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Impact of Environment on Architecture of Mesopotamia with Respect to the Use of Materials, Tools and Mode of Construction

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Abstract

Through architectural and engineering skills, humanity leaves its mark upon the earth. Urbanization started from Mesopotamia in west Asia where the Mesopotamian societies flourished. They evolved into various landscapes from the metal-rich highlands and elevations of southeastern Turkey to the Syrian deserts, from the woodman's of the Levant to the bogs of southern Iraq. Mesopotamian civilization, along with its architecture, survived more than three thousand years. The architecture of the Mesopotamian civilization is not only portentous in its outlook and proficient in planning, but it's also considered rational and technical with respect to its environment.

The civilization was very first of its kind, having technology and urban settlements that laid the foundation of future modern settlements. It considered the region's environment and climate as pivotal in the development of its culture and architecture.

This study discusses how the people, consciously or unconsciously, shaped the land or landscape around them in relation to their environment. This study is both basic and applied, according to architectural research methods. By content, the research in this article is according to the process of design and construction and the data in this research will be analyzed morphologically and technically. The Mesopotamian people used mud bricks, aqueducts, wooden beams, Archimedes screw, courtyard and tripartite houses. The study in this article proves that all these constructions and the techniques used were according to their environmental and climatic conditions.

1. Introduction

Mesopotamia is in the east of the district named "fertile crescent "- approximately a semi-circle with its open side facing the south and the west end to the southeast corner of the Mediterranean, the center directly to the north of Arabia, and the east end at the north end of Persian gulf, where cultivation and farming flourished (Mays L. W., 2010 p.30). (Fig 1). The desert sand buried Mesopotamia's great cities but its technology has survived and is in use until the present. The land of Mesopotamia is divided into two ecological zones-roughly: lower Mesopotamia (south) and upper Mesopotamia (north). The lower Mesopotamia known as southern Mesopotamia or Babylonian alluvium, lacked stone while in the northern Mesopotamia or plains of Assyria, stone was available. Further differences divide southern Babylonian into Akkad in the north and Sumer in the south. Large forests were lacking, the only wood available was the date palm wood. It was the name given to the area between two rivers as was largely dependent on the two rivers named Tigris and Euphrates. The Tigris and Euphrates River both shaped the society and the minds of the dwelling communities. These rivers not only provided water for agriculture but served main routes of communication (Mclntosh, 2005, p. 7) . This was the county where summer and winters reach thermometric extremes, here agriculture was contingent upon the artificial river water distribution (Kuiper, 2001, p. 135) . The climate of Mesopotamia was so uncertain with periodic floods that laid the basis of hydraulic engineering. The natural resources of any civilization largely determined the structural materials used by its architects and engineers – same is the case with Mesopotamian civilization (Faiella, 2006, p. 7).

It determines the basic shape, size and the style of the architecture produced. Three contributing factors to Mesopotamian art and architecture are: the socio political organization of the city states and of the kingdoms and the empires succeeding them; The second, even more important factor, however, is the major role played by organized religion in Mesopotamian affairs of state and the third factor is the influence of the natural environment. The practical limitations imposed upon architects by geology and climate of southern Iraq are immediately apparent (Kuiper, 2001, p. 136). The natural condition of this area does not favor architectural development. It is an alluvial plain and the only building material present in quantity is mud deposited by the two great rivers. Mud bricks were used for private and public houses. Since bitumen obtained at hits of Euphrates served as the water proof material. In the north gypsum known as Mosul marble but its transportation required so much man power that its use was restricted to the palaces and temples. The idea behind this research is that “enviros and climate of an area begets the architecture of an area with regard to the adoption of tools, material and mode of construction”.

The research is based on the following questions:

i. How and why mud was used as construction material considering developmental needs of Mesopotamian people?

ii. How were the houses built between the two rivers viewing the environmental conditions and feasibility of people?

iii. How methods of utilizing water led to the greatest achievement in mechanical and civil engineering?

This research article will deal with the architectural techniques of Mesopotamian civilization with respect to the environment, that includes building material and houses, techniques and construction and hydraulic engineering. Architectural research has characteristics of both scientific and technical research on the one hand and artistic and humanistic on the other hand. Christopher Frayling, rector of London’s royal College of Art, has argued that all research in architecture revolves around one of three or either all of the three prepositions; “Into”, “For” and “Through” (Linda N. Groat , David Wang , 2013). Research FOR design typically involves investigations of new technology, products and materials. Research THROUGH design embraces creative production, with the design process itself as a form of discovery new knowledge.

