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Environmental Problems Generated by Capillarity - Deteriorate Relationship in Buildings of the Lower Area of the Historic Centre of Santiago de Cuba

MSc. Ing. Mayelin González Trujillo[1], **Dr. Eduardo Beira Fontain**[2], **Dra. Odalys Alvarez Rodríguez**[3] & **Ing. Liber Galbán Rodríguez**[4]

Abstract

The phenomenon of moisture (humidity), witch affects the buildings or infrastructure resources, the landscape, and the human health, is considering the main cause of deterioration of these resources in any country. In Santiago of Cuba, the oriental province of this island, this problem is associated, in general, to the effects of the government to conserve the national historical centre of the island. For that reason, Cuba and specially, the its western province, Santiago and its historical centre, does not escape to the factors that cause this situation. The zone of the area is, fundamentally, residential and at the same time, with a high tourist value due to the inherited architectural patrimony given by the colonial ancestor. In this study, we will discuss and face several environmental factors that have a direct relationship with this problematic. In addition, this study has a huge valorization and benefits to the urban planning program. The study will produce too, a great amount of good quality information and data (knowledge), that cam be use to performance the public policy to conserve the historical colonial buildings and the urban heritage area.

Keywords: capillarity humidity, deterioration, heritage buildings, colonial ancestors, patrimony

Introduction

Is very important understand the natural process and the phenomenon that occur in the environment and its relationship to the sustainable development of the society. Specially, if these adverse effects are causing by the water in its phase call moisture or humidity. In others words, the humidity (moisture) conditions of the environment that affects their surrounding.

Although evidence suggest that the water resources is indispensable for the social development, but some times it can be dangerous and destructive through its interaction with the environment. In others words, the interaction of the water with the environment can cause flooding specially on unpaved areas, huge rain seasons, drought, and a phenomenon, which is not well understood, but is a great destructive process, call the humidity (moisture). The moisture destroy the buildings resources or infrastructure, the landscape, and adversely affects the health of the residents causing diseases and lungs problems.

[1] Facultad de Construcciones, Departamento de Ingeniería Hidráulica.
Email: mtrujillo@fco.uo.edu.cu. Universidad de Oriente. Santiago de Cuba. Cuba.
[2] Facultad de Construcciones, Departamento de Ingeniería Civil.
Email: efontain@fco.uo.edu.cu. Universidad de Oriente. Santiago de Cuba. Cuba.
[3] Vice decana docente, Facultad de Ingeniería Civil, Instituto Superior Politécnico Jose Antonio Echeverría. La Habana. Cuba. Email: oar@civil.cujae.edu.cu.
[4] Facultad de Construcciones, Departamento de Ingeniería Hidráulica, Universidad de Oriente, Santiago de Cuba. Cuba.
Email: liberg@fco.uo.edu.cu.

The impact of the humidity alter, basically, the edifications and cause the deterioration of the structure (frame) of the buildings (De Cusa, 1991) This is a result of a process knowing as capillarity-damage, a phenomenon that produce lost of the society income and human disease.

Humidity is characterized by the presence of unwanted liquid water in areas, seasons, and permanent or different periods (Collective of authors, 1990). When the moisture surrounds the objects, especially the humidity present in the moisture soil, a phenomenon capillarity moisture or absorption is produce. That effect has its explanation in the capillarity's phenomenon (Vennard and Street, 1992; Gran, 1968). This problem is usually associated according with the diagnosis made by the Curator's office, where Cuba is a country that does not escape this situation, especially the city of Santiago de Cuba and its historic center. Which is primarily residential area with a high tourism value because of the architectural heritage inherited from the colonial ancestors. According diagnosis made by the Office of the Curator of the City and analyzed by Lopez (2004), approximately 51.3% of the Historic Downtown area is occupied by housing, with a total of 16 619 properties (representing 15% the total city), in which there are approximately 66 326 inhabitants, where the state's housing stock is poor, having only 1 909 houses in good condition (11%), 8 794 in fair condition (53%) and 5 916 in poor condition (35%).

