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SUNLIGHTING AND DAYLIGHTING STRATEGIES IN THE TRADITIONAL URBAN SPACES AND BUILDINGS OF THE HOT ARID REGIONS.

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ABSTRACT

In hot arid regions sunlighting is an essential consideration to achieve an environmentally conscious architecture. This paper aims to identify the sunlighting strategies and their resulting typology in some urban spaces, different types of buildings and constructional details as they have been developed in the hot and arid regions of the Islamic world.

KEYWORDS

daylight, typology, urban space, Islamic architecture, arid regions.

INTRODUCTION

Traditionally, the sun has very often been used passively in town planning and architecture. Today's technological development offers new materials, techniques and strategies to optimally use the sun's energy. However, traditional concepts and techniques remain an interesting source of understanding and inspiration for urban planners and architects. In the hot arid regions several architectonic elements,

illustrating various sunlighting strategies, have been developed with prominent environmental and energy savings potential.

The interest on traditional sunlighting and daylighting strategies in the hot and arid regions arises from the great availability of daylight throughout the year; traditional adaptation to the intense sunlight; the cost of these devices is often out of reach of the developing countries.

This article presents an analytical study and classification of sunlighting strategies and their resulting architectural typology of various buildings, constructional details and urban spaces in the hot arid regions of the Islamic world.

URBAN SPACES

Street design in traditional Islamic cities varied according to their geographical location, type and function, i.e. residential or commercial. In residential areas, streets are either partially covered by cantilevered volumes or totally by additional living spaces (Figure 1).

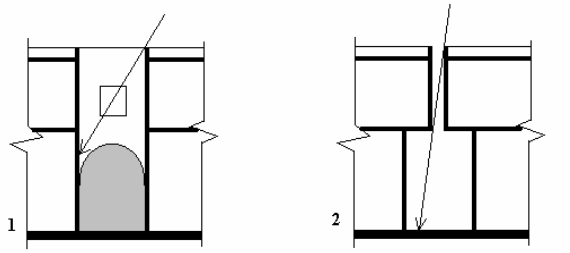

Figure 1.a: Types of urban roofing in the streets of residential areas: 1) partially covered, and 2) totally covered.

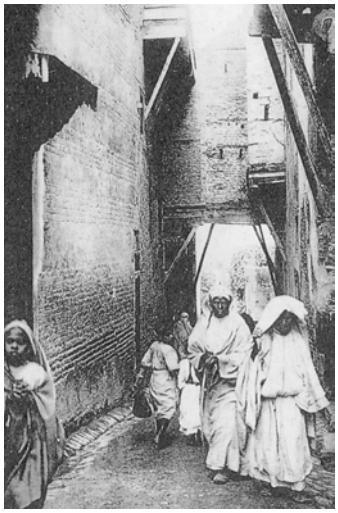

Figure 1.b: The cantilevered volumes constitute the means of a partially covered residential street (Source [1]).

The commercial street (*Suq*) is generally a segment of a larger street with ground floor shops on each side and dwellings on the upper floors. The streets are often totally covered either heavily by perforated vaults, semi-heavily by high parapets walls and double pitched roofs or lightly by thick plank and reed (Figure 2).

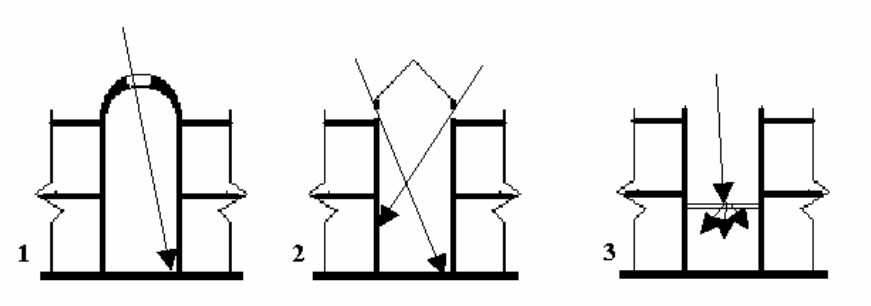

Figure 2.a: Types of urban roofing in the commercial streets: 1) heavily, 2) semi-heavily, and 3) lightly.

Figure 2.b: An example of heavily urban roofing in a commercial street (Source [2]).

