

THE PHYSICAL AND CLIMATIC DIMENSIONS OF THE MEDITERRANEAN HAMMĀMS

Jean Bouillot

Abstract

This paper attempts to explore the different experiences inside case study hammāms in a number of Mediterranean countries. It investigates the physical, climatic, bioclimatic, psychological as well as bathing and ritual aspects. The hammāms are located in six Mediterranean cities : Fez, Constantine, Cairo, Damascus, Tripoli and Ankara. Two main analyses are carried out of the two zones composing the hammāms : the passive ones with their specific devices and the active ones with different thermo-dynamic systems. General statements can be made from the climatic point of view : the hammām design is different and specific from one country to another ; all hammāms of the same city are designed in the same standards despite the fact that they were built at different historic periods. This allows us to point out the importance of the impact of the climate on the hammām design in order to achieve human comfort. Hence it is necessary to assess the passive energy areas directly linked to the outside urban context (i.e. spaces paths, souks and streets). There is also the need to assess the climate influence on the design of active areas, as this is the case in Cairo where the hot water pools have been developed possibly in order to prevent dehydration caused by the hot arid climate.

Keywords:

Hammām, water, energy, passive, active.

Introduction

The physical dimension of the hammām's experience is linked to the different senses of the human body i.e. touch, sight, hearing and smell. Most of the physical experience inside the hammām is bio-climatic and relates to the inter-relation between the air temperature and humidity and the body. Therefore the hammam is designed in order to provide certain thermal comfort conditions. These are linked to the rise in both the air temperature and hygrometry i.e. providing a "steam bath" which helps the sudation of the body. Surrounded by hot-dry conditions, the hammām could be considered as an itinerary through spaces with progressive increase in hot-humid conditions and back to the normal climate.

This progression takes place through three main areas:

- The urban microclimate : it is the outside passive area of paths, souks and gardens where the local climatic conditions are "corrected" by outside natural devices such as trees, canopies

and fountains, in order to make them more comfortable.

- The hammām passive area : is the inside area of the reception, the changing room and the rest hall where the internal thermal-dynamic devices such as air stratification, air movements, buried pit, fountains, high ventilation and high thermal mass help create comfortable conditions both in summer and in winter. They generally remain inside the comfort zone of the building bi-climatic chart (tab.1 and annex 2).

- The hammām active area : is the bathing area where the saturated environment, near approximately 35°C T° / 100% H° is provided through several rooms : frigidarium (cool), tepidarium (warm), calidarium (hot). The thermal-hygro-metry conditions are obtained through the internal production of energy i.e. burning fuel in the furnace in order to heat the water and produce steam, as well as providing under floor heating in the bathing spaces. Specific devices and practices are used for the same purpose in order to adapt to the local climatic conditions. Comparing the some of the architectural features of the hammāms in the case study cities, the following observations have been made :

- in Cairo : the elevated rest areas in the changing room is covered with a flat wooden roof with lanterns. The entrance has a lobby area, and a central fountain in the undressing room is a frequent feature. In the bathing areas there are hot water plunge pools in elevated small rooms.

- in Ankara the undressing room has a high dome and an upper gallery. A central fountain is a recurrent feature as well as a large dome

over the main central bathing space which has a number of iwans and low passageways.

- in Fez, the undressing room has a high dome and a wall fountain, the bathing spaces consist of a progression of rectangular spaces with barrel vaults and hot and cold water tanks.

- in Damascus, the undressing room has a high dome with centrally located fountain surrounded by raised sitting areas. An under floor duct travels from the furnace to the hot and warm rooms.

- in Constantine, there are buffer spaces between some of the bathing spaces and the undressing room has an upper gallery and a central dome.

These observations highlight some of the local characteristics of the hammāms as buildings which can be explained according to local climatic and cultural factors..

Climates

The case study buildings analysed in this paper are located in a number of countries around the Mediterranean. Field work was carried out in Tripoli (Lebanon) in November 2005, then Cairo (Egypt) in March 2006, then Ankara (Turkey) in July 2006, Fez (Morocco) in November 2006, Damascus (Syria) in February 2007 and finally Constantine (Algeria) in May 2007 (figure. 1).

