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Evaluation of different building designs to enhance thermal comfort or Comparative study of thermal comfort in traditional and modern buildings

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Access this Article Online	Quick Response Code:
Website: http://heb-nic.in/cass-studies	
Received on 05/02/2019	
Accepted on 07/02/2019 © HEB All rights reserved	

INTRODUCTION

According to International Energy Agency it is reported that worldwide buildings consume almost 40% of energy. With growing population and improvement in living standards this energy consumption may further increase. Therefore it is important to design buildings with enhanced thermal comfort with minimum use of fossil fuel based energy. Providing thermal comfort without increasing the cost is primary requirement in building construction. Present work is a small step in this direction, presenting the study of traditional and modern building design and materials.

Present work reports the comparison of old traditional passive building (1960) and modern day building (2008). The orientation of both buildings, size, direct gain area, wind flow, height of central room, wall size etc. have been compared. During the study observation have been taken for outside environment temperature, inside temperatures, humidity, wind flow etc. Understanding heat transfer and temperature distribution through building material and its design play an important role in designing better buildings. Thus the R and U factor for the traditional and modern building has been reported in the present work. The U-factor for walls of traditional building is 2.26 W/m^2-K and for modern building wall is 2.42 W/m^2-K. It is observed that traditional building offers better thermal comfort with higher temperatures in winters and lower temperatures in summers. This may be attributed due to the thick walls, more roof height and better ventilation, which may not be possible in modern buildings.

Comparative study of old Indian traditional materials such as limestone, cow dung, soil, soil pot and currently used material i.e. cement has been done. Study about these materials and climatic effect on these materials has been experimentally conducted through six cubicles constructed with size is 2 .9 feet by 2.9 feet by 2.5 feet . Materials such as limestone, cement, cow-dung and soil pots were studied on the cubicles and it was found that limestone was able to give more cooling.

Experiments were conducted to study the impact of white colored paints on cubicles as compared to cubicle without paint. It was found that the cubicles with paints showed lower temperatures around 2-3^{o}C less than the cubicle without paint.

This study is useful from the point of view of better designing of new residential buildings and for improving the energy efficiency of the buildings. Further for future it is important to develop multilayer insulating walls which can enhance thermal comfort without increasing the size and cost of construction.

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment . maintaining this standard of thermal comfort for occupants of the buildings and other enclosure is one of the important goals of HVAC (heating ,ventilation , air conditioning).[1]

The fundamental purpose of buildings is to provide man with a comfortable working and living space, protected from the extremes of climate. In these days of fuel crisis it is important that such comforts be provided with as little expenditure of energy as possible. Traditional architecture with hundreds of years of experience behind it, has evolved appropriate building methods for each type of climate. In most cases such buildings create a very comfortable living environment without any mechanical cooling or heating. In contrast with these, modern buildings provide a much lower degree of thermal comfort and many of these are not usable without mechanical cooling and heating. In India only a small percentage of population can afford the cost of air-conditioning, the majority lives in uncomfortable structures. The purpose of this paper is to suggest methods for ensuring thermal comfort in buildings by natural means. Many of the methods have been used in traditional buildings in India but there are some which are based on recent scientific research. Natural heating is not discussed here because the heating requirements in most parts of India are minimal.

Passive solar heating has been found to be popular in the U.S.A. and other countries because it can provide temperatures comparable to those provided by fuel based heating systems. In harsher climates solar heating reduces the need for conventional heating systems and thus saves large amount of energy. Natural cooling, on the other hand, can seldom provide the low temperatures that are possible with mechanical air-conditioning . In some cases it is necessary to supplement natural cooling with conventional air-conditioning. [2]

The coolness of an old building on a hot summer afternoon never fails to impress the visitor and makes one wonder how the builders could creates comfortable buildings without the aid of modern scientific knowledge. Spurred on by the energy crisis, we are today accumulating a vast body of technical literature on "passive cooling systems" and yet our present-day buildings tend to be poor performers compared to the well tempered buildings. When architects talk of passive cooling, it is as if the maintenance of certain specified temperatures in a building is an end in itself. On the other hand, the indigenous builder could not care less if the building was cool or warm so long as people could be comfortable within or without the building.

And in this, the builder's task was simplified by the willingness of the building users to put up with minor inconveniences.

The indigenous buildings were either humble dwellings or monumental palaces and temples. In either case, devoted workers in adequate numbers were available to maintain the buildings. The task of the modern architect who designs not only residences but factories, offices, hotels, hospitals, commercial centers, educational institutions and places of entertainment, is a lot more complicated. Some of these new buildings have more exacting requirements than those of the older ones, while the use is strictly impersonal. However, the tools, materials and techniques available today are more than what the indigenous builders had access to. The theory of passive cooled or naturally cooled buildings is well-developed. Various techniques suggested for environmental control in modern buildings are: [3]

(a) shading of building surfaces from sun
(b) damping of temperature variations by thermal mass
(c) selective ventilation
(d) radiation to night sky
(e) evaporation of water.

1.1.1 Some example of thermally comfortable old traditional buildings in Rajasthan 1. Amber fort

2. sheesh mahal amer
3. Birla Mandir Temple jaipur
4. Hawa Mahal Jaipur
5. Patwaon Ki Haweli Jaisalmer
6. Taragarh Fort
7. City palace Alwar

1.2 Climate of Rajasthan

In present situation we are focusing on energy efficient buildings due to shortage of energy . energy saving is duty of energy human. we need to study about basic need of energy efficient buildings . so we have requirement of knowledge about climatic requirement .climate of Rajasthan is differ in differ part of year.

