Vernacular and Passive Design Study of Kumauni Architecture

A Case study of Majhera Village in Nainital District of Uttarakhand, India

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Abstract: The traditional vernacular practice of any region are sources of wonderful knowledge for architects. These vernacular building practices holistically look at climate, social, cultural, economic and environmental aspects. The traditional-vernacular human settlements have been featured by conducting favorable practices to optimize the resources available locally. Their indigenous method of construction and designing techniques provide knowledge to cope up with severe local climate and geological conditions. Although new construction techniques and materials have taken over the market but the fundamental design elements remain the same. Thus it is important to learn and understand the indigenous building practices before designing building in the region. Therefore this paper analyses vernacular architecture of village Majhera in Nainital district of Kumaon region, from the perspective of sustainable and solar passive design. This research gives interesting study that how different typologies adopt different built form and orientation in the same prevailing climate. And also help to identify the hill architecture features of the region that can still be incorporated in contemporary constructions.

Index Terms **- Vernacular,-Kumauni architecture, lesser Himalaya, passive design, daylight zone, surface area to volume ratio.**

I. INTRODUCTION

The Kumaon region is one of the two regional settings of Uttarakhand which falls in eastern part of the state and lies in the IV seismic zone. The altitude of the region ranges from below 500m to above 4000m. As stated in (Negi, 1993) the climatic condition of Kumaon region varies from sub - tropical in the bhabar tract to alpine on the higher Himalayas and the inner dry upper Darma Vally.

The sample village for research lies in Nainital district which falls under lesser Himalayan region with an altitude ranging from 1113M to 1087M. And as per Negi,(Negi, 1993) Climatic regions based on the altitude, latitude and prevailing climatic conditions, Kumaon may be divided into six climatic regions, from which altitude ranging from 500-1500 falls in sub-tropical climate.

Kumar (Kumar & , 2014) has described that Settlements in hill regions are classified into three categories as ridge, mid land and valley

