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EUROPE IS FAR AWAY…OR NOT

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ABSTRACT

Is Europe prepared to solve the seismic risk problem? The paper is focused on two directions for reduction of the seismic risk in Europe and the increase of people resilience to earthquake: implementation of European legislation for the building design codes (structural design) and budgetary allocation for research from the European Commission. The standardization policy of the European Commission is presented. In the paper is studied the budgetary allocation for research in Europe emphasizing the discrepancies among the European states. The European policies for research in the field of reduction of seismic risk must be upgraded to give more chances to peoples to survive in the case of earthquakes. Solutions from Japan, Chile and the US are presented.

Keywords: Eurocodes; Seismic risk; Legislation

1. INTRODUCTION

Europe is affected by catastrophic events. Past moderate to large earthquakes were compiled in the European catalogue presented in Figure 1. The historical record of large disasters goes back to ancient Greece where an earthquake in Crete destroyed Alexandria. The last important event, 2016 central Italy earthquake killed 299 people and left 23.53 billion euro of damage, and destroyed a string of historical buildings. According to EM-DAT database, Europe has witnessed, from 1900 until today, more than 278684 deaths due to collapsed buildings during the earthquakes. Why do earthquakes in other wealthy countries seem to cause less damage and casualties than earthquakes in Europe? How far are Europeans from reaching Japan, New Zealand or Chile's resilience? These are two questions with possible solutions not only from Brussels politicians, but also from European scientific communities. The paper is focused on two directions for reduction of the seismic risk in Europe and increase of city resilience: implementation of European legislation for the building design codes (structural design) and budgetary allocation for research from the European Commission. Unfortunately, only 1 from 420 Technical Committees, the TC 250, is dealing with "Standardization of structural design rules for building and civil engineering works". In fact, within this TC are established the rules of making constructions that can withstand the natural or human hazards, the so called EUROCODES. In the paper is studied the budgetary allocation for research in Europe, emphasizing the discrepancies among the European states. The European policies in the field of reduction of seismic risk must be upgraded to provide safer houses and to give more chances to peoples to survive in the case of earthquakes. Unfortunately, during earthquakes, the consequence of the corruption factor in the construction industry is revealed.
The World Bank (2017) evaluates the earthquake risk of European Union states and the results are: annual average affected population of 1,000,000 and annual average affected GDP of $20 billion; Greece: 0.4 percent annual probability of occurrence could cause nearly 2,000 fatalities and $20 billion in capital loss (about 8 percent of GDP).

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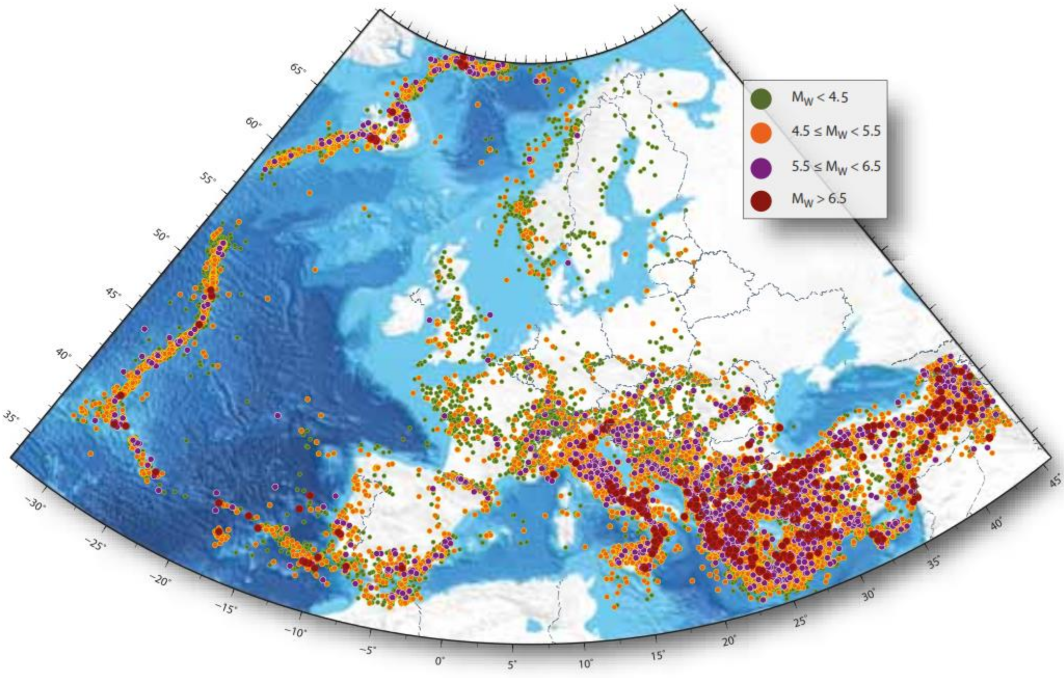


