



Review of energy efficient features in vernacular architecture for improving indoor thermal comfort conditions



S.S. Chandel^{a,*}, Vandna Sharma^b, Bhanu M. Marwah^b

^a Centre for Energy and Environmental Engineering, National Institute of Technology Hamirpur, 177005, Himachal Pradesh, India

^b Department of Architecture, National Institute of Technology, Hamirpur 177005, Himachal Pradesh, India

ARTICLE INFO

Article history:

Received 24 August 2015

Received in revised form

25 May 2016

Accepted 8 July 2016

Keywords:

Climate responsive features

Energy efficient features

India

North-Western Himalayas

Thermal comfort

Vernacular architecture

ABSTRACT

In this study a comprehensive review of vernacular architecture research status is presented. The objective of the study is to identify energy efficient vernacular architecture features affecting indoor thermal comfort conditions for adaptation in modern architecture to suit present day lifestyles. The main features identified are: built mass design, orientation with respect to sun, space planning, openings, sunspace provision, construction techniques, and building and roof materials. Earth with its low compressive strength and durability is found to be prominently used vernacular building material due to its thermal insulation property. The current status and codal provisions regulating use of earth as a building material in different countries namely Australia, New Zealand, South Africa, France, New Mexico, Colombia, Spain and India, are reviewed so as to assess its suitability in modern context. Vernacular architecture features in different climatic zones of India including north-western Himalayan state of Himachal Pradesh are also studied along with a case study in composite climate of Hamirpur region, which identifies the relation of vernacular architectural features with thermal comfort conditions. The study identifies an emerging architectural style for this Himalayan region incorporating thermal comfort, energy efficient features, passive solar features, current design and construction techniques. Studies to develop this architecture style, improvement in the strength and durability of earth as building material and thermal comfort studies of vernacular houses are identified as follow up research areas. The study is of relevance for utilizing vernacular materials and architectural features for improving thermal comfort in modern buildings worldwide.

© 2016 Elsevier Ltd. All rights reserved.

Contents

1. Introduction	460
2. Factors affecting vernacular architecture	461
2.1. Impact of climate and geographical conditions of region	461
2.2. Socio-economic and cultural factors	461
3. Relation of energy efficiency with vernacular architecture	461
3.1. Shape and energy efficiency	461
3.2. Materials and embodied energy	462
3.3. Relation of thermal comfort with vernacular architecture	463
3.4. Thermal comfort and passive environmental control features in vernacular architecture	464
3.5. Climate specific energy efficient features in vernacular architecture	465
4. Use of earth as building material and codal provisions	466
4.1. Present status	466
4.2. Earth as an energy efficient vernacular material	466
4.3. Overview of codes and legal regulations for the use of earth as building material	467
4.4. Adaptation of vernacular architecture for improving energy efficiency in modern context	467
5. Vernacular architecture of Indian state of Himachal Pradesh – a case study	468

* Corresponding author.

E-mail addresses: chandel_shyam@yahoo.com, sschandel2013@gmail.com (S.S. Chandel).

5.1.	Climatic zones	468
5.2.	Vernacular house design features in different climatic zones of the state	469
5.3.	Case study of vernacular architecture in Climatic Zone1 of Himachal Pradesh	470
5.3.1.	Methodology followed	471
5.3.2.	Survey results of vernacular houses	471
5.3.3.	Energy efficient features	471
6.	Results and discussion	472
6.1.	Analysis of survey	472
6.2.	Identification of factors influencing vernacular architecture	473
6.3.	New architectural style for the western Himalayan region	473
6.3.1.	Planning features	473
6.3.2.	Design features	473
6.3.3.	Materials and construction features	473
7.	Conclusions	473
Appendix I.	Sample questionnaire for socio-economic survey carried out for sample vernacular houses in district Hamirpur, Himachal Pradesh	474
References		476

1. Introduction

Vernacular architecture is evolved from centuries of experience of people living under different climatic conditions worldwide [1,2]. It involves design and construction techniques using locally available resources based on the environmental, cultural and historical background of people [3]. This architectural style takes care of climatic and energy conserving features providing enhanced thermal comfort. In modern context vernacular architecture can provide solutions for a number of problems like degradation of environment quality, indiscriminate depletion of resources, green house gas emissions, high energy usage, deforestation etc. However, presently this architectural style is on the verge of extinction as it has been abandoned by people to follow the so called modern conventional architectural style [4].

