EAEE

European Association for Earthquake Engineering

EARTHQUAKE RISK REDUCTION

IN THE EUROPEAN UNION

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PROPOSALS FOR A EUROPEAN EARTHQUAKE RISK REDUCTION PROGRAMME -A DISCUSSION DOCUMENT

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EXECUTIVE SUMMARY

1. Earthquakes are a serious threat to many European regions, particularly, but not only, in the south. They are a recurrent phenomenon that has already caused serious loss of life and is a threat to the sustainable development of those regions. However, the development of scientific knowledge now permits significant reduction of the risk to which people and goods are exposed in the most seismic prone regions of Europe.

2. Culminating a long process of debate, including the Workshop 2000 Mitigation of Seismic Risk, by the European Commission, and the Workshop "Reducing Earthquake Risk in Europe" in Lisbon in October 2005, organized by the European Association for Earthquake Engineering (EAEE), this document summarises the conclusions and recommendations of the second workshop.

3. Chapter 2 presents an overview of the problems of seismic risk in the European Union. It establishes in more detail the reasons for concern, and the actions needed to reduce seismic risk are then identified and listed. The chapter also identifies the European dimension of the problem, and argues that EU support for risk mitigation is evident in many existing decisions, programmes and policies. Chapter 3 discusses ways in which existing EU funding mechanisms could be used to promote the necessary activities of earthquake risk mitigation. Important developments in the use of the European Social Fund (ESF), European Regional Development Fund (ERDF), and the Cohesion Fund (CF) are proposed.

4. Chapter 4 reviews the state of research in the field of earthquake risk mitigation, and discusses the need for a new European-level research structure, complementary to national structures. It also discusses the role of DG-Research in leading such a structure and promoting the enhancement of cooperation between Europe and other earthquake-prone regions of the world, notably the USA and Japan. This Chapter is complemented by an Appendix, setting out an agenda for research needed during the FP7 Programme to contribute to earthquake risk reduction.

5. Chapter 5 discusses the role of the construction and other Codes in the reduction of earthquake risk. The first set of Eurocodes are now nearly complete, and it is widely agreed that their provisions contain an advance with regard to pre-existing norms but much remains to be done to bring them into widespread use throughout the EU. The Chapter discusses several aspects in which they can be enhanced and applied to aspects of the built environment not so far covered.

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6. Chapter 6 looks at the potential for the contribution of DG-Environment both in ensuring uniform approaches to risk management throughout the EU, as recommended by the 2006 ESPON Report, and in the development of collaboration between, and enhancement of, national Civil Protection activities.

Recommendations

7. In order to enhance the process of risk mitigation in Europe, the EAEE believes that the following actions should be considered, involving interactions between the European Commission, Member States and the scientific community:

- A review of the Role of DG-RTD to create a new longer-term support structure for European Research, with associated changes in funding mechanisms, relationship between EU-funded and nationally-funded research activities, and administrative arrangements (Chapter 4).
- An enhanced research programme at a European level covering aspects of earthquake hazard, better construction and communication of seismic risks to the general public and within the construction industry, and means to reduce the earthquake risk in existing buildings and infrastructure (Appendix 1), coupled with mechanisms for improved collaboration with countries outside Europe.
- Enhanced activity by DG-ENV to support the ability of Civil Protection agencies in Member States to respond after a major earthquake, and to ensure that land-use planning and urban development for sustainability incorporates provision for minimising seismic risks, alongside those from other more obvious natural hazards (Section 6.2)
- Further support to the development of Eurocode 8 and other codes by DG-ENT, in order to bring the fruits of new research into practice, to improve its applicability by the construction industry, and to strengthen its effectiveness for use in retrofit strengthening programmes, especially for the old urban centres of European cities (Section 5.5, 5.6).
- Use of European Regional Development Funds (ERDF), to support essential strengthening and upgrading for key infrastructure and public buildings such as schools and hospitals in areas of high seismicity. Ensuring construction to satisfactory antiseismic standards wherever the ERDF or the Cohesion Fund (CF) are used for other construction work (Section 3.2).
- Use of the European Social Fund (ESF) to support training and public awareness campaigns for earthquake-preparedness on the part of populations at risk (Section 3.2).
- To examine the scope for new mechanisms of funding to support actions to preserve historical monuments and buildings and artefacts of cultural importance from future earthquake damage (Section 3.2).

1. INTRODUCTION

Earthquakes remain a serious threat in many parts of the EU and its regions, and have continued to cause major loss of life and destruction in recent years. But earthquakes can no longer be regarded as natural disasters, since the main cause of damage - the inadequate seismic resistance of the building stock, lifelines and industry - is well-understood and can be avoided.

Earthquake risk has causes and consequences beyond national borders, and the EU has acknowledged its concern to reduce future earthquake risks in many ways, for example through its support for the Eurocodes, for the coordination and promotion of Civil Protection, and for related research programmes. However, much remains to be done in all these directions and, even more seriously, these actions do not touch what is now widely regarded as the most critical issue: the problem of the older vulnerable buildings and infrastructure, which were built before current regulations were adopted, and many of which perform vital functions in our cities.

At the European level, the first debate on this issue was promoted by the EC and organised by the JRC in Nov 2000. It made many useful recommendations but there was no follow-up plan. Subsequently, the European Association for Earthquake Engineering (EAEE) has been working with parliamentarians, the Commission and other international organisations to define an affordable and realistic set of policies for earthquake protection across the European-Mediterranean region; and in Portugal the Portuguese Society for Earthquake Engineering (SPES) and GECoRPA (Portuguese Association of Companies for Preservation and Restoration of the Architectural Heritage), have proposed new initiatives, aiming at establishing sets of coherent and coordinated policies to reduce earthquake risk, at all levels local, national and EU level.

This process culminated in the workshop "Reducing Earthquake Risk in Europe", organised by the European Association for Earthquake Engineering (EAEE) and the Portuguese Society for Earthquake Engineering (SPES), with the support of the European Commission's Joint Research Centre (JRC) and the UK Society for Earthquakes and Civil Engineering Dynamics, and hosted by the Portuguese Government in Lisbon on 31st October 2005. The Workshop was an opportunity for a face to face discussion between key members of the scientific community, the European Union and national Governments aimed at the formation of a strategy and a coordinated programme of actions to reduce earthquake risk in Europe.

This document is the product of that workshop. It presents an overview of the problems of seismic risk in the European Union compiled jointly by the authors, representing both EAEE and SPES. It first establishes in more detail the reasons for concern, and identifies the European dimension of the problem. The actions needed to reduce seismic risk are then identified and listed, and ways in which existing EU funding mechanisms could be used to promote these activities are suggested, as well as suggestions for the creation of other instruments. Subsequent sections then identify the potential role of DG-Research, of DG-Environment and of the development of the Eurocodes in future activities to reduce earthquake risk, and some recommendations are made. The document concludes with a summary of the main proposals.

2. BACKGROUND

2.1 Earthquake occurrence

Earthquakes have been the cause of more than 1.5 million deaths worldwide during the 20th century. A number of the most deadly earthquakes have occurred in Europe. Earthquakes have also caused economic losses which recent experience has shown are increasingly unacceptable in developed countries.