Figure 1. Earthquakes in Europe compiled in for the SHARE European Earthquake Catalog (SHEEC) covering the period 1000 - 2007 with moment magnitudes $M_w = 3.5$

2. EUROPEAN BUILDING DESIGN CODES

Starting with the first document Directive 73/23/EEC, The Low Voltage Directive, the EU finds a way for abolition of technical barriers to trade in Europe. CEN – European Committee for Standardization has the following role in EU: “European Standardization plays an important role in the development and consolidation of the European Single Market. Governments can be users of standards both for their procurement and in support for their legislative or other policies. They are therefore interested in having good standards available for use. The European Standards published by CEN are developed by experts, established by consensus and adopted by the Members of CEN. It is important to note that the use of standards is voluntary, and so there is no legal obligation to apply them”, but at the same time “unavoidable” in practice.

The European Commission has a dedicated unit dealing specifically with standardization policy for the EU, but the European Commission plays no role in relation to the technical choices made in the European Standards; it is only interested in ensuring that the standardization structures and procedures remain efficient, accountable and transparent.

The General Guidelines for the Cooperation between CEN, CENELEC (European Committee for Electrotechnical Standardization) and ETSI (European Standards Organisations) and the European Commission and the European Free Trade Association was signed in 28 March 2003, and published on Official Journal C 091, 16/04/2003 P. 0007 – 0011. The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) are two distinct private international non-profit organizations based in Brussels.

In CEN, the preparation of the standards is made by 420 Technical Committees (TC’s) that each have their own field of operation (scope) within which a 1633 Working Groups (WG’s) work programme of identified standards is developed and executed.

Only 1 from 420, the TC 250, is dealing with “Standardization of structural design rules for building and civil engineering works”. Within this TC are established the rules of making constructions that can withstand the natural or human hazards, so called EUROCODES.

Since the 1970’s Europe has invested from the European taxpayer a lot of public money in European standardization. For example, Horizon 2020, the biggest EU research and innovation programme ever

has €79 billion available over 7 years (2014-2020). The Joint Research Centre's the Commission's in-house science service and the only service responsible for direct research, through Horizon 2020 has a budget of €2 billion, will contribute with developing standards and providing references in support of European competitiveness.
In comparison, with only €0.07 billion budget (1999), CEN use the results from the JRC's and issue European Standards (EN) including the EUROCODES, documents and other technical deliverables and publications covered and protected by copyrights. As a fact, for the structural design projects of new or old buildings a civil engineer must spend more than 10.000 Euros only to purchase the EUROCODES (EN0 to EN9), i.e. "EN 1998-1:2010-12 Eurocode 8: Design of structures for earthquake resistance. General rules, seismic actions and rules for buildings" has the price of 418.7 EUR. Also, there are not dissemination policies of the EUROCODE's in the universities and most of the students from civil engineering field will not afford to study, or to use the EUROCODES. This is a huge mistake, and the European engineering/consultancy companies cannot promote the knowledge implemented in the EUROCODE outside Europe.
In comparison, let's look at the policy of United States of America: if public money is used, then the results of the research are free to be used by anyone. That is why in many countries from all the continents, the engineers are using the American building code models. Also, the initial phase of the building design software's that conquered the world, like ETABS or SHAKE were developed with public money, and the source code was available to anyone. A similar approach was used by Microsoft. The company allows the PC users to use Windows operation system at very low price or even made available to free download on low income countries, and now, they have more than 80% world market share.
The results of the implementation of EUROCODE regulations might be observed in Figure 1, where the differences between the seismic performances of the buildings will be very different in the case of a strong earthquake. In Figure 2 are presented two structures located in a high seismic area of a Mediterranean country. We can notice the outstanding engineering for the airport building, but in the same time in the opposite situation is the apartment building (photo in 2008). In Italy, the national annex of Eurocode 8 was published as UNI EN 1998-1 in 2007, together with the 56 national design parameters.


