Thermal Comfort Techniques for Urban Poor's Housing

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Abstract:

It is known to everyone, that urban lower income group peoples are not have sufficient money to construct their homes, they always try to curtail the cost of their home, by using cost-effective materials, but they do not use cost effective home construction techniques this will be the main risk at their home . due to housing area & volume deficiency many of urban peoples are suffering many deceases related to their health; i.e. indoor air pollution & heat strokes are the main cause to the health, these would be keep in control by some cost efficient thermal comfort techniques suggested by in chapter 5.0 , after of study different literatures.

Keywords: Thermal comfort techniques for urban poor's housing

1. Introduction

1.1 Meaning of thermal comfort

Human being has always striven to create a thermally comfortable environment. This is reflected in building traditions around the world - from ancient history to present day. Today, creating a thermally comfortable environment is still one of the most important parameters to be considered when designing buildings. But what exactly is Thermal Comfort? It is defined in the ISO 7730 standard as being "That condition of mind which expresses satisfaction with the thermal environment". A definition most people can agree on, but also a definition which is not easily converted into physical parameters.

Two conditions must be fulfilled to maintain thermal comfort. One is that the actual combination of skin temperature and the body's core temperature provide a sensation of thermal neutrality. The second is the fulfillment of the body's energy balance: the heat produced by the metabolism should be equal to the amount of heat lost from the body.

2. Physiological basis

The human body continuously produces heat. This metabolic heat production can be of two kinds:

- Basal metabolism, due to biological processes which are continuous and non-conscious
- Muscular metabolism, whilst carrying out work, which is consciously controllable (except in shivering).

Table 1 shows some typical metabolic rates, which can be expressed as power density, per unit body surface area (W/m²), as the power itself for an average person (W) or in a unit devised for thermal comfort studies, called the **met**. 1 met = 58.2 W/m². For an average sized man this corresponds to approximately 100 W. Du Bois (1916) proposed an estimate of the body surface area, on the basis of body mass (M, in kg) and height (h, in m), which is referred to as the "DuBois area" (m²): $AD = 0.202 M^{0.425} h^{0.725}$ e.g. for a person of 1.7 m height and 70 kg body mass AD = 0.202 • $70^{0.425}$ • $1.7^{0.725}$ = 1.8 m2

activity	met	W/m²	W(av)
sleeping	0.7	40	70
reclining, lying in bed	0.8	46	80
seated, at rest	1.0	58	100
standing, sedentary work	1.2	70	120
very light work (shopping, cooking, light industry)	1.6	93	160
medium light work (house~, machine tool ~)	2.0	116	200
steady medium work (jackhammer, social dancing)	3.0	175	300
heavy work (sawing, planing by hand, tennis) up to	6.0	350	600
very heavy work (squash, furnace work) up to	7.0	410	700

Table 1 "Metabolic rate at different activities"

The heat produced must be dissipated to the environment, or a change in body temperature will occur. The deep body temperature is about 37°C, whilst the skin temperature can vary between 31°C and 34°C under comfort conditions. Variations occur in time, but also between parts of the body, depending on clothing cover and blood circulation. There is a continuous transport of heat from deep tissues to the skin surface, from where it is dissipated by radiation, convection or (possibly) conduction and evaporation.

The body's heat balance can be expressed as

$M \pm R \pm Cv \pm Cd - E = \Delta S$ (W) ... 1.1)

where M = metabolic rate Cv = convection

R = net radiation Cd = conduction

E = evaporation heat loss ΔS = change in heat stored

If ΔS is positive, the body temperature increases, if negative, it decreases. The heat dissipation rate depends on environmental factors, but the body is not purely passive, it is homoeothermic: it has several physiological regulatory mechanisms.To **warm conditions** (or increased metabolic heat production) the body responds by vasodilation: subcutaneous blood vessels expand and increase the skin blood supply, thus the skin temperature, which in turn increases heat dissipation. If this cannot restore thermal equilibrium, the sweat glands are activated; the evaporative cooling mechanism will operate. Sweat can be produced for short periods at a rate of 4 L/h, but the mechanism is fatigable.

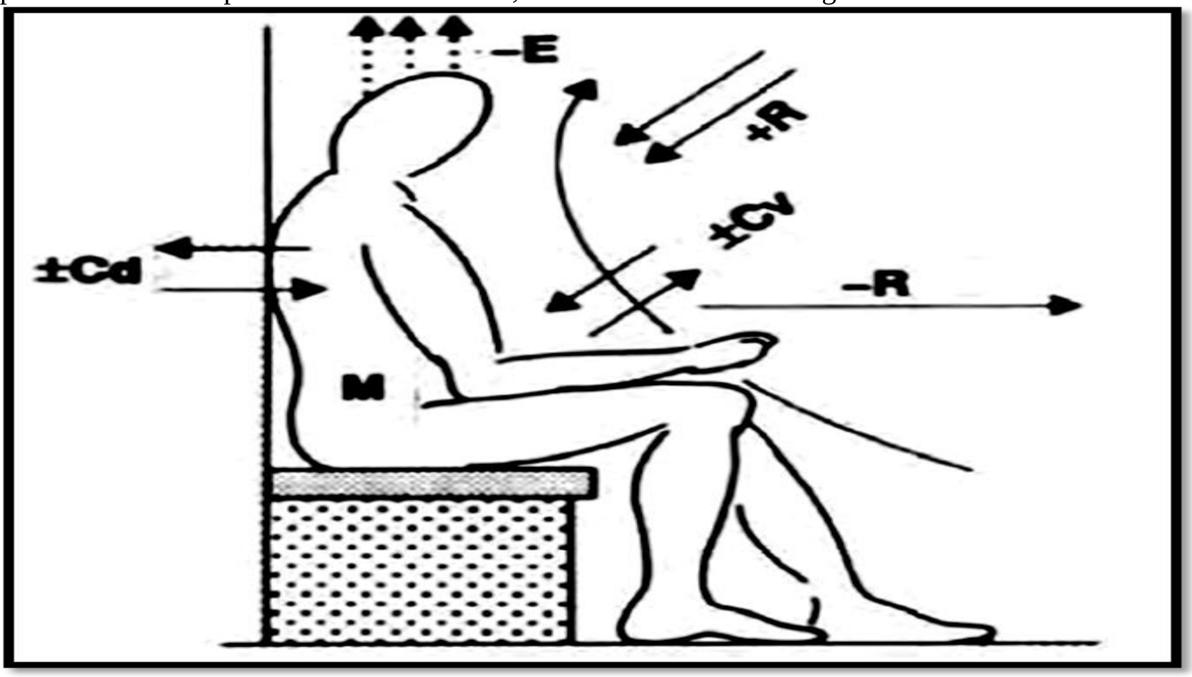

Fig. 1 Heat exchanges of the human body

The sustainable rate is about 1 L/h. Evaporation is an endothermic process, it absorbs heat at the rate of some 2.4 MJ/L (= 666 Wh/L). When these mechanisms cannot restore balance conditions, inevitable body heating, *hyperthermia* will occur. When the deep body temperature reaches about 40°C, heat stroke may develop. This is a circulatory failure (venous return to the heart is reduced) leading to fainting. Early symptoms are: fatigue, headache, dizziness when standing, loss of appetite, nausea, vomiting, shortness of breath, flushing of face and neck, rapid pulse rate (up to 150/min), glazed eyes, as well as mental disturbances, such as poor judgment, apathy or irritability. At heat stroke the temperature rapidly rises to over 41°C, sweating stops, coma sets in and death is imminent. Even if a person is saved at this point, the brain may have suffered irreparable damage. At about 42°C death would probably occur.To cold conditions the response is firstly vasoconstriction: reduced circulation to the skin, lowering of skin temperature, thus reduction of heat dissipation rate. (Associated with these goose-pimples may appear, an atavistic phenomenon: the erection of hair, which would make the fur a better thermal insulator.) If this is insufficient, thermo genesis will take place: muscular tension or shivering, thus increased metabolic heat production. Shivering can cause up to tenfold increase in heat production. The deep body tissues remain at the normal 37°C. Body extremities, fingers, toes, ear lobes may be starved of blood and may reach temperatures below 20°C, or in severe exposure may even freeze, before deep body temperature would be affected.

When these physiological adjustments fail to restore thermal equilibrium, *hypothermia*, i.e. inevitable body cooling will occur. The deep body temperature may drop to below 35°C. Death usually occurs between 25 and 30°C (except under medically controlled conditions). Even if hypothermia is not reached, continued exposure to cold conditions, which require full operation of vasomotor and thermo genetic controls, can cause mental disturbances (insufficient blood supply to the brain); willpower is "softened" and conscious control gives way to hallucinations, drowsiness and stupor (Lee, 1980; Grubich, 1961).