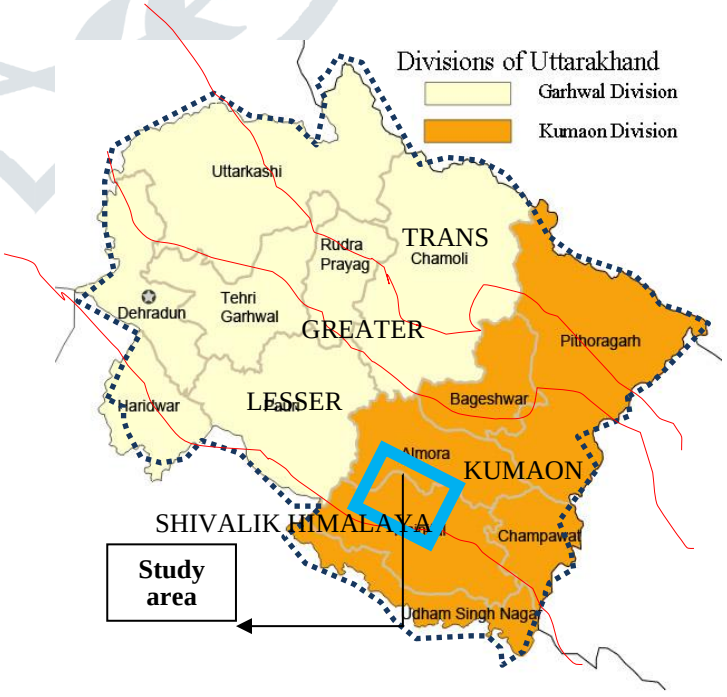
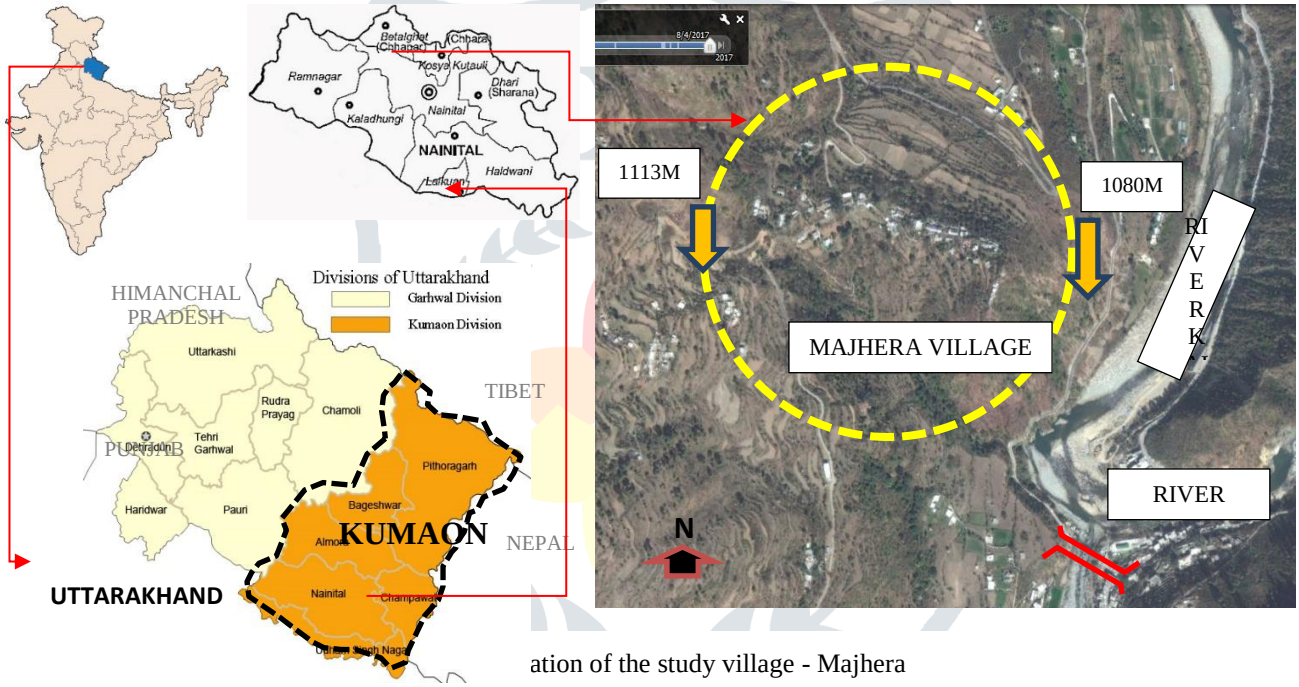


Figure 1location of the study area

settlements. Each type of settlement has its own peculiar issues for development which are unique and not present in other types of settlements. Planning and design of buildings vary in these settlements. The sample village studied here is an example of ridge settlement and radial planning.

As per (Sarkar, 2013) in a traditional vernacular settlements the shelters are designed to achieve maximum comfort with limited resources. In present the focal cities of hills are facing rapid and mass development due to the migration, socio-economic drift and urge for better facilities. Which has led to haphazard planning and uneven construction despite of the fact that the region falls under highly vulnerable zone in terms of severe climatic conditions, earthquake, landslide and water scarcity. The Traditional dwellings in the settlement are being constructed in a straight forward way based on the functional requirements of the users and the availability of the suitable building materials and construction techniques developed over the centuries to provide comfort to the users from the extreme cold (Sarkar, 2011). Hence it is required to incorporate the basic vernacular design elements in the buildings to make them sustainable and more efficient.

II. METHODOLOGY



ation of the study village - Majhera

The sample village is selected on the basis of altitude, climate and settlement type. The preliminary data on vernacular architecture of sample village is collected through question-air, interviews, and photographs. The data is collected on the basis of years of construction i.e. +200yrs, +130yrs and +60yrs. The secondary data is collected on basis of elevation, seismic zone, snowfall and climate through different government sites.
The different dwelling typologies are then measured under passive design tools of surface volume ratio and daylight zone. Other passive parameters like orientation and form are also considered in the paper.