Figure 2. Building structures built in high seismic areas (apartment bldg.-left; airport bldg.-right)

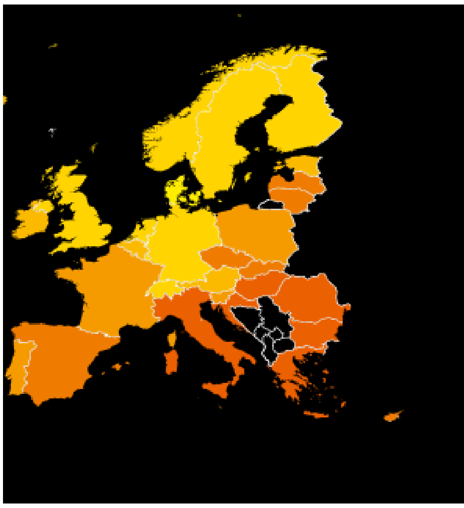
The apartment building will be damaged in the case of a strong earthquake, and the European scientific community knows that from many years ago. The structural engineers rely on the plastic deformability of beams, columns and walls of building structures during seismic design of structures. The ductility as plastic deformation of frames is the damage of structures. Of course, the Eurocode prescriptions provide limitations for masonry infill partitions, but the future inhabitants cannot use the building after the event. People don't want to live in the buildings that have to be demolished after the

big earthquake. Then, by this type of behavior, we cannot make our city sustainable and resilient against big earthquakes.
Figure 3 (Italy, April 6, 2009 earthquake) provides such evidence of the “good behavior” since the RC frame structure is not damaged and no “plastic hinges” were developed. But the taxpayer, owner of the apartment from Figure 3 will not agree with the engineering point of view. The owner lost his property/money without any responsibility because he was not informed about damages of non structural elements. This is an issue for the engineers/developers but also for the insurers industry.

Figure 3. Damage of apartment building in l’Aquila, Italy after April 6, 2009 earthquake

Are the European citizens of damaged properties guilty because they believe in the quality assurance system provided by EUROCODES? Perhaps yes, if they are not being insured - this is a policy maker’s point of view (mainly from seismic free countries). But after a large disaster the experience show that the insurers or reinsurers companies get bankrupt (see Kobe, Katrina, San Francisco, etc. disasters) and the citizens are not covered.
The solution found in the European Union, through the legislative technique of the ‘New Approach’, demonstrates perfectly that the responsibility for safety and other public interest matters lies with governments. Now, a question can be raised: How can we let an NGO (i.e. CEN) establish the rules of how to build houses, but in the case of disaster the governments are responsible if they will fall apart? Who is responsible? Why is Europe different and why there is no action taken? Why in seismic areas of Europe, the EUROCODES allow the use of unreinforced masonry walls (bricks or hollow clay tile), even if we have many damaging lessons from past disasters (Figure 2). It is worth to say that the unreinforced masonry walls are not used in California or in Japan since many years ago.
An example from a south of Europe is L’Aquila, capital city of Abruzzo (Italy) which has been severely damaged at least five times in the last 700 years, specifically in 1315 ($M_w \approx 6.7$), 1349 ($M_w \approx 6.5$), 1461 ($M_w \approx 6.5$), 1703 ($M_w \approx 6.7$), and 1915 ($M_w \approx 7.0$) but unfortunately the seismic building code adopted in 2003 provides only a 0.25g for the design peak ground acceleration. In the case of moderate April 6, 2009 earthquake, magnitude M_w=6.3, 308 people lost their lives in a very small affected area (the city of L’Aquila and nearby 26 villages). The estimated financial losses reached €16 billion. After 6 years, Italian government has spent more than €8 billion constructing a new town for residents of the city center and for reconstruction of the old city. The town, financed in part with European funds of €0.5 billion, has been hit by many scandals. According to the EU Court of Auditors, more than 4,000 apartments were bought at 158 percent above the market value. Many residents described the houses as being of “poor quality.”
The differences between EU and Japan, USA or Chile is that: "in California, an earthquake like this (l’Aquila earthquake, M_w=6.3) one would not have killed a single person"- Franco Barberi (head of Italian Civil Protection); it was "absurd" that people could die in "such a low magnitude earthquake (August 21, 2017, Ischia earthquake, M_w=4.2) " - Francesco Peduto (president of the Italian National Council of Geologists).
The wealthiest of nations afflicted by earthquakes can afford both to educate their populations and to purchase good-quality building materials and it is more probable that large numbers of fatalities from

