Geotechnical engineering practice and the implementation of Eurocode approach in Italy

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ABSTRACT: Since 2003 several efforts have been done in Italy by the Italian Government to modify Technical Standards, abandoning the conventional allowable stress approach and introducing the limit state approach, according to Eurocodes. More specifically in the paper the following aspects are discussed: a) the intrinsic incompatibility between the Eurocode approach and the Italian Legislation as far as the responsibilities of practising engineers are concerned; b) resistance of practising engineers and geologists to abandon conventional design methods together with a generalized reluctance in Italy towards continuous education programs; c) intrinsic incompatibility between EC7 (2004) and "structural" Eurocodes (more specifically EC8 (2004)). Eventually the difficulties of introducing the limit state approach in conventional education programs are discussed.

1 INTRODUCTION

On 31st October 2002 at 10.33 AM an earthquake of local Magnitude Ml = 5.4 struck the town of San Giuliano di Puglia (Central Italy) with an epicentral distance of about 3.3 km. In that occasion the primary school (Jovine), a two–floor rubble–masonry building, collapsed (pancake-type collapse), killing 27 pupils and a teacher (Figs 1, 2). The earthquake caused the collapse of two other buildings and the death of totally 30 people. The primary school has been constructed in the sixties and more recently (two months before the earthquake) the addition of a floor has been realized for a portion of the building which previously consisted of a single storey, so that the whole building had two floors at the time of the earthquake.

The Italian seismic macrozonation which has not been updated since 1984 did consider San Giuliano as a "non – seismic" area. Figure 3 shows the seismic macrozonation map of Italy in force at the time of the earthquake. Looking at the seismic macrozonation map of 1984, it is evident that such a map is the "political" consequence of a number of disastrous earthquakes (namely: 1908 Messina and Reggio, 1968 Belice, 1976 Friuli, 1980 Irpinia), because the higher seismic risk is concentrated near the areas affected by disastrous past earthquakes. This feature is completely evident by comparing the 1984 map and that produced by INGV (1999) on the basis of a probabilistic hazard analysis reported in Figure 4.

Figure 1. Aerial view of San Giuliano's school after earthquake.

The death of 27 children in San Giuliano di Puglia strongly affected the public opinion. As a consequence the Italian Prime Minister published a decree (OPCM 3274, 2003) mainly aimed at achieving the following results:

- seismic risk maps for the whole Italian Territory based on well consolidated and verifiable probabilistic approaches;

Figure 2. View of collapsed school.

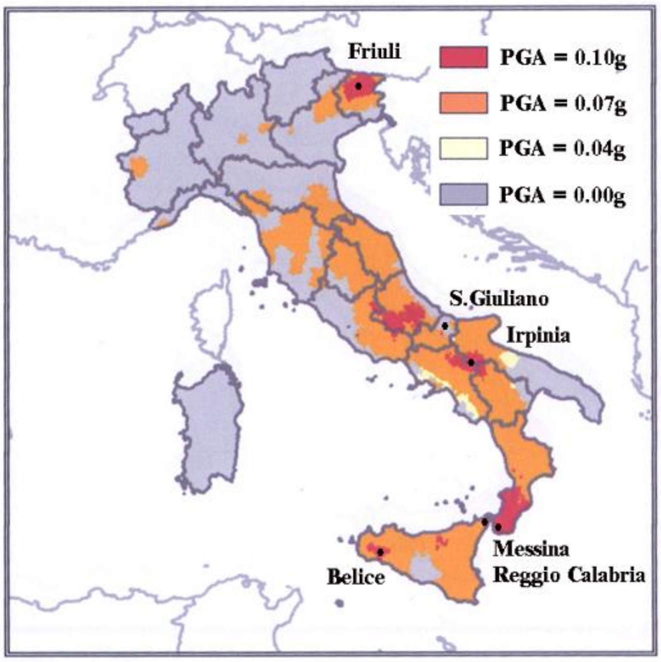

Figure 3. Seismic macrozonation map of Italy at the time of the earthquake.

- retrofitting of a number of strategic buildings (Hospitals, Operative Centres of the Civil Service, Schools, etc.)
- replacement of the existing technical codes, based on the allowable stress concept, introducing a sort of simplified version of Eurocodes.

In the following the intrinsic incompatibility between the Eurocode approach and the Italian Legislation is pointed out, referring to the case of the San Giuliano earthquake.

The incompatibility between EC7 (2004) and EC8 (2004) is also pointed out, referring to the design of flexible retaining structures.

