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Restoration Process of the Fronteira Palace

Restauration du Palais Fronteira

Instandsetzung des Fronteira-Palasts

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SUMMARY

The 'Palácio Fronteira', located in Lisbon, Portugal, is one of the best examples of late XVII century Portuguese architecture. The magnificent ensemble of buildings and gardens were designed under the influence of Italian mannerism. The north loggia of the main building showed extensive deterioration due in part to damaged roof tiles. The rehabilitation procedure included the strengthening of the exterior facade, masonry walls and the installation of a steel roofing structural system.

RÉSUMÉ

Le 'Palácio Fronteira' situé à Lisbonne, Portugal, est un des plus remarquables exemples de l'architecture portugaise de la fin du XVIIème siècle. L'ensemble architectural grandiose des bâtiments et des jardins a été conçu sous l'influence du style maniériste italien. La loggia nord du bâtiment principal présentait des signes généralisés de détérioration, dûs à l'infiltration des eaux de pluie par la toiture. La technique de restauration utilisée pour la façade extérieure a été étendue aux murs porteurs en maçonnerie de pierre et comprenait l'installation d'une nouvelle toiture en structure métallique.

ZUSAMMENFASSUNG

Der 'Palácio Fronteira' in Lissabon, Portugal, ist eines der bemerkenswertesten Beispiele portugisischer Architektur des ausgehenden XVII. Jahrhunderts. Das grossartige architektonische Gesamtwerk aus Gebäuden und Gärten wurde unter dem Einfluss des italienischen Manirismus konzipiert. Die nördliche Loggia des Hauptgebäudes wies starke Schäden auf, weil durch das undichte Dach Regenwasser eingedrungen war. Die Instandsetzungsarbeiten umfassten eine Verstärkung der Aussenfassade der Mauerwerkswände sowie die Verstärkung des Daches durch eine Stahlkonstruktion.

1. THE HISTORICAL MONUMENT

1.1 The Origins

The initial hunting lodge located at the Monsanto park foothills in Benfica was far from the bustling XVI century city of Lisbon. When in 1667 the Field Marshal D. João de Mascarenhas (1632-1681), Count of Tôrre, asked his friend the Regent Prince D. Pedro to wait for a "little while" invitation to a hunting party, so that the Field Marshal could improve the hunting lodge building conditions at his Domain of "Morgado Novo" at São Domingos de Benfica, no one expected that such a magnificent architectural example would arise.

The earliest date found in the buildings - 1584 - engraved over one of the Chapel door lintel may correspond to some early construtction works undertaken. Tradition says that St. Francis Xavier celebrated his last mass here before departing for India in April 1541. The construction lasted probably from 1667 (or 1668) to 1675 and one of the earliest reports on the building construction by the Marquis Filippo Corsini stated that the Italien Prince Cosme de Medicis visited the site on February 7, 1669, - "a magnificient house is under construction in Lisbon outskirts" (*"si va al presente fabbricando..."*), (AZEVEDO [1]).

After the tremendous 1755 Lisbon earthquake, the Marquis of Fronteira's main palace in the city was completely destroyed and the Marquis D. Fernado de Mascarenhas sought shelter in his palace in Benfica, Fig. 1.