earthquakes can be attributed largely to the effects of corruption. The last report of Transparency International (2016) rank Italy as having the lowest CPI =42 (corruption perception index) among the developed countries, Figure 4.
By contrast, Chile, Japan, USA and New Zealand are less corrupt than might be expected from their per capita income, and have low earthquake fatalities.



RANK	COUNTRY/TERRITORY	SCORE	RANK	COUNTRY/TERRITORY	SCORE
1	Denmark	90	29	Poland	62
3	Finland	89	29	Portugal	62
4	Sweden	88	31	Slovenia	61
5	Switzerland	86	38	Lithuania	59
6	Norway	85	41	Spain	58
8	Netherlands	83	44	Latvia	57
10	Germany	81	47	Cyprus	55
10	Luxembourg	81	47	Czech Republic	55
10	United Kingdom	81	47	Malta	55
14	Iceland	78	54	Slovakia	51
15	Belgium	77	55	Croatia	49
17	Austria	75	57	Hungary	48
19	Ireland	73	57	Romania	48
22	Estonia	70	60	Italy	47
23	France	69	69	Greece	44
			75	Bulgaria	41

Figure 4. Transparency international 2017. Corruption Perceptions Index (2016)

Maybe, one solution is to follow the experience of east European countries which experienced heavy damages during earthquakes (Slovenia after 1976 Friuli earthquake or Romania after 1977 earthquake). Enforcing the construction regulations, from building permits to the quality control of design or execution, provide safer constructions. One indicator, the number of illegal constructions, might show the vulnerability of building stock (Spain – 1,7 million of constructions; Italy - National Statistic Institute (ISTAT) estimate for 2016 that more than 20% of new building are illegal, and rose to 60%   in some regions in the south; Greece – more than 30% of existing buildings).
If former communist states experience (legislation) is not enough, EU might follow the Chilean or American quality control and responsibilities systems in the field of construction, where the developer, the structural engineer, the construction company and the official from the city hall, who make the verifications, have to be life responsible for the quality of their product.

3. RESEARCH ACTIVITIES

How far away is Europe in the field of earthquake engineering research? We can compare the budgets spend by Japan and the US in the field of structural testing with European one. Only for the E-Defense testing facility from MIKI/ Kobe, Japan paid €0.5 billion. It is evident that the best-equipped country for testing facilities against earthquakes is Japan since it owns and manages the largest shaking tables and reaction walls in the world. Moreover, it must be stressed that Japan is the only country having shaking tables allowing large scale model testings. The USA is well equipped particularly with regards reaction walls, while the shaking tables are limited to 85 tons. In Europe, there is only one large reaction wall, which is managed by the Joint Research Centre (JRC) of the European Commission at Ispra (VA, Italy). Also, in comparison to Japan, where private construction companies have large research facilities, the European Commission might act as the main investor while the big European construction companies do not invest in research facilities or in research programs.
The importance of the research in reducing the seismic risk of Europe is not on the agenda of the European Commission, and during the last years, the decrease in JRC's institutional programme funds was affecting the testing program at Ispra. There is the necessity to perform tests for: assessing the safety of existing facilities and for designing appropriate upgrading, assessment of materials (such as concrete beams and slabs, masonry, pipings and others) that may be affected by significant non-