The main goal of this study is to compare the same building type, the hammām (or Islamic public bath) in different climates and analyse the passive environmental solutions adopted in each location.

One can distinguish four kinds of climates (table 1):

- Coastal climate in Tripoli-Lebanon where both the sea proximity and the zero-altitude limit the year temperature range with a regular medium humidity ;
- Alluvial plain climate in Cairo-Egypt where the daily humidity ranges from normal humidity to dryness during two moderately contrasted seasons throughout the year
- Semi-humid southern plateau climates in Fez and in Constantine without total dryness in summer and no extreme cold in winter.
- Dry plateau climates in Damascus-Syria and in Ankara-Turkey with long dry summers and cold winters influenced by northern winds.



Figure 1: Mediterranean Cities in HAMMAM Project. (Source: Author).

Microclimatic sequences (table 1)

Bioclimatic surveys have been carried out inside the hammāms at different times of the year (March, July, November, February, May). Therefore the results cannot be compared directly.

The Analysis of the data obtained from the measurements of temperature and humidity taken outside the hammām (the street) and the entrance lobby area, shows that they fall within the comfort zone of the chart in Cairo (March), Ankara (July) and Fez (November). However, this is not the case for the data gathered for Damascus and Constantine where measurements were made during February and November respectively.

In February the temperatures fall down in Damascus and the entrance lobby temperature in the hammāms is 13°C at worst (al-Omari hammām) and 19°C at best without any heating (al- Silsile hammam). The lobbies remain in the comfort zone in the summer which is the longest season in the year; the passive systems in the lobbies are mostly designed according to this major season.

The results concerning the bathing spaces themselves (frigidarium, tepidarium, calidarium) can be compared to one another as the environments are heated and humidified by an active way throughout the year. Although the building inertia might be different between the various case study buildings with some hammāms being partially sunken in the ground, the results still allow comparison between the different active bathing spaces of the different hammāms.

Another important aspect to observe is the relative positions of the different measurements inside the active zone of the hammāms ; at best these positions reveal good progression sequences, at worst they reveal problems which are caused more often by poor maintenance or insensitive modifications of the spaces.

TOPICS CITIES	CLIMATES.....	Comfort in passive areas (number of months)	SEQUENCES ● outside & lobby → inside	Comments..... about sequences
CAIRO 30° lat 75 m alt 180 km from the sea 25 mm 22°C 51% temp-dry / hot-dry		<ul style="list-style-type: none"> . 3 : passive solar heating . 9 : shading . 9 : inertia . 7 : ventilation . 7 : evaporative cooling 		On 1 st March 06 Good progression in the temperatures and humidity even if the 3 rd point (frigidarium) could be closer to the 4 th , a door is missing.
ANKARA 40° lat 861 m alt 200 km from the sea 345 mm 11.7°C 58% cold-norm / hot-dry		<ul style="list-style-type: none"> . 6 : heating . 8 : passive solar heating . 6 : shading . 4 : inertia . 4 : ventilation . 4 : evaporative cooling 		On 5 th July 06 The curve initially close to vertical (frigidarium too much humid) becomes oblique (calidarium like a sauna). Distance from passive to active area.
FEZ 34° lat 415 m alt 120 km from the sea 537 mm 17.9°C 68% temp-norm / hot-norm		<ul style="list-style-type: none"> . 3 : heating . 6 : passive solar heating . 7 : shading . 6 : inertia . 6 : ventilation . 2 : evaporative cooling 		On 11 th November 06 The profile of the curve is good but in the hammam the tepidarium precedes the calidarium and that disorders the real sequence.
DAMASCUS 33° lat 719m alt 80 km from the sea 218 mm 17.2°C 47% temp-norm / hot-dry		<ul style="list-style-type: none"> . 3 : heating . 4 : passive solar heating . 7 : shading . 6 : inertia . 6 : ventilation . 6 : evaporative cooling 		On 15 th February 07 Even with a horizontal tendency in the tepidarium the sequence is quite balanced with a correct progression in the main rooms.
CONSTANTINE 36° lat 694 m alt 80 km from the sea 513 mm 12.6°C 68% temp-norm / hot-norm		<ul style="list-style-type: none"> . 4 : heating . 8 : passive solar heating . 6 : shading . 4 : inertia . 4 : ventilation 		On 7 th May 07 There is a strong disparity between the frigidarium close to the passive area and the other rooms of the active area : a door is missing between the two.
TRIPOLI 34° lat 10 m alt 2 km from the sea 901 mm 20.5°C 66% temperate - normal		<ul style="list-style-type: none"> . 2 : heating . 6 : passive solar heating . 8 : shading . 6 : inertia . 6 : ventilation 		Visit in November 05 but no measures

