ANNALI DI GEOFISICA, VOL. XXXVI, N. 1, April 1993

Seismic risk assessment on the urban and regional scale in Italy: some examples

Alfredo Corsanego
GNDT, Gruppo Nazionale Difesa dai Terremoti, Roma, Italia

Abstract
Eighteen examples of techniques, test cases and regulations, concerning seismic-risk assessment and mitigation, are presented. They have been chosen so as to offer a quite representative, even if not exhaustive, picture of what has been done in this field in Italy in the decade following the Irpinia earthquake.
Certain fundamental elements are specified for each example, *i.e.* the built system analyzed, the aims, the methodology used.
Some general remarks about the most characteristic features of the Italian situation, reflected in the examples, constitute the main body of this paper.

1. Premise

This kind of discussion for reasons of brevity cannot include extensive references to the concepts and definitions relative to the seismic risk. These can be found in existing works, for example that of the Working Group «*Vulnerability and Risk Analysis for Individual Structures and Systems*» of EAEE (Sandi, 1986), in which the three fundamental components of risk, *i.e.* hazard, vulnerability and exposure, are pointed out; here we will implicitly make reference to it.

2. General considerations

The bibliographical material on the seismic risk on the urban and regional scale in Italy, relative to the decade following the Irpinia earthquake, which dramatically revealed to public opinion that this risk was very high, gives a very varied picture and is not easily adapted to subdivision into classes, even though some classifications are possible.

The first classification can be referred to the nature of the published works; in this field in Italy there are:

(W1) test cases;
(W2) techniques;
(W3) regulations.

A second classification is applicable to the built systems analyzed, which can consist of:

(S1) stocks of buildings;
(S2) classes of buildings;
(S3) towns or cities;
(S4) areas;
(S5) regions;
(S6) networks.

A third classification may concern purposes; there are works aimed at:

(P1) town planning;
(P2) codes;
(P3) risk mitigation policies;
(P4) management of the emergency;
(P5) increase in knowledge.

A fourth classification is connected with the methodologies used; this is more complicated because, in the existing works about risk, there are varied combinations of the different techniques separately applicable to hazard, vulnerability and exposure, which essentially consist of:

(M1) methods based on theoretical behaviour models;
(M2) methods based on the statistics of observed events;
(M3) methods based on conventional indices;
(M4) qualitative methods;
(M5) mixed methods.

Because of the combinations, most of the methodologies turn out to be of the mixed type.

Here follow eighteen examples, they have been selected in order to offer a reasonably representative panorama of the test cases, techniques and regulations concerning Italy, developed in the decade after the Irpinia earthquake.

The examples of test cases are taken from the following towns, areas and Regions:

(01) Campania Region and Basilicata Region (Siro, 1982);
(02) Gubbio (Benedetti *et al.*, 1988);
(03) Noto (Coburn *et al.*, 1984);
(04) Friuli Region (Yang *et al.*, 1989);
(05) Etnean area (Lo Giudice and Novelli, 1989);
(06) Pozzuoli (Benedetti *et al.*, 1984; Giangreco, 1985);
(07) St. Arsenio (Angeletti *et al.*, 1990);
(08) Tuscany Region and Emilia Romagna Region (Petrini *et al.*, 1988);
(09) Syracuse (Giuffré *et al.*, 1988);
(10) Ancona (Stucchi, 1988).

The regulations refer to the Regions indicated here:

(11) Emilia Romagna Region (Bressan *et al.*, 1986; Regione Emilia Romagna, 1990);
(12) Marche Region (Dramis *et al.*, 1986; Regione Marche, 1990).

The techniques have been principally applied in the following Regions and towns:
(13) Campania Region (Zuccaro, 1989);
(14) Abruzzo Region (Ciampoli *et al.*, to appear);
(15) Tuscany Region (Imbesi, 1989);
(16) Umbria Region (Augusti and Borri, 1986);
(17) Calabria Region (Caldaretti *et al.*, 1987);
(18) Rimini (Regione Emilia Romagna and GNDT, 1989).

