Havelis in the State of Punjab: A Climate Responsive Habitat

Ar. Bhupinder Pal Singh Dhot[1] & Ar. (Dr) Prabhjot Kaur[2]
[1]Research scholar, I.K.G. P.T.U, Kapurthala , bpaldhot@hotmail.com; **Corresponding author**
[2] Professor, Department of Built Environment, I.K.G.P.T.U Campus Khunnimajra, Mohali,

Received Dec. 18, 2017 Accepted Jan. 25, 2018

ABSTRACT *Divergent climatic conditions of India have always posed challenges to the professionals in the planning, designing and construction of buildings to achieve appropriate level of thermal comfort .Traditional buildings built in the past, by and large, have followed sustainable approach adopting design strategies, whereas most of the buildings now being constructed have been found to be lacking in this context. Accordingly, these buildings have been found to be large consumers of energy.* ***Haveli's*** *in the Malwa region of Punjab (India) are telling examples of climatic responsive Architecture considering their genesis based on the climatic conditions of the region. Thermal comfort has been achieved in these Haveli's through design strategies which ensure warmth in winter and cooling in summer to the occupants without active support of any mechanical system. This paper is an attempt to understand, ascertain and illustrate the thermal performance through design strategies adopted for these Haveli's. In addition, a comparative analysis has also been made to showcase the thermal performance of Haveli with a recently constructed house in close proximity. Objective and focus of the present research study is to evaluate the thermal performance of Haveli as an example of climatic responsive architecture.*

Key words: *Haveli, climate responsive architecture, thermal comfort, design strategies.*

1.0 Introduction:

Built environment has been integral part of human history. Since pre- historical times, human beings have been through a process of building different types of structures in one form or other. This activity was deemed indispensible and had to be undertaken keeping in mind the basic needs of shelter, safety, security and comfort. The continuity of this process has resulted in, what we now perceive around us as large number of diverse typologies of buildings. In the words of *Lady Morgan 'Architecture is a printing press of all ages'*

Suzanne and Stafford have pointed out that over the centuries; different types of residential structures in India have been planned, designed and constructed in response to specific functional, climatic, cultural and ceremonial requirements.[1] These processes broadly and imperceptibly resulted in, emergence of what came to be gradually known as Haveli culture in different parts of the world, particularly in areas where the climatic conditions were both hot and dry. Word 'Haveli has its genesis from Persia, the origin of which could be traced to the old Arabic word "Haowala'', meaning enclosed space' [2]. According to Randhawa, Haveli is a medieval dwelling/ large mansion having courtyard within [3].

In the Indian context, Northern and Western states of our country especially Rajasthan, Gujarat and Punjab, falling in the hot and dry region, have emerged as the pioneers in promoting the Haveli culture. Several factors were responsible for promoting the culture of Haveli's. However, major factor, responsible was the prevailing harsh climate of these regions. [4]. Comfortable indoor environment in these Haveli's has been ensured through numerous climatic modifying features integrated in their planning, designing and construction. No mechanical device has been used in their interiors for heating or cooling [5]. In contrast, modern residences are largely dependent on the use of mechanical means to achieve the desired level of indoor thermal conditions. In this context, detailed study and in-depth analysis has been carried out at Bhanamal Haveli constructed in Bathinda to illustrate the efficacy and efficiency of Haveli, as an embodiment of sustainable habitat as compared to recently constructed residential building in close vicinity.

2.0 Need of the Study:

Haveli's have been found to exist in the states of Punjab, Rajasthan, Gujarat and Uttar Pradesh. As one goes through the related scientific studies pertaining to these Haveli's, one hardly comes across any scientific research work on the Haveli's in the state of Punjab. This gap adumbrated the **need** for research pertaining to the Haveli's of the state of Punjab. However the present research paper focuses on the Haveli's of Malwa region of the state of Punjab in general and city of Bathinda in particular in order to bring out the efficacy and efficiency of Haveli's in terms of their thermal performance.

3.0 Aim of the Study:

The basic aim of this research work is to ascertain scientifically, how far Haveli's of Malwa region of Punjab are realistic models of climatic responsive Architecture.

