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STRUCTURAL TYPOLOGY OF THE HISTORIC CENTER OF THE CITY OF SINCELEJO

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Abstract

The new achievements that have been reached in the field of structural design can be applied only to new constructions; but the existing structures are the representation, in a greater percentage, of the structural characteristics of the cities. This study seeks to know the Structural Typology of the downtown area of the City of Sincelejo, which represents an optimization mechanism for Seismic Risk studies.. As the main tool, the Geographic Information System (GIS) technology was used, since it facilitates the implementation of the methods to be used, the management of information, and above all, the visualization of the results. The data obtained in the statistical analysis are shown in tables and figures, where the different typological characteristics of the buildings in the area appear.

Keywords: structural typology, buildings, structural characteristics, historic center, GIS

1. INTRODUCTION

The dynamic behavior of buildings depends on the intrinsic characteristics of the structures themselves, since they present a different behavior when faced with the stresses to which they are subjected, according to the type of structure (Smith, 2010).

From experience, it is important to know, in an urban environment, the properties of its components, in order to determine vulnerability and carry out preventive actions in disaster management . In the present study, a characterization of the structures of the historic center of the city of Sincelejo was carried out, representing the results through the technology of the Geographic Information System GIS, which allows its rapid and efficient interpretation.

2. DATABASE

To create the database on the structural typology of the area, the survey technique was used, in which information was obtained related to the age of the buildings, the type of material used during construction, the types of finishes, the resistant structural system, the type of roof, among other aspects.

In total, 1435 buildings were analyzed in the entire study area, finding different types of structures, as indicated in the graphs below. The study area goes from the corner of 7 de Agosto at the intersection of Carrera 25 with Calle 19, to the corner of the Hotel ¨Panorama. Then it goes down Cauca Street, to the old Sucre General Clinic on Nariño Street and continues through the Mochila neighborhood, to the basketball court in the same neighborhood, and through Carrera 14 it reaches Calle 21. Calle goes up 21 that becomes Carrera 14 and reaches the intersection with San Carlos avenue. From here you get to the Cruz de Mayo, and by Calle de las Flores you get to the back of the Gran Centro el Parque. From this shopping center you come back to the corner of 7 de Agosto. Related studies in Caballero 2007 and Caballero Guerrero et al., 2020.

3. STRUCTURAL TYPOLOGY

Each one of the points of the survey is analyzed with graphs and Tables in Excel, with the information obtained from ArMap, where the information corresponding to the structures has been tabulated. This survey was carried out to all the structures. The information obtained is expressed below:

Height. Knowing the height of the buildings is very useful for Vulnerability studies, since it goes hand in hand with the distribution of the seismic force. Figure 1 shows the representation of the different heights, classified into three ranges. Heights are represented in meters.

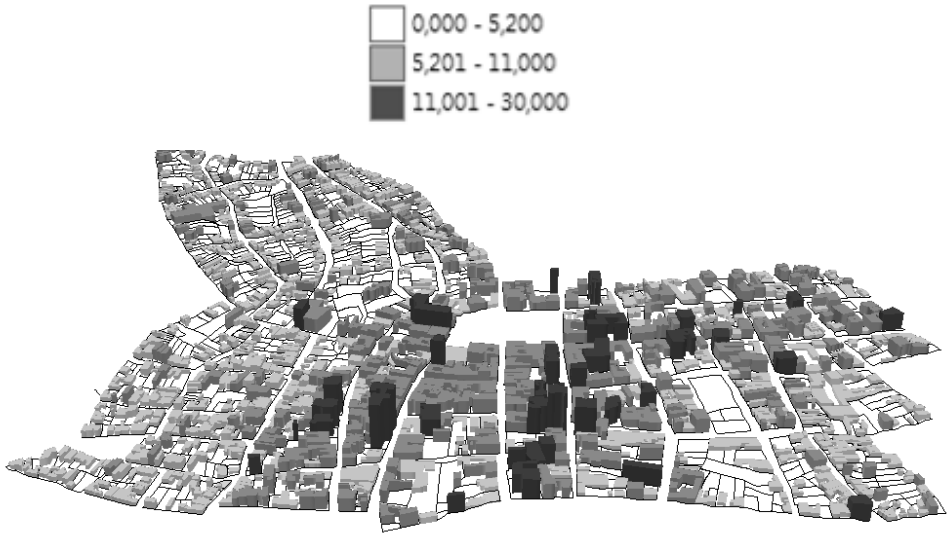

Figure 1. Distribution of the heights of the buildings

State of the structure. The state of the structure refers to the current conditions of the building. This point is subjective, that is, it is the pollster's criteria. From the ArMap database the result is the following:

