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TRADITION AND TECHNOLOGY IN THE RESTORATION AND REUSE. THE DAR DGI'RA IN RABAT, MOROCCO

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Abstract
The courtyard house is a type of familial and historic dwelling, which offers technical and design solutions to a variety of social needs, such as ventilation and family privacy. Previous studies show that the courtyard is a traditional typology that actively contributes to the wellbeing of the dwellers by providing aesthetic, thermal and social benefits. This study focuses on how traditional knowledge can be used as a tool to design contemporary sustainable architecture. Specifically the main research focuses on the spatial, static and material analysis of the case study Dar Dgi'ra in Rabat Morocco. The aim is to develop an exhaustive understanding of what is unique and significant about the Moroccan urban courtyard type (the Dar) so as to make informed choices for the management needed to preserve it for future generations. This project puts forward a design suggesting the adaption of the Dar using traditional knowledge for its reuse as a public hammam. The design proposal aims to conserve the Dar in a manner which respects its history while at the same time adapting it to ensure its future viability.

Keywords: Restoration, Reuse, Sustainability

Introduction

In contemporary architecture the courtyard can certainly be as successful as it has been historically. As Khattab (2004) indicates, working through vernacular architecture helps in considering the nature of dwellings, the origin of the built environment, the meaning of privacy and the energy efficiency of settlements. The courtyard house is a familial and historical dwelling type, which offers technical and design solutions capable of satisfying a variety of social and commercial needs. It is a type of dwelling characterized by the presence of a court completely surrounded by walls (Oxford Dictionary, 2010). Nikpour et al (2012) also define it as the combination of several different open and closed spaces that were designed in order to combine nature and living spaces. Torus (2011) agrees and adds that all courtyard houses are minimalist, sustainable (use of local materials and labor) and rationalist. This type of dwelling is one of the oldest forms of domestic development that dates back at least 5,000 years. The courtyard house spread from China to Morocco and became a traditional typology in arid climates. In addition to climatic and functional purposes, in the Islamic world, courtyard model has a cultural relevance too, since courtyards respond effectively to the Muslim religious requirements and to the women's position in the society (Edwards et al, 2006).

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Currently, in both regeneration projects and modern architectural design the courtyard is an important element to be taken into account. Firstly it is a symbol of a culture and secondly it can contribute to the efficiency of a community and ensure social security and privacy. In China, for example, there is the Hakka Walled complex in which many families live together. There is only one entrance and a circular communal court assures social security and collective activities (Rapoport, 2007).
This paper will assess how traditional knowledge can be conceived as tool to design sustainable contemporary architecture. Firstly, the courtyard's characteristics will be explored. Secondly, the case study Dar Dgi'ra in Rabat, Morocco will be analyzed: the close link between the layout of this élite type of dwelling and intangible expressions such as religion, ethos and secular traditions will be pointed out. Thirdly, a technical analysis will be illustrated and a conservation and reuse proposal will be suggested to preserve the building for future generations.

Methodology
The method of study used in this project is based on primary and secondary research. Firstly, in the literature review section, the courtyard dwelling typology and its characteristics will be presented, analyzing many studies which have been done up to now. The research is carried out using books, journal articles from academic databases such as
"Online Public Access Catalogue" , "Catalogo Unico Parmense", "Academic Source Complete", "Applied Science and Technology", "Full text British Architectural library Catalogue", dissertations done by students of Ecole National d'Architecture of Rabat, Morocco and a research done with the collaboration between the Faculty of Architecture of Palermo, the Polytechnic of Bari, the University Federico II of Naples and the University of Reggio Calabria, Italy.
Secondly, the analysis of the case study Dar Dgi'ra is based on critical site surveys: historical, static, typological and distributive analysis has been carried out. The first stage consisted of a survey with direct measurements. Then, a static analysis and an evaluation of the decay of materials have been done, drawing up intervention cards for each material. The methodology adopted is based on a conservative approach and not on a stylistic one. A stylistic "modus operandi" is based on the desire to perfectly reconstruct the original image. On the contrary a conservative approach aims to fully respect the building in its integrity with all its signs of time or alterations, since buildings are conceived as "historical documents".
Furthermore, the renovation design as a pubblic hammam is based on the rule of the "minimum intervention" through the discreet use of modern materials. Architectural elements and materials typical of our time are used to create a "slight contrast" between the ancient and the modern.

The courtyard
The courtyard house is an introversive type of dwelling. It has "a square or rectangular open space" which is usually located in the heart of the house, with a distinct separation between public and private open space (Salama, 2006 : 47; Macintosh, 1973; Edwards et al, 2006). Reynolds (2002 : 25) defines courtyard as a "special symbol of inwardness" symbolizing femininity. Traditionally it is associated with the Middle East where climatic, topographical, socio-cultural and religious aspects contribute to its layout. However, other examples are found in Latin America, China and Europe where the model has been reinterpreted. Courtyards have been built to satisfy family needs such as security, identity, social status and domestic comfort (Hyland and Al-Shahi, 1986). This strong relationship between the courtyard and Middle Eastern society has existed for 8000 years.

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As Bekleyen and Dalkilic (2011) state, the oldest examples of courtyard houses date back to the Sumer and Pharaonic periods in Egypt. Later on, this housing type appeared in western cultures during the Greek and Roman periods.
A considerable amount of literature has been published on courtyards and courtyard buildings. Many historians have explained courtyard characteristics, presenting how they meet human needs. The literature review shows 3 main functions of courtyards: aesthetic, thermal and social.