4.0 Methodology:

In order to evaluate the thermal performance of Haveli's vis-a-vis the recently constructed residential buildings, methodology adopted involves collection and comparison of real time data pertaining to inside and outside air temperature and relative humidity by using thermal data loggers. Methodology revolved around**:**

- Selection of a Haveli and a house recently constructed in close proximity in city of Bathinda falling in the Malwa Region of the state of Punjab.
- Collection of data pertaining to air temperature and relative humidity for both the buildings under study. in summer and winter by using thermal data loggers
- Data for 21st June 2016 and on 28th December 2016 - extreme summer and winter seasons- have been used for the purpose of analysis. .
- The thermal data so collected, have been compared in terms of difference in Air temperature and relative humidity between Haveli and recently constructed house with the outdoor ambient temperature. Climate conditions have also been analyzed with the prescribed norms and standards for the thermal comfort inside the building both in terms of Air temperature and relative humidity.

5.0 Case Study

State of Punjab is located in North Western part of the country. Based on the prevailing climatic conditions, state falls in the composite climate zone out of the five climatic zones of India. It has further been divided into three distinct zones based on the location, culture, rivers etc namely MAJHA, MALWA and DOABA. Among three, **Malwa** region is located in the Western part of the state, has the largest geographical area involving 12 out of 22 districts of the state namely Bathinda, Sangrur, Patiala, Fatehgarh Sahib, Ludhiana, Barnala, Ferozepur, Fazilka, Muktsar, Mansa, Moga and SAS Nagar. The Western Punjab with its harsh terrains and Composite climatic conditions invariably posed enormous challenges of comfortable living. To meet the climatic harshness, effectively and efficiently, people of this region adopted numerous innovative construction technologies to promote environment friendly buildings for comfortable living. Some of these residential buildings distinctively emerged in the shape of **Haveli's.**

5.1 Climate of Bathinda:

City of Bathinda, located in the southwest of Punjab, bordering state of Rajasthan, has composite climate having large variations between summer and winter temperatures. Average annual rainfall recorded in the region is in the range of 20 cm to 60 cm. In summers, temperature goes as high as 48°C and in winters, temperature is as low as 1°C. The weather is generally dry. However, due to monsoon weather becomes humid from mid-July to the end of August due to active monsoon operating in the region. [6].

5.2 Bhanamal Haveli:

In order to evaluate the performance of Haveli's in the Malwa region of Punjab, Bhanamal Haveli located in the core of Bathinda City Sirki Bazar has been selected for case study (Fig.3). The Haveli was constructed in the year 1920. Haveli was designed to accommodate two families. The main design feature of the Haveli includes symmetrical planning around a courtyard, high ceiling, thick walls, small openings, clerestory windows and large footprints of the building. The material used in the construction was Bricks laid in lime & surkhi (brick powder) paste added with marble chips and organic binders. The building was constructed as a double storied structure which includes number of courtyards at the first floor also. The Haveli has two roads providing access to it. South-West side of the Haveli has a long verandah to protect the habitable area from the harsh sun during summers. The front portion of Haveli is used for public gathering largely by the male members whereas the rear area is meant for privacy and caters to the females of the family as per Indian traditions. Courtyards are the main feature of this Haveli which not only define the perfect spatial organization, but also act as centre for rituals, marriages, festivals and social gatherings. Courtyard, nearly square in shape, gives connectivity to areas or spaces inside and outside besides providing air, light and ventilation to the adjoining rooms. The vertical part encloses courtyards and defines their volume. The elements like arches, niches, fireplaces, cornices make this space lively. Plans and pictures given below showcase the spatial planning and facades of Bhanamal Haveli

Fig.1: South west facade having deep verandah and recessed openings to reduce the impact of direct solar summer heat.

Fig.1: South west facade having deep verandah and recessed openings to reduce the impact of direct solar summer heat.