Table I has a summary scheme of the list of examples, in which the nature of the works carried out, the systems analyzed, the purposes and the methodologies are illustrated.

3. Some remarks

This section offers informally some comments on the examples, from the engineering point of view.

The values at risk considered in the assessments have been mainly economic values (*e.g.*, Examples 02), 04), 08)), assumed to be conventional measuring elements, and also human lives (*e.g.*, Examples 03), 08)). In some cases, risk has been evaluated with reference to the interruption of activities carried on in the buildings (*e.g.*, Examples 06), 08)); in others, more tied to the problems of the conservation of urban nuclei, the fabric of buildings in itself has been considered the element at risk (*e.g.*, Examples 03), 09)).

Table I. A scheme of the examples presented.

Example	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Type of work	W1	W1	W1	W1	W1	W1	W1	W1	W1	W1	W3	W3	W2	W2	W2	W2	W2	W2
System	S3	S1	S1	S5	S4	S1	S3	S2	S3	S3	S5	S5	S4	S6	S4	S5	S5	S3
Purpose	P4	P3	P5	P5	P2	P4	P3	P3	P3	P1	P1	P1	P1	P5	P1	P5	P3	P1
Methodology	M4	M5	M2	M2	M2	M3	M3	M5	M4	M4	M5	M5	M5	M1	M5	M5	M1	M5

The classic formulation of seismic-risk assessment followed in different parts of the world is of the probabilistic type. This is reflected in the well-known definition given by the EERI Committee on Seismic Risk (1984): «the probability that social or economic consequences of earthquakes will equal or exceed specified values at a site, at several sites, or in an area, during a specified exposure time». It results from this that the articulation of a risk assessment consists, for hazard, of the determination of exceedance probabilities concerning the intensity or other quantities such as the ground acceleration; for vulnerability, of the specification of probabilities of damage of built systems, given the intensity or the ground acceleration (primary vulnerability), and of the assigning of probabilities of adverse consequences for elements at risk, given the damage (secondary vulnerability) or, directly, of the specifying of probabilities of adverse consequences, given the intensity or the ground acceleration (summary vulnerability); for exposure, of a measure of the value of the elements at risk and in a probability of exposure. This scheme is reflected in various examples given here, in particular in Examples 02),...,08). There are however cases in which other approaches have been used in place of the probabilistic one. In particular it should be noted how, also in this field as in many others, lines of thinking are developing which tend to exploit the qualitative methods and to insert them in appropriate formal algorithms (see, for instance, Examples 01), 09), 10)).

The use of indices for characterizing local hazard (Example 02)), vulnerability (Examples 02), 06), 07), 08)), exposure (Examples 08), 10), has had quite important developments in Italy. Further research efforts are required for the problem of associating the indices with suitable relations between cause and effect, which, in the cases quoted, have been instituted on statistical bases or using expert judgement.

The majority of the examples given here have used Poisson models of seismicity. The hazard assessment has consequently produced intensities or ground accelerations having certain yearly probabilities of exceedance or certain return periods. In some cases instead (Examples 06), 09)) the maximum historical earthquake has been used as a reference. As for the local hazard variations due to the nature of the soil, semi-empirical treatments based on geological data have prevailed. The geotechnical characterization of sites and the consequent possibilities of making numeric models of the soil are, in effect, hindered in Italy by the complexity of the environmental scenarios and the frequent scarcity of available means for on-site investigations.

A point of origin of risk assessment on the urban scale in Italy can be found in Example 01) (Siro, 1982). After the earthquake of 23 November 1980, the National Geodynamics Project (PFG) organized, in collaboration with several Regional Administrations, a campaign of qualitative microzoning in towns in Campania and Basilicata (PFG, 1983), having the objective of furnishing urgent indications for planning the reconstruction. Some of the teams of researchers involved in the operation did not limit themselves to the hazard sector but extended it to the vulnerability and exposure sectors. Qualitative risk assessments emerged from this, based on linguistic variables and on rules, which were afterwards formalized by means of the fuzzy set theory (Corsanego, 1984).