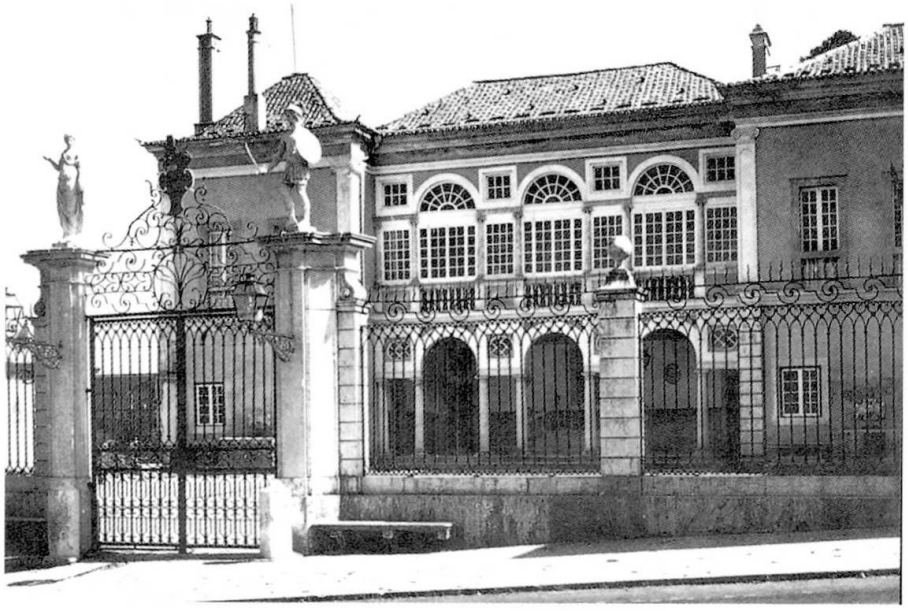


Fig. 1 - The Palácio de Fronteira in Benfica, (1988) Lisbon, Portugal. (AZEVEDO [1])

Important construction projects were completed in the following years in order to accomodate the family and servants. During the XVIII century, a new west wing adjoining the main north loggia facade and the entrance square yard were built. In the second half of the XXth century the city of Lisbon expanded and enveloped the Palace, leading to heavy traffic passing close to the Palace daily on roads never intended for such use. The vibrations caused by the traffic were very hard on the Palace and maintenance consisted only of superficial repairs such that the north loggia facade was near a state of collapse, when an extensive rehabilitation program was begun in the late 1980's.

1.2 The Architectural Compound

Although the Architect´s name is unknown, the main building facade design was probably inspired either by the engravings of Rubens "folio" of the Palaces in Genoa which shows the Villa Sauli by Galeazzo Alessi in 1555-1556, (KUBLER [2]), or on a well known drawing by the Italien architect Sebastiano Serlio, (AZEVEDO [1]). Clearly inspired by the Mannerist style, the north loggia main facade is slightly recessed from the two side towers. The ground floor triple arcade with separated columns supports a loggia with a similar first floor triple arcade supported by marble columns, Fig. 2.

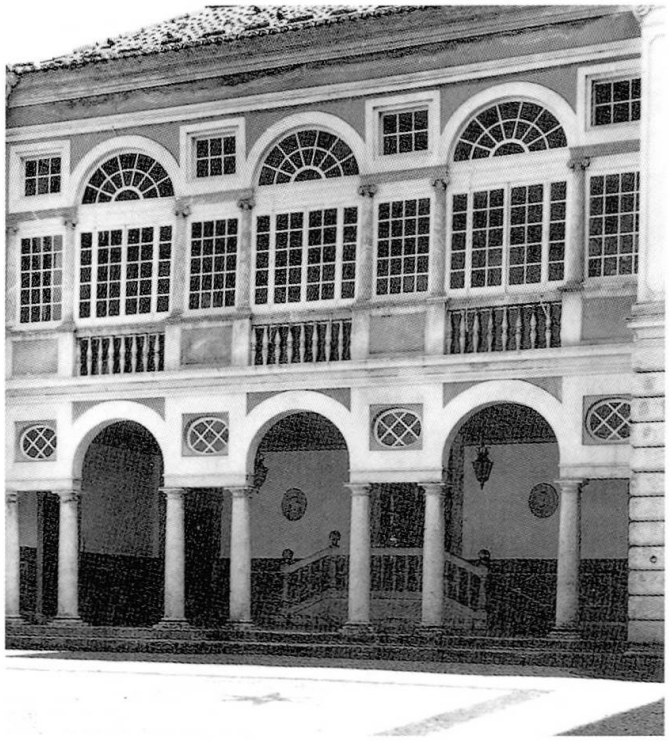


Fig. 2 - The North Loggia Main Facade. (AZEVEDO [1])

Although Alessi's building facade was richer than the prevailing Portuguese taste, the architect simplified the building's square - shaped layout by projecting simple tower-like elements from the four corners of the palace block. The whole building became a more intricate composition of volumes, (KUBLER [2]).