Table 1 : Climate and Bioclimatic Sequences Inside the Hammām Case Study. The climates are evaluated following a twin scale temperature/hygro-metry: cold, temperate & hot for temperatures ; humid (hum), normal (norm) & dry for hygro-metry. The combination of the two components gives typical extreme seasons: temp-dry / hot-dry (Cairo), cold-norm / hot-dry (Ankara), temp-nor/hot-dry (Damascus), temp-norm / hot-norm (Fez, Constantine). (Bouillot, 2001). Order of rooms in passive area & one graphs : 1 frigidarium (cool), 2 tepidarium (warm), 3 calidarium (hot). (Source: Author).

In addition to minor transformations such as doors missing between bathing spaces in Cairo and in Constantine, more drastic modifications are found such as the calidarium being transformed into a sauna and partitions introduced in the tepidarium in the case study of Ankara, or the inversion of circulation between the calidarium and the tepidarium in Fez. The sequences between the passive area (entrance lobby & rest areas) and the active area (frigidarium, tepidarium, calidarium) are clearly identified with the thermo-hygrometry environment. Hence what is the role of the architectural design in a hammām building?

Bioclimatic Behaviour and Devices in the Passive Areas (table 2)

Inside this first zone of the hammām, the architectural design aims to create a comfortable thermo-hygrometry environment with passive means. These conditions should remain inside the comfort zone throughout the year. The results indicate that the comfort zone in these spaces is maintained in the case of Cairo (in March), Ankara (in July), Fez (in November) and Constantine (in May). However, this was not the case in Damascus (in February) as the entrance to the case study hammām changing room opens directly onto the street (no buffer zone exists as is the case of all the other countries) and the door is frequently left open.

Dome Structures

Considering table 2, the verticality and the dome structure of the changing area are the dominant design elements, except in Cairo where almost all hammāms have a flat wooden roof with natural lighting and ventilation lanterns. This is the case in hammāms of Bab el

Bahr and Tambali.

In the summer periods, the height of the dome allows for stack effect to take place and the central fountain provides evaporative cooling of the undressing room. During the day, the lighter hot air can be eliminated through the oculus and the lantern windows, while the heavier cool air accumulated in the lower parts of the changing room during the night remains during most of the day as is the case in the courtyards of the neighbouring houses.

In winter, all the openings are closed and the water is stopped from the fountain. Hence the heat from the bathing spaces is stored in the heavy mass of the building and participate to convection air movements inside the volume. The vertical proportions of the changing area show that the summer thermal conditions are the most important to manage.

Mineral Walls

All hammāms walls were built of stones, and more rarely of brick (Egypt). This was meant to support the roofing structures, the ground pressures when the building is sunken in the ground, and to give a strong inertia to the building.

A Partially Sunken Structure

In Cairo, Damascus and Tripoli, the buildings are partially sunken into the ground and this helps to increase the inertia of the building and its capacity to store energy as it takes advantage of the ground insulation. Throughout the year, the thermal mass of the building helps to store heat inside the structures; this helps to keep the spaces warm during the winter. In the summer season, night ventilation allows to store cool air in the undressing room.