Table 1. State of the Structure

Structure State	Quantity	Percentage
Good	1043	74.87%
Bad	303	21.75%
Regular	47	3.37%
Total	**1393**	**100%**

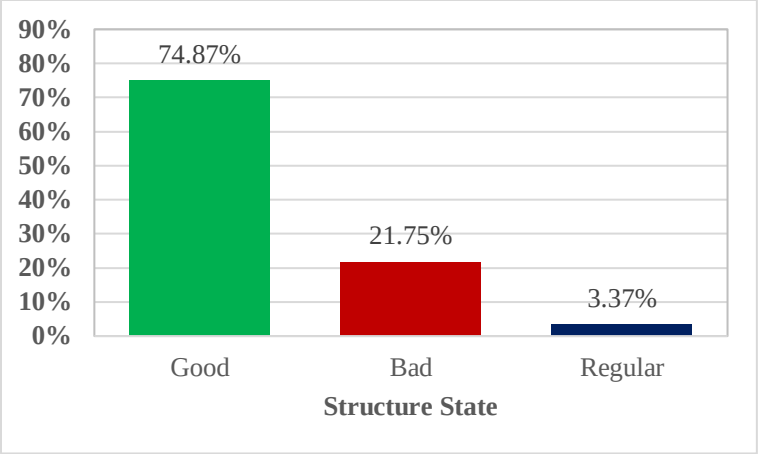

Figure 2. State of the structure

As can be seen, 75% of the structures are considered to be in good condition, compared to 22% that are considered to be in poor condition. Figure 3 shows the result of this parameter in ArScene.

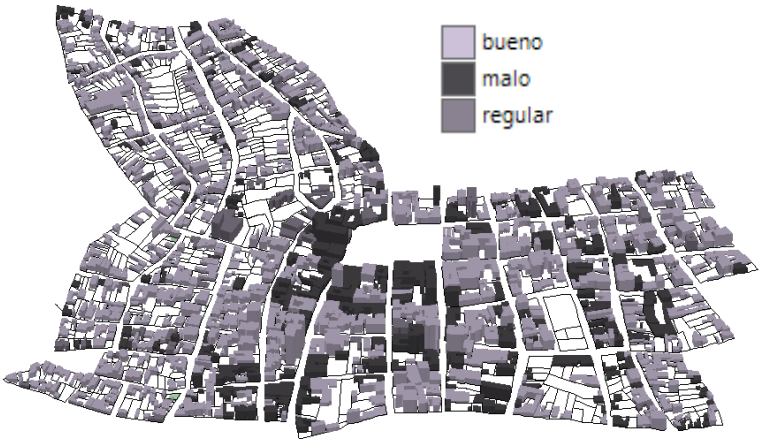

Figure 3. State of conservation of the structures. ArScene

Roof type. The type of cover is a parameter widely used in seismic vulnerability studies in the world, since it plays an important part in structural behavior. Also, as in the case of eternit roofs (asbestos cement sheet), due to their behavior as non-structural elements, since their placement depends on how much damage they cause.

In Figure 4 and Table 2, the statistics shown for this case are indicated, in which it is observed that the roof in eternit, is the one with the highest percentage, compared to the other types of roofs.

