Study of Seismic Risk and Tsunamis in Algarve Estimative of Debris and Number of Damage Assessment Inspectors

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SUMMARY:
The Portuguese National Authority for Civil Protection developed a methodology to quantify, after an earthquake, the number of inspectors needed to pursue damage assessment in structures and estimate the amount of debris to remove.
This methodology was implemented in Algarve, Portugal, based on Study of Seismic Risk and Tsunamis in Algarve (ERSTA) results. ERSTA identified and had characterized the seismic risk in Algarve, and this methodology has a positive benefit to civil protection attributions, namely related with preparedness to major events.
Considering the number of inspectors needed, is crucial to plan these actions with stakeholders and partners, such as Order of Engineers and Order of Architects.

Keywords: seismic risk; civil protection; emergency planning; damage assessment; inspections

1. STUDY OF SEISMIC RISK AND TSUNAMIS IN ALGARVE

The metropolitan region of Lisbon and the region of Algarve, in the south of Portugal, have been, historically, the regions in continental Portugal that suffered more intensively the seismic effects (Rocha *et al*; 2004). Aiming the preparedness to earthquake occurrences, the National Authority for Civil Protection (Portuguese acronym ANPC) had coordinated two projects for characterization of seismic risk in those regions. In 1997 started a project in the Metropolitan Region of Lisbon (ERSAML), with the collaboration of several Portuguese research institutions, and in 2007 was developed a study for the region of Algarve.

Historical records show that the Algarve, in south of Portugal, has recorded over time the major seismic intensities in Portugal. Algarve is a region of particular characteristics, with urban areas along the coast and as a touristic destination, with a national and international intense seasonally flux of population. Considering also that tsunami constitute a real threat in the Algarve region, the **Study of Seismic Risk and Tsunamis in Algarve** (ERSTA) was developed in order to comply with the fundamental objective of civil protection, namely prevention of collective risks and preparedness to major accidents and catastrophes. ERSTA covered 16 counties of the district of Faro (Figure 1), which corresponds to a maximum present daily population of about 1.5 million inhabitants (Gaspar, 2008).

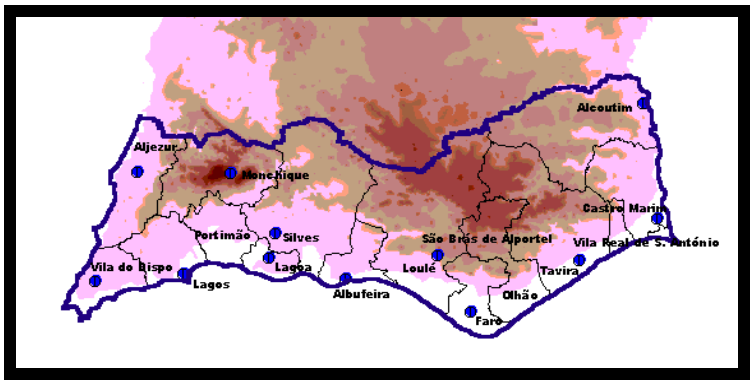


Figure 1 - Study Area: Faro District

The Study of Seismic Risk and Tsunamis in Algarve (ERSTA) started in January/2007 and was finished in December/2009. It was coordinated by the Portuguese Authority for Civil Protection, supported by a scientific coordinator and involved 9 scientific teams, working in several components.

- Instituto das Ciências da Terra e do Espaço (ICTE/FCUL);
- Instituto de Meteorologia (IM);
- Instituto Nacional de Engenharia, Tecnologia e Inovação (INETI);
- Instituto Politécnico de Beja/Escola Superior de Tecnologia e Gestão/FUZZY (IPB/ESTIG/FUZZY).
- Instituto Superior Técnico (ICIST/IST);
- Laboratório Nacional de Engenharia Civil (LNEC);
- Universidade do Algarve (UALG);
- Universidade do Algarve/Escola Superior de Tecnologia (UALG/EST);
- Universidade de Lisboa/ Faculdade de Letras/Centro de Estudos Geográficos (UL/FL/CEG);
- Universidade do Porto/Faculdade de Letras (FLUP);

ERSTA considered diverse technical and scientific components, to evaluate both human and material damage originated from an earthquake and tsunami. This was achieved by adding all the technical information in a "Seismic Simulator ". The results obtained from the technical teams were georeferenced and included in the seismic simulator (Mota de Sá, 2008). The main areas addressed by ERSTA are indicated in Figure 2.

