Traditional and Vernacular buildings are Ecological Sensitive, Climate Responsive Designs- Study of Himachal Pradesh

Sandeep Sharma and Puneet Sharma

***Abstract*—**The Traditional Architecture of Himachal Pradesh is the outcome of the prevailing topography, extremes of the climate and other natural forces. Indigenous architectural solutions have responded well to these natural forces. Moreover the vernacular architecture merges well with the hills at the backdrop. The Traditional Architecture forms the back bone of social and cultural set up of the place. It is essential for this architecture to retain its integrity. So the Traditional Architecture should not be disturbed, rather the contemporary architecture should be integrated well with the traditional architecture. This Traditional Architecture has stood till today. It commands deep interest and respect as it represents and reveals the many faceted realities of the people living there. In the traditional architecture, buildings were designed to achieve human comfort by using locally available building materials and construction technology which were more responsive to their climatic and geographic conditions. Learning from traditional wisdom of previous generations through the lessons of traditional buildings can be a very powerful tool for improving the buildings of the future.

***Keywords*—**Traditional Architecture; Climate responsive buildings; Vernacular Architecture; Sustainable Construction.

I. Introduction

CLIMATE-RESPONSIVE building design is about taking advantage of natural energy sources such as sun and wind that affect our built environment. The basic idea is that comfort is provided in close interaction with the dynamic conditions of the environment. Comfort is provided when needed and delivered where needed, while buildings can respond to changes in the internal and external climate and to occupant intervention.

Climate responsive buildings can improve human comfort and in doing so improve the human condition, in all parts of the world. Scientific knowledge provides us with the tools and methodologies needed for passive low energy-climate responsive buildings, and intelligent design dictates the strategies needed to implement such knowledge on the ground. Climate responsive design substantially reduces the economic and environmental costs of buildings to individual, regions and to nations.

Learning from traditional wisdom of previous generations through the lessons of traditional buildings can be a very powerful tool for improving the buildings of the future. This traditional architecture has stood till today. It commands deep interest and respect as it represents and reveals the many faceted realities of the people living in different climatic zones of Himachal Pradesh.

Traditional and Vernacular buildings in contrast to Modern buildings constructed in 20th century are more climate-receptive; the climate-responsive architecture originates in the pre-industrial era before the introduction of air-conditioning and electric lighting. Each region of the world employs its own techniques and designs in its buildings that are best suited to that particular region and that encompass the region's cultural patterns.

It is generally accepted that traditional or vernacular architecture is well adapted to the dominant climate of its surroundings by means of the method of trial and error. Tradition is dynamic as it changes with people's desires or cultural expressions. This is the reason of popular architecture is said to be the origin of bioclimatic architecture [3]. The Traditional Architecture of Himachal Pradesh is the outcome of the prevailing topography, extremes of the climate and other natural forces. Indigenous architectural solutions have responded well to these natural forces. Moreover the vernacular architecture merges well with the hills at the backdrop. The Traditional Architecture forms the back bone of social and cultural set up of the place. These architectural splendors serve as the living heritage and add to tourist attractions. It is essential for this architecture to retain its integrity. So the Traditional Architecture should not be disturbed, rather the contemporary architecture should be integrated well with the traditional architecture.

During hundreds of years man has developed some constructive techniques to obtain the internal comfort considering the local climatic conditions, the available materials and other conditions relating to culture. In the traditional architecture, buildings were designed to achieve human comfort by using locally available building materials and construction technology which were more responsive to their climatic and geographic conditions.

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II. Classification Of Climatic Zones And Their Traditional Construction Techniques

The character and forms are different from one climatic and geographic zone to other which can be identified in three separate zones, i.e., upto 4000 ft. (1200 m approx.), upto 9000 ft. (2700 m approx.) and above 9000 ft. (2700 m approx.) So the state of Himachal can be broadly classified into three zones depending upon their elevations (Fig.1).

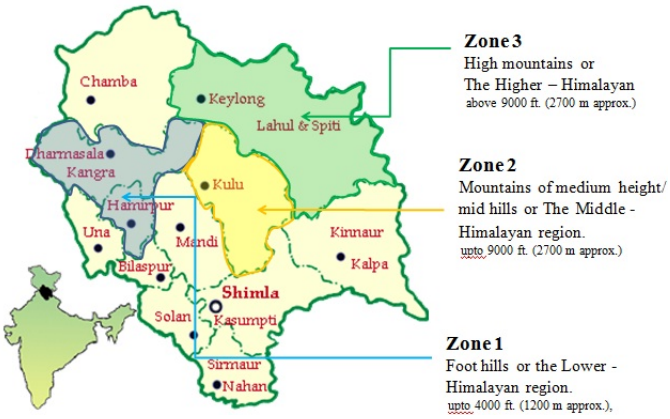

Fig. 1 Map of Himachal Pradesh showing classification of zones(Source:www.indianetzone.com/3/himachal_pradesh.htm

III. Foot Hills Or The Lower - Himalayan Region

In the first climatic zone i.e., up to height of 4,000 ft. (1200 m approx.), where climatic conditions are mild throughout the year, i.e., pleasant summers, mild winters and medium rain falls. Flora of this region is similar to that of Tarai belt. The special characteristics of this zone are absence of snow fall.