Figure 2.c: A semi-heavily urban roofing with openings located on parapet walls (Source [3]).

These types of roofing, by cutting off most of direct sunlight, provide comfortable thermal and luminous ambience. Further, the sequential experience of dark and lit spaces possesses an aesthetic appeal (Figure 3) [4].

Figure 3: The sequential experience of dark and lit constitutes a particular character of the urban space in the old Islamic city.

PUBLIC BUILDINGS

Mosques, schools (*madrasa*), Eastern inn (*khan*, *foundouk*), Turkish baths (*hammam*) and Hospitals (*bimaristan*) are the most common public buildings of the traditional Islamic city. In order to daylight the interior of these buildings, the courtyard and the domelight are the most common spatial configurations. These two architectural features while performing a similar function; i.e. catching and redirecting sunlight inward, are quite different in terms of the ambient atmosphere created in each space.

The mosque

The mosque has often gone beyond the provision of a religious space to include education and social meeting, funerals, etc. To express the equality between believers and to point out the unity of the architectural space, the hypostyle prayer hall was adopted, as well as through night lighting by candles and chandeliers.

From the general shape to the constructional details, several techniques are used to let in natural light in a hierarchical way. The courtyard, the principal source of daylighting [5], has generally a rectangular shape and is placed alongside the longest part of the prayer hall [6]. In addition, the prayer hall has a high ceiling and faces the courtyard with large openings, which maximize the penetration of both direct and reflected sunlight (Figure 4). The ground reflected light is further transmitted to the deepest parts of the prayer hall through the decorated ceiling (Figure 5).

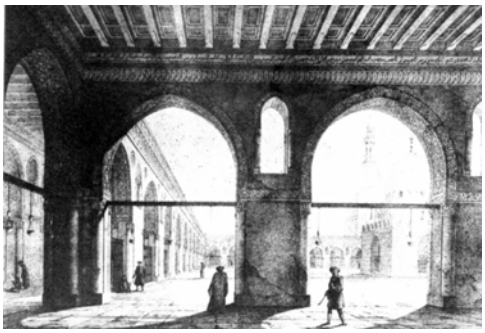

Figure 4: Various openings (open-spandrel arch naves and pierced tympanums) are used to maximise the penetration of daylight into the prayer hall (Source [7]).

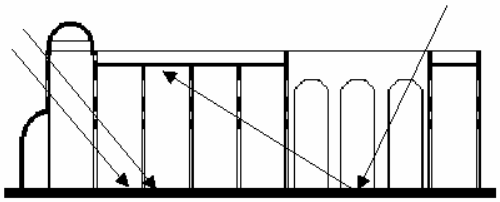

Figure 5: Courtyard, cupola and double arched naves: means of interior daylighting in mosques.

Further, the outer part of the building has deeply recessed and screened windows located high on the walls, adding a diffused natural light to the interior (Figure 6). Light is then reflected to the ceiling through the double arched naves or throughout the pierced tympanums. The cupola, on the other hand, is used to illuminate specific elements or spaces like the prayer niche (mihrab) [8], each extremity of the entire wall that faces Mecca (quibla wall) and the transept area, Thus providing a restful and pleasant space for quiet and spiritual activities.

Schools:

Throughout the Islamic world, the school (Madrasa) took various configurations often influenced by the religious rite adopted in that region. For example, under the Sunnite one, the school is made up of four areas (*Iwans*) surrounding the courtyard. The courtyard is higher than large and looks like a deeper light shaft surrounded by the entire facades of the four *iwans* (Figure 7). This spatial configuration provides a permanent visual contact between the *iwans* and the exterior environment as well as converts them from indoor spaces to semi-open spaces naturally lit. This luminous ambience is suitable for educational activities as well as to the climatic conditions of hot arid zones. In fact, when climatic conditions change a different spatial configuration is adopted, as illustrated by the school design in Anatolia [10], where, under the colder climate experienced in those regions, the courtyard is covered with a large cupola that has numerous small openings allowing an appropriate interior illumination.

