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RESEARCH ARTICLE

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## INFILTRATION: THE DISEASE OF THE STRUCTURE

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### ABSTRACT

In civil construction, moisture has been highlighted as the main cause of infiltration, with the solution of waterproofing systems that aim to protect the environment. About this issue, this article aims to analyze and elucidate the infiltration process and its consequences. In order to respond to the research objectives, the methodological choice was an exploratory and descriptive bibliographic review on the forms of pathological manifestation the buildings can present when affected by humidity. The research results show that the poor execution of the project and the lack of waterproofing in the structure are the main causes of structural pathologies. Found that the problem, the repair must be immediate. In addition, the study discusses the techniques and elements that should be used to avoid corrective repairs, preventing financial disorders, structural problems, public health and worsening of respiratory allergies in humans.



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## I. INTRODUCTION

Moisture is the biggest cause of infiltration and waterproofing systems are the recommended solution to protect the environment from this pathology, as it creates an impediment to the infiltration of water or directs to another location that is not affected by the fluid. In Brazil, the first appearance of this procedure was in the construction of the *São Paulo* subway, as it is a large project, an effective strategy was needed to combat this pathology in the future; then, the Brazilian Institute of Impermeabilization (IBI) was born, adopting this procedure in which whale oil was mixed with settlement mortar and cover [1].

According to [2], humidity has always been a cause of concern since man lived in caves, as they realized that moisture penetrated the walls through the soil, which made housing conditions dangerous and could cause unhealthy conditions in those caves. It was noted that water has a high penetrating power in various materials [2].

By ignoring important factors in the construction stage, such as the appropriate material, a team qualified to carry out the application of the waterproof coating and the type of system ideal for the situation, can lead to future problems due to humidity. However, this activity goes far beyond the merits of the construction, it shows that planning is essential and indispensable

in any work, professionals in the area must have high technical knowledge to act, thus avoiding future complications [3].

To [3] water is the biggest cause of pathologies in buildings. Water has the ability to cause degradation in structural construction, damage to paint along with health problems, as moisture penetrating the wall can cause respiratory diseases through fungi and bacteria, causing an unhealthy environment and harming health.

An evolution in civil construction was noted in terms of works management, but according to [1], waterproofing is missing in most works, as it is often considered expensive and therefore is soon discarded for not being noticed visually its existence or not [4].

According to [5], the right choice of products and the system applied for waterproofing is extremely important in the future there is no need for intervention for repairs or renovations. The cost of waterproofing during the work is from 0.45% to 1.95% and if there is a need for repairs due to lack of it, the cost goes up about 15%, because if there is no corrective or preventive intervention, the useful life of the work decreases according to the deterioration of the structure exposed to infiltration [6].

As a result, this bibliographic review article was developed through searches in scientific Institute of Technology and Education Galileo of the Amazon (ITEGAM), Google

Scholar, and others, using the keywords: “infiltration”; “infiltration into structures”; “Infiltration” + “waterproofing”, “structural pathologies” and “civil construction” + “infiltration”, having as factors the correct use of waterproofing and how the incorrect use of this process can cause damage to the structure, showing the origin and solution of the problem [7].

## II. WATERPROOFING

With changes in the construction method, which went from corrective to preventive, waterproofing is still difficult to fit into the planning of some works.

In the research related to the damages that the lack of a correct waterproofing can cause to the structure, questions arise in which circumstances the problems caused by the pathology can be related not only by the misuse of the products, but also by the carelessness at the time of the execution of the project.

Waterproofing is the set of operations and construction techniques (services), composed of one or more layers, whose purpose is to protect buildings against the deleterious action of fluids, vapors or moisture [7].

