LUMEN ET VIRTUS
ISSN: 2177-2789

PATHOLOGY IN MASONRY IN THE WEDGING REGION

https://doi.org/10.56238/levv16n46-043

Submitted on: 11/02/2025 **Publication date:** 11/03/2025

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ABSTRACT

Masonry wall wedging is the process of filling the remaining space between the structure and the last row of wall blocks. In addition to filling the remaining space between the last row of blocks and the structure, it must ensure balance and greater durability to the building. The procedure may involve both filling and pre-tensioning the masonry wall by means of suitable construction elements.

The retraction of the mortar and the transmission of forces from the structure to the masonry are factors that contribute to the formation of pathologies, such as: cracks that affect watertightness, the detachment of coatings, the crushing of blocks.

The lack of performance in the wedge region has generated concern among civil engineering professionals. The NBR 8545 (1984) standard presents recommendations for wedging, saying: "masonry, in works with reinforced concrete structures, must be interrupted below beams and slabs and filled in order to ensure the perfect locking between the masonry and the structure". It should be noted that, at the time of publication of this standard, concrete structures were lower, with smaller spans in slabs and beams, in addition to having less deformability compared to modern constructions.

With the advancement of civil engineering over the years, the increase in the strength of concrete has brought the need to use more flexible and adherent mortars in the wedging area. This process requires materials and techniques that guarantee the absorption of forces and promote maximum adhesion between the different construction elements.

Keywords: Wedging. Mortars. Pathology. Compressive strength. Tensile strength in bending.

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INTRODUCTION

With the significant growth of the civil construction sector, pathological manifestations have gained prominence, being observed in most buildings. According to Chaves (2009), these manifestations correspond to pathologies that, throughout the useful life of a building, compromise its performance.

According to Helene (1992), the understanding of pathological manifestations occurs through engineering, which studies the symptoms, mechanisms, causes and origins of defects in civil constructions. These manifestations generate significant impacts, causing inconvenience by affecting both the aesthetics and the structure of buildings, which is of great importance for investors and real estate buyers.

It is important to note that the appearance of pathologies is not always caused by a single factor. Its occurrence can be related to several aspects, such as design flaws, improper choice of materials, incorrect dosages in execution, use of unqualified labor or lack of maintenance, which is an attempt to minimize the appearance of problems.

Regarding the movements of structures, Lottermann (2013) emphasizes:

> The movement of structures is a fact proven by several researchers, that is, every concrete structure "works". In this way, it will be subject to a series of pathologies, which are the result of design and execution problems.

Cracks are one of the most common pathologies in buildings and can appear in different ways, such as due to thermal variations, accidental movements or the deformation of structures, which generate stresses transmitted to the masonry and coating. In addition to an aesthetic problem, cracks can allow water to infiltrate, which can cause the emergence of other pathologies.

Cracking occurs whenever the tensile deformation to which the concrete is subjected exceeds its own resistance (SANTOS, 2012). This deformation can be caused by several factors, including internal movements in the concrete, expansion of materials or external conditions that exert forces on the structure, commonly caused by material stresses (OLIVEIRA, 2012).

As Thomaz (2020) points out, there are no values to precisely define the difference between fissures, cracks, and cracks. It is generally accepted that cracks are those with openings ranging from capillarity to the order of 0.5mm, cracks with openings in the order of 2mm or 3mm and cracks with larger openings. These openings are a means of relieving tensions caused by the movement of materials and their constituent elements. They arise when the forces acting on the materials or their connections overcome the forces of resistance, as highlighted by (VEIGA, 1998).

HISTORY OF WALL WEDGING EXECUTION

The 30s marked a turning point in the execution of masonry wedging. Before this period, constructions widely exploited the potential of masonry. It was at this time that reinforced concrete began to be used intensively in small buildings, which led to the beginning of the execution of masonry wedging. Initially, wedging with ceramic sealing blocks inclined at 45º was the most common method. In this type of wedging, the stresses transmitted by the structures to the walls are absorbed by the adhesion between the laying mortar layer and the ceramic blocks.

