Implementation of Passive Solar Housing Technology in Western Himalayan State of Himachal Pradesh

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Abstract

Himachal Pradesh is the first state in India to take a political decision to make passive solar housing technology mandatory in governmental and semi-governmental sector. Following the decision, a number of residential, office, hospital and school buildings have been constructed. In order to provide technological backup, specialised training programmes were organised for architects, engineers of state housing agencies. In order to propagate the technology in cold regions of the state, carpenters and masons were trained in the construction of simple solar space heating systems like Trombe wall, attached green houses and solar thermo-siphoning heating panels using local materials. Retrofitting of rural houses was undertaken in Chamba, Kinnaur and Spiti region of the state. A massive campaign was launched in the state for creating awareness among the public, policy makers and planners about the benefits of this environmentally friendly technology. The monitoring of passive solar buildings shows that even simple interventions can lead to comfortable living conditions in winter besides saving 40 % to 60% of fuel wood, fossil fuels and electricity for space heating. The modification in the building byelaws to incorporate passive solar features has been carried out so as to make the technology initiative self-sustainable. This experience of passive solar building programme implementation in Himachal Pradesh is presented. The long term strategy for continuous research & development, capacity building and technical manpower development for the successful propagation of the passive solar technology, in the Himalayan states and Asian countries is outlined.

I. The Context

The State of Himachal Pradesh lies in the Western Himalayas and extends from snow covered mountains separating from Tibet in the North to plains of Punjab in the South and West. The State with a geographical area of 55673 sq km is located between latitudes 30° 22' 40" to 33° 12' 40" North and longitudes 75° 45' 55" to 79° 4' 20"East. The altitude ranges from 250 m to 6975 m above mean sea level. Due to peculiar topography and snowfall in high altitude regions, the state experiences severe winters. Areas above 2000 meters receive light to heavy snow fall whereas alpine zone remains under snow for 5-6 months in a year.

About 92% of the population of the state lives in villages and largely depend on fuel wood for space heating, water heating and cooking. About 4.82 million tons of fuel wood is used in the state annually for cooking, space heating, water heating, tarring of roads etc. out of which 4.5 million tons is used by the rural population. This requirement has resulted in large scale denudation of forests posing serious threat to the environment. Wood, charcoal, coal, kerosene, LPG and electricity are mainly used for cooking and space heating during winters. In tribal areas of the state, firewood, coal and kerosene are supplied on subsidy to public resulting in serious burden on Govt. exchequer.

In high altitude regions, Govt. buildings like offices, hospitals, require electric/ firewood/ fossil fuel based heating systems to create comfortable indoor conditions during winters. The installation and annual running costs of such heating systems are quite high. This cost can be considerably reduced if a building is designed incorporating passive solar features. Contrary to popular belief, 250-300 days of sunshine per year are available in Himachal Pradesh, with 7-8 mean hours sunshine per day, as such solar energy can effectively be utilized for space heating.

II. Activity -technology: Passive solar heating for cold regions

Passive solar Housing is a climate responsive architectural concept. The concept incorporates features like orientation of buildings, shading devices and uses appropriate building materials in order to conserve energy used in heating, cooling and interior lighting of buildings by utilizing sun energy. In cold climates, the strategy is to maximize heat gains from the sun, make provision for heat distribution, storage of solar energy within the building and minimize heat losses.

Solar building design strategy also includes day lighting strategy. The use of natural light is important in buildings which reduces electricity consumption. Govt sector is the biggest consumer of energy for space heating and day lighting in cold regions. The adoption of this technology not only creates comfortable living conditions but also results in savings of conventional fuels like fuel wood, coal, charcoal, electricity required for winter heating.

III. Implementation Methodology

In order to demonstrate the benefits of passive solar housing technology, a political decision was taken by the Govt which was catalysed by the Solar Energy Research Group of the Himachal Pradesh State Council for Science, Technology & Environment [HPSCSTE]. A Solar House Action Plan was formulated, which was approved by Govt and Himachal Pradesh became the first state in the country to take a policy decision in the year 1994 vide which all the govt and semi-govt buildings are to designed and constructed incorporating passive solar heating and natural day lighting features. A Technical Project Management Cell was setup in HPSCSTE and detailed guidelines were prepared for the implementation of the Solar House Action Plan [1].

In order to demonstrate the efficacy of the passive solar technology for winter space heating, 25 govt building were identified for which the funds for construction were available. A team of experts were involved with the architects and engineers of the concerned agencies for the preparation of the building designs after carrying out the detailed micro-climate and site analysis. Specialised training programmes were organised for architects, engineers, scientists, masons, carpenters and builders to ensure the sustainability of the programme. The constructed passive solar buildings were monitored during winters for thermal comfort evaluation. The solar radiation data which is required for the simulation of solar buildings was generated using sunshine hour data [3].

The retrofitting of houses with passive solar heating systems in high altitude areas of Bharmour, Spiti, Kinnaur were carried out through the rural artisans. The main aim of training rural artisans in the construction of passive solar systems like Trombe wall, attached green houses etc. is to sustain the technology in rural and high altitude regions where this technology is needed at most. The training for the rural artisans is being organised regularly at the Appropriate Technology Centre of the HPSCTE.