	Passive areas SUMMER	Devices & Materials	Passive areas WINTER	COMMENTS
C A I R O		<ul style="list-style-type: none"> . Cubic wooden volume . Flat mud roof . Wooden lantern . Towel drying attic . Burying . Central pit . Lateral upper floors 		<p>The partial burying system is efficient during the whole year, and the central pit allows entry of cool air in summer & protect against cold air in winter.</p> <p>The attic blocks summer heat & helps the drying of towels in winter</p>
A N K A R A		<ul style="list-style-type: none"> . Wooden dome volume . Lantern . Upper gallery . Stone walls with high windows . Towel drying attic . Central fountain . Stove 		<p>The high dome makes anabatic air movements easier all year long and provides a gallery to enjoy warmth and dry towels in winter.</p> <p>The fountain coolness in summer & the stove improves warmth in winter.</p>
F E Z		<ul style="list-style-type: none"> . High brick dome volume . Oculus . Lateral galleries . Stone walls . Lateral fountain 		<p>In summer the hot air can be let out while in winter it can be preserved to promote convection movements useful to the recycling of cold air.</p>
D A M A S C U S		<ul style="list-style-type: none"> . High brick dome volume . Top oculus . Lantern . Stone walls . Burying . Central pit & stairs . Sitting iwans . Smoke chimney . Centre fountain 		<p>The combination of the high dome with the buried central pit with stairs maximizes the thermal polarities. It keeps coolness in summer and warmth in winter due to convection air movements</p>
C O N S T A N T .		<ul style="list-style-type: none"> . Brick dome on centre cubic volume . Lower & upper galleries . Lateral upper windows . Stone walls . Towel drying gallery . Entrance skiffa . Buffer spaces 		<p>Like in Ankara the gallery can be used to provide warmth and dry towels during winter due to sun rays penetration (morning time mainly).</p> <p>The Skiffa entrance buffer space insulate the changing room throughout the whole year</p>
T R I P O L I		<ul style="list-style-type: none"> . High stone dome volume . Top oculus . Lantern . Stone walls . Central pit & stairs . Sitting iwans . Central fountain 		<p>The high central dome has been designed mainly for summer but the deep iwans around the central pit are best appreciated in winter to sit in warmer areas away from the cool air and to enjoy the strong inertia which keeps the building warm.</p>

Table 2 : Seasonal Bioclimatic Behaviour in Passive Areas. (Source: Author).

Pit System

The fact that the hammāms are partially sunken helps them to benefit from the pit system (a sunken floor area in the changing room) which allows the cool air to concentrate at the bottom of the undressing room and the warm air to accumulate in the upper air layers of the changing rooms, hence the availability of raised sitting areas in the the hammāms of Cairo, Damascus and Tripoli.

Mezzanine Level in the Changing Areas

The availability of raised changing areas in the undressing room is achieved in Ankara and Constantine through the availability of mezzanine levels. These raised areas offer warmer rest spaces during the winter season when the year temperatures are at their lowest (11.7 & 12.6°C). Furthermore, high spaces and mezzanine galleries also help to dry towels during the winter by taking advantage of the natural air stratification and air movement convection.

Entrance Buffer Spaces

In almost all the hammāms investigated, the entrance from the outside to the changing area is provided with a buffer space which insulates it from the outside air temperature both in winter and summer.

Heating

The heat losses from the active area (the bathing spaces) benefit the changing area. In colder climate seasons, stoves are used to heat the changing areas in the hammāms of Ankara and in Constantine. In Damascus case study hammāms, the heat from the chimney located in the warm room also contributes to the heating of the changing room.

Thermo Dynamic Systems and Behaviour in Active Areas (table 3)

Table 3 illustrates the main sequences inside the active area of the hammāms, from the grey arrow (entrance lobby) to the last room (calidarium). Usually, the sequence includes three main rooms: frigidarium, tepidarium, calidarium, like in the antique Roman thermal baths.

One can observe the two main organizations in the plans of hammāms around the Mediterranean:

- the directly Roman influenced one in Fez and in Constantine with linear sequences, barrel vaults and bucket system for water
 - the Ottoman system with tepidarium centred plan, domes and fixed individual basins system for water in Ankara and in Cairo
- And two particular and mixed cases with :
- linear-centred in Damascus combining the two organizations
 - linear-multi centred in Tripoli

In all these cases, except in Amouneh-Damascus, the tepidarium is the largest room inside the hammām : here the air and floor temperatures allow most of the users of the hammām to stay for a long period.