linearity under strong loads. Moreover, laboratory tests play a major role in the assessment and in the validation of design guidelines (using only numerical analysis cannot cover all the uncertainties). Also, new innovative technologies for earthquake protection and vibration control need laboratory tests for assessment, optimization, improvement and validation of both the devices and the associated design guidelines.
This is why, in Europe, even from the project phase, constructions are more vulnerable to earthquakes.

3.1 Financing the research activities from EU budget

A review of the “Sixth FP7 Monitoring Report, 2013, European Commission” and of the “Study on Network Analysis of the 7 Framework Programme Participation Final Report” shows huge differences among European countries. The total budget of FP7 was €29.3 billion. An invisible line almost similar with the delimitation between seismic areas of Europe divides Europe in: “North Countries – low seismicity”’ and “South Countries – high seismicity”.
In Figure 5 are presented the allocation (in percentage from total) of FP7 budget in each EU country (blue line) and also the population (in percentage from total) of each EU country (brown line). The size of red and black bars shows the differences between the two lines. In the red team we found all the former eastern (communist) countries and the south team: Italy, Spain, Portugal and France. Only one exception: Greece.

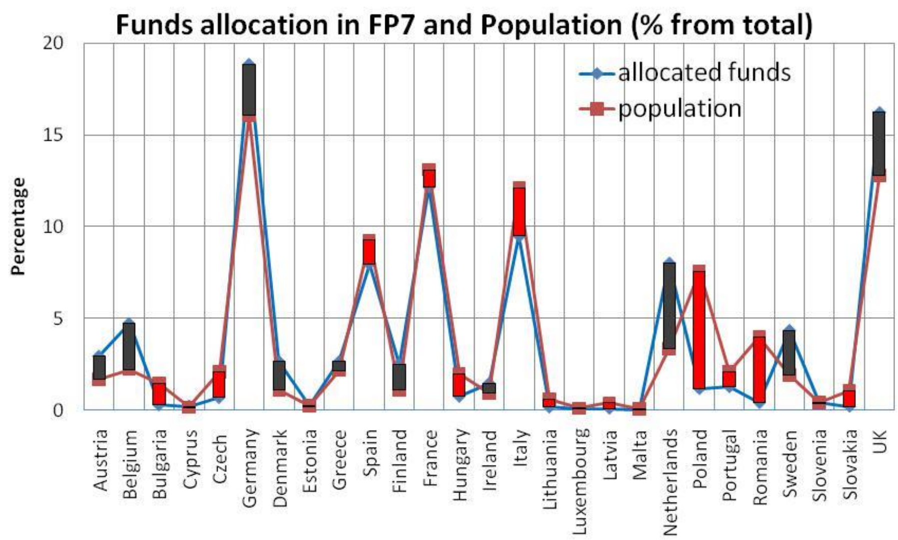


Figure 5. Funds allocation in FP7 research program by country and by population

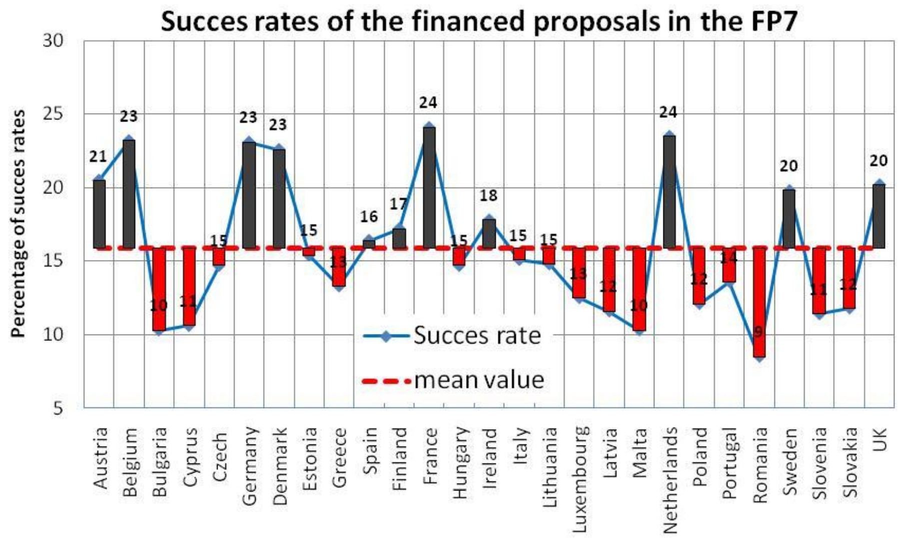


Figure 6. Rate of success in the FP7 for the European countries