The research in this article deals with the preposition “Into” – because research INTO design encompasses the historical and environmental behavior research. By content, the research in this article is according to the process of design and construction. The data in this research is analyzed morphologically and technically. Morphologically, it involves looking at the specific characteristics of research i.e. Influence of environment on Architecture. Technically; it involves looking at the specific area:

1. Mesopotamian Civilization

2.It is specified to mud houses / their techniques and hydraulic Engineering.

I. Climate and Ecology:

There is diversity in natural landscape, which includes desert, foot hills, steppes, marches, they all have one common feature: a lack of rain fall in the Summer. The climate and vegetation of Mesopotamia has probably not changed over the past ten thousand years. The desert zone had mild dry winters and hot, dry summers but there was no vegetation. In the foot hills, the winters were mild, and summers were dry and warm. The vegetation included oak, pine trees, terebinth trees, grasses, barley and wheat. The steppes also experienced mild and dry winters, and hot, dry summers. The steppe lands were grasslands that were almost treeless. The climate of central and southern Iraq is very hot sometimes reaching 120 degrees Fahrenheit in the Summer (Nemet-Nejat, 1998, p. 12).

II. Impact of Environment on Architecture:

The research deals with the impact of the environment on architecture in relation to the building materials, techniques and utilization or construction with respect to hydraulic system.

1.1.Building Material of Houses with Respect to the Environment

A shelter or a house is considered protection from the weather with barrier surfaces that are supported by a structure that is based on the environmental resources. Mesopotamia is a land of mud and mud-bricks architecture (Moorey, 1994) . Mud is a very versatile building material: walls can be built up in lumps, a technique known in Arabic as ‘tauf’ and normally called pise in English (Roaf, 1992, p. 423) . The clayish soil of southern Mesopotamia was ideally suited for the manufacturing of bricks (Bertman, 2003, p. 186). The material was then formed into rectangular bricks and left to dry (Wie, 2012) . There were two kinds of dried bricks – sundried and kiln dried. The sundried bricks were somewhat durable and cheap to produce, while kiln dried bricks were expensive because they required burning fuels, so kiln baked bricks were reserved for prestigious buildings and palaces. The perfect time to make sun-dried bricks was the summer time, when the sun was hot. For this reason, the ancient Mesopotamian people called the first month of summer "the month of bricks" (Bertman, 2003) . Eventually builders realized that mixing clay with straw made bricks stronger. It also kept mud and clay from cracking (Michael Woods , Marry B. Woods , 2000, p. 25). The shape of the Mesopotamian bricks changed over the course of history. These are categorized by period.

1.Patzen 80×40×15 cm: Late Uruk period (3600–3200 BCE)

2.Riemchen 16×16 cm: Late Uruk period (3600–3200 BCE)

3.Plano-convex 10x19x34 cm: Early Dynastic Period (3100–2300 BCE)

The earliest examples are long and thin. Beginning in the fourth millennium B.C.E and onto the third, they became uniformly rectangular, with their length double their width. In the Early dynastic period, they retained their rectangular outline but acquired a convex side produced by rounding off the soft clay atop the mold. Such "Plano-convex" bricks with their rounded sides turned outward, created a variegated wall surface. Still, later in the Akkadian period, the square brick, about 14 by 14 inches, came into its own (Bertman, 2003, p. 187) . The name Plano-convex brick was given because of its specific shape. Brick styles varied greatly over time. The advantages to Plano-convex bricks were the speed of manufacturing as well as the irregular surface which held the finishing plaster coat better than a smooth surface from other brick types (Delougaz, 1933).

Bitumen is a petroleum like substance found in the ancient Near East that bounded bricks in a morerefined manner compared to ordinary mortar because of its adhesive and cohesive properties (Bertman, 2003, p. 88). Moreover, it was used for coating roofs and pipes. The use of bitumen was common in Mesopotamia among other ancient civilizations because of its abundance in that area. Mud was sometimes mixed with gravel or lime to make them more stable. Lime or gravel has the capacity to become a stabilizer among other construction materials. In the present day, we use cement as a stabilizer instead of lime or gravel. Lime, on the other hand, is made from the same basic material as cement, but is thousands of years old, and can be manufactured almost anywhere on the spot, for a fraction of the energy and cost of cement, and it's a first class stabilizer for mud (S, 2013, p. 51) .

