

Seismic Vulnerability of the Dey's Palace (Algiers, Algeria)

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Abstract The Palace of the Dey at Algiers is located inside the Citadel of Algiers which was built in the 16th century (1516) by 'Arrudj (Barbarous). The citadel is located at the higher part of the city and was the first military building at that time. The citadel was the janissary barracks and initially contained a powder keg, a walk, Janissaries residence places and their mosque. Starting from the 18th century appear new constructive strata. In 1716 some part of this military edifice was destroyed by an earthquake. In 1783 the Spanish bombarded Algiers and a bomb fell into the first storey of the palace. The architectural transformations took place in 1817 when the Dey 'Ali Khūdja lived at the janissary's barracks. Thereafter and during 12 years several buildings were added to this whole defensive structure as the second and the third floors of the palace, the Dey's mosque, the bath, the Bey's palace and the winter garden. During the French colonization, the palace undergoes other transformations as the destruction of most of the rampart of the city contiguous to the palace which caused its instability and which until today accentuates its vulnerability. The lack of maintains, the abandonment and the bad restoration which took place during the 20th century increased this vulnerability. This work based on a visual screening will present the various aspects of vulnerability due to static weaknesses of the angles and absence of wind-bracing of this palace.

Keywords: Vulnerability, static weakness, wind-bracing, Palace of the Dey, Algiers, Algeria

Introduction

This study was undertaken in close cooperation between architects from Algerian university (Blida) and Italian architects from Bologna and Firenze Universities for training architects, civil engineers and archeologists of the Algerian Ministry of Culture. The project was untitled "*Initiative of training for the recovery and the valorization of the Casbah of Algiers according to the traditional techniques and their reuse in an innovating way*". The building analyzed in this study is the Palace of the Dey of Algiers. It shows common architectural feature of Arab Islamic houses. A central square courtyard surrounded by galleries. Detailed research on available historical sources does not enable us to determine all the construction process. But it was possible following an investigation of stratigraphic reading to identify the process of construction and the imprint of events (constructive typology, architectural alterations and earthquake). Based on historic documentations information's and stratigraphic reading, a sequential analysis has been developed as a preliminary seismic vulnerability evaluation. The results of this work could be used within the repair of this historical building in the field of the PERPETUATE Project. An essential issue of the diagnosis lays in the distinction of damage related to active phenomena, historical actions (as fire, bombing, lack of maintenances and inadequate restorations) and natural hazard (as earthquake and soil settlements).

Description of the Palace

Since the Ottoman occupation of Algiers by Barbarous Brothers, the reinforcement of the wall of the city, the gates and the fortifications was started. From the proclamation of *Arudj's* authority, he

started the rebuild of the citadel some 300 m higher than the oldest one. It was located towards the more culminating point of the city (De Haedo 1578-1581). The citadel was constructed around 1552-1572/73 (Missoum 2003). The first illustration which exists was drawn by a Spanish prisoner in 1563 (Braudel 1966). On that picture (Fig. 1) the citadel appears in the top of the medina and is separated from all districts.

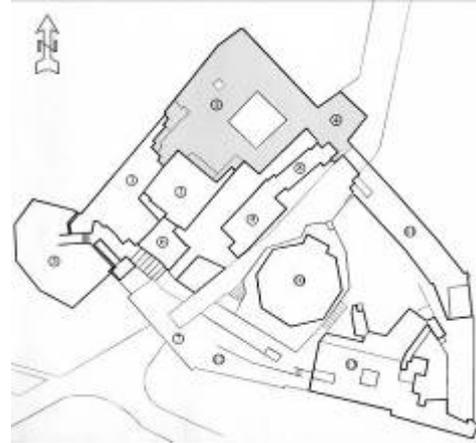


Figure 1: Algiers drawn by a prisoner in 1563 (Braudel 1966), Figure 2: Overall plan of the Citadel and the Palace in grey (Casbah 1984).