Thus, the use of various materials for wedging the walls is a characteristic of most constructions. Many builders opt for the simple filling of the wedging opening with resilient mortars, while others adopt more sophisticated methods, such as the use of 45º inclined bricks and mortars with expanding additives. These methods aim to improve the effectiveness and durability of wedging, ensuring greater performance of buildings.

EVOLUTION OF THE CHARACTERISTICS OF BUILDINGS

It is common to observe old buildings with robust structural elements, such as thick slabs, beams of great useful height, and large pillars. These characteristics are no longer common in newer constructions. Concrete, due to the evolution in chemical composition and the mastery of the properties of its components, today presents an increase in design strength, allowing the creation of more innovative structures and typologies. In addition, the construction processes, calculations and management techniques have also evolved, resulting in the emergence of pathological manifestations (MEDEIROS, 2005).

In order to optimize internal spaces, make better use of parking spaces and use lighter construction materials, modern building projects seek to save on the dimensions of structural elements. The use of fewer columns and thinner slabs results in more deformable structures, which can impact the performance and durability of buildings.

Thomaz (2020) argues:

> The evolution of the technology of construction materials and the techniques of design and execution of buildings have evolved in order to make them increasingly lighter, with slimmer structural components, less braced.

It is important to highlight the classification regarding the type of wedging, where according to the technique used, it is divided into three categories:

- **Pre-tensioning**: uses elements such as bricks arranged at 45° or expansive mortar, applied in order to induce initial tension in the system. Its main objective is to fix the masonry and the structure or to provide bracing of it.

- **No pre-tensioning**: employs mortar with a low modulus of elasticity, allowing greater deformability without the application of initial stresses. It is more directed to more deformal structures, having less probability of presenting cracks and its fixation is guaranteed by the initial adhesion of the mortar and deformation of the structure.
- **Plastic wedging**: made with materials such as polyurethane foam, providing flexibility and fast execution, being indicated for specific cases of structural accommodation such as very deformable structures and more rigid walls.

NBR 8545 (1984, defines the acceptable sizes of openings for wedging between the masonry and the structure (beam and slab), such as:

- **Mortar**: the opening should be approximately 3cm.
- **Prefabricated concrete wedges**: the opening should be approximately 8cm.
- **Mud brick wedges at 45º**: the opening should be 15cm.

Therefore, the choice of the wedging technique is made based on the structural and functional requirements of the project, considering factors such as deformability, stress absorption capacity, speed of execution and suitability to the materials used, in order to ensure the efficiency and safety of the construction system.

PATHOLOGY IN THE WEDGING REGION

The most common pathological manifestations observed in the wedging zone include cracking, detachment of coatings and, in more severe cases, crushing of blocks. These problems can compromise the integrity of the building and require corrective interventions to ensure its durability and safety.

Thomaz (2020) states that pathological manifestations can affect three fundamental aspects:

- warning of any dangerous state of rupture of masonry units;
- commitment to the performance of the building in service (watertightness, durability and acoustic insulation);
- psychological embarrassment of the user.

Medeiros (2005) points out:

> Sealing walls are breaking in the wedging zone, cracks between masonry and structures are visible, and problems in coatings in the wall wedging zone are more frequent. All because of the immediate and slow deformations that, if not foreseen, trigger the pathologies.
> Often controlled empirically, the problems are now less common than three years ago, but they have given the market a scare. There were many cases. Despite the

corrective actions, there is still a lack of knowledge to fully understand what is happening with these constructions.

For the execution of the wedging, it is essential to fill the openings between the masonry and the slab, as well as the opening between the masonry and the beam (figure 1) with appropriate and quality materials. Additionally, before starting filling, it is essential to ensure that the area is clean, free of dust, oils, or other contaminants that could compromise adhesion.

Another relevant point is that wedging must be performed before the application of plaster, configuring itself as an essential step to reinforce the connection between the structural elements and the masonry. In order to increase the resistance of the plaster to the stresses concentrated in the wedging region, the installation of wire mesh is recommended. This feature promotes the uniform distribution of loads, reducing the risk of cracks and detachments and ensuring greater durability and performance of the construction system.

