EUROPEAN STRATEGIC RESEARCH AGENDA ON EARTHQUAKE ENGINEERING, GAPS AND TRENDS

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ABSTRACT:

Earthquakes occur regularly in the European-Mediterranean area, and are frequently destructive. During the 20th century they claimed over 130,000 lives in the countries of today's EU alone (and over 400,000 in the wider European-Mediterranean area), as well as vast but uncalculated damage to property and economic activity. Over the last 40 years improved understanding and the experience of earthquake loss has driven the progressive development of new and better codes and regulations for building in earthquake areas; and buildings and facilities constructed to today's codes are unlikely to be heavily damaged or destroyed by expected earthquakes.

KEYWORDS: earthquake engineering; mitigation policies, research strategies.

1. INTRODUCTION

The awareness that earthquakes are killers is rising. It has been shown drastically that our current infrastructure does not comply with the requirements necessary to reasonably survive an earthquake disaster. Particular the collapse of key structures like schools (refer to the recent Wenchuan Earthquake in China and the school collapse in Italy) and other critical facilities is to be considered. Furthermore the dramatic consequences of earthquakes on national economies support the drive for new better applicable codes and standards. The main facts and criteria are highlighted in this paper and the gaps and deficiencies of the European approach towards earthquakes are named. The European Association of Earthquake Engineers (EAEE) has expressed the following opinion.

2. THE OPINION OF THE EUROPEAN EARTHQUAKE ENGINEERING COMMUNITY

But throughout the European area, most of the built environment was created before these codes were formulated and enforced, and without the benefit of today's understanding of the effects of earthquakes. Many of these buildings and facilities (which include schools, hospitals, and highway structures used continuously by the public) are unsafe by today's standards and are liable to be seriously damaged or collapse in foreseeable earthquakes. Even where buildings are built to the codes, some damage will occur, since codes are designed for life-safety, rather than for damage-prevention; and strong earthquakes are liable to be disruptive to the urban infrastructure virtually everywhere. Many historic centres of huge cultural importance are at risk.

However, the technical means to substantially reduce this risk are now available. Relatively straightforward modifications to existing structures will in most cases be sufficient to reduce risks to more acceptable levels, and a number of guidance documents to support such modification are now available, including a European Standard.

The EAEE considers it unacceptable in today's world that European citizens are daily exposed to major risks to their life which are well-understood and avoidable. This policy document sets out a programme of action which needs to be undertaken in order to bring earthquake risks under control. It is addressed to national governments and municipal authorities and to the parliamentarians and councillors who shape their policies; to business corporations and other owners of large estates; and to ordinary citizens concerned with their own and their fellow-citizens' safety.

3. STATEMENT

The EAEE calls on all national governments of earthquake-prone countries in the European and Mediterranean area to:

- bring regulations for newly constructed facilities into line with best European practice (as set out in the current European Standard, EC8)
- ensure that inspection systems are in place everywhere to ensure that new facilities are built as designed
- urgently carry out assessments of all public buildings and other structures for which they have responsibility against established safety criteria, starting with schools and hospitals, and put in place programmes of strengthening or replacement of those found to be unsafe
- establish national professional and technical education and training programmes to ensure that those who design and build new facilities understand earthquake hazards and the means to counter them
- promote, by support for research, a better understanding of the risks faced in their territory, and the means to build and modify the country's specific buildings
- ensure that emergency services are well-trained, well-equipped and sufficient in number to deal with the likely consequences of foreseeable future earthquakes
- promote the awareness, by the public and their elected political representatives, of the earthquake risks

faced by society and the means available to them to reduce these risks and enhance personal safety.
- provide financial and technical support to earthquake risk mitigation activities in poorer countries