Heating-Steaming Systems

The systems of space heating and production of steam for the bathing spaces are similar in all the hammāms of the same city but vary from one country to another as follows:

- hot water pool in Cairo
- hot water tank with steam window and hot massage bench in Ankara and in Tripoli
- hot water basin inside the calidarium and the

hypocaust in Fez

- hot water tank with steam window and hypocaust tunnel in Damascus

- hot water basin inside the calidarium and hot massage bench in Constantine




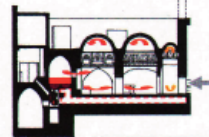


	ACTIVE AREAS.....	Devices & Materials	COMMENTS....
CAIRO		<ul style="list-style-type: none"> . Brick domes . Stone walls . Octagonal tepidarium . Central dome missing . 4 iwan structures . Burying . Hot water steaming pool . Massage bench with hot water fountain . Plumbing & bows 	<p>In Cairo the octagonal ottoman plan gathers 8 rooms around the central tepidarium.</p> <p>On one side the calidarium is situated higher, with a hot pool generating steam which is kept inside with the heat thanks to the dome working like a siphon.</p> <p>Doors are missing between the frigidarium and the lobby.</p>
ANKARA		<ul style="list-style-type: none"> . Brick domes . Stone walls . Octagonal tepidarium . 3 iwan structures . iwan partitioning . Hot massage bench . No steam room . Sauna & far cool pool . Plumbing and bows 	<p>In Ankara the traditional steam room calidarium, which is connected to the hot water tank has been transformed into a sauna room with under-floor hypocaust and cool pool.</p> <p>Iwans have been transformed to individual cabins.</p> <p>No steam in calidarium, no space in tepidarium</p>
FEZ		<ul style="list-style-type: none"> . Brick barrel vaults . Stone walls . Linear structure with volume progression . Hypocaust calidarium . Massage on floor . No plumbing & no bows . Hot & cold water basins in calidarium with buckets . Steaming hot water basin 	<p>The progression frigidarium-tepidarium has been inverted (card pages 1 & 3) perturbing the usual linear one (page 2).</p> <p>The volume proportions (from the low horizontal one in the frigidarium to the high narrow one in the calidarium) and the low door help keep the calidarium warm.</p>
DAMASCUS		<ul style="list-style-type: none"> . Brick domes . Stone walls . Burying . Linear structure . Hypocaust tunnel . Steam from hot water tank . Massage bench . Plumbing & bows . Large calidarium with lateral room 	<p>The rooms are organized along the buried smoke pipe which heats them successively.</p> <p>At the opposite of other hammams, where the tepidarium is the main room, the Damascus hammams adopt a linear calidarium with several smaller rooms alongside.</p>
CONSTANTINE		<ul style="list-style-type: none"> . Brick barrel vaults . Stone walls . Linear structure . Buffer spaces between rooms . Hot massage bench . High ventilations . Steaming hot water basin . Hot & cold water basins in calidarium with buckets 	<p>As for the Skiffa in the lobby, a ventilated buffer space insulates the calidarium from the frigidarium. Another skiffa between the frigidarium and the lobby has been cancelled.</p> <p>Many common features with Fez hammams</p>
TRIPOLI		<ul style="list-style-type: none"> . Brick domes . Stone walls . Linear structure with volume progression . Hot massage bench . Steam from hot water tank . Plumbing & bows 	<p>The volume progression in Tripoli, different from the Fez one, aims at the same target: keeping the heat inside the hammam, but the large dimensions of the successive rooms require much more energy, the thermal mass of the stone walls allow the storage of heat</p>

Table 3 : Thermo-Hygrometry Systems and Behaviour in Active Areas(Source: Author).