Table 2 summarizes the critical body temperatures. The skin should always be at a temperature less than the deep body, and the environment should be below the skin temperature, in order to allow adequate, but not excessive heat dissipation. The environmental conditions which allow this would ensure a sense of physical well-being and may be judged as comfortable.

Skin temperature		Deep body temperature	Regulatory zone
pain:	45°C	42°C	death
		40°C	hyperthermia
			evaporative zone
			vasodilation
	31-34°C	37°C	comfort
			vasoconstriction
			thermogenesis
		35°C	hypothermia
pain:	10°C	25°C	death

Table 2 Critical body temperatures (an approximate guide)

3. Climate and buildings

The weather of a place represents the state of the atmospheric environment over a brief period of time. Integrated weather condition over several years is generally referred to as climate or more specifically, as the 'macro-climate'. An analysis of the climate of a particular region can help in assessing the seasons or periods during which a person may experience comfortable or uncomfortable conditions. It further helps in identifying the climatic elements, as well as their severity, that cause discomfort. The information helps a designer to build a house that filters out adverse climatic effects, while simultaneously allowing those that are beneficial. Discomfort and the corresponding energy demand for mechanical systems can be significantly reduced by judicious control of the climatic effects. The built-form and arrangement of openings of a building can be suitably derived from this analysis. For example, in a place like Mumbai, one feels hot and sweaty owing to intense solar radiation accompanied by high humidity. Here, the building design should be such that (a) it is sufficiently shaded to prevent solar radiation from entering the house and, (b) it is ventilated to reduce discomfort due to high humidity. On the other hand, in a place like Shimla, it is necessary to maintain warmth inside the building due to the predominantly cold climate. Climate thus plays a pivotal role in determining the design and construction of a building.

3.1 Factors Affecting Climate

Both weather and climate are characterized by the certain variables known as climatic factors.
They are as follows:
(A) Solar radiation (B) Ambient temperature
(C) Air humidity (D) Precipitation
(E) Wind (F) Sky condition

(A) Solar radiation

Solar radiation is the radiant energy received from the sun. It is the intensity of sunrays falling per unit time per unit area and is usually expressed in Watts per square meter (W/m2). The radiation incident on a surface varies from moment to moment depending on its geographic location (latitude and longitude of the place), orientation, and season, time of day and atmospheric conditions (Fig. 2.1). Solar radiation is the most important weather variable that determines whether a place experiences high temperatures or is predominantly cold. The instruments used for measuring of solar radiation are the pyranometer and the pyrheliometer. The duration of sunshine is measured using a sunshine recorder.

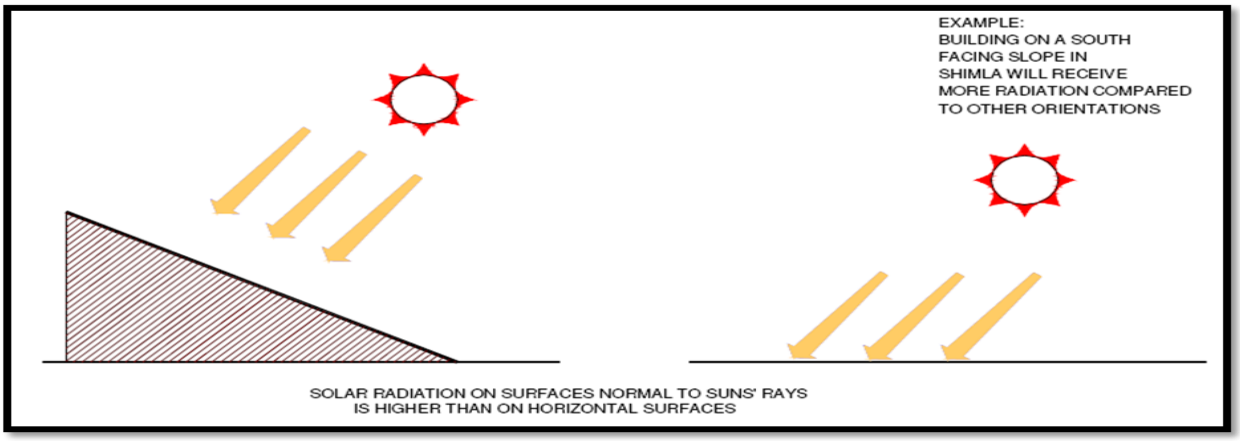

Fig. 2.1 (a) Factors affecting solar radiation "effect of orientation"

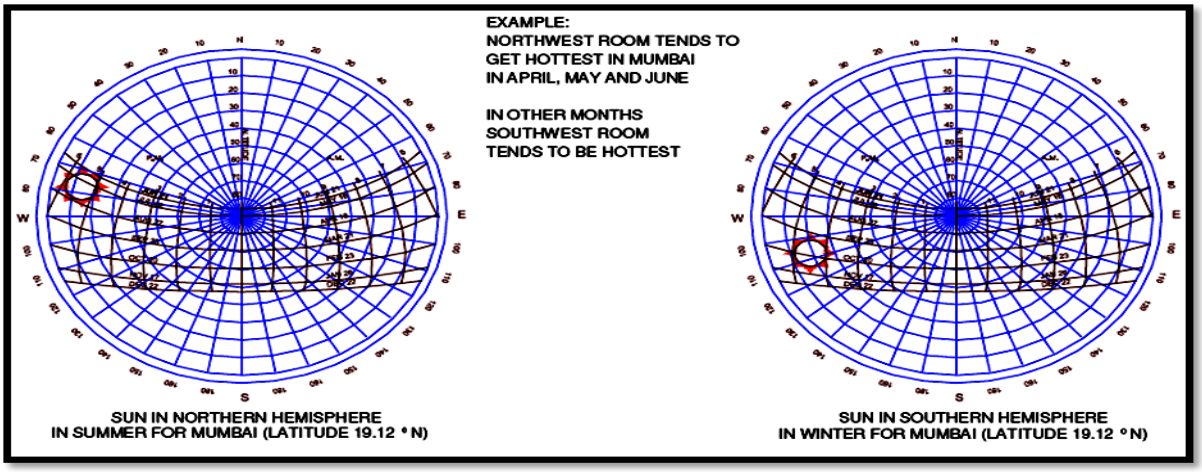

Fig. 2.1(b) Factors affecting solar radiation "effect of season"

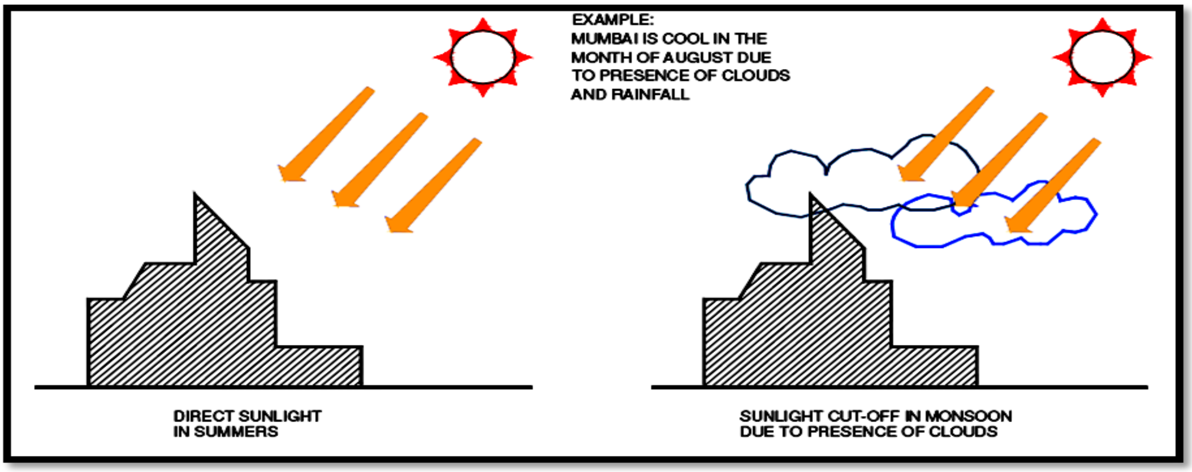

Fig. 2.1(c) Factors affecting solar radiation "effect of sky cover"