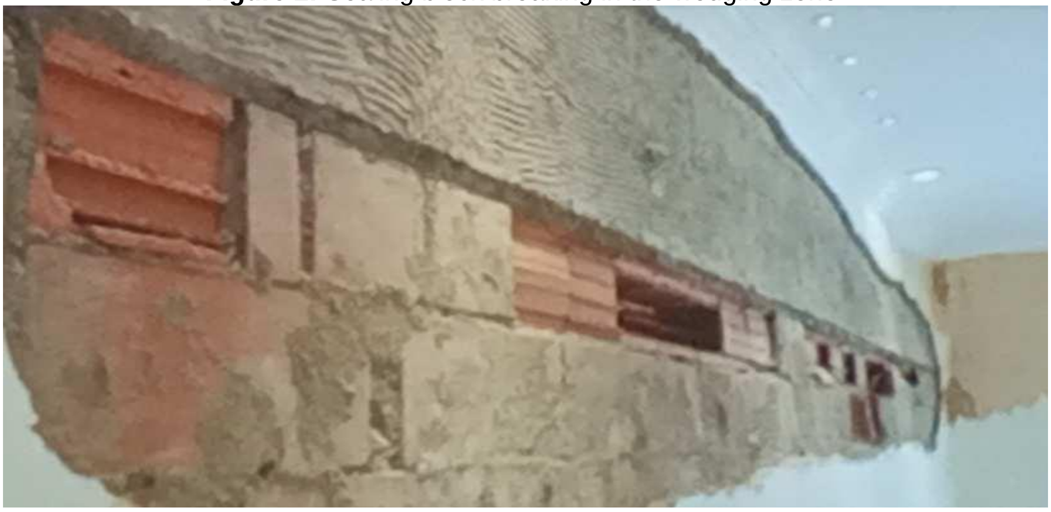
Figure 1: Opening between masonry and the slab (a). opening between masonry and beam (b). Both masonry will receive wedging.

Source: Authors.

It is important that the structure is completed at least 15 days before wedging, so that deformations can be identified, avoiding future adjustments. In buildings with multiple floors, wedging must occur from top to bottom, ensuring that when reaching the first floor, the load has been transferred and absorbed gradually by the lower elements, reducing unwanted stresses.

Figure 2 shows the rupture of the sealing block in the wedging zone, caused by the transfer of compressive stress from the beam to the mortar and masonry. It should be noted that the block has good tensile strength and lower compressive strength.

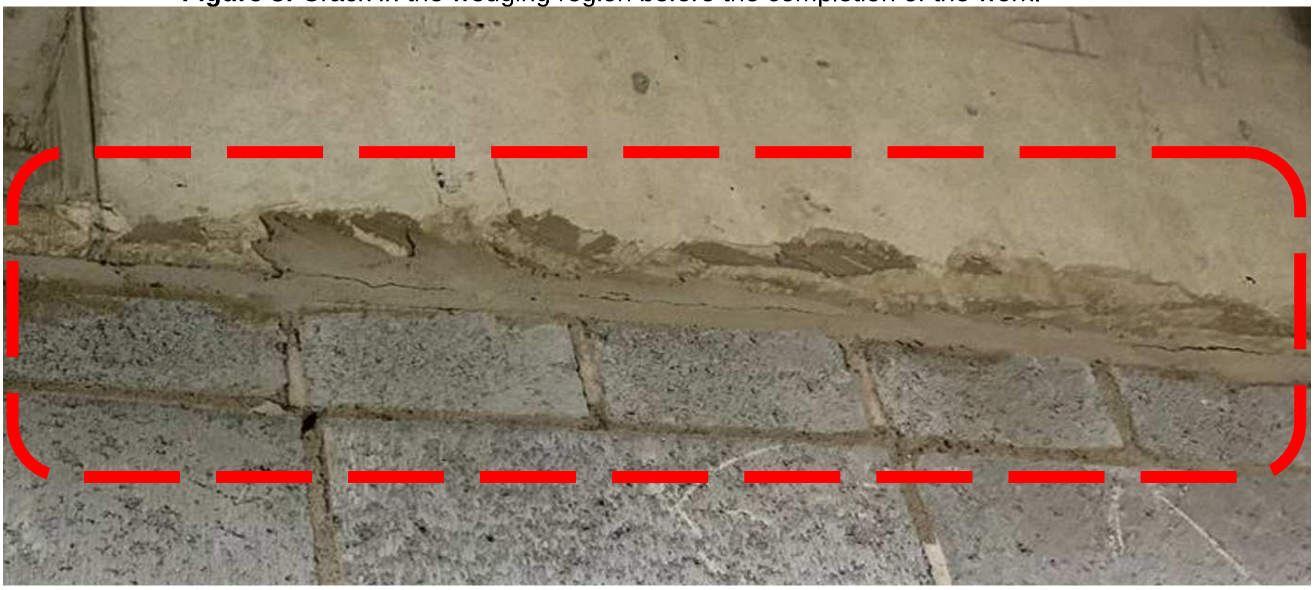
Figure 2: Sealing block breaking in the wedging zone.