Aesthetic function

Courtyard typology as archetype

Pfeifer (2008 : 9) defines typology "as the science of type" which classifies items into groups with the same characteristics in order to compare them and highlight differences and similarities. The term "type" derives from the Greek word "typos" and means imprint (Pfeifer, 2008, 10). Courtyards are considered an archetype and according to Oxford Dictionary (2010) archetype is "a primitive mental image inherited from ancestors supposed to be present in the collective unconscious". Ratti, Raydan and Steemers (2003 : 49) add that a courtyard "makes the best use of land" and Pfeifer (2008) echoes this idea identifying four types of courtyard: garden courtyard house or forecourt, shared courtyard house, L-shared house, group of L-shaped houses, patio house and atrium-type house. As can be seen in the Fig. 1 all the types of courtyard are arranged in relation to the position and proportion of the yard in order to provide a transitional area between the urban space and the indoor one (Ferrer Forés, 2010; Pfeifer, 2008).

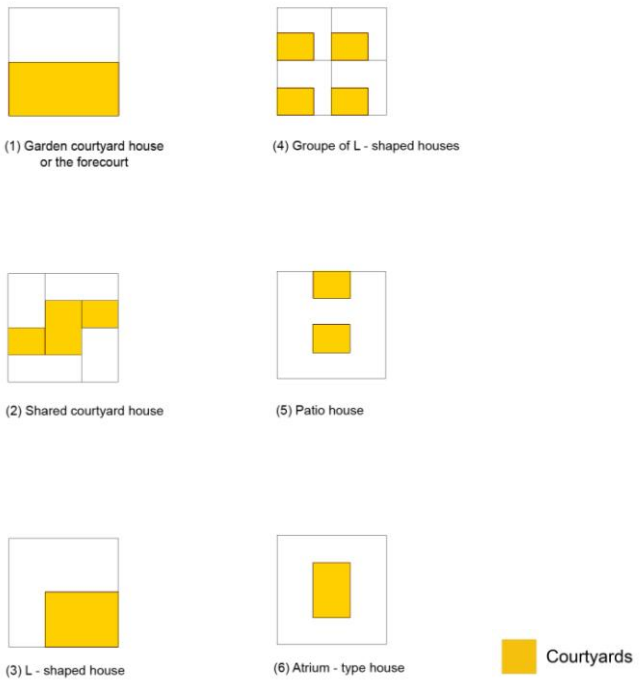

Fig 1. Schematization of the courtyard typologies defined by Pfeifer (2008).

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Internal disposition

Nikpour et al (2012) define the courtyard as the centre and the heart of the building. It is a space with an independent, central, internal and open geometric design which enables easy accessibility to all spaces located around providing good daylight and ventilation. There is a difference between rural, isolated courtyard houses, and urban ones. The second type creates a dense urban tissue revealing a high capacity to exploit urban space (Rapoport, 2007). In the same way Torus (2011) argues that the houses are not placed on a grid plan (classical Greek or Roman towns) but streets have formed after houses have been built underlining that the city as well the houses evolve according to the needs of dwellers.

Vegetation and water

Many studies show that there is a strong connection between courtyard, nature and the cosmos (Reynolds, 2002; Nikpour et al, 2012; Touland, 1980). The courtyard house responds simultaneously to cosmic, cultural and climatic forces (Edwards et al, 2006). In Islamic culture, nature is considered a sign of God's wisdom. Through the courtyard humans can be connected to nature (Nikpour et al, 2012). Since ancient times, courtyards have been associated with the "Garden of Eden" for their spiritual role (Reynolds, 2002). Considering Koran verses, they can be seen as the divine heaven expressed by four symbols: water, soil, wind and light. Water is the symbol of life, coolness and purity. Through a pool located in the centre of the patio it becomes a proper mirror of sky (Reynolds, 2002). Furthermore, water acts both as a decorative element, showing the visual axes of the house, and as a strategy to provide a microclimate (Nikpour et al, 2012). Wind, the third symbol, by passing above the water of the pool, becomes cool and wet, and through evaporation it cools the air (Touland, 1980). It is clear that water placed in the centre of the courtyard represents life and assures coolness, contributing to the mental and physical wellbeing of the residents.

Fig 2 View of an internal Riad (internal garden) of a Dar in Rabat

Fig 3 View of a fountain located in a patio of a Dar in Rabat

After water, as Nikpour et al (2012) described, soil is the most important element in Islamic architecture. Having high thermal capacity it can store the excessive heat during the day and transfer it to the air during the night, improving consequently the temperature of the rooms. In addition, Reynolds (2002) and Touran-Poshti, Naghizadeh and Nasrabadi (2011) present soil and vegetation as the organic and dynamic parts of the courtyard: plants can chill the air, provide aroma and decorate the courtyard delighting all the senses. The fourth element is the light, which is considered symbol of God (Nikpour et al, 2012).

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Traditional buildings have been shaped considering the natural sources of energy and were designed in a way to provide maximum light during the winter, and shadow in summer (Touland, 1980). In the Iranian house, for example, winter rooms were built on the northern side of the courtyard in order to use the winter light, while summer rooms were on the southern part to avoid the direct sunlight (Nikpour et al, 2012). So, nature can truly contribute to enhance inhabitants' comfort.