Earthquakes are geological phenomena, associated to a rupture in the solid exterior part of the Earth (lithosphere), triggering relative displacements along active faults, and are to a large extent unpredictable. It is not possible to predict where the next large earthquake is going to be triggered (and the affected zones), when it is going to happen, or its magnitude. However science has identified the generation mechanisms, which show that the zones where large earthquakes have taken place in the past are continuously subjected to the possibility of the occurrence of large earthquakes. It is therefore possible to identify the zones where strong earthquakes will happen in the future. In Europe those zones are essentially in the south of Europe (the Alps and the regions south of the Alps) close to the fault zone that separates the Euro-Asian plate from the African tectonic plate. This fault zone stretches from the islands of Açores, across the Mediterranean Sea as far as Turkey and the Middle East. In northern Europe lower magnitude earthquakes can also take place, affecting smaller areas, but with a potential for serious damage.

The SESAME Project earthquake hazard map (Fig 1) shows clearly the uneven distribution of earthquake hazard across Europe. Within today's EU, large parts of Italy, Greece, Romania and Slovenia experience the highest seismicity, while smaller parts of Portugal, Spain, France, Germany, Austria, Bulgaria and the Czech Republic also have significant risk. Areas of equally high and even higher risks are identifiable in bordering (accession) countries, namely Turkey. And most of the rest of the EU experiences some degree of seismic risk.

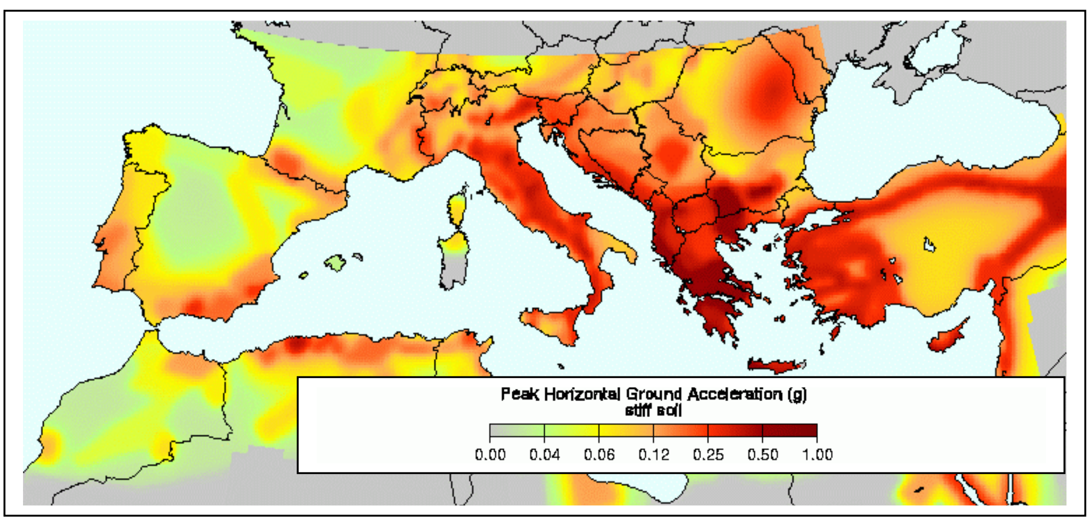

Fig 1 The 2003 SESAME Project Map of Seismic Hazard in Southern Europe and the Mediterranean. Shading shows the peak ground acceleration with a 10% exceedence probability within 500 years

2.2 Earthquake consequences

In order to give an overall view of the task of earthquake risk reduction, the different types of earthquake effects at the earth's surface are identified and possible actions to reduce their consequences are indicated:

I – Fault Rupture.

This effect happens when the fault along which rupture takes place appears at the Earth surface and accounts for only a small fraction of the losses.

Possible actions against this effect include not building across potential active faults, and building taking adequate precautions. The second option is usually only applicable to extreme situations, for instances opting between tunnel or bridge in a large crossing. Both actions involve research to identify and map this type of fault and restrictions to construction using territorial and urban planning instruments. In some cases this may not be possible or economically feasible. However it may be worth building roads and railways assuming some repairable damage is likely in the event of a major earthquake.

II – Landslides, subsidence and liquefaction

This involve changes in topography, usually associated to movements of large masses of soil in less stable slopes that become unstable during an earthquake. Liquefaction involves loss of soil load bearing capacity due to increased pore pressure and subsidence large soil settlements. These effects account on average for less than 10% of the losses.

Possible actions against this effects: avoid building in these zones or built taking adequate precautions, for instances stabilizing the soil, if technically feasible and economically worth it. This involves identifying and mapping this zones and restrictions to construction using territorial and urban planning instruments.

III – Tsunamis.

These only take place if the epicentre is at sea, if the displacement between the faults involves a change in the morphology of the sea bottom, and if the magnitude of the earthquake is large enough to induce a significant change in the morphology of the sea bottom. Tsunami waves travel at high sea at hundreds of km/hour but near the coast (at smaller depths) the speed reduces to tens of km/hour. Depending on the distance between the epicentre and the coast, there is a time gap between the occurrence of the earthquake and the arrival of the tsunami to the coast. The tsunami is a long length wave and is stopped essentially by the force of gravity. This means that zones a few meters above sea level are not reached by the waters and only coastal areas are affected. In most cases tsunami losses are small. But in certain circumstances (such as the Indian Ocean Tsunami of 26.12.04) they can be the predominant cause of loss.

Possible actions against this effect: in the coastal zones close to the epicentre the time gap between the earthquake and the arrival of the tsunami to the coast may be small (10 or 20 minutes, for instances). It may not be enough for the authorities to issue a warning and organize a large-scale evacuation. However if (i) the population is well informed and knows how to recognize the signals of danger, this is, the earthquake itself, and (ii) is prepared to act in such a situation, then a large scale evacuation can take place. In the coastal zones more far away from the epicentre, where the earthquake is not felt, the tsunami will only arrive a longer time after the earthquake that triggered it. If earthquakes are properly monitored, a few minutes may be enough for scientists to evaluate the probability of triggering a tsunami. A warning may then be issued with enough time before the tsunami arrives at the coast for civil protection authorities to organize the evacuation. The above actions may save the lives of the vast majority of the potentially affected populations, specially if there are no facilities with large concentration of people with low mobility (for instances hospitals, schools for young children, homes for elderly people) in the potentially affected zones and facilities with potential to cause environmental disasters. However many material losses in the affected zones cannot be avoided. Actions to decrease the consequences of tsunamis comprise (i) creation and maintenance of monitoring systems for the Mediterranean and for the Atlantic, (ii) information and preparation of the population, and (iii) avoid the construction of the above-mentioned type of facilities using territorial and urban planning instruments (iv) design to resist predictable levels of tsunami action.