III. VERNACULAR ARCHITECTURE MAJHERA

.Majhera village lies in Nainital District of Kumaon division, which falls in south-East direction of Uttarakhand and lies in lesser Himalayan belt. It is located in 29º29'56.40"N and 79º28'33.87"E with an altitude ranging from 1113M to 1087M and average slope of 43degree (earth, n.d.). It lies in seismic zone IV. Majhera is oriented along WNW to ESE axis at 15º tilt from west. The village is accessible through Bhowali – Ranikhet road. The village settlement is at the ridge of the hill which lies along the Khairna River. The village is spread up to 2km radius. The site also experiences cold northerly winds during winter and loo during summer season.

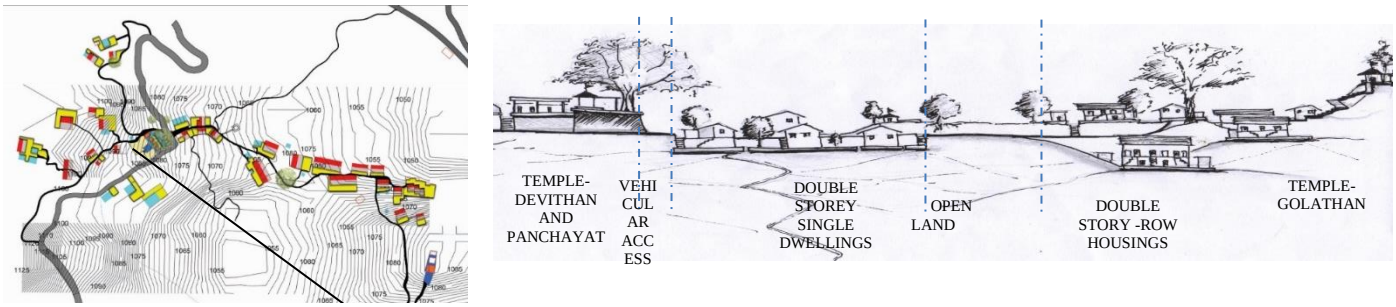


Figure 3 plan of the village and elevation A-A

The village has combination of vernacular and traditional architecture. The members of the house and skilled craftsman were equaly involved in the buiding construction process. Most of the dwellings face south east directions. Every housing complex consists of an Aagan, 2 storey structure, inbuilt or externally constructed cattle house. The dwellings are separated by a low height boundary wall which is almost 1'6" to 2ft wide, mostly used for seating purpose. The angan is an open interacting space where the women's perform their daily activities.

The dwellings are constructed with the help of local material i.e river stone,slate, rocks , local timber, cowdung or mud or black lantels (as a binding material). As per (Bisht, 2011) Deodar, pine, sal, toona, chid(pine) were used as timber in construction work. Mainly, the doors and windows were made of kedar (deodar), sal, rose wood, and had beautiful ornate carvings. The bedrooms and kitcen are kept on rear side as they are used during night time. Living room (chakh) is designed in front with chajj windows. This ensures good daylighting during day time. The walls and floors are plastered with a mixture of bmud and cow dung to keep it cool during the summer, the roof with slate tiles are low to conserve heat during winters (Tenkayala, 2011). As per the interview with the locals following data on the buiding structure is collected-

a. **Site selection**
The site is selected on the ridge from where the owner can watch his/her agriculture fields. That land parcel for building is choosed which is not suitable for agriculture.

b. **Walls**
The walls are usualy constructed in random rubble masonry with slate stones due to the unavailibilty of large river stones. The external walls of the dwellings are constructed 18 inches to 16 inches wide and are plastered with half inch cowdung +mud + reed paste. In some cases the masonry is left exposed.The internal walls are constructed with low height wooden partitions.

c. **Foundation :** The foundation is constructed two to four feet deep and 2 ft wide. And the plinth is raised to one feet height, in some cases it is raised upto 2 feet. For foundations large dressed or undressed stones are used.