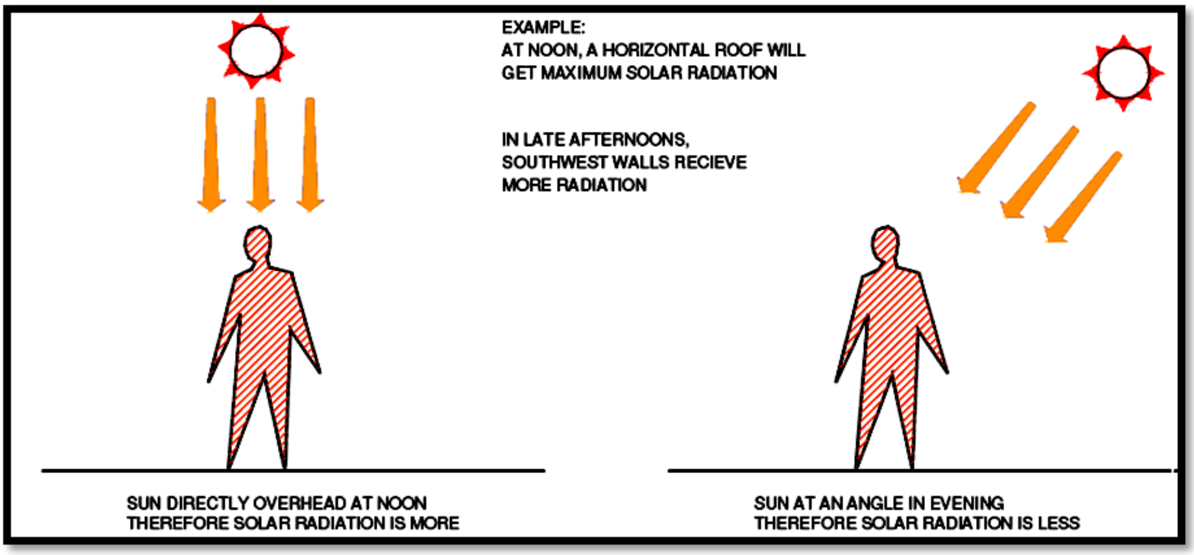

Fig. 2.1 (d) Factors affecting solar radiation "effect of time"

(B) Ambient temperature

The temperature of air in a shaded (but well ventilated) enclosure is known as the ambient temperature; it is generally expressed in degree Celsius (ºC). Temperature at a given site depends on wind as well as local factors such as shading, presence of water body, sunny condition, etc. When the wind speed is low, local factors strongly influence on temperature of air close to the ground. With higher wind speeds, the temperature of the incoming air is less affected by local factors. The effect of various factors on the ambient temperature is shown in Fig.2.2. A simple thermometer kept in a Stevenson's screen can measure ambient temperature.

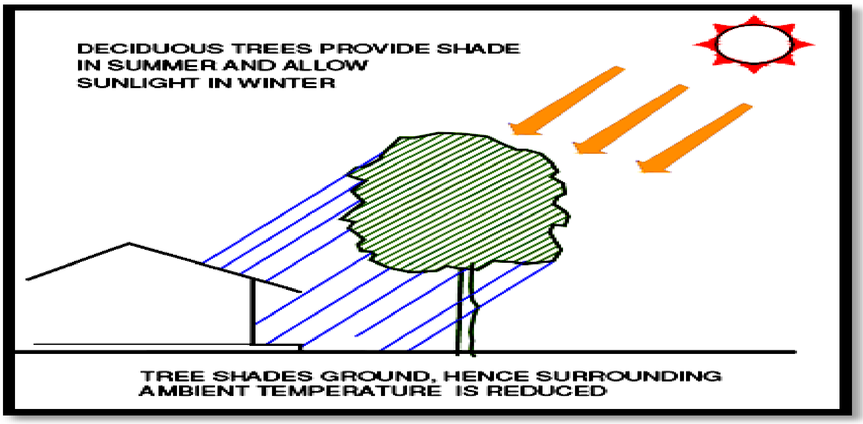

Fig. 2.2(a) Factors affecting ambient temperature "effect of shading"

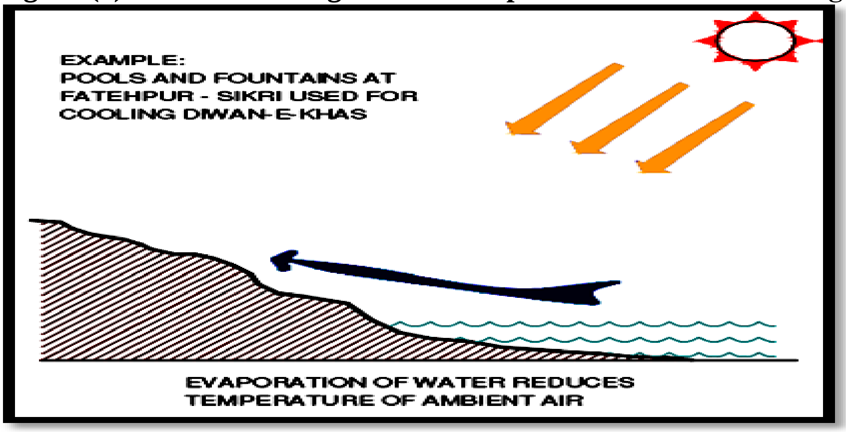

Fig. 2.2 (b) Factors affecting ambient temperature "effect of water body"

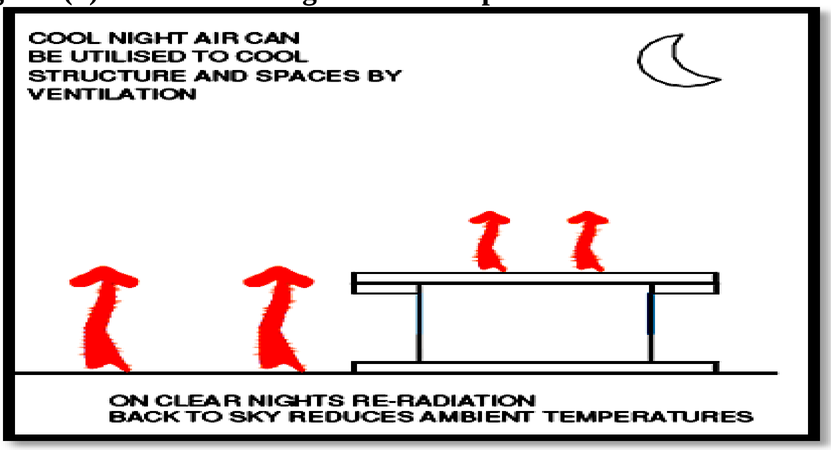

Fig. 2.2(c) Factors affecting ambient temperature "effect of sky condition"

(C) Air humidity

Air humidity, which represents the amount of moisture present in the air, is usually expressed in terms of 'relative humidity'. Relative humidity is defined as the ratio of the mass of water vapour in a certain volume of moist air at a given temperature, to the mass of water vapour in the same volume of saturated air at the same temperature; it is normally expressed as a percentage. It varies considerably, tending to be the highest close to dawn when the air temperature is at its lowest, and decreasing as the air temperature rises. The decrease in the relative humidity towards midday tends to be the largest in summer. In areas with high humidity levels, the transmission of solar radiation is reduced because of atmospheric absorption and scattering. High humidity reduces evaporation of water and sweat. Consequently, high humidity accompanied by high ambient temperature causes a lot of discomfort. The effects of various combinations of humidity and ambient temperature are presented in Fig. 2.3.

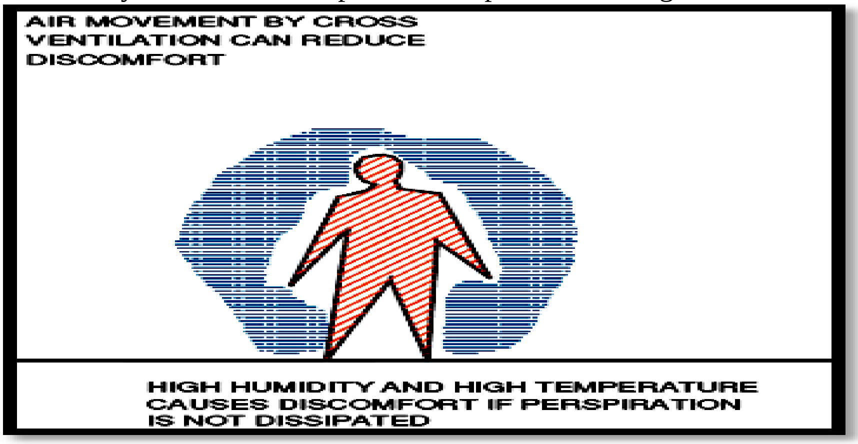

Fig. 2.3 Effects of air humidity **(a) "effect of high temperature & humidity"**

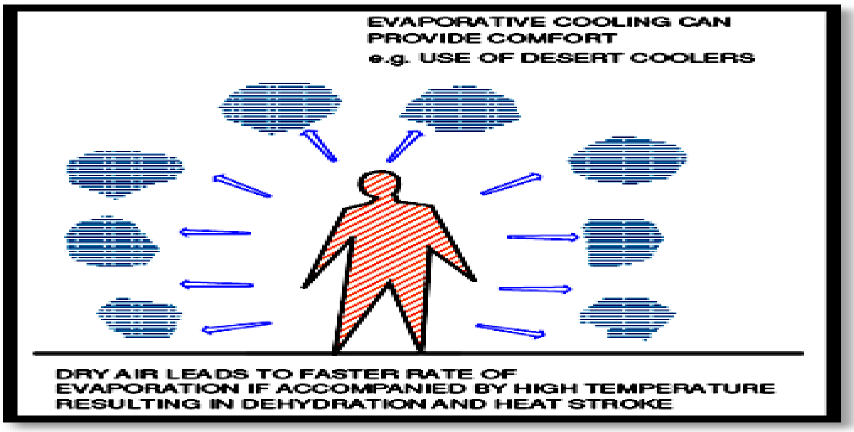

Fig. 2.3 Effects of air humidity (b) "effect of high temperature & low humidity"