Table 2. Type of roof

Roof type	Quantity	Percentage
Eternit	934	66.10%
Concrete	327	23.14%
Palm	37	2.62%
Zinc	12	0.85%
Other	103	7.29%
Total	**1413**	**100%**

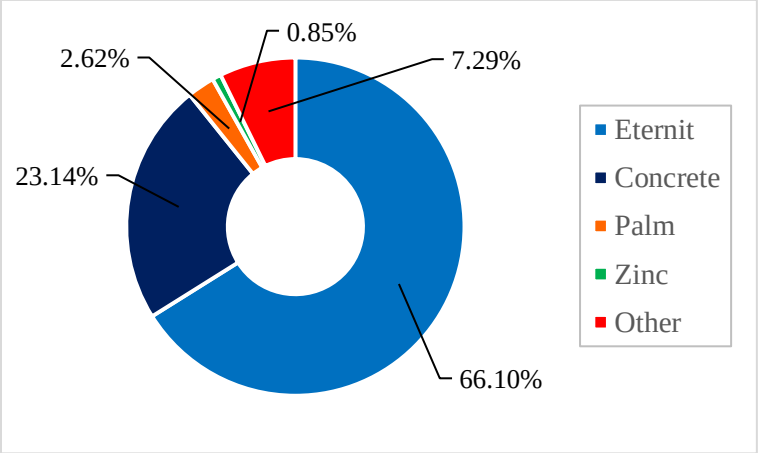

Figure 4. Type of roof

In Figure 5 shown below, it can be seen that the highest percentage of concrete roofs are found in the part of the banking area and the old market, which represents the largest number of buildings in the city.

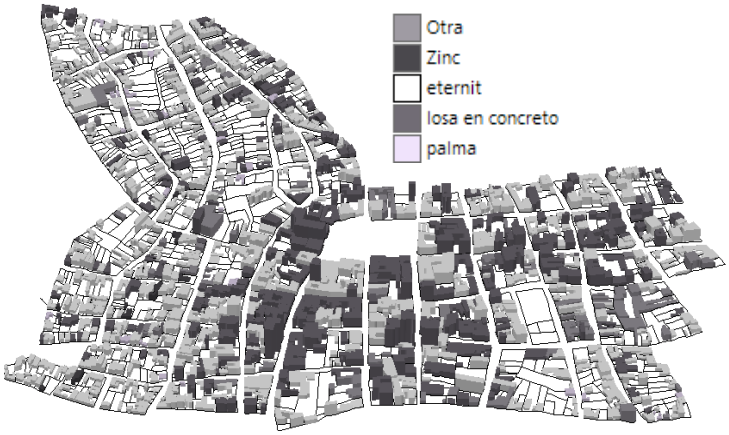

Figure 5. Type of cover. ArScene

Structure Type. The type of structure is one of the most important parameters to apply the Vulnerability Index method, since, as previously mentioned, this method can only be applied to Non-structural masonry structures and Reinforced Concrete structures. As can be seen in Table 3 and Figure 6, the two types of structures with the highest percentage in the study area are Non-structural Masonry and Reinforced Concrete, representing between them almost 97% of the total structures.

Table 3. Type of structure

Structure Type	Quantity	Percentage
Unreinforced Masonry	710	50.97%
Concrete	635	45.59%
Bahareque	9	0.65%
Other	39	2.81%
Total	**1393**	**100%**

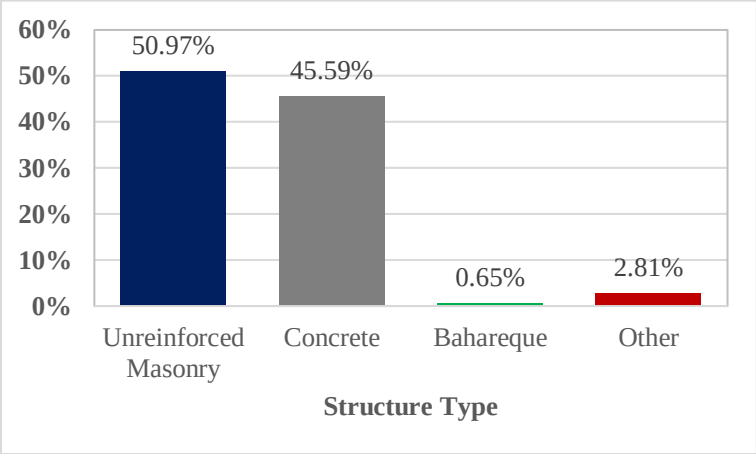

Figure 6. Type of structure

In addition, it is clearly observed, the scarcity of metallic structures and structural masonry, being the structures in bahareque (Palm House), in the XXI century, above these two types of structures.