In Figure 6 is presented the percentage of success rate of the proposals submitted by each country. The average value is 16% (financed 1 from 7 proposals). We can notice the strong political lobby of the countries having large black bars.

Another funding scheme is the European Research Council (ERC). The ERC has a budget of over €13 billion from 2014 to 2020 and is part of the EU research and innovation programme, Horizon 2020. A short description of the ERC is done by Jean-Pierre Bourguignon, President of ERC: “ERC has, in a short time, achieved world-class status as a funding body for excellent curiosity-driven frontier research. With its special emphasis on allowing top young talent to thrive, the ERC Scientific Council is committed to keeping to this course. The ERC will continue to help make Europe a power house for science and a place where innovation is fueled by a new generation”. The ERC financed 612 proposals out of 2153. The differences between North and South countries proposals follow the same pattern like in Figure 6.

In Figure 7 are represented the rate of success (blue line) for a proposal in each European country. Also is represented the average success rate (dotted red line), i.e. 28%. Similar with Figure 6, the size of red and black bars shows the differences between the two lines (rate of success and the average).

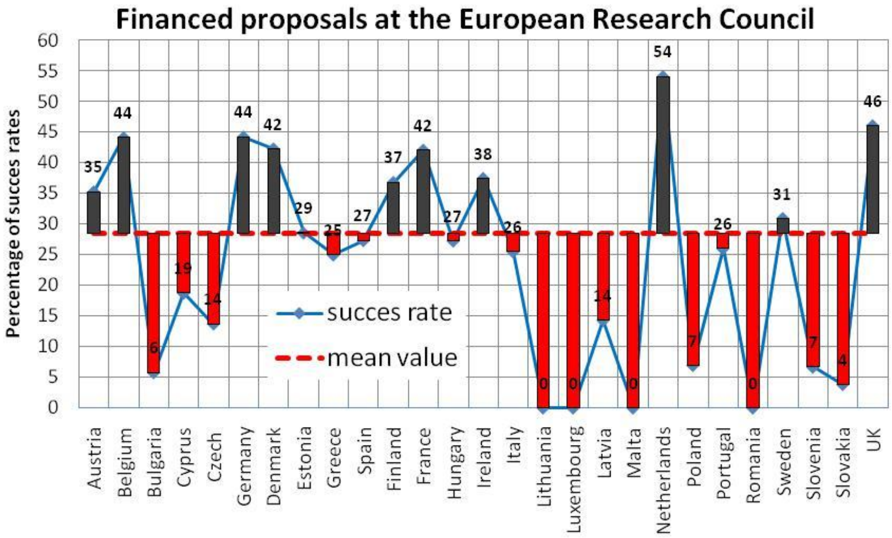


Figure 7. Rate of success of the research proposal at ERC for the European countries

The European population affected by strong earthquakes is similar with the Japanese one and is more than double of all the affected USA citizens.