Source: Ercio Thomaz (2024).

The inadequate use of mortars or the deficient execution of the wedging can cause uneven stresses, leading to the appearance of cracks in the masonry in the wedging region, before the completion of the work, as illustrated in figure 3.

Figure 3: Crack in the wedging region before the completion of the work.



Source: Authors.

It is important to note that wedging is a crucial step in the execution of the last row of masonry, responsible for ensuring the connection between the masonry and the structural elements, such as beams and slabs. However, when this phase is not carried out correctly, several problems can arise that compromise the safety, durability, and performance of the building.

MORTAR

Mortars are widely used in civil construction, with their main uses being in the laying of masonry and in the coating stages, such as plastering, plastering or single-layer coating on walls and ceilings. In addition, they are used in subfloors for the regularization of floors and in the laying and grouting of ceramic and stone coatings (CARASEK, 2010). NBR 7200 (1998) presents the definition of inorganic mortar as being:

Homogeneous mixture of fine aggregate(s), inorganic binder(s) and water, containing or not additives or additions, with adhesion and hardening properties.

NBR 13281 (2023) defines mortars as the homogeneous mixture of fine aggregates, inorganic binders, and water, which may or may not contain fibers, additives, or additions. These mortars have adhesion and hardening properties, and can be dosed directly on site or in their own facilities, as in the case of industrialized mortars.

Therefore, it is important to highlight the main functional requirements of mortars in the fresh state, which are: workability, consistency, plasticity, cohesion, water retention, thixotropy and adhesion (SOUZA, 2016).

According to NBR 13281 (2023), which establishes the requirements, classification and informative information must be presented clearly and visibly on packaging, technical sheets and/or in controls and work records. This requirement aims to ensure the transparency and accessibility of the technical specifications of the mortar, facilitating its correct use and application in civil construction projects. The standard seeks to ensure that all essential information is available to the professionals involved, contributing to the compliance and expected performance of the materials on site.

In the hardened state, mortars must meet requirements such as: compressive strength between ≥ 1.5 and < 5MPa, dimensional variation must be ≤ 0.80 mm/m and the potential tensile bond strength to substrates ≥ 0.20MPa. In addition to contributing to the acoustic and thermal insulation of masonry. It is also noteworthy that the adhesion (potential) (on standard substrate) must be greater than 0.20 MPa.

Classification of Mortars Regarding the Type of Binder

As for the type of binder, mortars can be classified into three types: lime mortar, cement mortar, and mixed mortar. Lime mortar uses lime as a binder, while cement mortar uses cement, and mixed mortar combines both, seeking to take advantage of the properties of each for different purposes in construction.

According to Sabbatini (1984), the English use the 1:3 ratio (binder: dry sand) in volume as a basic trace, assuming that, with this proportion, the voids in the sand are filled by the binding paste. This ratio is also widely used in Brazil, especially in traditional traits such as 1:1:6 (cement: lime: sand) for external coatings and 1:2:9 for internal coatings.

Classification as to Coating Function

According to NBR 13529 (2013), the layers of mortar coatings are classified as roughcast, plaster and plaster. The roughcast is the initial layer, applied to prepare the base, uniforming the surface in terms of absorption and improving the adhesion of the coating. The plaster is the intermediate layer, intended to cover and regularize the surface of the roughcast, creating a suitable base for the application of plaster or decorative coating. The plaster is the final layer, used to cover the plaster, providing the surface finish.