The EAEE calls on all municipal authorities in moderate and high-risk zones to:
- review the specific earthquake hazards faced within their jurisdiction
- ensure that inspection systems for new buildings are adequate
- urgently examine the safety of all public buildings and set in place programmes to strengthen or replace those found to be unsafe
- examine the entire urban system to form an assessment of the safety of its components (residential building stock, buildings and streets used by the public, lifelines, emergency services) and the system as a whole,
- consider means to reduce this risk through legislation, tax incentives, planning and other instruments
- ensure that earthquake risk mitigation is a key element of their urban sustainability planning
- promote awareness of earthquake risk amongst all members of the community and community organizations

The EAEE calls on private companies and other owners of large building estates in zones of moderate and high earthquake risk to:
- carry out safety assessments of their buildings, and strengthen or replace those found to be unsafe
- ensure that all new buildings are built to the latest available earthquake codes
- promote awareness of earthquake risk and personal safety among all staff and employees

The EAEE further calls on the EU to:
- consider issuing a directive requiring all member states to review existing buildings used by the public for earthquake safety and to bring them to acceptable life-safety standards
- promote earthquake safety (along with other disaster mitigation activities) as key elements of the planned urban sustainability goals for all EU cities
- enhance its research support for earthquake mitigation in the wider European area.

3.1. European Exposure

The European Seismic Hazard Map shows clearly that major parts of the enlarged Europe are exposed to earthquakes.

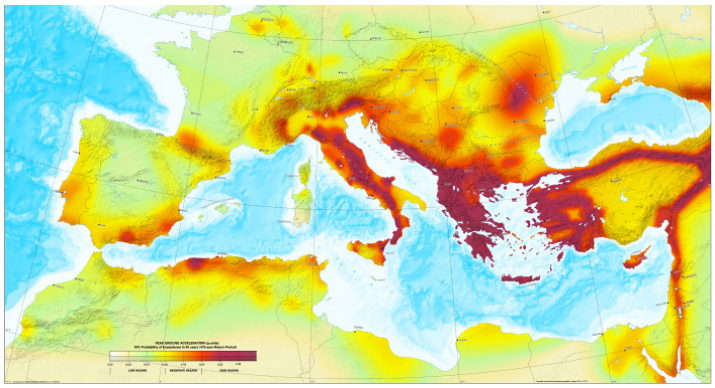

Figure 1 The 2003 SESAME Project Map of Seismic Hazard in Southern Europe and the Mediterranean. Shading shows the peak ground acceleration with a 10% exceedence probability within 500 years

Earthquakes are of concern for many European Member States in particular also for the New ones and some Candidates! (Source: European Research Project SESAME (2003))

3.2. Probability to be killed by an earthquake

The relative vulnerability of humans and the probability to be killed by an earthquake is considerably higher in Europe than in the United States or Japan. This is due to major mitigation programs in these countries implemented by their governments.

Disaster Risk for Earthquakes 1980-2000						
Country	Average number of events per year (event/year)	Number of people killed per year	Average number of people killed per million inhabitants	Average physical exposure per year (people/year)	Physical exposure in percentage of population (%)	Relative vulnerability (killed/million exposed)
ITALY	0.52	225.71	3.98	1 288 265	2.27	**175.21**
TURKEY	0.76	949.86	15.58	2 745 757	4.5	**345.94**
EUROPE	2.24	1187.6	2.97	7.187.388	5.2	**75.89**
JAPAN	1.14	281.29	2.31	30 855 862	25.39	**9.12**
USA	0.48	6.52	0.03	6.745.799	2.61	**0.97**

Figure 2 Earthquake Events and Vulnerability per Region
Note: These include events equal or greater than a magnitude 5.5 of the Richter scale.
(From: Reducing Disaster Risk, UNDP, Statistical Annex, page 143)

There is an obligation to protect the lives of Europeans as well as Americans or Japanese! (Source: UNDP (2006))

3.3. Role of Standards on Federal Level

The regulations for construction have been already amended in 1972 in the U.S., whereas the same happened on European Level only in 1992 (Eurocode 8). This gap has to be closed.

