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Influence of different outdoor design conditions on design cooling load and design capacities of air conditioning equipments

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Abstract

Outdoor design conditions are important parameters for energy efficiency of buildings. The result of incorrect selection of outdoor design conditions can be dramatic in view of comfort and energy consumption. In this study, the influence of different outdoor design conditions on air conditioning systems is investigated. For this purpose, cooling loads and capacities of air conditioning equipments for a sample building located in Adana, Turkey are calculated using different outdoor design conditions recommended by ASHRAE, the current design data used in Turkey and the daily maximum dry and wet bulb temperatures of July 21st, which is generally accepted as the design day. The cooling coil capacities obtained from the different outdoor design conditions considered in this study are compared with each other. The cost analysis of air conditioning systems is also performed. It is seen that the selection of outdoor design conditions is a very critical step in calculation of the building cooling loads and design capacities of air conditioning equipments.

Keywords: Weather design data; HVAC system; Cooling load; Cost analysis

1. Introduction

Local climatic conditions are important parameters for the energy efficiency of buildings. Because the energy consumption in buildings depends on climatic conditions and the performance of heating ventilating and air conditioning (HVAC) systems changes with them as well, better design in building HVAC applications that take account of the right climatic conditions will result in better comfort and more energy efficient buildings.

Outdoor design conditions are weather data information for design purposes showing the characteristic features of the climate at a particular location. They affect building loads and economical design. The result of incorrect selection of outdoor conditions can be dramatic in view of energy and comfort. If some very conservative, extreme conditions are taken, uneconomic design and over sizing may result. If design loads are underestimated, equipment and system operation will be affected. However, selecting the correct type of weather data is a difficult problem. To overcome the problem, Yoshida and Terai [1] constructed an autoregressive moving average (ARMA) type weather model by applying a system identification technique to the original weather data. Li et al. [2] studied climatic effects on cooling load determination in subtropical regions. They found that the outdoor climatic conditions developed for cooling load estimations are less stringent than the current outdoor design data and approaches adopted by local architectural and engineering practices. Zogou and Stamatelos [3] provided a comparative discussion on the effect of climatic conditions on the design optimization of heat pump systems and showed that climatic conditions significantly affect the performance of heat pump systems, which should lead to markedly different strategies for domestic heating and cooling, if an optimization is sought on sustainability grounds. Lam [4] studied

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climatic influences on the energy performance of air conditioned buildings and found that the predictions of annual cooling loads, peak cooling loads and annual electricity consumption differ by up to about 14%. Bulut et al. [5,6] determined new cooling and heating design data for Turkey. They used the current outdoor design data locally used and the new data presented in their studies [5,6] in order to evaluate the influence of the weather data set on the heating and cooling load. They found up to 25% and 32% differences between the cases considered for cooling and heating loads, respectively.

Outdoor design conditions corresponding to different frequency levels of probability for several locations in the United States and around the world are developed by the American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) [7]. Weather data includes design values of dry bulb temperature with mean coincident wet bulb temperature, design wet bulb temperature with mean coincident dry bulb temperature and design dew point temperature with mean coincident dry bulb temperature and corresponding humidity ratio. These design data are the outdoor conditions that are exceeded during a specified percentage of time. Warm season temperature and humidity conditions correspond to annual percentile values of 0.4, 1.0 and 2.0. Cold-season conditions are based on annual percentiles of 99.6 and 99.0. The 0.4%, 1.0% and 2.0% annual values of occurrence represent the value that occurs or is exceeded for a total of 35 h, 88 h and 175 h, respectively, on average, every year, over the period of record. The selection of frequency as risk level in design conditions depends on the applications. Representing the climatic design data for several frequencies of occurrence will also enable designers to consider various operational peak conditions.

The main goal of this study is to investigate the influence of the outdoor design conditions selected during sizing of on air conditioning system. The analysis consists of three main steps. In the first step, the total cooling loads of a sample building are calculated utilizing different outdoor design conditions such as the data given by ASHRAE [7] and the current design data used by project engineers in Turkey [8]. In the second step, design capacities of the all air central air conditioning equipments selected for the sample building are determined for the various outdoor design conditions considered in the study. Finally, cost analysis of the air conditioning system is performed for the cooling season.

