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Thesis:

Modeling of Fire Spread in Buildings and Modeling of Fire Spread from the Fire Building to Adjacent Buildings

Abstract:

The modeling of fire spread in buildings had been studied for decades. Due to the disadvantages of different models, none of previous models can really be used in practical applications involving large buildings. In this thesis, modeling of fire spread between buildings using Bayesian Network is proposed which can overcome the disadvantages of previous models. In practice, a general fire spread network has firstly to be built according to the floor plan of a building. Once the compartment of fire origin is known, a detailed fire spread model using a directed acyclic graph (DAG) of Bayesian network to express the fire spread process from the initial compartment to any destination compartment on the floor can be constructed. The probability of fire spread from the initial compartment to the destination compartment can be calculated by marginalizing the joint probability distribution of the Bayesian network.

Fire spread in a building is a dynamic process. Therefore, a dynamic fire spread model is proposed. The dynamic fire spread model is built on the basic concepts of dynamic Bayesian network and the static fire spread model proposed. In this model, the algorithms for simulating the fire spread process are developed and corresponding computer codes were developed. The probability of fire spread from the compartment of fire origin to any other compartment, the time of ignition, time of flashover and time of decay in each compartment can be calculated by the computer program. The fire spread dynamic model can be easily used in the application of any building including high rise buildings. In addition, the formulae calculating the input data for the dynamic fire spread model were derived. A user having a very basic knowledge of fire protection engineering will find no trouble using it.

Research on acceptable spatial separations between buildings to prevent fire spread between buildings has been conducted for more than 60 years. Several engineering methods have been presented. The shortcomings of these engineering methods are that there is no detailed description of the background on how the tables or graphs were obtained. There is no universally accepted method and different methods may result in different results.

In this thesis, three basic relationships between window/opening in a fire building and a target point on an exposed building are proposed. The numerical methods of calculation of the configuration factor from the fire building to an adjacent building are presented which are even available for buildings with an irregular distribution of windows, different sizes of openings and recessed portions. By letting the maximum configuration factor be less than the critical configuration factor, the required minimum separation distance between two buildings can be easily calculated.

Furthermore, twelve full-scale fire experiments were conducted to study the emissivity of the external flame and the radiation contribution from the external flame out of the window. Based on the theory of post-flashover compartment fires, the calculations of configuration factor and experimental results, the model of fire spread from the fire building to adjacent buildings by radiation was proposed. The minimum separation distance between buildings could be easily found by computer programming by letting the maximum radiation heat flux equal to the critical ignition heat flux of combustible materials of an adjacent building.

By combining the dynamic model of fire spread in buildings, an example of the calculation of separation distance between buildings as a function of time is presented. The results calculated by the two models of fire spread between buildings are compared with that required by the National Building Code of Canada (NBCC) 2005.

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