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Protection from earthquake damage provided by seismic classification and code in Italy

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ABSTRACT In terms of victims and damage, the loss due to earthquakes in Italy appears to be too high when compared to the average level of seismic hazard. Many reasons can be given to contribute to the situation: historical, economic and social. While technical skills and norms are at a similar level to the most advanced countries in the field, something needs to be changed in the socio-economic behaviour. This certainly includes a major effort to diminish the vulnerability of the pre-code buildings and more attention to the epicentral effects that cannot easily be regulated by the seismic code.

Key words: seismic classification, epicentral effects, Friuli earthquake, NE Italy.

1. Introduction

Protection against earthquake damage is a complex task. However, with the pre-requisite of a sound knowledge of the seismicity, it can be achieved with a modern seismic code suited to the culture, property and social behaviour of the country, by its rigorous application to new and old buildings, as well as by an efficient system of post-earthquake intervention (emergency management).

This paper gives a brief review of the state of art in Italy regarding how seismicity is defined. It goes on to make some proposals to overcome a number of the inadequacies in the system. These are very often at the roots of the extent of damage and number of victims, which are greater than one would reasonably expect from most of the moderate earthquakes affecting our country. Just for a rough comparison, it should be noted that in the last century in Italy there have been no more than three earthquakes of magnitude between 7.0 and 7.5 compared to at least eight in California and Japan (maximum 7.8 and 7.9, respectively).

The picture changes considerably if victims and damage are taken into account: in the 20th century, the casualties exceeded more than a 1000/year and in the last 40 years the annual expenditure for reconstruction and repairs has amounted to at least 4 billion euros. It goes without saying that it is nearly impossible to include, in terms of monetary cost, the deaths and enormous loss of priceless historical and artistic heritage.

Many factors contribute to this situation:

1) high population density (206 inhabitants/km^2; 140 in China, 31 in the U.S.A.);
2) the old age of a multitude of buildings (the year 1340 on the pediment of the university building where I graduated indicates its foundation) and consequent increase of vulnerability, due to ageing, even to minor shocks. It should be added that the situation

has often worsened because the demand for new housing has been met by adding new structures to old buildings, with scarce consideration for the possible effects of introducing asymmetries, increasing horizontal forces and overweighting the vertical structures (exemplary here is the case of the school of San Giuliano di Puglia, the only building in the region to collapse owing to the earthquake of 31 October 2002);

3) long return period of major earthquakes that contributes to lowering attention and awareness, of both the people and administrators, of the problem of seismic risk. For many years in the past, the location of part of villages and cities was chosen mainly to avoid malaria or depredation by pirates, whose risks were deemed primary. Nowadays, public administrators seem to consider spending public resources on lowering seismic risk, which in practice means reducing the vulnerability of existing buildings, as barely worthwhile, at least in terms of generating popularity and consensus Indeed, it is difficult for a legislator to demonstrate that his actions have saved lives and prevented damage. Experience shows that if a legislator performs well during an emergency and for the reconstruction, then also the previous legislator, who may have done nothing constructive, also gains a certain benefit and consensus.

