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Solar Passive Features of Himurja Office Building at Shimla

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Abstract- The Solar Passive HIMURJA building is one of the excellent solar passive designed buildings in India. It has been integrated with a number of Solar Passive features like Thermosyphoning Air Heating Panels, Sun Spaces, double glazed windows on the southern facade. It has an air lock lobby at the entrance; the northern wall and the roof are insulated with 40 mm thick glass wool and have no windows on this side. The monitoring results show that these solar passive features are keeping the indoors comfortable throughout the winters.

Keywords- HIMURJA Building, Thermal Comfort, Solar Passive, U value (Thermal Transmittance).

I. INTRODUCTION

The HIMURJA building is located in SDA Complex, Kasumpti, Shimla. Shimla is the capital city of western Himalayas State of Himachal Pradesh. The site of the building is located at an altitude of 2012 meters above mean sea level. The coordinates of the site are latitude 31.10 N, longitude 77.06 E. The layout and location plan of the building is given in Fig. 2. The longer axis of the building is facing the east west direction, providing a full solar exposure to the southern facade of the building. The narrow eastern part of the building is adjoining to HPSEB building. The small western facade of the building is providing entrance.

The results of the studies carried out by the HIMCOSTE in aforementioned buildings show that these buildings don't require any auxiliary heating during winters. These buildings are an example of optimum utilization of Solar Energy for attaining a level of indoor thermal comfort without depending on auxiliary sources of energy.

The building under present study is HIMURJA Office building. The building has proper orientation for full exposure to the Sun; it has sunspaces, thermosy phoning air heating panels, solar water heating, double glazed windows. The building has been monitored by the HIMCOSTE on number of occasions.

The results of monitoring of the building conducted by HIMCOSTE in January, 2001 shows that the indoor temperatures are varying between 18^{o}C – 28^{o}C while the outdoor temperature is varying between 9^{o}C-15^{o}C [1].

The solar passive housing technology makes use of walls, windows, roofs, and other components to collect, store and distribute the solar heat which ultimately reduce the dependency on auxiliary sources of space heating. Solar passive buildings generally have massive walls, northern walls, roofs are insulated, and fenestrations are natural which allow heat gain and loss. Such buildings have high thermal mass, adequately shaded, coupled with ground and compact in shape [2].

The amount of energy being consumed in buildings for attaining a level of thermal comfort needs to be controlled in view of global energy crisis. The buildings world over consume more than 48% of the total energy. In India, the 73% of the total 48% is utilized in residential buildings for space heating / cooling for providing comfortable indoors [3].

The present paper undertakes an analysis of Solar Passive Designed HIMURJA building. This building is considered as one of the best Solar Passive Buildings in India. Most of the principles of solar passive house designs, passive systems, and other strategies for house design have been incorporated in this

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building. The present paper is expected to provide an impetus to sustainable building design approach and energy efficient housing.

1. Energy saving strategies:

Table 1. Building Characteristics [4].

Parameters	Building characteristics/ specification/ solar passive features
Type of Building	Office Building
Name of Owner	HIMURJA (State Energy Development Agency)
Address	SDA Complex, Kasumpti, Shimla - 171009
Altitude	2012 Meters (absl)
Climate	Cold and Cloudy
Outer Walls	9 inches brick walls with black slate outer covers, 40 mm glass wool insulation on North Wall
Interior partition Walls	Wooden Partition
Windows	Double glazed windows with 10 mm air gap, 4mm Glass
Doors	Airlock lobbies at the entrance, wooden interior doors
Roof Type	Concrete slab roof with 40 mm glass wool insulation
Floor height	Ceiling at a level of 10 Feet
Sky lighting	Sky light on roof of top floor
Orientation	Longer Axis of the building is in East – West direction providing full solar exposure to the Southern facade of the building.
Window Size	Solariums on South side, 12 Thermosyphoning Air heating panels, No windows on northern wall.
Flooring	Wooden Flooring
Vegetation	The building is located in SDA Complex, no nearby trees
Veranda	Road in front of South and North facade of the building
Snowfall	1Feet to 1.5 Feet of average annual snowfall during January to February
Monitoring Period	Between January – February 2019

2. Solariums (Sun Spaces):

the balconies, on the southern facade, have been included in the room space by converting them into solariums. Such solariums act as winter gardens and heat collectors for the rooms. These are helpful in enhancing views, increasing comfort and livening up of the main facade [5]

3. Double Glazing:

Double Glazing openable panels with tight fitting are incorporated air circulation and infiltration control. Double glazing helps in reducing the heat loss as the reflected radiation are trapped by double glasses to a greater extent.