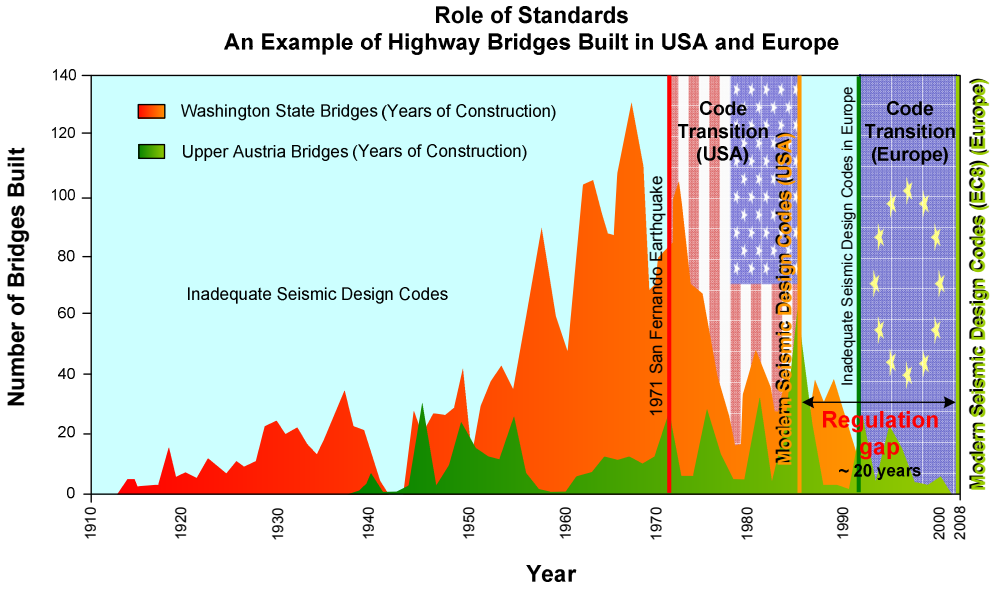

Figure 3 Development of Earthquake related Codes in The US vs. Europe over time
Note: National regulations in Europe have partly been ahead, i.e. Southern European Countries

The demand for Earthquake Engineering Improvement and Regulation on federal level has been recognized 20 years earlier in the USA resulting in considerably lower losses! (Source: EERI (2005), SAMCO (2006))

3.4. Budget for Earthquake Engineering

The annual budgets for earthquake engineering research in the U.S. or in Japan are approximately 10x larger than in Europe (Commission Level).

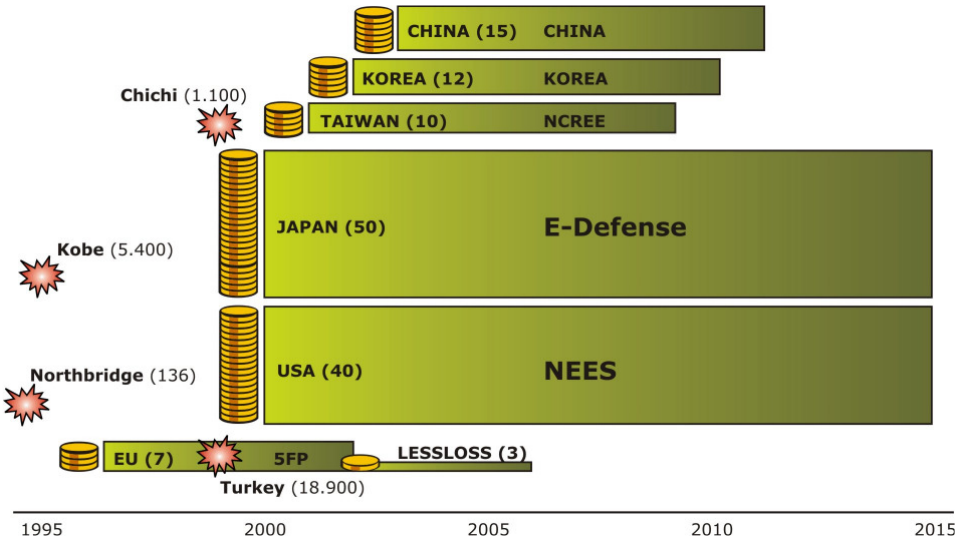

Figure 4 Annual Budget for Earthquake Engineering Research per Region
Note: Only federal level considered (no National Projects in any of the countries)