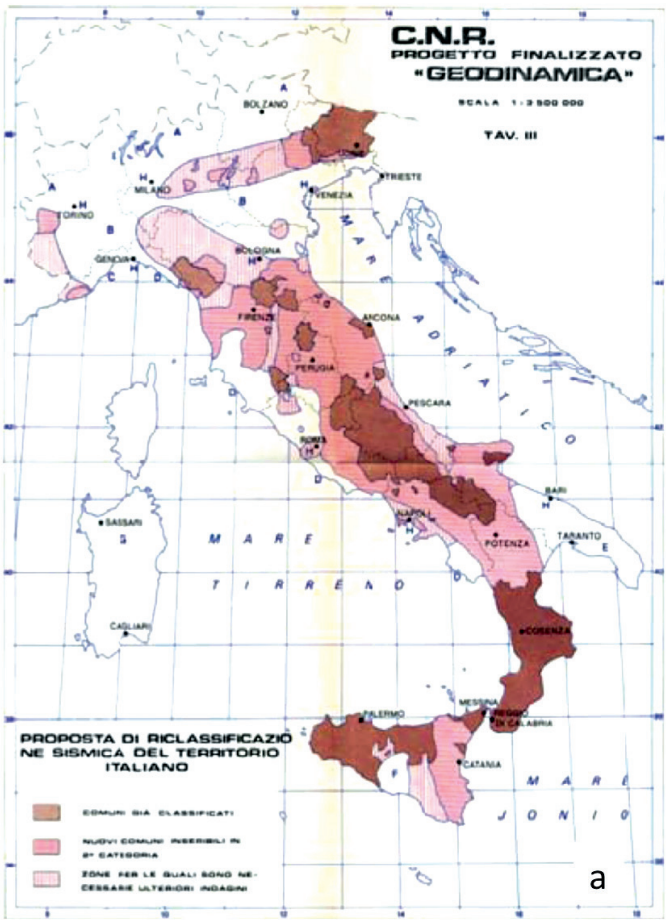
2. A short historical overview

The first highly destructive earthquake of the newly created Kingdom of Italy (1861-1946) hit the Messina-Reggio Calabria region on 28 December 1908. Messina was nearly razed to the ground by the shock and the following fire and tsunami. The echo of the event was heard all over the world, still reeling from the devastation of San Francisco earthquake in 1906. Soon after, with the Royal Decree n. 13 of 18 April 1909, the first Italian seismic law was promulgated. This had to be applied, perhaps rather incomprehensibly, only in the areas "hit by an earthquake". The nature of destructive earthquakes in terms of intensity, number of victims and extent of damage, were left to the arbitrary interpretation of the administrators (mainly the Minister of Public Works) who were in charge at the time. The concept of "earthquake prone areas" (i.e., seismic areas) was introduced only in 1984 after the disastrous Irpinia earthquake in 1980, following a proposal contained in a study made by a group of scientists of the Italian Geodynamics Project (PFG) led by V. Petrini (CNR-PFG, 1980) and commissioned by the Minister of Public Works. In the meantime, all the major earthquakes hit "aseismic areas".

The fatal consequence of this "philosophy", though never clearly stated but enacted with great perseverance, was the increase of the "seismic debt" of the country or, in other words, the continuation for nearly 80 years of building and planning cities without any consideration of their real seismicity. In such a way, we also missed the chances of ameliorating the situation given by the massive reconstruction efforts after the two world wars and during the decade of the so-called economic boom.

The main principles of the PFG proposal (Fig. 1a) were:

1) the seismic code needed to be graded according to the different level of hazard in which the territory was subdivided on the basis of the seismic history (1000 years) and the seismotectonic features;



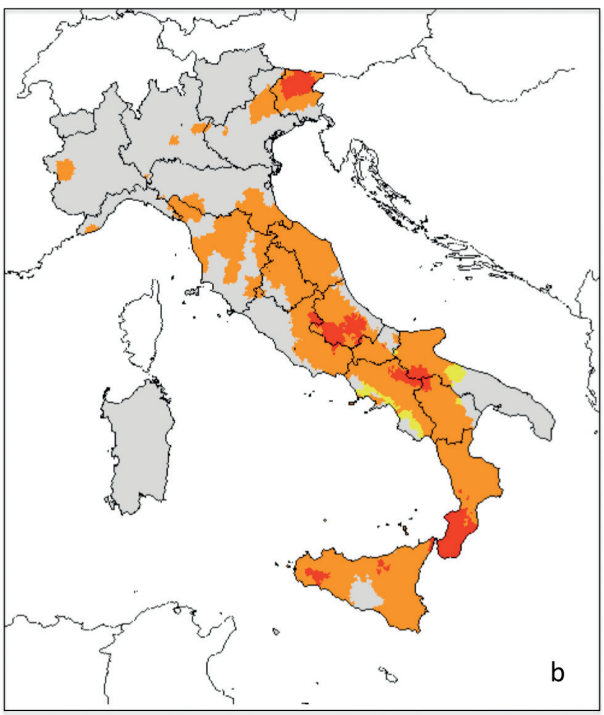


Fig. 1 - Italian classification: a) PFG proposal of 1980; b) official classification established between 1980 and 1984: red = first category (the most seismic), orange = second category, yellow = third category.

2) equality: the same level of risk compatible with the amount of resources that the state decides to assign must be assured to all citizens. Obviously, this implies a careful balance between costs and benefits;
3) in the first application the initial level of acceptable risk must be the same as what was implicitly decided, on average, from 1909 onwards. In a certain sense it was surprising to ascertain that statistical analysis gave the VIII degree of the MCS scale as the average criterion implicitly adopted to define an area as "hit by an earthquake" or seismic zone;
4) risk also depends on the return period and the maximum historical earthquake;
5) the marginal cost of one saved life must be acceptable. The statement cannot be directly transferred into laws and codes, but it is important to remind lawyers, judges and administrators that a far from negligible part of risk management must be handled not only from a correct technical vision, but also by paying due attention to the socio-cultural environment. Otherwise, it could, for instance, happen that the principal of a school, after an event causing deaths among junior students, was declared guilty because of failing to let them out of school despite the widespread rumours of an impending earthquake (rumours based on hypotheses officially declared unsustainable by the special scientific committee appointed by the board of the civil protection). In addition, the principal could be charged for not having retrofitted the edifice despite the "impending earthquake". There is also the concern that in the case of a false alarm (no earthquake occurred), a school principal may be accused of interrupting a public service and failing in the supervision of minors. Considering it is beyond doubt that the legislator has faithfully applied the law (hence accusing the principal), it follows that something in the law is not quite right.
6) the same level of hazard must be assigned to the whole seismogenic structure known to be responsible for a destructive earthquake.