(D) Precipitation

Precipitation includes water in all its forms rain, snow, hail or dew. It is usually measured in millimetres (mm) by using a rain gauge. The effects of precipitation on buildings are illustrated in Fig. 2.4.

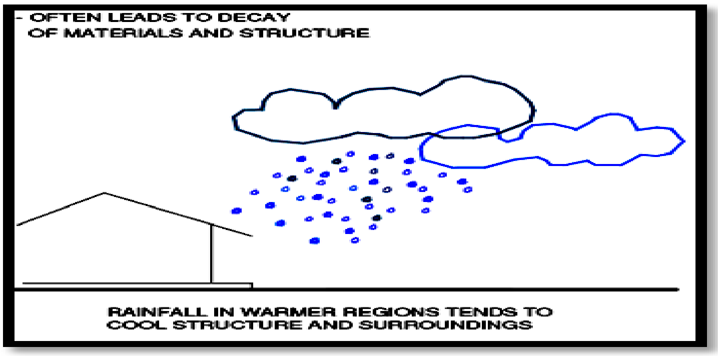

Fig. 2.4 Precipitation (a) "effect of rain fall"

(E) Wind

Wind is the movement of air due to a difference in atmospheric pressure, caused by differential heating of land and water mass on the earth's surface by solar radiation and rotation of earth. Wind speed can be measured by an anemometer and is usually expressed in meters per second (m/s). It is a major design consideration for architects because it affects indoor comfort conditions by influencing the convective heat exchanges of a building envelope, as well as causing air infiltration into the building (Fig. 2.5).

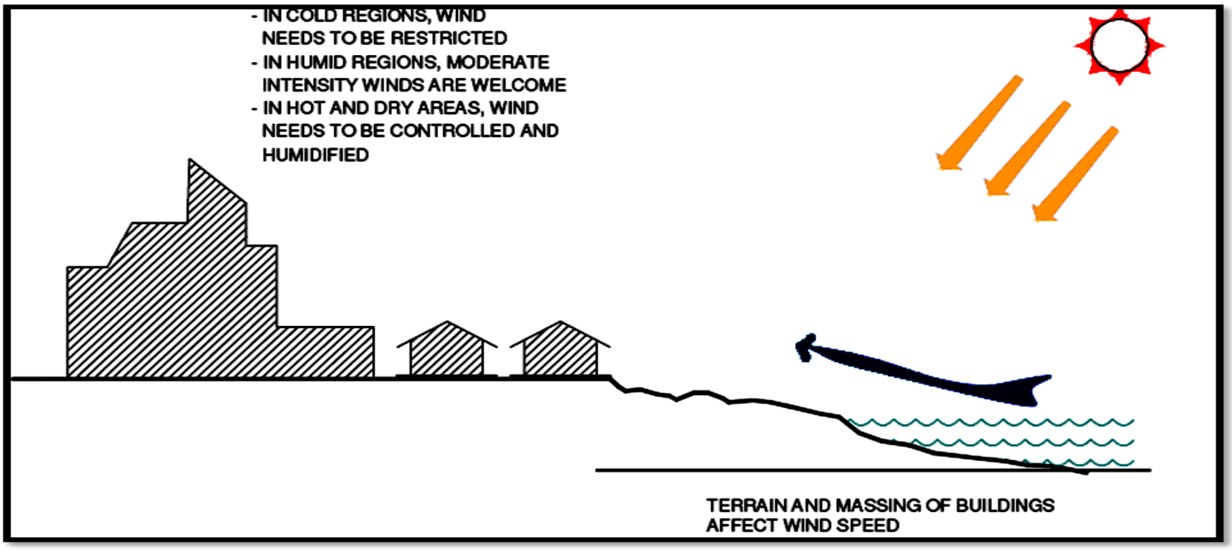

Fig.2.5 "Factors affecting wind"

(F) Sky condition

Sky condition generally refers to the extent of cloud cover in the sky or the duration of sunshine. Under clear sky conditions, the intensity of solar radiation increases; whereas it reduces in monsoon due to cloud cover. The re-radiation losses from the external surfaces of buildings increase when facing clear skies than covered skies. This is illustrated in Fig. 2.6. The measurement of sky cover is expressed in oktas. For example, 3 oktas means that 3/8th of the visible sky is covered by clouds.

4. A case study of Dhule city

4.1 History of Dhule city

Until the beginning of the 19th century, Dhule was an insignificant village, subordinate to Laling, the capital of the Laling or Fatehabad Subdivision. Under the rule of the Nizam, Laling was incorporated with the District of Daulatabad. The town passed successively through the hands of the Arab kings, the Mughals, and the Nizam, and into the power of the Peshwas about 1795. In 1803, it was completely deserted by its inhabitants on account of the ravages of Holkar and the terrible famine of that year. In the following year, Balaji Balwant, a dependant of the Vinchurkar, to whom the parganas of Laling and Songir had been granted by the Peshwa, repeopled the town, and received from the Vinchurkar, in return for his services, a grant of inam land and other privileges. He was subsequently entrusted with the entire management of the territory of Songir and Laling, and fixed his headquarters at Dhule, where he continued to exercise authority till the occupation of the country by the British in 1818. Dhule was immediately chosen as the headquarters of the newly formed District of Khandesh by Captain John Briggs. In January 1819, he obtained sanction for building public offices for the transaction of revenue and judicial business. Artificers were brought from distant places, and the buildings were erected at a total cost of £2700. Every encouragement was offered to traders and others to settle in the new town. Building sites were granted rent free in perpetuity, and advances were made both to the old inhabitants and strangers to enable them to erect substantial houses. At this time, Captain Briggs described Dhule as a small town, surrounded by garden cultivation, and shut in between an irrigation channel and the river. The town was located on the southern bank of the Panzara River with an area of about one square mile. In 1819, the population numbered only 2509 persons, living in 401 houses. In 1863, there were 10,000 inhabitants; while by 1872 the number had further increased to 12,489, with 2620 houses. From the date of its occupation by the British, the progress of Dhule had been steady. Towards the end of 19th century the town had already become significant trading centre due to the trade in cotton and linseed. Coarse cotton, woolen cloths and turbans were manufactured for local use around this time. In 1872, Dhule was visited by a severe flood, which did much damage to houses and property.

Dhule was a cantonment town, and in year 1881 had 2 hospitals, telegraph and post offices. In 1873-74 there were 4 Government schools, with 551 pupils. Historically, the town has been divided into New and Old Dhule. In the latter, the houses were irregularly built, the majority being of a very humble description.

4.2 Present situation of Dhule city

Dhule is district place , in last decade Dhule city has been converted into carporation from nagarpalika, in past the district was tribal district, Dhule city is easily connect by rural area, average rainfall of Dhule city is 465 mm ,average summer temperature is 44 degree siliceous and average winter temperature is 20 degree siliceous. Winter and rainy season is bearable for Dhule people but, summer is very uncomfortable for Dhule peoples, sun heating start from morning nine o'clock, its maximum in between 12 to 4 pm & lower down from 5pm, it quite difficult & dangerous to move on streets in between 12 pm to 6 pm in Dhule city , there are many chances attack of sunstroke on children's and elder peoples, many people's are taking care about sunstroke and avoid to move on in between 12 pm to 5 pm ,there are no huge water bodies surrounding to Dhule city & day by day vegetation& precipitation is going to decrease in Dhule city, the ground water recharging is also low due insufficient precipitation , all these points are responsible to increase the summer temperature of Dhule city , the day heating also heats the houses & the heat mass store in housing materials release in evening and the peoples suffering from green house effect up to middle night in addition urban poor people facing hosing & electricity problems and now days the situation going to become worst in Maharashtra energy is comes under the basic need, near @ 6 hour minimum load shading is district level of Maharashtra & recently the electricity charges are also beyond the limits of urban & rural poor people, the load shading is another factor which increase thermal discomfort in urban area, higher class and upper middle class people has invertors and generators at their home ,they runs fans ,coolers & air conditioners at their home will get relief from summer heat , housing condition & material of higher class and upper middle class people are quite good they can survive better in their home in summer , but it's quite difficult & dangerous for urban poor people(case study of Dhule city) to survive comfortably at their home in summer because of fallowing reasons.

a) They have insufficient volume of their home.
b) Lack of surface area at their home.
c) Insufficient height of rooms.
d) Lack ventilation and air circulation.
e) Lack of open spaces around the homes.
f) Lack of shadow trees & vegetation around home.
g) Thickness of roofing material.