Climate Condition at Different time period in a year At a Glance:

Period	**Temperature**	**Rainfall**
January to March	10 ºC - 27 ºC	4MM - 7MM
April to June	24 ºC - 50 ºC	11MM - 30MM
July to September	21 ºC - 35 ºC	100MM - 165MM
October to December	13 ºC - 30 ºC	3MM - 8MM

The geographical diversity of the state causes varied climatic conditions. The climate of Rajasthan can be divided into four seasons: Summer, monsoon, post-monsoon and winter.
Summer: This is the period from April to June. The summer starts by mid-March and temperature starts rising progressively through April, May and June. The temperature ranges from 32 ºC to 45 ºC. In May and June, the dry western region of Rajasthan records a maximum temperature of 48 ºC.On the other hand, Mt. Abu, the only hill station of Rajasthan (situated at the highest peak of the Aravali at an altitude of 1220 meters) registers the lowest temperatures ranging from 33 ºC to 23 ºC during this period.
Monsoon: This is the period from July to September. The monsoon arrives in late June in eastern and southern regions of the state and in mid-July in desert area. This period registers the maximum temperatures ranging from 29.5 ºC to 32.2 ºC in south and southeast of Rajasthan and an average of above 37.7 ºC in northern and northwestern regions. More than 90% of Rajasthan's rainfall occurs during this period. Humidity is high during this period, particularly in August.
Post-Monsoon: The monsoon generally ends by mid-September in all regions of the state and is followed by a second hot season during the months of October and November. This period records relatively uniform temperatures across the state. In October the average maximum temperature is 33 ºC to 38 ºC and the minimum is from 18 ºC to 20 ºC.
Winter: This is the season that attracts more tourists. Winter extends from December to March. This period records a considerable variation in maximum and minimum temperatures all over the state. January is the coldest month of the year. The minimum temperature falls to minus 2 ºC in the night at some places like Sikar, Churu, Pilani and Bikaner. A sharp decrease in night temperatures is experienced throughout the arid zone of western Rajasthan on account of quick release of thermal radiation from the sandy soil soon after the dark. The greater part of Rajasthan, except the southeastern part of Kota, Bundi and Baran and the western district of Barmer records the average temperatures of above 10 ºC. There is slight precipitation in the north and north eastern region of the state. Climate is pleasant during winter and this is the ideal time to travel. The most important thing is that a number of fairs and festivals take place during winter offering the traveler the best possible outlook of Rajasthani culture. [4]

1.3 Place of study :

During the present study a comparison of traditional and modern building has been done. For the study place selected building at Bandh-Baretha , Bayana , Bharatpur ,Rajasthan .

1.4.1 Design Details Traditional Building :

Area at inner side of the Main Room is 19.9 feet by 16.9 feet and wall size is 1.8 feet. On the north side wall three window at same distance are placed. Height of the Main Room is 14.9 feet from inner side and roof size is ½ feet. on the east face wall main gate and two window are available for the purpose of direct gain. We gain enough sun light from east side window and in winter season useful to assure direct gain heat. At the height of 12 feet there is availability of four ventilation of 1.6 feet* 1.6 feet. in which two ventilation are placed at north direction and two are placed at south direction of main room . the main room is covered from the three direction east, south and west with 10.0 feet . in many old traditional buildings thickness of wall consist near by 3 feet. window size 3.6*2.6 feet on the height of 2.6 from the ground. every window protected by shade of 3 feet who protect in summer direct gain heat and in winter protected from direct entrance of cold air.
Design of the building construction of old traditional buildings generally lime stone used as raw material because of its some specific properties .lime stone have maximum reflectivity and its required more time to rise and fall the temperature compare to other material and easier available in market on low cost , so important cost deduction of buildings.
Height of building and width of roof decrease the effect of solar radiation and reduce the chances of temperature rise. lime stone Insulation works to stop all three forms of heat transfer.
Solar Radiation is heat transferred by infrared rays from the sun to the interior of the building. The radiant energy absorbed by the roof assembly is emitted as infrared radiation into the attic heating the cavity fill insulation at the ceiling level. This is why the inside of attics in the South are so hot. R-value does not include the energy transferred to the building by radiation.

It is estimated that radiant heat transfer is responsible for 65% - 80% of heat flow through the building envelope during the heating season. In general, light colors and shiny surfaces reflect heat.

lime stone who used in construction of old traditional buildings as raw materials that are useful to reduce summer heat gain and winter heat loss, thereby reducing building heating and cooling energy use.[5]
Traditional building design discussion :
1 . 16.9ft*19.9ft*14.9ft of building length ,width and height
2. two ventilation in west side on 12 feet height . 3. ventilation is width 3.3ft and height 1.6ft

4. chimney on the west side wall

Figure 1: Passive building (Area ,ventilation and chimney)