Fig.2: Well proportioned courtyard provide ample light and adequate ventilation to the adjoining rooms

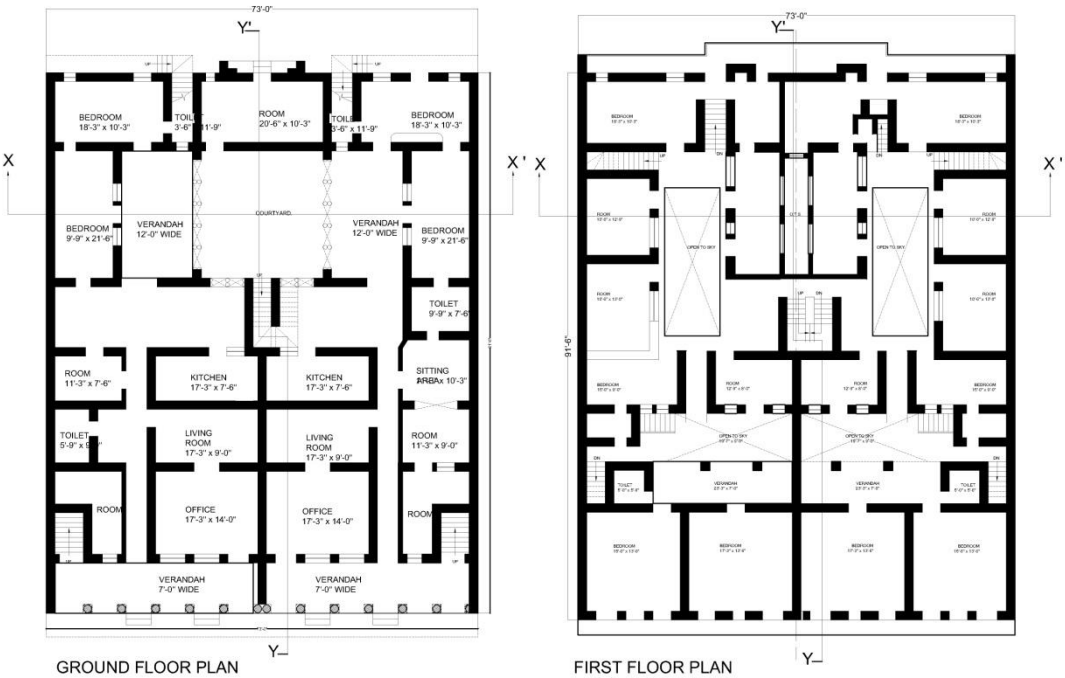

Fig.3: Plans of Haveli showing spatial planning.

5.3 Modern House:

In order to compare the thermal performance of recently constructed building a house within the close vicinity of Haveli has been selected (Fig.4). This residence is a part of row housing in a PUDA Approved Sheesh Mahal colony in the city of Bathinda built in the year 2007. It has double storied load bearing structure with 9" thick walls. It has compact planning having front and rear yards. Thickness of walls is 9" with R.C.C. roof having brick tile terracing. House is facing south- west orientation, similar to that of Bhanamal Haveli, leading to inappropriate climatic conditions which cause walls to heat up and permits the heat transferred into the living areas. House has two bedrooms at each floor along with a drawing room. In addition, it includes toilets at each floor with a stair providing vertical accessibility. Both floors have a kitchen each to cater to the cooking needs of the family along with a lobby acting as a family space for sitting and circulation. Being a part of row housing, house has the limitation of drawing light and ventilation from front and rear sides only i.e. South- West and North- East. Accordingly, side walls, which are common walls with the adjoining houses, are solid walls without any provision of opening. Floor Plans of the house at ground and first floor levels are given below:

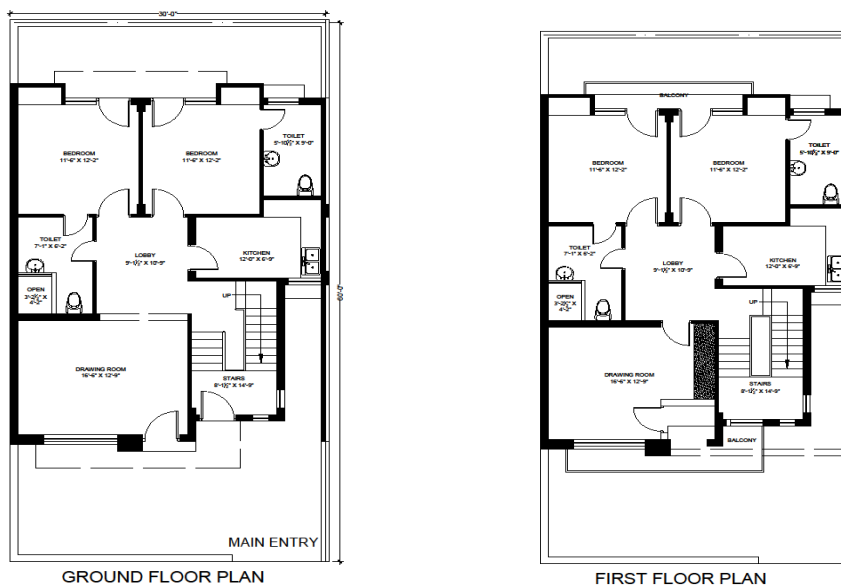

Fig.4: Plans of Modern House

5.4 Field Study Description:

For studying and understanding the thermal behaviour of buildings, onsite study has been carried out for Bhanamal Haveli and Modern house. The two sets of instruments were kept in both these houses simultaneously to record the required data. The field study was carried out for two consecutive days both in extreme summer and winter conditions. However, for this paper data pertaining to one day i.e. on 21st June 2016 during summer and on 28th December 2016 during winter has been taken for analysis. The data was recorded continuously for 24 Hrs. The data of the climatic attributes like the air temperature (both inside and outside the houses for study), relative humidity (both inside and outside the houses for study) were obtained, calculated and considered for analysis as detailed below:

5.5 Thermal Performance during *Summer*-- Bhanamal Haveli and Modern House:

5.5.1 Air temperature

The thermal performance of Bhanamal Haveli and Modern house in Bathinda was investigated by continuously monitoring the thermal comfort parameters (Air Temperature and relative humidity) in both the buildings and the performance was assessed. Data loggers were kept at First floor on south western side (being the hottest side) of the Haveli, as well as in modern house. One Data logger each was installed on the outside of both the houses to record outside Air temperature and Relative humidity. The data was recorded at an interval of 2 hours. Profile showing the variation in outside maximum and minimum temperature along with that of Haveli and the modern house has been drawn based on the data collected. The profile is shown in a graph given below. The outside temperature recorded has been shown in the green colour whereas that of Haveli is shown in blue and that of modern house in red colour. While large variation in

temperature have been observed both in the case of outside temperature and inside temperature of modern house whereas temperature within Haveli was found to be fairly constant with least variation. On 21st June, the maximum outdoor temperature recorded was found to be 39ºC and the minimum temperature was recorded as 29.3ºC. Diurnal variation of temperature was found to be very large i.e. of the order of 9.7ºC. In case of Haveli, inside air temperature variation was found to be fairly constant i.e. showing a diurnal variation merely by 1.4ºC only varying from 31ºC to 32.4ºC. However, during the same period, the variation of inside temperature in modern house was found to be 4.7°C i.e. varying from 32.1°C to 36.9°C. The diurnal variation in the modern house was found to be very high more than three times than that of Haveli. Thus it was observed that thermal performance of Haveli was found to be very satisfactory despite large variation in outside temperature as compared to that of Modern house