The rich decoration with its glazed ceramic tiles, the "azulejos", makes it one the most interesting palace in Portugal. Particularly interesting are the Battle Room "azulejos" which contain a remarkable series of battle scenes portraying the military history of the Restauration War (1640-1667), e.g., the battles of São Miguel (1658), Elvas (1659), Ameixial (1663) and Montes Claros (1665), Fig. 3. In these battles which guaranteed the Independence of Portugal from Spain, until the peace treaty signed in 1668, the First Marquis de Fronteira, D. João de Mascarenhas, is depicted in battle scenes where he distinguished himself with particular bravery.

a. "Azulejos" Panel

b. Detail

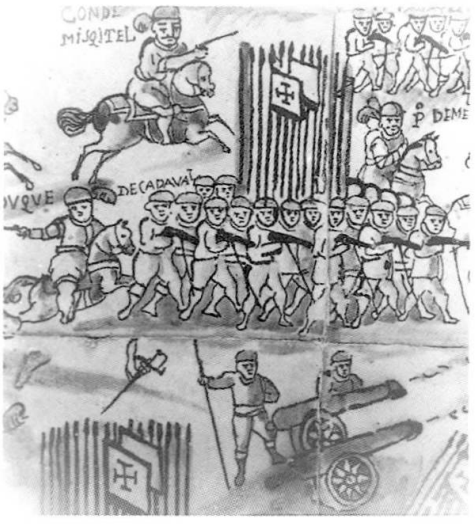
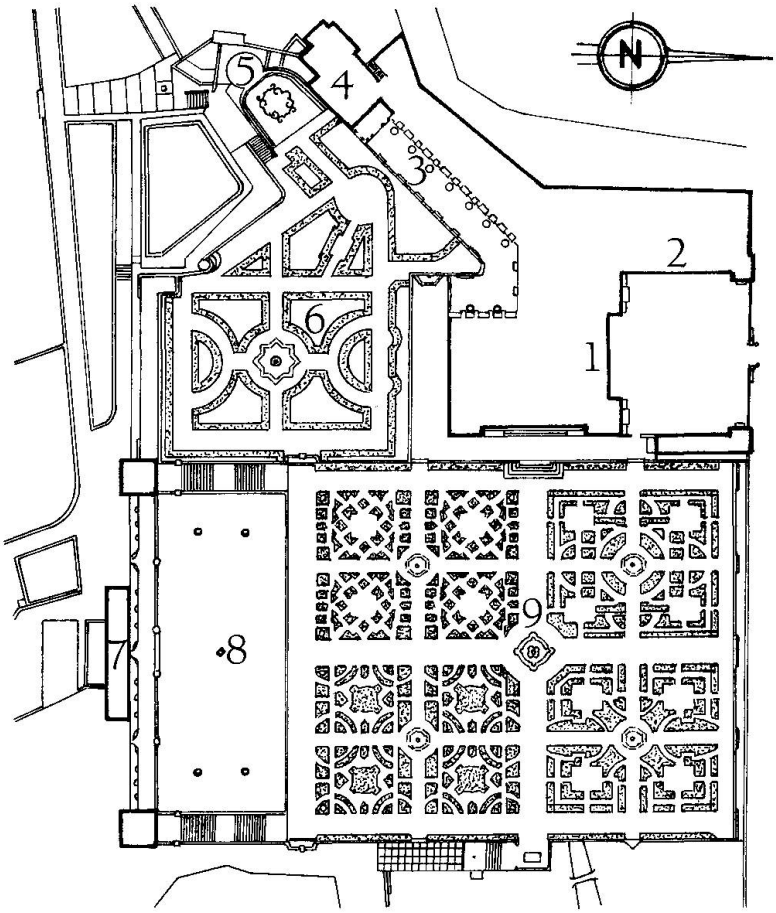


Fig. 3 - Battle Room "Azulejos" Panel.

