Study of Climate Responsive Building form for Kutch Region

[1]Plabita Sharma [2]Ruchi Singhal [3]Bhagyashree Sisode [4]Dr. Krupesh A. Chauhan
[1,2]M.Tech Student [3]Ph.D. Scholar [4]Associate Professor
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]SVNIT, Surat, Gujarat, India

Abstract

The traditional architecture of Kutch represents the social and cultural background of the region and its people. The climate responsive buildings were designed with emphasis on the human comfort which was largely accomplished through the use of locally available materials and sustainable construction techniques. Learning from tradition, which is a powerhouse of knowledge and wisdom of previous generations through the lessons of traditional building can be very powerful tool for improving the buildings of the future.

Keyword- Traditional Architecture, Climate Responsive Building, Sustainable Construction

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I. INTRODUCTION

Kutch is a district of Gujarat state in Western India. (As shown in figure 1) Covering an area of 45,652 km², it is the largest district of India. The population of Kutch is 21 Lakh, literacy rate is 59.79%. It is also an earthquake prone area.

Fig. 1: Map showing location of Kutch district
(Source: www.pravinvankar.com)

Kutch district is divided in two major parts (as shown in Figure 2): Rann of Kutch – It is a wet and dry region without any settlements. Salt flat lands are prevalent in summer and flooded in rainy season. Kutch – The area is dry with settlement both traditional and modern. Topography -Whole Kutch region is flat with grasslands, not much vegetation.

Fig. 2: Topography of Kutch Region
(Source: www.mapsofindia.com)

II. LOCATION AND CONTEXT

Bhungas are mainly set up in desert islands (fertile land in the middle of the desert) in the northern parts of Kutch region of Gujarat- specially Banni and Pachham. (As shown in Figure 3) Banni is a flat plain area with silty clay soil type. There are no stones or aggregates available for construction. Hence mud and thatch are most commonly used locally available construction materials. Pachham Island and the greater Rann of Kutch has two hill ranges, Kalo Dungar and Goro Dungar. It is an undulating and cultivable land where limestone is amply available. Most Bhungas in Pachham use limestone in uncoursed rubble masonry for construction of foundation and the superstructures may vary.

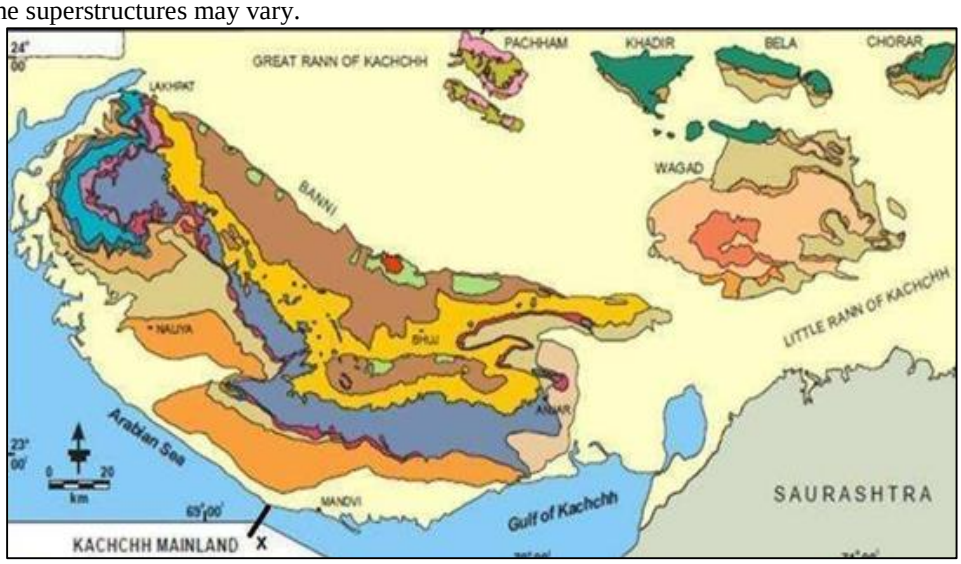

Fig. 3: Map showing Kutch Mainland regions.
(Source: www.researchgate.net/figure/Geological-map-of-Kachchh-Basin)

A. Bhunga

The Bhunga is a traditional construction type in the Kutch district which has a very high earthquake risk. The Bhunga has a conical roof supported by cylindrical walls (as shown in figure 4). Bhunga construction has existed for several hundred years. This type of house is quite durable and appropriate for prevalent desert conditions.