With regard to these situations, there is a constructive plan of restoration of the representative's values. It is a great concern to the Curator's office of the city (OCC), set the goals to intervene in this issue. But before of the implementation, previous studies and considerations of the behavior of each one will be doing. Using the attributes such as uniqueness and importance and taking in consideration its typology, within the historical centre of Santiago city as base of the process, every structure or building will receive a value to be recue. For that process is necessary know a lot of details about the structure that belong to the city. A complete investigation work is necessary to do as a result of the damages produced by the effects of the interaction capillarity-deterioration, in edifications of the lower zone of the historical centre of Santiago of Cuba, and due the negative consequences that coming together with this phenomenon that affects the environmental conditions of the zone and the society.

Environmental Problems Caused by the Presence of Humidity

The Historic Center is limited to the north along the Paseo Martí, on the south by the Trail (now Avenida 24 de Febrero), on the east by Central Road (now Avenida de Los Libertadores) and west along the Paseo de La Alameda (now Avenida Jesus Menendez), which coincides with its lower part which is bounded in turn, on the east by the Gallo street (10 de Octubre) and Barracones street (now Carlos Dubois) (See Figure 1).

This area has a historic record of approximately five centuries, shows a characteristic imagine of nature urban's architecture, conditioned by a necessary adaptation to a singular topographic imagine related with its climatic and seismic conditions, witch in turn, determine that the edifications will be constructed in the national territory generis.

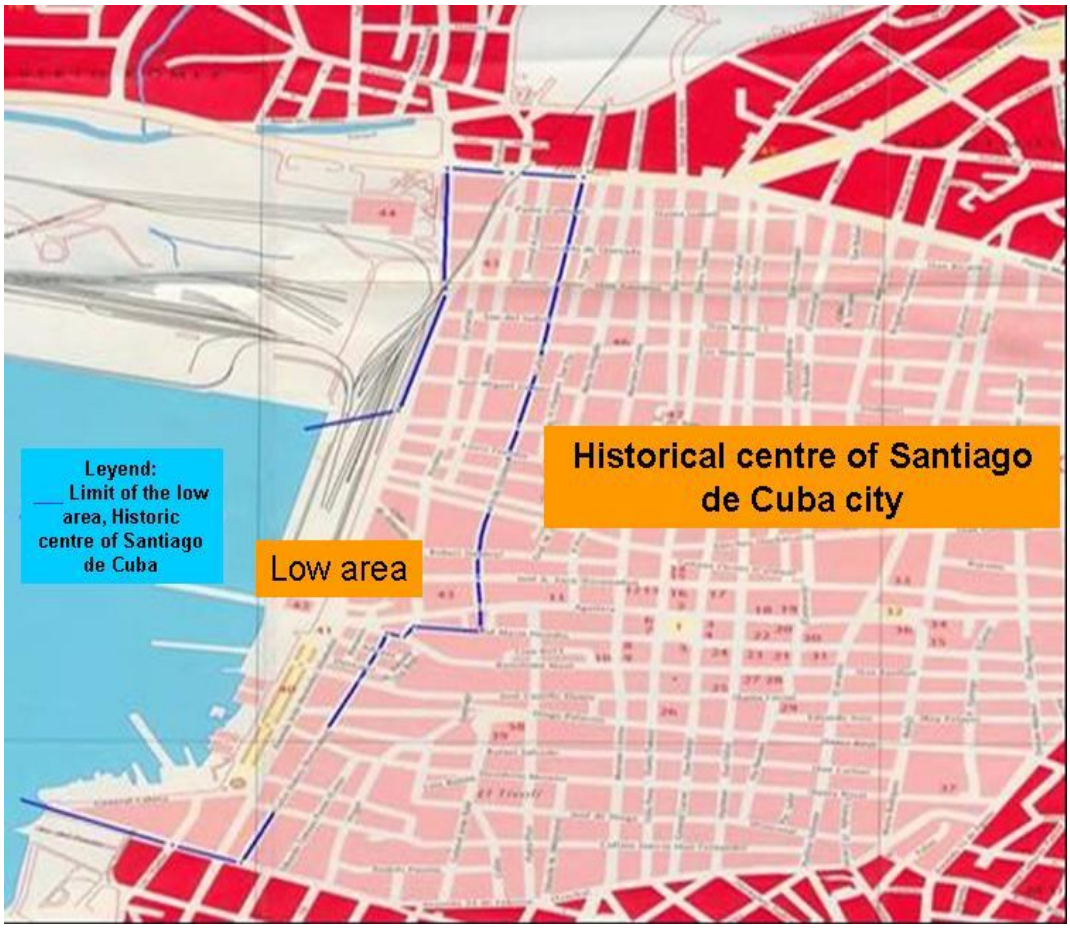

Figure 1: Delimitation of the Lower Area of the Historic Center of Santiago de Cuba (Blue Boundaries)