The orientation of the buildings in this zone is mostly East and South. The slope of the land is from 0 to 30æ approximately. Materials available for construction are stone slabs for flooring and roofing, stone and earth for walls and wooden plank supports on wooden joists for intermediate floors. A typical innovative technique for construction of earthen walls is use of a bottomless wooden box 0.60X0.90 m, with a height of 0.23 m in which earth is filled and rammed thus creating 0.23 m layer of rammed earth at every stage for the construction of a wall which is 0.60 m thick. The another innovative techniques is the use of locally available slate stone which are used for sloping roof and are placed on heavy wooden supports with overlapping of 0.0254 - 0.0308 m. These slates are not fixed to wooden supports but remain in place by weight only or sometimes they nailed to the wooden joists/rafters. The slope of roof is confined to maximum 22.5 degree.

ln areas of heavy rainfall such as Dharamshala and Palampur steeply-sloping roofs and deep verandahs are necessary, the former to drain off the rains quickly and the later to allow open-air living during rainy season and for protection of the walls. Before the British influence, the buildings constructed in these areas bore the influence of Rajasthan and Mughal architecture which existed throughout northern India at that time. However, with the coming of the British the jack-arch was introduced and Dharamshala-type roofing was evolved for areas of heavy rainfall using plain or galvanized iron sheets for roofing. tables and figures you insert in your document are only to help you gauge the size of your paper, for the convenience of the referees, and to make it easy for you to distribute preprints.

A. Traditional Construction Techniques - Mud Construction

Mud construction is prevalent in Himachal in two types, rammed earth conduction and sun dried mud brick construction. Sun dried mud bricks are used in the Kangra region where good quality of mud is available from the river beds. The walls are made of sun dried bricks about 0.60 – 0.90 mt. thick plastered with mud phuska. These walls are susceptible to erosion due to rain thus the buildings are raised over stone or plastered to avoid erosion. The floors are made of wood plastered with mud enabling insulation (Fig. 2).

Fig. 2 Views of Mud construction (a) Rammed Earth Construction (b) Staircase detail in Mud House (c) Modern House made up by traditional construction techniques (d) Interior details of mud brick house.

B. Traditional Construction Techniques - Dry Stone Construction

Dry stone construction is common in Kangra region where slate is in abundance (Fig.3). However this type of construction is also common in Kinnaur district where good quality stone can be quarried. Different sized stones are placed over each other and compacted without the mortar. Through stones are used at regular intervals. A stronger bond is achieved by interlocking the stone rather than adding smaller stones in gaps. Interior surface may be mud plastered. The stone masonry structural walls take main lateral and gravity load. The walls uniformly distribute the load in both orthogonal directions.

Fig. 3 Views of Dry Stone Construction at Dharamshala - Kangra (Vill. Thathri-Khaniyara)

IV. Mountains Of Medium Height/ Mid Hills Or The Middle - Himalayan Region

In the second climatic zone up to 9000 ft. (2700 mt. approx.), the hills are steeper. Northern slopes of the mountains are thickly forested, while habitation is confined to Southern slopes. The climate throughout the year is mild to chilly in comparison to planes, i.e., cool in summer and rainy season with heavy rain fall. During winter there is always snow fall and temperature goes down below zero. The flora in the region consists of temperate zone species; Pine in lower altitudes and Deodar, Chilgosa and Betula in higher altitudes. The design of buildings in this zone is influenced by the elements of snow fall, chilly winter and heavy rain fall. The building materials available in inaccessible areas are stone and wood. ln this zone, most better-class houses and even poor ones are built with stone and wood, without mortar.

The typical Himalayan house of this region consists of two or more stories (Fig. 4), with cattles in the ground floor, grains in the middle floor and dwelling in upper floor surrounded by a deep over hanging verandah which is used for various purposes such as living and storage of fuel wood and fodder. The typical feature of vernacular architecture in this zone is the projection of upper floor [1]. The walls construction is done with stone and wood without mortar.