Bhunga architecture is a very unique aspect of traditional desert architecture of Kutch region in which the size, location and orientation of the Bhunga are planned for very good structural and functional results.

Fig. 4: A circular Bhunga type

The factors influencing Bhunga design are:

- Climate: The thick walls, made of mud, keep the interior cool when the temperature rises to 40+ degrees Celsius in summer and warm when it drops below 5 degrees in winter.
- Culture: Culture is revealed in the decoration of the Bhunga (outside as well as inside) from painting on exterior walls to Glass designing on interior walls.
- Calamities: It performed very well in the recent M7.6 Bhuj earthquake in 2001. Very few Bhungas experienced significant damage in the epicentre region and the damage that did occur can be mainly attributed to poor quality of the construction materials or improper maintenance of the structure. It has also been observed that the failure of
- Bhungas in the last earthquake caused very few injuries to the occupants due to the type of collapse.

III. CONSTRUCTION OF THE BHUNGA

Bhunga is circular in plan having an inner diameter typically between 3m to 6m, generally has only three openings one door and two small windows. Bhungas are connected through plinths and circulation is also carried out in that way (as shown in Figure 6). A cluster of Bhunga is built on one plinth usually the cluster contains settlements of one whole family.

Fig. 5: Bhunga connected through plinth

The components required for the construction of walls and foundations are:

1) Clayey soil and rice husk for earth blocks.
2) Cement mortar used for foundations.
3) Earth sourced from Banni, cow dung and local earth for plaster.

Construction stages of walls are as follows:

1) A trench 30 cm deep and 45 cm wide is dug. The process of laying the blocks is locally called chanter.
2) Walls are raised on foundations, using cow dung plus local mud mortar, mixed with water to make the compound workable.
3) Lintels and doors and window frames are inserted where necessary.
4) A platform-otla-is then built using rubble stone and earth, up to a height of about 45 cm.

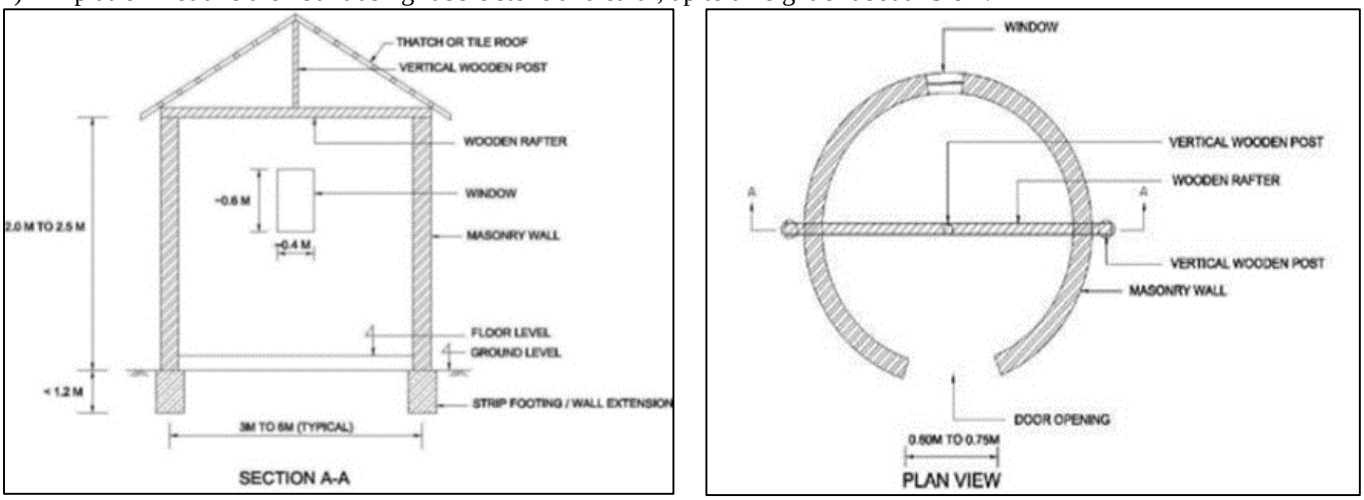

Fig. 6: Typical plan and section of a Bhunga

IV. WALL CONSTRUCTION OF BHUNGA

The mixture for the plaster layer, locally called gobar Lipan, is made with cow dung and local mud. Water is added to improve its workability. A first layer is applied on the outer surface of the wall, and smoothed using hands. It takes about a day to complete it, and then another layer is applied on the inner surface. These inner and outer layers are alternated, up to seven layers are applied on both surfaces of the wall. The last layer of Lipan is done using earth sourced from Banni . The roofing in wall are resisted through shell action providing excellent resistance to lateral forces. In materials are generally very light weight, and develops low inertia forces.

