

## Mini Review

# Short Notes on the Seismic Vulnerability of Greece under Austerity

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This work presents the current state of seismic vulnerability in Greece, the most seismically active region in Europe and the corresponding impacts of austerity measures imposed to the nation during the last five years. The analysis of physical risks and socio-economic conditions shows a very dangerous situation, which has to be promptly confronted, in terms of a revised and prioritized National reinforcement effort regarding pre-seismic preparedness and post-seismic interventions. The latter certainly requires funding, however it has to be coupled with restorative measures for the existing socio-political status embracing authorities, communities and individuals.

**Keywords:** Seismic vulnerability; Greece; Austerity**Introduction**

Vulnerability is a set of prevailing or consequential conditions, composed of physical and socio-political factors that adversely affect an individual, a household or a community's ability to mitigate, prepare for or respond to an earthquake hazard [1]. Earthquakes can expose such points of issue within minutes and usually continue to do so long after their occurrence. The scale of physical damage and social disruption in times of crises is the measure of the resilience of the community and/or the nation. These short notes focus on issues concerning the seismic vulnerability of Greece, the most seismically active region in Europe, having suffered devastating earthquakes. Within the Greek territory a M5 earthquake occurs on a monthly basis and a M6 earthquake every year [2]. An M>6.5 event has not taken place since several decades hence such an event is presumably possible to occur in the oncoming future.

The focal point of this article is to present risks due to the expected or unexpected seismic hazard under certain conditions contributing to the vulnerability of Greece. These conditions are unrealistic austerity measures that have impoverished a large part of the population [3] imposed huge diminutions of the collective aptitude, life systems and infrastructures, thus causing a brought down of the country's and the nation's endurance to earthquake hazard, combined with a social standstill of the population [4]. As a result, today Greece stands thoroughly traumatized to a point that one can't discern whether the next step will constitute a safe passage towards exiting from the crisis or onto a greater plunge.

Hereby, earthquake vulnerabilities are grouped into two categories: (a) physical, regarding the built and natural environment (b) social, regarding the level of awareness of the population and the effectiveness of its coping mechanisms.

**Aspects on the physical vulnerability**

Seismic design in Greece follows the EAK-2003 provisions [5], an updated code after the destructive 1999 M5.9 Athens earthquake [6], which has matured further, more rigorous with respect to the previous one introduced in 1995. It has been however globally

manifested for numerous cases of devastating earthquakes that generic provisions are grossly misleading, with ground motion parameters and macroseismic effects found far higher than predicted [7]. That was the case also in Greece during the 2003 Lefkas and 2014 Cephalonia earthquakes; ground motion records surprisingly exceeded the seismic code provisions, implying for strong site effects [8,9]. Further, regions registered seismically quiet have been proven hazardous, hosting destructive earthquakes as the 1995 Kozani [10] and the 1999 Athens earthquakes [11]. Likewise, in the 2014 Cephalonia earthquakes [12] the active fault system was startlingly located much closer to the affected community than the forecasted zone [13].

Such punctuated cases, although being samples of the complexity of the seismic hazard in Greece, prove the limitations of the effective provisions and therefrom the necessity for small scale models to be constructed, employing detailed building vulnerability assessment, site condition analyses, and worst case scenario estimates with incorporating new knowledge and international experience. Such scenarios can be valid tools to forecast losses and organize sufficient interventions at the existing structures.

In constructing sufficient loss scenarios, four aspects are essential to be determined in detail and further combined: (i) Seismic hazard on a local basis (ii) Vulnerability of structures (iii) Site effects and (iv) Socio-economic considerations, such as the population density, the level and nature of the exposed building stock, economic activities located in the earthquake risk zones, etc. The requirement of a large amount of data, which if not already available, it is in principal unlikely to be accomplished nowadays in Greece, due to the economic restrictions. Our research group in the Seismological Laboratory of the University of Athens has elaborated loss models for Lefkada Island [14], while models are currently under development for Cephalonia Island. Nevertheless, gathering the required data from several sectors of the public domain has been proven tedious, thanks to bureaucracy and governmental unresponsiveness.