4. Thermosyphoning Air Heating Panels (TAPs):

TAPs have been installed on the southern facade of the building along with the walls. Such TAPs provide heat gain through convective heat current loops. Solariums on South side have been provided along with 12 Thermosyphoning Air heating panels, No windows on northern wall to avoid heat losses.

5. Air lock lobbies:

Airlock lobbies have been provided at the entrance to avoid the heat losses through frequent door openings. Wooden interior doors have been provided in all floors as the U value (thermal transmittance) of wood is much less in comparison to steel or other door materials.

6. Insulated Roof:

Concrete slab roof with 40 mm glass wool insulation has been provided to deny the heat losses through roof. Besides, the north walls are insulated with glass wool. The height of the floor is 10 feet as the compact rooms sizes are best for energy conservation.

7. Orientation:

Longer Axis of the building is in East – West direction providing full solar exposure to the Southern facade of the building.

II. THERMAL PERFORMANCE EVALUATION OF HIMURJA BUILDING

The aforementioned solar passive features are responsible for providing a level of indoor thermal comfort even in extreme winter conditions. The monitoring of the HIMURJA building has been carried out by the author during winter months of

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January, February, 2020. The indoor temperature was found to be little more than the thermal comfort temperatures. It was found that the indoors temperatures of HIMURJA building were found to be in conformity with all indoor thermal comfort models. The building is providing indoor thermal comfort throughout the winters without any auxiliary heating [6].

A similar study conducted on the same building by Himachal Pradesh Council for Science, Technology & Environment (HIMCOSTE) corroborate the results of the author wherein the indoor temperatures is varying between 18°C to 28°C when the outdoor temperature is varying between 9°C to 15°C .

The building has been monitored w.e.f. January, 2020 to February, 2020 for a period of two winter months and the results has been compared with modern buildings monitored in District Shimla and District Kinnaur.

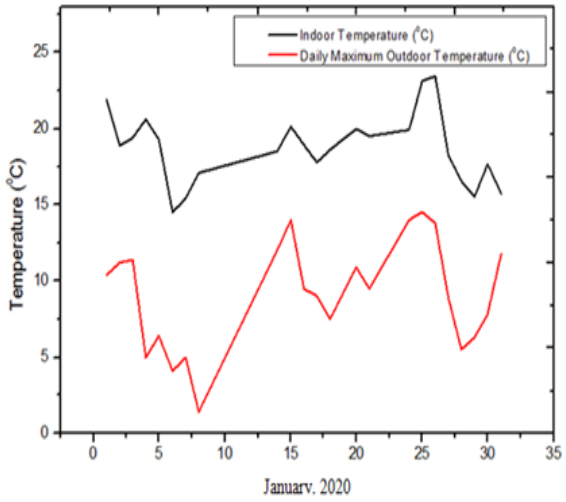

Fig 1. Plot between indoor temperature and outdoor temperature for HIMURJA Building, January, 2020.

The indoor temperature remains around 10°C higher than the outdoor temperature during entire monitoring period without any auxiliary heating. These indoor temperatures are even higher than the comfort temperatures as calculated using Humphreys, 1978 equation for thermal comfort. The indoor comfort temperatures for HIMURJA building have been calculated using the equation;

$$T_c = 12.1 + 0.53\ T_o\ [7]$$

Where T_c is the comfort temperature and T_o is the outdoor temperature.

Table 2. Daily Indoor, outdoor and comfort temperatures for HIMURJA Office Building, Shimla – January, 2020.