Figure2 : Passive building (Area ,ventilation and chimney and height

1.4.2 Traditional building Design From outer side

1.height of building is 15.6 ft

2. roof plaster size is 9 inch

3. East side covered from 11.3 feet roof

4. west side covered 11.3 feet

5. 2 window in east

6. Main building A height is 15.6 from outer and covered from 11.3 feet height is 12 feet

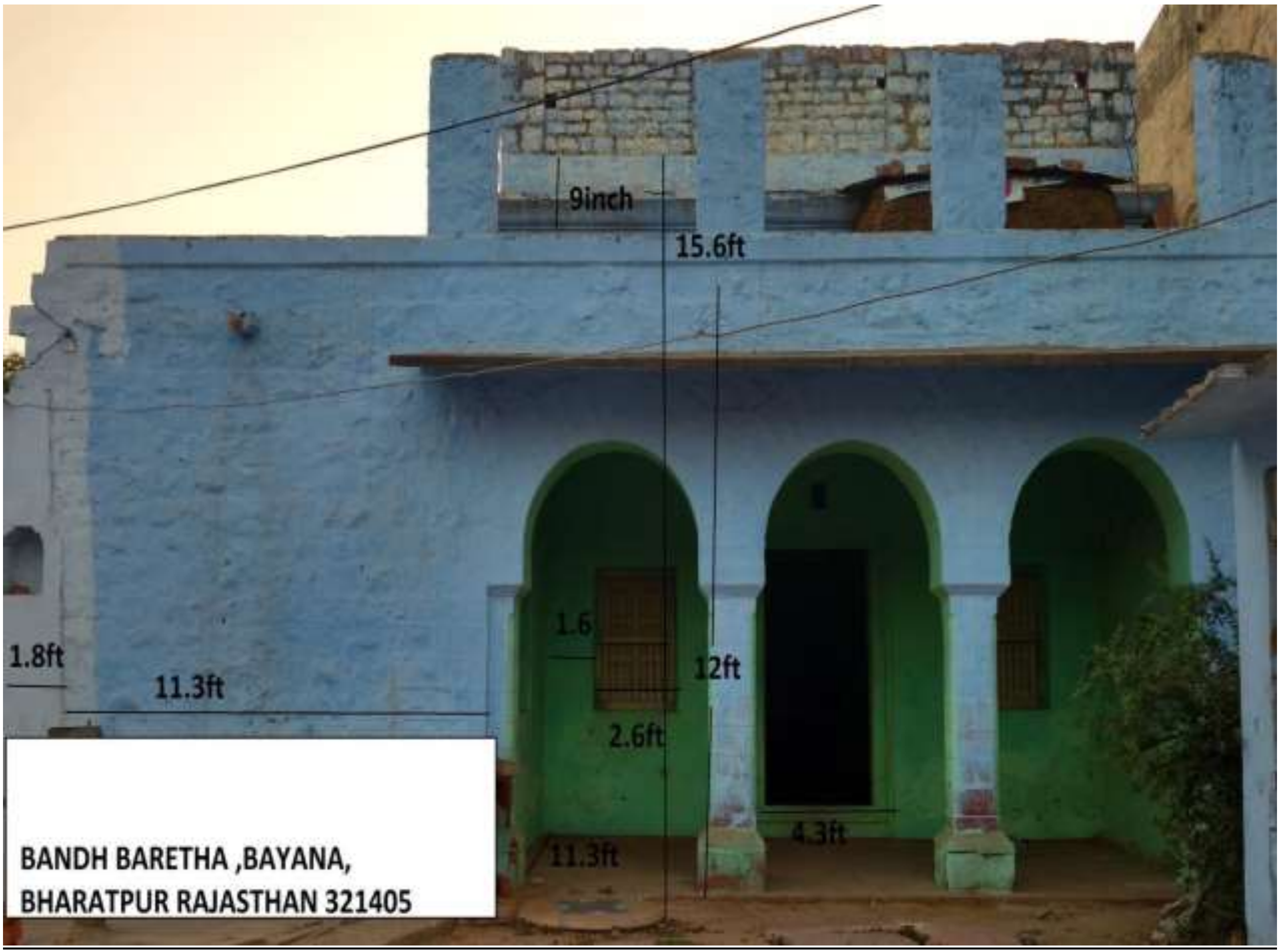


Figure 3 : Traditional building Design From outer side

1.4.3 Old traditional building north side Wall (window and ventilation)

1. two ventilation in north side wall on the height of 12 feet (1.6ft by 3.3ft by 1.6ft)
2. 3 window on north side wall 1.8ft by 3.6ft by 3.3 on the height 2.6 feet from the ground.

Figure 4 : North Wall (Window and Ventilation)

1.4.4 South side wall protected from another small room roof (11.3 feet)

Figure 5 : South Wall protected by small room roof

1.4.5 West side wall protected from 11.3feet roof

Figure 6 : West Side Protection Roof

1.4.6 Ventilation protected with 2.6 feet

Figure 7: Ventilation protected with 2.6 feet

1.4.7 Wall Size

1.Wall size is 1.8 feet (insulation)

2. Plaster of limestone on the wall is 2 inch 1

3. Masonry /stone is 1.6 feet

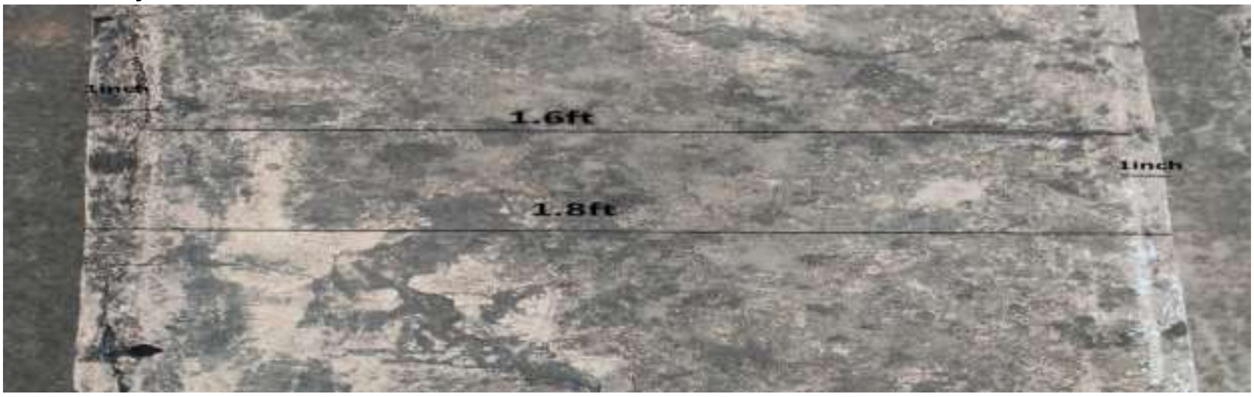


Figure 8 : Wall

1.4.8 Chimney

Figure 9 . Chimney

1.4.9 Material used in construction

1. stone used in construction
2. limestone used as plaster and in construction
3. All the window and ventilations are protected with 2.6 feet to protect from rain and direct sun light

2.5 Modern building:

In present time east face buildings that have 20 feet by 15 feet have 10 feet height . thickness of walls is 18 inch. in east side window size is 3*2 have 2 nos. west side 4*3 have 2 window. Cement used in the building as raw material and stone size is big as compare to old traditional building. we also compare the result of this building with the south face building of same design .

The problems observed within a buildings depends on the building design including wall , orientation ,direct gain from door and window ,color spacing, wind flow and building material used etc. in the construction along with climatic conditions .

We have observed near 30 days temperature at different height on ground , 5 feet and 10 feet and find 1.5 ^{o}C more temperature from the ground and at near 10 feet temperature increases 2.5 ^{o}C from the ground.

2.4.2 Design and Construction

1. building area length*width*height (12ft by 15ft by 9.6ft)
2. on the north side wall 2 window and on the east side wall 1 window(width 4 feet and height 5 feet)
3. wall size is 1.6 feet and 1/2 inch plaster width both side.
4. ventilation size is 1 feet by 1feet in north wall at the 8.5 feet height.

2.5 Experimental Method:

We observed temperature of the main traditional building , comparative modern building, outer environment temperature and humidity with the help of thermo hygrometer and thermocouple based thermo hygrometer.