d. **Floor :** The dwellings consists of ground floor, first floor and attic floor. The height of the floor is kept between 7 to 8 feet. the ground floor contains cattle room and granary(goth) and semi open space called daan. Daan is used in summers for daytime activities and also to perform rituals and ceremonies, this space is also used to keep animal fodder and pestle(okhli). The upper floor contains living room called chakh, bedroom called bhiter and kitchen called rashya. The entire dwelling is divide into two section with a main door called "daroj". The daroj is 4ft wide in width and the opening is kept 2'4" to 6'. The landing of daroj is called khoi. The door height is kept about 4'6" and width 2'4".

e. **Roof :** Roofs are constructed with pine wood battens called as "balli". These balli's are extended outward and used as an aesthetic feature. The balli's are rested over "moori" a peakock shaped corbels, which are usually placed at a centre to centre distance of 1 feet to two feet. The top of the balli's are covered with slate stones known as " Pather" roof. The joints of the two slates are covered with another small slate stone called "tope". The slope is designed at 17deg tilt.

f. **Openings :** The doors are kept small in size so that when a person enters the room he/she spontaneously bow the home, door size 2'-0"x5'-0" as per the casestudies.. The windows frames are designed large but the opening is left small to avoid harsh winds. The window are called as "chajj". It consits of 2feet height parapet. This type of window also serves as balcony during day time. Through chajj the solar radiations penetrate deep inside the room. The space adjacent to these window called "chaak" or living room, get heated during day time and act as a thermal storage during night. These windows were used by women's of the house to perform their indoor activity and also play important role in social integration.

g. **Seismic consideration :** To make the building seismic responsive the lower structure is constructed with thich stone walls internal and external. And the upper storey is kept lighter. The internal walls of the first floor is constructed in wooden partition which reduces the dead load of the building. The large wooden window frames also lower down the dead load of first floor.

h. **Climate consideration :** The site falls in sub tropical climate and experence harsh summers and severe winters, the vernacular structure are constructed with thick stone walls. Which keeps the interior comfortable during summer and winter. the also recieves good rainfall hence the pitched roof are constructed.

i. **Environment consideration :** At the beam level small holes are left open for sparrows.For drinking water villagers are dependent on natural ground water spring called dhara.The dhara is specifically for drinking water and naula which is a small enclosed baori used for bathing. The overflow from the naula and dhara is stored in open low height tanks for animals.

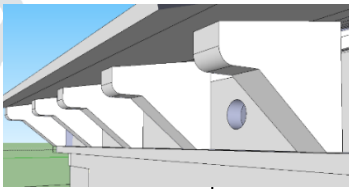


Figure 4 bird house

j. **Design features :**Symmetry in facade, harmony, contrasting colors for door windows and light colors for walls

IV. ENERGY EFFICIENCY TOOLS USED TO ANALYSE SOLAR PASSIVE DESIGN FOR DIFFERENT TYPOLOGIES

1. Daylight zone

Daylit zone is defined as an area having depth twice the height of the window(Y) and in the directional parallel to the window the daylit area extends a horizontal equal to the width of the of the window and 1m on each side of the aperture (partnership, n.d.).

2. Surface to volume ratio- ideal building form

As per Lachner A building envelope with a smaller surface area to volume will gradually reduce unwanted heat loss in the building. Being able to reduce the amount of heat loss in a building helps reduce the amount of mechanical or electrical energy that the building needs to stay warm in colder climates (Lechner , 1994).