The building's architectural design shows the clear link between the Portuguese Restoration taste and the North Italian models of Mannerist style.

1.3 The Gardens

The beauty of the gardens, strongly influenced by the Italian style, with the elegant building design creates a magnificent architectural compound built in an epoch in which noblemen took greater pleasure in wars than in arts, (CASSIANO NEVES [3]), see Fig. 4, (QUIGNARD and MECO [4]).



LEGEND:

1- Main building north loggia;
2- XVIIIth century west wing;
3- Statues verandah;
4- Chapel;
5- "Casa do Fresco"
6- Venus Gardens;
7- Kings Gallery;
8- Great Lake;
9- Classical Garden.

Fig. 4 - The Palácio Fronteira and its Gardens (GIL [5], CARITA and CARDOSO [6].)

The building's surrounding gardens and lakes are an elegant solution to a delicate problem, i.e., to create an enjoyable environment with enought water supply during the summer months. A series of descending water reservoirs (supplied by the nearby Monsanto Hills underground drains) starting at the "Casa do Fresco" (5), and continuing down to the Great Lake (8) are used to water the Venus Garden (6) and the Classical Garden (9), Fig. 4.

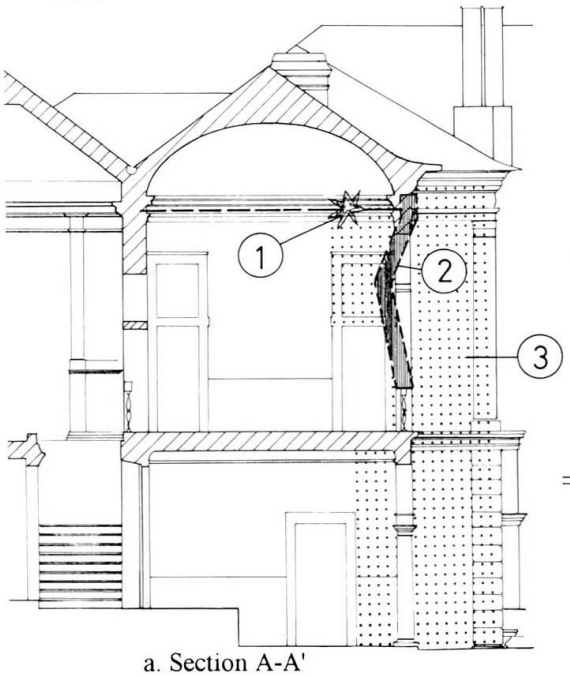
Adjacent to the Classical Garden is the Kings Gallery (7) with the remarkable marble statues (first floor) and the "azulejos" panels depicting twelve knights and two Marquis of Fronteira. The spatial effect created by the reflection in the Great Lake pond strongly enhances the garden, the Kings Gallery and the Palace building ensemble, Fig 5.