Just as the land of Mesopotamia provided its people with the clay to make bricks and bitumen to cement them together, it also provided them with the reeds they employed to fashion some of the earliest homes. Because of their natural buoyancy, bundles of reeds have long been used to make boats, but the earliest people used the same material to build houses.

Mud, in this manner, can effectively be used to satisfy the majority of the development needs of a general public; it can not only be utilized for fortifications, temples or palaces, but it is also a highly versatile material for domestic use. Mud has a reasonable compressive strength, permitting the construction of walls, platform and arches but it's susceptible to the effects of water, requiring the surfaces to be protected. High thermal capacity confers advantages in environmental control. A major advantage of mud is its ready availability and its ease of use (R.S Narayanan , A.W.Beeby , 2001, p. 56). The mud construction system is less energy intensive and very effective in different climatic conditions (S, 2013, p. 38).

It is usually assumed that the addition of substances like cedar, ghee, or honey to mud mortar and bricks improves the cohesive properties. Substances like tannins, proteins, or sugar can stabilize mud-bricks. (As organic material decomposes inside ageing bricks they would not easily be identified by modern analyses) (Moorey, 1994, p. 305).

1.2. Construction Techniques

Town planning might sound like a modern idea, but actually, town planning started in ancient times. Babylonians were the first to introduce town planning. The Greek historian Herodotus described the town planning of Babylonians as: "It lies on a great plain , and is in the shape of a square , each side a hundred and twenty furlongs in length , thus 480 furlongs make the complete circuit of the city … they built houses , of a single chamber facing each other , with space enough for the driving of a four-house chariot … There are a hundred gates in the circle of the wall, all of bronze with posts and lintels of the same kind …." (Michael Woods , Marry B. Woods , 2000). The building methods developed rapidly but the earliest buildings were semi sunken round huts. Digging a series of holes in the ground, the builders would insert a tall bundle of reeds in each hole. A circle of holes would be used to make a circular house and two parallel rows to make a rectangular one. Once the bundles were firmly inserted, the ones opposite to each other would be bent over and tied at the top to form a roof. The thick bundle of reeds provided shading and some insulation (Bertman, 2003, p. 188)(Fig 2)(Fig 3).

Later on, the use of rectangular rooms with walls of sundried bricks and mud plastered roofs supported by wooden beams appeared in the Husanan, Sammaran and Ubaid periods perhaps as early as 6000 B.C.E. Before beginning construction, the buildings were thoroughly planned on a clay tablet (Roaf, 1992). Variations had been noticed in the construction of different houses. For example, the houses in Sammaran period had many rectangular rooms with the internal walls matching the external buttresses, while those at Tell-sawan were T shaped and divided into two parts. At Songor and Choga Mami, houses were rectangular forming a regular grid. In the Halaf period, the typical houses were round structures often with a rectangular annex (incorrectly called tholoi). Some of the roofs of the houses were built with poles or sticks weaved with reeds having a toping of clay on it (Fig 4).

In the Ubaid period, the houses were tripartite; they had a large central room at par with the width of the buildings with rows of smaller rooms on both sides. During the Uruk period, the tripartite house continued but there was also a new form of domestic residence; a courtyard house with rooms on all sides was introduced. The main reception room was away from the entrance – on the sides of the courtyards. The courtyard houses play an important role in facilitating natural light, thermal comfort and ventilation. Moreover, they also played a major role in creating an open space within houses (Myneni, 2013, p. 633). They provide a cooling effect by creating conventional currents. A major challenge faced by ancient builders was that of the door and the passageways. The openings of doors and windows were as wide as the longest available beams. If too much weight was placed on the top of the lintel, the stress could cause the lintel to be damaged. The only engineering solution was to build an arch that was presented by Sumerians (Bertman, 2003, p. 193). The stair cases were found in the courtyards of most of the houses giving access to upper floors to the roof space of houses. (Baird, 2014, p. 94) Mostly Wooden ladders gave access to the roof, where families spent much of their time except during the hottest part of summer days. In large Mesopotamian cities, roof holes often provided the only entry. In the Early dynastic period, the only consistent use of stone in the south in buildings was for door-sockets, otherwise its appearances are sporadic (Moorey, 1994, p. 340). The mud brick work used in Mesopotamia tended to be protected either by fired or glazed bricks on the outer face or by an imported stone facing. Another example of successful use of mud in the construction of dwellings is in the arid region. The thick mud walls of houses usually were lime washed to give a light, sun reflecting surface, providing a mean of controlling the environment within the dwellings. (R.S Narayanan , A.W.Beeby , 2001, p. 56). The unavailability of stone and timber forced the builders to look for some other way of erecting the ceilings – the vault brick ceiling. The vaults were built without frame work as a series of arches with inclination arranged in transverse rows. In Mesopotamia, an arched vault was the basis for the structure (Fedulova, 2014, p. 44). The valley of the two rivers experienced floods, so all important buildings, temples and palaces were erected on high foundations or platforms. Architectural expressions were based on the ratio of the volumes and the masses in the tower like ledged composition. The most important monument of Sumerian architecture is the ziggurats of Ur that refers to the end of 3rd millennium BC (Fedulova, 2014).