Thermal function

Ventilation

Climate has had a great influence on the role of courtyard and its design features in hot and arid zones. The courtyard plays an important role in facilitating air movement, regulating circulation and providing a microclimate due to its position (Nikpour et al, 2012). Salama (2006) also adds that the courtyard performs an important function as modifier of climate as well as for lighting purposes. This theory is not supported by Rapoport (2007) who states that views about courtyard climate regulation tend to be romanticized. Al -Masri and Abu-Hijleh (2012) echo this idea and argue that contemporary models of housing with large glass facades are more popular since they are considered climatically more comfortable than courtyard houses.

Social function

Research shows that a courtyard provides privacy, protection and sense of safety (Sartor, 2008). In Muslim society religion is more than a code of ethics, it is a proper way of life with a strong impact on social behavior and social interaction. Architecture mirrors these social, economic and cultural forces (Touland, 1980).

Community and privacy

Many studies have found that privacy is the distinctive feature of the courtyard houses (Macintosh, 1973; Salama, 2006; Bekleyen and Dalkilic, 2011). As Rapoport (2011) states the most important feature of courtyards is the privacy provided by using both physical elements such as walls and doors and other mechanisms such as separation in time, rules, and distance between rooms. In traditional Middle Eastern Islamic culture, it was very important to separate males and females and protect the house against strangers as well as to prevent visual contact (Bekleyen and Dalkilic, 2011). The courtyard being the representative area of the house was usually used to welcome the guests (Bekleyen and Dalkilic, 2011). Kasimee and Mcquillan (2002) add that family ties are very strong and hospitality is the basis of family life. Salama (2006) also adds that in courtyards daily activities were carried out too. Wives and mothers-in-law performed many social activities there including the celebration of weddings, male circumcision and births (Alhusban and Al-Shorman, 2011).

The case study

The following research will focus on the analysis of a Moroccan Dar to develop a critical understanding of what is unique and significant so as to make informed choices for the management needed to preserve it for future generations.

Specifically this study, analyzing the case study of Dar Dgi'ra in Rabat Morocco, aims to develop a sympathetic and appropriate design proposal for a public hammam to conserve and adapt the building in accordance to its history.

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The Dar Dgi'ra, in Rabat, Morocco: the history and the place

The name Dar Dgi'ra, comes from its owner the Pasha Arbi Dgi'ra and (as is common in the medina) is located in a Der (an alley), which in this case also bears his name (Der Jirari). The building is located in the historic core of the town of Rabat called "medina" (town surrounded by walls) near the Kasbah of Oudaya, the most ancient part of the city.

The building is thought to have been built in the second half of the 19th century as it was over this period that the Pasha was active. This assessment was reinforced by the declaration of an old man living in the area. However, it is possible that the building is earlier and that the Pasha adapted and embellished an existing building located inside the Almohaidite walls dated approximately around the XIII century.

Fig.4 Rabat. Kasbah of Oudaya with its door (Bab Oudaya) and walls

Fig.5 View of the Dar Dgi'ra from the main street Charia el Alou

Internal layout

It is a two storey building lime plastered externally. There is a distinct contrast between the simplicity of the external facade, that has small windows (called '*claustra*') and the richness of the decoration in the interior, an important symbol of the social status of the owner.

Since there was neither historic nor technical documentation concerning the building, a comparison has been made with other vernacular examples located in the neighborhood which present the same characteristics.

Life in the Moroccan house follows precise habits and behaviours.

In Islamic culture the rules of the Koran are the basis for the organization of domestic life and for the internal layout of dwellings. The Arabic word for house "*sakan*" is related to "*sakina*" that means peaceful and holy place. The house can be defined as a tangible representation of hierarchical social relationships.

There are two entrances, one for guests and the other for servants. When the visitor enters through the main door "*bab el dar*" he is welcomed in the entrance "*satwan*". It is a traditional elbow shaped entrance formed by a series of small columns and arches decorated with cones.

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Fig.6 View of the main door (*bab el Dar*)

Fig.7 View of the *satwan* with the *dukkana*

The "*satwan*" leads to the internal courtyard "w*ast-el dar*", the most representative and noble space of the house. A guest sitting on the "*dukkana*", little masonry bench set against the entrance wall, could not see what happened in the patio and how the domestic life was organized.
An interesting aspect is how architecture can shape the concept of domestic privacy: the external world was not admitted into the private family life, while the internal space seems to have no privacy at all.

Fig.8 View of the *Wast-el dar*

Fig.9 Internal view of the gesso decorations from the Dar Dgi'ra courtyard

The microcosm of the family gathered around the patio that was an extension of all the rooms "*bitu*" placed around it.
The members were obliged to use this external space to reach all the rooms in the house. At the centre of the patio there was usually a fountain covered with typical Islamic zellige (mosaic tiles) since water symbolizes purification and life. The fountain in the centre of the garden "*riad*", was also source of cool relief. All the rooms were organized with few furnishings, such as carpets, wool mattresses, little tables.

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They were used for sleeping, eating and praying simply by pulling a curtain from one side of the room to the other. In the middle of the room there was always a big wooden door that allowed the light to enter. In this élite type of dwelling there was always a "*hammam"* plastered with "*tadelak*" and used as place for body care. This covering is a natural material (lime plaster), air-permeable, water repellent, very fragile with fungicide and bactericide characteristics. It needs regular maintenance but it has an exceptional lifespan.