Use of the structure. One of the characteristics that were taken into account in this study was the type of use of the structure, in order to know the activities that are carried out in them, and obtain the loads to which they are subjected. In Table 4 and Figure 7, this parameter is detailed. As can be seen, 97% of the structures are for commercial, residential or mixed use. Then, a considerable number of buildings such as hospitals, clinics, educational centers, banks and state entities follow, showing the importance of the area in terms of managing the city and the region.

Table 4. Use of the structure

Type of Use	Quantity	Percentage
Residential	633	48.25%
Commercial	541	41.23%
Mixed	91	6.94%
Other	47	3.59%
Total	**1312**	**100%**

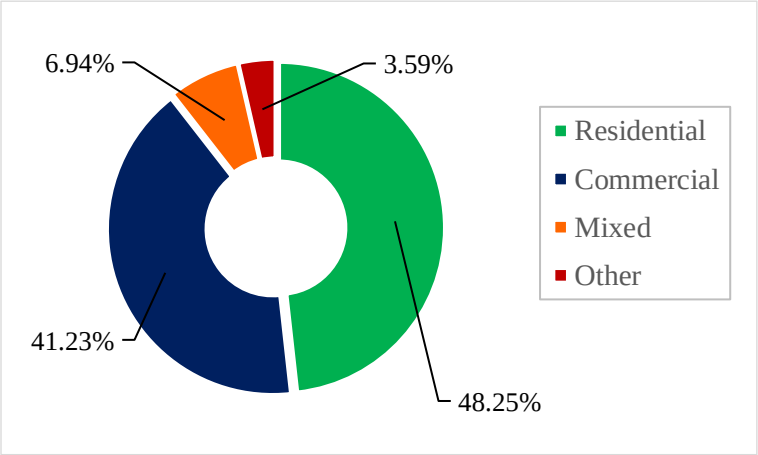

Figure 7. Use of the structure

Plant configuration. With the plans obtained in the Agustín Codazzi, in the City of Sincelejo, each one of the lots and built areas can be clearly observed, as well as their configuration in plan, which is another of the parameters that are taken into account in the determination of the seismic vulnerability of the structures. As can be seen in Table 5 and Figure 8, almost half of the structures studied have a good configuration, and the other half either have a regular or poor plan configuration.

Table 5. Plant configuration

Plant Configuration	Quantity	Percentage
Good	702	52.54%
Bad	461	34.51%
Regular	173	12.95%
Total	**1336**	**100%**

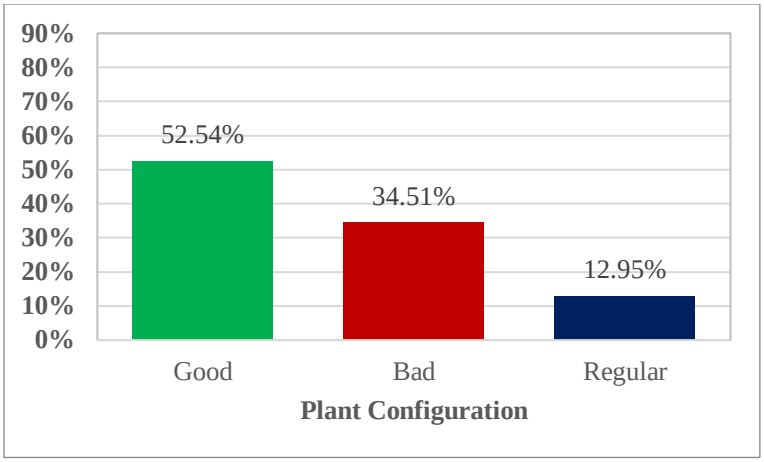

Figure 8. Configuration in plan

Wall type. The type of wall is, like the type of structure, one of the important parameters in seismic vulnerability studies, and especially the Vulnerability Index Method. In Table 6 and Figure 9, it can be seen that 94.4% of the walls are made of cement block, this being a somewhat unfavorable point with respect to the weight of the structures, since it is heavier than the other types of walls. , and, when an earthquake occurs, they are very dangerous, since when one of these falls, they cause great damage, and the largest number of deaths that occur as a consequence of these natural phenomena are due to the fall of these non-structural elements. Something in favor is the rigidity that these walls add to the structure, and that was not taken into account at the time of the structural analysis; but this can be somewhat unfavorable to the structure, if there is an increase in eccentricity, by moving the center of mass away from the center of rigidity.

