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Analysis of the thermal performance of a building design located at 2465 m: Antalya-Saklikent National Observatory guesthouse

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Abstract

This study is based on thermal performance analysis and evaluation of the National Observatory guesthouse with the software SUNCODE-PC. The study is unique owing to its high-altitude site (2465 m) in a remote area, harsh climate (with almost no data available), and functional restrictions of astronomical facilities. The design is thermally evaluated through different modes of application of insulation, materials, types of glazing, window/wall ratios, Trombe walls, winter night insulation, summer ventilation and shading.

Keywords: Thermal performance; Passive solar architecture; Astronomical facility

1. Introduction

In 1994, Turkey's National Observatory and its guesthouse were proposed to be built in Bakirlitepe-Saklikent, (at 36.85°N latitude and 30.33°E longitude and 2465 m altitude) by the Basic Research Sciences Group of the Scientific and Technical Research Council of Turkey. It is one of the skiing resorts of Antalya with a deserted, massive rock crest. The site fulfilled the best observational criteria among four candidate sites, which were in turn chosen from 17 possible sites after one to two seasonal measurements [1].

The project consists of two observatory buildings for 40 and 150 cm diameter telescopes and a guesthouse for the accommodation of researchers. The factors described under the topic 'Design Criteria' governed the considerations of utilization of solar energy in the guesthouse. After the first phase of the design stage, thermal analysis and evaluation of the proposed building is conducted. The construction of the buildings was completed in 1997 and the building is in use from that time on (Fig. 1). The information given in this paper does not produce any new rules or guidelines for passively heated buildings built under normal climatic conditions and at moderate altitudes. It presents the design criteria, thermal analysis, and evaluation of the design of the guesthouse under very special conditions. The lack of previous studies for similarly harsh climates forced the authors to analyze extraordinary solutions like metal-Trombe walls. Different alternatives are discussed in comparative form. The authors hope that such a presentation will be a contribution

Fig. 1. Guesthouse of TÜBİTAK National Observatory.

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Nomenclature

DG	double glazing
DGW	direct gain windows
FM	floor material
GH	greenhouse
ITW	isolated Trombe walls
O	original design
Q_{aux}	the auxiliary heating load
SHF	solar heating fraction
TW	Trombe walls

to fill the gap for the prediction of the thermal performance of special-purpose buildings, under coarse climates at high altitudes.

2. Design criteria

The environmental and functional restrictions of the buildings due to the characteristics of astronomical observation can be summarized as follows:

- the astronomical observations require a completely clear, dark, stable and clean environment, and so the building needed to be specially designed not to produce any smoke, dust or light.
- The guesthouse should not radiate any direct electromagnetic wave in the thermal or visible range towards the observatory during the observation period. Hence, heat radiation at night time had to be strictly avoided.
- The guesthouse, when in use, has to serve as a comfortable building. During wintertime, snow closes the access roads and blocks out the site from the rest of the world. When the building is turned off during this season, the mechanical and electrical equipment may be adversely affected by harsh climatic conditions, hence, internal temperatures should be maintained above the freezing point.
- Due to the occasional usage of the building, manual control and maintenance should be minimized.
- The astronomers sleep and rest during daytime. Therefore, the bedrooms should not receive direct sunlight for the comfort of the occupants.

2.1. The functions and description of the building

The activities in the building are divided into three categories. The first one is technical, such as preparing and planning of the observation, data collection and analysis, which takes place through the day and nighttime. A computer room and a seminar/meeting room were provided for this function. The second is the accommodation of astronomers and technical staff, hence, seven bedrooms, dining room and rest rooms were proposed. A workshop was provided for the third activity, which is the maintenance and repairing of some parts of the telescope. Two-story building has a total area of 720 m^2 (Fig. 2).

The highly insulated building is earth bermed from the northern side and has openings only on the southern façade. A sloped window, constructed in front of the south wall, forms a greenhouse on the ground floor. The glazing extends to the first floor with the same tilt angle in order to increase the amount of received solar radiation and the black painted wall runs parallel to it with an air gap in between. It is an isolated system Trombe wall, i.e., insulated Trombe wall permits only convective heat transfer to the interior space. In order to protect the building from overheating in summer, side vents are placed at the lower parts of the greenhouse. In this way, chilly and fresh outdoor air flows into the greenhouse and hot air is exhausted via roof vents (Fig. 3).

2.2. The climatic data

The necessary outdoor climatic data for thermal analysis of the building should contain the hourly values of outdoor air temperature (°C), outdoor dew point temperature (°C), wind velocity (m/s), direct normal radiation (kJ/m^2), and horizontal total radiation (kJ/m^2). The site has climatic data for the four months summer period only, during which astronomical observation is conducted [1]. The climatic data needed for thermal analysis of the building were incomplete; therefore had to be generated for the computation and analysis.

Outdoor air temperature, ground temperature, wind, and relative humidity data measured for periods of more than 6 years in six meteorological stations with altitudes varying from 1725 to 2400 m and latitudes ranging between 37.57°N and 40.30°N have been analyzed [2]. The most important geographical characteristics of Saklikent are its altitude and proximity to the Mediterranean Sea. The town named Van-Başkale that is close to Lake Van with an altitude of 2400 m and latitude 38.47°N, was selected among these candidate locations for use in the remaining period for the site. An hourly climatic data set of a typical winter day was produced by using the values of this town, and for the overheated period calculations, the available summer data of Saklikent has been used. In order to be on the safer side in the analysis, the mean of the minimum air temperature values of January and the maximum values of August for the hours 7:00, 14:00, and 21:00, were used. Furthermore, comparison of the cloudiness of Van-Başkale (i.e., 50%) with the number of clear nights in Bakirlitepe (i.e., 284 days [1]) indicated that the winter nights are probably colder in Bakirlitepe due to excess night-sky radiation. This led the authors to include the minimum value of air temperature of Başkale, which occurred once in 7 years, to the generated winter data set.

The relative humidity data were based on the winter values of Van-Başkale and summer values of Bakirlitepe and