According to [7], the waterproofing project is divided into two: the basic project and the executive project. The basic project contains the fundamental information for the waterproofing to be done correctly. Fulfilling the function of protecting the building from moisture. It must be carry out for works of multifamily, commercial, mixed, industrial buildings, as well as for tunnels, dams and works of art, by the same person responsible for the legal architecture project [7], according to [8]. The executive project is the union of information based on the basic waterproofing project, however it has detailed specifications of all waterproofing systems to be used in the construction. In addition, the project must be done taking into account the existence of the architectural, structural, hydraulic-sanitary, rainwater, gas and electrical projects so as not to cause problems with overloads, detailing, and even with the aesthetics of the building [8].

The appropriate type of waterproofing to be used in civil construction must be determined according to the request imposed by the fluid on the construction parts that require tightness. The request can occur in four different ways, as follows:

- imposed by percolating water;
- imposed by the condensation water;
- imposed by soil moisture;
- imposed by the fluid on unilateral or bilateral pressure

[7].

## III. MANIFESTATION OF INFILTRATION

Pathological manifestations of infiltrations can occur in several ways, with which they can be detected visually through specific tests, analyzes or calculations.

Often, only visual observation can cause uncertainties about the pathology, due to the fact that several of these symptoms are not specific to a given type of infiltration [9].

It can be said that the humidity in a building manifests itself in several different ways, among which stand out:

- humidity by capillarity;
- building humidity;
- precipitation humidity;
- humidity due to other causes.

## III.1 DEFINITION OF THE MAIN RESEARCH CENCEITES AND PARAMETERS

Capillarity consists of the phenomenon of rising water from the soil on the walls of a building through surface tension. The intensity of the surface tension is directly related to the viscosity of the liquid.

The water rises on the walls through the capillaries, which come from the discontinuity of the materials used in civil construction, forming a network of spaces filled with air, which are being saturated by the water as it moves within the material [10].

Not only water from the soil, but also the salts on the ground and in the building materials themselves are dissolved by the water and transported through the walls to higher levels. Upon evaporation, this water will cause the crystallization of these salts that will close the existing pores, reducing their permeability and increasing the level of humidity [11].

The action of water by capillarity is visually perceived, as it causes the appearance of spots in the regions usually close to the ground, accompanied by mold spots, cryptoflowering, efflorescence or parasitic vegetation, especially in places with poor ventilation.

In the Figure 1, shows a pathology found in a building in the city of Manaus, AM. It was identified that the wall is in parallel with the ground. This causes water to percolate from the soil to the inner side of the wall and can manifest diseases caused by the accumulation of fungi.



Figure 1: Wall with pathology caused by capillarity.

Source: Authors, (2020).

## III.2 DEFINITION OF THE RESEARCH STRATEGY

Most materials require water for mixing, some of that water evaporates more easily, the other part takes longer. In this process, the most porous materials use three distinct phases. The first phase, the evaporation of surface water. The second phase, the water that is retained in the pores with the largest diameter where it takes a longer time to evaporate. In the third phase, the water that is trapped in the smaller diameter pores begins to be released in a slower process, which can happen for years. In general, the pathologies found due to this type of humidity tend to cease for a more or less short period, depending on the characteristics of the type of use of the enterprise and the climatic region that is found [12].

### III.3 PRECIPITATION HUMIDITY

In this type of humidity, we will have the appearance of stains on the external walls or slabs in different dimensions. During periods of precipitation, they tend to appear and during prolonged periods of rain, mold, efflorescences and cryptoflorescences may appear [12].

### III.4 HUMIDITY DUE TO OTHER CAUSES

This humidity has many types of occurrences, it becomes very difficult to summarize all its causes in a specific way. Its causes are usually the result of installation failures, defects in construction, accidents or even lack of maintenance [12].

### IV. MANIFESTATION OF INFILTRATION IN WET AREA

In civil construction, water permeates the empty spaces of some solid body, which are divided into two distinct groups.

One says about the infiltration that occurs from the outside in, caused by precipitation, humidity, soil type or groundwater action. The other group, on the other hand, concerns infiltrations from the inside out, which appear through leaks in the hydraulic network due to poor installation, inadequate material, or the absence of adequate coatings to act in wet areas [13].