Also compare the data with . www.weather.com [8]

2.5.1 Thermo hygrometer

A hygrometer is an instrument used for measuring the moisture content in the atmosphere . Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity. [6]

2.5.2 Specification of the instrument

1. Range -0~50C/ -32~122F(Indoor Range) & -50c~70C/ - 58F~158F(Outdoor)
2. Humidity Range: 10%~99%RH
3. Accuracy +/- 1% & humidity +/-5%RH

2.5.3 Thermometer

Thermometer is a device that measures temperature or a temperature gradient. A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer) in which some physical change occurs with temperature, and (2) some means of converting this physical change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer). Thermometers are widely used in industry to control and regulate processes, in the study of weather, in medicine, and in scientific research . [11]

Thermocouple

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. The voltage can then be interpreted using thermocouple to calculate temperature . [12]

Figure 34 : Thermo hygrometer and Temperature Meter

2.6 Experimental Observations:

2.6.1 Data from January to April month

Date	Time	Main room temp C	Main room humidity	Outer temperature	Outer humidity	Small room Temp.	Small room humidity%
06.01.17	10.15AM	18.2	68	25.0	51	18.7	66
	11.30AM	17.9	66	27.0	40	19.0	65
	01.38 PM	18.4	64	28.3	40	20.4	63
11.01.17	10.45AM	14.5	63	19.0	60	11.0	66
	01.30PM	15.8	52	21.0	50	14.0	55
05.02.17	12.30 PM	19.8	65	25.7	60	19.0	74
	04.38PM	20.5	55	25.6	60	21.7	74
06.02.17	09.10AM	19.5	74	18.7	85	17.0	84
13.02.17	09.56AM	17.4	69	19.3	50	14.6	69
	12.55PM	18.0	66	27.0	46	15.4	62
	01.40PM	18.5	66	28.0	40	17.0	64
	02.00PM	18.5	66	29.0	37	17.0	64
	05.30PM	19.1	67	25.0	46	19.0	64
14.02.17	10.30AM	18.0	64	24.0	25	15.8	64
20.02.17	10.01AM	23.5	50	29.0	40	22.5	56
	01.00PM	25.0	49	35.0	25	27.1	47
	03.42PM	25.0	49	36.0	20	27.4	45
24.02.17	11.00AM	21.3	40	26.2	30	18.7	46
02.03.17	10.15AM	22.5	58	28.2	55	20.5	64
	11.00AM	22.5	56	31.1	45	23.0	61
	12.00AM	23.0	55	33.0	45	23.5	60
	01.00PM	23.5	55	33.5	44	25.0	56
	02.40PM	24.0	53	34.8	43	27.9	50

	04.00PM	23.9	55	33.0	45	25.5	50
04.03.17	08.00AM	21.8	54	20.2	50	18.8	55
	09.00AM	22.2	52	22.5	48	19.5	54
	10.15AM	22.2	52	26.3	40	19.5	54
	12.00AM	22.9	42	31.5	28	23.5	44
	01.00PM	23.4	37	32.4	18	25.0	37
	02.00PM	23.5	36	33.0	13	25.9	35
04.03.17	4.30PM	24.0	36	31.8	15	22.5	44
	6.00PM	24.5	35	26.2	26	22.0	35
	7.20PM	23.9	40	20.5	32	21.2	36
	9.00PM	23.7	39	17.0	40	20.3	42
05.03.17	6.00AM	22.4	42	9.5	70	15.0	55
	8.34AM	23.0	40	23.1	42	18.0	48
08.03.17	9.15PM	24.5	42	22.1	37	26.0	37
	11.00PM	24.5	37	20.9	39	25.3	35
09.03.17	6.00AM	23.3	42	17.7	49	20.0	40
	8.45AM	23.3	46	26.6	42	24.1	34
	10.00AM	23.8	46	29.2	32	26.2	29
	12.00AM	24.1	48	36.6	21	26.2	29
	2.00PM	24.1	38	37.5	10	28.0	15
	4.00PM	24.3	38	38.4	10	28.5	13
	6.00PM	24.8	44	28.9	29	30.0	10
	8.00PM	25.0	44	21.3	54	25.9	40
	9.30PM	24.0	48	20.3	57	24.0	46
10.03.17	9.00AM	23.9	55	25.9	50	21.7	56
12.03.17	10.30AM	19.3	69	24.2	55	17.1	71
	12.00AM	19.9	68	29.9	43	17.3	70
	1.15AM	20.3	64	33.8	29	23.0	58
	2.42PM	20.9	64	31.7	26	23.5	55
	4.00PM	21.1	56	30.9	25	23.5	58
	6.00PM	21.1	50	21.5	37	24.0	55
	9.00PM	20.4	58	13.8	60	20.4	58
13.03.17	9.15AM	21.1	51	18.0	50	17.2	57
	11.00AM	21.4	49	25.0	44	17.5	51
	12.00AM	21.6	48	27.0	26	18.7	50
	03.00PM	22.5	40	29.0	24	22.5	42
	05.30PM	21.7	45	28.0	30	24.0	35
	09.30PM	21.5	50	15.9	57	18.1	52
14.03.17	08.00AM	20.6	52	17.1	76	17.4	60
27.03.17	8.30AM	20.9	48	33.1	31	27.1	41
01.04.17	10.00AM	30.9	21	38.0	19	33.0	20
	12.00AM	31.5	18	41.5	10	35.0	15

	3.00PM	32.5	14	41.8	10	36.0	15
04.04.17	9.00AM	28.0	35	33.0	28	29.0	35
	10.00AM	31.1	35	35.0	25	31.8	34
	11.00AM	31.1	36	37.0	15	34.2	30
	12.40PM	31.4	34	40.0	10	35.8	25
	2.00PM	32.4	27	40.0	10	37.4	21
	3.30PM	32.1	32	42.0	6	38.7	17
	5.20PM	32.1	32	39.0	10	40.4	15
	6.30PM	32.6	27	37.0	18	39.8	15
	8.30PM	32.2	30	32.0	29	37.1	20
05.04.17	9.00AM	30.4	35	32.0	33	31.5	31
	12.00AM	32.1	36	38.0	12	35.2	26
	1.40PM	32.4	26	42.0	18	36.6	24
	2.50PM	32.5	30	42.5	12	37.4	23
	4.50PM	39.0	19	39.0	19	39.0	19
	6.45PM	37.0	21	37.0	21	37.0	21

06.04.17	9.02AM	31.0	40	33.0	35	32.8	37
	10.30AM	32.2	34	36.0	20	34.1	30
	2.00PM	33.6	25	40.0	10	37.2	21
08.04.17	11.00AM	30.5	11	33.0	10	31.7	10
	1.00PM	31.1	10	36.0	8	32.6	10
	3.45PM	31.1	10	38.0	7	36.0	10
10.04.17	10.00AM	28.0	11	31.0	19	29.4	10
	8.39PM	29.3	16	25.0	20	33.6	10
11.04.17	9.00AM	28.0	15	33.0	19	28.4	10
	11.00AM	29.0	13	40.0	8	31.5	10
13.04.17	9.00AM	27.0	18	33.0	12	30.0	15
	12.00AM	29.0	15	43.0	7	37.6	10
	3.00PM	30.0	12	47.0	5	39.9	10
	6.00PM	28.0	13	35.0	11	36.0	10
	9.00PM	26.0	15	20.0	19	21.0	18
	12.0PM	24.0	18	16.0	24	18.0	20
16.04.17	8.00AM	20.0	20	21.0	18	18.0	21
	9.00AM	24.0	15	33.0	11	28.0	15
	12.00AM	31.0	13	42.0	8	35.0	10
	2.00PM	32.0	13	48.0	7	40.0	10
	3.00PM	33.5	12	48.0	7	40.0	10
	5.00PM	32.5	12	35.0	10	38.0	10
	8.00PM	29.0	14	24.0	14	24.5	16
20.04.17	11.00AM	30.0	15	38.0	9	35.1	16
	3.00PM	33.5	11	47.5	7	40.0	16