It is possible to classify these techniques according to the geographic region as follows:

- The systems of the hot water pool (Cairo) or hot water basins (Fez and Constantine) located in the hot room (calidarium) are found in North African countries. In the case of Fez in Morocco and Constantine in Algeria, hot water is collected from the hot water pool in the hot room, using buckets. This could be the result of climatic, but also cultural and historical factors. In the hammāms of Cairo the hot water pools are plunge pools. However, hot water for washing is collected in individual washing basins with hot and cold water tabs. This is certainly climatically well-adapted to the local dry and dusty environment.

- The systems with hot water tank in the furnace, a steam window in the hot room, fixed individual stone washing basins and a hot massage stone table are typical features of the hammāms in the near East as they are found in Ankara (Turkey), Tripoli (Lebanon) and Damascus (Syria). In the case study of the hammām in Ankara the steam window has been removed and the steam room has been transformed into a hot dry room (called sauna by hammām managers).

Volume Sequences

All the bathing areas of the hammāms (in all case study cities) are covered by a system of vaults and domes:

- A system of barrel vaults is widely used in Fez and in Constantine
 - Domes are widely used on the hot rooms of the hammāms of Cairo, Damascus, Ankara and in Tripoli

In the two cases, contrary to a flat ceiling, a curved one has been adopted to help improve

the air convection circulation from bottom to top (anabatic) and from top to bottom (katabatic). The flat roof replacing the former dome above the tepidarium of hammām Bab el Bahr in Cairo is not a good solution because it causes damp niches in upper angles.

The organization of the volume sequences is :

- In Cairo (tab.3): following a low large dome in the frigidarium, the high domed (formerly) tepidarium is supplied by the higher hot pool calidarium. Air stratification and siphon effect of this last room organize the heat and steam distribution inside the tepidarium. (Bouillot 2006).

- In Fez-Saffarin (fig. 2), the high progression of the barrel vaults helps to concentrate the heat and the steam inside the last high-narrow calidarium. Furthermore, the steam from the hot water basin, the absence of doors between the rooms and the water on the floor above the hypocaust help to concentrate heat and steam in the calidarium and diffuse them progressively inside the other rooms; the normal progression from the changing room has been disrupted by entering the tepidarium before the frigidarium (inversion of the accesses due to insensitive alterations). In Fez – Moulay-Idriss (fig 3.), there is a progression from a high-large-square changing area to lower bathing spaces with reduced reaching a low-narrow-long calidarium where the steam and the heat are concentrated.

- In Tripoli, the domed volumes follow an increase in height and width hierarchically from the frigidarium to the calidarium, the steam and the heat are trapped and kept as the volume gets higher and larger, and the thermo-hygrography environment increases naturally towards the

last room.

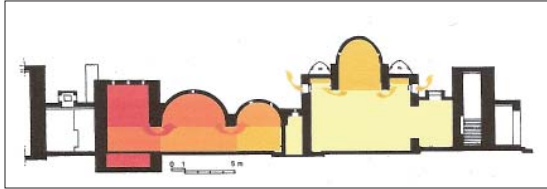


Figure 2: Sequence in Hammam Safarin in Fez. Moulay (Source: Author).

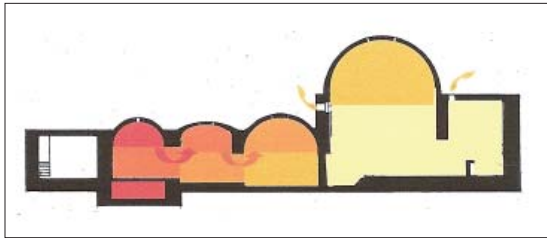


Figure 3: Sequence in Hammām Idriss in Fez (Source: Author).

- In Constantine, barrel vaults have the same height in all the rooms and the progression is achieved by a buffer space between the lobby and the frigidarium (no doors) and by another one between the frigidarium and the calidarium. The latter one is not considered as a real tepidarium.

- In Ankara (tab. 3), the calidarium was located between the central tepidarium and the hot water tank; which provides heat and steam through a window. Large proportions and the small low access to this room helps keep the hot steamy atmosphere inside the room. The heat and the steam from the hot massage bench maintain the balanced environment of the large tepidarium surrounded by three iwans. Hypocaust air ducts with chimneys compose

the complex underground heating system which keeps high temperatures inside the thermal mass.

