III.26
Repair Mortars for the National Congress Building, Argentina

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Abstract The architecture of the Honourable National Congress had its origin in a project contest that took place in 1885. Argentines and foreigner architects participated in this contest. Some of them were foreigners living permanently in Argentina. The building was designed by an Italian architect Victor Meano. Meano’s project refers entirely to the architectural vision that recognizes as fundamental principles three central ideas: academicism, eclecticism and classicism. This tripartite condition confirms it as a paradigmatic architectural work of the time of its creation: the ending of the 19th Century and the first decades of the 20th Century in Argentina. This building has stone blocks walls up to a certain height, and then there is a masonry wall with an external stone coat, a granite socle in the lower section and limestone in the upper sections. This job is limited to the base sector in the Dome Building.

1 Introduction

This report represents a preliminary approximation to the restoration topics of the Honourable National Congress, a building of patrimonial value. The restoration works will have to be supported by technical assistance during the whole process. Fig. 1 shows the Main Façade of the National Congress.
2 Survey of existing information about the construction site

The construction company Paul Besana y Cía. began the construction works in 1898 under the direction of architect Meano. On July 1st, 1904, Victor Meano was murdered, so the building was finished under the direction of the Belgian architect Julio Dormal, who respected the original design.

This building of the palace of the congress was declared Historical and Artistic National Monument in 1993. The building possesses a socle of 6 meters in height composed by granite from Uruguay. The rest of the components are about 75,000 limestone tooled stones from the province of Cordoba (centre of Argentina). Fig. 2 shows the facades of the National Congress without the stone cladding.
3 Research topics

3.1 Climatic and exposure conditions

The climatic conditions can give an idea of the external factors that affect the building under study.

In Buenos Aires city, the average temperature is about 17.6°C and the annual rainfall is 1147.0 mm. This building is located in the center of the city where there are over 760000 cars plus another 740 000 vehicles that enter every day from the suburban areas. Also 9600 buses (belonging to 134 different lines) and 44 000 taxis are moving around. All these vehicles send pollutant gases towards the atmosphere that are in permanent contact with the surrounding exteriors of the building.

3.2 Fragments of pathologies in exterior facades

During the survey of pathologies, images of the different problems were taken. The following pictures show them (Figs. 3 to 10)
3.3 Interior survey and sectors of interest

There is a large drainage on the main cornice marked in Fig. 11 that was inspected due to a high number of fissures in the stone claddings. Internally this
drainage shows equidistant points with metallic elements, which were previously partially removed. Remaining parts of these metallic elements (see Fig. 12) are affected by corrosion which causes deterioration of the stone by increasing the volume of the metals.

![Fig. 11 Big drainage on cornice](image1.png) ![Fig. 12 Equidistant metallic elements](image2.png)

### 3.4 Infrared thermography

We used infrared thermography to detect points of water accumulation in the base of the dome which was inaccessible.

![Fig. 13 Thermographic image shows the accumulated water](image3.png)

The thermographic image on Fig. 13 shows a small area of water accumulation. The most probable cause for it could be the obstruction of drainage in the exterior, or the incorrect slope of drainage. The definitive diagnosis needs an exterior survey to evaluate this sector.
3.5 Mapping of pathologies

An image of each façade was drawn, summarizing the pathologies found in the survey. Fig. 14 shows the west façade.

![West façade with graphical expression of the found pathologies.](image)

Fig. 14 West façade with graphical expression of the found pathologies.

![The references show the partial percentage of surface affected with pathologies.](image)

Fig. 15 The references show the partial percentage of surface affected with pathologies.

4 Characterization of stone

The building of the dome is totally stone cladded. We note a granitic socle that surrounds the whole tower and from there towards the top sectors, the rest of the coatings, ornaments, cornices and columns are made of limestone.
The characteristic damages on the limestone, which has been affected by so many years of exposure (climate and pollution), are external superficial alterations as granulation, exfoliation and detachments. Fissures along the structure of the rock that in some cases generate important detachments are also observed. Environmental dirt and dust alter the façade by showing darkness in the surfaces to the point of forming black crusts in the protected areas, where also small plants grow.