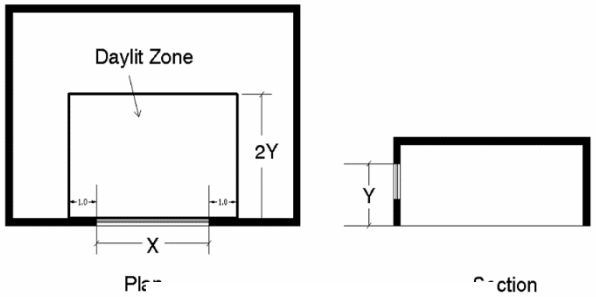


Figure 5 daylight zone

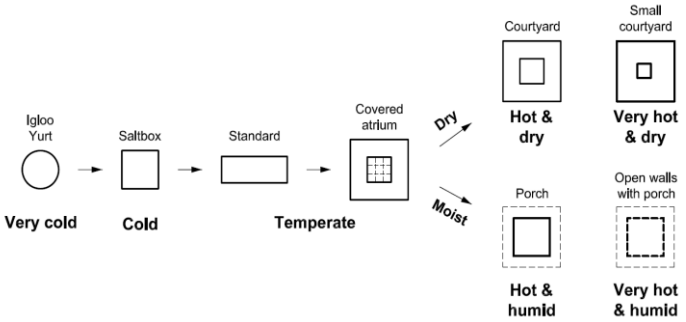


Figure 6 ideal building forms for different climates

V. DWELLING TYPOLOGIES STUDIED

The dwelling typologies of the sample village varies from ±200 years to ±60 year. Each typology exhibits its own certain properties and concept. Different typologies are as follows:

1. Dwelling typology 1 – single dwelling 2 floors (200+yrs)

The house is located in the western part of the village and oriented in north-south direction. The house is in poor condition and was abandoned in year 2017. But still the doors and windows are intact.
The front facde of the house face north therefore a balcony is constructed on the south direction to capture winter sun. the east and west windows are smaller. The north window is full length windw called chajj with a 2feet heigh parapet. The opening in north window is very small to prevent northerly cold winds.

Figure 7location and front elevation of the house

2. Dwelling typology 2 – bungalow 2 floors 150+yrs)

The bangalow is located in the southern part of the village and oriented in east-west direction. The main entrance is facing east with green covered aangan in front for open activities. The rear facde facing west is obstructed with hill to south. A long varnadah is constructed in east direction allows the winter sun to penetrate deep into the building. The living rooms in upper storey contains long folding doors.The house exhibit colonial elements like tin roof and thick columns. The house is in good condition.

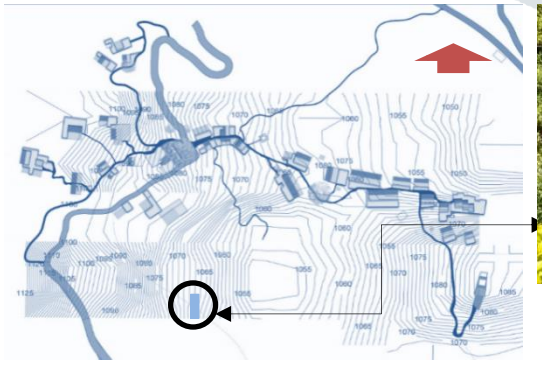
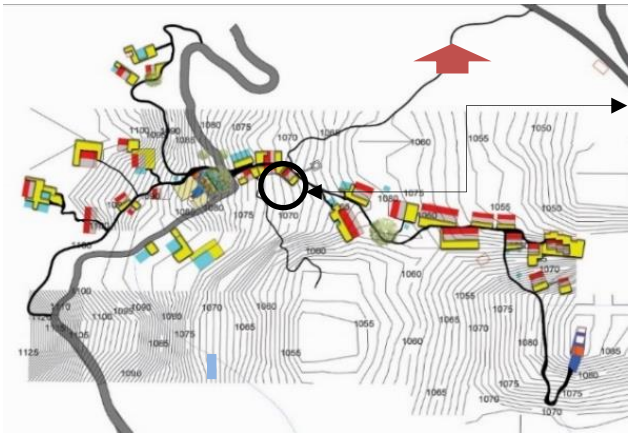


Figure 8 location and view of the house

Figure 9 Balcony and the long openable doors

3. Dwelling typology 3 – single dwelling 2 floors (60+yrs)

The house is located at the centre of the village and oriented in southeast- northwest direction. The house has modified traditional characteristics. The door sizes and the chajjs have been slightly modified. The intricate details have been simplified. This house is in good condition.