The citadel probably contained, at the beginning, a walk way, the powder keg and the janissaries *diwan*'s room. There is no any date of construction of the other buildings such as the palace of the *Dey* its mosque and *hammam*, and the palace of the *Beys* (Fig. 2). During the Ottoman Regency no *Dey* of Algiers resided at the Citadel. In 1817, the *Dey Ali Khudja* left the official residence *Al Djanina* located in the lower part of the city to find refuge in the Citadel. No building had been designed to accommodate the sovereign and his court. They leave in this barracks of janissaries. The palace of the *Dey* is occupying the north-eastern angle of the citadel. Its form is a rectangle with a large interior court or patio. In the south-eastern angle is located the advanced entry called *sqifa*. The whole building is heterogeneous because of its different strata and periods of construction. The palace constitutes the greatest part of the citadel considering its volume and surface. The external walls of the northern-east belong to the ramparts. The whole building forms an irregular rectangle surrounded by four galleries. The North-West wings of this building rises on three levels while the South-East wings raises two levels (Fig. 3).



Figure 3: View of the Palace of the Dey's Patio (Lessor and Wield 1984)

The Ground Floor: A part the patio and the four galleries, the ground floor contains several spaces surrounding them. In the North-Western part, the gallery is duplicated by a second one. Just after let us find three oblong spaces covered by vaults: these are the treasure. There is only one gallery in the North-Eastern part, behind which are located two series of joint spaces. In the first line are four rectangular spaces which represent magazines. The second line is a long covered of cross vaults space with bored loopholes and which is called *dahliz*. The two other South-Eastern and South-Western

parts have each one only one gallery, behind which are rectangular spaces covered by wooden floors. These are also magazines (Fig. 4 a).

The First Floor: We can find four galleries surrounding the central space. The *Harem* and the apartment of the *Dey* are located in the North-Western and in the North-Eastern part. The kitchen and rooms are respectively located in the South-Western and South-Eastern parts. The whole of this storey is covered by wooden floors except the kitchen which is covered by cross vaults (Fig. 4b).

The Second Floor: On the second floor we find three galleries located in the North-Eastern, South-Eastern and South-Western parts. The *Harem*, the *hammam* and the residence of the employed personnel are respectively in the north-western and the south-western parts. There is no building in the south-eastern part but only a gallery. In the north-eastern part there are different spaces as the library, and the musical room which is covered by an octagonal dome and is located at the North-East angle (Fig. 4c).

The Third Floor: It contains only an attic storey made of wood located in the North-Eastern part (Fig. 4d).

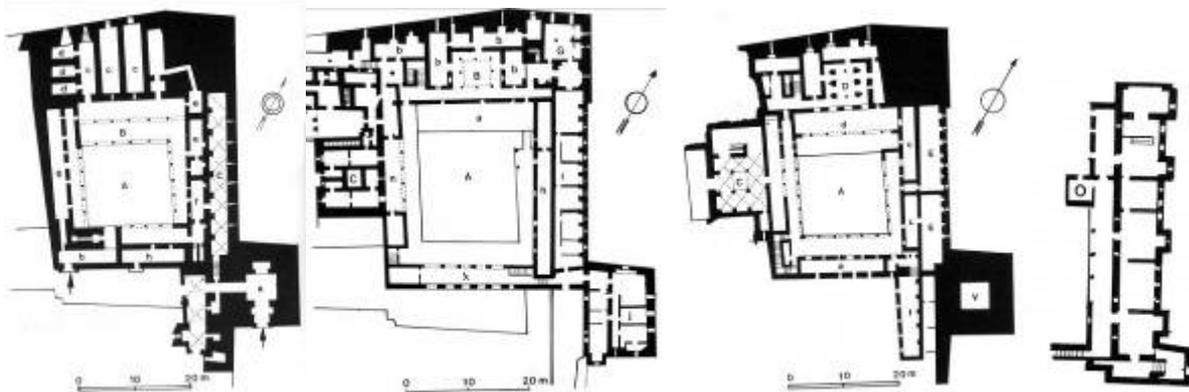


Figure 4: a- ground floor; b-first floor; c-second floor and d- third floor of the Palace