IV – Ground motion / ground shaking.
This affects all the zones within a certain radius of the epicentre, therefore it is impossible to avoid its consequences only with territorial and urban planning instruments. Ground motions are also the cause of the vast majority of the human and economic losses caused by earthquakes, typically more than 80%. Therefore it is essential to reduce the consequences of ground motion if it is intended to avoid most earthquakes consequences. Since seismic waves travel at several kilometres per second, no action that depends on human intervention is possible in the time interval after an earthquake occurs and the time when the motion is felt. Only some automatic actions, like shutting down lifelines, factory equipment or opening doors of fire brigades facilities, based on Early Warning Systems (EWS), can be done in some cases. And after the earthquake has happened it is too late to avoid most of the damage or reduce significantly the number of victims. Therefore it is absolutely necessary to act before earthquakes happen, building constructions and infrastructures that resist earthquakes. This is possible with the existing scientific knowledge, making use of the capabilities of modern seismology and earthquake engineering, as follows:

(i) by studying the historical earthquakes, the recorded earthquakes (essentially during the last 100 years), and studying the faults that can generate earthquakes, seismologists can also estimate the probability that earthquakes of certain characteristics affect given zones during given periods of time. This information forms the basis for the definition of design earthquakes, embodied in structural codes all over the world, including the new Eurocode for seismic regions, EC 8.

(ii) by applying modern earthquake engineering knowledge, which has the capability to design and built constructions and equipments to resist to those earthquakes.

The main actions needed against this effect are:
Evaluate the seismic resistance of existing buildings and strengthening those with insufficient seismic resistance. This is relevant in many European countries, where large parts of the building stock are old and where many buildings were built prior to the enforcement of modern seismic design (approximately by the beginning of the second half of the 20th century). Some buildings built afterwards, particularly before 1980 at the initial stages of the application of the codes, may also be vulnerable.

Ensure the quality of construction: this applies both to new construction as well as strengthening existing ones. Experience shows that in recent construction, that is supposed to be designed to withstand earthquakes, the level of damage is inversely proportional to the quality of construction. The existence of scientific knowledge and good codes of practice is not enough to ensure the construction of earthquake resistant structures. It is fundamental that knowledge and codes are properly applied in design and construction.

Evaluate the seismic resistance of lifelines (power, telecommunications, gas, water and sewage) and transportation networks and strengthen where necessary. In the early stages of the development of modern earthquake engineering attention focussed essentially on the safeguard of human life, therefore on buildings and civil engineering structures. The lifelines did not have the importance they have today and did not receive as much attention. As a consequence equipment associated with the lifelines not designed by civil engineers were not designed to withstand earthquakes, creating weak points.

Evaluate the seismic resistance of industrial facilities and strengthen where necessary. What was referred to the equipments of the lifelines also applies in industry. And some types of industrial buildings, specially pre-fabricated, that have shown poor seismic performance in the past, may need strengthening.

Strengthen monuments and buildings of high cultural value. This is an important part of Europe's priceless cultural heritage and an important component of national identity. Special care has to be taken when intervening in these structures to do not change their "character". This leads to the application of techniques as less intrusive as possible.

V – Fires. These are not a direct effect of the earthquake, but take place often during and after the earthquake and can be a major cause of damage and loss of live. Fires are caused mainly by disruption on the gas and electrical networks and gas escapes on the final users. The proportion of fire losses has diminished over recent decades
Possible actions against this effect: education of the population to minimize the risks of triggering fires at private houses and offices and design of gas networks (electrical networks usually contain safety devices that shut down the networks a few seconds after strong earthquakes start) including location of large deposits of gas, etc.

2.3 - The role of Civil Protection

While it is agreed that post-event actions, such as most of the Civil Protection actions, are not the most efficient way of avoiding damage or reduce the number of victims of earthquakes, these activities are nevertheless very important because prevention can reduce damage and the number of victims very significantly but can not avoid them completely. Therefore search and rescue operations are an additional contribution to reduce the number of victims, taking wounded people to hospital also contributes to avoid more dead and suffering, putting down fires also saves lives and reduces damage. Civil Protection action is also very important to the recovery of the populations and economy of the affected zones, namely by providing support to the survivors that may need temporary shelter and other forms of support to survive, identification of buildings and facilities that can be used and which ones are unsafe, etc. and other tasks important to bring the affected zones to normality.

The design of buildings to withstand earthquake ground shaking does not prevent the buildings from shaking. This may induce damage inside houses and offices, injuring people. In a preventive approach Civil Protection agencies usually recommend adequate procedures for people to minimize the likelihood of such injuries.

Civil Protection activities should also comprise, and in many cases do, contributions to prevention, for instance by means of information on how the population can and must act before and during earthquakes. Therefore in tackling the earthquake problem, Civil Protection actions must be regarded as an indispensable and important complement of the main preventive policies.

2.4 -The Political Background

European integration involves, in many instances, the pooling of national sovereignty in favour of EU institutions, therefore creating a European dimension in many important issues for European citizens, including the reduction of the effects of natural catastrophes. This was clearly recognized by European leaders during the floods of 2002 in central Europe. One of the examples was the declaration of the German Chancellor stating "he was expecting help from Brussels, since the dimension of the catastrophe was beyond the limits of national intervention". The fairness of this view was widely recognized and has already led to the creation of the Solidarity Fund.

The European dimension of the problem of natural catastrophes is also implicit in other EU decisions and policies. Several examples can be given: (i) the support to research in the fields of seismology and earthquake engineering, (ii) the development of structural codes, in particular Eurocode 8 applicable to the design of structures in seismic regions, and (iii) the establishment of a centre for coordination of Emergency aid, which can be very useful for the optimisation of the application of European Civil Protection resources following large earthquakes. However, despite the importance of these policies, they are not enough as do not address many of the actions needed to a significant reduction of seismic risk.

The EU cohesion policy aims at promoting sustainable development throughout the EU. However large earthquakes can cause severe damage and destroy the physical infrastructure that underpins social and economic development. Thus, there is an incompatibility between the objectives of EU policies and the very high levels of seismic risk to which large European regions and populations are subjected. It is therefore indispensable to address fully the challenge of seismic risk prevention to ensure the sustainability of the benefits of EU policies. Moreover it is unacceptable that European citizens are daily exposed to major risks to their life, which are well understood and avoidable.

Other countries such as the USA (California), New Zealand and Japan have for a long time been enforcing policies for the reduction of earthquake risk, in particular in the lifelines, transportation networks and strategic buildings and facilities (buildings or other facilities important for running the economy and the public administration or for life saving or social reasons). The EU should not continue to lag behind these countries.

3. POTENTIAL APPLICATION OF EU FUNDS FOR EARTHQUAKE RISK REDUCTION

3.1 The role of the EU in the reduction of seismic risk

It was shown above that the reduction of earthquake risk is a complex task that involves actions in several domains at different levels of Government activity. Therefore the most efficient way of tackling this problem involves coordinated efforts from the EU, national and local authorities. The EU can contribute to this effort by (i) pursuing and strengthening the policies already enforced and referred to in 2.4 (ii) issuing recommendations or directives requiring Member States to ensure minimum standards of earthquake safety of important facilities and public buildings, (iii) creating the structure and coordinating national contributions to tasks that are better performed at transnational and international level, such as creation and maintenance of tsunami warning centres for the Atlantic and the Mediterranean, and (iv) supporting the Member States in the implementation of the policies necessary to enforce the recommendations or directives mentioned in (ii) and other actions referred to earlier. The EU can also contribute significantly to the reduction in seismic risk worldwide through its humanitarian and development aid activities.