2. Description of the sample building

A high school building was selected in order to conduct the analysis. The sample building is located in Adana, Turkey (36°59′ latitude, 35°18′ longitude and 20 m altitude). Adana, an agricultural and industrial centre and the nation's fifth largest city, is near the Mediterranean Sea. It is hot and humid in the cooling season. The sample building has three almost identical floors. Fig. 1 shows the architectural plan of the first floor. The gross area of the building is 1628 m^2, and the outside surfaces of the walls are light colored. The long sides of the building face north and south. The sample building is used as a high school and is occupied between 08:00 and 17:00 h. The high school has 224 students, 15 teachers, 4 officers and 3 laborers. The building has 14 classrooms, 3 laboratories, 5 offices, 1 library, 1 computer room and 3 corridors. The building complies with the insulation requirement imposed by Turkish Standard-TS 825, "Thermal Insulation in

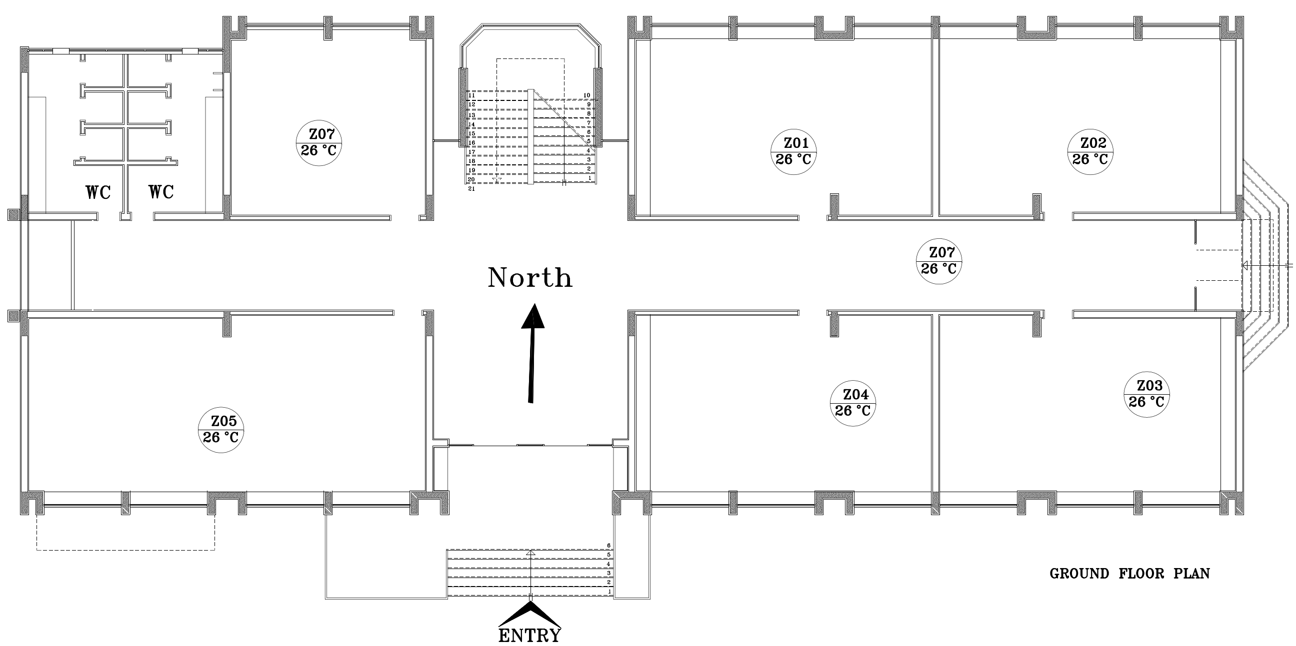

Fig. 1. Architectural plan of the sample building.