S E N S ' 2 0 0 6

Second Scientific Conference with International Participation

SPACE, ECOLOGY, NANOTECHNOLOGY, SAFETY

14 – 16 June 2006, Varna, Bulgaria

SEISMIC RISK MAPPING – STATE OF THE ART IN THE PECO* COUNTRIES (PART 1)

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Key words*: *Earthquakes, risk mapping, PECO countries.

Abstract: *The survey presents the results of the distributed among the PECO countries and their experts a questionnaire on the seismic risk mapping. This problem is considered as the common hazard in several PECO countries. The main aim of the questionnaire is to establish the state of the art of the risk mapping process on the earthquakes. The results after the processing procedure of the collected data are presented. They are illustrated by many tables and other information tools. They show very similar picture of the abilities of the different countries to map the seismic risk. The first part considers the seismic hazard data and hazard maps. The problem has several peculiarities in comparison with some other hazards also displayed in the same questionnaire:*

- *the vulnerability of the different structures to the earthquakes*
- *the vulnerability of population to the effects of the earthquakes*
- *the risk mapping as a combination of the hazard mapping and the vulnerable elements.*

Most of the countries are well prepared for these activities (i.e. base maps exist), but almost no one is using GIS technology for this mapping. The main aim of this survey is to make conclusions and some suggestions to the EC policy makers for the homogenization and legislation to be applied for all PECO countries. Most of the investigated countries mentioned that they would like to play positive role in such process.

*PECO is the EC acronym of the new member states and the candidate countries for the EU.

Introduction

The state of the art in the field of the seismic risk mapping in the PECO countries (acronym in EC used for the new member states and the candidate countries) was investigated using the preliminary created questionnaire [1], distributed among all PECO countries (except Malta). Here the results of the processed questionnaire are presented with some preliminary analysis.

Earthquakes in EU countries (general definitions and clarifications)

The questionnaire targeted to the seismic risk mapping is focused on the establishment of the state of the art of the hazard mapping and data collection, vulnerability and risk mapping. Earthquakes have a powerful destructive potential. In Europe there are many countries prone to this hazard. Mostly Greece, Portugal, Spain, Italy and partially UK, Belgium, France and Germany (from the member states) and from the PECO countries - Slovenia, (partially Hungary, Check and Slovak republics) and the both accession countries – Romania and Bulgaria are among the countries threaten by this hazard. The both last countries survived in the past very strong earthquakes – for example Romania (Vrancea intermedia source – the last strong event in 1977 - (M=7.3) and Bulgaria – the last very strong event (crust source Kresna) in 1904 (M=7.8)

A) Seismic hazard data

The seismic hazard data consist of the seismic higher magnitude events and their consequences. The main parameters derived from the seismograms and the seismic data processing are:

- the origin time,
- epicenter coordinates,
- magnitude,
- depth.
- fault plane solutions (sometimes they are very useful).

There are several European centers collecting and processing similar data – CSEM (http://www.emsc-csem.org/) ORPHEUS (http://orfeus.knmi.nl/), ISC (UK), etc.

The strong motion instruments records the observed acceleration. They are very useful in case of the near strong seismic events, and for the used models verification.

Sometimes for the seismic environment description the lower magnitude events are necessary for the active faults delineation, defused seismicity assessment, seimotectonic boundaries definition, etc. Frequently very useful are the detailed descriptions on the macroseismic fields, the destructions, the deaths and injured, the affected life-lines, etc. These data could be used for the vulnerability assessment, economic and social damage assessment, etc.

Analysis

The results about the seismic hazard data collection in the PECO countries are presented on Table 1. According to Table 1 all national seismic surveys are collecting such information by several ways:

- instrumental (seismograms and accelerogrames),
- descriptive (notes, visual observations),
- questionnaires for the felt events and their consequences,
- old historical descriptions, (and paleoseismological studies).