3.2 Application of EU Funds

The main actions referred to above are restated below and numbered. For the purpose of the analysis that follows Action 3 was subdivided in 2 parts, to distinguish strategic buildings from other buildings.

Action 1. Territorial and urban planning.
Action 2. Informing and preparation of the population.

Action 3. Evaluation of the seismic resistance of existing buildings and strengthening the ones with insufficient seismic resistance.

3a – Strategic buildings

3b – Current buildings

Action 4. Ensuring the quality of construction.

Action 5. Evaluation of the seismic resistance of lifelines and transportation networks and strengthen where necessary.

Action 6. Evaluation of the seismic resistance of industrial facilities and strengthen where necessary.

Action 7. Strengthening monuments and buildings of high cultural value.

Action 8. Civil Protection actions.

In general these actions should be of the initiative of the Member-States with support of the EU. The analysis that follows aims at identifying suitable instruments to support the proposed actions and, if they do not exist, to suggest possible ways to create those instruments. The analysis will be done considering two groups of actions: the ones which need limited resources to be developed and the actions involving strengthening of existing buildings or facilities and that may need higher levels of resources to be implemented. The first group consists of actions 1, 2, 4 and 8 and the second group comprises actions 3, 5, 6 and 7. Relatively to the actions 3, 5, 6 and 7 that need larger resources to be implemented it is necessary to establish priorities and upper limits for the EU contribution. Those priorities should consider several factors such as the seismic hazard level (the probability of occurrence of earthquakes with certain characteristics during given periods of time) in each region, results of cost-benefit analysis and the potential for life saving. The upper limits of the EU contribution for each Member State should account for the potential dimension of the problem, the available resources, and, in line with the German Chancellor's argument, the dimension of potential catastrophe to be avoided as compared to the capacity of the Member State to recover from it. To establish hazard levels it is proposed to consider 4 possible levels: High, Medium, Low and Very Low seismicity. The distinction between the different levels can be established as a function of the design peak ground acceleration established in the codes of each Member State for each region (see Fig 1).

Action 1 Territorial and urban planning.

Action 1 is a subject to be dealt with at national and local level. However research work is necessary to produce the information to be embodied in the charts and regulations that support the urban and territorial planning decisions. Research is a field in which the EU has been active, and the background work necessary for the development of Action 1 fits within DG-RDT initiatives and support.

Action 2. Informing and preparing the population.

This action should be implemented by Civil Protection and/or other agencies at national level and does not involve very large resources. Campaigns with this purpose should be eligible to receive contributions from the EU, and it is suggested that the European Social Fund (ESF) might be used for this purpose. The ESF funds training and formation activities aimed at improving the skills of the work force, in support of employment, and to promote environmentally sound economic growth (Article 1.2). Therefore the mentioned campaigns would fit within the objectives and regulation of the ESF, as they are part of a set of coordinated policies aimed at ensuring the long-term environmental sustainability of the benefits of other policies supported by the EU. It is not envisaged that the ESF will need extra funding to support these activities. After a few years of implementation this situation may be reanalysed if the need for such is felt.

Action 3 Evaluation and strengthening of existing buildings
Action 3a. Strategic buildings
A qualitative relative cost-benefit analysis would probably indicate that Actions 3a and 5 (lifelines) are the ones likely to avoid the largest economic losses, when compared with the losses avoided with similar resources invested in other Actions. The lifelines are today essential instruments of support of the life of the populations and of the economy. For instances if the power, telecommunications and transportation networks are disabled for a long period the economy will stop, the life of the populations will become unbearable and Civil Protection will not be able to act efficiently. Long disruption of water and sewage networks will create the potential for spreading large epidemics. Damage to strategic buildings, for instances buildings that host services and public equipments indispensable for the efficient running of the economy and of the public administration, are likely to cause large economic losses. It may also increase the death toll if the level of damage disrupts services and equipments for a considerable period. Strategic buildings should also include important facilities in Emergency situations, such as Fire Brigades facilities, communication centres of Civil Protection agencies and hospitals. Schools with large concentration of children can also be considered strategic buildings for social reasons.

The ERDF already funds the construction and upgrading of such buildings and equipments. It is therefore natural that it is used to upgrade and ensure the safety and operationality of such facilities in Emergency situations in which are most needed. Given the importance of the lifelines and strategic facilities it would be appropriate to support actions 3a and 5 in regions of High and Medium seismicity in a first stage, and extend it to Low seismicity areas in a second stage. It is not expected that in the short term a very large amount of projects in this area, as compared with the existing ones funded by the ERDF, would create the need for extra resources to be provided to the ERDF. The projects and activities in this field of action would probably be preceded, in some areas of activity, by studies and research work aiming at identifying priorities and solutions, and would tend to increase gradually. The experience of the first years would indicate if a later increase of the resources available to support actions 3a and 5 would be necessary.

Action 3b. Other buildings
In urban rehabilitation of buildings two components can be distinguished: that associated with improving safety conditions and that associated with conservation and improvement of living conditions. Action 3b refers <u>only</u> to the first component.

Action 3b may have almost any dimension, depending on the scope of application. If it was aimed at ensuring to all citizens safety standards similar to the ones required by current codes it would be necessary to strengthen or replace (demolish + rebuild) all buildings which have less seismic strength than the high levels required by current codes. It is recognized that this is impossible. The scope of application of Action 3b would be severely reduced if only the situations in which the cost of strengthening is less than the expected material losses are considered eligible. However this criterion alone is also excessively restrictive. The EU planned urban sustainability goals for all EU cities imply that minimum safety levels should be ensured in all buildings. Therefore a reasonable option is to consider eligible the buildings that meet one of the two criteria or both. Even though the definition of a minimum acceptable level of safety is a political decision, whatever the decision is, the number of eligible buildings would probably be considerable.

In this condition it is necessary to assume that there are no short-term solutions for this problem and that Action 3b may last for several decades in some regions. Therefore the later the process starts, less work will be performed before new earthquakes take place. The dimension of the problem makes necessary to establish priorities. It is proposed that in a first phase Action 3b is restricted to regions of High seismicity and should start by the weakest buildings to be strengthened, where the ratio (gains in structural safety) / (necessary resources) is higher. The eventual end of the first phase and possible extension of Action 3b to zones of Medium seismicity would certainly not occur in the short term and the respective timing should be decided as a function of the progress achieved.

Regarding the instruments chosen to provide support for Action 3b, two main possibilities can be foreseen: the ERDF, which has already been used to support the Urban Community Initiative aiming, among other objectives, at promoting the physical regeneration of EU cities in order to promote sustainable urban development. Even though the objective was essentially the regeneration of socially degraded areas, the extension to zones presenting problems of structural security should be natural within the broader aim of promoting sustainable urban development. Action 3b clearly would contribute to the physical regeneration of cities by increasing structural safety of the weakest buildings. The other possibility is the use of the Solidarity Fund (SF), which was created to minimize the consequences of natural catastrophes. Unfortunately the logic of the regulation of the Solidarity Fund is of an intervention after the catastrophe has happened and its regulation only allows preventive measures "following a disaster". The limitations of this approach in the case of large earthquakes have already been pointed out.