Fig. 5 - The Kings Gallery and the Great Lake

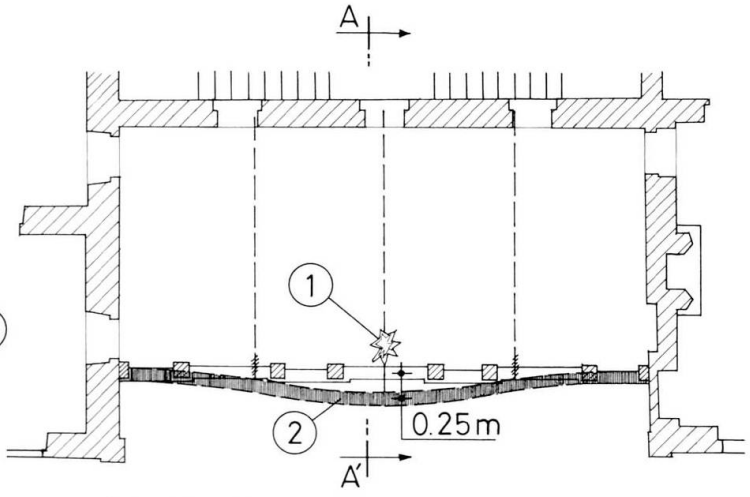
2. THE STRUCTURAL RESTORATION PROCESS

2.1 The Near State of Collapse Diagnosis

The site report of the Summer of 1988, showed that the North Loggia facade was on the verge of collapse. The first floor marble columns displayed a horizontal inward displacement which reached 0.25m at the facade midspan. The cornice had horizontal outward displacement of 0.25m, Fig. 6. The facade's generalized bent shape resulted from: (1) a midspan ruptured iron tension bar; (2) the continuous debris falling from the roof the inner plaster painted shell ceiling adjacent to the facade; and, (3) the roof truss deterioration in the wood beam connnections.



a. Section A-A'



b. Ceiling Plan.

LEGEND:
1- Broken tension tie;
2- Buckled curtain wall;
3- Consolidated masonry wall.

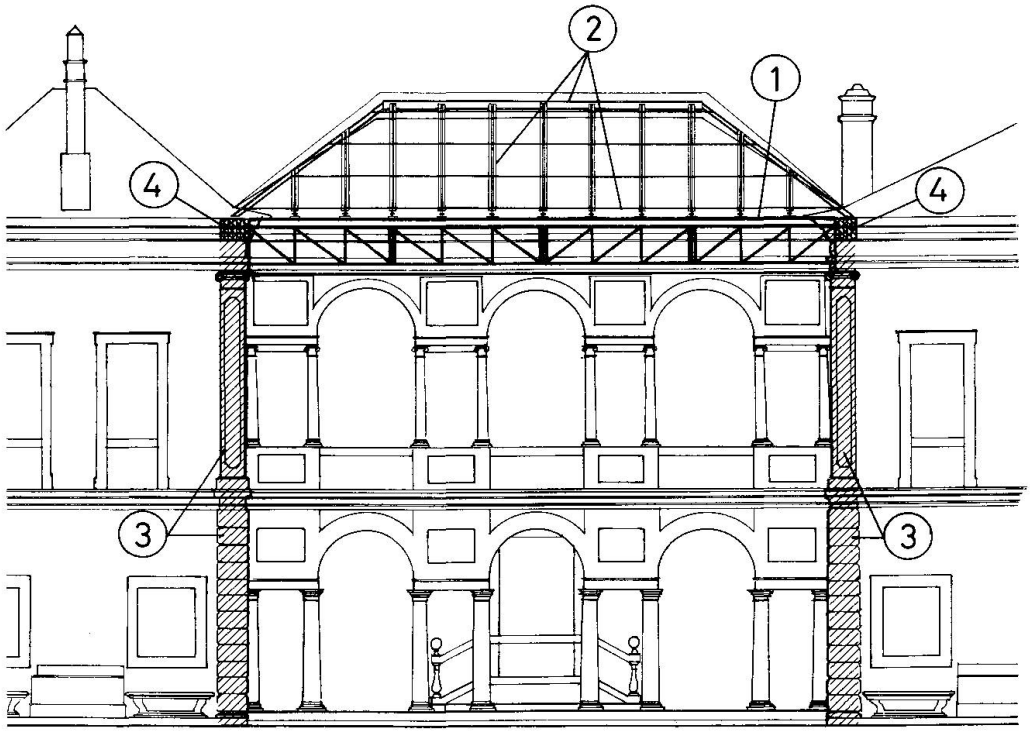
Fig. 6 - North Loggia Facade Collapse Mode.