1.3. Hydraulic Engineering

Hydraulic technology was in use was long before the great works of such investigators like Vinci, Galileo, Pascal, and Archimedes. The people of ancient times gained those concepts before the developments of concepts of mass momentum, conservation of mass, energy, buoyant force etc. The ideas to control the flow of water was invented in the Neolithic phase but was implemented in Mesopotamian period (Mays L. W., 2008). Mesopotamia's land was blessed with life-giving water, and that is one of the leading reasons why civilizations began there (Camp, 1995). The water had to be bent according to the use of man – this was one of the important reasons that led to the invention of the greatest achievement in civil and mechanical engineering. Both the rivers Tigris and Euphrates were opposite in nature. The Tigris was more violent than the Euphrats, so the calmness of Euphrates was more readily turned to farmers for aid. Water lifting devices were very famous in ancient Mesopotamia. Shaduf – a seesaw like contraption consisting of a long pool with an empty bucket at one end and counter bucket or a counter balance at another end was used to raise the water when the water of the river dropped below the inlet point. In fact, by using more than one shaduf, water can be raised from one level to another (Fig 5).

To supply water to hanging gardens, an army of gardeners would have been required, but this enormous task was achieved by a device known as Archimedes screw. This was the device described in the inscriptions of the Assyrian period, centuries before the invention of Archimedes (Mclntosh, 2005). Archaeologists believe that river water was taken from the river Euphrates. A chain pump (A chain pump was a series of buckets on a chain looped around two wheels. The bottom wheel sat in a pool of water. As it turned the buckets dipped into the water and carried it to the upper wheel, where they tipped the water out) carried to a pool at the top of the gardens (Fig 6). Gardens opened to send the water into channels that watered the gardens. To stop the clay bricks from getting damp, and to avoid seepage of water, the plants grew in containers lined with stone, reeds, bitumen, tiles and lead. (Samuel, 2013, p. 22)

The Mesopotamian people built extensive networks of canals that they dug out by using primitive hand tools, and they lined the sides with bricks (Faiella, 2006, p. 28). As the flow of water depended upon gravity, the slope of the canal was critical to its operation. (Bertman, 2003, p. 204). The slope of the canal had to be precise because if the slope was too steep, the water would flow too fast eroding the canal and dropping the level of water to flow out into the fields. If the slope was too gradual, water would flow too slowly and the canal would clog up with silt (Faiella, 2006, p. 28).

Surveyors had to calculate, not only the slope of the canal, but its depth, width and positioning of sluice gates. Archaeologist found a number of tablets showing the calculations for digging of a canal (Fig 7).

In addition to canals, wells have been formed in Mesopotamia. In these wells, the bucket was easily sent in the well. This job too was made easier by the invention of the pulley (Bertman, 2003, p. 205). Water was regularly transported to the lands of Mesopotamia by an underground conduit, using a device for underground water transportation named qanat. Vertical channels were dug into the rock at regular intervals. It was a device with a constant slope having a regular series of access holes. These holes were used for maintenance and to release the air pressure that can build up and impede flow when the rush of water through the pipes becomes too fast. This qanat was not suitable for southern Mesopotamia because of the softness of the earth. In southern Mesopotamia, the above ground canals were the method of choice for moving water (Richard W. Bulliet , Pamela Kyle Crossley , Danial R. Headrick , 2008). Hydraulic development involved, not only the digging of canal, but also the restoration and maintenance of river courses. Besides dikes and canals, rock cuts were used to block the river water for diverting water into artificial lakes (Viollet, 2005, p. 30).