Since the ERDF has already been used for purposes similar to the ones proposed, it seems to be the most adequate instrument for this purpose. However, within the framework of the Urban Community Initiative interventions could take place at social equipments but not on private housing. It is recognized that support for the rehabilitation of the housing stock without limits could stress EU resources beyond reasonable limits. It is therefore proposed that the regulation of the ERDF is changed to allow supporting interventions on the housing stock, or part of those interventions, with specific objectives, namely (but not exclusively) to provide minimum levels of safety. This means that only specific parts of the works to be performed would qualify for EU support, decreasing the demand from the Member-States. In order to keep under control the total amount of resources to be spent for this purpose it is also suggested that upper limits for the EU contribution should be established for each Member-State, considering the priority criteria already mentioned. Anyway a large scale strengthening of buildings will require some preparation in the Member States, as the construction industry would need to develop the respective know-how in large numbers of companies. This implies a large effort in formation of specialized personnel and cannot be done too quickly. In these conditions it is anticipated that the demand for EU support for Action 3b from the Member States would be gradual. And the bulk of the costs of any upgrading actions will have to be found by the building owners themselves and Member States. The EU would provide incentives and support a common regulatory framework for action.

Action 4 Ensuring the quality of construction

This action applies both to new construction and strengthening existing construction (as well as design, making and installation of electrical, mechanical and other types of equipments in the lifelines and industry) and is fundamental to ensure that actual and future investments (by the EU and Member States) are not lost due to the occurrence of strong earthquakes. For this purpose in general it is necessary some type of control of the quality of design and construction and a clear assumption of responsibilities with regard to these issues.

The choice of the best tools and mechanisms to control and hold responsible the agents of the construction and industrial sectors depends on cultural factors and practices that vary from region to region and between sectors of activity. Therefore ensuring the quality of construction is a matter to be decided and pursued essentially at national level. However the EU can stimulate this process by demanding guarantees from the Member States on the control of quality of all works partially supported with EU Funds. This should apply not only to the activities proposed in this document to reduce earthquake risk but also to all new investments on buildings and infrastructures susceptible of being damaged by earthquakes. The form of these guarantees may vary between Member States. Besides the normal assumption of responsibilities by the agents of the construction process (or other), it should involve the presentation by the entity that promotes each project of a document from an external independent checker assuming responsibility by the quality (including seismic resistance) of the final product. Where adequate and possible this guaranty should be accompanied by an insurance covering seismic damage. This procedure would also minimize the added bureaucratic work for Commission Services, leaving most of the responsibility with the Member States. It is thought that the proposed division of tasks and responsibilities between the Commission and the Member States corresponds to the best possible application of the subsidiarity principle in this case.

The above would therefore apply to the vast majority of the projects financed by the European Regional Development Fund (ERDF) and the Cohesion Fund (CF). Changes in the regulations of these Funds would probably be necessary to make these requirements compulsory.

Action 5. Evaluation of the seismic resistance of lifelines and transportation networks and strengthen where necessary.
This action has been discussed under Action 3a above

Action 6 Evaluation of the seismic resistance of industrial facilities and strengthen where necessary.
Action 6 should start with “Evaluation” in order to characterize better the actual situation and needs, both on what regard the buildings and the equipments. Only after those studies are performed and the current situation assessed will be possible to estimate the cost of the necessary strengthening and upgrading actions. However it is anticipated that will be less extensive than in the building stock. It is also anticipated that in particular in what regards the electrical and mechanical equipment it will be possible to achieve substantial improvements in the potential seismic performance by acting upon previously identified weak points. Situations of this type could be clearly observed after the Kocaeli (Turkey) earthquake of August 1999 as for instances power transformers where damaged or damaged adjacent equipments because they moved away from their positions due to the lack of appropriate fixing systems. The cost of those systems is extremely small compared with the cost of the equipment or the economic losses that its inexistence has caused. And other situations of the same type probably exist. This means that many interventions to solve this type of problems will be localized and not extensive, therefore much cheaper than large-scale interventions. If the above is confirmed by the initial studies, it is proposed to extend Action 6 to the zones of High and Medium seismicity.

The ERDF seems to be the appropriate instrument to support the necessary strengthening and upgrading actions, as it fits in its objectives and regulation. The eventual need (or not) for further resources to support Action 6 will be better evaluated after the initial studies. In the framework of the assessment of the existing situation, it is important to identify possible shortcomings in the technical legislation or recommendations for the manufacturing, transportation, installation and maintenance of electrical and mechanical equipment. A complete evaluation of the needs, followed by the development of technical recommendations or codes in areas in which the existing ones do not exist or do not include seismic design should be done. This work should be promoted by DG-ENT and DG-RTD.

Action 7. Strengthening monuments and buildings of high cultural value.
The EU has already recognized the importance of the preservation and protection of the built cultural heritage and transferring it to future generations in reasonable safety and conservation conditions. This is an objective certainly supported by the vast majority of EU citizens. Interventions in buildings of high cultural value and monuments require extra care and limits to structural interventions in order to minimize changes in their nature or in their main characteristics, including often the structural materials. However this added benefit may justify added resources as compared to the ones applicable to common housing or office buildings, as well as the acceptance of an higher level of risk, in particular if the occupancy (by people) is not as intense as in other buildings.

Actions with the purpose of preserving monuments and buildings of high cultural value have already been performed, for instances research work at the JRC. Many projects aiming at the conservation and rehabilitation of monuments were already supported by the EU through the ERDF. And for the rehabilitation to be complete it should include the component of structural safety. Thus the existing practice indicates that the ERDF is the most suitable instrument to support projects aiming at the preservation and protection of monuments and buildings of high cultural value, considering not only earthquakes but also other causes of damage or degradation. The necessary level of financial support for this Action will be better evaluated after an initial appraisal of the current situation and future needs. It is suggested that Action 7 applies at least in zones of High and Medium seismicity, safeguarding the possibility of a future extension to zones of Low seismicity.

Action 8. Civil Protection actions.
This is dealt with in more detail in Section 6. It is not foreseen any need to change the regulation of EU Funds nor the need to allocate more resources for the proposed activities.

3.3 Summary on application of EU funds
The above discussion on the several actions needed is summarized in the following table:

Action	Fund	Need for change in the Regulation	Need to increase resources of the Fund
2	ESF	No	No
3a	ERDF	No	No
3b	ERDF	Yes	Yes
4	ERDF + CF	Yes	No
5	ERDF	No	No
6	ERDF	No	
7	ERDF	No	

The above discussion was based on the use of the existing instruments to support activities necessary to reduce earthquake risk. However the eventual future experience of application of the proposed suggestions may lead to the conclusion that instead of using different existing Funds to support different activities, it may be more efficient to create a single new Fund to support in a coordinated manner the activities aimed at the prevention of the consequences of natural phenomena. It is thought that the discussion on this possibility may be premature at the present stage at which there is no experience of the application of many of the new policies proposed. However it may be worth reviewing the process after a few years of application of any new policies, eventually during the preparation of the EU Financial Perspectives for the period starting in 2013.