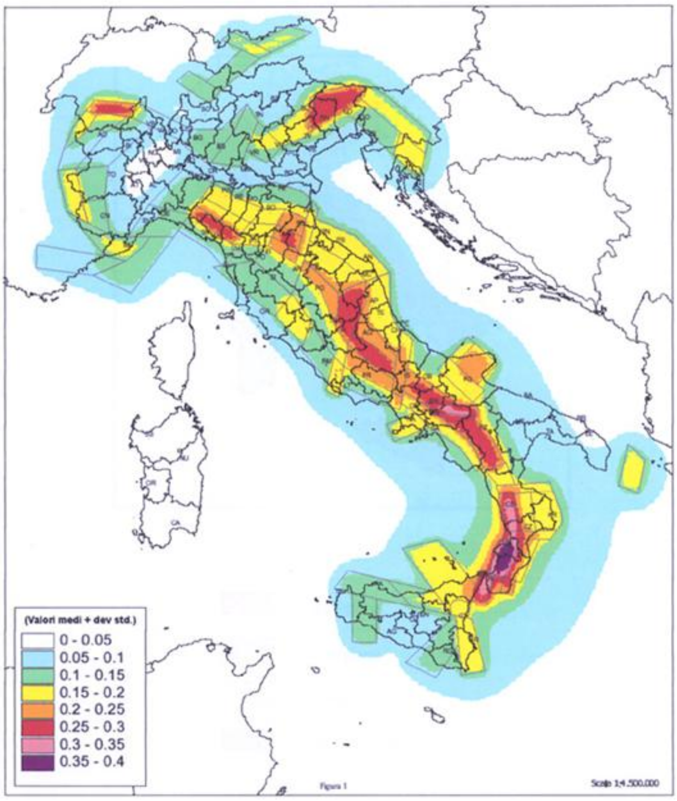

Figure 4. Seismic macrozonation map of Italy based on a probabilistic approach.

Eventually the difficulties of introducing the limit state approach in conventional education programs in Italy are discussed.

2 EUROCODE APPROACH AND ITALIAN LEGISLATION

After the collapse of Jovine school in San Giuliano, a number of people were prosecuted for fraudulently disaster, manslaughter homicide and forgery. More specifically the following people were prosecuted: 1) the mayor of San Giuliano, 2) the technician in charge for technical and administrative control of the recent works completed in 2002, 3) the firms that realized these works and 4) the designer and the work manager.

Those interested in the San Giuliano case can found technical data and information in various documents (see as an example, Dumitriu (2003), Sanò et al. (2004), Goretti (2004), Judgement (2007)).

Omitting the details of the long trial which ended only in the summer 2007, it is instructive to report the judgement conclusions. The accused peoples were considered innocent mainly for the following reason. It was accepted that the school (and another building as well) collapsed because of the earthquake. The inability of the school to resist earthquake was therefore evident. Until 1984 San Giuliano was considered a non-seismic zone. In 1998 the town was classified as seismic (2nd Category, according to GU (1997)). Such a recognition in 1998 only gave financial contributions and reduced taxes to those who repaired or retrofitted existing buildings in high seismic areas. Apart the financial support, the macrozonation introduced by GU (1997) and the a-seismic design in seismic zones should become compulsory only after approval of the Regional Governments that, unfortunately, delayed their decisions for several years. As a consequence, since the zone was not yet officially recognized as seismic, there was no duty to design and construct a seismic – resisting building. Moreover, nonetheless the added floor had several parts in reinforced concrete, the structure was essentially done of rubble masonry. Consequently (according to the Italian Technical Standards) there was no reason to apply the very accurate technical prescriptions for reinforced concrete but only the very light recommendations for masonry have to be satisfied. Such a recommendations essentially concern the shape of the stones and the resistance and quality of the cement mortar. For analogous reasons, even the final inspection was not considered mandatory for masonry constructions if the cost of the works was less than 200’000,00 euros.

In few words, the Italian Legislation, considers the application of technical standards as mandatory (not just as guidelines) and sentences the “FORMAL” inobservance of them. This is in clear contrast with Eurocodes that are essentially guidelines and give the possibility of defining different level of safety for different types of constructions or infrastructures.

The decree (OPCM 3274, 2003), published by the Italian Prime Minister just after the collapse of the Jovine school in San Giuliano, was just a light version of EC8 but in the total absence in the Italian Standards of the rest of Eurocodes. Therefore its application resulted problematic. An other critical issue related to the application of OPCM 3274 (2003) was the prescription of retrofitting a large number of strategic buildings, a part of which is represented by historical monuments. The problems were related to the costs and, from a technical point of view, to the application of modern a-seismic design concepts to buildings constructed hundreds of years ago.

Anyway, NTC (2005) and their most recent version NTC (2008) represented a necessary step to overcome the intrinsic limitations of OPCM 3274 (2003). The main goals of the above evolution of the Italian Technical Standards are:

- availability on the whole territory of PGA values, for different return periods at the nodes of a square net having a side of 0.05°;
- introduction in the Italian Standards of the limit state design.