Vulnerability of structures signifies the evaluation of the susceptibility of structural systems to potential damage from

seismic shaking. Resistance of buildings in Greece has been proven controversial in several cases of earthquakes during the last decades as the severity of destruction is not only due to the intensity of the seismic event but also to the urbanization of the affected region and the vulnerability of certain types of buildings [15]. However, a strong earthquake ( $M > 7$ ) has not occurred near urban areas since the 1953 Cephalonia seismic series, which demolished the largest part of the island's building stock, as well as in the nearby region [16]. In consequence, the seismic vulnerability has not been evaluated under extreme ground shaking. Up until 1953 buildings were mainly rubble masonry and stone masonry constructions [17], built without an earthquake resistant plan, thereupon being highly vulnerable. Thereafter, four seismic codes have been introduced in Greece, in 1959, 1985, 1995 and 2004. Accordingly, buildings are classified into three categories regarding their earthquake resistant design (ERD): those built before 1959 without ERD, those built between 1959 and 1995 with a moderate ERD and post 1995 buildings with a modern ERD [18].

The current status is as following: 80% of buildings in Greece have been constructed before 1985, without or with a moderate ERD [18]. These have been proven quite susceptible and in need of strengthening measures which are lacking [19]. Pre-seismic inspection appears problematic and although a fast track inspection of all public buildings was ordered by the central government after the devastating 1999 Athens earthquake, only 15% of them have been inspected up to the present. Moreover, 50% of schools and hospitals have been constructed prior to the present-day building code, while an important issue exists for the industrial buildings, whereby mandatory inspections are not performed and often they are inappropriate for use and/or are operated without a license. A sound example is the "FARAN" building collapse with several casualties during the 1999 Athens earthquake [20].

A serious disadvantage of the built structures in Greece, especially the ones constructed before 1985 are irregularities imposed at a later stage of their construction, often without a valid design, as well as the presence of soft-storey at the ground floors [18]. Furthermore, the experience of several recent earthquakes has shown that damage is highly related to the topography and the soil conditions of the location of the buildings, implying that pre-construction geotechnical surveys, essential to predict additional structural reinforcement requirements were not performed, or if they were performed they were not taken up [21].

Given the age of the major part of the building stock in Greece, interventions and continuous maintenance is necessary, especially for the public buildings, which in many cases should be replaced with modern ones. However, during at least the last five years of the economic crisis, the construction industry has been reduced by ~70% revealing the scale of degradation imposed on structures, while similar conditions exist for the main facilities [22].

### Aspects on the social vulnerability

A large share pertaining to the ability of the individuals to optimally address earthquake survival and recovery issues derives from training. Readiness contributes to the capacity of the communities to properly react during the period of seismic activity, forbearing the undoing of public welfare and eventually overcoming losses [23]. It is

a common practice implemented in school curricula and the regular preparedness exercise of the population in the developed countries globally. In Greece, seismic training is mainly organized by EPPO (Earthquake Planning and Protection Organization), which under the current economic situation appears unable to respond with even elementary adequacy. Moreover, seismic awareness training has never been systematically dealt with, or prioritized. The same holds for the social and local services. Likewise, individuals wind up deficiently trained, except if they do so through their own research. It is worth mentioning that the only earthquake center for public awareness in Athens "Seismopolis" closed shortly after the initiation of the economic crisis due to lack of funding (<http://www.oasp.gr/node/211>) [24]. Another weighty aspect of the issue at hand is the propagation of inaccurate information by the mass media, frequently exaggerating the seismic phenomenon, thus producing a cloud of chaotic perspectives, intensifying stress and insecurity.

Awareness of the population is largely dependent on the earthquake monitoring potential. This has been greatly improved in Greece currently, with the integration of a permanent seismological network and two accelerometric networks. As a result, notification of the public is fast and valid, accomplished through the electronic media within few minutes after the occurrence of earthquakes (e.g. <http://www.geophysics.geol.uoa.gr>). A large disadvantage though stems from the involvement of five separate institutes in handling these networks. For each institution involved, the efficiency of the seismic instruments' maintenance and data management depends on a different level of operational potential, mainly regarding each institution's available man power and funding capabilities. The separate outlooks and priorities of each institution often conclude in an overall weakened communication among the institutes and also in lack of collaboration among the scientists. Apparently, the dramatic reduction of funding and human resources over the last years in Greece decreased analogously the maintenance efficiency of the costly modern infrastructure, as well as the functionality of the involved institutes.

Emergency plans include guidelines for in-building self-protection, fast building evacuation and coordinated escape towards secured locations. In Greece the existing emergency plan "Xenokratiss" dates back to the 50's. It was last updated in 2003 with several adaptations to modern conditions. However, in some cases its implementation was proven problematic (i.e. during the Cephalonia 2014 earthquakes) and hence its replacement with a modern code is considered essential [25].