2.6.2 R factor :

R-value is a measure of thermal resistance, or ability of heat to transfer from hot to cold, through materials (such as insulation) and assemblies of materials (such as walls and floors). The higher the R-value, the more a material prevents heat transfer. R-value depends on materials' resistance to heat conduction, as well as the thickness and (for loose or porous material) any heat losses due to convection and radiative heat transfer. However it does not account for the radiative or convective properties of the material's surface, which may be an important factor for some applications. R varies with temperature but in construction it is common to treat it as being constant for a given material (or assembly). It is closely related to the thermal transmittance (U-value) of a material or assembly, but is easier to manipulate in some calculations since it can be simply added for materials and assemblies that are arranged in layers, or scaled proportionately if the thickness of a material changes. R-values expressed in United States customary units are about 5.67 times larger than those expressed in metric (SI) units.

R is expressed as the thickness of the material normalized to the thermal conductivity, and under uniform conditions it is the ratio of the temperature difference across an insulator and the Heat Flux Density (heat transfer per unit time per unit area) . [13]

2.6.3 U factor:

The U-factor or U-value, is the overall heat transfer coefficient that describes how well a building element conducts heat or the rate of transfer of heat (in watts) through one square meter of a structure divided by the difference in temperature across the structure. The elements are commonly assemblies of many layers of components such as those that make up walls/floors/roofs etc. It measures the rate of heat transfer through a building element over a given area under standardized conditions. The usual standard is at a temperature gradient of 24 °C (75 °F), at 50% humidity with no wind (a smaller U-factor is better at reducing heat transfer). It is expressed in watts per meter squared kelvin (W/m^2K). This means that the higher the U-value the worse the thermal performance of the building envelope. A low U-value usually indicates high levels of insulation. They are useful as it is a way of predicting the composite behavior of an entire building element rather than relying on the properties of individual materials.

In most countries the properties of specific materials (such as insulation) are indicated by the thermal conductivity, sometimes called a k-value or lambda-value (lowercase λ). The thermal conductivity (k-value) is the ability of a material to conduct heat ; hence, the lower the k-value, the better the material is for insulation. Expanded polystyrene (EPS), has a k-value of around 0.033 W/m-K. For comparison, phenolic foam insulation has a k-value of around 0.018 W/m-K, While wood varies anywhere from 0.15 to 0.75 W/m-K, and steel has a k-value of approximately 50.0 W/m-K. U is the inverse of R with SI units of $W/(m^2K)$.[14]

2.6.4 Properties of building material :

Material	Specific heat(KJ/Kg-K)	Thermal conductivity(W/m-K)
Bricks	0.88	0.811
Stone	0.84	1.83
Cement	0.84	0.721
Limestone	0.84	1.800

[15] & [16]

2.6.5 Old traditional building or main building R Factor :

L_1 – Inner side Plaster Thickness on Wall , L_2 - Sand stone Wall Thickness L_3 –Outer side Plaster Thickness, h_i - Enclosed air conductance , h_0 – Outer side Air Conductance, R_T –Total thermal resistance

L_1 = 0.025 m; k1 = 1.800 W/m^2-K

L_2 = 0.457 m; k2 = 1.830 W/m^2-K L_3 = 0.025 m; k3 = 1.800 W/m^2-K h_i = 8.3 W/m2-K; ho = 22.7 W/m^2-K

R_T = 1/8.3 + 0.025/1.800 + 0.457/1.830 + 0.025/1.800 + 1/22.7 = 0.44203

U = 1/R_T= 2.26228 W/m^2-k

2.6.7 Modern Building:

L_1 – Inner side Plaster Thickness on Wall , L_2 - Sand stone Wall Thickness L_3 –Outer side Plaster Thickness, h_i - Enclosed air conductance , h_0 – Outer side Air Conductance, R_T - Total thermal resistance

L_1 = 0.012 m; k1 = 1.721 W/m^2-K L_2 = 0.425 m; k2 = 1.811 W/m^2-K L_3 = 0.012 m; k3 = 1.721 W/m^2-K h_i = 8.3 W/m2-K; ho = 22.7 W/m^2-K