As result of this situation, several studies where been done to classify the injuries, but there is a lack of awareness of the interrelationship of the environment with the whole building where a key player is water. Given the situation it is clear that there are problems of an economic, social, environmental, socio-cultural and education.

The inventory to study the characterization of the state of the buildings affected by the injury in a first stage of the research, included the entire front line of Gallo and Barracones streets and Avenida Jesus Menendez (east and west boundaries) with Batch 211 which represents 21% of the lots in the area, of these, 64.90% are affected by capillarity humidity, as shown in Table 1.

Table 1: Batch Moisture Values in Each Range Studied (According to Gonzalez ET All. 2009)

Street segments	Parcel numbers	With humidity	Without humidity	% of parcels with capillarrity humidity
Avenida Jesús Menéndez	62	27	35	56,45
Gallo y Barracones	149	47	102	68,46
TOTAL	**211**	**74**	**137**	**64,90**

The height of capillarity humidity in the facades of the buildings of the Jesus Menendez Avenue and streets Gallo and Barracones, where it was observed that the buildings are affected by this injury.

In Jesus Menendez Avenue are 62 lots in the resulting graph shows the 35 lots that appeared rising damp, representing 65,45% of the total in this avenue and from them the highest percentage of moisture are related to capillary height of 2 to 3 meters. In Gallo and Barracones streets are 149 lots in the graph are tabulated the 102 lots that appeared rising damp, representing 68,45% of all buildings and of these the highest percentage of moisture is associated with height capillary of 1 to 2 meters. (See Figure 2). In this area the water table values ranging from one to four meters high values compared with normal measured in the city.

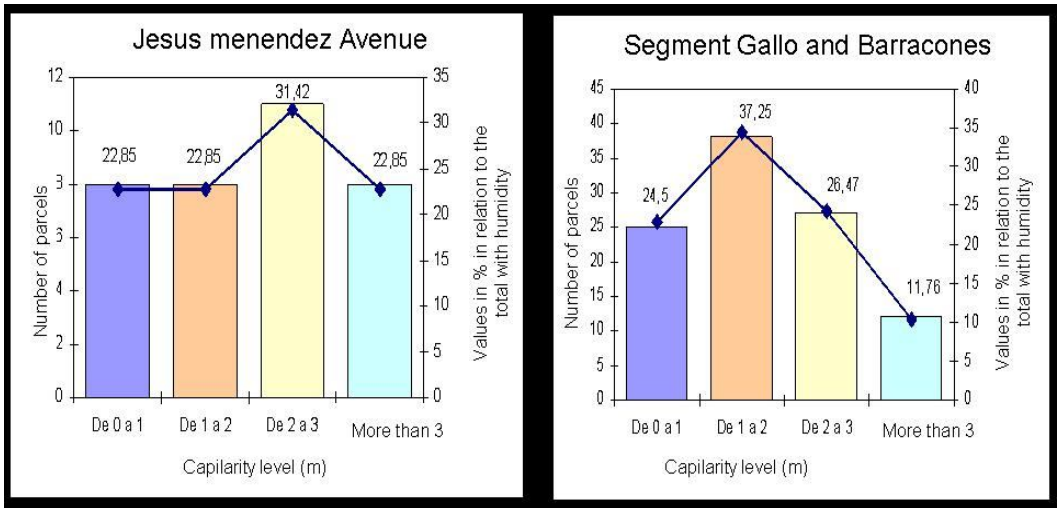

Figure 2: Results of Capillary Height Measurements in the Studied Sections in the Lower Part of the Historic center of Santiago de Cuba

As you can see the deterioration of buildings is critical and the appearance of the lesion is common in batches with high capillary heights. Figure 3 shows images of the state of the buildings in this area by capillarity humidity attack.