Different associations promoted, since 2003, many updating courses for practising engineers, architects and geologists, in order to make them acquainted on the new standards. As lecturers of some of these courses, we have observed a big reluctance of abandoning the conventional design methods. The main reasons for such a reluctance was the necessity of making choices, taking decisions and assuming responsibilities.

3 EUROCODE 7 VS. EUROCODE 8

Basically, Eurocodes define the safety assuming a semi-probabilistic approach which mainly consists of the following steps:

- definition of limit states;
- extreme (characteristics) values of resistances (R_k) and actions or their effects (F_k, E_k), which are considered as independent variables, are assumed on the basis of a given probability. More specifically, the characteristic value of actions is that corresponding to a given probability of non-exceedance during the construction life-time and a given probability of combination among permanent and variable actions. The characteristic value of a resistance parameter is usually that corresponding to a probability of non exceedance of 95%;
- design values of resistances (R_d) and actions or their effects (E_d) are obtained from the characteristic values by applying appropriate partial safety factors which depend on the considered limit state;
- if (R_d) ≥ (E_d) the safety is verified.

The above scheme is quite simple but it becomes very confusing when considering structural and geotechnical verification of Ground-Foundation Limit States. More specifically:

- even though it is evident that the characteristic resistance of geomaterials cannot be defined as that of concrete or steel, in any case the criteria shown in EC7 (2004) in order to obtain the characteristic values remain really obscure;
- the introduction of several design approaches which give the possibility of considering partial safety factors of actions and/or strength parameters and/or resistance is really a nightmare and the one of the weakest aspects of Eurocodes.

As an example consider the design of a sheet pile wall for a berth, which design profile is shown in Figure 5. Table 1 summarizes penetrations for ULS under static and seismic loading. Excluding the seismic condition which has been practically computed according to EC8 (NTC 2005), there are at least four different cases, for this quite simple example, if the Design Approach 1 is considered. If other DA are considered, the number of cases increases. The case is quite simple because “structural loadings” are absent.

The most critical issue is that the various cases differ of up to 3 m and these differences occur only because of the different ways of considering partial safety factors, without any rational explanation.

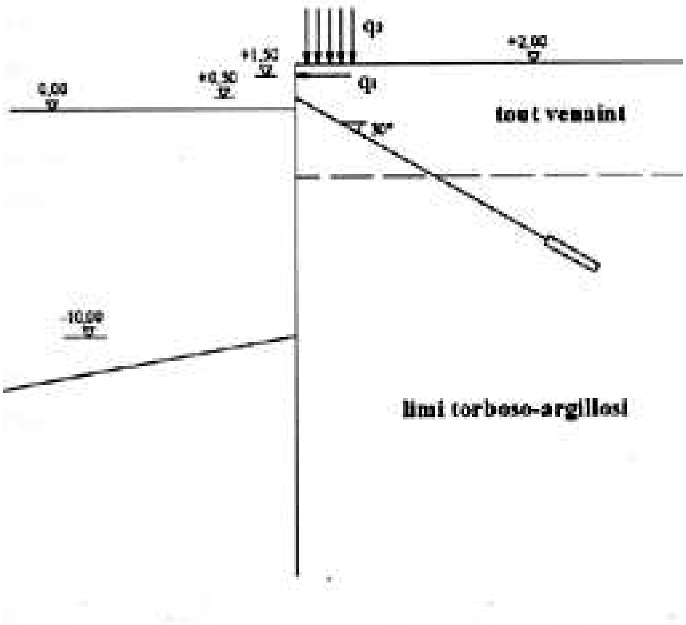

Figure 4 – Scheme of the diaphragm wall

Table 1. Length of penetration of the sheet pile wall.

Code and considered SLU	L [m]
NTC 2005 A1 M1 Combination 1	5.34
NTC 2005 A1 M1 Combination 2	5.50
NTC 2005 A2 M2 Combination 1	7.85
NTC 2005 A2 M2 Combination 2	8.08
NTC 2005 with seismic action	13.10
DM 1988 FS = 2.0	9.42
DM 1988 FS = 1.5	7.32
DM 1988 FS = 1.25	6.31
DM 1996 seismic FS = 2.0	14.85
DM 1996 seismic FS = 1.5	10.90
DM 1996 seismic FS = 1.25	9.15

The authors believe that the various Design Approaches are just a compromise between different European practices mainly based on empirical or semi-empirical design methods.

As for the introduction of the limit state approach in education programs, while it is very straightforward to develop the concepts outlined at the beginning of this section, to explain the different Design Approaches is not possible because there is not any rationale behind them. Therefore everything is reduced to a mere application of rules.

4 CONCLUSIONS

The paper shows the intrinsic incompatibility between the Eurocode approach and the Italian Legislation and some efforts done in recent years to modify the Italian Technical Standards with some positive results and many problems to be still solved.

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