Energy Efficient Passive Building: A Case Study of SODHA BERS COMPLEX

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Contents

Abstract

A composite climate case study has been carried out of a newly-constructed, passive-cooled, four-story building in Varanasi (UP), India. This four-story, passively-cooled building is known as SODHA BERS COMPLEX (SBC). In the design of the SBC building, most of the older cooling concepts such as orientation, cross ventilation, day lighting, unglazed Trombe walls, earth sheltering, wind towers etc. were considered. Additionally, a solar water heating system, a roof top PV system and a photovoltaic thermal greenhouse dryer have also been integrated, in order to meet the energy demand of buildings. The total initial embodied energy, CO_2 emission, annual energy saving and CO_2 credit of SBC have all been evaluated. Based on the present study, it has been seen that during harsh summers and cold climatic conditions, the earth sheltering/basement ($\cong$ 28°) and first and second floors ($\cong$ 18–20°) are the most comfortable zones from a passive cooling/heating point of view respectively. It has also been observed that there are approximately 4740 tons of earned CO_2 credit with (i) a payback period of 20 years, and (ii) one unit of energy saving of ₹ 3 for an average 10° temperature difference between the room and the ambient air temperature.

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Introduction

The depletion of fossil fuels and climate change needs to be addressed in every sector of life, including building design, which has been continuously increasing since the beginning of industrialization. It is important to mention that these two problems are tightly connected and need to be resolved as a holistic solution. In the United States, there is a 48% energy consumption in the building sector against a 29% energy consumption in the domestic sector in India (CEA 2009). The pattern of energy consumption in buildings is shown in Figure 1.1, which clearly shows that 59% of the energy is consumed in the cooling and heating of the building. Only 12% of energy is required for artificial lighting in India. Pacheco et al. [2012] and Stevanović [2013] have reviewed the work on passive heating/cooling mechanism of buildings which includes the orientation, ventilation, radiative cooling, shape, shade, glazing and phase change materials etc. Recently, Chen et al. [2015] have comprehensively reviewed the passive building design criteria by considering the building layout, envelope, thermo physics, building geometry, air-tightness and infiltration performance, and their effects on energy consumption. This shows the strong requirement to design passive cooled/heated buildings across the Indian continent, from fossil

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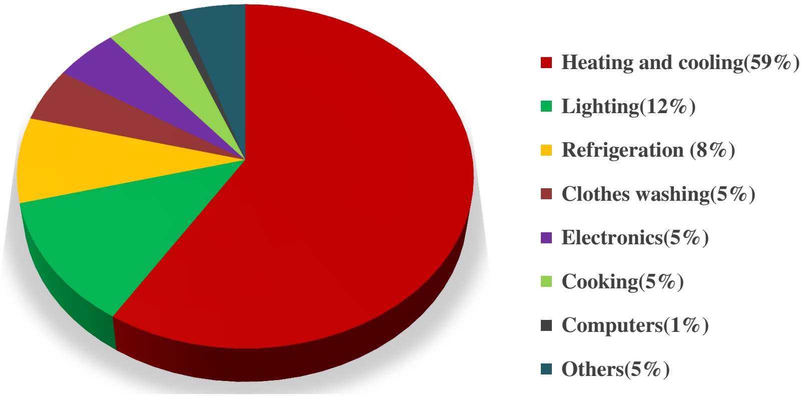

Figure 1.1: Pattern of energy consumption in a residential building (source: Department of energy)

fuel based energy conservation to sustain the climate. Furthermore, the passive design of a building from an energy conservation point of view mainly depends on local climatic condition.

Bansal and Minke [1988] have made an attempt to classify the Indian climatic condition based on a heating and cooling point of view and it is summarized in Table 1.1. However, the proposed classification can be valid globally. For example, the weather in many European countries including the UK, Ireland, Germany, France and Italy fall under the category of cold and cloudy like Srinagar and Jammu. Countries in the Middle East such as Saudi Arabia, Oman, Iran and Iraq, all have a hot and dry climatic condition. Here it is important to mention that the design and performance of buildings from a heating, lighting and cooling point of view will be different for each climatic condition.

From Table 1.1, one can see that the northern part of India, covering a maximum populated area, comes under a composite climatic condition with temperatures ranging between 2 °C and 50 °C. However, a harsh cold climatic condition is only present for a few days during December to January (approximately 30 days) and a warm condition is the norm for about seven months (April to October). Hence, there is a need to design passive buildings in northern India from a cooling

Table 1.1: Criteria for the classification of climatic condition based on monthly average climatic parameters, [Bansal and Minke, 1988].

Climate	Air Temperature in °C	Relative humidity (γ) in %	Precipitation (rain/snowfall) in mm	Number of clear day	Example
Hot and dry (HD)	>30	<55	<5	>20	Jodhpur; Jaipur
Warm and humid (WH)	>30	>55	>5	<20	Chennai; Mumbai
Moderate (MO)	25–30	<75	<5	<20	Bangalore
Cold and cloudy (CC)	<25	>55	>5	>20	Srinagar; Jammu
Cold and sunny (CS)	<25	<55	<5	>20	Leh; Ladah
Composite (CO)	This applies, when six months or more do not fall within any of the above categories				New Delhi; Varanasi

rather than a heating point of view to sustain the climate. As mentioned earlier, there are many passive cooling concepts available in the literature and some of them will be used in the present study by using locally available building materials and skilled manpower.

In the past, energy supply to the building sectors in India is mostly from coal-based power plants. Recently, the government of India is encouraging the use of solar energy in the heating and cooling of buildings by passive and active modes.

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