Fissures in stone cladding are of two types. Small slabs present vertical central fissures due to constructive problems (Fig. 16). On the other hand, big slabs, located in the upper rectangles and ornamentation, show fissures that follow the original rock structure (Fig. 17).

Equipments of optical microscopy, X-ray diffraction and SEM with microprobe were used for mineralogical and chemical studies.

4.1 Granitic rock

It is a gray rock composed of large grains of feldspar, quartz, biotite and other accessory minerals. After cleaning the dirt, salt, remains of paintings and other materials that cover it, the rock presents good condition of conservation, without noticing important differences between the exposed surface and the interior of the material.

4.2 Calcareous rock

Due to the evident heterogeneity of the calcareous rock that constitutes the claddings and ornaments of the facades, different samples were taken for its analysis. We concluded that the variations are derived from the original quarries, since the basic characteristics of all the samples are the same.

The samples are dolomitic limestones with some evidences of metamorphism. The size of the crystals is medium, and the smaller crystals are near the zones with
fissures. The principal minerals are dolomite and calcite. In fresh material, where the layer of alteration was removed to observe the original characteristics of the rock, carbonates appear without alteration.

Also, groups of silicate minerals appear making heaps with frequent concentric structures and slight alterations. Here, the existence of serpentine, flogopita and talc was identified. In the pink zones, there are concentration of oxides and hydroxides of magnesium and iron.

5 Conclusions of the initial survey

Different meetings were conducted with the personnel of the Palace of the Congress, with its advisers in restoration and our team of work, with the objective of choosing an intervention criterion for decelerating the process of deterioration in the facades of the building. This intervention should be reversible.

It was decided to design a mortar to repair the limestone slabs. It should have specific proportions to apply on the stone in the case of fissures, fractures, and impacts in the stone cladding. The stone slabs, where the deterioration or the missing elements is greater than 90%, a replacement of the whole stone block should be evaluated, depending of its position in the façade.

6 Characterization of the mortar for stone repair

Bearing in mind the original composition of the ornamental rock, research was conducted looking for different aggregates for the mortar that possess a mineralogical compatible composition. The following composition has been proposed (Table1).

Table 1

<table>
<thead>
<tr>
<th>BINDERS 24% (vol.-)</th>
<th>AGGREGATE 76% (vol.-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Portland cement</td>
<td>Sienna Dolomite from Olavarria</td>
</tr>
<tr>
<td>Gray Portland cement</td>
<td>White Marmoline from Alta Gracia</td>
</tr>
<tr>
<td>Lime</td>
<td>Green Serpentine from San Luis</td>
</tr>
<tr>
<td></td>
<td>Gray Crushed Marble (San Juan)</td>
</tr>
<tr>
<td></td>
<td>Crushed Quartz from Entre Ríos</td>
</tr>
</tbody>
</table>

The repair mortar is being developed by a private company and the exact proportions will be defined by the compatibility with the rocks.

Other requirements were solicited to the private company:
• Reversible repair
• Chemical compatibility: chemical composition of aggregates should be similar to the original stone.
• Achieve a similar coloring by a combination of aggregates, not by pigments.
• Achieve an appearance and texture similar to the stone.
• Similar permeability to rain water both for the mortar and the stone.
• Capacity of permeability to water vapor that should allow the passage of moisture from the inside to the outside of the cladding.
• Similarity in absorption and superficial hardness between the repair mortar and stone.
• Adhesion to the substrate ≥0.15 MPa
• The tensile strength should not be higher than the cohesive force of the mortar.
• Mortar should not change its colour after 1500 hs of ultra violet ray exposure.

6.1 **Initials Tests**

Materials for test received in laboratory:
1) Repair Mortar (company: Tarquini), Figs. 18 and 19. Composition detailed in point 6.

![Fig. 18 Specimen with substratum for adherence, resistance to the impact and permeability to rain water.](image1)

![Fig. 19 Specimen without substratum for absorption test.](image2)

2) Sample of original stone (Fig. 20), extracted from the facades of the National Congress.

![Fig. 20 Original stone](image3)
6.1.1 Permeability to rain water

This test was realized following the methods in the Note of Technical Information N° 121 from the CSTB (France), also described in reference 10.

