Seismic Hazard Estimates Using Ill-defined Macroseismic Data at Site

D. Albarello\textsuperscript{1} and M. Mucciarelli\textsuperscript{2}

Abstract—A new approach is proposed to the seismic hazard estimate based on documentary data concerning local history of seismic effects. The adopted methodology allows for the use of “poor” data, such as the macroseismic ones, within a formally coherent approach that permits overcoming a number of problems connected to the forcing of available information in the frame of “standard” methodologies calibrated on the use of instrumental data. The use of the proposed methodology allows full exploitation of all the available information (that for many towns in Italy covers several centuries) making possible a correct use of macroseismic data characterized by different levels of completeness and reliability. As an application of the proposed methodology, seismic hazard estimates are presented for two towns located in Northern Italy: Bologna and Carpi.

Key words: Seismic hazard, catalogue completeness, macroseismic data, intensity.

1. Introduction

Historical research carried out in Italy during recent years (see, e.g., Boschi \textit{et al.}, 1997; Monachesi and Stucchi, 1997) has substantially improved present knowledge of past seismic history of the country. However, to date, this large data set has not been fully exploited for seismic hazard estimates in Italy. This is mostly due to the peculiar character of information produced by historical research that, due to its semi-qualitative character (in general documentary information is coded in terms of specific “macroseismic” scales), cannot be easily translated in quantitative terms suitable for the application of “standard” methodologies (e.g., Bender and Perkins, 1987) devoted to seismic hazard estimates. This problem may led some people to think that historical information is so “poor” with respect to instrumental data, that its actual contribution to reliable seismic hazard estimates is marginal. Others instead, tend to “force” seismic data deduced from documentary data (macroseismic information) into the frame of categories typical of instrumental data (earthquake

\textsuperscript{1} Dip. di Scienze della Terra, Università di Siena, Siena, Italia. E-mail: albarello@unisi.it.

\textsuperscript{2} Dip. di Strutture, Geotecnica e Geologia Applicata, Università della Basilicata, Potenza, Italia.
epicenter, macroseismic magnitude, etc.). In order to overcome both of these misleading attitudes, it is necessary to develop quantitative methodologies specifically devoted to the use of macroseismic data able to take into account both the specific character of basic information and the different levels of completeness and uncertainty associated with available data.

Some procedures have been presented in the literature to perform seismic hazard estimates by considering the time-varying quality of data (see, e.g., Kijko and Sollevoll, 1990; Egozcue and Rutter, 1997). A new attempt in this direction, specifically devoted to the analysis of macroseismic data and to a more extensive treatment of relevant uncertainties, has been performed in the frame of the National Group for Defence from Earthquakes (GNDT-CNR) and is outlined in the following. The methodology outlined below represents the integration in the frame of a unique coherent formulation of earlier preliminary attempts sparsely reported in the literature (Mucciarelli et al., 1992, 1996; Magri et al., 1994; Rotondi et al., 1994; Guidoboni and Ferrari, 1997; Martinelli and Albarello, 1997).

The practical application of such a methodology is currently limited to the simplest case of the estimate of mean return period. Besides the case studies reported in the aforementioned papers, the methodology has been applied as:

- a comparison with standard probabilistic seismic hazard assessment (PSHA) techniques for 600 Italian towns (Mucciarelli et al., 2000);
- a reference frame for deterministic scenarios for a large town (Azzaro et al., 1999);
- a borrowing strength tool combined with horizontal vs. vertical spectral ratios (HVSR) measurement to identify site amplification (Gallipoli et al., 2000).

In order to show performances of the proposed methodology and its capability, a sample application is shown concerning two sites, both located in Northern Italy: Bologna and Carpi. The results obtained in this way are then compared with analogous estimates obtained by the application of standard PSHA procedures.

2. Methodology

Hazard estimates are essentially an estimate of uncertainty in the form of the degree of belief (quantified in terms of a probability $H$) associated to statements such as: “During a future time span of $\Delta t$ years (exposure time), the site under study will be shaken by at least one seismic event characterised by intensity at least equal to Io.” This definition presumes an “epistemic” view of seismic hazard, which is considered as a measure of our worldwide knowledge (in particular about the future occurrence of earthquakes) and not a property of any stochastic process. Thus, the degree of belief represented by seismic hazard strictly depends on the reliability associated to available information pertinent to the seismic process, past seismicity in the area of interest and other relevant data. In this sense, seismic hazard estimates