Table 6. Type of Wall

Wall Type	**Quantity**	**Percentage**
Concrete block	1314	94.40%
Brick	38	2.73%
Bahareque	26	1.87%
Other	14	1.01%
Total	**1392**	**100%**

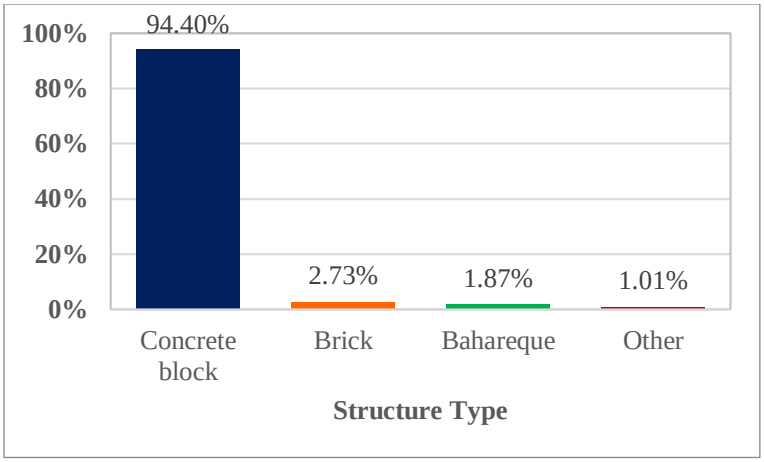

Figure 9. Type of wall

Presence of slab or Horizontal slab. The horizontal slab or slab is something that greatly influences the behavior of the structure under seismic loads. It all depends on how the slab is working together with the structural system and how it is linked to it. This can cause a considerable increase or decrease in vulnerability.

Initially, in Table 7 and Figure 10, the results of the presence or absence of slabs in the structure are shown, being able to observe that in most one-story structures there are no slabs, the roof being made up of a material other than concrete, as is the case of roofs made of sheets of asbestos-cement. Then, Table 8 and Figures 11 and 12 show the distribution of the different types of slabs, for the structures that have them, whether they are mezzanines or as roofs. It is observed that the largest number of existing slabs are solid, which can be explained by the fact that a large proportion of the buildings are more than 50 years old, this being the type of slab commonly used.

Table 7. Presence of slab

Slab Presence	**Quantity**	**Percentage**
Yes	663	47.70%
No	727	52.30%
Total	**1390**	**100%**

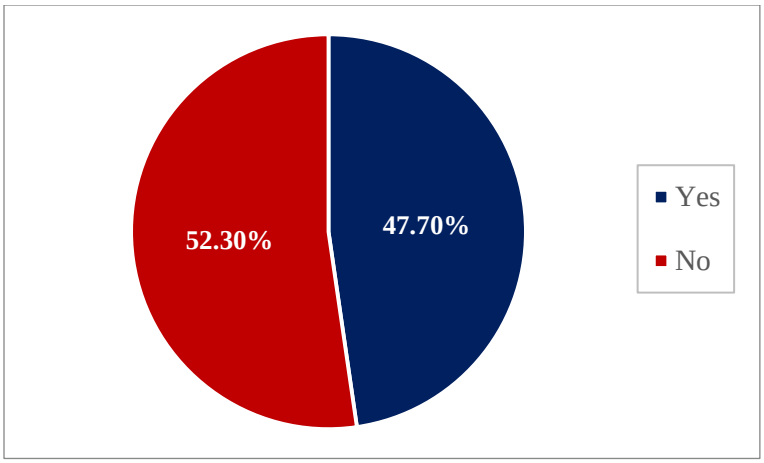

Figure 10. Presence of slab

Slab type. Next, the types of slabs found in the studied dwellings are presented, as can be seen the predominant types of slabs are lightened slabs and solid slabs. In addition, it is noteworthy that of the total number of buildings, only 663 had slabs.