The passive solar design features have been incorporated in the building bye-laws so that the technology is adopted in all buildings like hotels, industry and houses also.

IV. Financing

The passive solar building programme was financed by the HP Govt, Ministry of New & Renewable Energy (MNRE), Government of India and under USAID and ICIMOD funded projects. The funds were obtained only for capacity building, training and fabrication of solar heating systems. The funds for building construction were provided by the concerned agencies or the house owner. The MNRE provides incentives for detailed project preparation of a solar building and for incorporating passive solar features. The Govt Sector is the biggest consumer of energy for space heating and day lighting in cold regions.

V. Results

More than 200 passive solar buildings including offices, hospitals, schools, houses were constructed under the programme which has resulted in 40% to 60 % of energy required for winter heating. A number of engineers, architects were trained in the design and construction of solar heating systems. Rural Artisans trained were actively involved in house construction in rural areas. Awareness about the energy saving technology has been created. The Passive solar building programme is being successfully implemented in the state and the experience gained in implementing the technology can be shared among other cold regions of Asia. Inputs were provided to some states of India namely Uttrakhand, Sikkim, Manipur, Nagaland and Arunachal Pradesh.

The current status and strategy leading to the success is outlined as follows:
Based on the successful implementation of Passive solar housing technology, Himachal Pradesh Govt. took another policy decision for the implementation of Passive solar building technology in the State on Aug.18, 2000 according to which for all departments including Corporations, Boards, Universities, Public works Department, Himachal Pradesh Housing Board will design and construct buildings above 2000 meters by incorporating passive solar design features.

The passive solar building programme was reviewed on Oct 14, 2005 and a decision was taken that all buildings, industrial complexes, tourist resorts, hotels in government or semi-government and private sector must incorporate passive solar heating and cooling, Earth Quake Resistant and Rain Water Harvesting Structure features in the State of Himachal Pradesh. It was also decided to set up computerized design cells in government agencies. Besides, building byelaws for making provision for passive solar features, solar space heating systems, solar access to buildings, colonies and new townships will be modified by Department of Country & Town Planning ,Municipal Corporations and other concerned agencies. The State Govt is considering another policy decision so as to make passive solar heating features mandatory in houses and private buildings which are large consumers of energy like hotels, industry etc.

5.1 Case Studies of Passive solar buildings

The monitoring of the constructed passive solar buildings was carried out to study thermal comfort conditions, efficacy of passive solar features and actual energy savings. The monitoring of constructed Passive solar HP Co-operative Bank Himurja office and MLA Hostel buildings shows that buildings are comfortable in winters and dependence on the electricity for heating has been reduced considerably. The users have also expressed satisfaction over the comfort level.

i. HP Co-operative Bank building

The multi-storey bank building located in Shimla is oriented to 10° West of South [Fig 1]. This building had little choice for orientation as well as availability of sunshine. Consequently roof top solar air collector with an electrical backup heating system was also installed, along with two sunspaces, solar heat collecting wall, double glazed windows. The cost of passive solar features was only 5 % of the total cost with a pay back period of 3-5 years due to saving in fuel bills.

The monitoring of the building shows a temperature rise of 10-17 °C above the ambient temperature and the electric backup is required only for one to two hours during extreme cold and partially cloudy days.

iii. Himurja office Building

The building located in Shimla is exposed to winter sun and has day lighting features, sunspace, thermo-siphoning heating panels, and double glazed windows, solar water heating and solar photovoltaic lighting features [Fig.2]. This building does not require any auxiliary heating in winter. The monitoring of building shows inside temperatures of 18°C to 28° C with ambient temperature variation from 9°C to 15°C.

iv. Passive solar buildings in tribal regions

A number of passive solar schools, teacher's hostels and rural houses have been constructed in Tabo, Kaza, Sagnam, Dhankar, Rangrik, Kibber, Hansa and Losar in Spiti Valley at altitudes from 12,500 ft to 14,500 ft where the minimum temperature drops to -40°C in winters. The Solar Trombe wall which is effective in providing night time heating was installed at Tabo Monastry Residential Complex [Fig 3].

v. Retrofitting of traditional houses

Under the Plan, a number of traditional houses were retrofitted with locally fabricated and low cost thermo-siphoning air heating panels, sunspace and Trombe wall heating systems in the tribal areas of the HP in Sangla Valley, District Kinnaur and Bharmour, Distt Chamba which resulted in wider awareness and acceptability for people. One Women training Centre was retrofitted with a Sunspace which resulted in providing comfortable working space for rural women during winters [Fig 4].

VI. Impact

6.1 Social change

The passive solar building programme has led to greater awareness among people to adopt the technology in house construction. The dependence on traditional fuels like wood, coal, electricity, LPG has considerably reduced leading to better living conditions besides preserving women and children from indoor smoke pollution. The training of rural masons in Solar house construction led to upgrading of their skills with better income opportunities [Fig 5 & 6].