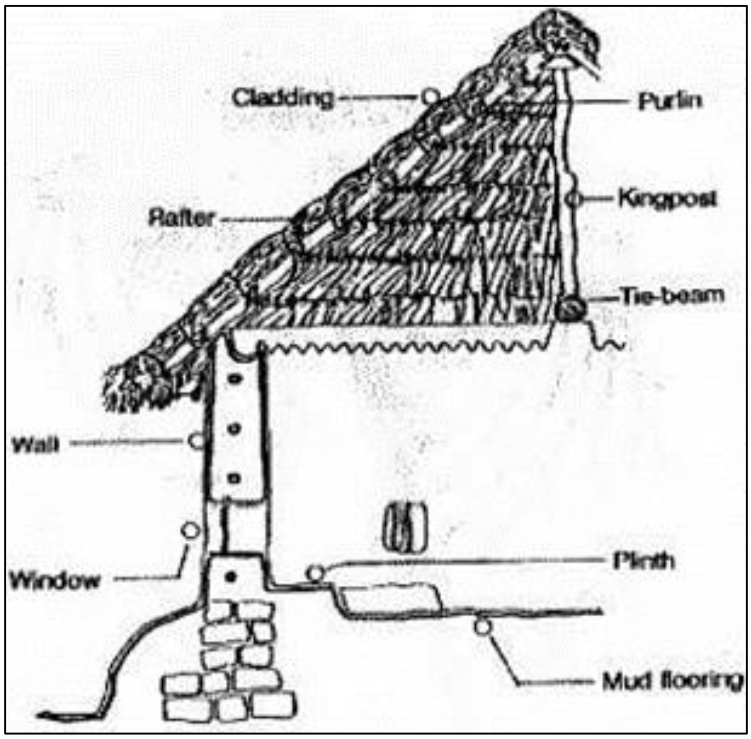

Fig. 7: A typical cross sectional view

V. ROOF CONSTRUCTION OF BHUNGA HOUSES

The components required for roof's construction are:

- One horizontal beam (diameter 15 to 18 cm).
- A base for the vertical kingpost - patli - size 5x7x25.
- A central kingpost (ranging from 180 to 270 cm, diameter 10 cm).
- A cone - MANN - at the top of the kingpost (diameter 40 cm, 45 cm high). Babool wood rafters forming the backbone of the roof – VALI – (having a diameter between 6 365 cm long).
- Culms of split bamboo which constitute the secondary warping - KHAPATIS – (diameter 2 .5 cm, length 365 cm).
- Rope - KATHI -, (1.25 cm thick. 30 kg of rope are required).
- Straw - KHEEP – (for roofing).