Due to above all the technical faults in the urban poor area (case study of Dhule city), the urban poor people's have been suffering from lots of health's problems e.g. asthmatic problems, lungs deceases,

respiratory system deceases & again due to thermal discomfort they are suffering from heat strokes especially children's & elder peoples at their home itself .
For this project work it was decided to conduct the house to house construction survey of economically weaker area of Dhule city survey of around 50 house of Deopur area (part of Dhule city) was conducted in month march and temperature was measured & construction details also taken.
Following are common construction and other faults were found out at the time of survey.
a) Room height was 2.4 m to 2.7 m maximum.
b) Window area was insufficient.
c) There were no ventilators or very less.
d) Roofing material were G.I sheets.
e) Some houses were non plastered.
f) In some cases rear & side margins were absent.
g) There was no cross or through ventilation concept.
h) Kerosene & wood fuel was used for cooking.
i) Volume of furniture was near @ 40 % max as compare to volume of room.
j) Absence of shadow trees & greenery around the houses.
k) Windows without weather shades or insufficient width of weather shades.
All these common construction and other faults are responsible for indoor air pollution & thermal discomfort for the users, indoor air pollution is the silent killer for the users & the thermal discomfort in case of summer will responsible for heat stroke. So it very important to think over these two points.

4.3 Techniques of thermal comfort for urban poor's

Food, shelter, and clothing these are basic need of every human being, all these basic needs of human being are fulfilled by civil engineering, today there is big shortage in urban housing, day by day rural peoples are migrating toward urban areas, these things putting extra load on urban areas e.g huge shortage of land, shortage of power, water supply etc, but shelter is important need for survival every human being in urban area. Housing prices are beyond limits of lower income group people .They do not have to buy piece of land in this situation or to make sound construction for their permanent shelters. The next paragraph has some lines about housing from view of architect "lauri baker"

"A small house of his own to live in is the cherished dream of the little man in our country, whether he is a daily laborer, a small farmer, a low paid employee in Government or other service or a pretty merchant. More often his dream remains unfulfilled. This is mainly because of the high cost of house building. What contributes to this high cost is not only the high cost of materials and the high rates of wages prevailing especially in our State; It is also because of the insane craze for the so called 'new fashions' in house building which the large majority of our engineers are advocating and persuading their clientele to adopt. Very often the poor house holder is at the mercy of the 'all knowing' engineer and he cannot or dare not have his way as to what sort of house he really wants. The result is that houses are built with lavish use of steel and cement and painted all over in garish colours. It is hardly fit, to live in, because it is hot as an oven, during summer. And for this contraption the poor man has to spend his whole fortune. Such is the picture of the house - building activity in our State at the present time. People have begun to realize the folly of the whole thing and are seeking ways and means of building houses of reasonably good quality and capable of fulfilling their real needs."

Indian government has tried different schemes for urban housing, but all these schemes are not sufficient poor people's living in urban area. Due to shortage of land& high prices of land & construction materials, urban poor people are living in the very unhealthy situation , they are compromising in the land ,material quality and quantity all these compromising points are responsible for their life .They are living in the area and its volume is too less as required , if we see every one's life span minimum 75 % life span of human being is spend in buildings itself 50 % in residential buildings & 25 % in public building and others types of buildings, in which residence is very important ,because all mankind are spend minimum

50 % of his or her life span in residential building , as I saw when the surveys of urban poor's houses were conducted in Dhule city the many construction and other faults were describe in this chapter in heading 5.1, as we see the basic needs of human beings which are fulfilled by civil engineering and being civil engineer it's my duty to give my knowledge benefit to my society that's why I choose this area for my social civil work . Due to housing area & volume deficiency many of urban peoples are suffering many deceases related to their health; in this chapter we see that indoor air pollution & heat strokes are the main cause to the health, these would be keep in control by some cost efficient thermal comfort techniques suggested by me, after of study different literatures.

As we see urban lower income group people are not have sufficient money to construct their homes, they always try to curtail the cost of their home, by using cost-effective materials, but they do not use cost effective home construction techniques this will be the main risk at their home .I have suggested some minor changes for their houses, these will provide better natural light , ventilation & thermal comfort at their premises, all these techniques are following which would be beneficial to them in present & future constructions.

(A) Thermal comfort technique no.1 "for urban poor's housing"

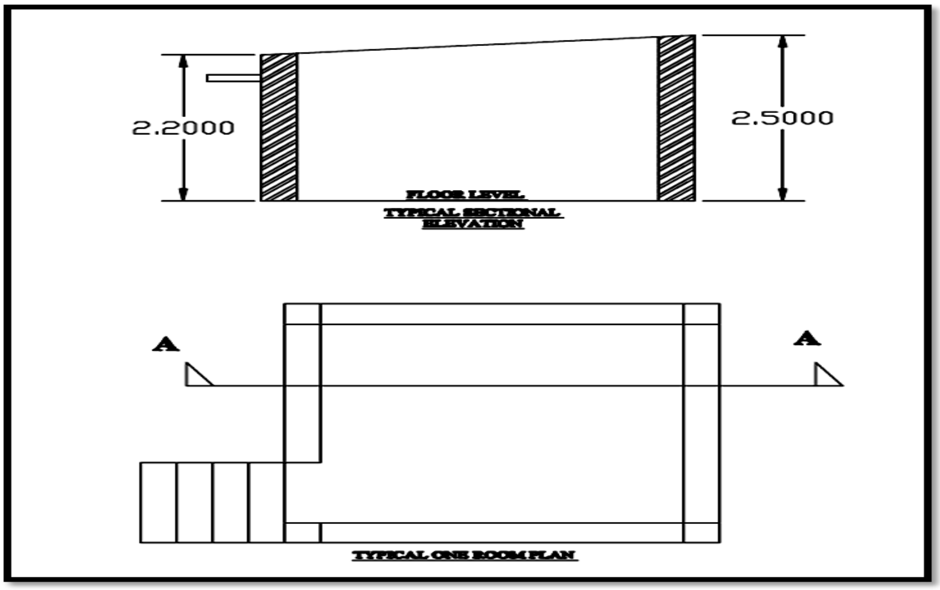

Fig 5.1 "typical one room plan of urban poor's house"

Figure no 5.1 shows one room plan & its sectional elevation which would be consider for urban poor's hosing thermal comfort techniques for this project work, it found that many time they have only one room area that's why minimum one room is consider for this work ,which used for all purposes (drawing/bed/kitchen etc),the structure is consider as load bearing structure, the building material is consider for this room majority bricks for super structures (walls),foundation stepped wall foundation in U.C.R ,roof G.I sheets, door flush door with R.C.C frame work single coat internal & external plaster. Figure no 5.2 shows the slightly change in figure 5.1 which would give thermal comfort by increasing the height of the roof at entry end 3.0 m & at other end 3.5m, which is 2.2m at entry & 2.5m at other end in figure no 5.1, which is common practice of urban poor people, to save the cost of wall constructions, but in case of figure 5.2 slightly increase of room height without any change in another components, which will give better thermal comfort as compare to figure 5.1.