Figura 3: Attack of the Capillarity Humidity in Buildings of the Study Area. A, C y D: Inside Houses Locations; B, E, F, G y H: Facades

Each year, this phenomenon is causing a great amount of economic looses. The situation is worsening because the edification's rehabilitations works in charge by the curator's office of the city, have been doing in more than two occasions in the same group of buildings, resulting in excessive appends of materials and human's hours labor works, etc.

In short, addition to the adverse impact to the citizens, there is a huge economic consequences produced by this phenomenon.

As well, the nation is having great economic losses due to the increase cost of the human resources, time and prime materials using in the restoration phase of these edifications. Furthermore, in many cases, the authorities do not know the real causes that create the capillary humidity, and this uncertainty takes them to apply inadequate treatment that lack to control the deteriorations problems. Short time later, the symptoms appear again, and the authorities need to spend another amount of money and resources in the restoration activity.

Such is the case in the study area, that in order to avoid the high economic cost of necessary repairs or simply through ignorance, in homes affected by the humidity, we have tried to cover them with new plaster or with various coatings.

These are "makeup", which only serve to temporarily hide. The moisture and fungi present state will continue and is likely to produce new exposures in the wall at a level above. This results in an attempt to waterproof the walls and the surface. In the best case is achieved by temporarily hiding moisture, but the real result is none other than the 'chimney effect' that raises even more moisture through the wall. This does not solve the problem but worsens and becomes more expensive the solution for the need to re-address the situation.

From an environmental perspective, these are different causes that produce the deterioration of these edifications. The main cause occur due lack of environmental and technical know ledges at the time the buildings are done. The technicians or contractors do not take in consideration the climate and soil variables for the construction purposes. The zone has a high phreatic (water table) level close to the surface and the soil is, generally, compound of clay and sediments poor compacted (silt slightly compacted). This type of soil retains a high amount of humidity plus a high relative humidity of the environment exacerbates the humidity conditions of the area. Also not made a suitable selection of the type which would be compatible and allow to minimize these environmental features. Since the construction in this area mostly from the colonial era, in which building materials were mostly of adobe, a compound of clay, highly absorbent of water and retaining of humidity, which ultimately is a material ideal for capillary phenomena (especially in the foundations and lower parts of the interior and exterior walls). These issues discussed increasing deterioration of the buildings in the area.

Based on the morphology and topography, the bottom, falls on the first terrace of the historic center of Santiago de Cuba, an area that was reclaimed from the sea, which was consolidated an area of warehouses, workshops and small industries related primarily to port. Jesus Menendez Avenue as the main artery of the area, has a length of 1 651m and forms the western boundary of the Historic Center, in the north-south, the topography reaches a certain regularity due to the small slope, however the streets running in an east-west as natural drainage, ending in a sewer system located in that avenue, this sewer system is not working properly, there are blockages in the drains caused by insufficient capacity for the disposal of liquid due to the age of design and construction, and also by factors related to the accumulation of solid waste within, the obstruction by later constructions and poor maintenance and cleaning.

These issues are exacerbated in the period of heavy rain, causing flooding in the area, raising the water table which in itself in this area are high, creating a conflict in the interaction of water resources with the buildings and infrastructure built in the area.

In addition to these variables is added an important anthropic factor, related to the poor technical condition and insufficient construction of sewerage and drainage system in the area, exacerbated by frequent earthquakes in Santiago de Cuba. Also, influences by paved surfaces in almost the entire area, causing moisture retained in the impervious surface and preventing the evaporation of water.

Technically, the trend of the specialists is to address the problem by treated it according to their area of expertise. Architects and civil limited to the study of pathology, focusing its efforts in treating the injury with water repellents directly on the building, regardless of the behavior of water and its interaction with the soil, climate and structure (variables influential in the study area).

Clearly, these isolated responses tend to solve the problem for a given period of time, but they may occur again. The disease of the buildings appear again due to the corrective actions was against the symptom and not over the real causes of the problems. We most know that the building does not be considered as an isolated entity; due it is in constant interaction with several factors present in the surround environment in time and space.