The existence of heavy compression loads on the 11.50m long "curtain" open wall (4.0m height and 0.25m thick) support system created the ideal conditions for the 2.0m tall marble columns to buckle. The bracing provided by the iron bar ties with a 35mm x 55mm section disappeared when the rainwater, (infiltrating through cracked roof tiles and opened masonry joint), corroded the anchorage eyebar, Fig. 6. The wood roof beams also showed extensive deterioration mainly in the connections at the creast (broken roof tiles) and at the edge supports. Consequently, the bracing effect that once existed throught the roof trusses slowly vanished as rotten wood connections developed.

2.2 The Recommended Structural Solution

The site visit (Summer 1989) showed an extensively damaged shored roof area in which particular care was taken to preserve the inner ceiling's plaster shell paintings. The ovelying roof debris was removed and the masonry clay brick cornice was disassembled, after the moulds and contours were recorded. The recommended structural retrofitting solution consisted in creating a huge portal frame made of a 11.60m long longitudinal steel truss girder and two 0.60m x 3.00m x 10.0m masonry stone columns. The existing wood roof structure was suspended through a second roof steel system installed with hinged connections to the longitudinal beam to avoid roof bending moments.

The objectives with this recommended structural solution were: (1) to reduce the cornice dead load on the columns; (2) to tranfer the roof loads applied on the exterior thin wall to the thicker side walls via the longitudinal steel girder; (3) to provide a continuous spatial bracing between the U-shaped masonry wall envelope, the open exterior "curtain" wall and the roof system; and, (4) to increase the safety factor of the existing structure, Fig. 7.



LEGEND:

1- Longitudinal beam;
2- Roof truss system;
3- Reinforced masonry walls;
4- Reinforced concrete ring beam.

Fig. 7 - North Loggia Facade - Structural Solution

In order to guarantee the overall stability careful site inspection was conducted of the masonry walls Throught several 25mm holes drilled in the walls it was verified that the existing mortar filling the joint had either disintegrated after 300 years in service (probably washed away by infiltrated rainwatwer) or was in such poor condition that had to be strengthened. A limited "*reticolo cementato*" technique was used in a 3.00m wall portion. About six hundred 1.0m- long holes were drilled, filled with cement mortar and a 8mm steel rebar. In order to reduce the possibility of steel corrosion the exterior wall was protected with cement epoxy-based mortar.The steel longitudinal beam was coated in rich galvanized zinc to protect it from corrosion and in order to match the existing building cornice, a diamond-shaped zinc coated wiremesh covered with epoxy coated mortar was used, Fig 8.

The architectural detail was easily obtained through the use of these wiremesh panels. The beam top flange was composite with concrete and made continuous with the wall reinforced concrete (RC) ring beam. On the beam top flange stainless steel hinged supports were installed to connect the steel roof truss system. Before constructing the steel roof, the wood truss connections were thoroughly repaired, the inner plaster painted shell ceiling was inspected and a steel tension tie was installed to brace the longitudinal beam, Fig. 9.

Before laying the roof tiles, the wood roofing system was suspended from the steel system with zinc-coated steel rods. Then, moisture-resistant plywood panels covered with an undulated flexible waterproofing membrane were placed on top of the steel truss, so that the roof tiles could be fixed to the structural system.