4. ROLE OF DG-RTD IN A EUROPEAN EARTHQUAKE RISK REDUCTION PROGRAMME.

4.1 Problems in Earthquake Risk Reduction and motivation for EU funded research.

Each country in the European Union possess entities which, under various covers, deal with natural hazards. They are:

- Ministries in charge of land management and urbanism.
- Research Institutions dealing more specifically with one of the various natural hazards, in this case earthquakes. These Institutions may be pure research Institutions or University Laboratories.

In many countries there is no organised chain of responsibility in charge of the components of seismic risk: seismology, geology, evaluation of buildings vulnerability, evaluation of risk to buildings, evaluation of risk to people, retrofitting of existing buildings, earthquake event management, and seismic design aspects in new construction technology.
There can be additional problems:

- An insufficient background in seismic risk evaluation
- A poor implementation of seismic design codes
- A lack of retrofitting measures
- Repairs after earthquake made in ignorance of seismic design principles
- In low seismicity regions, an unawareness of earthquakes at the Ministry or professional level, due to the "rare event" character of earthquakes and because of the mentioned poor exchanges between various competencies.

In all countries there is:

- A need for better connection between the various national entities in charge of the evaluation and the reduction of earthquake risk.
- A need for approved European procedures in seismic risk evaluation & mitigation.
- A resulting need for European research cooperation in seismic risk mitigation.

From the explanation above, it can be concluded that an effective mitigation of earthquake risks requires a dedicated European Research Structure.

4.2 European Research Structure.

The structure proposed here is similar to the one used in the development of Eurocode 8, which has recently concluded its work with success. It involves two research levels, with one connection:

A. One European Network of Expertise
B. In each country, one national "mirror" Network of Expertise
C. One "liaison" person between the European and the national Networks

The European Network of Expertise would be in charge of:

- leading research
- making scientific breakthroughs in all aspects of earthquake risk mitigation
- proposing European scientific procedures needed in earthquake risk evaluation
- creating and maintaining a website dedicated to the deliverables of research work
- developing original earthquake resistant construction systems

- bringing improvement to Eurocode 8 in its periodic revision.

The European Network of Expertise would be led by a "Top Lead Unit" composed of 2 persons: one Chairman, one vice chairman. The European Network of Expertise would be composed on the basis of the scientific-research excellence proved through international qualification criteria (publications, available man-power, etc). The same applies to research infrastructure: for the efficiency of the research activity, research infrastructures of experimental and numerical-analytical natures are of prior importance. They should be part of the aforementioned evaluation of a research group. Groups would be formed to cover focussed topics such as: seismology, evaluation of buildings vulnerability, new design, etc. Each research group would be driven by one lead person or "coordinator". The partners in the group would be members from EU top research units working on the focused subject. In a research project, periodic meetings with 1 "liaison" representative for each nation would be organised.

For dissemination of its projects results, each project would have to produce as deliverables two books. One book would be a "Guide for Application"; it would describe the practical output. The second book would be a background document which reflected in an extensive way the details of the research work and the options taken to define the content of the Guide for Application.

The research activity at the European Network of Expertise level would funded by the EC's DG-RTD in long duration projects of at least 6 years, in order to avoid the present "stop and go" situation, in which lead researchers have to hunt for the next funding 1,5 year after obtaining the previous one. The "Top Lead Unit" would be funded for the general management of research and overview of all projects in the European Network of Expertise.

National "mirror" Networks of Expertise would be in charge of national implementation of European research output and European agreed procedures in earthquake risk evaluation. It is proposed that they would be collaborative units joining public research institutions (pure Laboratories, Universities), industry (designers, construction companies) and Public Authorities. The existence of these national "mirror" Networks is justified by the fact that several research aspects of earthquake mitigation require calibration taking into account national characteristics: seismic action, sites effects, peculiarities of building practice (materials, composition of walls, etc…). This activity can best be achieved at a national level. It has a feature of "application" of research and corresponds to less sophisticated developments than those made at the European Network level, but the activity remains research, due to its very specialised content. National Authorities would be required to set up those "mirror" groups so that the various national entities do cooperate in order to realise the "chain" of competencies at a national level, which is presently often missing.

The research activity at that level would be funded on a national basis in the framework of a EU-Nations Cooperative Research Agreement to be formalised, by which a country commits itself to bring the "mirror money" necessary for the implementation of European agreed evaluation procedures related to the mitigation of earthquakes risks. Funding at national level would thus run in parallel to EU funding in long duration projects of at least 6 years.

4.3. Definition of the research agenda.

A distinction must be made between problems related to the existing building stock and problems related to new constructions. For seismic risk mitigation related to new construction, a close cooperation with the industry (i.e. ECTP) is necessary from scientific and R&D point of view. The role of each part must be specified. Fundamental research should not be marginalized. Applied engineering oriented R&D and fundamental research should be well balanced. Development of innovative techniques and methods to improve the seismic performance of buildings, infrastructures (and their components) and integrated approaches in a city or /and network scale are of prior importance.

For seismic risk mitigation related to the existing building stock, a cooperation with public authorities of countries should be started in order to define their expectations. This is absolutely necessary:

- to check that a seismic risk reduction is really intended in a given country
- because the funding scheme explained above involves national contributions, which requires a national motivation
- because the implementation of any type of measures in a country will necessarily go through national channels.

A tentative list of subject needing further research at a European level is shown in Appendix 2. For earthquake risk reduction studies, the priority in subjects should be established considering, among other things, the expected reduction in uncertainties brought by a specific research development, in comparison with present state of the art; subjects bringing the highest reduction being given priority.

4.4. Administrative management.

In comparison to FP6, the administrative work should be reduced and conditions for "manageability". EU funded projects should respect the following requirements:

- the maximum number of partners in a project (= research group) should be 6.
- 1 technical report/year/partner is required; it should be sent to the project coordinator.
- 1 activity report/year is required; it should be prepared by the project coordinator and sent to the EU Officer and to the "Top Lead Unit"; it should be presented by the project coordinator to an evaluation committee; national "liaison" persons and "Top Leaders" would attend that meeting to be informed of work progress and to discuss issues.
- 1 cost statement/year would be established by each partner and sent to the project coordinator, who would gather them and send them to the EU Officer.
- the planning of a project would be defined at the submission stage. There would be no requirement to revise each year the original planning. A revision of the planning revision might be asked by the coordinator, with justifications.
- Deliverables of the project would be defined at the submission stage (content + delivery date); no milestone definition and no yearly compulsory updating of deliverables would be required.
- The final report of the Project would be constituted by the deliverables. It may be approved or not approved by the evaluation committee. Justifications and requirements for improved versions would have to be explicit. The improved documents would have to be delivered within 6 months from the evaluation committee meeting.