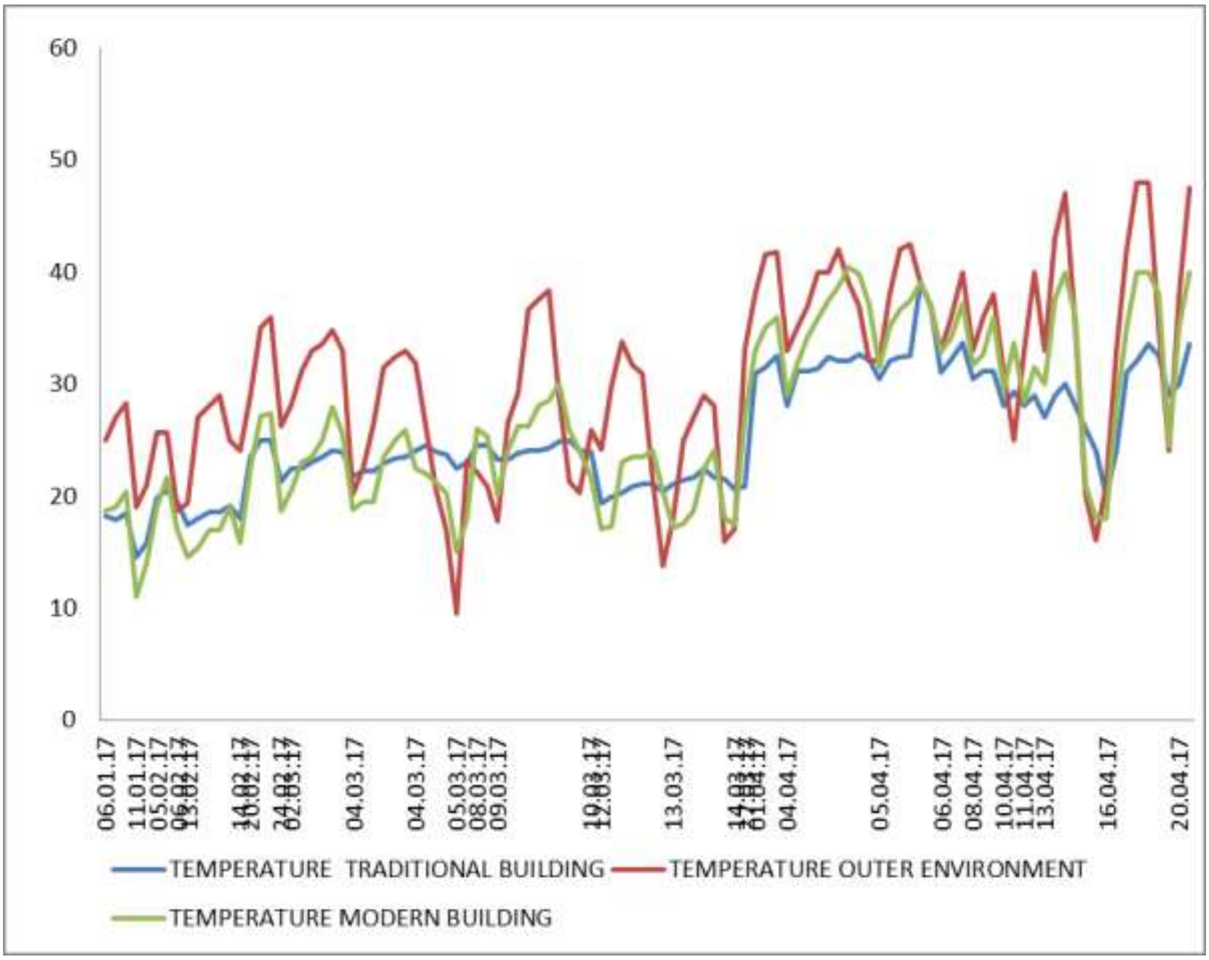
R_T = 1/8.3 + 0.012/1.721 + 0.425/1.811+ 0.012/1.721 + 1/22.7 = 0.4131

U = 1/RT= 2.4207 W/m2-k

Result And Discussion:

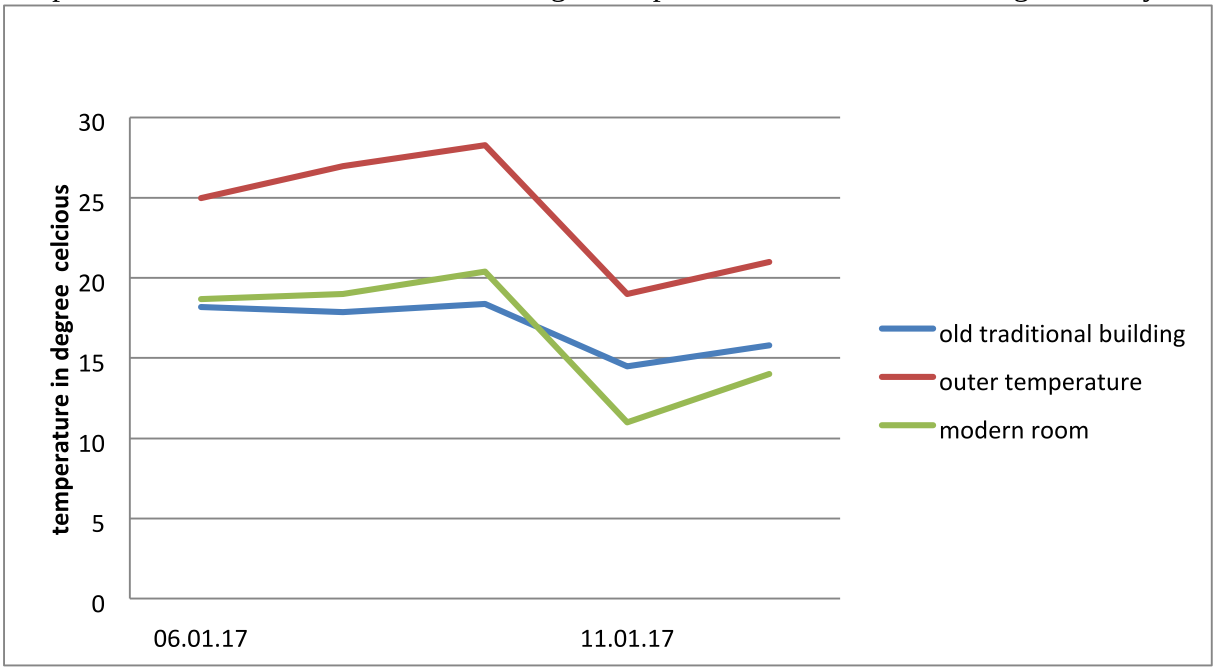
The temperature between January to April on different days at different time . In summer and winter we have different climate in India so therefor we have need specific material which can be utilize in different climates. In this project we compare the data temperature of modern and old traditional building. We have long tradition of thermal comfort buildings in India .

According to resultant data temperature of old traditional buildings varies delay compare to modern buildings because of its design and materials selection .the results of air temperature taken from the survey in the line chart graphs. The X-axis represents the day / date when the study took air temperature data from indoor and outdoor, while the Y-axis represents the degree of air temperature in degree Celsius (°C). The graphs illustrated that the old traditional building temperature and modern building temperature . in modern building temperature started to rise up from the morning to reach the peak at 3 pm to 5 pm then start to decrease . temperature of both buildings is lowest in night .In old traditional building temperature is constant comparative modern building . According to time , old traditional building temperature rises between 8:00AM to 2:00PM and after this time temperature rises slowly till 5:00pm because of south and west side wall covered. Temperature of old traditional building comparative to modern building is constant.



Graph 1: Traditional and Modern building temperature comparison with Outer Temp.