Fig.10 Internal view of the *hammam*

Fig.11 View of the vaulted ceiling of the *hammam*

Fig.12 View of the wall niche used to for the hot water supply from the *matbah* (kitchen) to the *hammam*

In the past, on the top floor there was the "*masyria*", the biggest room of the floor used by the landlord for his parties. He could spend evenings in the company of his guests without being disturbed. The room could be reached only through a secondary stair located directly on the road.
There were two stairs, the main named "*qubba"* led only to the first floor and was reserved for the members of the family and the second one named "*drüj*" was reserved for the Pasha, his guests and the servants. On the first floor there was the '*harem*'. The name derives from woman "*harim*" and sacred place "*haram*". On this floor there was the first wife's room too named "*bit mul al-bahwu*" finely decorated with a "*mushrabiya*".

Fig.13 View of the *masyria*.

Fig.14 View of a wall niche of the *masyria*

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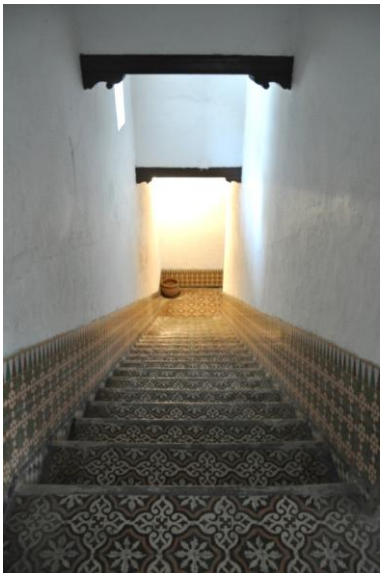
Fig.15 View of the *qubba*


Fig.16 Internal view of the *bit mul al-bahwu*


Fig.17 Detail of the gesso decoration of the *bit mul al-bahwu*

The "*mushrabiya*" is a 'diaphragm' delimitated externally by a wooden structure divided into two parts: the lower part with a close grate and the upper one with a large-meshed net. This architectural frame can actively benefit the inner space and has several useful functions (Picone (2001)):
- control of air flow
- reduction of air temperature
- creation of natural ventilation
- control of light
- protection of privacy
- aesthetic function of embellishment


Fig.18 View of an example of *mushrabiya*

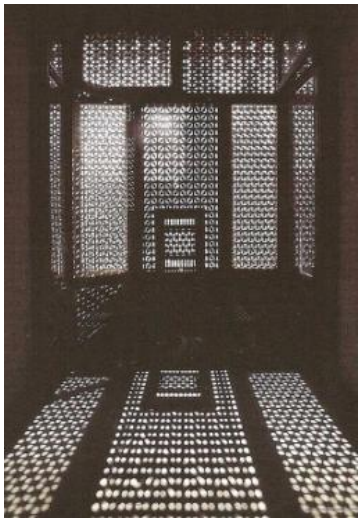
Fig.19 Internal view of an example of *mushrabiya*

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On the top of the building there was always a terrace, "*suth"*, an outdoor place for private life. The women more than men, hidden from the indiscretion of the road, used this space to communicate with the neighbourhood. During the night, when the five main doors of the medina "Bad El Alou, El Had, Rouah, Cellah and Bab Oudaya" were closed the terraces were used like streets to reach different areas of the city becoming therefore an 'elevated city'. It is interesting to note how the urban space in the Moroccan city changes in relation to the time of day.

State of preservation

The analysis of the Dar Dgi'ra showed that the construction materials used were: clay, stone, plaster, ceramic zellige, tiles for floor and a mix of concrete and clay for the external walls. The mix of concrete, stone of various sizes with clay, allowed the consolidation of the structure that otherwise would have been too fragile.

The walls were built using the "Pisé technique" that consists of compacting the slightly damped ground in formworks with the help of a piseur. This eco-friendly technique allows the construction of monolithic walls up to two or three floors without energy or processing machines. It reduces the cost of transportation and consumption of non-renewable raw materials and it is suitable for do-it-yourself too.

It is a good rule to erect the unbaked earth walls on a stone plinth to protect them against rising damp. Moreover, the stone distributes the load of the structure evenly forming a barrier to the capillary rise of soil moisture. To sum up, the unbaked earthen buildings breathe and are hygroscopic and exempt from the phenomenon of static electricity.

They are very durable and with good structural capacities (A.A. V.V. (2005)).

<u>Performance data:</u>

Density: 1000 - 1600 Kg/m^3

Heat transmission rate: 1,7-2,3 W/m^2K

Water vapour diffusion resistance : μ 7

Soundproofing: 500 Hz 45 dB

Compression-resistance <30Kg/cm^2

Fig. 20 Detail of the wall in Pisé of the Dar Dgi'ra

Fig. 21 Detail of the materials granulometry of a wall

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Regarding the features and materials, the analysis revealed that there was some important degradations. The vertical structure was the most affected, owing mainly to capillary rising damp. During the renovation in 1956 the introduction of washable plaster on the lower part of the walls moved the issue to a higher level, worsening the situation rather than solving it. Furthermore, the humidity heavily damaged some of the wooden boards of the floors causing marcescence. The decay was bad enough to require a replacement. From the observation of the cracks it was clear that the building, near the hammam, had subsided vertically owing to the waterlogged soil. Practically, for many years the hammam had discharged the water into the ground because of the lack of a draining system. To overcome that serious problem, as the flooring was not original anymore, an effective solution would be the introduction of a ventilation system (e.g. igloos) located in the basement of the ground floor.
The presence of features on the south and west facades showed that the building was falling outwards. The eccentricity evaluation of the loads acting on a portion of the external wall confirmed the assessment. To overcome this problem the joists should be consolidated on site vicing them to the beams present in the wall as the fragile consistency of the wall (Pisé tecnique) would not allow the use of tension rods.