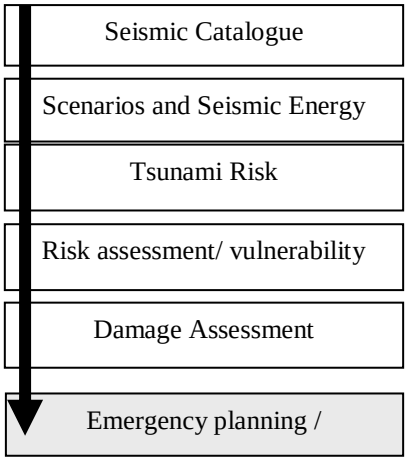


Figure 2. ERSTA components

The simulator was designed in modules that address the different aspects mentioned above. The calculation starts with the definition of an earthquake, giving the location of i) epicenter ii) associated

fault, iii) magnitude, date and iv) time of occurrence (Figure 3). Thereafter, the simulator calculates a set of parameters that express the seismic action (with or without the influence of soils) and gives an estimative of damage occurred in buildings and the affected population and results were presented at intervals with upper and lower limits. The results are expressed either in maps (georeferenced) or in tables.

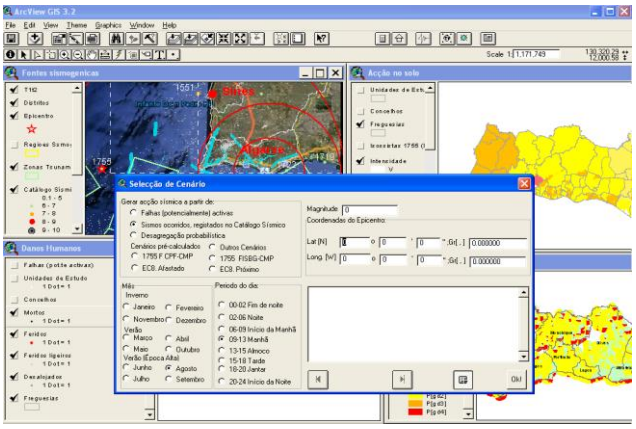
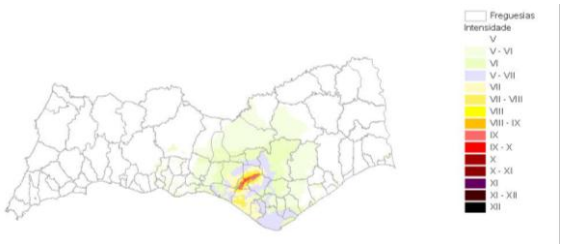


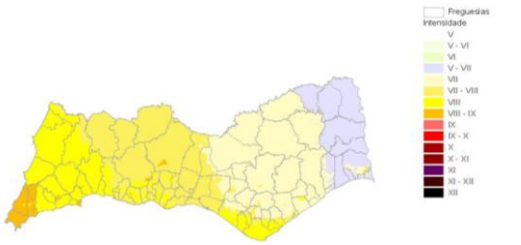
Figure 3. Simulator interface

2. RESULTS OF ERSTA

Two scenarios were modelled in the simulator to estimate damages in case of earthquake. **Scenario A** is an earthquake with an epicenter on land, 13.8 km NNW from Faro (Carcavai fault), and magnitude 6. The scenario considered the event in May, at 10h00. **Scenario B** corresponds to the epicenter onshore, 118 km, WSW from Faro and magnitude of 8.0. The scenario considered the occurrence in August, at 12h00. Outputs are presented in Figure 4.