A different and very particular qualitative-approach version is that given more recently by the Example 09) (Giuffré *et al.*, 1988), devoted to offering guidelines for mitigating the risk to old buildings; in this approach historical data and the observation of building typologies have been used. The chronology of the macroseismic intensity (according to the MCS scale) manifested in the past in the urban nuclei has been interpreted as an instrument for arriving at the knowledge of the damage caused by previous earthquakes and for making forecasts for the future one, on the hypothesis that the typology of the buildings has remained substantially the same in time. In many Italian urban nuclei, like that of Syracuse, this hypothesis can be considered justified.

Examples 02) and 03) are relevant because, in them, two alternative methodologies, today very widespread in Italy, are used to assess vulnerability. Both refer to Poisson laws for seismicity. For exposure, the first has taken economic values and human lives account while the second has not introduced specific elements at risk.

Example 02) (Benedetti *et al.*, 1988), which, as its object, has the stock of ordinary buildings in Gubbio and which is part of a wider research programme regarding Umbria (Augusti *et al.*, 1986; Regione Umbria, 1989), is aimed at identifying upgrading strategies for the existing buildings. As has been mentioned above, this determines the vulnerability of the buildings in terms of an index, assessed on the basis of a methodology of Benedetti and Petrini (1984). The modality for defining the index according to this methodology is based on the definition of a certain number of behaviour factors (structural layout, foundations, etc.). For each factor there is a finite number of possible levels described by detailed rules and characterizing progressively worse behaviour. On the basis of the level associated with the generic factor, a partial vulnerability index is assigned to this. The global index concerning the whole building is obtained from the partial ones by means of a weighted average. Also for the local fluctuations of the hazard due to the soil, a conceptually analogous index, given by a methodology of Augusti *et al.* (1985), has been used: this is based on soil behaviour factors (morphology, discontinuities, etc.) and on different possible levels which can be associated with each factor.

Example 03) (Coburn *et al.*, 1984) has, as its object, the stock of ordinary buildings in Noto. Vulnerability has been estimated by applying a statistical method introduced by Braga *et al.* (1982) and based on the observation of the damage caused by recent Italian earthquakes. The characteristic element of the methodology is the introduction of typological building classes, obtained through the intersection of types of vertical structures (hewn stone masonry, brick masonry, etc.) and horizontal structures (wooden floors, r.c. floors, etc.); for each class probabilistic relations between intensity and damage are given. The influence of the soil has been analyzed, specifying a set of cases of soil-building typologies, on the basis of the situations that recur in that town (Hughes, 1984).

In the old Italian towns seismic risk is notably influenced by a vulnerability added to the one involving buildings, namely the so-called urban vulnerability due to the configuration of the town and the modality of its use. In Example 7) (Angeletti *et al.*, 1990) which refers to an assessment made in St.Arsenio and in which, as in the two preceding examples, Poisson models of seismicity have been used and evaluations of the local effects based on the geological characterization have been carried out, urban vulnerability has been taken into consideration with a corrective index which takes account of the location of the building within the urban structure, of the distance between buildings and «safe places» and of the morphology of the town.

While in the test cases discussed above the objects of study were stocks of buildings belonging to an urban nucleus, in Example 08) (Petrini, 1988) a functional class of buildings - Public Buildings - has been examined in a vast area of Tuscany and Emilia Romagna, with the objective of formulating a preliminary classification, in terms of risk, within the class. The vastness of the area has clearly made it necessary to bear in mind, in this case, the spatial variation of the seismicity which was assumed to be uniform in the previous cases. Another aspect that distinguishes this example consists of the use of several techniques to assess the vulnerability of the buildings according to their type of structure; the unitary approach has been maintained by assuming a single linear law between ground acceleration and damage, and each technique has been considered as an instrument to use only for quantifying the linear law for each type of structure, through the specifying of the accelerations that produce the onset of damage and there the collapse. A third aspect derives from the attempt to express exposure by means of an index; as it is a question of Public Buildings, the index has been made to depend on both their occupation potential and also on the activities carried out inside them.