Table 8. Type of slab

Slab Type	Quantity	Percentage
Lightened	258	38.91%
Solid	401	60.48%
Wood	4	0.60%
Total	**663**	**100%**

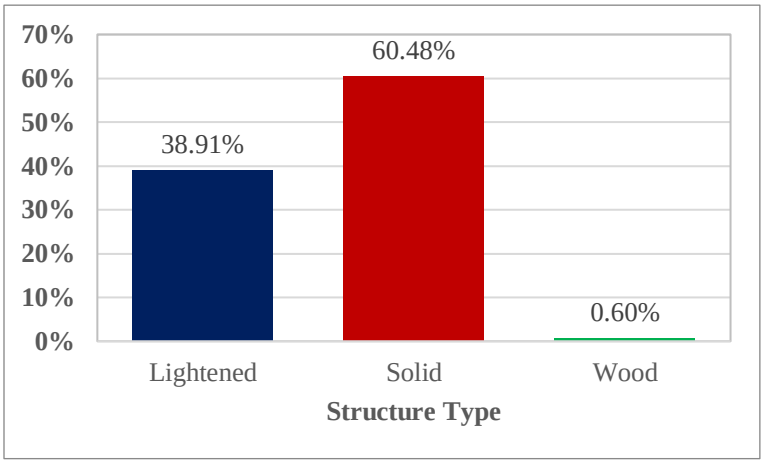

Figure 11. Type of slab

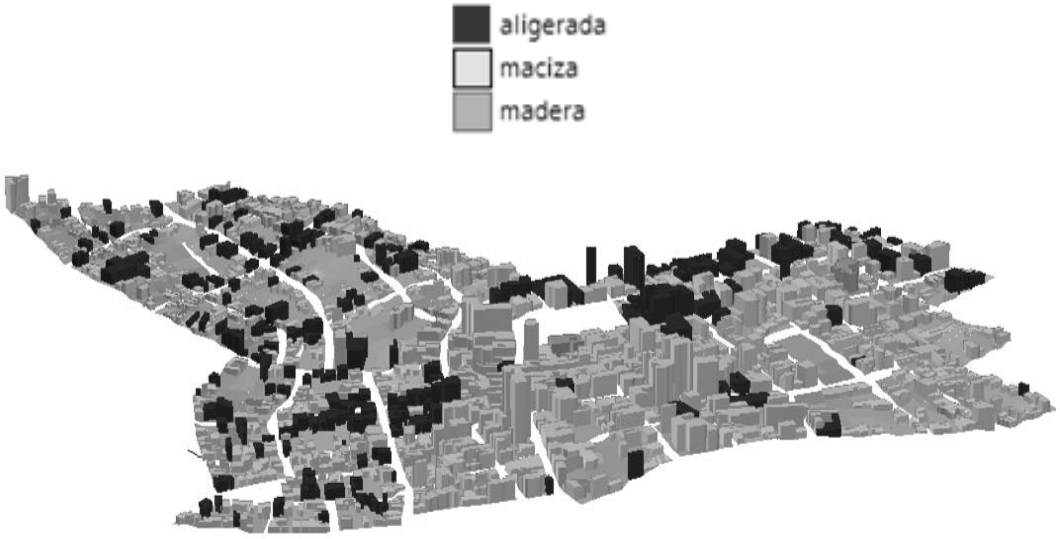

Figure 12. Type of slab. ArScene

Floor Type. The floor, like the type of roof, is a characteristic of the structure, which is taken into account in studies of structural characterization or structure typology. It is not really taken into account in the determination of seismic vulnerability, but when finding the economic damage indices, they are very important, since their repair costs, in the event of an earthquake, are very high, causing the damage rate to increase. The different types of floors that occur in the studied structures are shown in Table 9 and Figure 13:

