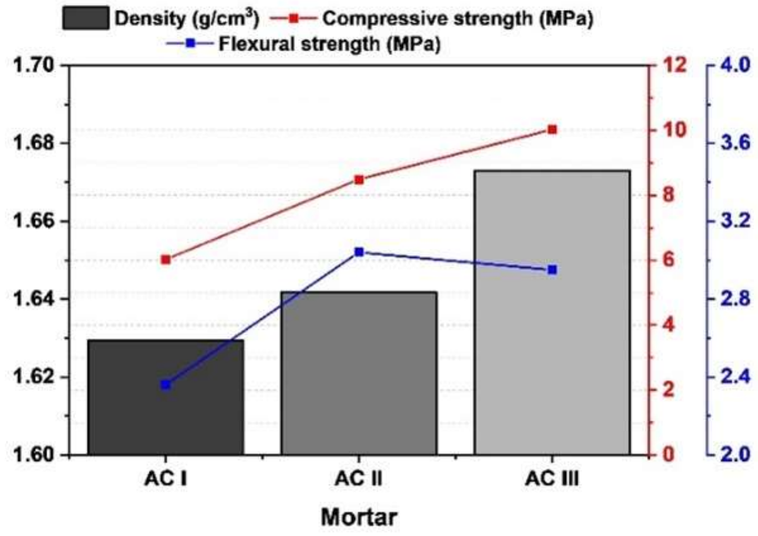
Overall, the fresh state results indicate that AC II and AC III offer improved workability compared to AC I, while maintaining equivalent slip resistance. This combination is advantageous for installation, especially in large-format or vertical tile applications.

However, improved workability in AC III depends on correct water dosage. Deviations in field conditions—such as excess water addition—may compromise the balance between workability, slip resistance, and hardened properties, reinforcing the need for strict adherence to manufacturer specifications.

3.1.2 Hardened State

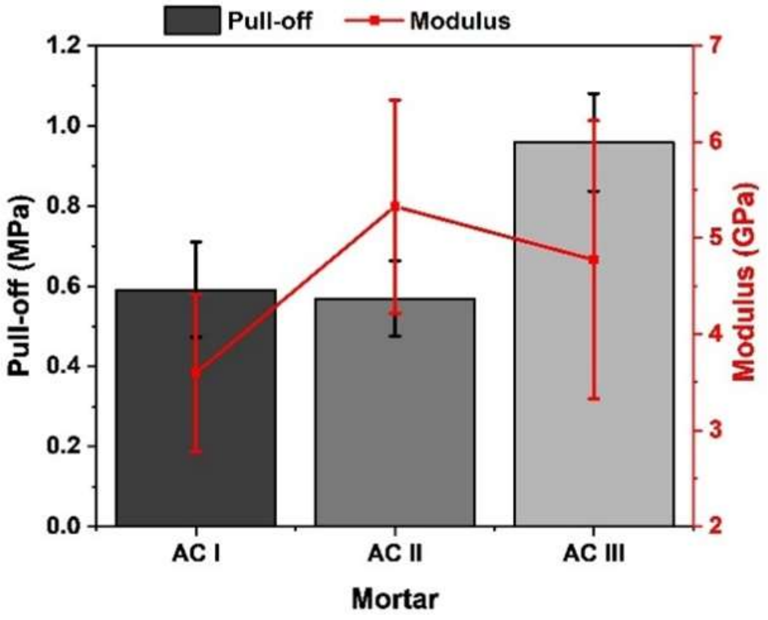
The mechanical performance of adhesive mortars in the hardened state determines their long-term durability and suitability for different application conditions. Figure 6 presents the results for density, compressive strength, and flexural tensile strength, while Figure 7 shows the pull-off strength and elastic modulus results.

Figure 6 – Results of density, compressive strength, and flexural tensile strength tests



Source: Author

Figure 7 – Results of pull-off strength and elastic modulus tests



Source: Author

The density values for mortars AC I, AC II, and AC III were 1.63 g/cm³, 1.64 g/cm³, and 1.67 g/cm³, respectively. The progressive increase in density from AC I to AC III correlates with the particle size distribution shown in Figure 1, confirming that finer particles enable better packing efficiency. This relationship is consistent with the literature (Ferreira et al., 2023; Tikkanen; Penttala; Cwirzen, 2011).