The USA and Japan have recognized the necessity to invest in Earthquake Engineering Research obtaining a considerably lower vulnerability of the population. More has to be done in Europe! (Source: SAMCO (2006))

3.5. Economic Losses to be expected

The direct economic loss has been significant in the order of 10% to 15% of GNP in the earthquakes of the past 30 years and might reach up to 50% of GNP in the expected big Istanbul EQ.

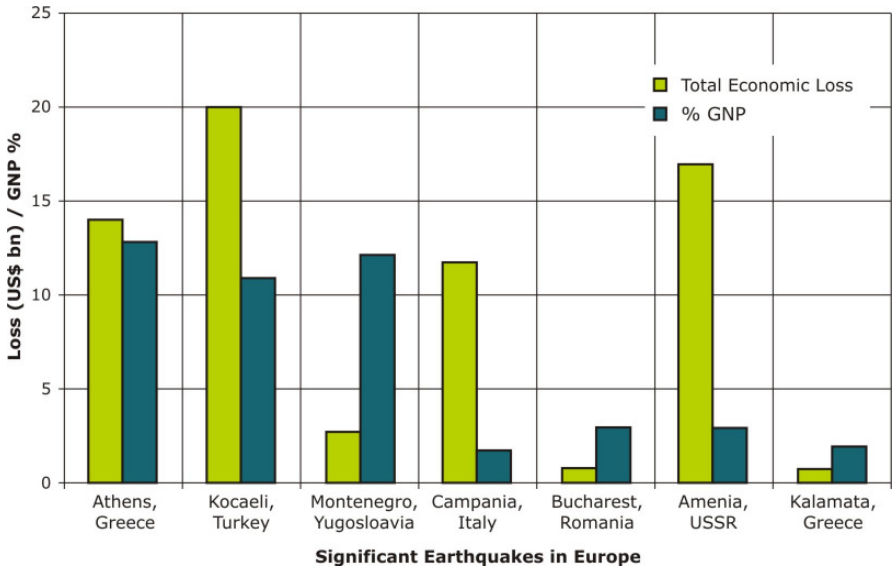

Figure 5 Display of Economic Losses of recent European Earthquake events (1975-2005)

The Investment in Earthquake Engineering Research helps to minimize avoidable economic losses! (Source: RISK-EU Project (2005))

3.6. Indirect Losses

Indirect losses can be even more significant as demonstrated by the drop of tourist arrival in central Italy after the 1999 Assisi earthquake.