To understand the seismic risk the first step was to evaluate the seismic hazard of Europe. In the Figure 8 (left) is presented one of the results of the Global Seismic Hazard Assessment Program (GSHAP), 1999. The last research program for estimating the seismic hazard is SHARE, a Collaborative Project in the Cooperation programme of the Seventh Framework Program of the European Commission. SHARE has published recently, 2014, the European Seismic Hazard Map showing the 10% exceedance probability in 50 years for Peak Ground Acceleration, Figure 7 (right). The evolution/differences between the maps presented in Figure 8 can be noticed and are justified by the use of new models for the seismic sources of Europe. In the SHARE European Seismic Hazard Map, the hazard values are referenced to a rock velocity of $v_{s,30}$=800m/s and in the case of GSHAP for stiff soil condition.

The SHARE research project was incorporated in the hazard maps of the GEM (Global Earthquake Model). Unfortunately the results from GEM are not reliable. One example, endorsed by GEM, is in the paper “Exploring Risk-targeted Hazard Maps for Europe” by Silva et al. published recently (September 2015) in Earthquake Spectra; Romania has a seismic risk for new buildings similar with the one of low seismicity zones or high seismicity zones (alternatively without any pattern). Another example from the same authors shows that the probability of collapse of new buildings in “Slatina” is 6 times smaller than the probability of collapse of new buildings in “Catanzaro”, although the seismic hazard from SHARE is the same and the construction regulations are similar for both cities.

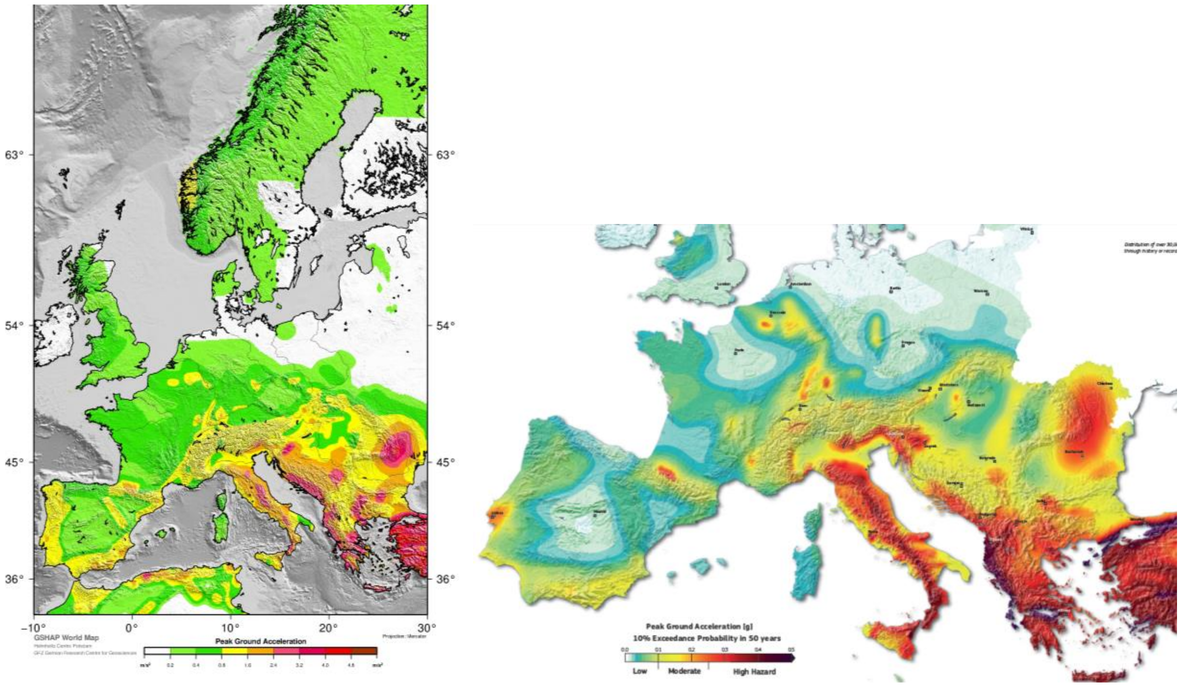


Figure 8. Global Seismic Hazard Assessment Program (GSHAP) and results for Europe (left) and SHARE European Seismic Hazard Map 2013 (right) – Peak Ground Acceleration for 475 years MRI