(Golvin 2003)

Construction Process through Stratigraphic Analysis

Construction of the Dey palace began on 1596-1599 as a janissary citadel. It involved, in the first place, the construction of the full perimeter, including magazines surrounding the patio, a walk way, the powder keg and the janissaries' *diwan's* room. This study on the palace showed that several actions of construction, demolition and rebuilding took place successively in time. Unfortunately, we do not have any dating. Only the materials and the techniques of construction have reveals these actions. The architectural stratification applied to the patio of the palace showed that constructive strata are characterized by negative and positive actions of construction and of transformation's actions which modified what existed. The periods of use which interpose between the successive constructive phases express by entropic degradations due to the use of the palace, as well as natural deterioration due mainly to the earthquakes and to the action of the atmospheric agents (marine salt). The architectural stratification thus appeared by layers; which represent different remanent parts of the various founder's shares which occurred throughout the history of this building as well as negative interfaces which are the demolitions traces. The example of the south-eastern part of the ground floor represents the negative interfaces because there were demolitions then positive interfaces representing the rebuilding of these same interfaces (Fig. 5). While the south-eastern face underwent

many phases of construction. On the part of this patio's frontage (gallery wall), negative interfaces due to the demolitions and positive interfaces due to the rebuilding of these same negative interfaces are visible. The architectural layers for this wall are laid out in various directions.

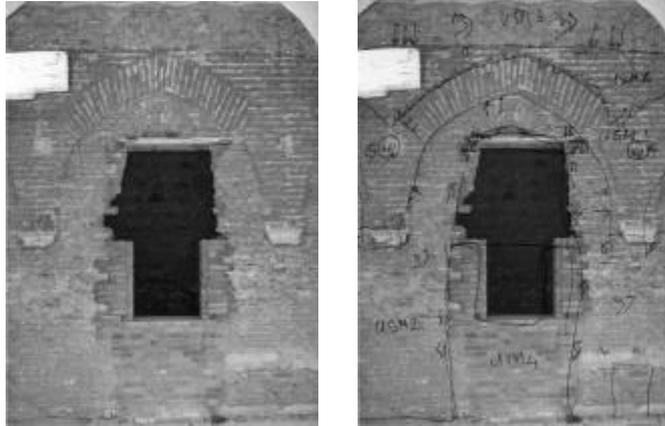


Figure 5: South-eastern frontage with the various layers and interfaces (Foufa 2006)

The stratigraphic units are characterized by the used materials. In this case we have traditional bricks masonry of 3 x12 X20 cm size bounded by lime and earth mortar having 3 cm thickness. Beside the layer of filling is built by industrialized bricks having 5 x10 X20 cm size and are bound by a cement mortar of 1cm thickness. If we consider, the northern frontage, the stratigraphic study showed us that the interventions are tinier and that this part of the building comprises only positive interfaces which represent the layers of repair (Fig. 6). The southern and western frontages underwent heightening which sheltered respectively the Harem and the private apartments of the Dey.



Figure 6: Different view of the southern patio's frontage (Foufa 2006)

The constructive typologies of the Dey's Palace are various. Some walls are in emplecton masonry using bricks and lime mortar. Since the 1716 earthquake some others techniques were introduced in order to resist the seismic loads (Foufa 2005).

Existing Damages

Two angles in the Dey palace present static weakness:

- The stairs well located in the south-western angle
- The music room located in the opposite angle i.e. north-eastern.

Four different types of alterations, visible in both parts of building, are highlight and discussed:

Cracking in Walls and Façade: Cracks exist in walls of both spaces. Vertical and oblique cracks have developed across the bricks masonry walls extending to all their depth and can be also

recognized in exterior. These cracks are due to the ageing of materials, the excessive loads and effects of the earthquakes (Fig. 7a). In the stair-well the orthogonal walls are not connected that induced the vertical cracks (Fig. 7b).