A risk which cannot be ignored in Italy is the one connected to surface seismicity. These phenomena are examined, in very different contexts, in Examples 05) and 06).

For Example 05) (Lo Giudice and Novelli, 1989) in which the risk in the area influenced by Volcano Etna has been examined with the aim of contributing to *ad hoc* regulations for mitigating it, the particularity of the presence of two seismic hazards is noticeable: one connected to regional seismicity and one linked to the activity of the volcano. The latter is characterized by surface focal centres and therefore by noteworthy tremors localized in restricted zones.

Example 06) (Benedetti *et al.*, 1984; Giangreco, 1985) refers to an assessment made in Pozzuoli to evaluate the risk implied by the bradyseismic phenomena which recur historically in that town and which at the beginning of the Eighties caused damage to buildings and made some of them unusable. Hypothesizing an event of intensity equal to 7MSK degree, the analysis was mainly directed towards the risk of unusability. We can observe the use of a technique for assessing vulnerability based on indices similar to but not the same as those used in other cases mentioned above; a clear difference is the connection between indices and expected damage, which in the cases in question had statistical bases while in Pozzuoli it was based on expert judgement.

A serious obstacle to the development of risk assessments on the regional scale in Italy is the high cost of the surveys to be carried out to obtain the data about the buildings, necessary to assess their vulnerability. Example 04) (Yang *et al.*, 1989) reveals the possibility of carrying out, even in special situations, assessments using data which already exist about building property. With reference to Friuli, classes of buildings have been constituted on the basis of their age (which is a generally available element). The costs of damage repair, assumed as measurers of the seismic impact, have been evaluated for each class on the basis of the MSK intensity, using data from the earthquake of 6 May 1976. A Poisson model of the region's seismicity there has enabled the construction of regional maps of risk for an assigned return period.

Among the different aims that a risk assessment can have when carried out in a town, that of giving support to the drawing up and up-dating of the Town Plan is certainly very important. The great value of this support has been little understood, in Italy, by the Local Administrations. Ancona is a notable exception where, for the revision of the existing Town Plan, they decided to make a risk assessment, which makes up Example 10) (Stucchi, 1988); the work carried out was based on relative-risk concepts which deserve to be illustrated.

The town was subdivided into zones which were sufficiently homogeneous within themselves. The seismic risk in each was considered to be divisible into two parts: an average risk characterizing the zone complex and a relative risk which represents the fluctuation with respect to the average given by the single zones. A possible zone whose risk coincided with the average one and whose relative risk was therefore nil was defined as «standard».

The following alternative was then established:

a) the average risk is rather higher than that considered acceptable in Italian towns; political decisions are therefore called for.

b) The average risk is comparable with or less than what is considered acceptable in Italian towns; urban planning can then be relied upon to level out the fluctuations, transforming the present zones into standard zones.

The example of Ancona, where the maximum historical earthquake was taken as a reference point because of its non-high seismicity, is in situation b).

The assessment in question should be mentioned also because of the wide use of qualitative methods which fit it into a methodological current already discussed.

Examples 13),..., 18) do not respond to effective-risk assessments because they have more indirect objectives or because, up to now, they have only developed preliminary phases; however, they have interesting elements which make, at least, a summary appropriate.

In most of the works commented on here, we see an examination process of inhabited territory in which the starting point is the forecasting of the damage to buildings and its direct consequences (victims, costs of repair) and the substantial consideration of the other components of the seismic impact as expressible in terms of these consequences. This approach constitutes a methodological way that is, by now, consolidated. However, researchers nearer to the planning field on the regional scale have observed that, reducing complex realities to a few global parameters, it does not allow the reading of the individualized risk of every inhabited centre, each one of which is an organism with a history and physiognomy. Other approaches have therefore been proposed (Imbesi, 1988), to be understood as complementary to the usual ones, in which the course of the risk assessments passes through the different forms of conurbation (city, town, village, quarter).