1.4.CONCLUSION:

Mesopotamia a civilization that was the first of its kind; it had technology and urban settlements that laid the foundation of future modern settlements. It considered the region's environment and climate as pivotal in the development of its culture and architecture. This study discussed how the people consciously or unconsciously shaped the land or landscape around them in relation to their environment. The natural resources of any civilization largely determines the structural materials used by its architects and engineers – same is the case with the Mesopotamian civilization. The natural condition of this area does not favor architectural development. It is an alluvial plain and the only building material present in quantity is mud deposited by the two great rivers. Since bitumen obtained at hits of Euphrates served as the water proof material. In the north there was gypsum, known as Mosul marble, but its transportation required so much man power that its use was restricted to the palaces and temples. They therefore effectively used all the materials in construction according to their environment. As this land was largely dependent upon the two rivers, the water course and its abundance led to the invention of civil and mechanical engineering like Archimedes Screw, water Pumps, Fulcrum and pulley etc. Hence Environment and climate of an area begets the architecture of an area with regards to the adaption of tools, material and modes of construction.

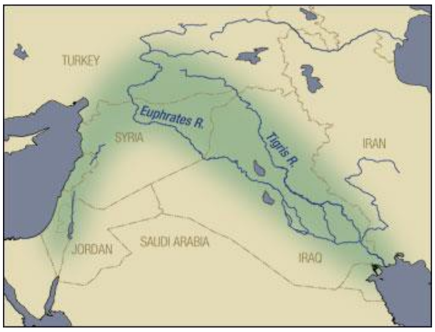

Figure 1: Map of Mesopotamia with Fertile Crescent and the twin rivers

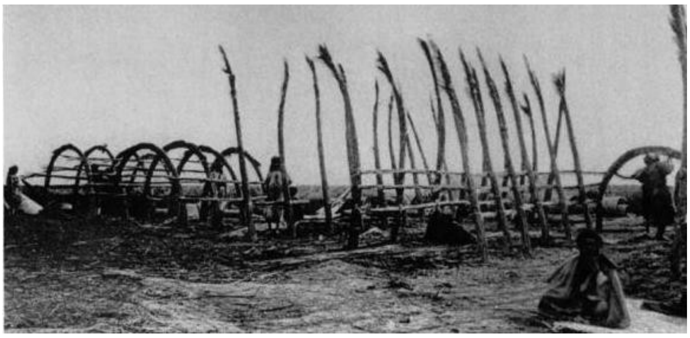

Figure 2 : Construction of reed houses

Figure 3 : Clay tablet showing a reed house

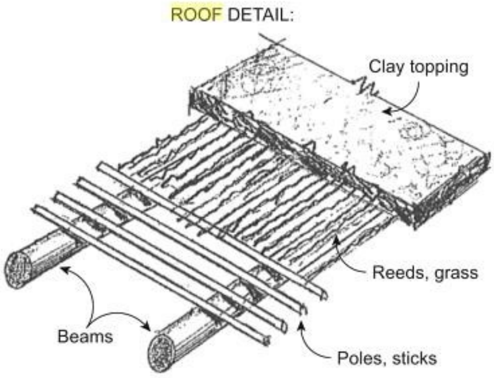

Figure 4: Technique of roof construction

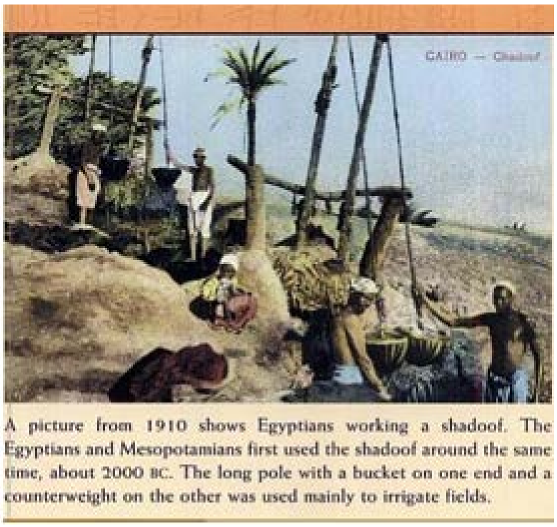

Figure 5: A painting of technique Shaduf

Figure 6: Mechanism of Hanging garden

Figure 7: Canals in Mesopotamia

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