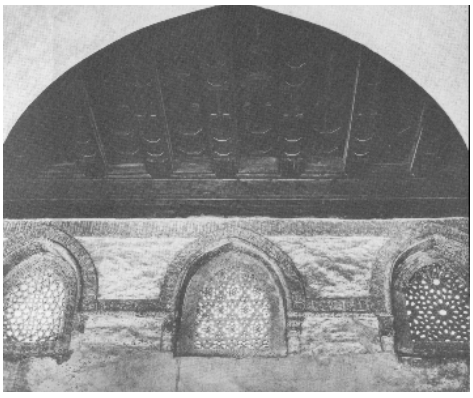

Figure 6: To illuminate the deepest parts of the prayer hall, recessed and screened windows are located near the ceiling (Source: [7]).

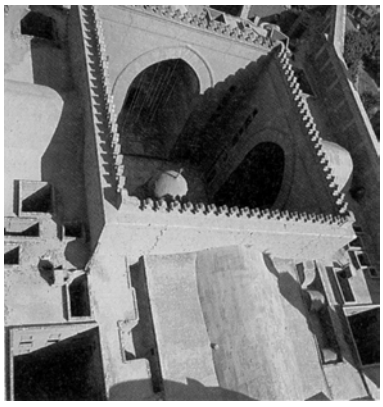

Figure 7: In the Madrasa, the courtyard constitutes a deeper light shaft providing a well-adopted luminous ambience to the educational activities requirements (Source: [9]).

Eastern Inn (*Khan*):

The *Khan* is a building to lodge travelling merchants and store their merchandise. In general, the *khans'* design are of three types [9, 11, 12]: 1) organised around a central courtyard surrounded by galleries and peripheral rooms at the ground and upper floors, 2) built around a square or a rectangular courtyard covered by vaults or big cupolas, or 3) built on both sides of a long narrow courtyard like a closed street.

In the first case, the open courtyard is the main source of daylighting. The galleries constitute an inside/outside space filtering sunlight entering to peripheral rooms (Figure 8).

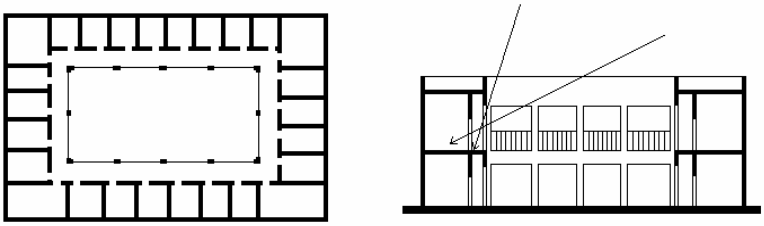

Figure 8.a: Plan and section of a Khan with an open courtyard.

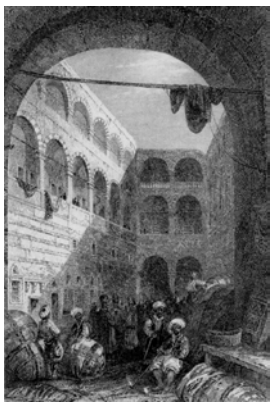

Figure 8.b: In the case of the Khan with an open courtyard, the galleries filter sunlight reflected from courtyard into the peripheral rooms (Source: [1]).

For the second spatial configuration, openings located at the top of the vaults act as skylighting and provide sufficient daylight as well as solar protection (Figure 9). The last case presents a building with two linear parallel units grouped on the second floor by transverse arches supporting a partial flat roofing. The latter shades the openings on the internal sides of the khan while admitting daylight. When they are not looking to the courtyard, the corridors at the upper floors are daylit by openings located on the roof level (Figure 10).

Figure 9: Plan and section of a Khan with a covered courtyard.

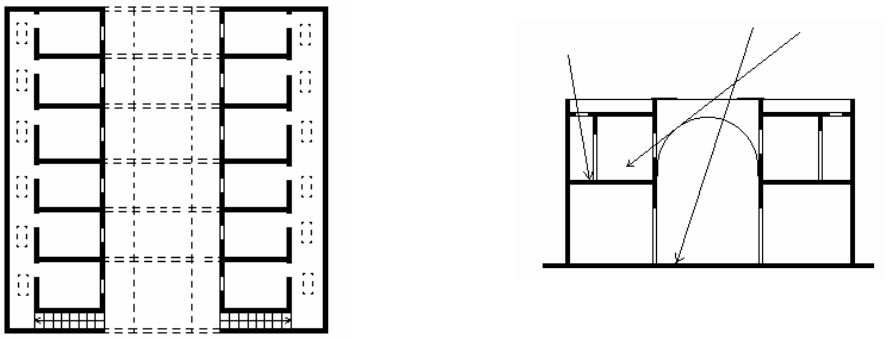

Figure 10: Plan and section of an elongated Khan**.**

Turkish baths (*hammam*):