Fig. 4 Cattles on the Ground floor and dwelling on First Floor also the Fenestration on south facing at Kullu

In this traditional Himalayan method of construction the wooden beams extend to the whole length of the wall, one beam on the outside and another on the inside, the space in between filled up with stone. The wall at right angles has its beams laid on the two just mentioned and the alternate placing of these beams continue in this way. From this it will be understood that the construction is capable of holding itself together without the stones which are filled in to form a solid wall. On top of this mingling of wood and stone stands the real dwelling, which is entirely of wood. Supported by beams, it over hangs the more solid structure beneath. A row of small pieces of wood, named 'Jhallar' are hung from the upper cornice. The bells at the corner also hang loose and are moved by the wind.

This type of construction is mainly found in the higher ranges of Kinnaur and Kullu districts of Himachal. The most common type of kath - kunnni wall is made by laying apart two square sectioned wooden wall beams (Fig. 5 b, d) longitudinally parallel to each other to define the width of the wall. In order to ensure the proper bond between the two these are dove-tailed or lap jointed by the cross-joists, suitably placed along the length of the wall.

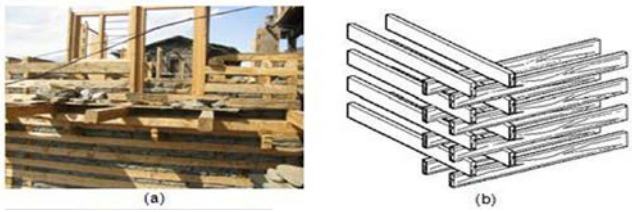

Fig. 5 Views of Kath- Kunni Construction

The walls are constructed of alternate layers of wood and stone (Fig. 5 a, c). The wood battens 0.10-0.15 m thick extend beyond the wall length and interlock with the wood on perpendicular wall. The wooden planks are interlocked by lap joint. Floors are made of wood not more than 2.10-2.40 m high for better insulation. The upper floors project out of the stone wall with wooden balconies creating a sun space for sitting. Thus maximizes the heat gain. This type of construction is earthquake resistant as the wooden battens form a framework which is well bonded and gives ductility to the otherwise rigid stone wall [5], [2].

A. Traditional Construction Techniques - Dhajji Wall Construction

Dhajji-Dewari is derived from Persian meaning "patch quilt wall." Due to its resemblance in the appearance to quilt patchwork of Persian weavers it is called as “Dhajji” [4]. Such construction is common in the Kashmir valley and the hills of Shimla. It mainly consists of a braced timber frame where the spaces between the bracings and the frames are filled up with stone and brick masonry laid in mud mortar (Fig.6c). The large timber members rest along the load bearing masonry walls with the floor beams and the runners for the cross walls lapping over them. The wood serves to tie the walls of the structure together with the floors. The components of Dhajji wall are the Foundation, Plinth Beams (Dasa), Frame

Structure, Joints, Roof Truss, Walls and Bracings, Windows and Doors, Infills and Plaster (Fig.6b). It is lighter in weight allowing for its use on walls that are cantilevered over the street. The surface is plastered with a coat of mud and lime at some places. This type of construction is economical and structurally stable. The fame of wood distributes the lateral loads in case of an earthquake. A typical "Dhajji House" (Fig. 6 a) is composed of small panels, stone masonry and timber of thickness 0.45-0.60 m which has a time lag of 8-9 hours which keeps the house warm in winter and cool in summer for maximum part of the year [5].

Fig. 6 Views of Dhajji-Dewari Construction

B. Traditional Construction Techniques - Wooden Construction

Wooden construction is very common in hilly areas for easy availability of construction wood and its thermal properties provide relief from the cool winters. In Himachal this construction is common in most of the areas except cold and dry areas of Lahaul-Spiti, in combination with other techniques at times. Houses are built 2-3 storeys high (Fig 7 a) where the vertical wooden posts are meant to carry the load. Horizontal members are placed at different levels with an in-fill of wooden battens [5]. The upper flowers are cantilevered thus providing living space all around. In some cases, the ground floor is built in stone masonry with the upper floor of wood (Fig. 7b).

(a)

(b)

Fig. 7 Views of wooden houses (a) Two storied wooden house (b) Wooden cantilevered upper floor with ground floor of stone masonry.

V. HIGH MOUNTAINS OR THE HIGHER – HIMALAYAN REGION

In the third climatic zone which starts from 9000 ft. (2700 m approx.) and extends to higher reaches of literal snow, last human habitation is at an altitude of about 15000 ft. (4500 m approx.). The climatic conditions keep on changing with the altitude, i.e., from 9000 ft. to 11000 ft. (2700-3300 m approx.) there is rain falls as well as snow fall, but after 11000 ft. (3300 m approx.) there is only snow fall.

Habitants of this area who had never experienced rains in their living memory are now witnessing rain fall which is a new phenomena in the area. This is due to emission of hydro-carbons from fossil fuel driven vehicles layer of atmosphere, altering the temperature.