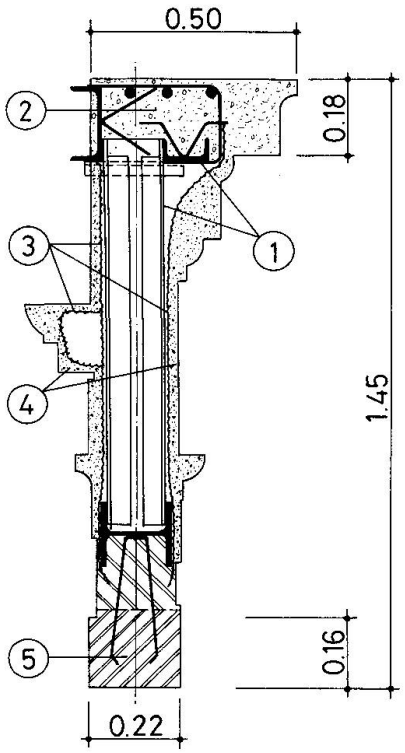
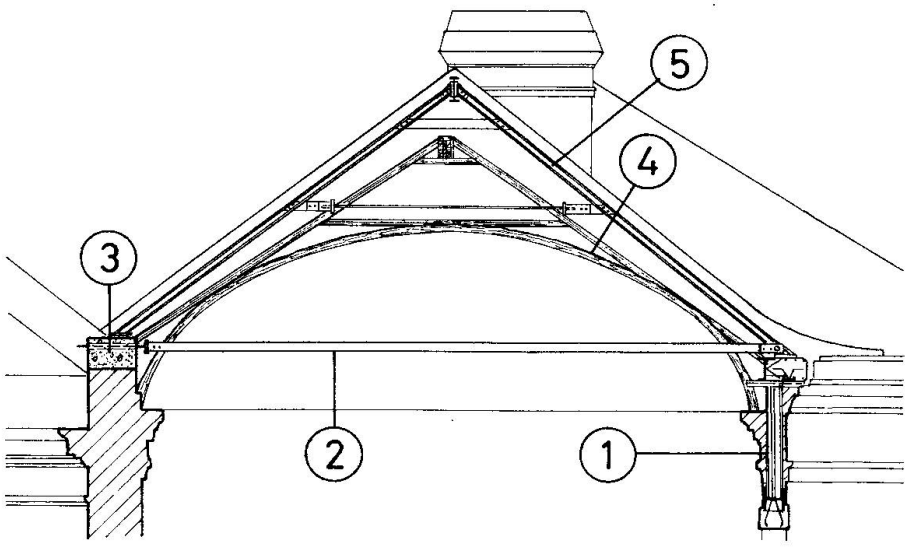


Fig. 8 - Longitudinal beam cross section.



Legend:

1- Steel members;
2- Cast in-situ concrete;
3- Steel wiremesh;
4- Epoxy coated morter;
5- Masonry arch keystone.

Legend:

1- Longit. Steel Beam;
2- Tension Tie;
3- RC Concrete Ring;
4- Painted Plaster Dome;
5- Roof Steel Truss.

Fig. 9 - Palace North Loggia - Ceiling Cross Section.

2.3 Project and Construction Limitations

Several important constraints related to this restoration project should be emphasized: (1) the use of a structural steel system was difficult because the need to fit the system into an existing building; (2) the difficulty of quantifying load actions, particularly of the material's dead load (e.g. the "moorish" roof tile system); (3) the need to use no-readily available materials (e.g. the facade steel wiremesh; epoxy-coating mortars) and to specify custom-made structural elements; (4) matching three hundred year old building techniques with the vast array of "high-tech" materials available nowadays; and, (5) defining a satisfactory factor of safety while ascertaining the existing safety conditions.

3. CONCLUSIONS

The "Palácio Fronteira" is one of the most well-known examples of the XVII century Portuguese domestic architecture with its buildings, gardens, lakes and the magnificent "azulejos".

In 1988, the main building's north loggia facade was near a state of collapse when a general restoration program was implemented. The strengthening of the existing stone masonry walls with the introduction of a structural steel system (longitudinal beam and roof trusses) was deemed necessary. Particular care was taken to maintain the existing building conditions and to make the new structural system compatible with that of the original Palace.

The use of a structural steel system (longitudinal beam and roof trusses) coupled to a RC ring beam was considered adequate to meet both architectural and engineering requirements. With this solution, the stability of the slender "curtain" wall in the building north loggia facade would be achieved.

4. AKNOWLEDGEMENTS

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