Date	Avg. Indoor temp (°C)	R. Humidity (%)	Daily Maximum Outdoor Temp (°C)	Indoor thermal comfort temperature T_c (°C)
1-1-2020	21.9	27.0	10.4	17.6
2-1-2020	18.9	30.0	11.2	18.0
3-1-2020	19.4	30.0	11.4	18.1
4-1-2020	20.6	33.5	5.0	14.8
5-1-2020	19.3	32.4	6.4	15.5
6-1-2020	14.5	40.0	4.1	14.3
7-1-2020	15.4	44.7	5.0	14.8
8-1-2020	17.1	34.0	1.4	12.8
14-1-2020	18.5	39.5	12.0	18.5
15-1-2020	20.2	35.0	14.0	19.5
16-1-2020	19.0	37.5	9.5	17.1
17-1-2020	17.8	38.5	9.0	16.9
18-1-2020	18.6	36.0	7.5	16.1
20-1-2020	20.0	31.5	10.9	17.9
21-1-2020	19.5	34.0	9.5	17.1
24-1-2020	19.9	26.5	14.0	19.5
25-1-2020	23.1	27.7	14.5	19.8
26-1-2020	23.4	29.3	13.8	19.4
27-1-2020	18.2	32.7	8.9	16.8
28-1-2020	16.6	37.4	5.5	15.0
29-1-2020	15.5	37.5	6.3	15.4
30-1-2020	17.7	35.7	7.8	16.2
31-1-2020	15.8	35.0	11.8	18.4
Average	18.7	34.1	9.1	16.9

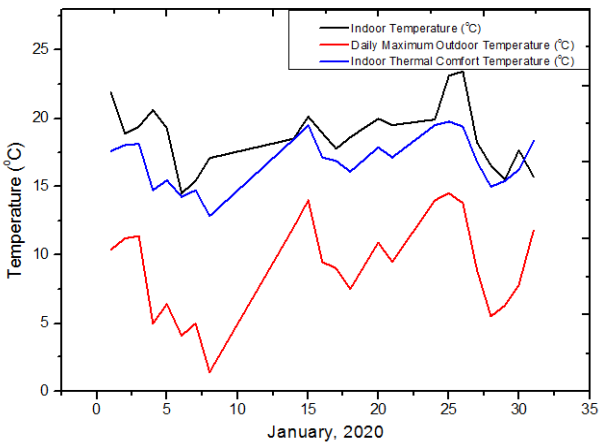

Fig 2. Plot between daily average indoor temperature, daily outdoor maximum temperature and daily thermal comfort temperatures for HIMURJA office building, January 2020.

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It is observed from the above graph that the indoor thermal comfort temperatures are easily achievable in the Solar Passive HIMURJA office building without any external/ artificial source of heating. The average indoor thermal comfort temperatures are around 18°C and the indoor room temperatures are around 20°C throughout the monitoring period.

Such temperatures are providing good indoor comfortable conditions for office work with full efficiency.

III. THERMAL PERFORMANCE OF MODERN CEMENT CONCRETE BUILDING, VILLAGE KHANOG, DISTRICT SHIMLA

Table 3. Building Characteristic – Modern House, Village Khanog, Distt. Shimla.

Parameters	Building characteristics/ specification
Type of Building	Modern Building
Address	Village Khanog, Distt. Shimla (60 Kms from Shimla)
Altitude	2250 Meters (absl)
Climate	Cold and Cloudy
Outer Walls	4.5 inches brick walls
Interior partition Walls	4.5 inches brick walls
Windows	Wooden with 4mm Glass
Doors	Wooden
Roof Type	CGI Sheet roofing (Over the lanter of top floor)
Floor height	Concrete Slab at level of 10 Feet
Orientation	Longer Axis of the building is making an approximate angle of 40° with North South Direction.
Window Size	Large as compared to modern house
Flooring	Cement concrete flooring
Vegetation	Deodar Trees nearby along with Apple orchards
Veranda	No Verandah, only balcony in front of rooms
Snowfall	2 to 3 Feet of annual snowfall during December to February
Monitoring Period	Between December 2018 – February 2019 for 36 days

The building has been monitored for indoor room temperatures for a period of about two months from December 2018 to February, 2019. The room under observation is a guest bedroom occasionally used for guests only. The building is located just in vicinity of the traditional building. The minimum temperature of -1.6°C was observed on 8th January, 2019 when the outdoor temperature is also below zero degrees (-1.2°C) at 9.00 AM.

