Chapter 4.20
Structural Assessment of RC Constructions and Fuzzy Expert Systems

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ABSTRACT

The chapter deals with the structural assessment of existing constructions, with a particular attention to seismic risk mitigation. Two aspects are involved: the appraisal of the actual conditions of the structure (material deterioration, preexist-ing damages) and the evaluation of the structural "vulnerability," that is, the propensity to suffer damage because of the intrinsic geometric and structural arrangement, boundary conditions, specific structural details. Attention is first focused on the investigation protocol, which is organized through a multilevel, hierarchical scheme: the

procedure includes visual inspections, surveys, experimental testing on site and in laboratory, and gradually proceeds into the details of the problem, progressively refining and verifying hypotheses and preliminary judgments. In a second part, the definition of effective tools for uncertainty management and decision making is performed, by presenting a genetic-fuzzy expert system which handles the procedure of the assessment properly accounting for uncertainty and errors, and is able to tune the parameters involved on the basis of experts' knowledge, "training" the system. Finally, a case study is presented, applying the whole assessment procedure and the fuzzy genetic algorithm.

INTRODUCTION AND DEFINITION OF THE PROBLEM

History, even the most recent, has shown how devastating can be the effects of natural catastrophes—in particular earthquakes—over unprepared territories and communities. Actually, "disaster prevention" is the buzzword of the last few years at a scientific, administrative and political level, and risk mitigation strategies have become a field of great political and economical engagement, with a consistent financial and technical effort. Of course, the scientific community plays a crucial role in these processes, and is charged with the task of defining—at a theoretical level—proper methods for the analyses and the interventions, and to transfer this knowledge to the community in the form of practical decisional tools.

The question should be framed in a definition of *risk*—by now widely acknowledged in the scientific world—as the "average expected losses" from a given disastrous event over a specified future time period, whether expressed in terms of numbers of lives lost or in terms of expected economic loss, physical damage to property, structures, and activities. An element of a society is considered "at risk" or "vulnerable" when

it has a high propensity to suffer damage under the occurrence of a given disaster (hazard). There are three essential components in the determination of risk, each of which should be separately quantified:

1. **The hazard occurrence probability:** The likelihood of experiencing any natural or technological hazard at a specific location
2. **The elements at risk:** Elements which would be affected by the hazard
3. **The vulnerability of the elements at risk:** The propensity to suffer damage under a given hazard

The elements at risk of a society can be (besides human lives, buildings, and properties) facilities; transportation networks; strategic, economical, and directional activities; and even the same structure and social cohesion. With specific regard to the *urban environment,* eight components at risk can be singled out: population, space, functions, activities, government, regulation, identity, and image.

For instance, transportation facilities represent a strategic element, fundamental in order to guarantee the organizational functionality in the emergency phase and to preserve the continuity of the economical and productive activities. Risk is symbolically defined through a simple mathematical formula (see Figure 1), which expresses the dynamic relationship existing among the concepts of vulnerability, hazard, and risk: The greater the potential occurrence of a hazard, the more vulnerable the elements and the greater their importance and implications, the higher is the likelihood that the occurrence of a natural catastrophe will result in a disaster.

Hence, the assessment of the risk related to a particular disaster involves the quantification of the expected losses in a specific location during a fixed time frame. Such an evaluation includes, on the one hand, the availability and analysis of data about the probability occurrence of a particular

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