3. The current trend

In the last 30 years, together with continuous improvements in the technical regulations for building, the prevailing approach in the policy of defence against earthquakes has been a constant tendency to increase the reference horizontal ground acceleration. In such a way attention has gradually been shifted to the earthquakes with longer return period, earthquakes that, in some cases, have never happened in the last 2000 years.

Only at first glance may this "overprotection" seem positive. Actually, it produces a major increase in the marginal costs, discourages effective policies and, if enacted, increases the inequality of the risk between those citizens living in old or new buildings.

The question arising is: does the increase of the reference horizontal ground motion give acceptable results when assessed with due care to the cost/benefit ratio?

The response is that while in the far field the resulting reduction of the vulnerability has positive effects, in general it is highly dubious: experience shows that many of the last devastating earthquakes affecting our territory are relatively shallow and therefore characterized by a large amount of near field effects, torsional effects already described by Mallet (1862),

permanent vertical displacements, large vertical ground accelerations like those causing so many collapses of industrial warehouses in the Emilia-Romagna region (2012), and activation of fossil landslides, which cannot be tackled with such a simple approach.

4. A brief look at Friuli

After 50 years, the memory of the tragedy is still alive in the community [see Slejko (2018) for an overview of the 1976 Friuli earthquake]. In a sense, the year 1976 is a new temporal watershed, replacing the Second World War (it is a common saying: "before or after" the earthquake) in popular sentiment (see Slejko *et al*., 2018).

People in the region are very proud of the way in which reconstruction has been completed; it is worth pointing out that never before in Italy has the final result been so good and rapidly achieved (see Zamberletti, 2018).

In ten years not only has nearly everything been restored, but economic development has also had a significant boost: new infrastructure has been established, a new university (in Udine) and an important research centre (the Centre for Seismological Research, in Udine, which is a section of the National Institute of Oceanography and Experimental Geophysics - OGS) have been fully funded, activities connected with both private and public buildings have had a significant increase. Moreover, during this decade administrators and politicians have been closer than ever to the real needs of their communities.

The picture looks even better when considered in relation to what happened before and after in Italy. Many factors have contributed to this; worthy of mention are the unswerving support from all over the world, inspired also by the contribution given by Friulian emigrants, the new administrative and legislative (see Carpenedo, 2018) system, as well as the timeliness and flexibility with which the regional assembly alleviated or removed most of the bureaucratic obstacles that unnecessarily hinder progress and growth in Italy (as demonstrated by the extent of corruption afflicting our country). In this respect, it is a remarkable fact that, in ten years, only one case of malfeasance has been judged and sentenced.

Obviously, not everything went smoothly and correctly, but the negative points cannot spoil the entire process. Nonetheless, instead of ignoring them, they should be matter for reflection to make improvements in what is generally (and somehow improperly) called the "Modello Friuli".

5. The future

Setting aside the obvious considerations on the possibility of further improvements in technique, skills and rules for building in earthquake prone areas, a radical change in our policies seems unavoidable. It should be based on:

1) major pluriannual financial and technical effort to face the problem of the old (pre-code) buildings in which more than half the population live. A side effect could be an increase in the gross domestic product, mostly in the less industrialized areas of the country where the effect of the recent and long-lasting economic recession has been the strongest;

2) switching the focus from high acceleration to near field effects (Grimaz and Malisan, 2014). As far as they are foreseeable, it would probably be effective to individuate areas to be declared "restricted". With whatever caution necessary, any construction of buildings of paramount importance owing to their utility during emergencies (hospitals, fire stations, main power plants, telecommunication exchanges, etc.) or because of the high population density (schools, great industrial plants, and so on) should be prohibited in such areas. In our legislation, they are defined as "strategic edifices". The numerous descriptions of past earthquakes, the thousands of isoseismal maps collected and thoroughly revised in recent years and the accurate geologic and geomorphological data sets accompanied with detailed microzoning, could make such an approach feasible in most of the seismic areas;
3) it is very likely that important results could, however, be achieved simply by avoiding wrong and/or fraudulent practices in designing and building, together with re-introducing strict testing of work in progress.

In conclusion, it is worth highlighting that in the years following the Friuli and Irpinia earthquakes there has generally been a positive trend in the struggle against earthquakes: better laws and rules, better preparedness for the events, better general culture (reflected, for instance, by the conduct of the communication media). Nonetheless, there remains the paradox that the more (in truth the only) active and pro-positive Regions are, generally, those with less seismic hazard.

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