The maximum temperature recorded on 13th February during monitoring period is that of 7.5°C at 3.00 PM when the outdoor temperature at the same time is 8.5°C. The temperature during most part of monitoring period lies around 1°C to 3°C. It is important to notice that the room is not in common use; the temperature of the room never rises or equals the outdoor temperature during entire monitoring period.

No heating appliances are used in the room. Residents live in adjoining rooms, where they make the indoors comfortable with the help of proper clothing and continuous use of heating appliances.

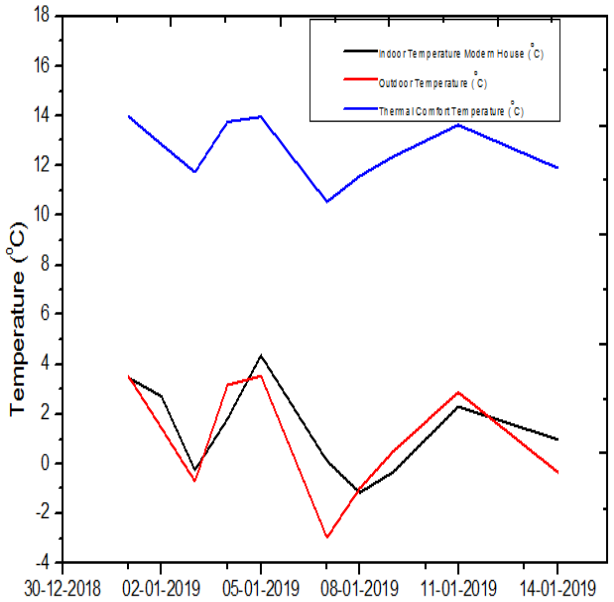

Fig 3. Comparative analysis of indoor temperatures in modern house and outdoor temperature for Khanog, Distt. Shimla.

As is evident from above graph the indoor room temperature of the modern house is somewhat similar to that of outdoor temperature throughout the monitoring period. When the outdoor temperature is below 0°C, the room temperature is also below freezing point. The walls of modern room are 9" thick constructed using bricks, cement concrete.

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The interior walls are 4.5" inch thick. Sunspaces are not included in the design, in place, balcony has been designed. No mechanism to trap the heat inside as it escapes through doors and windows in the absence of Sunspace. The Height of the roof is more than 10 feet, causing the air to get cold at floor level. Lot of energy is required to heat up the interiors. The wood is used only in doors and windows. It seems to be a tough task to store the heat inside as the transmittance (U) value of bricks and cement concrete is higher in comparison to mud and wood.

IV. CONCLUSION

The results of the HIMURJA office building at Shimla are encouraging where indoor thermal comfort level is being achieved easily without any auxiliary heating appliances even on extreme winter days. It can be easily attributed to all of the incorporated solar passive features like Sun spaces, Thermosyphoning air heating panels, double glazed windows, glass wool insulation in northern walls and roof. During entire monitoring period, the room temperature in HIMURJA building was around 20^{o}C, which is quite comfortable, in spite of large diurnal variations in the outdoor temperature.

The results of HIMURJA building show that the indoor temperature remains about 10^{o}C to 12^{o}C more than the outdoor temperature during entire monitoring period acknowledging the need for adoption of solar passive housing technology in high altitude cold climatic region of Himachal Pradesh

It has also been observed that modern RCC style constructions are also in wide use because of their flexible design options and, easy availability of construction material, long durability, and aesthetic features of modern houses. Such modern buildings have also been monitored in district Shimla.

The monitoring results of these modern building are not in conformity with indoor thermal comfort. The indoor temperatures in modern house, at monitored location in district Shiml, are 6^{o}C to 7^{o}C below than the indoor temperatures in traditional houses and much below than the HIMURJA office building. On discussion with the house owners, it was reported that such houses are climatically unsuitable and require design improvements.

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