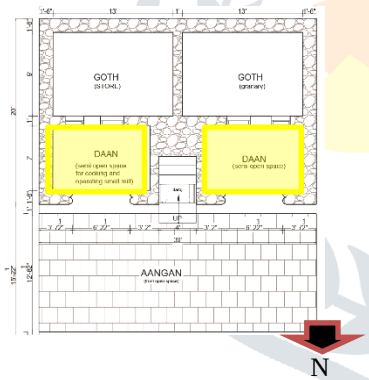
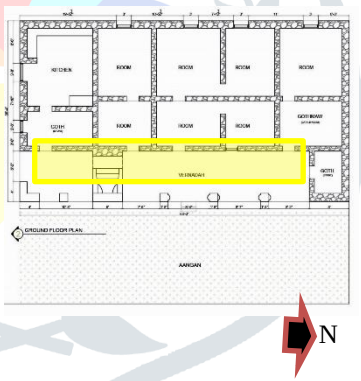
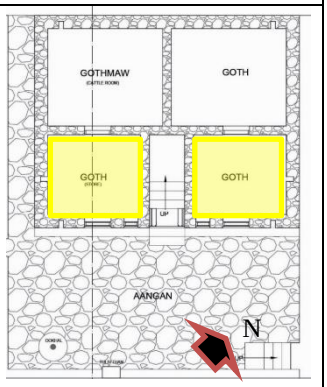
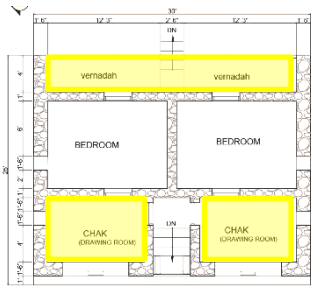
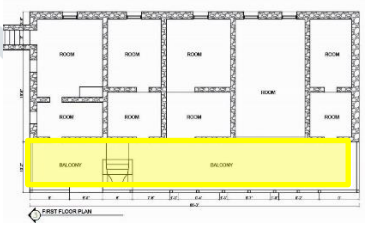
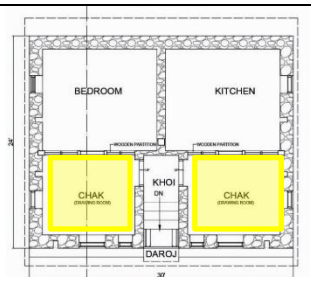
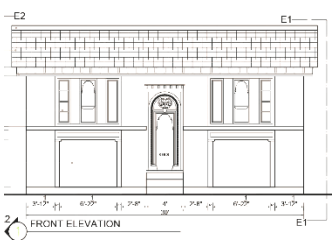
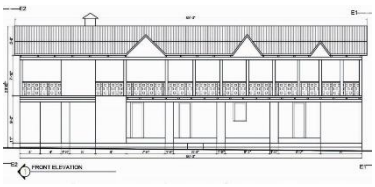
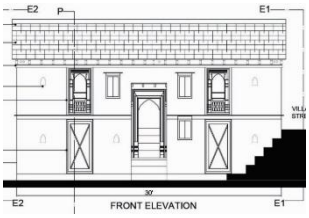


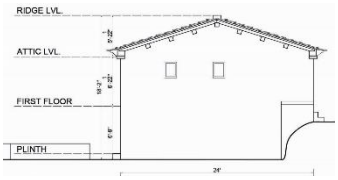
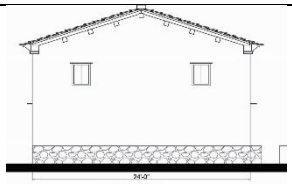
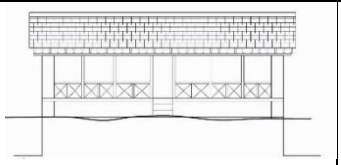
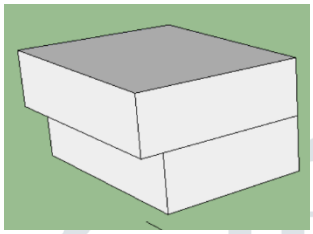
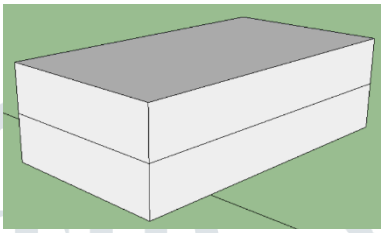
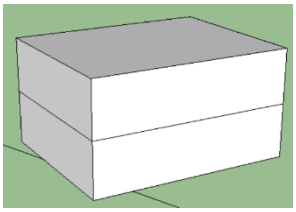
In place of daan (semi open room at ground floor) closed rooms are constructed