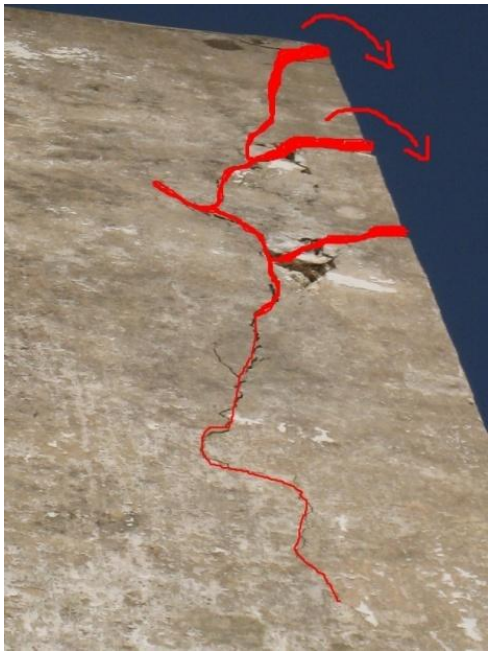

Fig. 22 Detail of a crack on the external elevation

Fig. 23 Detail of features on the main elevation

Fig. 24 Detail of feature on the terrace wall

Analysis of the material decay:
The conservation project aims to eliminate the causes that led to the onset of the state of disrepair. The analysis of the degradation took into consideration both "extrinsic causes" that are in fact nearly always present, and "intrinsic causes" based on the weakness of the construction.
It is possible to identify three types of decay:
- physical degradation: mainly due to the mineralogic composition and texture of materials. e.g.: crystallization of salts.

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- chemical degradation which is always linked to the presence of water in materials due to rain or condensation. e.g.: acid rains.
- biological degradation: mainly due to the action of animals and plants.

The most common "extrinsic cause" is water. This seems to be the main cause of the chemical decay mechanisms such as salt crystallization, carbonation, sulphation ..etc. The growth of biological organisms that cause degradation is consequently accelerated.
The analysis of the material decay of the Dar Dgi'ra revealed the following main pathologies:

- Efflorescence
- Biological patina: thin homogeneous layer formed by microorganisms variable for texture, colour and adhesion to the substrate in relation to environmental conditions
- Erosion and corrosion: phenomenon of natural decay of metallic materials due to chemical reactions with the environment;
- Exfoliation and detachment;
- Black crust: alteration of the superficial layer of materials of variable thickness, often distinguishable by the colour.

The final step of the analysis was the drawing up of synthesis cards describing each type of decay with the respective intervention to take place.

The conservation project can be divided into three distinct phases: cleaning, consolidation and protection.

Cleaning:
The aim of the cleaning consists in removing deposits, encrustations, various layers of decay without producing material damage. It is one of the most complex operations and it requires careful analysis of the problem, a thorough knowledge both of the specific nature of degradation and of the consistency of the materials. It is necessary to strengthen the surface to prevent loss of material during the cleaning (eg. with ethyl silicate).

Consolidation:
The consolidation is a rather complex and delicate action within the conservation project.
It requires careful analysis of the general pathological picture. It includes a series of treatments aimed at improving the cohesion and adhesion between the components of the materials; with this process the mechanical strength is reinforced and it is more difficult for water, saline and acid solutions to attack the components.

Protection:
The protection has the purpose of limiting and reducing the process of transformation, from which the material tends to suffer because of the imbalance that occurs within the environment in which it is placed.
Some specific products, always preceded by laboratory tests which verified the actual effectiveness, will therefore be applied to create a protective shield. Furthermore, the application of protective products is common practice for the periodic maintenance post-intervention. The main characteristics required in a protective chemical product are reversibility and unalterability.

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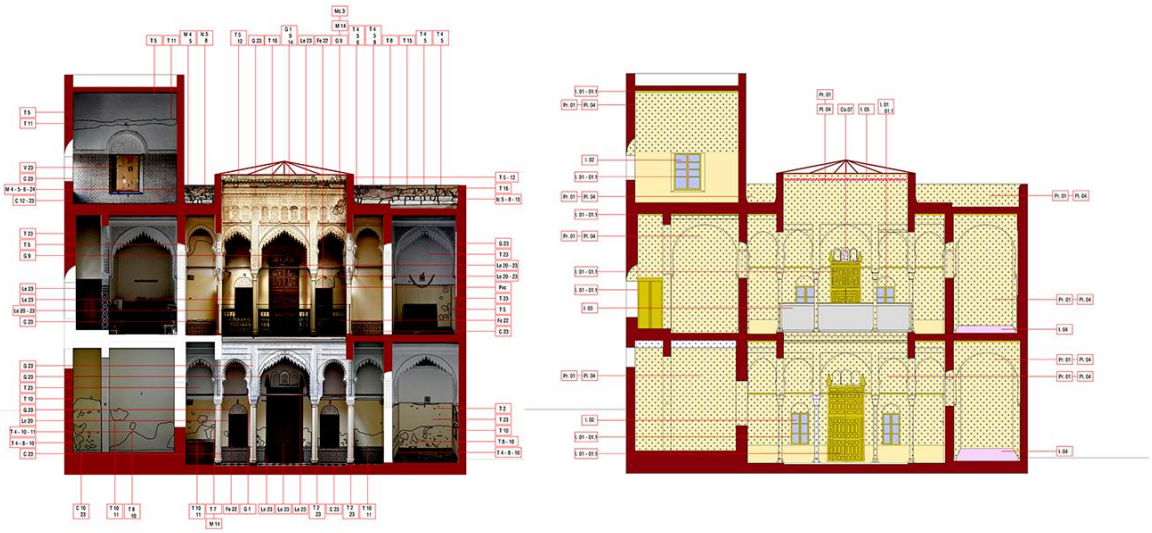