The case study shows the real interest the city must has in terms to do the study about the behavior of the different variables whose interaction modulate the relationship capillarity-deterioration of the buildings that belong to the low zone of the historical centre. The study will give knowledge elements that permit us best understand the phenomenon of capillary moisture. By this way, we can develop several answers and solutions that guarantee (warrantee) mitigate the deterioration of the buildings and the negatives consequences that are part of the environmental conditions of the zone and the society. From the point of view related to the health, moisture causes negative impact on the health of the citizen. If you are living in the environment with cold conditions, unpleasant, with fungus, and others disease's causing organism and elements, you are in the risk environment that increase the possibility to suffer health problems and as result of this situation, a chain reaction occur and worsen environment can be produce.

To give an idea, the wood floors darken as a result of the wood decomposition. The decomposition material cumulated bacteria and fungus that at the final of this process, do contact with the residents of the buildings. In the smooth concrete floor, there are spots together with white edges (salts). This salts elements, in addition to create a dark appearance, produce and dark and lugubrious environment with low rate of liquids evaporation as a natural process. That result is an increase of the relative humidity in the interior of the building and health problems of the residents when they do contacts with these salts, specially, during cleaning activity.

In the basement manifestations resemble those walls, but usually is more intense under cold and the strong smell conditions due to the poor aeration.

The continued presence of capillary humidity, causing further decay in furniture and other wooden items near the wetland, affecting not only health but also the economic welfare the residents living there and their animate state and your mood, which in contradiction between social behavior and quality of life.

In general, this situation leads to health problems associated with a set of typical respiratory diseases among the inhabitants of this area. We know the risks of allergies and the existence of a large number of people with asthma due to these causes.

From a cognitive standpoint, the wrong and inadequate behavior and management of the resident persist, related to the treatment of the buildings injuries caused by the humidity-capillarity phenomenon. Instead to solve the problem, they worsened the situation using inappropriate reparations techniques that in place to decrease the deterioration condition increase the manifestation of the capillarity. For example, there is a famous technique frequent using by the residents that consist in a "flagstone veneer", (see Figure 4).

Figure 4: Flagstone Veneer Buildings in the Historic Center Santiago. Note the Capillary Phenomenon over the Slabs

The construction materials frequently used of these buildings are naturally absorbent and porous, as in the case of masonry, ie (solid brick, hollow brick, natural stone, etc.). Enluciados plaster or cement, which may have impaired due to water absorption, which leads to the formation of salts, mosses and efflorescence. These events in turn cause dimensional changes in the components, causing cracks and fissures parallel vertical and located in areas with easy wetting and drying continues (starts foundation with damp hair and coronations bit protected facades). On the walls there are stains, includes painting and finally begin to discard the plaster or coatings (see Figure 5).

Figure 5: Deterioration in Facades and Walls of Buildings in the Historic Center Santiago

The main contradiction in this section is the construction technique and materials used, and other materials that could be applied more resistant to water or other construction techniques according to the situation.

On the other hand it is valid to point out the ignorance and / or violations on the part of the area's population of legal rules and regulations established by state agencies related to the investment processes of construction and land restoration programs of this area controlled by the Office of the Curator of the City as it continues building failing to observe these issues and making changes inadequate structural design of some buildings.

From a socio-cultural perspective, the deterioration of buildings in the area analyzed and therefore the visual degradation of the landscape has consequences in tourism development.

Tourism in the city of Santiago de Cuba is classified as a tourist city, where buildings in the historic center, play a key role for its historical and cultural value inherited from the colonial architectural heritage is in contradiction to observe the state is depressing, because instead of promoting interest, disgust and discomfort due to the deteriorating situation in the landscape, reducing tourist arrivals to the city and therefore also affects monetary losses.

From a politically and administratively, it is confirm, the buildings of the area are in a deplorable conditions. By this, is very important take this issues in agenda with the planners and decision making office of the city. A soon intervention would improve the environmental conditions of the area and therefore the welfare of its inhabitants.

Actually, the area is under a constructive plan for restoration of their representative values. It is a great concern to the curator's office of the city (OCC), traced the goal of intervening in a range of space and endless, but with previous behavioral studies and considerations of each building, its uniqueness and importance into the historical centre of Santiago of Cuba. Rescue each structure have been valorized according to their type and historical importance and, according to economic and technical feasibility of Santiago provincial government, for that is necessary to do so knowing all the technical scientific information available, and see the problem as a whole within branch that forms the city.