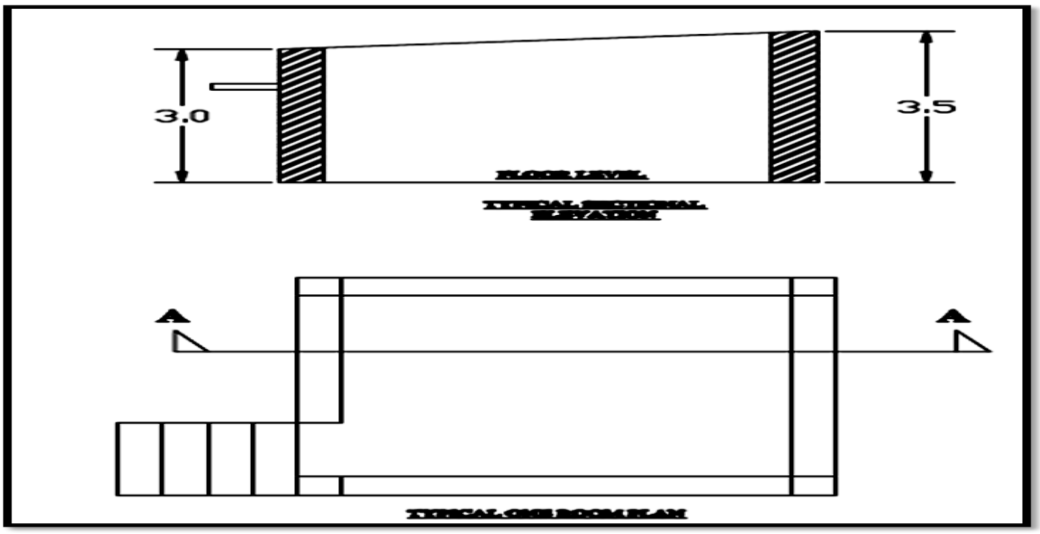

Fig 5.2 "height modification in figure 5.1"

(B) Thermal comfort technique no. 2 "for urban poor's housing"

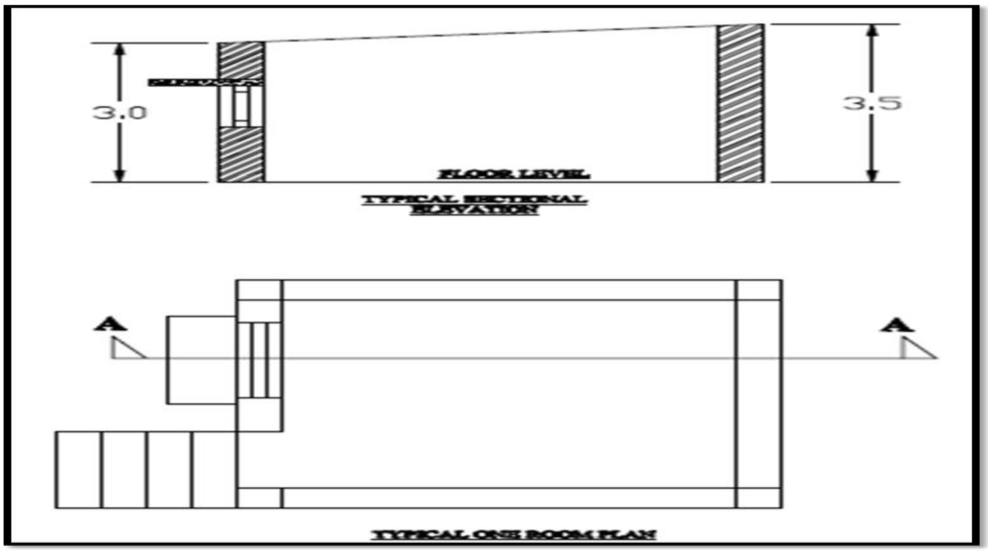

Fig 5.3 "window modification in figure 5.2"

Generally many urban people try to avoid window for their houses, they add cement grill normal .045 m x 0.3 m for replacement of window because to save the cost of steel grills & window frames and shutters, but adding window of size say 1.5m x 1.2 m, will gives addition ventilation and light as compare to figure 5.2 due to this it will better thermal comfort as compare to figure 5.2.

(C) Thermal comfort technique no. 3 "for urban poor's housing"

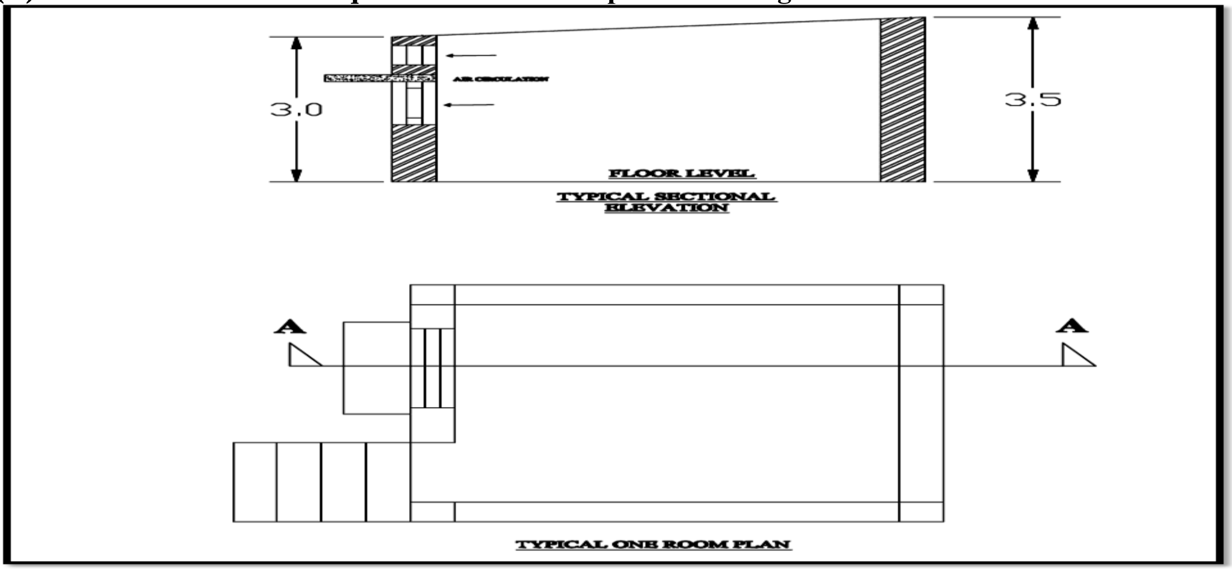

Fig 5.4 "one ventilator modification in figure 5.3"

In figure 5.3 after addition of one window size 1.5m x 1.2m will gives better light ventilation & thermal comfort than figure 5.2, but adding one ventilator of size (0.45 m x 0.3m) slightly below the roof level will provide escape of warm air which tries to accommodate at roof bottom which will gives better thermal comfort than the figure no 5.3.

(D) Thermal comfort technique no. 4 "for urban poor's housing"

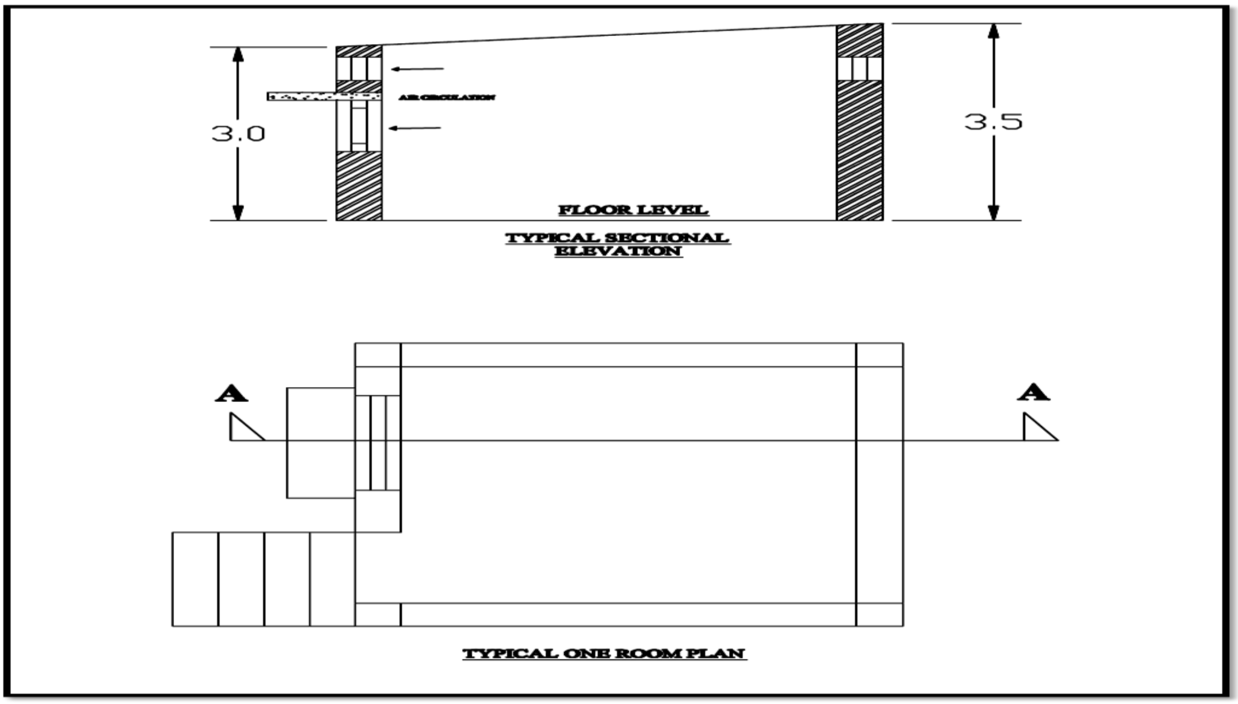

Fig 5.5 "Two ventilators & one window"

Two ventilators of size (0.45m x 0.3m) will give two escape for war air which the another better solution than the previous one.