Fig. 25 Conservation project of the materials

The reuse project

The reuse project as a public *hammam* emerged from the idea to offer a place deeply rooted in the Arabic culture to this part of the town. In addition, being the area located in the city centre it could attract many people who could enjoy this service which remains faithful to tradition. Thus, the design proposal was conceived both as an opportunity to improve corporal well-being before the daily prayers, and as a place of socialization.

The word *hammam* derives from the Arabic verb "to warm" (the literal translation is "heat spreader") and indicates all places where Muslims perform ritual ablutions so as to be pure before the daily prayers (Mozzati (2009)).

Religious motivations, mixed with hygiene requirements and social practice made these spaces a popular meeting point.

Furthermore, in ancient times open pools had also a "divine" significance, precisely, the sky mirroring in the water allowed the study of the stars as in a Planetarium.

The renovation project of Dar Dgi'ra as public hammam therefore has been conceived as a place where purification took place by walking through three pools: Calidarium, Tepidarium and Frigidarium.

- Calidarium: hot room full of steam with a temperature between 30° and 60° degrees
- Tepidarium: lukewarm room with heated marble benches
- Frigidarium: cool room with a temperature between 20°and 25° degrees
- Apoditerium: room usually covered by a dome and fitted with a fountain in the middle, equipped with benches where people can meet and chat (Mozzati (2009)).

The choice for a SPA took into consideration important aspects such as: geographic location, proximity to the ocean, exposure of the sun, wind and above all the presence of a small hammam inside the house.

Being a public building, a lift has been planned to guarantee an easy access for disabled people to all the floors.

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The lift placed externally on the main facade has been properly hidden by a metallic "*mushrabiya*" designed with simpler patterns than traditional ones. This choice emerged from the need to satisfy practical needs in a discrete way.

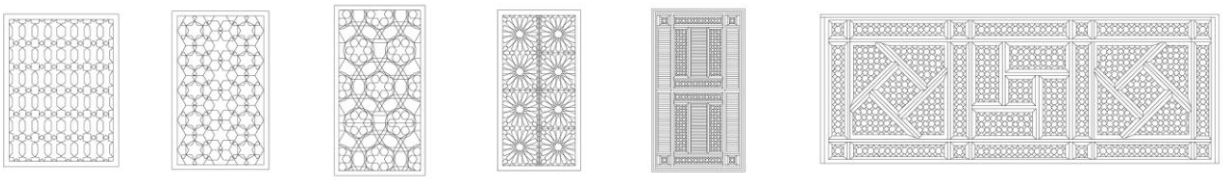

Fig. 26 Geometrical study of the *mushrabiya* metal structure

The new internal layout is structured this way:

- Ground floor: hammam with three pools. Realm of water and relaxation
- First floor: beauty centre for ladies
- Second floor and terrace: tea rooms and refreshment area.

As far as the maintenance of the building the radiant heaters have been placed inside the floor and solar panels orientated to south have been located on the roof to use solar energy to warm the pools.

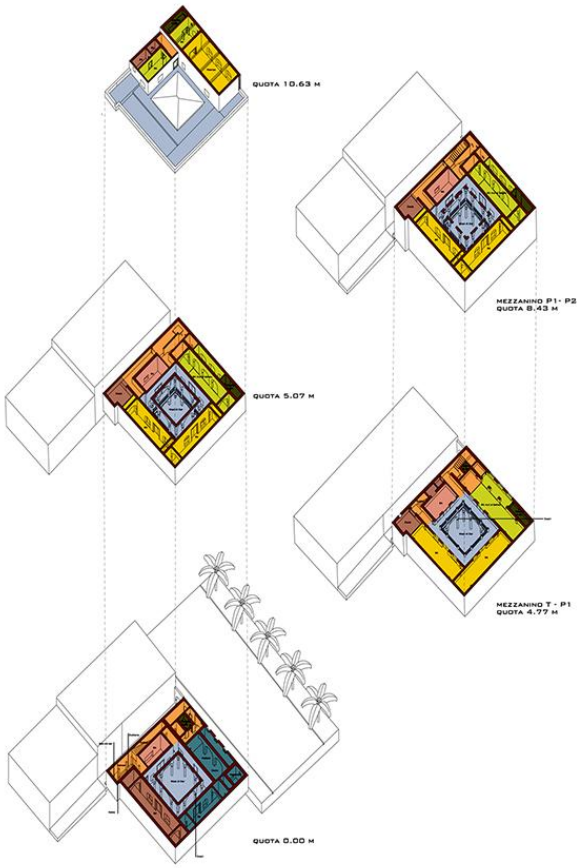

Fig. 27 The reuse project: the public *hammam* (SPA)

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From 1956 until 2005 the building was used as a school and for practical reasons an iron-glass roof was built. The main problem was the inadequate connection of the new roof to the building. Therefore, owing to the penetration of water from the covering, the gesso decorations placed in the lower part of the cover have been seriously damaged. As a rule in Morocco, decorations are rebuilt with layers of gesso on the original surface. It is clear that over time signs and decorations get lost.