Table 9. Type of floor

Floor Type	**Quantity**	**Percentage**
Ceramic	1024	76.02%
Tile	219	16.26%
No Floor	14	1.04%
Other	90	6.69%
Total	**1347**	**100%**

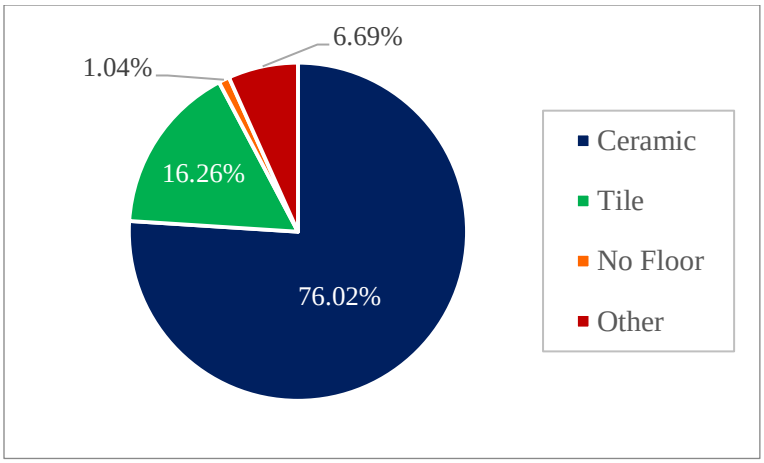

Figure 13. Type of floor

Facade type. The facades of the area under study are mainly composed of vinyl, granite and veneer, although there is a considerable representation of other types of structures such as bahareque.

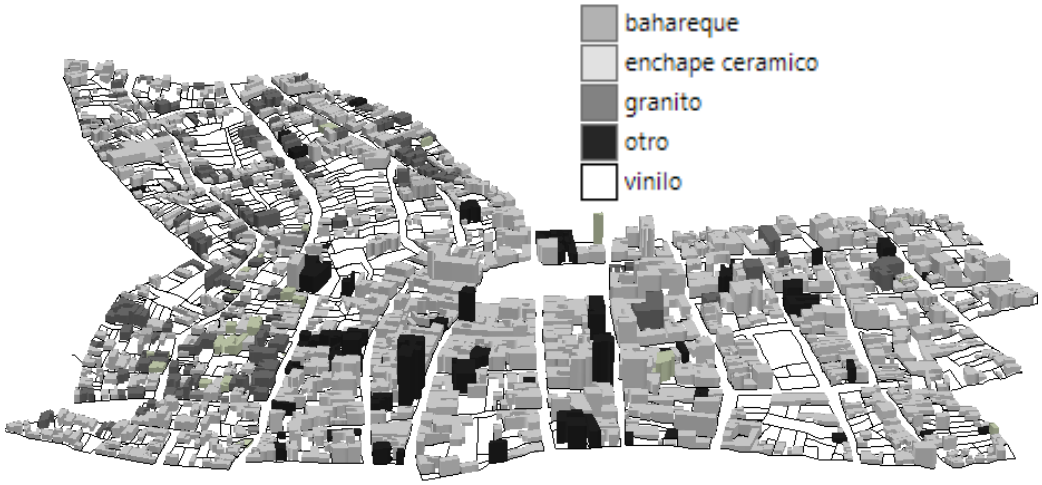

Figure 14. Types of facade

4. CONCLUSIONS AND RECOMMENDATIONS

The buildings in the historic center of the city of Sincelejo are, for the most part (97%), structures of Reinforced Concrete (46%) and Non-Structural Masonry (51%). According to this, it can be affirmed that it is possible to use the Vulnerability Index Method to determine the Seismic Vulnerability of the area, since it is applied only for this typology. In the remaining percentage of the types of structures, those of Bahareque, predominate over those of steel and Reinforced Masonry, which reflects an incipient use of new construction processes.

The results obtained in each of the parameters used in this study, to determine the structural typology, suggests that in the buildings of the downtown area of the City of Sincelejo, no new materials have been introduced, as in the case of the cement blocks in the wall systems, ceramics in the floors, or asbestos-cement sheets, in the case of roofs.

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