Sustainable Design and Function of Architectural Space and its Composition of Mud Brick in Buildings in Hadhramout Valley, Yemen

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ARTICLE INFO

Article history:
Received April 15, 2012
Received in revised form
July 01, 2012
Accepted July 15, 2012
Available online
July 25, 2012

Keywords:
Sustainable Architecture
Function;
Form;
Space;
Composition.

ABSTRACT

Function should always be regarded as the most important subject before the consideration of form and space be fulfilled. The design reaches its level of aesthetic when it is able to integrate all the required relationships in the design process with clear objectives. This can be seen clearly in the case of mud clay architecture in Hadhramout region, Yemen. The issue of material durability, traditional construction techniques, beauty, and affordability becomes the crucial factors that will be able to fulfill the user’s level of satisfaction, comfort, financial, and spiritual needs. Based on the architectural knowledge gained over the years, the Hadhrami local master builders have acquired brilliant skills and expertise to shape the regional environment and architectural heritage. They always consider ‘functional spaces’ before the buildings and houses are erected. This study investigates the use of mud clay architecture in relation to the design of the building function with its specific architectural form and space in Wadi Hadhramout. It focuses on the residential and religious buildings.

1 Introduction

Architecture is a subject dealing with building design of form, space and function, which enables to portray the design with the meanings of cultures at specific socio-economic activities, technology, place and time. Architectural work is seen as a function that comes first as a design and any spatial architecture designed must meet this function. Design is the ability to set out the required elements in specific and clear relations. This was seen clearly in rooting in and carrying out the artistic environment in Hadhramout Valley. The environment has achieved functional and artistic perfection in organizing the buildings to suit human standards. However, the Hadhrami has produced the instinctive sense to measure things. Measurement was known even in the past in different civilization like using parts of the human body, such as the arm as a measurement unit. Rhythm is considered one of the main bases that lead and connect the architectural structure of the buildings. This reflects on repeating certain artistic architectural elements such as structure, vents and vertical sequent storeys. These architectural elements can be built up in mud for many houses’ facades. The Yemeni architecture in general and the mud architecture particularly in Hadhramout Valley have their uniqueness of employing the natural elements from the surroundings and the heritage. The style is very distinctive in Yemen which is different from other parts of the world in its creative value, architecture and shape. Researchers considered the style as unique and a valuable edifice. It has a rare status in smooth shaping of multiple structures, patterns and functioning harmony in interior spaces. The Hadhrami architecture exemplifies a typical style for human beings living creatively and effectively with the surroundings. The Hadhramies through different ages managed to succeed in making constructional and architectural compositions and to find out a matching environment to appropriate the Hadhrami and his regional surroundings. In fact, he has really managed to create different styles to surpass the world ones. The traditional architecture and construction go very well with the surroundings and meet the functional aspects; they also go with the religious nature of the inhabitants. Creativity has become part of the Yemeni architects’ concern in terms of incorporating the terrains with his design, employing the raw materials and building techniques available. In his design, he takes the four seasons in the region into his consideration for a convenient housing design with provision for human needs, for instance, proper housing, work, worship (Al-Muqatri, 2000). The mud-brick high-rise buildings in Shibam, built in cluster pyramid by a city wall exude the genius of Hadhrami architecture. Today Shibam is recognised as one of the heritage site under UNESCO’s World and construction heritage lists, and
it won the 2007 Aga Khan Award for Architecture which is the world’s largest architectural award. As a result, the study is important to search for architectural design elements that can be integrated in the development of space planning design in Hadhramout region. This paper studies the elements of the historical and architectural value in its diverse architectural layout styles. The architectural space and its relationship to form based on a specific function are significant to the Hadhrami architecture which has artistic designs of mud clay buildings. The architectural spaces in mud construction in Hadhramout Valley will be implemented by using different architectural styles.