WEDGE MORTAR

The main functions of wedging mortars are to close the region between the last row of masonry and the bottom of beams and slabs, in addition to absorbing and distributing the stresses and forces transmitted by the structure to the masonry. However, these regions often face difficulties in absorbing structural movements, which can lead to the appearance of fissures, characterized as pathological manifestations.

In the past, concrete structures were less prone to warping, which reduced concerns about the wedging region. At that time, rigid mortars were used for filling (SAYEGH, 2007). However, with the evolution of engineering and the development of new techniques, concrete structures have become more slender and susceptible to deformation. These deformations are transferred to the masonry and coatings, causing cracks. Therefore, it became necessary to use more flexible mortars, capable of withstanding such deformations and minimizing the appearance of pathological manifestations.

WORKABILITY AND CONSISTENCY OF MORTAR

According to Baía and Sabbatini (2008), the workability of mortars is defined by the combination of characteristics such as cohesion, consistency, plasticity, viscosity and initial adhesion. In practice, this property determines the ease with which the mortar can be handled, covering steps such as mixing, transporting and applying, in addition to ensuring a homogeneous finish after its application. Among the main compositions of mortar for wedging, the following stand out:

- **Cement and sand mortar with expander additive or shrinkage compensator**: classified as rigid wedging, it provides high structural rigidity.
- **Cement mortar, sand and lime paste or PVA glue**: known as resilient wedging, it has a low cement content and uses adhesive components to improve the workability and adhesion of the mixture.
- **Prefabricated mortars**: industrialized products with controlled dosage, ensuring uniformity, quality and high technical performance.

According to Turra (2016), the unsatisfactory workability of the mortar compromises the final performance of the coating, as it affects its correct application and, consequently, important properties in the hardened state, such as adhesion. The author also points out that the mortar must have sufficient workability to allow the professional high performance, ensuring a satisfactory, fast and economical work.

In this context, Hermann and Rocha (2013) point out that the consistency of the mortar, defined as the tendency of the material to resist deformation, is directly related to workability and can be measured by means of a consistency index and the squeeze-flow method as described in NBR 15839 (2010).

According to Cascudo et al. (2005), the quantitative evaluation of the workability of mortars and the definition of specific values through tests face significant challenges. This is due to the fact that workability depends not only on the intrinsic properties of the mortar, but also on the skill of the applicator, the characteristics of the substrate and the technique used. Thus, workability is considered a qualitative property of a complex nature.

For Selmo (1989), the coating mortar is considered to have good workability when it has the following characteristics: it allows easy penetration with the trowel, without being excessively fluid; when transported to the planer and thrown against the base, it remains cohesive, without adhering to the spoon; and it remains moist enough to be spread, slatted and receive the surface finish, as shown in figure 4.

Figure 4: Masonry in sealing block ready to be finished.

Source: Authors.

NBR 13276 (2016) establishes the guidelines for the preparation of mortar mixtures and presents the method to determine the workability index. The test consists of evaluating the degree of fluidity or the resistance to spreading of the mortar under specific conditions, providing an objective parameter that helps in quality control and the adequacy of the material to the application requirements.

MORTAR WITH AIR ENVELOPING ADDITIVE

According to Santos (2006), the air enveloping additive is used in industrialized mortars to modify their rheological properties. This additive introduces discrete, almost spherical air bubbles into the mixture. These bubbles do not form channels that allow fluids to flow through, ensuring that the permeability of the material is not increased with the use of the additive. The air incorporator thus contributes to improving the workability and resistance of the mortars without compromising their impermeability.

The use of the air envelop additive results in a significant improvement in the workability of the mortar in the fresh state. This occurs due to the formation of a large amount of microbubbles of air that are independent of each other, which facilitates the handling and application of the mortar (ALVES, 2002).

For the authors Rixon and Mailvaganan (1999 apud ALVES, 2002, p.28), they present the concept:

> Air enveloping additives are organic matter, usually presented in the form of a solution that, when added to concrete, mortars or cement pastes, produce a controlled amount of microscopic air bubbles, uniformly dispersed. This type of air should not be confused with trapped air, which is usually present in concrete and mortar in the form of irregular cavities and is usually produced due to inadequate compaction or compaction.