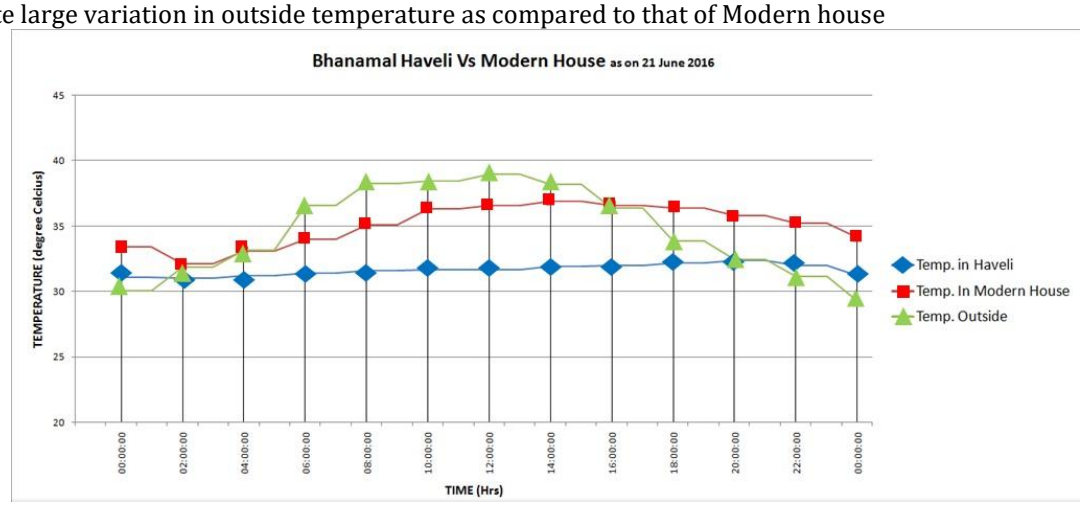

Fig.5: Profile showing Air Temperature in Bhanamal Haveli, Modern house and Outside.

5.5.2 Time Lag

For assessing the thermal performance both the buildings were also evaluated in terms of Time lag and Decrement factor. In case of Haveli, the time lag (the time delay due to the thermal mass like wall or roof etc.) observed between the outdoor and the indoor temperature was found to be very high i.e. around 8 hours and the decrement factor (ratio of diurnal variations in indoor temperature to that of outdoor temperature) was merely 0.144 At the same time, in case of modern house, the time lag observed between the outdoor and the indoor temperature was about merely 2 hour and the decrement factor (ratio of diurnal variations in indoor temperature to that of outdoor temperature) was found to be very high(0.586) as shown in Table-1 below. Thus it can be observed that the building envelop of Haveli performed much better as compared to Modern house both in terms of time lag and decrement factor. However, this needs to be appreciated that walls made of small bricks in case of Haveli, were laid in lime mortar having thickness of 18" as compared to 9' in case of modern house in cement mortar. Thus thickness of walls and lime mortar used as binder performed much better than that of cement based mortar for improving thermal sustainability of the walls.

Table 1: Table showing Time lag, Decrement Factor for Both Haveli and Modern House

S. No.	Description	Bhanamal haveli Bathinda	Modern House Bathinda
1.	Time Lag	8 hours	2 hrs.
2.	Decrement Factor	0.144	0.484
3.	Wall thickness	18 inches	9 inches

5.5.3 Relative Humidity:

The buildings were also recorded, evaluated and analysed in terms of humidity for 24 hours on 21st June and their performance have been shown in the graph indicated below. In the Graph-1b, outside humidity recorded has been shown in the green colour whereas that of Haveli in blue and of modern house in red colour The outdoor RH was recorded to be varying in the range of 30% to 77%. In case of Haveli, the RH during the same time was recorded to be varying from 56.8% to 64.4%, whereas relative humidity in case of modern house was in the range of 51.4% to 60.7%. Thus while outdoor the buildings, fluctuation in RH was found to be 47%, variation in indoor RH in case of Haveli during the same period was 7.6% and in

case of modern house fluctuation was 9.3%. The data recorded clearly indicate that despite large outside RH variations, variation in case of Haveli were minimal as compared to that of modern house leading to the conclusion that Haveli performed much better as compared to modern house even in the RH values, which have been found to be within the norms specified for the thermal comfort.