Fig. 8: Exposed Roofing material

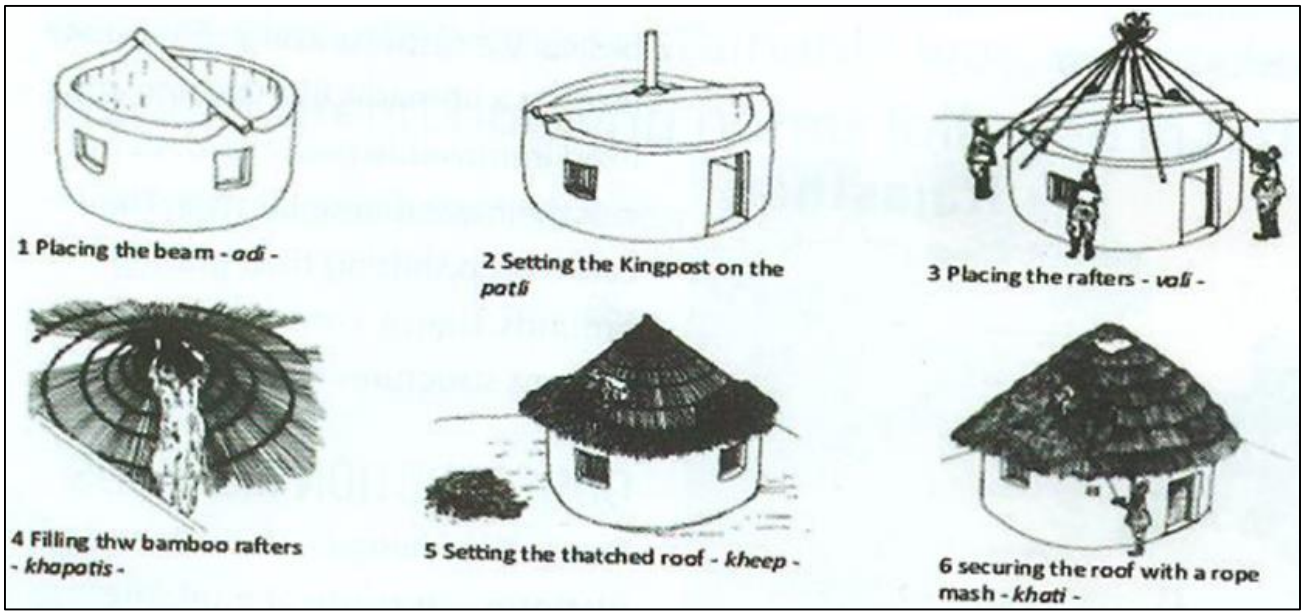

Fig. 9: Roof construction of Bhunga,
(Source: aina.wikidot.com/documentation:traditional-circular-house-form-bhunga)

The conical roof of a Bhunga is supported at its crest by a vertical central wooden post, which rests on a wooden joist. The base of the roof and the wooden joist are generally directly supported on Bhunga walls. Sometimes, the roof load on wooden joist is transferred to diametrically placed timber posts (vertical members) adjacent to the cylindrical wall. This reduces the roof-load on the walls.

In several Bhungas, the roof joist is not directly supported on the cylindrical walls, but is supported by two wooden vertical posts outside the Bhunga, which further improves seismic resistance of the inertia force generated in the roof.

In some instances, reinforcing bands at lintel level and collar level have been used to provide additional strength. These bands are constructed from bamboo or from RCC. These increase the lateral load-carrying strength greatly and increase the seismic resistance of the Bhungas.

VI. EVOLUTION OF BHUNGAS

Traditional Bhungas consists of light-weight conical roof while recent Bhungas constructions have used wide variety of construction materials including heavy Mangalore tiles on roofs (as shown in figure 10).

Fig. 10: Roof constructed with Mangalore tiles

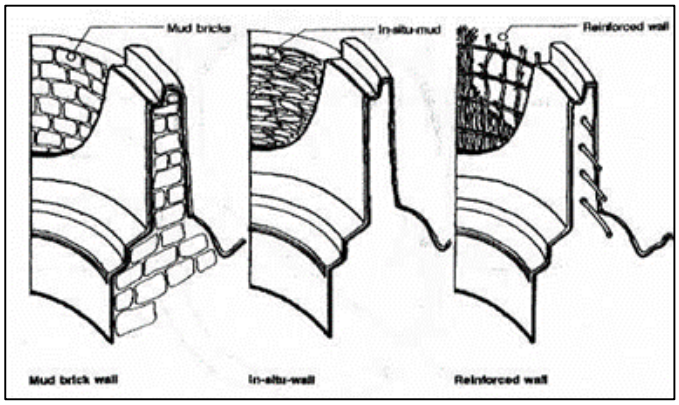

Fig. 11: Wall construction materials
(Source: www.priyashah.com/mig/ludiya)

Fig. 12 (a): Traditional circular Bhunga with precast columns and addition of seating areas thatched roof

Fig. 12 (b): Bhunga house having roof supported by precast columns and addition of seating areas