4.5. Project results dissemination.

Each Project would have to produce as deliverables, at least:

- Two books/EU funded projects. One book would describes the practical output, the way to use the results in practical application; it would be a "Guide for application". The second book would be a background document which reflected in an extensive way the details of the research work and the options taken to define the content of the Guide for application.
- One report on nationally funded projects

Those books & Reports will be accessible on the “European Network of Expertise” website, for free download, and as books edited in official and unified presentation with EU funding supports

Besides these channels, access to the information should take place in conference and journal papers. To increase the dissemination, DG-RTD would support the promotion of education in earthquake engineering by pushing the development of an agreed European curriculum at the “Master” level (using the Bologna system). Thereby a wide dissemination will be achieved by Universities, Schools of Architecture and professional Associations in charge of higher and continued education. Success at exams in the curriculum will result in a “European Seismic Certificate” which should be made compulsory for designers making projects in seismic zones.

4.6. Enhancement of cooperation with the international research community.
It is essential to develop good links with the top research teams internationally:

- to inform European research about developments in countries which are steps ahead of the EU in specific topics
- to avoid duplication of efforts
- to find better routes to application of research results.

Cooperation with the international research community will be enhanced:

- By allowance to use part of the projects funds for participation in International Forums, Conferences and Workshops bearing on specific topics in direct relation with the research project.
- By funding grants to allow EU researchers to work in foreign Institutions (Japan, US, NZ) where research of international excellence is carried out.

5. THE ROLE OF CODES IN THE REDUCTION OF EARTHQUAKE RISK

5.1 The normative European Context

One of the European directives, published in 1989, was directly related to the sector of construction (directive “products of construction”) and comprised six Essential Requirements, the first being the requirement of mechanical resistance and stability, the second dealing with safety against fire.

The "Eurocodes" programme initiated in 1975 aimed in particular at the harmonisation of the technical specifications in the field of construction, in order to eliminate in this field the technical obstacles to the free exchange inside the Common Market. It thus naturally lay within the scope of the directive of 1989, its development being entrusted to the CEN the same year.

Eurocodes constitute today a coherent set of 57 standards, based on a unified philosophy of safety. In particular, the structural checks are carried out at limit states which should not be exceeded.

5.2 Eurocode 8

In the set of Eurocodes, Eurocode 8 plays a particular role, since it brings additional provisions to other Eurocodes to ensure the resistance and the limitation of damage in seismic situations. In addition, in certain countries like France, it is brought to be used as a regulatory basis for the seismic protection required by the law. Eurocode 8 covers on a rational basis a large variety of civil works conceived with the great types of structural materials covered by the other Eurocodes.

By leaving to the National Authorities appropriate choices to adapt to the seismic hazard and to the local economic conditions, Eurocode 8 makes it possible to cover the whole of the European populations, within the limit of the structures and situations which it covers.

Compared to other existing codes, Eurocode 8 brings substantial progress, on the one hand by covering structural and geotechnical aspects, not covered until now, in addition by introducing recent methods such as pushover analysis.

5. 3. Eurocode 8 and seismic codes from the point of view of their effectiveness

Compared to the codes previously in force in the Member States, though it certainly constitutes a fundamental step forward, Eurocode 8 is also incontestably difficult to master for the majority of engineers, (as indeed are also many other parts of Eurocodes).

A first consequence is that a particular effort will have to be devoted to the training of the engineers, so that they assimilate on the one hand the philosophy of safety and the methods of antiseismic design underlain by Eurocode 8, on the other hand the procedures associated with these methods.

So that the seismic protection brought by Eurocode 8 is effective, it is necessary that, in practice, it is accepted and applied by all the actors: owners, architects, engineers and constructors. It can be expected that for the constructions of some importance, Eurocode 8 will be actually applied rather quickly; but the problem of its applicability will arise for the more general building stock, for which it is difficult moreover to carry out controls of conformity in an extensive way.

From this point of view, Member States will have to study the measures to be taken at the legislative level, or by information and promotional measures, so that the standard is actually applied.

On the other hand, it appears obvious that simpler documents should be developed, having the statute of standards when Eurocode 8 allows it; these may include application documents developing simplified procedures for common cases. Indeed Eurocode 8 already envisages a simplified procedure, without calculation, for small masonry buildings.

5.4 Standards as engineering tool for the seismic design.

First of all, a standard constitutes a technical and contractual tool. It is necessary to point out the initial intention of the Member States when the Eurocode project was launched. It was a question of abolishing all that could block free movements of construction products. Eurocodes were thus conceived like a conceptual base giving common tools for the design of the works and the construction products. Beyond its particular characteristics of seismic protection, Eurocode 8 must thus also be regarded as one of the components of the economic optimisation within Europe, as a contractual base allowing calls for tenders and as a single framework for the development of new products designed to meet the needs for the population of the continent.

Eurocode 8 thus fits with the professional engineering tasks, on the one hand for itself for the design of the works, on the other hand as support for the choice of the products and the constitution of the call for tenders of contractors, by offering "deemed to satisfy” procedures.

A more legal aspect remains nevertheless to be cleared up: which would be the responsibility for engineering in the event of failure without fault, i.e. if a disaster occurred in the course of an earthquake in a construction where Eurocode 8 had been respected? This responsibility would be on the States, or on CEN? Or does Eurocode 8 give only an obligation of means?

5.5 Research and developments of the Norm

As for every technical Norm, Eurocode 8 offers rules and procedures which represent the state of the art of design at a certain time and recognised by the professional Community. The Norm does not necessarily take into consideration the latest scientific discoveries; neither does it hinder in any way their development: it should never be an impediment to innovation. Even between the experimental ENV and the present EN, Eurocode8 has benefited from important discoveries due mainly to research programmes which took place just before and during the conversion period. It is certain therefore that research programmes presently underway in Europe or elsewhere should lead in a near future to a development of the norm, thus allowing to greatly improving safety measures when faced with earthquakes.

The research programmes are obviously oriented toward a better knowledge of the behaviour of structures during an earthquake. Developments of the norm should always strive to obtain high efficiency in terms of safety and cost. Naturally, to be efficient from a social point of view, antiseismic protection should be attained at a minimum cost: the less expensive the cost the easier it will be for it to be accepted and implemented. Research work carried out must take into account the economical aspect in order to improve social efficiency of their results.

5.6 A better coverage of the field of protection

One can consider that the present antiseismic norms, in particular Eurocode8, already offer sufficient protection for new constructions. For new constructions, however, the question still remains of what is the best way in which to apply the rules to the structure, as explained earlier. Also, the research in the seismic field is tightly linked to research on materials and will benefit from its findings, which is another cause for evolution of the codes. In addition, we already know that certain aspects of the present version need to be reviewed and corrected, for instance:

- A more satisfactory description of seismic hazard is needed: in the American code, two parameters: short period spectral acceleration and 1 spectral acceleration are used instead of one in EC8 (peak ground acceleration).
- A better representation of the dependence of local amplification of ground motions by the soils on the amplitude of motion is also needed.
- Prestressed concrete, high strength steel and concrete and other materials such as fibre reinforced composites could be further addressed.

But the reduction of earthquake related risk in Europe is dependant essentially on the assessment and strengthening of the existing structure. This in itself presents very serious technical and socio-economical problems.

