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Design guidelines for energy-efficient hotels in Nepal

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Abstract

It is predicted that the major increase in energy consumption and, thus, carbon emissions, will happen in the developing world. However, in most developing countries the knowledge about energy efficiency, particularly in the building sector, is quite low. Strategies developed for industrialised countries might not be suitable or must be adapted for the very different context of developing countries. This research aims to find energy-efficient and cost-effective building design options for the case of Nepal. Energy-efficient building design is a non-trivial issue involving a number of interdependent design criteria. Particularly, in composite climates, passive design strategies might conflict each other leading to an inefficient building design. This paper explores the energy conservation potential in hotel design for all bioclimatic zones of Nepal using building energy simulation with parametric analysis. Based on extensive field studies, reference models for typical hotel buildings ranging from small-scale resort hotels to large-scale multi-storey hotels were developed. These reference designs were optimised by varying design parameters such as window-to-wall ratio, glazing material, shading devices, glazing type and insulation levels. During the design optimisation, energy demand as well as cost effectiveness were evaluated. Finally, recommendations for energy-efficient and cost-effective hotel design solutions were suggested. In addition, the bioclimatic zoning for Nepal was consolidated leading to five elevation-based zones that can be used to introduce building energy regulations in the future.

Keywords: Energy efficiency; Hotel buildings; Passive design; Building energy simulation; Parametric study

1. Introduction

The hospitality industry is one of the most important sectors for economic development in Nepal because of tourism. The number of tourists has almost grown by 400 percent in the last decade reaching over 800,000 visitors in 2012 (GoN, 2014). In 2013, the travel and tourism industry contributed 1.5 billion US-Dollars[1] to Nepal's Gross Domestic Product (GDP) which corresponds to 8.2 percent of total GDP. Moreover, the sector is estimated to grow by 5 percent every year in the next decade (WTTC, 2014). The hotel and restaurant business experienced an annual growth rate of over 6 percent per year from 2009 to 2013 (CBS, 2013). The growing numbers of tourists and the boom in the tourism sector have led to more hotels being built by investors.

Many newly constructed hotel buildings are equipped with modern HVAC systems that provide comfortable

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[1] 1 US-Dollar = 100 Nepalese Rupees.

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lodging for their guests. Therefore, the energy consumption in the sector has increased considerably. Due to an increasing gap between electricity demand and supply, Nepal is experiencing a power crisis of unprecedented severity for more than seven years (WECS, 2010). Scheduled power outages of up to 10 h a day in dry season have forced many hotels to instal huge and expensive diesel generator backup systems to ensure the operation of air-conditioning equipment.

New hotel designs often do not consider climate-responsive design strategies or apply any energy efficiency technologies. There are a number of reasons for that. Firstly, the government has not placed any energy conservation regulations. Secondly, architects, engineers and contractors are not familiar with the application of insulation materials for walls, roofs and flooring. Hotel investors are also not aware about potential energy and cost savings that can result from having a hotel with energy-efficient design or increased insulation. Finally, energy-efficient building technology like thermal insulation or double glazing windows are new and expensive leading to high initial investment cost. Business developers do not have the know-how to estimate energy cost savings in monetary terms which is necessary to justify increased investment cost.

Another challenge for energy-efficient building design in Nepal is the diversity of climatic conditions which is the result of a geography ranging from an elevation of 60 metres to the highest mountain of the world at 8848 m. Nepal can be divided into four bioclimatic zones (Bodach, 2014): 1. Warm temperate, 2. Temperate, 3. Cool temperate and 4. Cold climate (see Table 1). The climate in most regions is of composite character with a wide daily temperature swing. This means that passive design strategies, which are effective in reducing heating, might increase cooling demand. The only way to evaluate the effectiveness of different design strategies is the use of simulation-based design optimisation.

This study is the first comprehensive research that assesses design strategies for energy-efficient hotel buildings in Nepal using building energy simulation. The overall objective is to develop design recommendations for hotels in Nepal focusing on passive design and envelope optimisation to reduce energy consumption for heating and cooling. Thereby, this study covers all climates of Nepal and considers different typical construction technologies.

Table 1
Climate conditions in bioclimatic zones of Nepal (Bodach, 2014).

Bioclimatic zone	Temperature in Summer	Temperature in Winter	Relative Humidity
Warm temperate	22–35 °C	9–26 °C	25–90%
Temperate	18–35 °C	5–25 °C	20–90%
Cool Temperate	14–26 °C	−2–20 °C	30–90%
Cold	7–22 °C	−10– −2 °C	10–90%

2. Methodology

2.1. Research framework

The overall research framework of this study is illustrated in Fig. 1. The main method used is dynamic building energy simulation which is a common approach to explore the energy performance of design alternatives and estimate the energy saving potentials of passive design strategies and energy-efficient building technologies (Stevanović, 2013). Based on an extensive field research, typical building typologies for hotel design were developed and different construction materials were assigned. In order to come up with recommendations for passive design on one side and for insulation levels on the other side, two sets of simulation runs were necessary; 1. Passive design optimisation run and 2. Thermal insulation optimisation. A secondary input for determining insulation levels was a literature review on international and regional standards and building codes. All used methods are described in more detail in the following section.

2.2. Climate data

Hourly climate data are one of the most important inputs for building energy simulation. In order to cover the whole climatic diversity of the country, two locations in each bioclimatic zone were selected for the simulation (see Table 2 and Fig. 2). The selection was done considering the relevance of the location for tourism activities as this research is focused on hotel buildings. For each of these eight locations, monthly weather data of at least 20 years were collected from Department of Meteorology and Hydrology of Nepal (DHMN, 2012) and used to generate the typical meteorological year with the software tool METEONORM (Meteotest, 2014).

2.3. Building typologies

Vernacular Nepalese architecture used building design and construction technologies that were very well adapted to the local climate (Bodach et al., 2014). In the warm temperate region, for example, light materials like wattle and daub were applied as walling and thatch was applied as roofing material. In contrast, in the hilly region with a more temperate climate, walls were built with higher mass like burned bricks or locally available stone masonry and roofing was made out of brick tiles or slates. In the cold and harsh mountains, houses had a compact layout using very thick stone walls to decrease the heat loss of the building.

Some of those traditional elements can be still found in modern hotel architecture. For example, in the warm temperate climate one of the cottage type hotels, which were visited during the field research, was built in lightweight construction as timber frame with thatch roofing. Thatch

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