These actions are affected by administrative problems, and that these small investments that are running, according to the administrative budget allocated does not solve the problem definitively, because the investment is not enough to apply the appropriate treatment solutions to this injury, and adopted solutions in the short time that they do is mask the symptoms without eliminating the problem, causing at some time need to make another investment to manifest the symptoms again.

This raises the important awareness and ensure that decision makers internalize and technically know what actions to take to solve these problems and show their support in adopting suitable to these solutions, in order to save the economy and improve the quality of life of the inhabitants of these buildings.

These socio-cultural, cognitive and political-administrative indicate that there are educational problems, or to be instructed through courses, lectures, and other methods to the population of this area, technicians and administrative managers face the task of restoring these buildings, so they are better prepared to tackle the problem.

Given these social contradictions that generate negative consequences on the environment, economy, society, health, etc.., Is demonstrated the need to study the relation-capillary damage to buildings, to know the elements that will take the necessary in planning appropriate treatment and restoration of the infrastructure built in this area, to thereby mitigate this relationship and improve the quality of life for its inhabitants. Which is the main objective of this research.

Benefits

One of the fundamental objectives of all research is to contribute to social and environmental development in pursuit of meeting the growing needs and problems of society. So the most important contributions, is framed to ensure increased quality of life of citizens, as its main task of our socialist revolution. The study of the relationship-impaired capillary buildings following benefits are obtained after the development of society.

Social Benefit

From this point of view will get benefits aimed at improving the quality of life for residents and tourists in the area, such as:

• It will provide the necessary elements in understanding the phenomenon, so the restorers use appropriate methods in the treatment of injury and improve the living conditions of residents and environmental conditions in the area.

• It will contribute to the mood and the stability of the health of people with the restoration of buildings, as well as its economic investment in the purchase of paintings and domestic property, with the absence of moisture.

Environmental Benefit: Provide for a comprehensive notion of how to analyze the problem and investigate aspects needed to achieve results that support the elements necessary for understanding the phenomenon, creating a database and a digital model which reflects the stage risk, through which decision makers can meet the operational and able to adopt policies to implement and how to implement actions to resolve or minimize damage in built resources, landscape and human balancing if necessary, impacts that have resulted from uncontrolled modifications of man on the environment.

Economic benefits: savings will be achieved in the recruitment of technical personnel and materials in the restoration of buildings, knowing the proper treatment.

• It contributes to the increased inflow of tourism personnel in this area to restore conditions and historical-cultural landscape.
• It contributes to better preservation of the storage facilities are located port and affected by the phenomenon, and other economic infrastructure in the area.

Benefits of knowledge:

• A proposed methodology to obtain knowledge and understanding of process-capillary damage in buildings, from the study and analysis of relevant variables that modulate this relationship, delving into the phenomenon of rising damp as aggravating the condition.
• A model obtained from a geographic information system (GIS), which determine risk scenarios through the model output resulting from the capillary susceptibility, which allows the staff of the Office of the Curator of the City to know the areas most susceptible to deterioration from this phenomenon.

Political benefits: The decision makers, technical and administrative staff involved in these constructive efforts, as well as political and mass organizations will have the elements necessary to adopt policies and administrative measures in decision making, to thereby meet the concerns of local residents and the city.

Conclusions

1. The deterioration of the buildings with the presence of rising damp can be caused by the high water table associated with the building type, soil type, combined with high relative humidity and paving, maintain high soil moisture, it makes clear that the combination of these variables modulate capillarity - deteriorate relationship.
2. The capillarity - deteriorate relationship impairment causes an ecological imbalance in the study area, and causing serious consequences that affect social development, primarily in the quality of life for residents and tourists who enjoy the colonial cityscape of these buildings.
3. From the economic point of view, excessive moisture in buildings in the study area, causing deterioration and therefore the continuous investment of resources for their restoration.
4. They manifest cognitive and sociocultural issues associated with the implementation and management of work and injuries, without sufficient technical knowledge of the problem.
5. There are educational problems, so it is necessary to educate those involved in the process, to be better prepared to deal with the situation.
6. The study of the capillarity - deteriorate relationship are obtained social benefits, environmental, technical, economic and political development that favor environmental status of the lower area of the historic center of the city of Santiago de Cuba.

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