Fig. 28 View of the iron-glass roof from the terrace

Fig. 29 Detail of the iron-glass roof

To remedy the existing state of alteration, both a new roof and a conservative intervention on the decoration frieze have been designed. As for the decoration, a simpler pattern located at lower level than the original has been considered in order to clearly show the new intervention. Meanwhile to solve the problem of linking, a new roof (a dome) has been designed following the Arabian tradition.

Usually the lighting in the hammam filtered through the "eyes of the dome" of different geometric shape called "*ommriyad*" (Picone (2001)). In addition, the choice to use this typology of coverage came from both the need to abide by the tradition and to introduce an effective bio-climatic device.

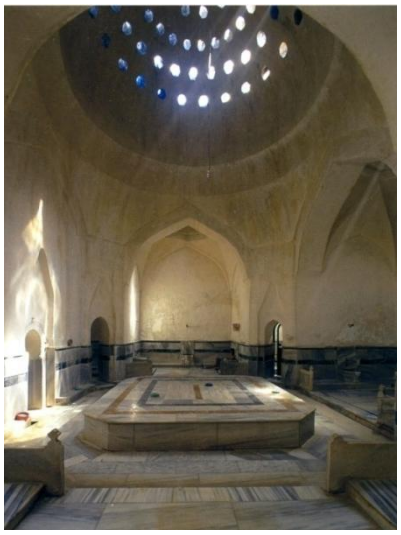

Fig. 30 Internal view of a traditional *hammam* (Mozzati (2009)).

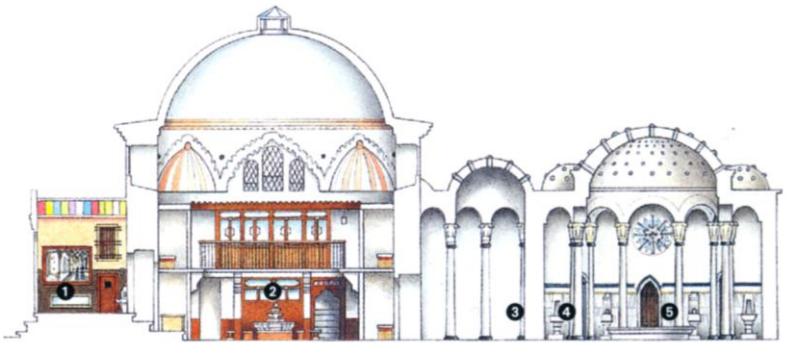

Fig. 31 Drawing of a traditional *hammam* (Mozzati (2009)).

Indeed, the domes can be greatly beneficial for the inner spaces in different ways (Moretti (2006)):

- the lower layers are fresher than the upper ones since the dome collects the hot air on the top due to its greater height.

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- thermal effect is less in the environment below due to the fact that the rays of sun light hit a greater surface than a flat roof
- Greater extraction of heat on the surface of the dome due to the larger surface area exposed to the night sky.
-

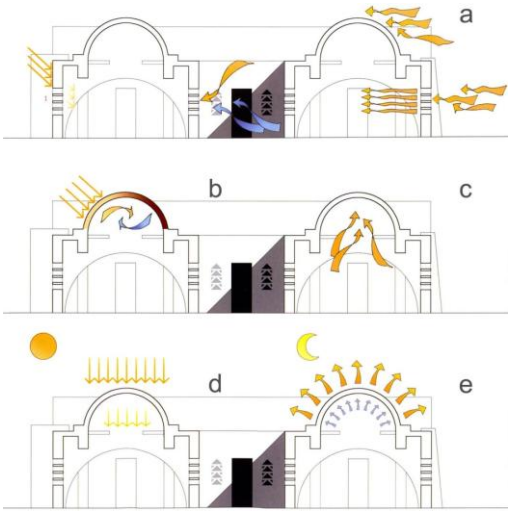

Fig. 32 Dome benefits (Moretti (2006)

Dome features:

The dome has been designed as an octagon to perfectly join to the existing square walls of the patio. The internal height of the dome is only 2.10 m and the maximum distance between two opposite sides of the cover is equal to 5.70 m (diameter of the dome). The modest dome dimension allows maintenance works, a fundamental aspect to prevent the loss of the gesso decorations, and provide satisfactory internal comfort.

The main structure of the dome is made up of eight curved beams made of laminated wood. To prevent excessive deformation of the dome (also due to wind load) three levels of wooden chains with rectangular section (10x5 cm) have been positioned at the bottom, at the centre and at the upper part of the main beam.

On the top, a circular ring of steel covered with wood (glued with resins) has been placed. It joins the eight main beams to the lantern allowing ventilation as a consequence. On the lower part, the eight main beams are connected to the wooden tambour by L shaped iron plates.

The dome in CORT-TEN (weathering steels) consists in the juxtaposition of two skins perforated by holes appropriately staggered to achieve interesting geometric patterns with light and shadow in the space below.

In addition, in the air space between the two skins a curvilinear Perspex sheet and an insulating board have been introduced to insulate the patio from weather conditions.