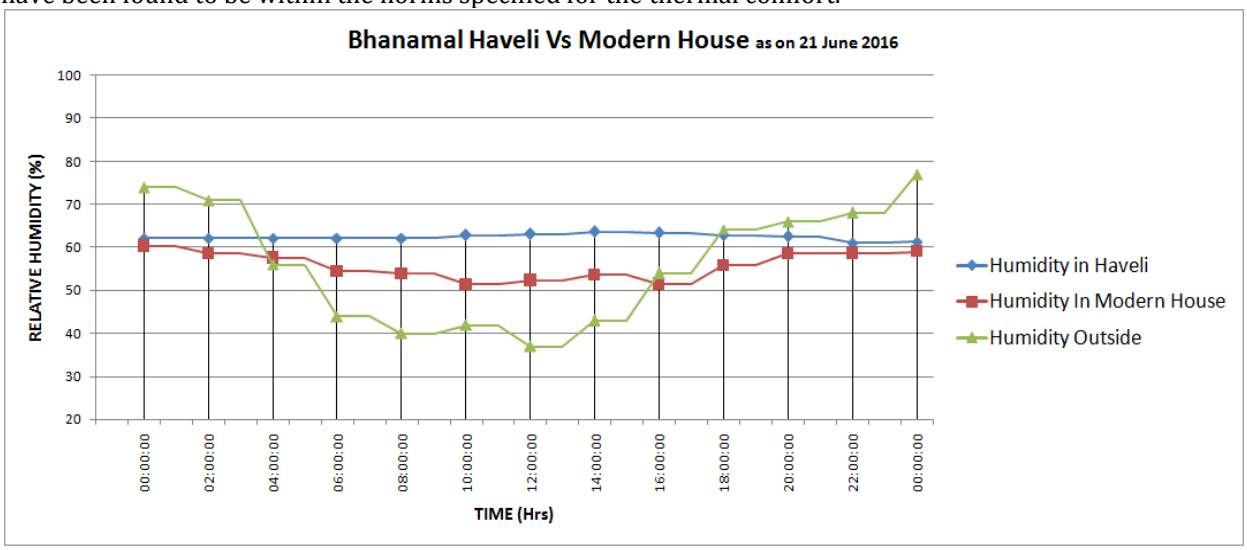

Fig.6: Profile showing Relative Humidity in Bhanamal Haveli, modern house and Outside

5.6 Thermal Performance during *Winter* - Bhanamal Haveli and Modern House:

Similar procedure was adopted for assessing thermal performance of buildings under study during winter for data collection study and analysis. TWO data loggers were kept at GROUND FLOOR on the Northern side (Being the coldest side) of the Haveli, as well as in modern house for assessing climate responsiveness during extreme winter conditions on December 28, 2016. One additional data logger was also installed outside both houses to record Air temperature and Relative humidity. The data was recorded at an interval of 2 hours with the windows kept open during the day and closed during night.

5.6.1 Air Temperature

It was observed that on December 28, 2016 large variation in maximum and minimum was recorded. While maximum outdoor air temperature recorded was 20.3ºC whereas minimum temperature was merely 7ºC. The diurnal variation was observed to be 13.3ºC

