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A methodology for evacuation design for urban areas: theoretical aspects and experimentation

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This paper proposes an unifying approach for the simulation and design of a transportation system under conditions of incoming safety and/or security. Safety and security are concerned with threats generated by very different factors and which, in turn, generate emergency conditions, such as the 9/11, Madrid and London attacks, the Asian tsunami, and the Katrina hurricane; just considering the last five years.
In transportation systems, when exogenous events happen and there is a sufficient interval time between the instant when the event happens and the instant when the event has effect on the population, it is possible to reduce the negative effects with the population evacuation.
For this event in every case it is possible to prepare with short and long term the evacuation. For other event it is possible also to plan the real time evacuation inside the general risk methodology. The development of models for emergency conditions in transportation systems has not received much attention in the literature. The main findings in this area are limited to only a few public research centres and private companies.
In general, there is no systematic analysis of the risk theory applied in the transportation system. Very often, in practice, the vulnerability and exposure in the transportation system are considered as similar variables, or in other worse cases the exposure variables are treated as vulnerability variables. Models and algorithms specified and calibrated in ordinary conditions cannot be directly applied in emergency conditions under the usual hypothesis considered.
This paper is developed with the following main objectives:
(a) to formalize the risk problem with clear diversification (for the consequences) in the definition of the vulnerability and exposure in a transportation system; thus the book offers improvements over consolidated quantitative risk analysis models, especially transportation risk analysis models (risk assessment);
(b) to formalize a system of models for evacuation simulation;
(c) to calibrate and validate system of model for evacuation simulation from a real experimentation.
In relation to the proposed objectives in this paper:
(a) a general framework about risk analysis is reported in the first part, with specific methods and models to analyze urban transportation system performances in emergency conditions when exogenous phenomena occur and for the specification of the risk function;
(b) a formulation of the general evacuation problem in the standard simulation context of "what if" approach is specified in the second part with reference to the model considered for the simulation of transportation system in ordinary condition;
(c) a set of models specified in the second part are calibrated and validated from a real experimentation in the third part.
The experimentation was developed in the central business district of an Italian village and about 1000 inhabitants were evacuated, in order to construct a complete data-base. Our experiment required that socioeconomic information (population, number employed, public buildings, schools, etc.) and transport supply characteristics (infrastructures, etc.) be measured before and during experimentation. The real data of evacuation were recorded with 30 video cameras for laboratory analysis.
The results are divided into six strictly connected tasks: Demand models; Supply and supply-demand interaction models for users; Simulation of refuge areas for users; Design of path choice models for emergency vehicles; Pedestrian outflow models in a building; Planning process and guidelines.