Despite this trend, statistical analysis (Table 4) indicates that these differences are not significant at $p < 0.05$, suggesting that formulation similarities maintain comparable bulk density among mortars.

Table 4 – Linear regression analysis for hardened state tests

	Pull-off		Compression		Flexural		Modulus	
	t	p	t	p	t	p	t	p
Intercept	12.540	<0.001	8.56	<0.001	8.55	<0.001	6.22	<0.001
ACII–AC I	-0.162	0.872	2.47	0.022	1.75	0.114	2.08	0.067
ACIII–AC I	6.498	<0.001	4.04	<0.001	1.53	0.159	1.41	0.192

Source: Author

The compressive strength results followed a clear increasing trend: 6.02±2.71 MPa for AC I, 8.48±1.62 MPa for AC II, and 10.03±2.64 MPa for AC III. Statistical analysis confirms significant differences between all mortars ($p < 0.05$), indicating that these variations reflect real formulation effects.

These values are consistent with polymer-modified mortars reported in the literature (Dvorkin et al., 2022), where strength development is associated with polymer film formation and improved matrix cohesion.

In contrast, flexural strength did not follow a strictly increasing trend, with AC II (3.04±0.79 MPa) and AC III (2.95±0.46 MPa) showing statistically similar performance, both higher than AC I (2.36±0.27 MPa). This behavior indicates that flexural performance is more dependent on interfacial transition zone quality than on bulk density alone (Liao et al., 2021; Petit et al., 2016).

Pull-off strength results were 0.591±0.118 MPa (AC I), 0.568±0.095 MPa (AC II), and 0.958±0.112 MPa (AC III). AC III exhibited significantly higher adhesion ($p < 0.001$), while AC I and AC II showed no statistical difference.

This improvement is attributed to polymer-modified interfacial bonding and enhanced mechanical interlocking (Jenni et al., 2006; Petit et al., 2016).

Elastic modulus values were 3.597±0.821 GPa (AC I), 5.326±1.106 GPa (AC II), and 4.774±1.446 GPa (AC III), with no statistically significant differences ($p > 0.05$). The observed variation is associated with the balance between packing density, porosity, and polymer-induced deformability (Mehta; Monteiro, 2001; Neville, 2006).

4 CONCLUSIONS

Through this study, three types of industrial adhesive mortars from the same manufacturer were characterized in both fresh and hardened states. The results demonstrated that AC I and AC II mortars meet the bond strength requirements established by NBR 14081 (0.50 MPa), while AC III satisfies the more stringent requirement of 1.00 MPa. Additionally, no significant differences were observed in slip behavior among the mortars, with all results complying with the standard limit of less than 2.00 mm. These findings indicate that all analyzed mortars present adequate performance to maintain their position under load, contributing to the durability and structural integrity of ceramic coating systems.

From a sustainability perspective, the adequate mechanical performance and adhesion capacity of these mortars are directly associated with increased service life of coating systems, reducing the need for maintenance, rework, and material replacement. This contributes to the reduction of construction waste and the consumption of raw materials, as well as to lower environmental and economic impacts throughout the life cycle of the building. In this context, proper specification of adhesive mortars by designers and engineers plays a fundamental role in promoting more efficient and sustainable construction practices.

Furthermore, the study enabled the analysis of the influence of particle size distribution on physical and mechanical properties, such as density, compressive strength, and flexural tensile strength. An inverse relationship was observed between particle size and these properties, with finer particles leading to increased density and improved mechanical performance.

Finally, the presence of porosity in the samples negatively affected mechanical strength by acting as stress concentrators and contributing to premature failure. These results reinforce that optimization of granulometric distribution not only enhances mechanical performance but also contributes to durability and longevity of mortar systems, supporting sustainability by minimizing degradation processes and extending service life of construction materials.

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