- In Damascus (tab.3) the successive volumes are of standard sized dome-units (2 units and 1 lateral small one). They compose the tepidarium and a larger calidarium (3 units with 2 lateral ones). The areas temperatures are controlled by the doors separating them.

General Statements about the Climatic Impact on Hammām Design

As shown earlier under heading 4, the first zone of all the hammāms works only according to the local climate with the help of the passive features which compose the architectural design of entrance lobbies, reception and rest areas. This first zone is named the passive area as it has no active system of heating or cooling. As shown under heading 5, the second zone operates with the production of energy from burning fuel in the furnace in order to heat the water, the building and generate steam in the bathing spaces. This zone of the hammām is named the active area as it is heated by the energy produced in the furnace. Although this second relies on an active heating system, it is also characterised by various energy conservation strategies linked to the local climate and to a balanced and efficient thermo-dynamic entities based on carefully chosen proportions of the bathing rooms.

From a global point of view, the hammām design is different from one city to another, even if some similarities can appear in some fields. Within the same city, hammāms built in different historic periods present the same basic

design, based on the same principles. These observations highlight the local dimension of hammām buildings which are designed according to local climatic and cultural factors. This is a reason why the comparison between the different interpretations of the same programme presents a limited interest in itself except providing the opportunity to stress the specificities of each building.

Why do hammāms buildings forms vary from a hammām to another ? This is a challenging question which is discussed in the following sections. Another question that is addressed is related to the passive areas and their responsiveness to the extreme season requirements, of summer and winter. Although there are many similarities that can be justified by similar climates, each climate remains specific to its geographic location. Amongst the five climates in this study, only two, Fez and Constantine, can be considered of the same family (tab.1), However there are still slight differences due to cooler conditions in the second case as the hammāms of Constantine (unlike those of Fez) present an upper gallery in their changing room and a closed dome with low proportions and no ventilation.

Indeed the design challenge is as difficult as the extreme seasons are far from each other (i.e. Damascus). In that case we observe that the design has privileged two main devices useful during the two extreme seasons: 1- The inertia of the structure, maximized by the partial sinking of the building into the ground, which can store the energy and restore it when temperature falls. 2. A simple and large volume that can promote different air movements according to the opening and the closing of the upper oculus

and windows.

It is a fact that Damascus and Ankara have climatic similarities with a long hot-dry season (tab.1), even if the second one is colder in winter (11.7°C year average temperature), and the first one hotter in summer (17°C) . However, the profiles on the charts are similar (tab. 1). The analysis shows that, in this case, the hammams have been designed by adapting mainly to summer conditions.

In the case of Cairo, the climate is very specific. It has daytime high dryness during all seasons (tab.1). Hence all the Cairene hammāms have a specifically designed entrance and undressing room. It is covered with a soil flat roof without a dome and comprises wooden lantern(s), a wooden structure, a central pit, an attic for towel drying, cross ventilation system and rest areas on elevated lateral galleries.

The most specific element in this case study is the soil flat roof on wooden structure with an attic and a wooden lantern, which prevent heat radiation during summer. If the roof is too hot, it radiates inside the attic volume but this hot air is immediately evacuated outside via the open lantern. This ventilated attic is considered as a cooling device working with the help of the evaporative effect of the drying towels, the heavier cool air moves down inside the lobby during summer periods, while in winter the towels dryer works only because of the warm air stratification.

In Fez and Constantine, the climate profiles are almost similar (tab.1). However it is hotter in the first one (17.9°C year average temperature) and colder in the second (12.6°C). As observed previously the lobbies are smaller in size, like in

Cairo, with a centre dome standing on columns creating peripheral galleries. In Constantine, like in Ankara, upper galleries complete the design probably in order to provide warmer conditions in winter, as its colder than in Fez where the volume remains a single unit.