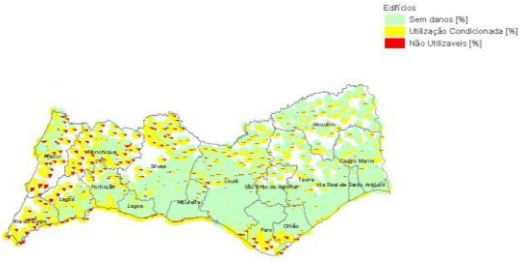


Scenario A - Intensities EMS-98



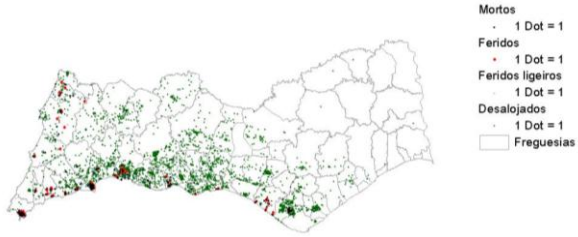
Scenario B - Intensities EMS-98

. Scenario A - Damages in buildings



Scenario B - Damages in buildings

. Scenario A - Human damages



Scenario C - Human damages

Figure 4. Outputs for Scenarios A and B

The development of seismic scenarios are an important contribute to implement a damage assessment program, to support the civil protection actions before and during the emergency, and to define areas of intervention that will be based on the response of civil protection agents. Figura 5 shows affected areas by a tsunami in Quarteira e Vilamoura, considering Scenario B.

Figure 5. Affected areas by tsunami (Baptista *et al*, 2008)

Table 2.1. Human damages

Human Impacts (average)	Scenario A	Scenario B
Displaced	954	5 097
Injured	145	520
Injured in Hospital	46	178
Fatalities	51	243

Table 2.2. Building damages

Human Impacts (average)	Scenario A	Scenario B
Displaced	280	782
Injured	775	4 421
Injured in Hospital	8 042	44 728

3. ESTIMATIVE OF DEBRIS AND DAMAGE ASSESSMENT INSPECTORS

After search and rescue activities, there is a whole set of actions to implement to return to normality. Those actions include the remove of debris in affected areas and inspection activities that are necessary to ensure the conditions of safe use of buildings and infrastructures affected.

Based on characterization of the building stock developed in ERSTA, it is possible to estimate the average number of floors with the housing and which is approximately the estimated amount of debris. Was assumed an average construction area of of 250 m^2/floor and a construction volume of approximately 1350 m^3 (Lourenço, 2007).

The estimative of the number of technicians needed to perform the inspections was based in the actions implemented in L'Aquila earthquake, Italy, in 2009, namely: i) teams of 2 inspectors; ii) a team performing 5 inspections a day; iii) all inspections concluded in 3 months. This, in worse scenario (scenario B), it would be needed more than 300 technicians, full time, on filed activities.

Table 3.1 - Estimative of inspectors

Damage (average)	Scenario A	Scenario B
Builings to inspect	8 817	49 149
Days to inspect	1 763	9 830
Tteams	29	164
Inspectors	53	328

Table 3.2. Estimative of debris

Damage (average)	A	B
Colapsed	280	782
Volume of construction	1 350	
Debris (m3)	378 000	1 055 700

4. DISCUSSION

Based on the simulator developed in the Study of Seismic and Tsunami Risk in Algarve, ANPC has developed a methodology to quantify the resources to allocate after an earthquake, such as the number of inspectors required for evaluation of structures and the volume of debris to remove. This methodology proves to be very useful for the continued activities of civil protection, particularly with regard to the preparation for response to seismic events.

Taking into account the number of technicians needed to perform the inspections, is essential to involve national experts in damage assessment, in the process of emergency planning and plan such actions. Order of Engineers and Order of Architects are key partners in this area.

ACKNOWLEDGEMENT

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