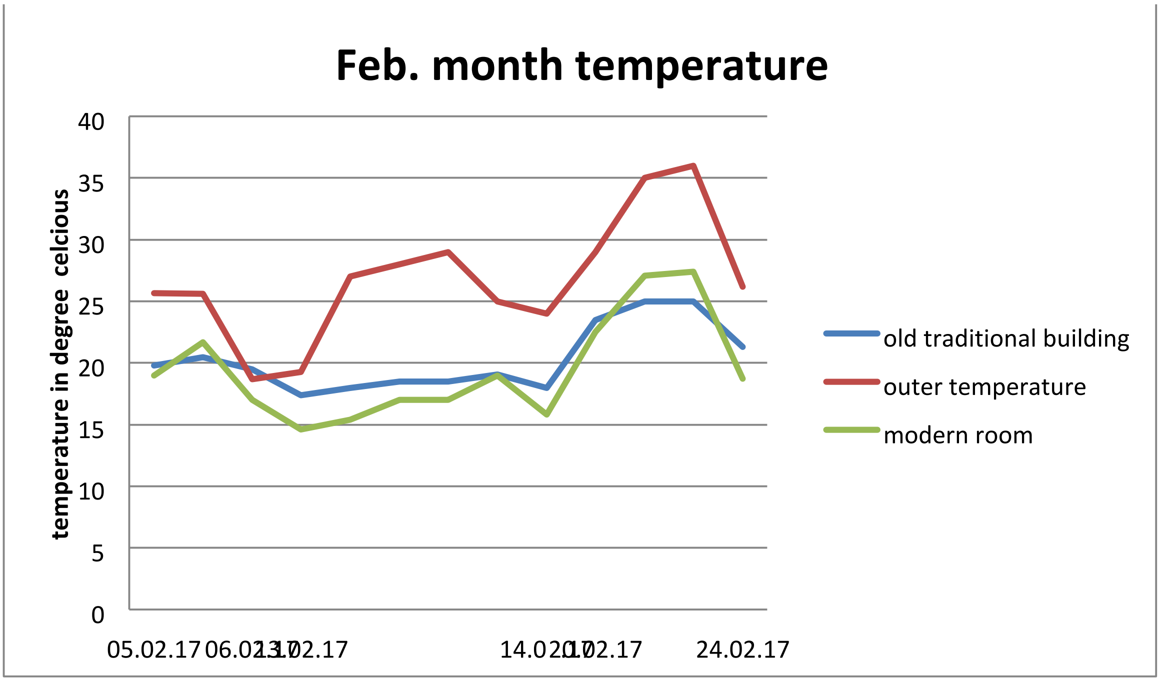
January month : modern building temperature between 14 to 19 ^{0}C and modern building temperature between 11 to 21 ^{0}C. in night temperature of modern building suddenly down .



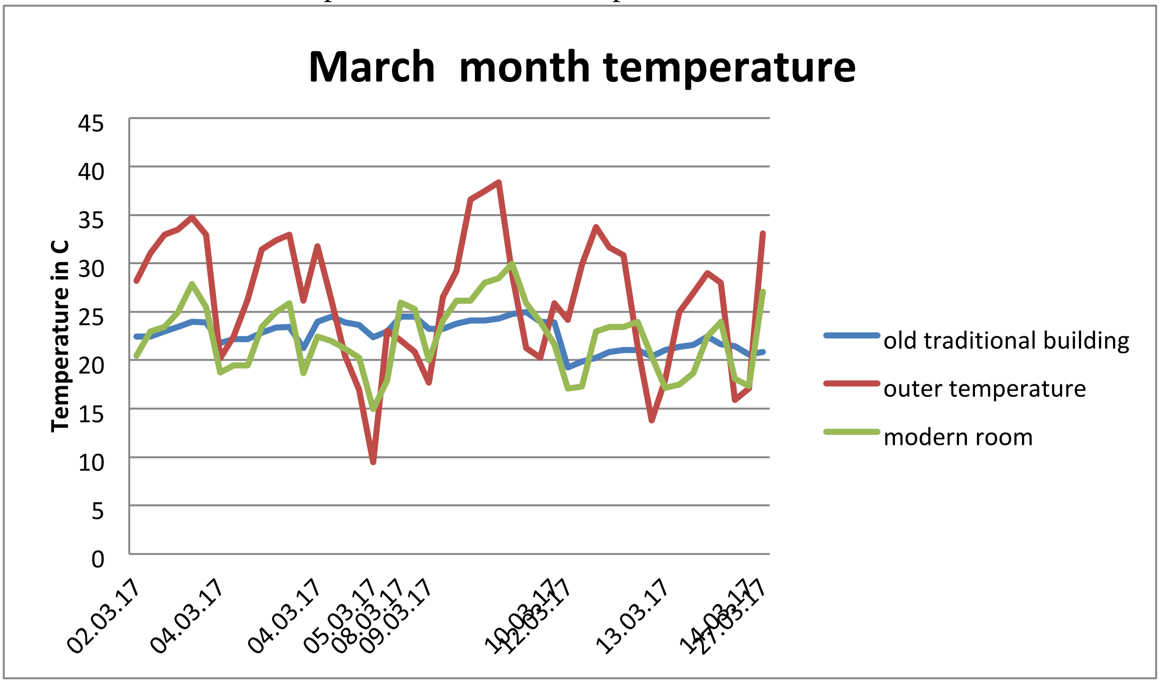
january month temperature

Graph 2 : January Month

February month: modern building temperature follow thermal comfort zone and modern building temperature move according to outer temperature so in modern buildings outer temperature directly effected inner side temperature. In march when due to summer climate change suddenly and temperature between 15 to 40 ^{0}C . temperature of modern building is suddenly increases but in old buildings temperature rises but still in thermal comfort zone.