All seismic prone countries have their own seismic data collection systems. They are usually consisting of:

- a seismic stations network,
- processing data centre (and sometimes visualization survey)

Most of the countries have old paper recordings and manual processing of the seismic data (may be with some exceptions – Slovenia – for example). The main outputs are seismic bulletins and catalogues on paper and/or digital form. Main parameters are epicenter location, magnitude, dept and Intensity in a case of felt event. All of the National data collecting bodies make posteriori surveys (after the felt seismic events) of the macroseismic fields using developed questionnaires. Many of the countries' seismic data centers institutions are still in search of the old chronics and historical descriptions of the historical seismic events.

Most of the national seismic data centers are highly concentrated scientific bodies (with some exceptions – Romania and Bulgaria, for example, where two national institutions exist, separately for the seismic data and for the strong motion data). The positive fact is that the whole data processing uses standard procedures unified by the IASPEI. (Manual of the resent seismological observatory practice, by Petter Borman, 2000). Now a big effort in Europe is made in the direction of the cooperation for the field studies – an international team for the Rapid Intervention Field Investigation (FITESC) is created (http://fitesc.8m.com/) under the European Seismological Commission (EMSC is a headquarters' unit on this team).

Usually the geology mapping and related topics are not incorporated in the seismic centers. In all countries the geology data and mapping are collected and processed by the separate institutions dealing with the geology mapping

Table 1. "Seismic Hazard data information" for the PECO countries

Country	Seismology parameters	Surface geology	Events	Other	Format
Bulgaria	Intensity, Magnitude, Ground acceleration.	LITHOLOGY, STRATIGRAPHY	yes	historical descriptions on old strong events	mainly paper, new data -digital
Czech Rep.	Intensity, Magnitude.	not answered	yes	no	mainly paper, new data -digital
Cyprus	Intensity, Magnitude, Ground acceleration.	LITHOLOGY, STRATIGRAPHY	yes	historical descriptions on old strong events	mainly paper, new data -digital
Estonia	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a
Latvia	n/a	n/a	n/a	n/a	n/a
Lithuania	MAGNITUDE	LITHOLOGY, STRATIGRAPHY	no	no	Nordic-digital
Poland	n/a	n/a	n/a	n/a	n/a
Romania	Intensity, Magnitude, Ground acceleration.	not answered	yes	continuous measurements	paper, new data -digital
Slovakia	n/a	n/a	n/a	n/a	n/a
Slovenia	Intensity, Magnitude, Ground acceleration.	not answered	yes	instrumental	paper, digital

n/a – means not applicable

B) Seismic hazards maps.

There are several kinds of maps in use in the PECO countries:

- Intensities maps – presenting isolines (or different colors) of the expected intensities for a certain time period
- Accelerations maps – presenting isolines (or different colors) of the probability of exceedance of the expected PGA (Peek Ground Acceleration) for certain time period.

Sometimes the respective seismic coefficients for civil engineers and designers are presented as well

The main necessary data and information (additional maps, catalogues, etc.) to produce the seismic hazard maps are:

- The epicentral maps (inventory)
- The seismotectonic maps
- The (surface) geology maps
- The active faults maps (inventory)
- Earthquake catalogues – to establish the recurrence periods (sometimes – the paleoseismological data are used for such purpose as well)
- Attenuation lows (for intensities and/or accelerations)

As a result of this data processing – the so called seismotectonic sources could be outlined.

Then taking into account the relevant maps information and about the attenuation lows and applying the respective methodology (for example McGuire, 1993, Cornell, 1968, etc.), the seismic hazard maps could be produced. They could be constructed as:

- expected intensity maps for a certain period of time (the old methodology) or as
- expected acceleration maps for a certain time period (the new methodology), which are more useful for the design engineering purposes. Usually the maps are produced taking into account the average soil conditions.

If there are some requirements to consider the soil conditions for different purposes (seismic safety studies for certain sites, high risky objects such as NPP's, dams, Seveso II installations, etc.), the microzonation studies have to be performed.