(D) Thermal comfort technique no. 5 "for urban poor's housing"

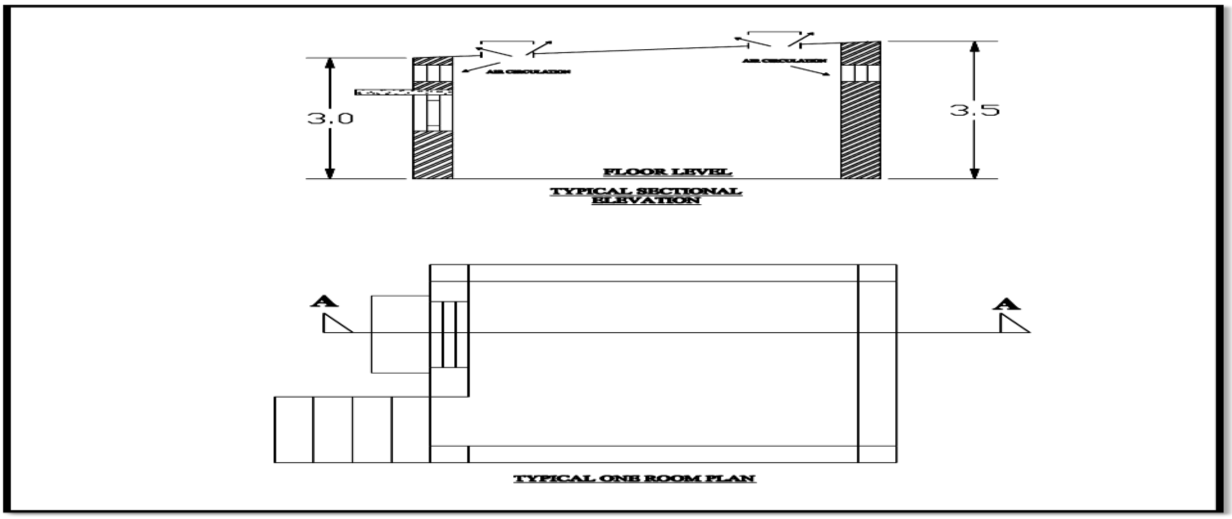

Fig 5.6"one window, two ventilators & roof dormers"

One window of size 1.5 m x 1.2 m, two ventilators slightly below the roof level & additional two dormers' at roof surface will continuously moves the wind from all surfaces is the better solution than the previous all.

(E) Thermal comfort technique no. 6 "for urban poor's housing"

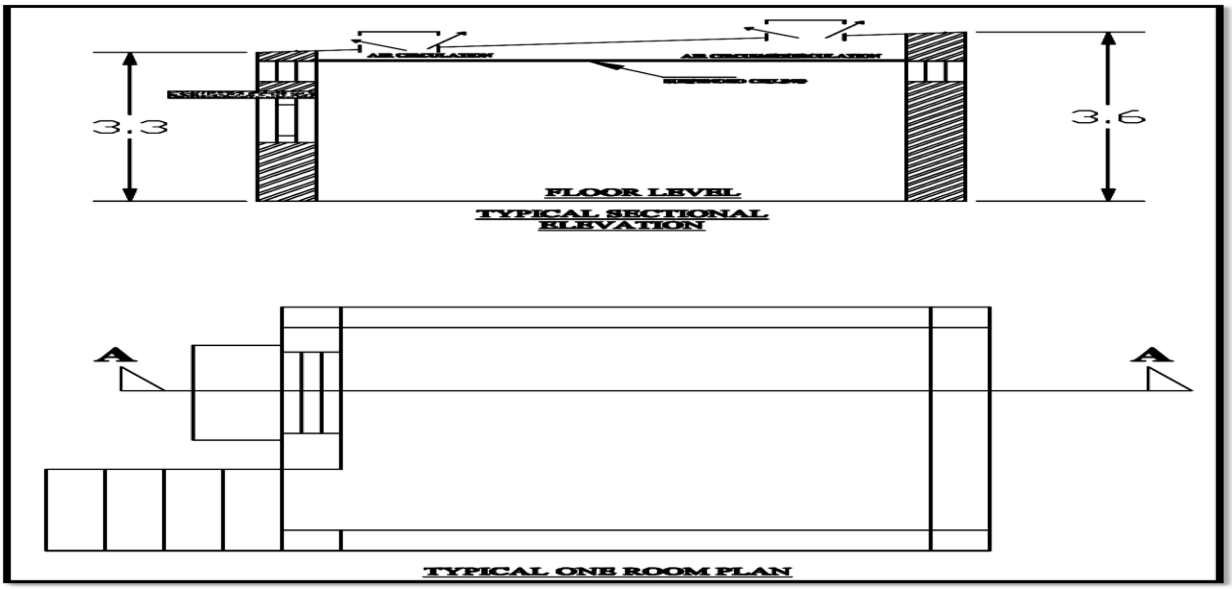

Fig 5.7"one window, two ventilators, roof dormers & suspended ceiling"

Figure no 5.6 is slightly different than figure 5.5 additional suspended ceiling will reduce tepentrature inside the room, cost effective materials like thermo coal sheets, jute lime sheets will be used as suspended ceiling.

(F) Thermal comfort technique no. 7(a) "for urban poor's housing"

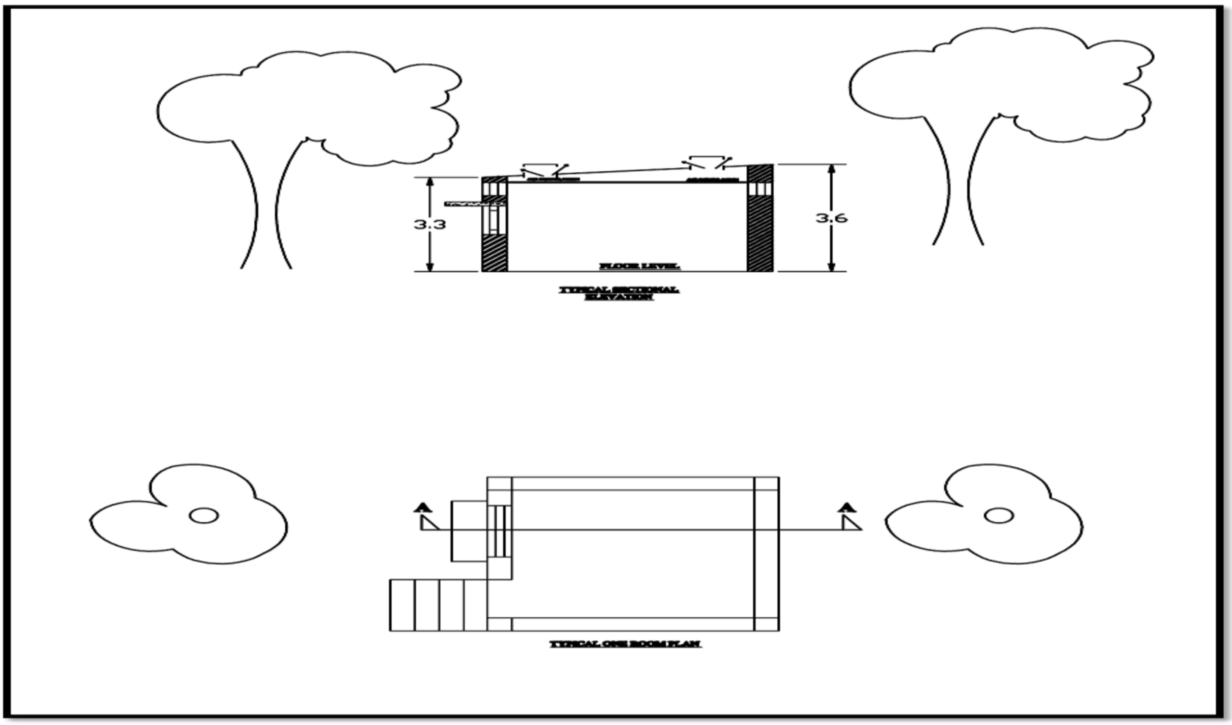

Fig 5.8 - a "shadow trees protect homes from heat"

In addition to thermal comfort techniques A to E, shadow trees protect the homes from excessive heat gain .if the home is of row house type ,it's possible to grow shadow tress on two sides only ,i.e front and rear only.