Two main questions raise at this stage : why is there an obvious size difference from a climatic point of view ? And why are there internal galleries ? We can assume that the internal gallery system presents several advantages : it sustains the structure with smaller elements, it divides the space vertically and creates a central air column, where the vertical anabatic (down-top) and katabatic (top-down) air movements will work more easily respectively in summer and in winter.

In Constantine, in hammām Suq el Ghazel, the dome is mainly designed for winter periods to help katabatic air movements. However, it is not adaptable during summer periods because it does not provide any openings. This assumption is confirmed by the down-top gallery which can be used in winter to provide warm air which naturally stratifies upwards.

From Physical to Psychological Dimension

From the physical dimension, all the elements in this internal zone are concentrated around the same components: water, fire, earth and air together inside the grotto-like, steam, cold water and hot water. This other world leads us into silence, sounds of water, echoes, resonance, feeling, meditation, reconnaissance and identification.

The walk from the outside environment, entering

the lobby, undressing and going through the warm-humid-dark progression through the different spaces until reaching the limit where the body cannot support the heat anymore, could be compared to the human prenatal experience of being in the mother's womb environment: warm, humid and dark. This metaphore reminds us of our human condition: our physical condition is immediately linked to our imaginative and interrogative mind, as much in space (building and outside) as in our spiritual life (past and future). Hence the hammam is considered as a life renewal experience for those who use it regularly.

From Physical to Ritual Dimension

Hammām are facilities that are frequently located next to mosques because of the need to wash the body and carry out ablutions before praying. It is therefore linked to strong religious rituals : ritual of daily prayers, ritual of the Friday prayer, ritual of the Thursday bath, pre-nuptial ritual , Ramadan ritual etc. The ritual is built around natural elements: the grotto like environment of the hammām, the flowing water, the fire and the steam, the human body (mind and spirit).

The spatial organization and the progression from the street to the extreme hot-humid area are structured around the following sequences : undressing inside the entrance lobby, staying in tepidarium, crossing the calidarium and mixing "à la carte" individual attitudes and meeting people. The spatial environment freely meets everybody's needs. However, the hammām hygienic function seems to have become stronger than its ritual function, and stronger than its own spirit.

Conclusion

The observation, analysis and comparison of these hammāms help to develop an understanding of the passive architecture specificities of each hammām according to the city where it is located. This fact emphasizes the basic internal climatic dimension of these buildings.

Today, the world in general and countries in arid and semi-arid climates in particular are facing environmental, energy and water supply problems. Studying these types of buildings helps to understand and face the problems of natural resources in the near future by delivering innovative solutions. For example, if energy resources can be found in the reuse of wooden materials or of agricultural waste, possibly with a combination of local solar potentials, the energy consumption of the hammāms could be carefully addresses. However, water can become a real issue in dry climates regions such as Damascus (218 mm) and Ankara (345 mm).

From the mid twentieth century, there has been a deep evolution in ways of life, mentalities, mixing of cultures, tourism influences and private bathroom facilities in housing. These have had a deep impact on the "hammām world" mainly due to the important place it has had in the mind and life of people living in the historic cores of Islamic cities. A number of questions are raised in relation to the future of the hammām in the 21st Century What is the hammām for ? A taste ? A pleasure? A ritual? A forgotten habit? A luxurious facility product? A souvenir? A monument ? An exciting experience ? A patrimony ? (Bouillot 2007). Probably all these together are valid attributes.

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Jean Bouillot

Jean Bouillot is freelance architect practising in Beaune – France. From the seventies till to 1987, he has been working overseas in Lebanon, Syria and Iraq mainly . on tourism projects inside private offices, then in Togo and Niger : planning and housing programmes inside structures from French Ministry of the Cooperation. Since 1988, he is practising in France, with construction projects of bioclimatic buildings, new or retrofitting, on social and private housing, tourism and education

programmes; in the same time developing a research activity in environment field, introducing to collaborate on larger development and planning programmes in Jordan (1999-2000) and China (2002-2005) ; this research activity is materialized with reference documents in the frame of international organizations privileging the sustainable development, as UIA and PLEA. Within H.a.m.m.a.m. sustainable development EU programme in the Mediterranean and diverse new and retrofitting projects in France.