The *hammam* holds an important place in the social life of the old Islamic city, where religious, social and healthy functions are fulfilled [10, 13, 14]. The internal ambience is characterized by warmth and softness in order to provide comfort, relaxation and leisure. The Turkish bath illustrates probably best the combined effect of top lighting and creation of a bright diffused luminous ambience. The cupola is here uniquely garnished by translucent coloured glass occuli and has no openings at the drum level as usual (Figure 11). The incoming diffused light combined with the water vapours creates a colourful diffused light.

Hospitals (*Bimaristan*):

In the old Islamic cities, hospitals called *Bimaristan* existed in large numbers. The *bimaristan* is organized as a group of various buildings including health care centers, clinics (treatment halls and dormitories), medical schools, library, chemistry, prayer area and often it also included a section for the treatment of the mentally retarded patients and to cure neural diseases [10].

Thus, the *bimaristan* was designed in order to provide the most adequate environmental conditions [15]. To achieve balance in physical and spiritual needs, the selection of a site for the hospital was a crucial parameter. Different natural elements were used in its design such as landscaped gardens and sometimes canals of running waters.

Sunlight, was believed to confer therapeutic benefits and was an integral element of *bimaristan's* design. However, the harshness of the local climate imposed a control of

sunlight admission to avoid overheating and glare. Hence, partially covered courtyard, *Iwan* and screened windows were used according to the type of the activities carried out in the various spaces of the *bimaristan* (Figure 12).

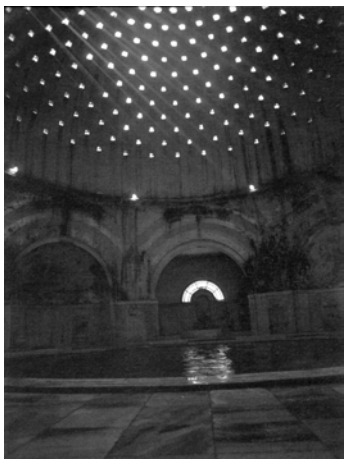

Figure 11: The translucent coloured glass occuli garnishing the cupola of the Turkish bath provide a falling down natural light that creates a particular luminous ambience when combining with the water vapour (Source: [9]).

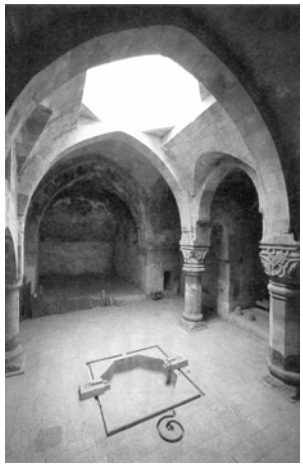

Figure 12: The central room of the Bimaristan is mainly daylit by the cupola's openings which could present various kinds such as a large opening at the top level of the cupola (Source: [9]).

HOUSING:

The inward looking courtyard and various configurations of windows are the daylighting channels in traditional housing. Variations are found in different parts of the Islamic world, due to the change of climate (Figure 13). Hence, in the harsh Algerian desert, the courtyard is almost totally covered, leaving a small opening at the top to admit sunlight when needed [16]. The internal white surfaces of the courtyard reflected diffuse light towards the peripheral rooms. The courtyard may also be open to the sky with surrounded covered arches or covered parts (*sabats*) acting as sunlight overhangs and protecting alleyways. In this case, generally a sandy courtyard ground is used for a thermal purpose [17, 18].