In infiltrations from the wet area, where there is a process to know where, and how the pathology arose, usually caused by failure or absence of waterproofing.

The humidity as it increases, causes an expansion of the material, and when it decreases the contraction is proven. Hygroscopic changes influence the deformability characteristics of masonry, as they cause the dimensional changes they perform (Figure 2). Volumetric variation can cause cracks, and is similar to those caused by shrinkage [14].



Figure 2: Infiltration in reinforced concrete slab.  
Source: Authors, (2020).

According to [6], the executive waterproofing project must meet some constructive details such as the diameter of the hydraulic collectors, on the expansion joints, external pipes, vertical waterproofing plans [5].

According to [14], the cost of implementing a waterproofing project in the work varies from 1% to 3% of the total value, involving design, execution, consultancy, inspection and materials. And when the implementation is not carried out, these costs reach up to 15% of the total value of the work [15].

### V. WATERPROOFING PROCESS

Choosing an appropriate material for the waterproofing process must undergo a careful analysis in view of the circumstance of the place where the material will be used, because for the purpose of waterproofing there will be a specific material. Some materials that stand out are: asphalt, cement mortar and polymeric resins [16].

According to [15] the existing waterproofing systems are:

- Flexible membranes molded in loco;
- Pre-molded flexible blankets;
- Molded rigid membranes [17].

The type of waterproofing chosen depends on characteristics and working conditions, such as:

**Condensed water:** able to withstand the action of water on the structure by the condensation process.

**Percolation water:** resists percolation water without confinement in slabs for example.

**Water by soil moisture:** supports the action of water on floors in contact with soil or mold on walls [18].

Some waterproofing systems are chosen according to the characteristics of the work, mechanical resistance, cost, environment etc. Waterproofing systems are:

**Water repellents:** They chase away water, being able to apply it directly on the surface and it is indicated for exposed concrete, stone facades, ceramic tile and porous ceramic.

**Crystallizers:** Mixing an adhesive component with a cementitious component, creates a consistency and applying it on a wet surface, crystals are formed that when they dry, create a protective barrier.

**Polymeric Mortar:** Composed of additives, cement, polymers and aggregates. Must be used in cold areas as it is a waterproof coating.

**Acrylic emulsion:** Must be used on exposed surfaces. It is a liquid membrane, applying it cold and molding it in the applied area.

**Asphalt emulsion:** Must be used in slabs and cold areas. It is a single component inserted in the place like paint.

**Asphalt emulsion:** Must be used in slabs and cold areas. It is a single component inserted in the place like painting.

**Caulker:** Must be used for general waterproofing use.

**Water repellent:** Expels excess water. Suitable for use on bricks, stone facades, ceramic tile and porous ceramic [19].

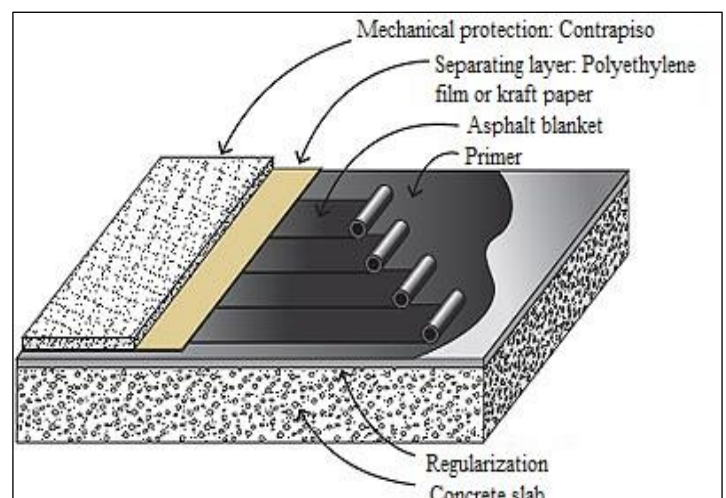


Figure 3: Waterproofing of asphalt blanket on a slab.  
Source: Adapted of [20].

