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Time-dependent fire risk assessment for occupant evacuation in public assembly buildings

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Abstract

A time-dependent approach to evaluate fire risk for occupant evacuation is presented in this article. Fire risk is proposed as the product of probability and consequence. Some uncertainties of fire dynamics, occupant characteristics, building environment are considered in the process. When evaluating probability, event tree technique is employed to analyze probable fire scenarios. Probability of every event is considered as a time-dependent variable by coupling fire models and Monte Carlo method. Then, probability of every fire scenario is also obtained as a time-dependent variable based on event tree analysis. When evaluating consequence, ASET (Available Safe Egress Time)/RSET (Required Safe Egress Time) timeline assessment is presented. Traditionally, ASET and RSET are both regarded as definite values. Moreover, ASET and RSET are treated as two independent events. In this approach, uncertainties of ASET and RSET are considered by stochastic analysis. The interdependency between ASET and RSET is considered by uncertainty of design fires. Then, consequence is evaluated as number of fatalities under various Risk Intervals. Based on time-dependent probability, number of fatalities under various Risk Intervals and fire statistics, fire risk can be evaluated as expected risk to life (ERL). To demonstrate the approach, a case study is discussed.

Highlights

► We develop an approach to evaluate fire risk assessment to occupant evacuation. ► We simulate probability of every fire scenario as a time-dependent variable. ► We consider uncertainties and interdependencies of ASET (Available Safe Egress Time)/RSET (Required Safe Egress Time). ► Number of fatalities is treated as a stochastic variable.

Keywords

Time-dependent; Fire risk; Occupant evacuation; Uncertainty; Interdependency

Figures and tables from this article:

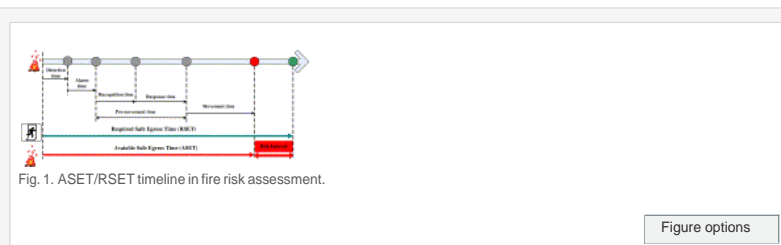Fig. 1. ASET/RSET timeline in fire risk assessment.
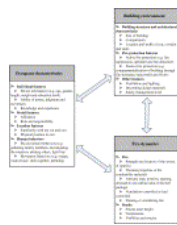
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Fig. 2. The schematic relationship of fire dynamics, occupant characteristics and building environment.

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Fig. 3. The schematic framework of time-dependent risk assessment for occupant evacuation.
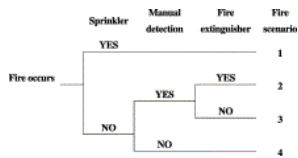
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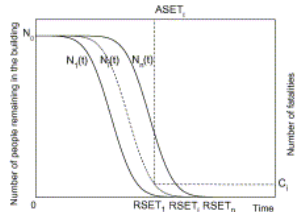Fig. 4. An typical event tree analyze on probable fire scenarios.

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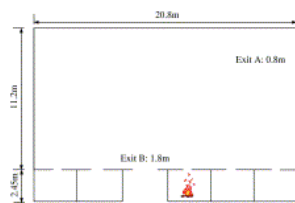Fig. 5. The cluster of evacuation curves.

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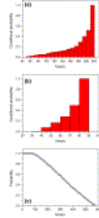Fig. 6. Plan of the buildings in the case study.

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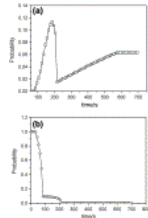Fig. 7. Probability of every event: (a) sprinkler; (b) manual detection; (c) fire extinguisher.

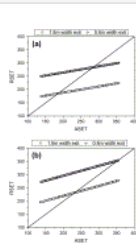Fig. 8. Time-dependent probability of every fire scenario: (a) scenario 3; (b) scenario 4.

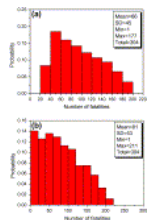Fig. 9. The scatter diagram of ASET and RSET: (a) scenario 3; (b) scenario 4.

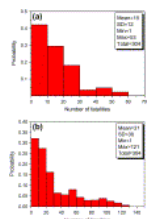Fig. 10. The histogram of number of fatalities of 0.8 m-wide exit: (a) scenario 3; (b) scenario 4.

Fig. 11. The histogram of number of fatalities of 1.8 m-wide exit: (a) scenario 3; (b) scenario 4.
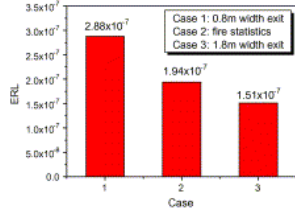
Fig. 12. The expected risk to life of various cases.

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Table 1. A list of input of simulation scenario.

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