Thermal comfort technique no. 7 (b) "for urban poor's housing"

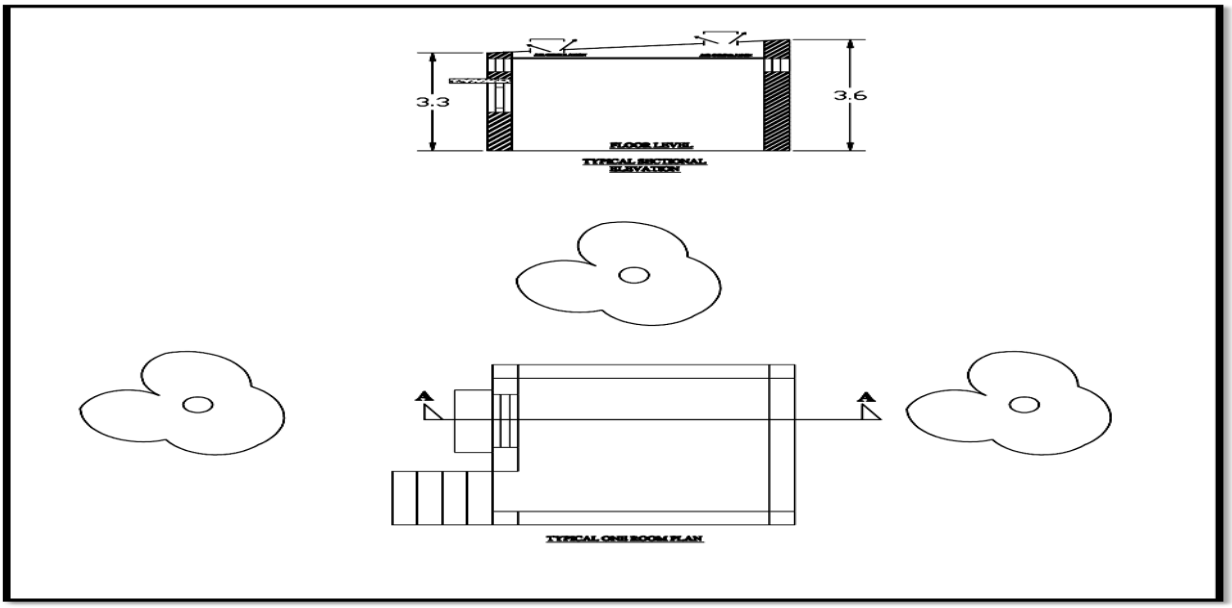

Fig 5.8 - b "shadow trees protect homes from heat"

In addition to thermal comfort techniques A to E, shadow trees protect the homes from excessive heat gain .if the home is of semi detach type ,it's possible to grow shadow tress on three sides only ,i.e. front ,rear & one side only. This will protect the side walls & roof from excessive heat gain.

Thermal comfort technique no. 7 (c) "for urban poor's housing"

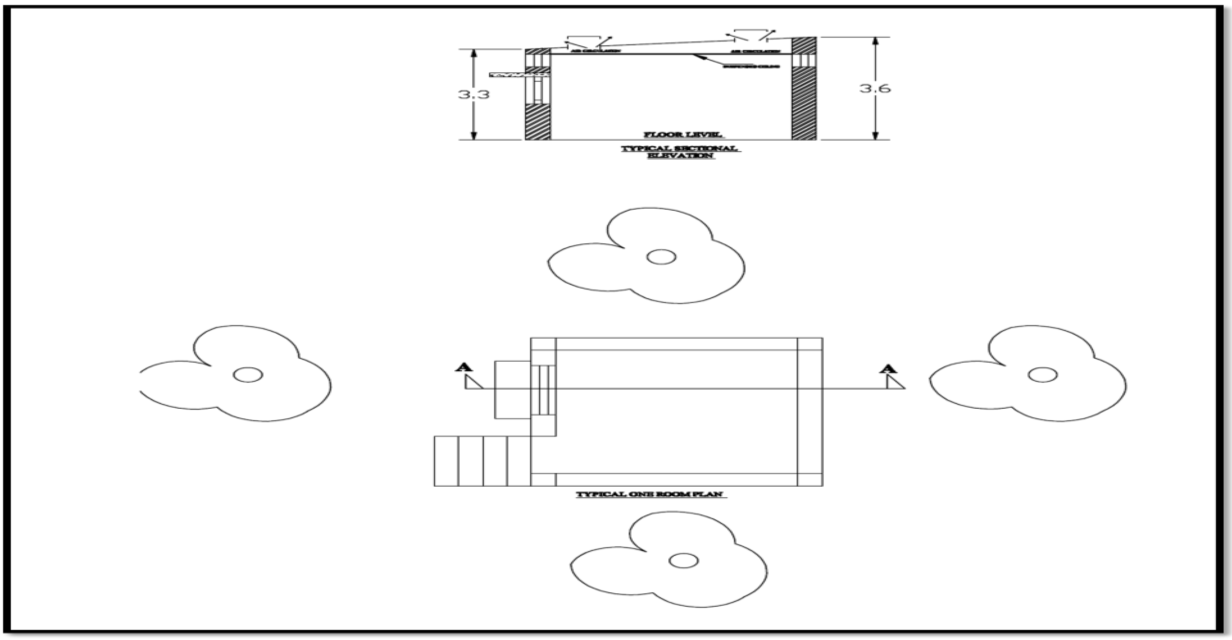

Fig 5.8- c "shadow trees protect homes from heat"

In addition to thermal comfort techniques A to E, shadow trees protect the homes from excessive heat gain .if the home is of fully detach type, it's possible to grow shadow tress on four side, i.e. front, rear & two sides only. This will protect the side walls & roof from excessive heat gain.

5. Conclusions

Population in rural & urban areas of the developing countries like India do not have condition to provide artificial systems of cooling or heating & along with this there is shortage of electricity. The buildings located, especially in hot-dry climate, are provided with natural cooling systems. Parameters which influence natural cooling of such buildings can be classified as (i) surrounding environmental factors and (ii) parameters associated with the buildings.

It is known to everyone, that urban lower income group peoples are not have sufficient money to construct their homes, they always try to curtail the cost of their home, by using cost-effective materials, but they do not use cost effective home construction techniques this will be the main risk at their home .

It is seen that, every one's life span minimum 75 % life span of human being is spend in buildings itself 50 % in residential buildings & 25 % in public building and others types of buildings, in which residence is very important ,because all mankind are spend minimum 50 % of his or her life span in residential building. But, due to housing area & volume deficiency many of urban peoples are suffering many deceases related to their health; i.e. indoor air pollution & heat strokes are the main cause to the health, these would be keep in control by some cost efficient thermal comfort techniques suggested by in chapter 5.0 , after of study different literatures.

Dhule city comes under hot and dry climate; the thermal comfort techniques suggested in chapter 5.0 would be helpful for construction of urban housing with use of cost efficient housing materials.

All these techniques are suggested after detail construction survey of urban poor's housing , it was found that in side temperature was not only depend on the construction material of houses ,but it is also depend on surrounding environmental factors of the particular houses , i.e many houses were row housing types ,the all middle house of similar roofing materials and construction details has found minimum temperatures as compares to the last end house , because the middle house were three side (roof ,front & rear wall) exposed to sunrays & end houses are four sides (roof, front, one side & rear wall) were exposed to direct sunrays .Some houses were of fully detached type ,their inside temperature was high as compare to row house and semidetached type of houses because in fully detached type of housing all five sides were exposed to direct sunrays. In some cases house were surrounded by shadow trees their temperature were found low as compare to above all type of houses, because shadow trees protects the houses from direct heat gain. As surveying of different houses and their surrounding conditions A to E construction techniques are suggested in chapter five in which some literatures from books are also studied to decide these techniques. Some houses were found maximum inside temperature 42 degree Celsius & minimum of 34 degree Celsius. Houses those have inside temperature 42 degree Celsius and more were at most of high risk of sunstroke for children's & elder peoples inside it. All these techniques suggested will helpful for planning and construction of urban poor's housing in hot and dry climate.

6. Future scope & limitations of the work

In this project report , developed thermal comfort techniques for urban poor's housing are consider on the basis of hot and dry climate only ,these would no used in other climatic zones , there is scope of development of another techniques for different climatic zones rather than hot and dry climate.

7. Acknowledgment

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