This alternative vision is present in studies carried out in Tuscany (Regione Toscana and GNDT, 1986), where, starting from a preliminary assessment on the regional scale in which only hazard and exposure are examined, the studies pass on to more and more circumscribed assessments in which hazard, vulnerability and exposure are determined by more and more detailed procedures until reaching the single building scale. Example 15) (Imbesi, 1989) refers to preliminary assessment and has analyzed the part of it that concerns exposure; using clustering operations it has classified the cities on the basis of three requisites (population, functions, capacity to attract) and the road networks on the basis of five requisites (functions, impact, connection, feeding, replaceability).

Investigations carried out in Emilia Romagna at Rimini which make up Example 18) (Regione Emilia Romagna and GNDT, 1989) can be considered similar with regard to the gradualness of the approach. Also these are self-defined as preliminary but put themselves in the urban scale and therefore refer to more limited spatial ambits than that in Example 15); their characteristic is that of defining a certain number of indicators of vulnerability and exposure by means of the processing of already existing data, in particular the information afforded by the ISTAT census, saving the carrying out of surveys to a later, more detailed assessment phase.

The relationships between risk assessments aimed at policies for its mitigation and the effective putting into action of those policies have always been difficult in Italy. Knowing this it seemed appropriate that extremely clear representations of the consequences of the various possible decisions and of the costs and benefits connected to the modifications that each decision could bring to seismic risk, were offered to Public Bodies. Representations of this kind obviously require computerized management of the data at the regional level and of the processes for the communication of these data. Example 13) (Zuccaro, 1989), concerning Campania and Example 16) (Augusti and Borri, 1986), concerning Umbria, show that research meant to give this support.

A considerable gap in the series of studies made in Italy in the last decade is the scarcity of research into the risk to the networks (communication systems, energy supply, etc.). It is well known that the breakdown of a network can have very serious consequences in the emergency after an earthquake but can have grave effects also in the next phase; the lack of a coordinated complex of activities in this sector must be seen as a negative factor. Among the few works produced up to now, Example 14) (Ciampoli *et al.*, to appear) has examined a part of the medium-voltage electrical network serving an area round Pescara in Abruzzo and assessed the collapse probability of the system, schematized in a graph, using a minimal path set approach. In Example 17) (Caldaretti *et al.*, 1987) the road network in an area of Calabria has been analyzed; this has also been schematized in a graph and an «inconvenience» caused by seismic damage to the network has been assumed as a significative parameter for the estimate of risk.

We end these informal comments with some considerations about the important question of the introduction of Regulations and Guidelines that establish criteria for the carrying out of seismic-risk assessments and for their utilization for the use of territory.

In Italy, Law 741 of 10 December 1981 stipulates that the regional Administrations must issue Regulations so that Town Planning contributes to the mitigation of seismic risk.

In reality, the application of this law in the following years has been very unequal in the different Regions. In most of them, in effect, the Regulations issued have only concerned measures for the mitigation of the geological components of seismic risk without facing the theme of seismic risk in its complexity. There are two important exceptions in Emilia Romagna and Marche. In both these Regions the Regulations have also been furnished with Guidelines, which form Example 11) (Bressan *et al.*, 1986; Regione Emilia Romagna, 1990) and Example 12) (Dramis *et al.*, 1986; Regione Marche, 1990) and which have sufficiently similar general characteristics to permit a single discussion.

The leading element in the Guidelines is, above all, the sub-division of the Region into three zones with different seismicity. Within this macrozoning inhabited centres are taken into consideration and the urban planning is given the task (among others) of rebalancing in them the seismic risk, whose spatial fluctuations are taken from a graduation, between homogeneous urban areas, obtained by means of a triple classification respectively of the soil (for local hazard), the buildings (for vulnerability), the elements at risk (for exposure). The conceptual approach is like the one experimented in Ancona, which has been an important «test-bench» for Marche; the Rimini experience has provided the «test-bench» for Emilia Romagna.

A notably positive element in these Guidelines is their flexibility which permits them to be adapted to the multiplicity of local situations.