2 Interior Space Shaping in Mud Buildings

The Hadhrami architects took the interest in the interior space and function and treated them in different ways, and they found out solutions which improved the buildings. They also indicate that they progressed in conformity with the traditional methods accumulated cognitively and culturally over the years. It is also noted that Hadhrami architects gained transcendent ability that qualified them to deal with time and place variables. They had the way to form the functional spaces that were more convenient to the environment (the nature and the society) (Al-Shibany and Al-Madhajy, 2000). Space and volume arrangement in mud buildings was made in accordance with the shape and volume of the building on the basis of the functional and environmental requirements. The building layout has also been made taking into account the religious believe of its occupants. These factors can be clearly observed in the interior space layout of the buildings that inherently tackled the weather problems. Such a combination of natural materials along with a layout that suits the different requirements mentioned above is a good example of dealing with the different environmental and climatic factors by controlling the function at the design and construction level. Comfortable temperatures could be maintained inside the building through proper selection of natural insulating construction material and through control over the flow of air currents via narrow openings located near the top and bottom of the interior spaces. The trend of the architectural design resulted in buildings that are of closed nature and vertically expanding in order to cope up with the requirements of the increasing number of big families. Type of spaces decided the nature of the ornamentation being used inside and outside the building. Different
patterns are used to decorate the frames of windows, doors, and frames of different woodwork. Mud builders are characterised by homogenous and monotonous texture with respect to height, mass, balconies, and the bridges elements between the buildings. Exterior walls of mud buildings are constructed in such a way as to give a tapering shape (wide near the bottom and relatively narrow near the top) to the building when looked at from outside. Upper stories and roofs are lime washed and projections are provided as shading elements and protection against rain water. As far as proportions are concerned, the buildings form masses and plane areas with opening in the facades. The buildings are not symmetrical in plan and the exterior elevations are neither dependent on symmetry of mass nor shape of the architectural elements. Elements of residential, service, and religious buildings differ depending on the function to be achieved. The layout (Figure 1) may be formed of square, rectangular, or compound masses discerned by the unique Hadhrami building style in terms of elements and decoration that reflect the ancient Hadhrami and Islamic art and architecture (Damluji, 2007).

![Figure 1: Plans and Interior Spaces of the Houses](image)

### 3 Scale

Scale has been used by Hadhrami since ancient times when they dealt with different objects and their relative proportions as can be seen in the old mud buildings. The "arm" is used as a measuring unit in buildings and the "mutaira" used as a land measurement unit. Use of projections in some of the upper parts of buildings facing the side alleys result in shading of parts of the exterior walls and impart a perspective dimension from an optical point of view (Figure 2). The
facades themselves are overlooking the street or a public square or an alley so as to facilitate sufficient lighting and ventilation, and to provide a good view of the public space, without exposing the interior of the neighbouring houses to view or threatening the privacy of their inhabitants. These windows are generally distributed in such an organized fashion in the facade so as to avoid placing the openings in the side walls of neighbouring houses since the houses of Shibam are either attached or extremely close to each other. The distribution of these windows follows an organised and traditional pattern. Hence, in the ground and the first floors, only small openings are present, while wide ornamented and glass-free wooden windows are used beginning with the Mahdarah (men's reception) on the second floor. The visitor also notes that in order to allow large and numerous openings in the windows in the facade, screen windows consisting of networks of geometric and floral patterns, made of local ilb tree, are fitted in and assembled in a variety of compositions.

![Facade and Axonometric of the Houses](image)

**Figure 2:** Facade and Axonometric of the Houses

4 **Colour**

The colour is the most important and inseparable aspect of material and its characteristics. It is considered one of the advanced aspects of the material that has an influence on its size, rate and shape. The colour is an essential element in the architectural composition and its sense. It is an indispensable part in architecture and its relation with volume and space and it has a great impact.
on the shape of the architectural elements. The outside colours of the mud house were often obtained from the raw material available in the surrounding environment. The particular usage of the whitewash for the mud houses was based on its climatic task related to the temperature and light. It is also noted that there is a colour harmony in the mud houses. The mud colour and the decoration of the windows and doors and the white colour used over the doors and windows create a contrast between the light and dark colours. This contrast creates in turn a visual effect that makes the viewer feel lively and vigorous and this also helps clearly emphasizing the visual decoration that produces a genuine and unique expression of architecture.