Table 1: Summary of waterproofing solutions.

Localization	Solution	Materials
Foundations	Solid brick masonry	Crystallizers
Buried structures	Outside	Asphalt blanket + Drain
Buried structures	Inside	Polymer mortar
Slabs	Waterproofing	Asphalt blanket and acrylic membranes
Reservoirs	Lifts	Asphalt blanket and PVC blanket
Reservoirs	Buried	Polymeric mortar and acrylic membranes

Source: Authors, (2020).



Figure 5: Mold infecting the object.  
Source: Authors, (2020).

## VI. THE IMPORTANCE OF WATERPROOFING IN BUILDING

The waterproofing prevents water from coming into contact with the materials, preventing infiltration, stains, mold, peeling, efflorescence, corrosion of the armature, among other pathologies. Without proper waterproofing, these claims can occur in wet areas such as slabs, pools, walls that receive water from precipitation, reservoirs and others.

The sealing and sealing of the pores depends on the correct waterproofing, since without its correct application, the construction will fail. With the waterproofing carried out properly, the environment will be safe from recurring pathologies the action of water is comfortable for the regulars and residents of the building.

This process is one of the most important stages in civil construction, and sometimes it is not applied due to lack of resources or cut in the budgetary expenses of the work, thus causing future problems in the building.

Many construction companies choose to install the waterproofing only at the end of the work, but the sooner it is applied, the more effective it will be, avoiding problems during the construction, as they result in an unpleasant humidity.

## VII. MOFO AND BOLOR: DAMAGE TO HEALTH

In addition to the infiltration damaging the structure with mold and mildew, it can cause residents respiratory diseases. Mold and mildew are caused by fungi that proliferate in humid environments, caused by poor ventilation, infiltration and by closed environments.

Children, the elderly, allergic and pregnant people are at risk for acquiring respiratory diseases due to mold and mildew, such as sinusitis and even asthma. In addition to diseases they cause unpleasant spots on the structure and a bad smell.

The solution to this pathology caused by infiltration is waterproofing. Other ways to also get rid of mold and mildew is by opening ventilation at the site.

Mold and mildew have differences. Mold erodes the affected material and mold infects the object. They are housed in closets, clothes, walls and furniture.



Figure 4: Wall mold caused by moisture.  
Source: Authors, (2020).

## VIII. CONCLUSION

In this article, some pathologies of civil construction were addressed, with the objective of showing the importance of the lack of waterproofing caused in homes and how much this is harmful to the enterprise and even the health of the residents. The failures related to waterproofing are usually caused by the lack of specialization of professionals who do not use the minimum standards for the preparation of the project, technical standards are available to the construction professional so that infiltration does not occur at any time. It was noted that in most cases it is due to the fact that there are no mandatory rules for a waterproofing project in single-family homes, in which those responsible for the work choose the cost, thus making waterproofing an option, leaving aside its great role in the project, if it was mandatory in the initial phase of the work, maintenance costs can reach 15% of the total value of the work, whereas this cost can reach up to 50% of the repair value at the affected site, if it is not carried out at the time of the activity.

All the pathologies presented show that the failures, in general, can be concluded as negligence arising from the lack of training of the professionals involved, since most of the single-family homes where the infiltrations occurred were recently carried out and emergency maintenance was not yet necessary. The current norms present, in addition to concepts, minimum requirements for the correct functioning of the structure to be built, thus the professionals registered in the CREA system can guarantee the project's efficiency, thus following all the requirements, since the normal are studied in detail by the commissions studies, thus making possible the standardization of the content presented. Having new solutions to consolidate the problem has to be constant, so being aware of new research technologies, bring advantages increasingly demanded by the job market, thereby prioritizing human life.

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