6.2 Economics of Passive solar Buildings

In the passive solar buildings constructed in the state, there is only a marginal increase in the cost ranging from 0 to 10 % depending on the nature of passive solar features adopted. This minor increase in cost further reduces, if proper site planning, design and selection of materials are done at initial stages. Due to continuous saving of fuel / electricity required for space heating/cooling in such buildings, this additional cost can be recovered within 2--3 years. The passive solar buildings can be classified in to three main categories:

i. Solar Buildings with no additional costs

In case of buildings for which there is freedom for proper site planning, appropriate building materials and efficient functional planning at initial stages, the cost of passive solar design features can be 0 to 5 %.

ii. Solar Buildings with incremental costs of 5-10%

Buildings for which there is less independence in site selection and orientation, the incremental cost can vary from 5 to 10%.

iii. Buildings requiring retrofitting - back up electric heating systems

Buildings like hospitals or offices, in extremely cold sites above 3000 m requiring roof collector solar space/air/water heating systems with electric back ups or in which passive solar systems are to be retrofitted, the cost can go up to 15 %. However, due to lesser fuel consumption this incremental cost can be recovered in 2 to 3 years. Thus the technology costs are not high; however incentives of govt to public for adopting the technology can lead to faster adoption of technology.

6.3 Environmental Impact

The adoption of environmentally friendly passive solar housing technology for space heating in entire Himalayan region countries will lessen the burden on firewood thus saving the forests from extinction besides creating pollution free environment leading to decrease greenhouse gas emissions.

6.4 Lessons learnt

Being the coordinator of the Solar House Action Plan for the State Of Himachal Pradesh, it was difficult to change the mindset for adopting the new technological inputs and orient architects and engineers, especially in govt sector, to incorporate the technology. It requires long term technological backup besides continuous trust and zeal to promote this technology and ensure the availability of motivated technical manpower in order to sustain the programme.

6.5 Replicability

The passive solar building programme has been successfully implemented in the Western Himalayan state of Himachal Pradesh and the experience gained can be shared and replicated not only in the hill states of India like Uttrakhand, Sikkim, Jammu & Kashmir, Manipur, Meghalaya, Arunachal Pradesh, Nagaland but also in other cold regions of Asia like Tibet, Nepal, China and Afghanistan etc. The Policy decision and implementation strategy adopted in the Western Himalayan State can be followed in the Cold region countries for wider dissemination of the technology which leads to comfortable living conditions in cold regions.

VII. References

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2. SS Chandel & RK Aggrwal ,Performance Evaluation of a Passive Solar Building in Western Himalayas Renewable Energy –An International Journal [Elsevier ,UK] Vol.33,, 2166-2173, 2008

3. SS Chandel, RK Aggarwal, A,N. Pandey, New Correlation to Estimate Global Solar Radiation on Horizontal Surfaces Using Sun Shine Hour & Temperature Data for Indian Sites ,Journal of Solar Energy Engineering [Elsevier,U.K.] Vol.127, 3, 417-420, 2005

ANNEXURE _1 - Figures :

Fig 1.Passive Solar Bank Building at Shimla

Fig 2.Passive Solar Office Building at Shimla HIMURJA

Fig 3 Solar Trombe wall System Tabo monastry, Spiti

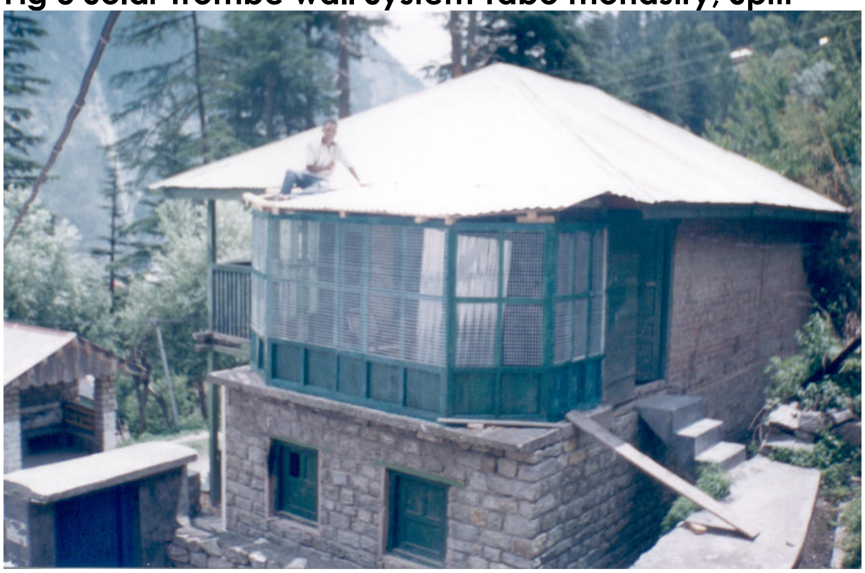

Fig 4 Retrofitting of Women Training Centre in Kinnaur

Fig 5. Construction of Passive solar Rural House by Trainee Masons

Fig 6. Training of Masons in Cavity wall construction