According to Alves (2002), air-incorporating additives are anionic surfactants that, when added to cement pastes, adsorb to solid particles through their polar part, while the nonpolar part is oriented to the aqueous phase, giving a hydrophobic character to the cement particles. The formation of air bubbles occurs mainly by surfactants that remain free in the aqueous phase. However, some adsorbed surfactants can also contribute to the production of bubbles through the so-called "bridge effect", in which cement particles interconnect, increasing the cohesion between them and, consequently, the viscosity of the paste.

METHODOLOGY

This article was prepared based on the bibliographic research method, based on pre-existing sources and without direct practical application. According to Boccato (2006, p. 266), bibliographic research aims to develop solutions based on theoretical references already published, allowing analysis and discussions on these materials. In addition, it offers the researcher greater ease to access a wide range of information (GIL, 2002).

RESULTS

Wedging is essential for integrating masonry and concrete structures, ensuring the union between blocks and structural elements. Historically, concrete structures were robust, allowing for rigid mortars. However, the emergence of slimmer and more deformable structures demanded flexible and adherent mortars, capable of absorbing and distributing structural forces, preventing cracks, detachments and other problems.

The mortars, composed of binders, fine aggregates, water and additives, perform functions such as laying, coating and surface regularization. Properties such as workability, consistency, and plasticity are crucial in the fresh state, while mechanical strength and low shrinkage are highlighted in the hardened state. Workability, measured by NBR 13276 (2016), depends on the cohesion and consistency of the mixture, and is improved by the use of additives, such as air incorporators and expanders, which reduce shrinkage and increase durability.

The evolution of mortars reflects the continuous search for materials that meet the modern demands of civil construction, ensuring greater safety, efficiency and resistance to pathologies. In line with technological advances, these solutions promote more durable, sustainable buildings adapted to the needs of the sector.

DISCUSSION

The analysis of the properties and behaviors of mortars, especially in the application in critical areas such as wedging, highlights the complexity and importance of this material in civil construction. The evolution of construction techniques and concrete structures over the decades has brought new demands for mortars, requiring more flexible, adherent materials capable of withstanding the deformations imposed by slender and modern structures.

Issues such as workability, consistency, and the ability to absorb stresses and distribute efforts are fundamental to ensure the durability, aesthetics, and functionality of buildings, minimizing the appearance of pathological manifestations. The introduction of additives, the adoption of standardized test methods, such as those provided for in NBR 13276 (2016), and the development of more specialized mortars reflect the continuous effort of civil engineering to improve the quality and performance of construction systems.

The improvement of mortars, both in terms of formulation and application, is essential to meet the current requirements of the sector, ensuring safer, more durable and efficient constructions, in line with technological advances and market expectations.

CONCLUSION

Wedging plays a key role in the interaction between masonry and concrete structures, ensuring proper closure between the last row of blocks and slabs or beams. Historically, concrete structures were more robust and less deformable, allowing the use of rigid mortars. With the evolution of engineering and the advent of slimmer and deformable structures, the need arose for more flexible and adherent mortars, capable of absorbing and distributing the forces transmitted by the structure, avoiding pathological manifestations such as cracks, detachment of coatings and crushing of blocks.

Mortars are materials widely used in civil construction for laying, coating and surface leveling. According to NBR 13281 (2023), they are composed of binders, small aggregates and water, and may include additives. Its main properties in the fresh state include workability, consistency, plasticity and adhesion, while in the hardened state mechanical resistance, low shrinkage and absorption stand out, in addition to contributing to thermal and acoustic insulation.

Workability is a critical aspect, influenced by the cohesion, consistency and plasticity of the mortar. Lack of proper workability can compromise the final performance of the coating. Methods such as the consistency index, defined by NBR 13276 (2016), are used to evaluate these characteristics.

The use of additives, such as air incorporators, improves workability by introducing microbubbles that increase the cohesion and viscosity of the slurry. In addition, expander additives are employed in wedging mortars to reduce shrinkage and improve performance in areas subject to structural stresses.

Finally, the continuous study of the properties of mortars and their adaptation to the modern demands of civil construction are essential to improve the durability, safety and efficiency of buildings, reducing the impact of pathologies and promoting innovative solutions in the sector.

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