The effective implementation of an emergency plan requires localized constraints aligned with the urban setting and further dissemination to the public via contiguous training. Notwithstanding this is far from real, since local authorities and the central government fail in taking proper care and actions. Consequently, negligence, along with social degradation and repeated funding cuts, leads to the severe weakening of first aid services and to the deficiency of suitable temporary hosting facilities. Post-seismic response involves fast damage surveys, prompt compensation and damage rehabilitation. The experience from past and recent seismic crises is rather disappointing, demonstrating poor motivation and ability on the part of the Greek state in confronting the matter. To this point, in almost a year after the January-February 2014 damaging earthquakes of

Cephalonia, recovery has not yet been offered by obstacles related to bureaucracy and funding postponement, causing further discomfort to inhabitants and delaying regulation.

Assessing the corroding impact of stress on a society that's economically challenged and that might be further tested with the occurrence of a severe earthquake, is an intimidating case especially for the traumatized individual; experiencing stress symptoms such as hyper-focusing on the issues of poor finances and earthquakes or other catastrophic events, or displaying avoidance behaviors; e.g. neglecting self-care and health issues, being unwilling to educate one's self on earthquake preparedness, is inevitable. When there is no sense of hope and financial instability prevails, anxieties that are of little consequence when placidity is the order of the day, emerge under stress as flash points, which may intensify depression and panic [26].

### The unpledged scenario

Taking into consideration both countries' diminutive size and their unprosperous economic situation, we set side by side the probable, as is the case with a post large scale earthquake scenario in Greece and the actual, as is the circumstance of what went on half a decade after the 2010 M7 earthquake that devastated Haiti, killing more than 160,000 and displacing close to 1.5 million of its people. Despite the unprecedented financial assistance the country obtained as humanitarian relief since, Haitians are still challenged by devastation [27].

The economic situation is worse than before with foreign investors and creditors withdrawing and the people feeling abandoned [28]. Even up to two years back, in 2013, only a scanty part of the aid funds collected for the country's long term relief solutions had actually been spent for that cause and still up until today, many losses merely fall apart perpetuating the problem of reconstruction. Haiti's slow recovery also reflects a long history of corruption and mismanagement by the nation's government and correspondingly, not all the money pledged by the international community has been contributed and there are also plenty of questions raised about how money is and was administered [29].

Another grave issue concerning recovery concentrates on the cholera outbreak which took place ten months after the disastrous earthquake, and spread quickly throughout the nation, with the UN taking up the responsibility for the infection. After approximately five years, restitution still rests on political and legal pressure on demanding funding for the nation's health recovery, something which has been done by the UN, but only partly [30].

### Conclusion

Identifying with Haiti's still bleeding wounds after the tragedy of 2010, one can rationally conclude that great care and responsibility must be taken to provide reliable seismic protection in earthquake-prone countries like Greece, where the impact of a large earthquake, especially in megacities like Athens, with industrial facilities and significant resident density, is liable to cause massive loss of human life and to finish off the nation's weak economy. Although in Greece, rules and regulations on the seismic risk mitigation certainly exist, a thorough unravelment is required in order to prevent the unexpected; namely a modern plan is required to facilitate interventions regarding

the worst earthquake scenarios. The country's strong scientific potential and modern observational infrastructure should largely contribute to the risk mitigation, yet an effective central coordination is needed.

Existing advantages though appear annihilated because of the drawbacks imposed by the socio-political conditions over the years of austerity. Thereupon, the central government with its supercilious stance combined with the powerlessness of the decentralized authorities and the uncontrolled individual conceits obviously increase seismic vulnerability. The situation today is really dangerous and the occurrence of future strong earthquakes is, sadly, expected to rapidly reveal the failing of the nation to cope with consequences.

With Greece being latched on to the most corrupt public sector in Europe (as outlined by the Transparency International's Corruption Perceptions Index) and seeing how it is that exact public sector that mainly organizes, regulates and coordinates both pre- and post-earthquake urgencies, one can even determine, especially after having kept an eye on Haiti's earthquake vulnerability by way of perpetual political turmoil, that the disheartening dynamic of earthquake affliction could very well be incontrovertible.

Concluding, the development of an effective and applicable National plan of warning, awareness, preparedness, emergency and post-seismic healing interventions is a prime priority. Given the current funding scarcity in Greece, the solidarity of other economically robust nations is greatly requested beforehand. Nonetheless, even if funds are ensured, a great national reinforcement effort should definitely require overcoming of significant socio-political handicaps of the authorities, the communities and the individuals.

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