4. Conclusions

The picture presented here shows that the seismic-risk assessments carried up out to now in Italy and the methodologies associated with them are a very varied mosaic.

The interesting elements that emerge from this mosaic are quite numerous. But a gap is also clear. It is the gross lack of a non-occasional link between the world of research and that of decisions about the use of territory.

The development in the coming years of valid action for the mitigation of seismic risk in Italy will depend on a better integration of these two worlds.

REFERENCES

ANGELETTI, P., A. CHERUBINI, C. GAVARINI and V. PETRINI (1990): Assessing seismic risk in historical towns, *9th European Conference on Earthquake Engineering, Moscow, 1990*, orally presented report.

AUGUSTI, G., A. BORRI and T. CRESPELLANI (1985): Dynamic maps and seismic risk reduction, *Proceedings of the International Conference on Reconstruction, Restoration and Urban Planning of Towns and Regions in Seismic Prone Areas, Skopje*, pp. 67-76.

AUGUSTI, G., D. BENEDETTI and A. CORSANEGO (1986): Investigations on seismic vulnerability and seismic risk in Italy, *Proceedings of the 4th International Conference on Structural Safety and Reliability, Kobe*, Vol. 2, pp. 267-276.

AUGUSTI, G. and A. BORRI (1986): Vulnerability data and seismic risk assessment: an example of dynamic mapping, *Proceedings of the 8th European Conference on Earthquake Engineering, Lisbon*, Vol. 1, 3.1-3.8.

BENEDETTI, D. and V. PETRINI (1984): On seismic vulnerability of masonry buildings: proposal of an evaluation procedure, *L'Industria delle Costruzioni*, **18**, 66-78.

BENEDETTI, D., F. BRAGA, A. CORSANEGO, C. GAVARINI, C. GRECO, F. M. MAZZOLANI, G. MELE, R. RAMASCO and G. ZINGONE (1984): Indagine sulla vulnerabilità sismica degli edifici di Pozzuoli, *Proceedings of the 2nd Italian Conference on Earthquake Engineering, Rapallo*, pp. 63-80.

BENEDETTI, D., G. M. BENZONI and M. A. PARISI (1988): Seismic vulnerability and risk evaluation for old urban nuclei, *Earthquake Eng. Struct. Dyn.*, **16**, 183-201.

BRAGA, F., M. DOLCE and D. LIBERATORE (1982): A statistical study on damaged buildings and an ensuing review of the MSK/76 Scale, *Proceedings of the 7th European Conference on Earthquake Engineering, Athens*, Vol. 7, pp. 431- 450.

BRESSAN, G., G. POLI, M. SANI and M. STUCCHI (1986): Preliminary, low cost, urban planning oriented investigations in seismic areas: a methodology and some applications, *Proceedings of the International Symposium on Engineering Geology Problems in Seismic Areas, Bari*, Vol. 4, pp. 397-406.

CALDARETTI, S., W. FABIETTI and A. RIGGIO (1987): *La vulnerabilità sismica dei sistemi territoriali* (DEI, Roma).

CIAMPOLI, M., R. GIANNINI, C. NUTI, T. PAGNONI and P. E. PINTO: Valutazione del rischio sismico delle reti di trasmissione dell'energia elettrica (to appear).

COBURN, A.W., L. P. LEONE, R. J. SPENCE and R. WILHELM (1984): An approach to urban seismic vulnerability assessment: the case of study of Noto, Sicily, *Proceedings of the International Seminary "Vulnerabilità ai Terremoti e Metodi per la Riduzione del Rischio Sismico", Noto*, pp. 83-112.

CORSANEGO, A. (1984): Indagini diagnostiche veloci in zone sismiche; una trattazione in termini di insiemi fuzzy, *Proceedings of the International Seminary "Vulnerabilità ai Terremoti e Metodi per la Riduzione del Rischio Sismico", Noto*, pp. 267-280.