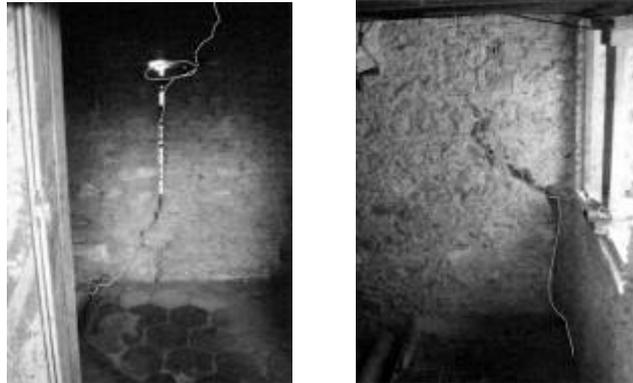


Figure 7: a-Vertical cracks; b- vertical cracks in the corner (Foufa 2006)

Cracking in Floor: Horizontal cracks have developed across the wooden floor and the marble staircases. In addition to that, the wooden beams; acting as elements of wind-bracing; inserted in the external wall of the stair-well and on the wall of the *sqifa* were divided. This weakened this angle and increased its vulnerability.

Cracking in Vault: In the cross vault of the music room (Fig. 8a), cracks have developed following the keystone of the transverse sides (Fig. 8b). These cracks are due to the horizontal displacement of abutment which is due to the destruction of the city-wall which acted as wind-bracing to this massive block of constructions (Fig. 8c).



Figure 8a: Section through the music room (PKZ 1980); b- Cracks in the cross vault. (Foufa 2006); c- External view since the room of music of the remainder city wall (Foufa 2006)

Cracking in Cupola: In the octagonal cupola cracks have developed following the transverse sides (Fig. 9a and Fig. 9b). These cracks are due to the horizontal displacement of abutment which is due to the destruction of the city-wall which acted as wind-bracing to this massive block of construction.

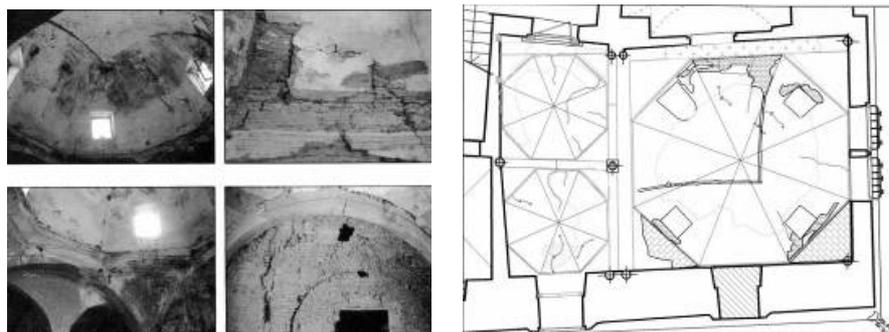


Figure 9: a and b- cracks in the octagonal cupola (Foufa 2006)

Cracking in Arches: Arches carrying the cross vault and the octagonal cupola are fissured at the level of their keystone because of the highest compression of these cover built and of the weakness of the abutments. The city wall of which the thickness reached more than 1m 50 and which leant against the music room was destroyed at the French occupation time. This wall constituted an excellent wind-bracing at this part of the palace (north-eastern). Since its demolition, the angle is in a constant instability whence the appearance of these various disorders which amplified its vulnerability (Fig. 13).

Conclusion

As shown in the two angles investigated using visual screening, the construction process may have significant influence on the initial condition of construction. Some of alterations (large deformation in walls, damage on cupola and vault) might be attributed to the destruction process which belongs to the historical evolution of the Palace. Later entropic actions (repairs) should be included as a part of deterioration.

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