Figure 10location and view of the house

VI. ANALYSIS OF THE THREE TYPOLOGIES

Table 1 Analysis of the three typologies

	Dwelling 1	Dwelling 2	Dwelling 3
Year of buit	200±	150±	60±
No.of occupants	-	2	4
Orientation	N-S	SE-NW	E-W
Ground floor Plan With Daylight zones			
First floor plan With Daylight zones			
Front Elevation			

Side elvation			
Rear elevation		NA	NA
Form	 Square form	 Rectangular form	 Square form
View			
Door	 Large door with little opening Intricate likhai work	 large openable door with no likhai work	 Door with large open area Minimal likhai work
Window design			

Balcony	NA		No balcony
Wall			
Exterior wall	Dry masonry construction with slate Wall thickness- 18 inches wide	Dry masonry construction with slate Wall thickness- 18 inches wide	Random rubble masonry, 16inches thick wall
Interior wall	Wood partitions	12inches stone wall	Wood partitions
Roof	Timber –slate roof Slope- 17deg	Timber- corrugated tin roof Slope- 15 deg	Timber –slate roof Slope- 17 deg
House for birds	Yes	No	Yes
S/V	0.14	0.09	0.11
House condition	Poor	Good	Good

VII. Result and Discussion

The analysis shows that the built form is been evolved according to the topography and influencing climatic conditions. All three dwellings are constructed along the different contour line. And to gain solar radiation the first typology extended its southern façade as balcony, in second front balcony is designed 8 feet deep to receive solar radiations and curtail down summer sun, in third the balcony is omitted. The use of timber is been reduced with the passage of time due to the unavailibilty of wood and as well as skilled craftsmen. The intricate door window details has been simplified. The door openings are little increase to suit the present lifestyle. In second typology the door opening is designed full length to allow winter sun to penetrate deep inside the room. In the third typology maximum number of windows are designed on south eastern façade to receive solar radiations.

The planning of the house is also modified with change in requirement. The old house and bungalow has large semi open spaces to keep animal fodder etc, this space is omitted in third typology. In all the three typologies, wall thickness is kept between 18inches to 16 inches. The roof slope is designed around 15 to 17 deg. The analysis also shows that even being different forms all the typologies exhibits small surface to volume ratio. Smaller the S/V ratio , lesser the heat loss from indoor environments. The dwellings receive good day lighting due to small window to floor ratio. In all three typologies the upper storey is been kept lighter with the use of wood and ground floor is constructed with heavier walls. This helps the building to withstand the seismic hazard. As per (Khanna, 2011)there is a reasonably good awareness of the need for disaster resistance of buildings which needs to be emphasized in the mainstream building design. The approach should be to avoid collapse of buildings, even though they might suffer damage depending on the intensity of the hazard.

VIII. Conclusion

This study gives a interesting result that in same climate how different forms can be evolved while considering the climatic conditions and topography. In all three typologies the concept is how to receive maximum solar radiations and mimimum wind effect. The evolution of dweling shows that even with the limited available the identity of the vernacular architecture can be attained. The results also proof that built

forms must follow the small surface to volume ratio. The traditional Chajj window, pitched roof and holes for birds nest can be adopted in contemporary construction. This will help the architects to reflect the hill architecture identity in their designs. The contemporary constructions can also adopt tradtional window to floor ratios for better daylighting.

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