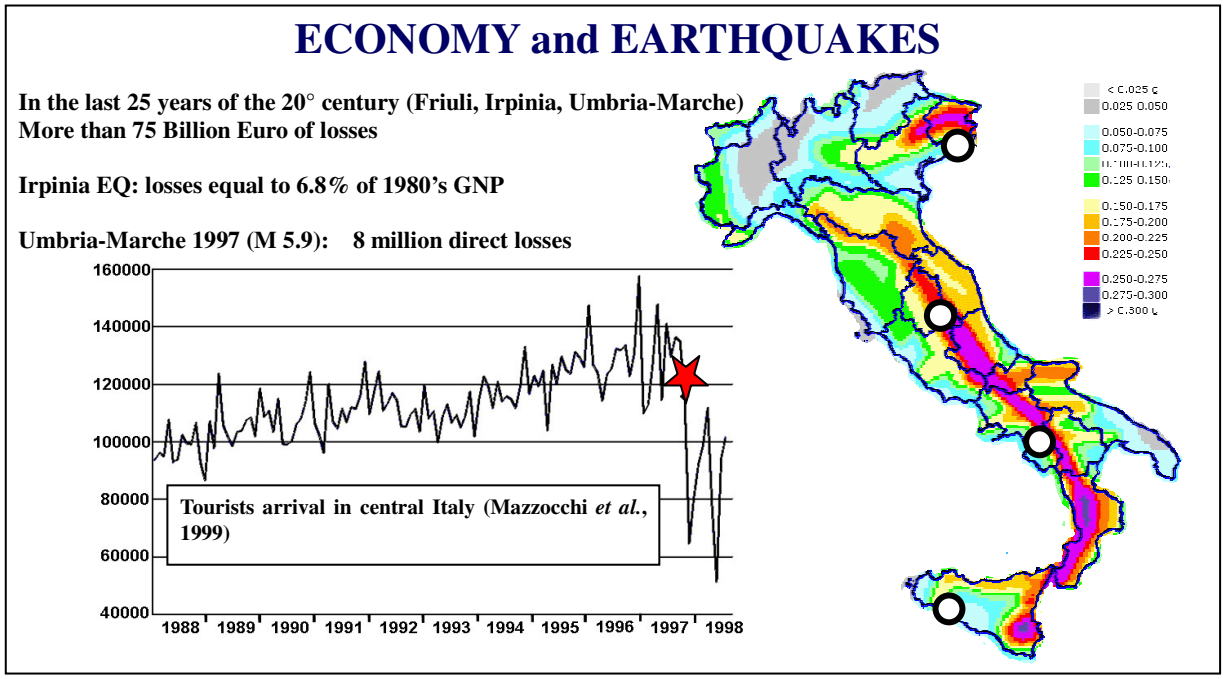

Figure 6 Indirect economic losses demonstrated on events in Italy

Indirect losses due to earthquakes reach macro economic scale and shall be reduced by Earthquake Engineering means! (Source: Internet (2007))

3.7. Total Economic Losses

According to an UNDP study the total economic loss due to earthquakes is the highest in Europe and Asia.

Earthquakes from 1901 to 2005 (figures referred to year 2005 prices)			
	Number of Events	**Total Damage (1000's US$)**	**Average damage per event (1000's US$)**
AFRICA	69	11,073,899	160,491
AMERICAS	236	46,335,306	196,336
ASIA	544	200,772,941	369,068
EUROPE	144	58,394,376	405,517
OCEANIA	38	2,509,419	66,037

Top 10 countries affected by earthquake (Sorted by economic damage)		
Country	**Date**	**Damage in US$ (1000's)**
Japan	17-Jan-1995	100,000,000
Japan	23-Oct-2004	28,000,000
Italy	23-Nov-1980	20,000,000
United States	17-Jan-1994	16,500,000
Taiwan (China)	21-Sep-1999	14,100,000
Soviet union	7-Dec-1988	14,000,000
Turkey	17-Aug-1999	8,500,000
Iran Islam. Rep.	21-Jun-1990	8,000,000
China	27-Jul-1976	5,600,000
United States	18-Oct-1989	5,600,000

Figure 7 Continental and National Damage figures (Note: Figures are as occurred (not inflated))

Europe has an outstanding Earthquake Damage Record! (Source: EM-DAT: The OFD/CRED International Disaster database (2005))

3.8. European Know How is exportable

The development of mega cities in earthquake prone areas increases the exposure of population to earthquake disasters. Europe has an obligation to help by exporting know-how and technologies.