DRAMIS, F., G. MONACHESI, C. PACE, F. PERGALANI and M. STUCCHI (1986): Seismic-safe urban planning: analysis of an approach and some results of the investigations carried out on some urban areas in the Marche Region, Central Italy, *Proceedings of the International Symposium on Engineering Geology Problems in Seismic Areas, Bari*, Vol. 4, pp. 455-469.

EERI Committee on Seismic Risk (1984): Glossary of terms for probabilistic seismic-risk and hazard analysis, *Earthquake Spectra*, **1**, 33-40.

GIANGRECO, E. (1985): Il «Caso Pozzuoli» nel quadro bradisismico-vulcanico dell'Area Flegrea, *Proceedings of the Conference on Seismic Risk, Pescara*, pp. 25-47.

GIUFFRE', A., M. ZAMPILLI, V. CERADINI and A. PUGLIANO (1988): *Centri storici in zona sismica. Analisi tipologica della danneggiabilità e tecniche di intervento conservativo* (Dipartimento di Ingegneria Strutturale e Geotecnica, Università La Sapienza, Roma).

HUGHES, R. (1984): The seismic vulnerability of the historic city of Noto, Southern Sicily, *Proceedings of the Interna-*

tional Seminary «Vulnerabilità ai Terremoti e Metodi per la Riduzione del Rischio Sismico», Noto, pp. 155-202.

IMBESI, G. (1988): Rischio sismico e cultura del piano, in *Una geografia per la pianificazione*, edited by P. M. MURA (Gangemi, Roma).

IMBESI, G. (1989): *Analisi dell'esposizione all'evento sismico dei sistemi territoriali della Toscana* (Dipartimento di Pianificazione Territoriale e Urbanistica, Università La Sapienza, Roma).

LO GIUDICE, E. and F. NOVELLI (1989): Valutazione preliminare del rischio da sismicità superficiale dell'area etnea, *Proceedings of the 4th Italian Conference on Earthquake Engineering, Milan*, Vol. 1, pp. 54-87.

PETRINI, V. (coord.) (1988): *Valutazione di criteri di priorità in base ai livelli di rischio di singoli edifici* (Ministero della Protezione Civile, Roma).

PFG (1983): *Indagini di microzonazione sismica* (Roma).

Regione Emilia Romagna (1990): Proposta al Consiglio Regionale di adozione di indirizzi per la formazione dei piani regolatori generali comunali e loro varianti, Bologna.

Regione Emilia Romanga and GNDT (1989): Analisi delle caratteristiche del patrimonio edilizio ai fini della organizzazione di indagini sulla vulnerabilità, Bologna.

Regione Marche (1990): Relazione tecnico-illustrativa della Circolare n.17 ex L.33/84, Art.10/11, Ancona.

Regione Toscana and GNDT (1986): Progetto terremoto in Garfagnana e Lunigiana, Firenze.

Regione Umbria (1989): Conoscere il rischio sismico, Perugia.

SANDI, H. (coord.) (1986): Report of the Working Group EAEE «Vulnerability and Risk Analysis for Individual Structures and Systems», *Proceedings of the 8th European Conference on Earthquake Engineering, Lisbon*, Vol. 7, pp. 11-69.

SIRO, L. (1982): Microzonations in the emergency: a short technical report, *Proceedings of the 7th European Conference on Earthquake Engineering, Athens*, Vol. 7, pp. 419-429.

STUCCHI, M. (coord.) (1988): *Comune di Ancona. Indagine per la valutazione e la riduzione del rischio sismico con riferimento alla Variante Generale al PRG* (Consiglio Nazionale delle Ricerche, Milano).

YANG, W. S., D. SLEJKO, D. VIEZZOLI and F. GASPARO (1989): Seismic risk in Friuli-Venezia Giulia: an approach, *Soil Dynamics and Earthquake Engineering*, **8**, 96-104.

ZUCCARO, G. (1989): Un modello computerizzato di rischio sismico per la regione Campania - SISMA, *Proceedings of the 4th Italian Conference on Earthquake Engineering, Milan*, Vol. 1, pp. 88-105.