Since the SHARE was financed by public money, the European Commission is pushing for a practical output (the results have to be used by engineers). One proposal is to use the results from SHARE research project in the future hazard maps of EUROCODE 8 without any verification, discussions at national level. It is maybe the easy way to show to the European Commission the uses of the money spend by SHARE researchers. Unfortunately, there is vulnerability in the European scientific community: the understanding of the effect of surface geology on ground motion parameters, which is correlated with the prediction of seismic hazard. The experience of European researchers in obtaining the dynamic soil parameters is rather limited in comparing with the one from Japan or USA. A European program for investigating the surface geology in all European countries was never financed. The seismic hazard at the rock and the seismic hazard at the surface are very different, and question might be for the case of cities like Bucharest where the rock is at depths of around 1 km. And if we take into account that during the last century the largest magnitude earthquakes occurred in Romania (10.11.1940 M_w=7.7; 4.03.1977 M_w=7.5), how is SHARE going to be used?

What is the solution? The scientists from non seismic areas, leading such important projects, must look more at the experiences obtained by scientists from seismic areas. It is not necessary to grasp the Japan, USA or New Zealand experience, but maybe to look closer.

4. CONCLUSIONS

Reducing the seismic risk in the South part of Europe must be the top priority on the European agenda. Unfortunately, now, the research policies of EU become more like the ones from 80' of Romania. For example: in May 14, 1981 the first Romanian person goes to space, but in the same time, with the infant mortality rate of 29.3 ‰ Romania was the "first" in Europe. Now in 2017, the Europe is financing the project "Gas and Dust from the stars to the Laboratory: Exploring the Nanocosmos" but in the same time on the Earth, the European citizens are in danger in losing their life or properties due to small magnitude earthquakes.

Let's make Europe a "low seismic risk" place to live, travel or study.

The pattern of the European seismic hazard shows large differences between North and South. Unfortunately, not only the population from South is exposed to seismic hazard. The long term or

short term vacations, business or study trips might be the reason that the citizens from North countries might be also get exposed to earthquakes.
The 2016 Italian earthquakes, 24 August 2016 - M_w = 6.0, "produce" economic losses of EUR 7.1 billion, and the earthquakes between 26 and 30 October 2016 with M_w 5.4, 5.9 and 6.5 impacted Central Italy with EUR 16.5 billion losses.
The 21 August 2017, Ischia (bay of Naples), Italy was shook by M_w = 4.2 earthquake. In the same area the 1883 earthquake killed more than 2,000 people. The 2017 event was a very small earthquake (equivalent with 15tons of TNT or equivalent of Chernobyl nuclear explosion) and made a huge impact on the population of about 50,000 and their buildings. "When the government announced two illegal building amnesties in recent years, it received 27,000 applications from Ischia alone". "This was a ridiculous quake with tragic results, something we cannot accept in a modern country," said Domenico Angelone, spokesman for Italy's National Assn. of Geologists. These statements about Ischia show the European reality: corruption and luck of political leadership.
The legal frame for quality control and responsibilities systems in the field of construction must be improved.
Investments in dynamic soil and structure investigations (field and laboratory testing) are needed. Dedicated programs for earthquake disaster mitigation in Europe are needed.
The scientific community and the politicians must have the priority in protecting the lives and the properties of the European taxpayer.
Today, at the European Council there aren't any policies related with reduction of seismic risk. If no actions will be taken by all partners (policy makers, European Council, scientists) the proposed alternative might be in Figure 9. The traditional house from south of Romania is resilient to earthquakes and eco efficient. Even, it is not used anymore in Romania but can be an alternative…since the huge amount of money are spent on climate change, thermal efficiency or dust from the stars and not so much remain for saving the life during earthquakes.

Figure 9. Traditional house in Romania. Resilient to earthquakes and eco efficient. Not used anymore. (Village Museum in Bucharest)

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