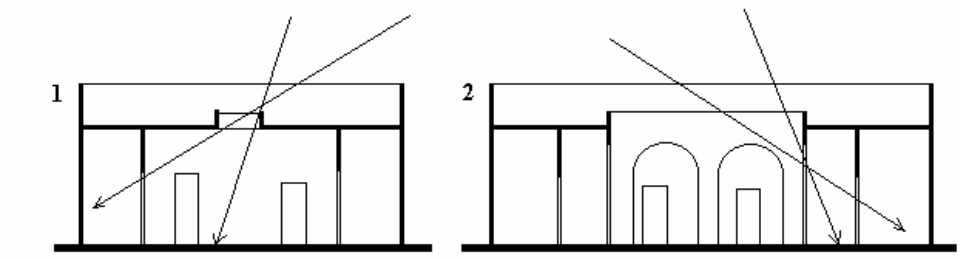

Figure 13: The configuration of the dwellings' courtyard varies due to the change in climate: 1) totally covered, and 2) partially with surrounded covered arcades.

Space occupancy is also related to the daily and seasonal brightness of spaces. The most occupied ones are oriented south-east to catch the early sunrays [19]. This is, for example, the case of the women living room (*Izefri*) in the dwelling of the M'zab Valley in Algeria (Figure 14).

Similarly, in several cases of dwellings, sunlight has been used to emphasis a geometric spatial composition of the living room. Beside the light provided by peripheral windows a skylight is strategically located above the central fountain of the living room, namely *Durqua'a*, of the Mamelouk era in Cairo [21, 22] (Figure 15). The association of natural light and water creates a pleasant and refreshing atmosphere while providing an inside / outside scene.

In the old city of Algiers, daylight decreases from the room entrance to the mid lower wall niche (*K'bou*) [20, 23]. The clearest areas (such as the *K'bou*) are intended for domestic activities and to preserve privacy while the darkest ones (on both sides of the *K'bou*) are used for sleeping (Figure 16).

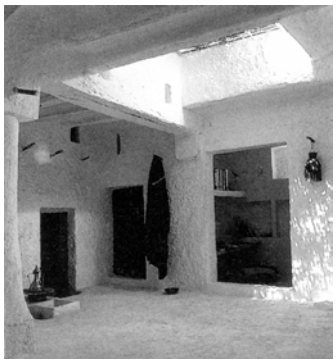

Figure 14: To catch the earlier sunrays, the women morning living room (Izefri), in the M'zab dwelling in Algeria, is often oriented to the south or southeast and is widely opened to the courtyard (Source: [20]).

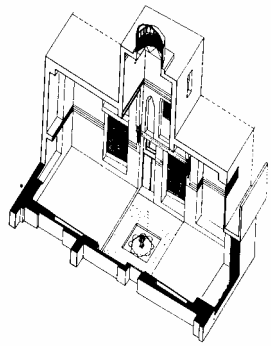

Figure 15: A perspective section of the Egyptian living room of the Mamluk period, called the Durqua'a, shows the position of the skylight above the fountain (Source: [21]).

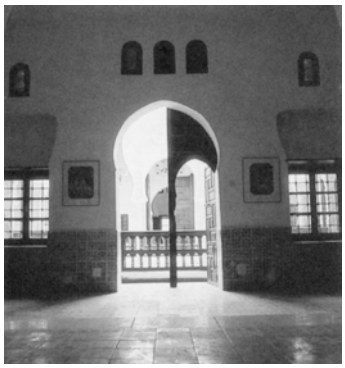

Figure 16: The room, in the old Algiers Casbah, attests of a spatial and functional structurations emerging from the brightness distribution inside it (Source: [23]).

The room layout in the house of the *Medina* of Constantine shows a centrality in relation to its entrance space, distinguished by particular roofing and revealed by the luminous ambience. The entrance and the *K'bou* are more daylit than the extreme parts

[20, 23] (Figure 17). The best daylit spaces are used for the principal domestic activities (i.e.: living room) and the least lit ones for the secondary functions (i.e.: storage, stairs). Whenever external windows exist, they are of small size and often totally screened. An original window design is found in the traditional Yemenite house. It presents unique features; it is divided in a number of openings of various sizes and location in the external wall so as to best accommodate the various window function: ventilation, natural light admission, provision of view and privacy [25].