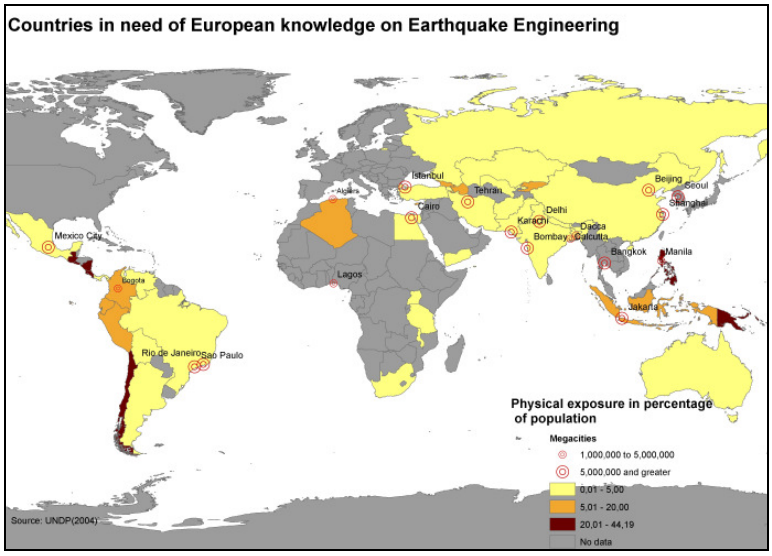

Figure 8 Countries and Mega Cities where European Earthquake Engineering Know How could help to improve the situation considerably

There is a better chance to take the European Role in Global Disaster Mitigation than currently practiced! (Source: UNDP (2006))

3.9. Trend in Natural Disasters

The time trend of natural disasters shows a clear increase of events over the recent 30 years.

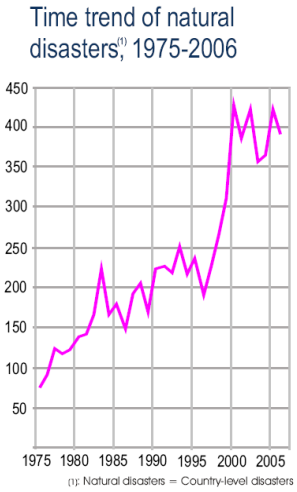

Figure9 Global Time Trend of Natural Disasters 1975 - 2006

The Subject of Natural Disasters will further increase in importance and particular public awareness! (Source: UNDP (2006))

3.10. Earthquakes are Killers

The total number of people killed globally per year by natural disasters shows that about 2/3 of the numbers are earthquake related.

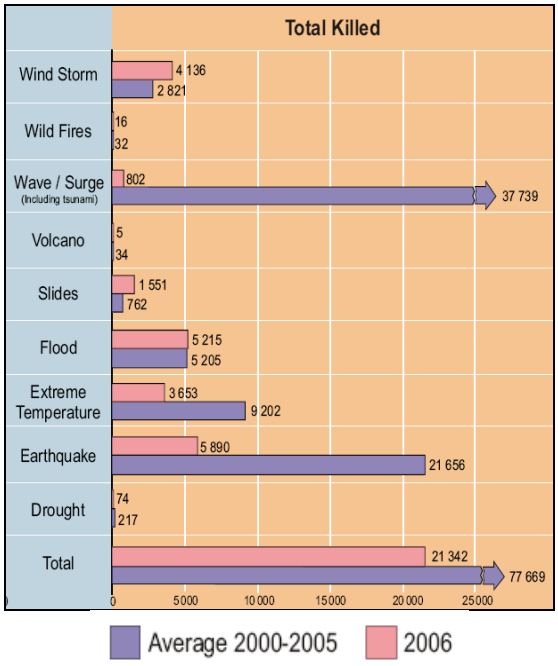

Figure 10 People killed by Earthquakes vs other Natural Disasters

Increased obligation to invest in mitigation found by Earthquake Engineering Research to reduce the loss of lives!
Source: UNDP (2006)

4. CONCLUSION

The following is stated by the earthquake engineering community:

- It is unacceptable that large parts of the European population are exposed to earthquake hazards without reasonable mitigation concepts
- Earthquake engineering research on European and national level does not meet the required standard and funding levels
- The existing standard (EC8) is to be enlarged to cover all aspects of earthquake engineering as quick as possible and complemented by national documents specifying the specific conditions for each region

A major effort is necessary in order to improve the situation to a comparable level with other well developed regions in America or Japan.

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