Flora in this region consists of Bitula Chilgosa and at higher altitude Willows which also give way to alpine pastures after 14000 ft. (4200 m approx.) Due to climatic conditions the development of vernacular architecture is based on construction techniques which are entirely different than any other region. The rocks keep on disintegrating due to vast temperature difference between day and night. The snow falls is also in powder form, due to winter temperature of minus zero reaching upto minus 32 degree in mid winter. The mode of construction used is rammed earth block for walls beaten earth for flooring and flat roof consisting earth layer over 6-7 layers of Bitula barks which are placed over wooden planks supported by wooden joists (Fig. 8a-b).

There is 0.10 m layer of sand in between two layers of Bitula barks. To conserve energy the height of rooms are confined to 2.10 m and openings are very small. A technique of supporting 2 thick earthen wall over 0.075 m frame by using small size battens kept at right angle to each other in alternate layers is same thing peculiar to this region. In the high altitude cold desert areas of Spiti, flat roof consisting earth covering ever willow branches resting in wooden joists is an innovative method of constructing flat roof (Fig. 8 a-b). This technique has been evolved due to absence of any other material available for roofing.

(a) (b)

Fig. 8 Views showing building typology (a) Mud houses at Tabo, Kinnaur, (b) Dwelling at Spiti Valley

A. Traditional Construction Techniques - Mud Construction

Mud construction is prevalent in this region of Himachal Pradesh. The popular form of construction is rammed earth conduction. Rammed earth construction is common in the areas where construction materials like stone and wood is not available like the cold desert of Lahaul-Spiti, Kinnaur etc.. Thick walls upto 0.60 m wide are built with by pouring wet mud mortar and ramming it to make it compact before pouring another layer (Fig.9 a-d). Monolithic walls thus constructed keep the interiors cold in the chilling winters but earthquake

resistance of this construction varies with the form of and the building the type of loading on the walls. Thick flat mud roofs are used for insulation in Lahaul while in places with rainfall slate roofs are adopted. The roof is built over wooden frame resting on the mud walls. flat roofs are formed of wooden beams with birch—bark (bhojpatral, which is perfectly waterproof, laid in one or two layers over wooden planks and covered with beaten earth; this is smoothed into a flat roof on which fruits and grains are laid out to dry.

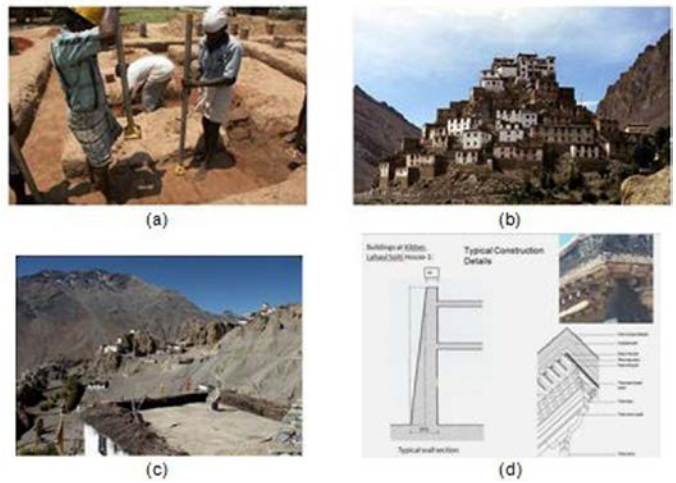

Fig. 9 Views of Mud construction (a) Rammed Earth Construction (b) View of Kie Monastry (c) dwelling at Spiti valley (d) Construction details of the rammed earth mud houses.

B. Traditional Construction Techniques - Dry Stone Construction

Dry stone construction is common in Kangra region where slate is in abundance. However this type of construction is also common in Kinnaur (Fig.10) district where good quality stone can be quarried. Different sized stones are placed over each other and compacted without the mortar. Through stones are used at regular intervals. A stronger bond is achieved by interlocking the stone rather than adding smaller stones in gaps. Interior surface may be mud plastered. The stone masonry structural walls take main lateral and gravity load. The walls uniformly distribute the load in both orthogonal directions.

Fig. 10 Use of dry stone masonry at Nako, Kinnaur

VI. Conclusion

In the end it is concluded that the traditional and vernacular buildings are ecological sensitive, climate responsive designs. Any change in these designs should aim for human comfort and aesthetical needs and these sustainable designs help to save culture at the lowest possible ecological cost. The traditional construction method and process provides thermally comfortable shelter to the occupants by giving due considerations to local climatic conditions. Traditional construction techniques in hills are dictated by the climatic constraints and the availability of the materials. The most common building materials used is wood, stone and mud bricks. And now the places which got connected by motorable roads, certain new techniques have been evolved by using local materials for the construction of the buildings suiting to local climatic conditions. Any new development should respect the site and adhere to the local needs.

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