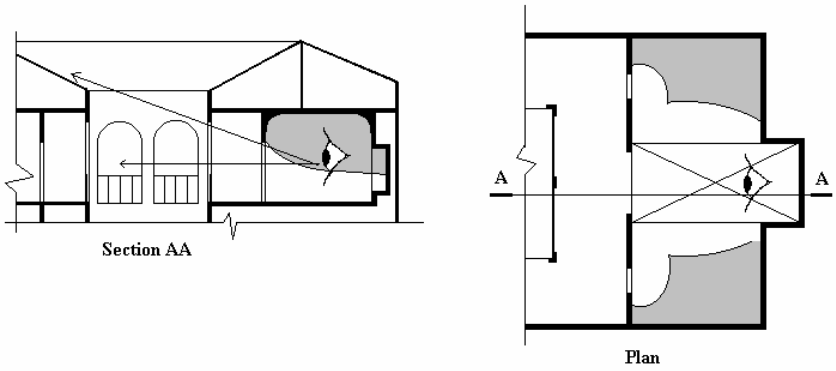

Figure 17: In the Medina of Constantine, a morphological characterization of the room's space (vaulted roofing) underlines the functional and spatial structuration due to daylight.

CONSTRUCTIONAL DETAILS:

Some constructional details are often an elaborate development of the ancient ones such as the '*moucharaby'*, a wooden lattice of cylinders joined with spherical joints used to screen unglazed openings. The round surface of the composing elements of the *moucharaby* reflect and grade the light very softly, while also allowing ventilation, minimizing heat penetration and providing visual privacy [25] (Figure 18). Split window, with an increasing section from outside to inside is another architectonic element, which admit daylight and control sunlight (Figure 19).

The *muquarnas* is another constructional element used inside the buildings and contributing to diffuse natural light [26]. It consists of more or less complex honeycomb of small niches, which diffuses sunlight. It eliminates any kind of plasticity, creating an ornamental and luminous environment (Figure 20). To alleviate the heavy visual effect of the massive bearing walls, reflect the direct sunlight as well as reduce

glare at the sitting level, a great deal of use was made of the white and coloured ceramic tiles on the courtyard's walls [9].

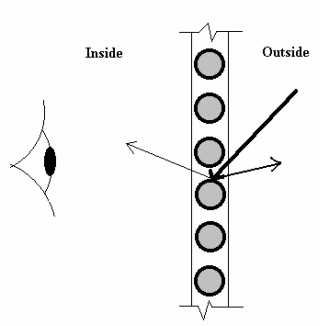

Figure 18: the round surfaces and sections of the components of the moucharaby control sunlight admission by reflecting and grading light very softly.

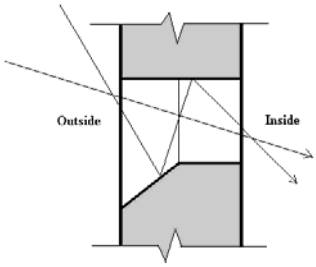

Figure 19: The split window is a specific design adopted to admit and control sunlight.

Figure 20: The muquarnas diffuse sunlight inside the building and create an ornamental and delightful luminous environment (Source [2]).

CONCLUSION

Traditional built environments in hot arid regions reveals the importance given to sunlight among other environmental parameters (heat, cooling, ventilation…). This study highlights several sunlighting strategies adopted in the traditional built environment of the hot and arid regions of the Islamic world. These strategies are mainly based on the admission of the reflected sunlight inside urban and architectural spaces. The internal reflected component of daylight is the solely used to illuminate the inner spaces of buildings.

The study of several kinds of streets and buildings revealed that the principal means of daylighting and sunlighting control are: 1) courtyards with various configurations (totally and / or partially covered), 2) semi-open spaces (*Iwan* and *Sabat*), 3) skylights (with particular locations), 4) different shapes of windows (recessed, screened, small size), and 5) some constructional and aesthetic details (*Muquarnas*, ceramic tiles). These elements are designed together in a systemic way and with respect to other considerations such as thermal (the use of sandy courtyard in the house of El-Oued oasis in Algeria) and privacy (the *moucharaby* in the urban house of Cairo) ones.

The salient outcome is that the solutions often go beyond the sole consideration of amount of light (sometimes quantitatively considered below standards) to encompass the qualitative characteristics with psychological, spiritual and socio-cultural connotations. The variety of architectural design and components in the context considered imply that a daylighting culture exist in the traditional built form. This investigation highlighted the power of natural light to structure the architectural space.

Finally, it is worth emphasising that daylight's consideration cannot be limited to quantitative evaluations, but should consider equally the quality of daylight distribution, the perceptual needs of the occupants, their cultural background, the type of task performed and its frequency and their implication on architectural design.

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