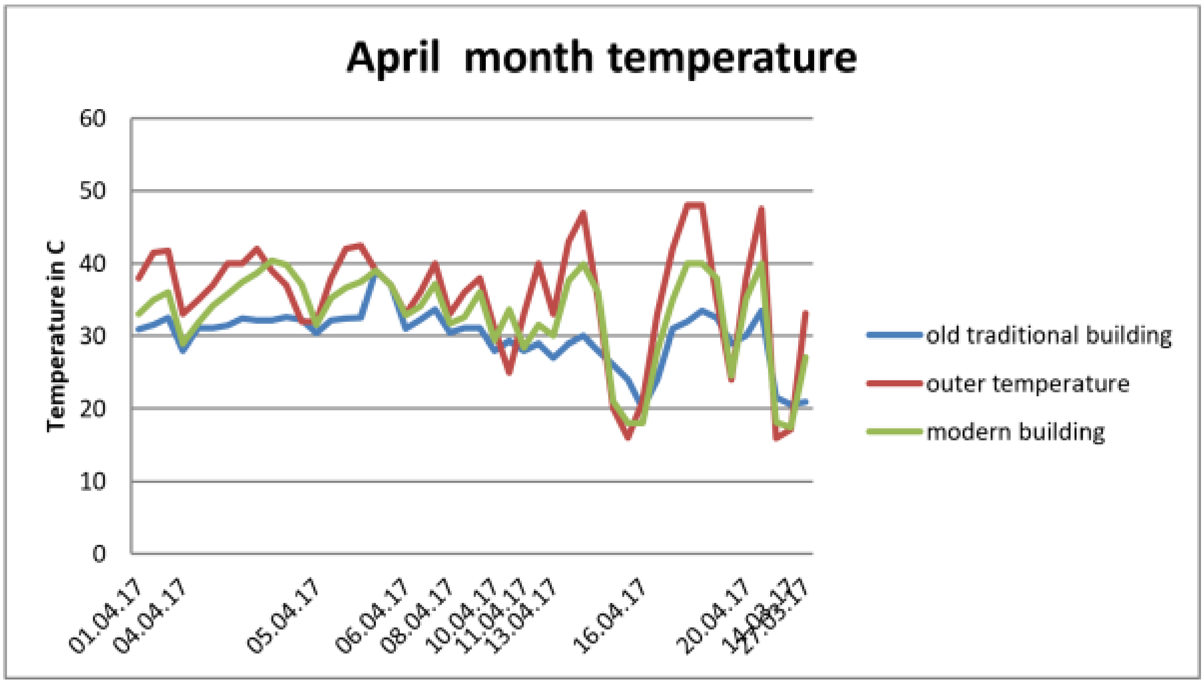


Graph 3 : Feb Month Temperature



Graph 4 : March Month Temperature

In Rajasthan 15 to 49 ^{0}C temperature of the summers (April to July) so required thermal comfort building to reduce effect of hot climate. Temperature of old traditional building between 21 to 36 ^{0}C but when we compare it with modern buildings 19 to 41 ^{0}C performance is batter.



Graph 5 : April Month Temperature

If we observe the temperature of different time period of the day when minimum temperature is 10 ^{0}C and maximum temperature is 48 ^{0}C when after 2 O'clock temperature rises slowly in old traditional building and maximum temperature on thermo hygrometer observe at 3 o'clock.

Now we discuss about the design of both buildings and effect on result of design : As per study in old traditional buildings wall size and height of building reduce the effect of thermal radiation . They also focus on orientation to decrease effect on thermal or electromagnetic radiations . Effective ventilation and luminance improve thermal comfort and energy efficiency. But in modern building due to less space wall size thicker and height of building is minimize. Because of easier availability and minimum work cost we are prefer cement as raw material in plaster of wall and roof.

Conclusions and Scope for Future Work 4.1 Conclusions

The present study is based on evaluation of thermal comfort parameters for traditional and modern building design and materials. During the present study a traditional building was chosen and compared with a modern building on the basis of various parameters such as wall thickness, wall height, orientation, air flow, ventilation, direct solar gain etc. It was observed that traditionally the wall thickness used to be more and wall heights were around 15 feet. The experimental observations for temperature and humidity reveal that traditional building provided better thermal comfort with variation of 4-5^{o}C, temperatures were higher in winters and lower in summers. Humidity levels were almost similar. The R and U factor for the traditional and modern building has been reported in the present work. The U-factor for walls of traditional building is 2.26 W/m^{2}-K and for modern building wall is 2.42 W/m^{2}-K.

On the basis of the comparison of orientation and solar gain of both buildings it may be concluded that direct solar gain can be avoided if more openings/windows are on the North side to provide better ventilation and cooling in summers. The wall insulation should be good to resist heat flow

and increased wall height improves cooling in summers. Therefore, while designing buildings if the wall thickness cannot be increased as in traditional buildings, multi layer insulation should be used. Where ever possible roof height should be kept more and as maximum heat gain is through roof, better insulation should be used for roof also.
Comparative study of old Indian traditional materials such as limestone, cow dung, soil, soil pot and currently used material i.e. cement has also been done in the present study. Experimental study about these materials and climatic effect on these materials has been conducted through six cubicles constructed with size is 2 .9 feet by 2.9 feet by 2.5 feet. Materials such as limestone, cement, cowdung and soil pots were studied on the cubicles and it was found that limestone was able to give more cooling in summers.

4.2 Scope for Future Work

This study revealed the importance of wall thickness, wall height, orientation, ventilation and different materials for achieving thermal comfort in buildings in Rajasthan. Further studies are required for development of multilayer insulating walls and roofs with low cost solutions which can help reduce the heat flow and improve thermal comfort. Climate of Rajasthan is hot and dry for most of the months of the year and winters are quite cold for two to three months. Thus, buildings should be designed keeping in mind the climatic conditions of this area so that minimum energy is required for maintaining thermal comfort in the buildings.

References:

1. http://www.buildingsplatform.org/cms/_ The Energy Performance in Buildings Directive supported by the European Commission & Energy Efficiency Requirements in building codes energy efficiencies policies in new buildings IEA Publication ,March 2008
2. https://en.wikipedia.org/wiki/Passive_cooling
3. https://en.wikipedia.org/wiki/Passive_solar_building_design
4. Climate, Comfort, & Natural Ventilation: A new adaptive comfort standard for ASHRAE Standard 55, UC Berkeley: Center for the Built Environment - April 2001 - Brager, G, S., de Dear, R.(2011) and Teri
5. Ghosh, Bijit: Jaisalmer - Urban Form and Pattern of a Medieval Indian Town. Urban and Rural Planning Thought. XI (1) (1968)
6. n.k. bansal and gernot minke (1988) Climatic Zones and Rural Housing in India
7. http://www.thermalbuildingconcepts.com/radiation-effect/
8. www.weather.com
9. https://en.wikipedia.org/wiki/Hygrometer
10. http://www.thermocoupleinfo.com/
11. http://zeus.phys.uconn.edu/halld/diamonds/heating-10-2004/heatcap.html
12. http://www.marble-institute.com/stoneprofessionals/technical-bulletins/rvalue/
13. https://en.wikipedia.org/wiki/R-value_(insulation)
14. http://www.climatechwiki.org/technology/traditional-building-materials-and-design
15. https://en.wikipedia.org/wiki/Cement
16. https://theconstructor.org/building/types-of-building-materials-construction/699/
17. https://web.mst.edu/~cottrell/ME240/Resources/Temperature/Temperature.pdf 18. http://zeus.phys.uconn.edu/halld/diamonds/heating-10-2004/heatcap.html

19. http://www.marble-institute.com/stoneprofessionals/technical-bulletins/rvalue/
20. International Agro physics ,Institute of Agro physics Lublin Pland M.A.Nayyeri , M.H. Kianmehr , S.R.Hssan (Tehran,2009)