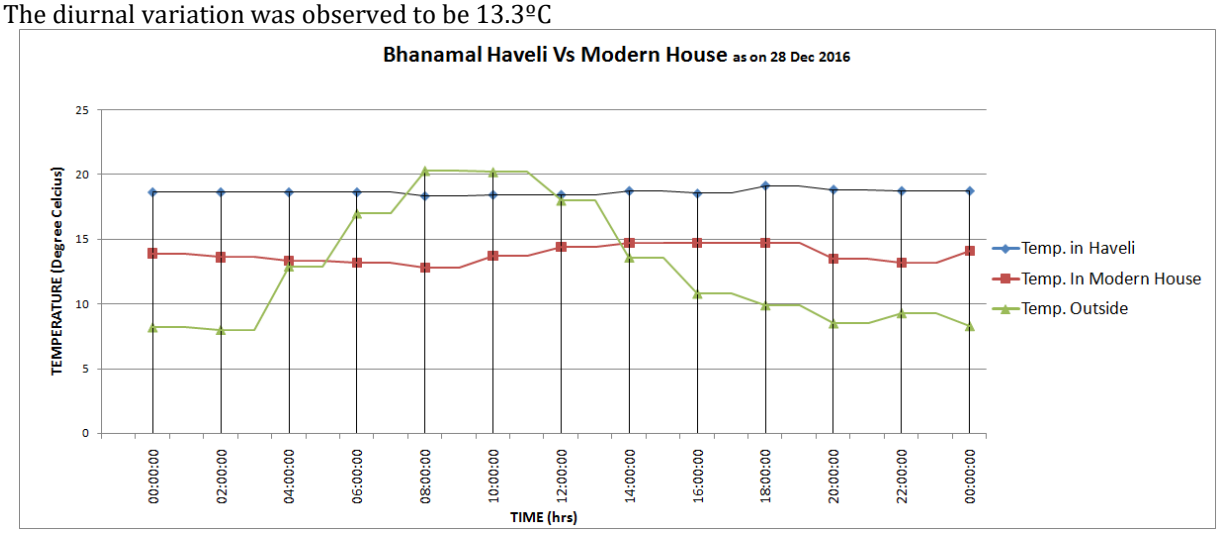

Fig.8: Profile showing Air temperature during winter

During the same period the indoor Air temperature recorded in case of Haveli varied from 18.3ºC to 19.4ºC indicating a diurnal variation of 1.1ºC whereas in case of modern house indoor mean temperature was found to be varying from 12.8°C to 16.2°C showing a difference of 3.4°C adversely impacting the indoor temperature of Haveli, which was very close to the desirable level of thermal comfort. However,

temperature variation in Modern house varied three fold as compared to Haveli, with minimum temperature dropping quiet low calling for the need of mechanical heating. Thus, the thermal performance of *building envelop* of Haveli was found to be much better as compared to Modern House. Figure 8 shows the variations in air temperature recorded.

5.6.2 Relative Humidity The outdoor RH value on the said day, December 28, 2016, was found to be varying between 54% to 99%. The indoor RH in case of Haveli was recorded to be varying between 61.1% to 66.8%, whereas relative humidity in case of modern house was observed to be between 66.8% to 77.2%. On the basis of analysis made of the data recorded ,it is observed that as against outdoor RH fluctuation of 45% in RH, the indoor RH difference in case of Haveli was found to be very small (6.7%) . It was found to be higher (10.4%) in case of modern house, clearly indicating that Haveli performed much better than the modern house even in the most adverse humid conditions. Figure 9 shows the pattern of variation in RH recorded.