5 Elements of Clay Building

Among the interior elements of a Hadhrami house unit are the doors, the windows/\textit{Mashrabiya} and the interior walls, the holes in the walls (vents), the railings and the security bars, the columns and the beams, the roof-design, the ceiling-design, and floor-design, the spaces for males and females, and the orientation to the \textit{Kiblah}. The wooden doors that are mounted in the front facade of the buildings are differentiated by their grandeur and by their thickness. For most houses, the main door of the building is its only access. In the wooden frame at the top of the door the date of the construction of the building is engraved.

5.1 Loading Bearing Walls

The exterior of the building takes a pyramid like shape with the exterior walls being tapered. The building is wide at the base and narrows towards the top. The idea of mud walls generally depends on selecting the proper type of soil that when mixed with water and given the desired shape result in a storing solid entity. Proper bond of the mud blocks is achieved through either natural drying process as is the case with Adobe which is sun dried before construction or through in-situ drying of mud (soil and water mixture) as in the case of cob (\textit{Midamk}).

5.2 Columns

Columns are called (\textit{Sahm}). They are classified as wooden, stone or mud columns. The interior columns supporting the roof are made of \textit{nabk} wood. Mud columns (\textit{Madar}) are circular or rectangular in cross-section. Diameter of circular columns ranges from 30 cm to 70cm. Size of the columns depends on the desired function inside or outside the building. Circular columns are widely used in the yards (portico) of mosques. The capitals (the upper part of these interior
columns) (Figure 3) of these wooden columns have the same forms. Usually they are in a simple rectangular cross-section and several carved protrusions. In appearance they are almost similar to the capitals of the columns used in the prehistoric civilisation of the Arabian Peninsula and Persia, especially those capitals carrying the heads of two arms. These are known as kabsh meaning ‘ram’ in Arabic although birds or pigeons may be seen in some other cases. Furthermore, a large percentage of cylindrical columns with circular cross-sections, and columns with square cross-sections, are built from madar or stones. These are moulded from madar or cut from stone in circular and semi-circular forms for that purpose. They are then smoothen up and covered with a layer of mortar (mulat) to look like one homogeneous piece. Some of the capitals of these columns are similar to the base of the square Islamic columns; in the others especially in the case of the capitals in the palaces (such as in Tarim and Sayion) which were built around the turn of the century and which were influenced in their details and ornamentations by the classical Western civilisation, they have the form of classical Doric and Ionic Greek columns.

![Figure 3: Columns of the House.](image)

5.3 Stair Walls

Being an important element of the building, this column is called the "bride" (arus). It is constructed from square or rectangular mud blocks (120cm x 150cm). It is attached to the stairs leading to the upper floors and raised to match the height of the building. The stairwell (Figure 4) is located centrally around arus, a vertical column near the entrance forming the main support for the
storeys of the building stretching vertically through the building to its upper floors carrying the stairs around it. The height of the ground floor ranges from 4-5 meters (13-16 feet). There are one or two additional basement storeys, known as *khann*. This is accommodated in order to take into account the variation between the main street level and the level of the city's raised site.

Figure 4: Sections and Stairs of the Houses

5.4 Arches

Closing narrow and long areas is the main function of arches in mud building of Hadhramout valley. Sometimes branches of green trees are used to temporarily support the arches; these branches are taken away after two or three months when the roofs have dried out. The master-builders build the rows of the bricks over the thresholds using the traditional way until they reached the level of the ceiling. The Arched Ceiling Construction (Figure 5), is an expression (*jamlul*, or *yamlul*) which refers to the method used in constructing arched ceilings or vaults. This method is composed of laying the brick (*madar*) in a circular or spiral pattern, when constructing a dome, or arranging them in the shape of an arch stretching longitudinally. When constructing arched vault (*aqd*), the entire three-dimensional arch receives the shape of a segment of a circle, less than a semi-circle. The *jamlu* then, does not relate to the details of the building method itself, but rather to the method in which the interior and exterior walls are vaulted. Usually, the construction of the ceiling is carried out when the builders have completed the task of constructing the first floor. They either lay the wood (*ud*) for a flat ceiling or employ the method arch (*ukuf*). The arched ceilings can be in the form of domes or vaults (*jalabab*), operating in length. *Jalabab* and *ukuf* are expressions locally used to refer to that (Baeissa & Hassan 2006).
5.5 Windows