Initial measurement consists of placing the Karsten tube on the substrate for 24 hours and making readings at 1, 2, 5, 10 and 30 minutes and at 1, 2, 4 and 24 hours. The results are expressed in millimeters of decline in the level of the water column (Initial water column: 50mm). From Table 2, we observe that permeability is very different between the mortar and the stone, since the first one is more permeable than the last one.

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Decrease of the water column (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 min</td>
</tr>
<tr>
<td>STONE</td>
<td>0</td>
</tr>
<tr>
<td>MORTAR</td>
<td>7</td>
</tr>
<tr>
<td>MORTAR</td>
<td>1</td>
</tr>
</tbody>
</table>

(*)Note: Without water.

6.1.2 Absorption

This test was realized according to method ASTM C97 “Absorption and bulk specific gravity of dimension stone” (2009), while the intensive method was realized according to IRAM 1522 “Cement tile” (Argentina 1971).

The weight percentage absorption method done, consists in the determination by difference of weight of dried specimen and weight of the specimen after immersion in water for 24 hours at laboratory temperature.

Bulk specific gravity: Calculate as follows:

\[
\text{Bulk specific gravity [g/cm}^3\text{]} = \frac{A}{(B-C)}
\]

A: weight of the dried specimen in water.
B: weight of the soaked and surface-dried specimen in air.
C: weight of the soaked specimen in water.

The Intensive method (Weight percentage absorption) done, consists in the determination by difference of weight of dried specimen and weight of the specimen after immersion in water for 3 hours at 100ºC temperature.

From Table 3, we observe that the absorption is very different between the mortar and the stone, since the first one is more absorbent than the last one.
Table 3

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Intensive Method</th>
<th>Method ASTM C97</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absorption %</td>
<td>Absorption %</td>
</tr>
<tr>
<td></td>
<td>(IRAM 1522)</td>
<td></td>
</tr>
<tr>
<td>STONE</td>
<td>0.25</td>
<td>0.37</td>
</tr>
<tr>
<td>STONE</td>
<td>0.90</td>
<td>0.89</td>
</tr>
<tr>
<td>MORTAR</td>
<td>10.51</td>
<td>9.58</td>
</tr>
<tr>
<td>MORTAR</td>
<td>10.89</td>
<td>9.55</td>
</tr>
</tbody>
</table>

6.1.3 Resistance to the impact

The method “Perfotest Baronnie” according to general directives UEAtc CSTB 1812 (1982) was used. It consists in performing different types of mark through the test equipment “Perfotest”, which has various steel gravers, that impact on the sample producing imprints. This is just a comparative test to see the superficial resistance of the different samples. In Table 4 we observe that the stone has a greater superficial resistance than the mortar.

Hemispheric graver: it reproduces the fall of a steel ball of 500 grams falling from a height of 0.765 meters.
Cylindrical graver: with diameters between 4mm to 30mm.
Constant of the spring: 9 Joules.

Table 4

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Hemispheric Graver</th>
<th>Cylindrical Graver</th>
</tr>
</thead>
<tbody>
<tr>
<td>STONE</td>
<td>Small detachments of materials</td>
<td>Small detachments of materials</td>
</tr>
<tr>
<td>MORTAR</td>
<td>Visible stamp Ø 7 / Ø 10 mm</td>
<td>Ø 15</td>
</tr>
</tbody>
</table>

6.1.4 Adherence to the substrate (Repair Mortar)

Average adherence, for direct tension obtained in 9 samples, was 1.39 MPa. We consider this result as too high with respect to what it was requested.

7 Tasks in progress

According to the laboratory test programs, compatible texture and colour of stone and mortar was achieved (Fig. 21).
Fig. 21 Repair mortar (left) versus original stone (right).

An important difference of absorption and superficial hardness between mortar/stone exists. We have suggested to the producer of the mortar to modify the capacity of the water absorption.

To achieve this characteristic, we have decided that the producer should prepare two new repair mortars:

a) Repair mortar tested with the incorporation of one additive (acrylic polymers). This additive is to be applied in water.

b) Repair mortar tested with the incorporation of silicates.

After approaching our goal, we will perform the tests “in situ” to finally define the choice of the repair mortar for the limestone slabs in the façades of the building of “The Argentine National Congress”.

8 References


9. The rocks in the monuments construction: its deterioration and intervention techniques.