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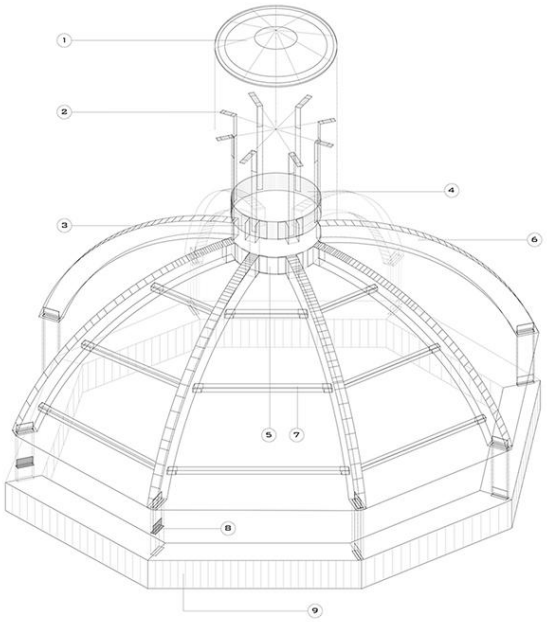

Fig. 33 Axonometric view of the dome

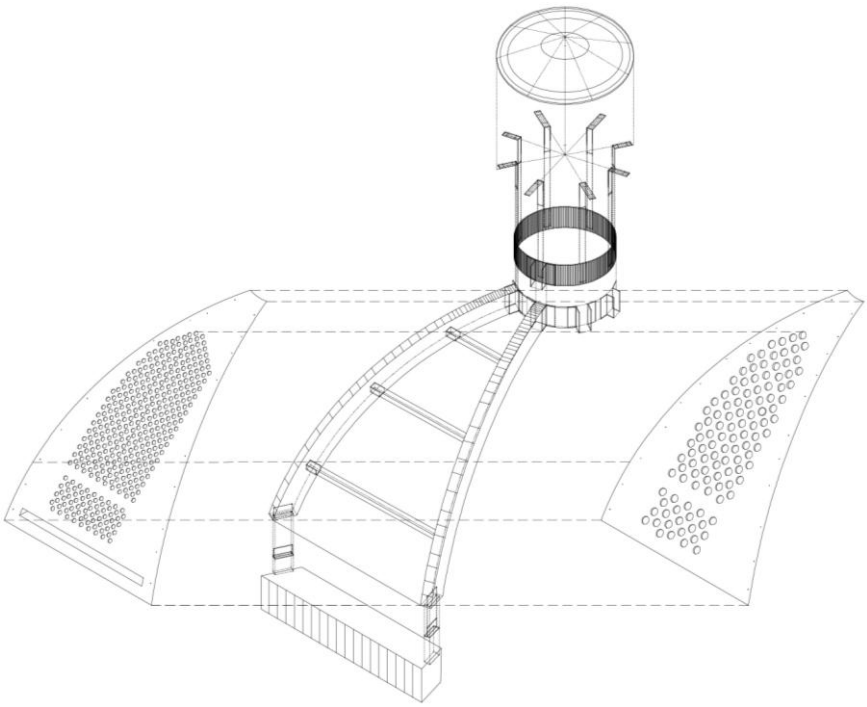

Fig. 34 Detail of the two skins in CORT-TEN

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Conclusion

The purpose of this study has been to analyze courtyard characteristics through a case study.
This work has shown that a courtyard can guarantee privacy, safety, easy accessibility to all spaces, wellbeing, social interaction and both good daily light and ventilation. Thus, the courtyard is an effective and significant typology to answer private and public needs. The three main functions characterizing the courtyard typology concern the aesthetic, thermal and social aspects and they are strongly related to each other. Considering the aesthetic aspect the main advantages are given by the achievement of the privacy, safety and easy accessibility to all spaces. However, it should be pointed out that a possible limit could be the sensation of seclusion or isolation of the dwellers provoked by an extreme condition of privacy due to the fact that exterior cannot have any contacts with the interior or vice versa. Moreover, thermal advantages are given by a good sunlight both in hot and cold climates. Nevertheless, in northern climates one limit could be bad weather. Since the courtyard is an open and passing space it could not be considered an optimal solution during wintertime due to the fact that the atmospheric conditions influence the convenience and the easiness of residents' movement. Another possible limit could be the proportions of the patio in relation to the height of the building. The higher the building is the wider the courtyard should be in order to guarantee ventilation otherwise, sultriness would result. Finally, the courtyard provides privacy, protection and sense of safety. So, it is clear that the proportions of the patio are fundamental to obtain thermal benefits whereas ventilation, sun light and vegetation can actively contribute to the mental and physical wellbeing of the residents. People live and enjoy the space improving social interaction. The three examined aspects are in strong connection through a cause-effect link: each aspect contributes to improve the other ones with the result of complete wellbeing of the residents. To sum up, the literature review shows that the courtyard is an introvertive type of dwelling that actively contributes to the comfort and socialization of residents. The analysis of the case study Dar Dgi'ra shows that religion, ethos and culture have strongly influenced the layout of this élite type of dwelling pointing out how family behaves behind the doors of the Moroccan home. Routine duties and religious experience have shaped the home to meet everyday demands of domestic life. The women's role is distinctively evident both by the location of their rooms and by the ingenious fret work panels (*mushrabiya*) placed on the windows. Concerning the technical investigation, the static and material analysis shows that the structure was falling down because of saturated soil due to the lack of a drainage system close to the hammam. Consequently a conservation project both of the structure and the materials should be done. Specifically, the connection between the joists and the beams placed inside the wall should be consolidated on site as the fragile consistency of the wall (Pisé technique) does not allow for the positioning of tension rods. In conclusion, this research has shown how tradition can be a fundamental source of knowledge in designing sustainable contemporary architecture and also how reuse and adaptation can contribute to regeneration and sustainability on many levels.

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