Ventilation and lighting are the main functions of the wooden windows in mud buildings of Hadhramout valley. Location of windows takes into account the social aspects and lifestyle such as provision of privacy. Windows are generally located on the facades of buildings facing the main road and interior open yards. The windows contain screens of beautiful geometric figures that limit entrance of the sun light and regulate the movement of air currents inside the building. Coloured glass is widely used in windows of buildings of Seiyun and Tarim nabk wood is in making the windows. The windows (Figure 6) are small and they are constructed close to the floor, and usually decorated as well as carved in latticework screens with wooden frames and shutters. Above the
windows, many small rectangular openings are designed to allow the light in when the lower shutter is closed. Here a plain mat, made of plaited palm, may be placed on the floor while wealthy people may place camel-hair rugs striped in rust-brown, white and black. Hard cushions are often placed against the walls for relaxation. The distribution and arrangement of the windows on the external facades of Hadhrami houses add a special aesthetic character to the buildings as a whole. The main windows of each house are articulated over the main facade of the house. The facades themselves are overlooking the street or a public square or an alley so as to facilitate sufficient lighting and ventilation, and to provide a good view of the public space, without exposing the interior of the neighbouring houses to view or threatening the privacy of their inhabitant.

**Figure 6:** Facade and Decorative Window of the Houses

### 5.6 Light-Openings "Manwar" or "Shammah"

In general the type of openings (Figure 7) used in Hadhrami architecture can be seen in the ground floor which contains the main entrance and the spaces for grain stores. The walls have small ventilated holes; also there is a little hole (mannor) near the stairs for air movement (ventilation) and temperature. The stairs rally around a huge pillar near the entrance that forms the main support for the house. They are designed to stretch vertically inside the house, from the ground floor up to the roof; and they are usually adjacent to the stairwell, sharing a wall with it, and providing it with light and ventilation. The ground floor layout provides efficient lighting from the Al-Shammasah from Shams (the sun) which provides ventilation and the interior temperature of the house. Vents provide the space with ventilation and interior lighting for the house and extend on the length and
height of the building vertically from the ground floor to the last floor which intervene rectangular long small holes. In various locations across the length of the Shammash, there are small longitudinal and rectangular openings made out of mud known as *Khaysh*, differing in their forms and ornamentations, which are usually a simple repeated pattern of squares, triangles or circles. The longitudinal and narrow, or circular openings called the *Al-Ukrah* is for ventilation purposes. Mostly they are located at the upper end of the walls of the ground and first floors, near the ceiling; but sometimes they are inserted between the openings of the large windows or above them, for the purposes of ventilation and lighting (Damluji, 1992).

![Figure 7: Openings at the Interior Walls, Shammash.](image)

### 5.7 Doors

The wooden doors (Figure 8) that are mounted in the front facade of the buildings are differentiated by their grandeur and by their thickness. For the most part, the main door of the building is its only access. In the wooden frame at the top of the door the date of the construction of the building is engraved. Generally the doors are impressed and dovetailed, as well as adorned with enormous iron nails and famous wooden bolts in two parts (*galudah* and *gayshamah*), which can be unlocked by wooden keys (*iqlid*). These wooden keys are also made by the carpenters and may have some simple pattern. Baeissa and Hassan (2005) also notice that the keys and locks come in different sizes according to the sizes of the exterior or the interior doors. The most magnificent doors are found in the popular traditional and customs museum in Sayion. These doors are loaded...
with geometric ornamentations and Arabic calligraphy, and made with a precision and skill approaching excellence. They further noted that contemporary local doors cannot match the articulate eminence of exquisiteness attained by the old craftsmen, regardless of the fact that the present day artisans in Al-Sahil perform their carpentry and wood work in the same way as their predecessors had done many years before. Doors are made of nabk wood and are generally characterized by their thickness and beauty of the ornamental work and the artistic Arabic writings.