Analysis

From the investigated ten countries, five presented information about the seismic hazard maps and five – not. So, 50 % of the PECO countries have been covered. For the rest – the seismic hazard is not considered as a priority hazard – marked as n/a – not applicable.

For all countries presented the seismic hazard maps, they are developed on the national level. Some of them are upgraded soon (1998-2000), some – keep the old fashion methodology and results (example Bulgaria -1987). All maps refer to an average soil conditions. Almost all of them are in paper form (with some exceptions - Slovenia, Cyprus and Lithuania for example.). The main use of the seismic hazard maps is connected with the

National building codes and rules. The experts expressed their feelings that they can be used as well for the land use planning, prevention and protection etc.

The scales of the seismic hazard maps are varying between 1:400 000 and 1: 1 000 000. This depends of the countries' size. But almost all maps are on different cartographic projections. It means that the homogenization appears as an important topic. The background information consists (on the most frequent cases) of administrative boundaries, water bodies, roads, railways. The results of the questionnaire data processing are presented on Table 2.

Positive observed facts:

- Most countries have their own national hazard maps usually used for the seismic design codes and rules and their implementation in practice.
- Almost all countries have the respective legislation, but it is targeted mostly to the seismic design codes, but not especially to the mapping. For example – Romania – has more important map from practical point of view – digital, (for expected acceleration), but it is not included in the legislation acts.
- All countries consider that they have enough data to produce their seismic hazard maps.

Table.2. "Earthquake Hazard Maps information" for the PECO countries

Country	Type of map	Scale	Area coverage	Projection	Format (digital/ paper)	Date created	Map features or symbols
Bulgaria	zoning	1:1 000 000	National	Baltic	paper	1987	Intensities (Kc)
Czech Rep.	zoning	not answered	National	Gauss-Krüger	paper	2000	Intensities and PGA
Cyprus	Zoning Microzoning	1:25 000	National, city of Nicosia	UTM-EU1950	digital/ paper	1983, 2003	Indicating PGA, Probability and degree of hazard
Estonia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	zoning	1:400 000	National	UTM-LKS-94	digital	1998	Earthquake potential
Poland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	zoning	1:1 000 000-1:25 000	National, Regional, Provincional	Gauss-Krüger	paper	2001	Intensities
Slovakia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	zoning	1:500 000	National	Gauss-Krüger	digital/ paper	2001	Intensities and PGA

Negatives:

- The questionnaire was not designed to consider the different methodologies applied for the hazard mapping in the different countries. That's why there is not a possibility for the methodologies assessment.
- Most of the countries used different cartographic projections, which is a serious problem concerning the unification of the mapping process.
- Another negative problem is that very frequently the contours of the respective isolines (intensities, accelerations, etc.) do not coincide at the both sides of the state boundaries.
- For the earthquakes hazard maps are never considered the possible secondary hazard effects frequently leading to more negative consequences like surface ruptures, aftershocks, floods, mudflows and landslides generation, tsunami effects, etc. [Ranguelov, 2004].

Usually the availability of the hazard maps is wide open to the population and decision makers with some exceptions concerning the Civil Defense action plans and the military purposes.

A Comment

A European common methodology on seismic hazard mapping exists. The implementation of the new EUROCODES system needs harmonized and unified approach in all design and construction works. This was the main reason for a big international team of European specialists (funded by several big projects) to create the unified Seismic Hazard Map of Europe. [Jimenec et al, 2001] – scale – 1:5 000 000 for the expected Peak Ground Acceleration (PGA) for 10% exceedance in 50 years (475-year return period), published in 2003 - http://wija.ija.csic.es/gt/earthquakes/. This is a very good example how to proceed in such a way for unification of the methodology for the seismic hazard mapping. Both parameters - 50 years and 475 years return period - are recommended by the EUROCODE 8. Same approach could be applied for all hazards, vulnerability and risk mapping, but this needs large efforts, funds, specialists.

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***Acknowledgements: This study was executed during the author's stay as a visiting scientist in JRC, Ispra during 2003-2005*.**