MODELING OF WEATHER DATA BY TIME SERIES ANALYSIS FOR AIR-CONDITIONING LOAD CALCULATIONS

H. Yoshida, Dr. Eng. **T. Terai, Dr. Eng.**

ABSTRACT

A method for modeling weather data is proposed. Three weather elements—temperature, global solar radiation, and absolute humidity—are selected to be modeled in the present paper. Each record is decomposed into deterministic or periodic and random components. The former is modeled by a Fourier series and the latter is modeled as a time series model, such as a multivariate auto-regressive moving average or vectored ARMA model. The statistical tests showed that the model can substitute the reference year data that are used for similar load calculations.

The systematic treatment of climatic change or climatic differences between locations, which generates an approximate weather model where a precise weather record is not available, and data compaction is made possible by the modeling. In addition, the model, which is identified as a linear system, can provide a new load calculation method based on linear system theory with the stochastic weather data as input.

INTRODUCTION

Energy conservation continues to be an important aspect of building system design. However, sophisticated design measures are needed to increase the efficiency of building systems because common measures, the effects of which can be easily estimated, have already been applied.

One of the tools used to evaluate a heating, ventilating, and air-conditioning (HVAC) system design is hour-by-hour simulation of heating and cooling loads or energy consumption of the system. Simulation may also be used for validating a simplified load calculation method. However, simulation is more important at the design stage.

Providing appropriate weather data for the simulation is very important because the data significantly affect the results. Test Reference Year data—a year-long hourly weather data set—are widely used in many countries including Japan. However, the following problems still remain: (a) improving the reliability of statistical properties of the data, (b) adapting to climatic change with time, and (c) providing the data of a location where only simple weather measurements are carried out.

One of the important aims of providing a weather data model other than an hourly weather data set such as the Test Reference Year is to understand the characteristics of climate and use the knowledge to provide adequate data and load calculations. Spectral analysis of weather data was carried out by Cumali (1970) to investigate cross-correlations between weather elements. He suggested that the results can be used to select a representative period from the long-term record and proposed building a mathematical model. Periodicity and randomness in the weather record were analyzed and modeled by Hittle and Pedersen (1981). They introduced an auto-regressive (AR) time series model to express randomness and proposed using the model as a substitute for the Test Reference Year. However, they only treated temperature and direct solar radiatIon without considering cross-correlations.

In the present paper, the authors describe a modeling procedure for three weather elements—temperature, global solar radiation, and humidity—considering auto- and cross-correlations among them and how to overcome the problems related to the Reference Year data previously mentioned.

THE OBJECTIVES OF MODELING

The objectives of building a weather model are as follows:

1. *More reliable statistical properties:* Weather varies with time, not only deterministically due to diurnal and annual periodicity, but also randomly due to unpredictable atmospheric conditions. Therefore, several years of weather data, such as 10 years or more, are required to increase the statistical reliability of estimated loads. Even with a short data period, for instance, one year, significant discrepancies will not occur when the load is evaluated on an integrated annual basis. However, when statistical distribution of load and energy consumption is desired, discrepancies will be larger with the short data period. Providing a weather model, which contains long-term

Harunori Yoshida is an associate professor in the Department of Global Environment Engineering and **Toshio Terai** is a professor in the Department of Architecture, Kyoto University, Kyoto, Japan.