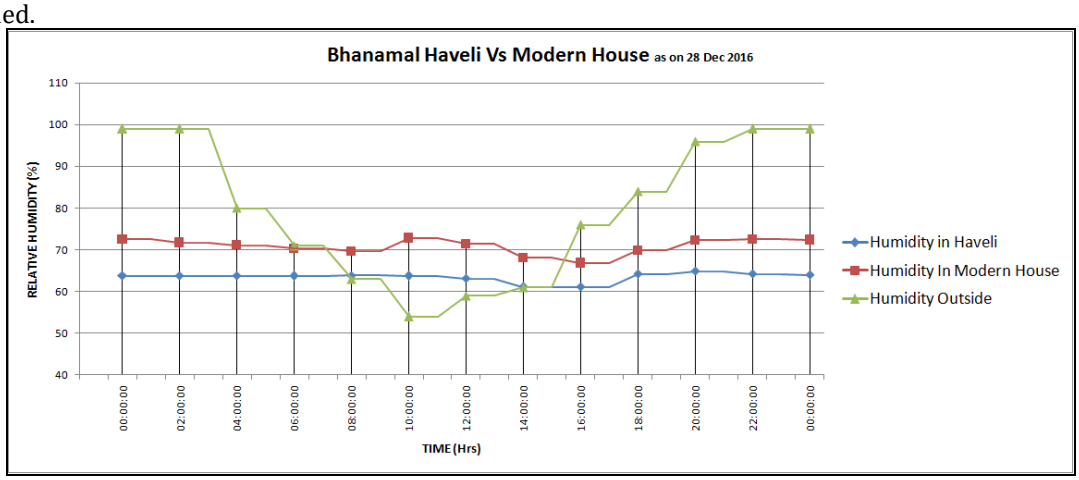

Fig.9: Profile showing Relative humidity during winter

Table 2: Comparison between Air temperature and Relative humidity during winter

BHANAMAL HAVELI Vs Modern house ,BATHINDA as on 21 June 2016						
SUMMER	**TEMPERATURE (°C)**			**HUMIDITY (%)**		
	Max.	**Min.**	**Difference**	**Max.**	**Min.**	**Difference**
HAVELI	32.4	31	1.4	64.4	56.8	7.6
MODERN HOUSE	36.9	32.1	4.8	60.7	51.4	9.3
OUTER	39	29.3	9.7	77	30	47
BHANAMAL HAVELI Vs Modern house BATHINDA as on 28 DEC 2016						
WINTER	**TEMPERATURE (° C)**			**HUMIDITY (%)**		
	Max.	**Min.**	**Difference**	**Max.**	**Min.**	**Difference**
HAVELI	19.4	18.3	1.1	66.8	61.1	5.7
MODERN HOUSE	16.2	12.8	4.6	77.2	66.8	10.4
OUTER	20.3	7	12.7	99	54	45

6.0 Conclusion:

It is clear from the above data that the Haveli has a much better thermal performance both during winter and summer as compared to modern house in terms of indoor air temperature which was recorded to be lower by *4° c to5° c during summer and higher by 3°c to 4°c in winter* as compared to the temperature recorded in Modern house. It is also found that the Haveli's are also better placed in terms of indoor diurnal variation which was found to be much less in case of Haveli as compared to outdoor diurnal variation and that of modern house both during winter and summer. In addition, "time lag" of about 8 hours was noticed in case of Haveli whereas it was merely 2 hours in case of Modern house indicating much better thermal performance of building envelop of Haveli . The comfort range as defined by "Sharma, Ali and Mallick", air temperature ranges from 24° C to 32°C for summer and 17°C to 32°C during winters with relative humidity ranges from 30-60%. As per the results obtained, this comfort level has been largely achieved in case of Bhanamal Haveli as compared to Modern House highlighting the *climatic responsiveness* of Haveli.

Considering the Climatic responsiveness, the principles of planning and designing for achieving thermal comfort in Bhanamal Haveli have been precisely worked out and actually followed. Natural and passive means have been employed for minimising dependence on mechanical energy. Overall planning of the Haveli with courtyards as the central theme, around which entire planning gravitates, its construction with locally available materials, its immunity from the harshness of summer- winter seasons, its naturally controlled flow of air and openness for natural light has resulted in reducing dependence upon mechanical energy to constitute cogent evidence of its climate responsiveness.

Harmony with the physical and social environment along with its structural characteristics clearly indicate that even after 100 years of its existence, Haveli have emerged as the embodiment of sustainability and are providers of assured comfortable indoor environment as compared to the modern built environment..

Accordingly, Haveli's have a significant theme, message and lessons for professionals involved in the planning, designing and construction of built environment. It is hoped that the outcomes of this study would provide necessary insight to the Architects for evolving appropriate design strategies to achieve the goal of energy efficient and sustainable structures. It can be recognised from the study that traditional buildings are not just remnants of the past, but great lessons for the future of mankind. So the need for making present day built environment sustainable may well be served by using climate responsive designs solution and principles followed in traditional architecture.

Acknowledgement: The authors extend sincere thanks to Ar. Jeet Kumar Gupta (Retd. Senior Town Planner) and Dr. Surjeet Singh Sekha for their support and guidance.

References:

1. Slesin, Suzanne. Cliff, Stafford., (1998). "*Indian Style"*. by Thames & Hudson Ltd. (July 16, 1990).
2. Jain, Shikha. (2004). "*Havelis: A Living tradition of Rajasthan"* by Shubhi Publications, 01-Jan-2004
3. Randhawa,T.S.,(1999). "*The Indian Courtyard House"*. by Prakash Books (1999)
4. Jain, K., Jain, M., (2000). "*Architecture of the Indian Desert"*. Ahmadabad:
5. Mohamad,Arif Kamal., Ph.d. Thesis "*Climatic Responsiveness in Traditional Built Form of Lucknow".* Conference Proceedings of International network for Traditional Building, Architecture and Urbanism (INTBAU).
6. "Climate of Bathinda", https;//en.wikipedia.org/wiki/Bathinda

The best way to predict your future is to create it.
~ Anonymous