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THE APPLICATION OF A HYBRID RECURRENCE MODEL TO THE PROBABILISTIC SEISMIC HAZARD ANALYSIS FOR THE CITY OF CATANIA

A recently proposed renewal hybrid method has been applied for the evaluation of the seismic hazard of the City of Catania (East Sicily). Since the site seismicity appears to be dominated by the Malta Escarpment, an offshore fault developing for over 200 km, the traditional Poissonian model has been used only for the representation of low magnitude background occurrences. The characteristic earthquakes generated by the fault have been described through a renewal process assuming that the event occurrence probability is also function of the time elapsed from the previous characteristic event. In order to have a better representation of the local seismicity a reshaping of the traditional seismic zonation proposed by the Italian Group for the Defence against Earthquakes (GNDT) and a reconsideration of associated seismic events have been required.

The results, mainly in terms of uniform hazard seismic spectra, have been represented also in de-aggregated format in order to define the probabilistic scenario earthquake.

The seismic hazard maps of Italy drawn by the Group for the Defence against Earthquakes (GNDT) (Slejko et. al, 1998) are based upon the representation of the seismicity through a Poissonian distribution of occurrence time and an exponential distribution of magnitudes. The latter is derived from the well-known Gutenberg-Richter (G-R) relationship (Gutenberg and Richter, 1954).

The reliability of both those models is a critical issue, since they have been found to represent adequately the seismic occurrences only in case of large regions embracing a population of several seismogenic faults with a wide range of potential rupture lengths.

The seismicity observed on an individual fault can deviate from the log-linear G-R relationship, generally showing at the higher magnitudes an activity rate greater than the one predicted. In order to explain this bias, Schwartz and Coppersmith (1984) have proposed the characteristic earthquake model.

This theory is based on the geologic evidence that individual fault segments tend to generate earthquakes having a relatively narrow range of magnitudes, magnitudes, associated with the maximum rupture length allowed by the tectonic framework.

Moreover inter-event times of large earthquakes have been observed to be stochastically dependent, transgressing the event memory-less occurrence implied by the Poissonian model. This motivates the attempt to introduce in seismic hazard analysis the representation of the time process through non-Poissonian models that release at all or in part the hypotheses of no-memory process and time-magnitude independence. Among them the most preferred seems to be the renewal process. It is a theory initially proposed to predict the failure probability and maintenance time of mechanical or electrical components like light bulbs and whose main characteristic is to have a one-step memory that considers the time since the most recent critical event has occurred (Cox, 1962).

The concrete application of this kind of model to the Italian case is now topic of
explorative research efforts as shown by several works (Grandori et al., 1984, Peruzza et al., 1996, Romeo and Pugliese, 2000).

The model adopted in the study is based on the work of Wu et al. (1995).

It supposes that the seismic events can be split into two categories:

- small and moderate earthquakes ($P$) follow a Poissonian process in time and an exponential distribution in magnitude within the category boundaries $m^P$ and $m^{P+}$;
- characteristic earthquakes ($C$) follow a renewal process in time and a characteristic earthquake model for magnitudes within the boundaries $m^C$ and $m^{C+}$.

According to the renewal theory, the distribution of the time of occurrence of a characteristic earthquake $p(t)$, is assumed to restart every time $t^*$ a characteristic earthquake has occurred (with obviously $t > t^*$).

The city of Catania has been recently the object of a comprehensive earthquake damage scenario study named “Catania project”. This study was carried out by several national scientific institutions within the GNDT (Italian Group for the Defence against Earthquakes), under the scientific co-ordination of Prof. Ezio Faccioli and funded by the national Civil Defence Department (Faccioli, 1999; Faccioli and Pessina, 1999). Catania is located in a highly seismic area, as demonstrated by historical evidence, which shows two $M \approx 7$ earthquakes in 1169 and 1693. The city, which has been entirely reconstructed after 1693, saw a large expansion immediately after World War II with somewhat relaxed building standards, and especially in the absence of seismic codes, enforced in the municipality only after 1981. This urban evolution is quite typical and can be assumed representative of the situation of several important cities of Southern Italy and other Mediterranean countries facing a high seismic risk exposure. The main assumptions introduced in this study are reported in the following.

In Italy the Seismic Zone (SZ) framework has been defined by Scandone et al. (1992) and assumed as a National standard for seismic hazard analysis by the Italian Group for the Defence against Earthquakes (GNDT). It has mainly been based on the kinematic modelling of main active tectonic units, permitting to define 81 zones homogeneous by the point of view of geodynamics and of rupture mechanisms.

The shortcomings regard the spreading over the same zone of earthquakes generated by master faults and associated minor seismicity. For what concerns the Eastern Sicily area, which falls inside four seismic zones, namely SZ 73, 74, 78 and 79, the tectonic framework is quite complicated in terms of geometry, dynamics and kinematics, and no interpretation has been unequivocally accepted so far. However, recent studies have stressed that the most significant part of local seismicity seems to be concentrated along the Malta Escarpment, an offshore fault supposed to be the source of the strongest earthquakes in the region (Azzaro and Barbano, 2000).

This seismogenetic interpretation clearly outlines as erroneous for the analysed area the assumption of earthquake sources spread all over the whole seismic zone area introduced by the GNDT zonation. Also it generates the suspicion that the standard GNDT hazard assessment procedure can drive, in our case, to lower than real estimates. This has been illustrated by Rebez and Stucchi (1999), who have explored the consequences of a reshaping of SZ 79 until its geographical overlay on the Malta Escarpment.
REFERENCES