![Decorative Doors of a House](image)

**Figure 8:** Decorative Doors of a House

### 6 Ornamentation

The prominence of the skilful ability of the Hadhrami architect, which is built from one substance and two designations as well as technical constructions, made up the occupations for its need and functions to provide comfort and relaxation. Its strength reflects spiritual desires through its beauty. This is because of the production of the profound perception in the way of making up architectural occupations between the perception and awareness that deals with changes, place and time. In addition to this, it provides characteristics of specific and changeable places, climate and social settings. On the other hand, the changeability of time, specific effectiveness, as a result of the same belief and social harmony and the Hadhrami spiritual traditions in different regions are all attractions that make Hadhramout a unique place to live. There are several beautiful palaces, buildings and mosques built of mud with beautiful ornamental and decorative works that consist of different geometrical and botanical shapes. These elements reflect the high class of art work of its performers. Ornamentation has been widely used on walls and facades of old buildings in the form
of carved patterns and engraved writings. Such kind of work was also used to decorate windows (Figure 6), doors (Figure 8), wooden columns (Figure 3) and mud columns. Decoration has always been used in mud buildings as an element to express the importance of the building and to highlight its beautiful aspects.

7 Domes

A dome is a structural element of architecture that resembles the hollow upper half of a sphere. The dome (Figure 9) has taken on a defining role in the organization of interior and exterior space in the built environment and developed a high level of specialization by types. Domes are usually used in the Hadhrami architecture in the ground and first floors of the buildings. Domes have been widely used in mud building and became one of its distinguishing elements, especially in mosques and tombs. Semi spherical domes have also been used and constructed by placing clay bricks (madar) of circular shapes during the construction of domes. When these have been built, the walls of the upper floors are then built. The extreme thickness of the walls in proportion to the height of the dome is another indication that these chambers stood at the beginning of the series. Hadhramies used the domes as mosque, tomb and palaces roofs.

Figure 9: Domes design in Mosques and Tombs
8 Conclusions

In conclusion:

1. The Hadhrami styles are distinguished in function, shape, spaces, elements and decorations.
2. The main construction material is brick.
3. The subordinate construction materials are clay, lime and wood.
4. The system of the main and external construction is loading walls.
5. The system of construction is from arches and column free.
6. The design for walk and prosperities of the planning is blocked and a vertical design for big and extended family. It constitutes with the other quarters join with services such as mosques and yards.
7. The building fabric is coherent and well-adjusted in heights and spaces, as well as balconies.
8. The distinguished main front of the building is located on the Main Street or yards. The decorations are seen (Mashrabiya) and covered the building at the bottom and the top with lime.
9. The distinctive characteristics of the main facades of the buildings look out on the streets or squares. Patterns are represented by windows (Mashrabiya). The buildings are painted with limestone for protection. The external walls are generally pyramided.
10. The external decoration consist of simple frames and shapes around the windows. They are centred in the wood setters of the windows and doors.
11. The type of building design and characteristics of planning is enclosed and vertically directed in building. It forms with the other buildings zones sharing similar public services functions, mosques, and squares.
12. The composition of religions service building is different in plan. The form of the building is square and rectangular open to the outside.
13. The Hadhrami city model is unique with morphologically and functionally created objects, elements, and pattern. There exist an interrelationship of ancient Hadhrami architecture and Islamic art along with the perpetuating experience laden with knowledge accumulation.
14. Simplicity of similar and different elements in the pattern morphology inside and outside and the gradual heights. There is also a variety in the forms of the openings on the surface of
the facade, by changing the size and the position of rectangular form of the openings, along with the harmonious colour distribution.

15. The environmental control of climate; the architectural type is rich in its experiences with the ability of environmental climatic control in creating heat comfort given the direction of building and functions, selection of building materials having thermal isolation ability, volume control of acquired heat, air movement activation through narrow low and high openings.

10 References


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Peer Review: This article has been internationally peer-reviewed and accepted for publication according to the guidelines given at the journal's website. Note: This article was accepted and presented at the 2nd International Conference-Workshop on Sustainable Architecture and Urban Design (ICWSAUD) organized by School of Housing, Building & Planning, Universiti Sains Malaysia, Penang, Malaysia from March 3rd -5th, 2012.