The importance of energy efficient features in vernacular architecture has been highlighted by a number of authors. Liu et al. [5] and Chandel et al. [6–9] suggested that it is important to adopt indigenous design and construction styles or to opt for more flexible modern construction systems which incorporate features of traditional architecture and passive solar techniques. The adaption of these features can lead to better amalgamation of vernacular techniques in modern houses to improve energy efficiency, cost effectiveness and sustainability as shown by Chandel and Sarkar [10] and Foruzanmehr and Vellinga [11]. Priya et al. [12] suggested that by spatial organization, design/planning techniques, construction materials, inclusion of passive solar design features, comfortable indoor environment can be achieved in modern houses.

Aguilero et al. [13] discussed the bio-climatic features of traditional architecture worldwide. Different bio-climatic zones have different types of design, planning and spatial organization of dwellings. Use of these climate responsive design strategies, their incorporation in modern buildings by construction industry would promote the bio-climatic architecture in urban planning. The study also points out that the inclusion of bio-climatic guidelines would result in indoor comfortable environment and save energy consumed in buildings for heating and cooling.

Dili et al. [14] studied passive features of vernacular architecture of Kerala and showed that prevalence of modular building concept, internal open courtyards as per ancient geometrical grids, proportions and scale, verandah, orientation of building, spatial organization of internal spaces, use of local materials and special methods of construction will lead to creation of comfortable indoor environment in houses without input of external energy equipments. The study showed that these passive bio-climatic features resulted in maintaining of higher indoor air temperatures

in winters and lower indoor air temperatures thereby creating comfortable indoors. Moreover, the features also maintain a continuous gentle flow of wind inside the building which resulted in a balanced level of temperature and humidity inside the building irrespective of outside conditions. Thus planning /design and material usage features of vernacular houses can be advantageously applied in modern houses.

The main objective of the study is to identify energy efficient features in vernacular architecture affecting indoor thermal comfort conditions for adaptation in modern architecture to suit present day lifestyles. In this context a detailed literature review of relevant research studies carried out during the period 1975–2015, is presented with focus on thermal comfort and energy performance. The factors affecting vernacular architecture and their relation with climate, energy efficiency for built mass in terms of shape, materials, embodied energy, thermal comfort and passive heating or cooling techniques are identified. The current status of earth construction and codal provisions regulating use of earth and adaptations are discussed briefly in the study. The associated problems like low compressive strength and durability in the use of earth are also studied.

Along with the review of worldwide study, the traditional architecture features in different climatic zones of north-western Himalayan Indian state of Himachal Pradesh are also studied followed by a specific case study of Hamirpur region, which identifies relation between vernacular architecture and thermal comfort conditions. The vernacular architecture features in design, construction and planning aspects which affect indoor thermal comfort in houses are identified. Consequently a new type of architecture called “Modern Himalayan Architecture Style” has been proposed for building construction for this region of India. Energy efficient features of this architectural style can be advantageously added for improving indoor thermal comfort in residences and commercial buildings alike.

The paper is organized as follows: Section 2 gives parameters affecting vernacular architecture, Section 3 identifies relation of energy efficiency with vernacular architecture focusing on shape, design, materials, embodied energy, thermal comfort and passive cooling features, Section 4 discusses current status of use of earth as building material, codal provisions and adaptations of vernacular architecture for improving energy efficiency in modern context in terms of improving traditional materials and designs, Section 5 presents case study of traditional architecture of an Indian state of Himachal Pradesh; Section 6 presents results and discussion followed by conclusion in Section 7.

Download English Version:

<https://daneshyari.com/en/article/8112855>

Download Persian Version:

<https://daneshyari.com/article/8112855>

[Daneshyari.com](https://daneshyari.com)