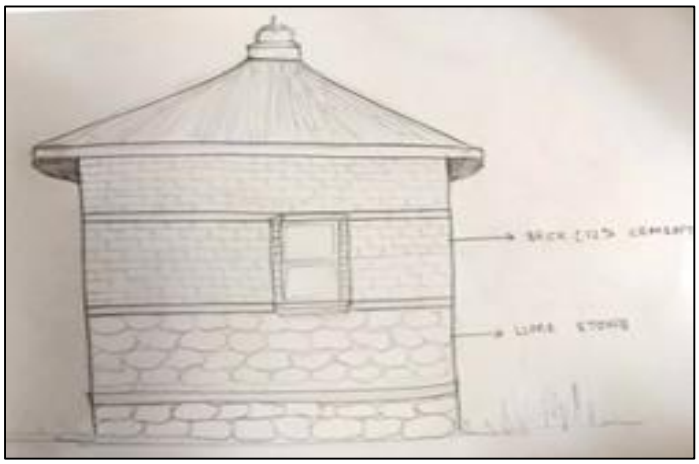

Fig. 12 (c): Modern Bhunga with brick and stone construction

VII. LABOURS AND MATERIALS USED

- These constructions are carried out by local village masons with very few unskilled labourers and can be completed within 30 days.
- The locally available soft stone can easily be cut or chiselled into rectangular blocks, which are used for wall masonry.
- The local soil is used for mud mortar and to make adobe blocks. Locally available timber and bamboo are used for roof.
- The entire construction cost of 1 Bhunga is approximately 10000-15000, with maximum cost is covered by labour and materials.
- The rent of a conventional Bhunga is approximately Rs. 2000 and that of air conditioned Bhunga is Rs. 5000.

VIII. ARCHITECTURAL ELEMENTS

The circular mud house is an integration of exact geometry and property of materials for the climatic conditions to evolve a perfect architectural form of the house. Due to circular shape of wall in plan, inertial forces developed in wall are resisted through shell action providing excellent resistance to lateral forces. In addition, the thick walls required for thermal insulation have high in-plane stiffness which provides excellent performance under lateral loads.

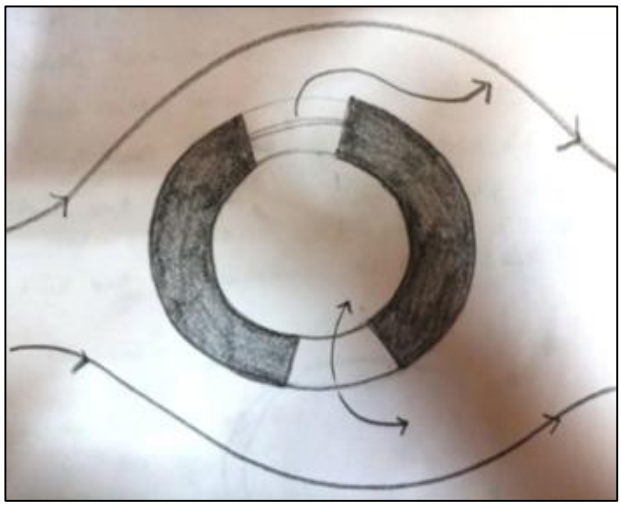

Fig. 13: Resistance to lateral force due to circular shape

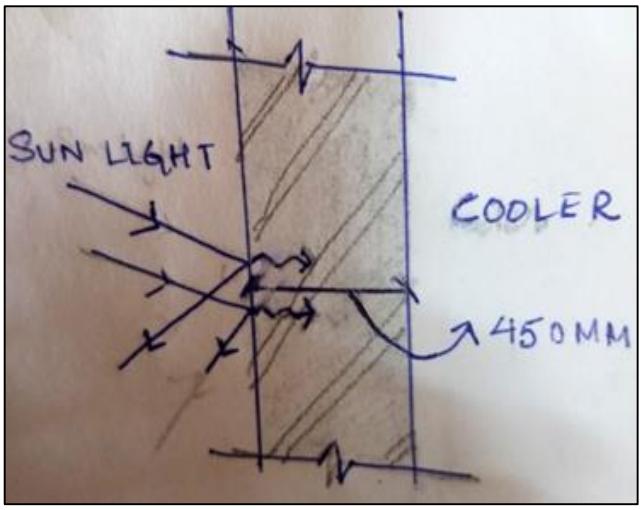

Fig. 14: Thick walls for thermal insulation

IX. CONCLUSION

During our study, it was observed that the use of locally available materials in the construction of Bhunga imparts a sense of traditionalism and is also energy efficient in their design. However, even though the Bhungas are inspired by the traditional architecture, some resorts have rooms styled as Bhungas, but equipped with air-conditioning and flat screen television sets taking away the essence of vernacularism. Also, its success can be partially attributed to the fact that it is small in scale and operation and can thus operate at the level of each individual tourist. But now a days it is scaled up to cater to mass tourism, so there is the risk that it will lose its exclusivity and unique selling point.

Fig. 15: Air-conditioned Bhunga

Fig. 16: Dholavira Resort

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