Even though Eurocode 8 has, in Part 3, innovated by proposing original assessing procedures and set up limit states for existing constructions, it became immediately obvious to the writers that the procedures for checking construction materials could neither have the feed-back experience nor the same reliability as in cases of new structural elements. As a consequence of this, very useful information concerning the checking of different materials has been added in informative annexes giving this information. There exists therefore a wide field of potential research to improve and enrich the text of Eurocode 8 Part 3. Also, it would appear that old buildings still in existence in European towns, especially if these buildings dated before the mid-20th century, constitute entire blocks of constructions where the different buildings are interdependent, and where it is not possible to treat each building individually. For these buildings, which are often of great historical value and have to be preserved, it is important to set up appropriate rules. As Part 3, in its present version, treats only individual buildings, there is a great need to develop methods and rules which would cover this type of blocks of buildings, rules which present problems going far beyond technical ones.

The economic damage caused by strong earthquakes has increased dramatically during the 20th century in developed countries. A great part of economical losses is caused by damage in industrial installations and lifelines. Part of the equipments and industrial installations in European countries were not designed, built and installed with the concern of providing seismic resistance. This situation is due to the fact that when the first modern structural codes started to be developed, at the end of the first half of the XX century, (i) the attention focussed almost exclusively on the safeguard of the human life, therefore on civil engineering constructions (mainly buildings and bridges) and (ii) the lifelines did not have the importance for the support of the life of the populations and the economy they have today in developed countries. In several domains there is still a lack of codes or technical recommendations for the design, fabrication and installation of mechanical, electrical and other equipments. It is therefore proposed:

- to identify the areas in which there may a shortcoming of codes or technical recommendations for the seismic design, fabrication and instalation of equipments of the lifelines or industry.
- to develop the necessary codes or technical recommendations

Each community having only limited means (not infinite), it is clear that politics of assessment and strengthening cannot be implemented on a wide scale unless the methods used are efficient and offer the best safety measures at the lowest cost. That implies not only having the best norms, but also to implement political choices in terms of priority of action, the level of safety to be attained and planning.

As we can see, the field of research work and code development which still has to be undertaken to significantly improve security when faced with earthquakes, is vast and, in parallel, there remain important developments of the standard to be taken into consideration in the relatively near future.

6. THE CONTRIBUTION OF DG ENVIRONMENT TO CIVIL PROTECTION

6.1 Background

Looking at the results of the INTERREG III ESPON (European Spatial Planning Operation Network) 2006 programme, on the Spatial Effects and Management of Natural and Technological Hazards in Europe - ESPON 1.3.1, it is striking to note that some of the most earthquake-prone areas in Europe are considered to have low risk when an integrated evaluation of all the natural and some technological hazards is made (see fig. 2 and 3). This happens in spite of the fact that earthquakes produce the largest number of deaths and the biggest economic damage among the natural hazards. This can be explained by the procedure to draw these maps, which is based on the Delphi Method and, then, on the opinion of experts rather than on objective figures. But this also highlights that the lack of perception of seismic risk probably leads to underestimation of the actual dimension of the problem. The following sentences are drawn from the NEHRP-strategic plan 2001-2005 for U.S.A., but they fit well also the European situation.

> *Although damaging earthquakes occur infrequently, their consequences can be staggering. As recent earthquakes around the world have demonstrated, high population densities and development pressures, particularly in urban areas, are increasingly vulnerable. Unacceptably high loss of life and enormous economic consequences are associated with recent global earthquakes, and it is only a*

matter of time before the United States faces a similar experience (the same holds for Europe). *One only needs to look to Japan's experience during the 1995 Kobe earthquake to appreciate the catastrophic potential of even a moderate urban earthquake. The M6.7 Kobe earthquake—similar in size and duration to the Northridge earthquake—caused $100-200B in damage and approximately 5500 fatalities (NEHRP-Strategic Plan 2001-2005).*

On the other hand some general guiding principles of ESPON for the integrated risk fit well with the needed action required to DG-ENV to mitigate seismic risk:

- Risk management should be made an integral and explicit part of EU cohesion policy. This calls for better coordination of policy measures at all spatial scales.
- Both substantive goals and procedural rules related to vulnerability reduction and risk mitigation could be integrated into policies and programmes.

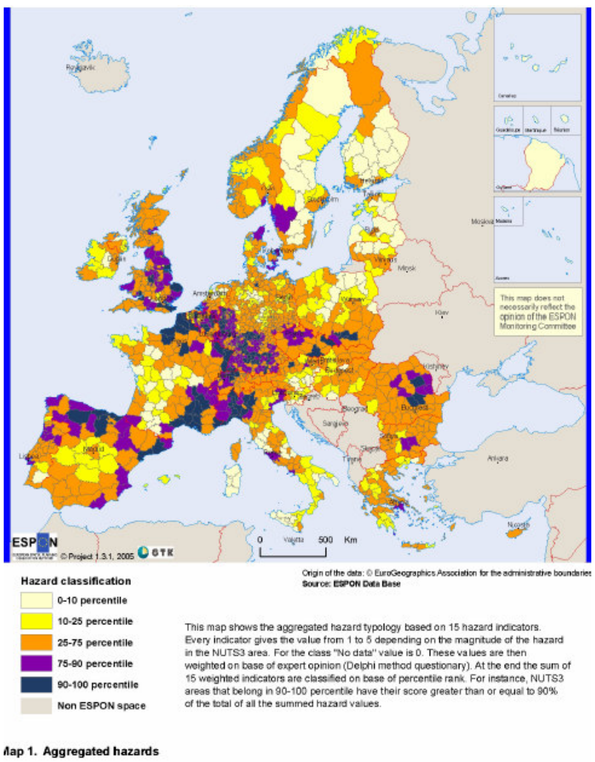

Fig. 2 Aggregated Hazards
Source: ESPON Report, 2005

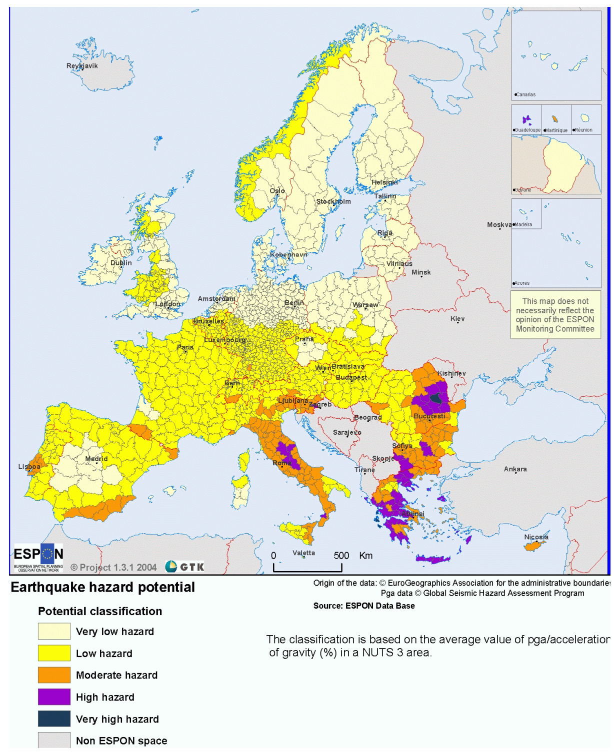

Fig. 3 Earthquake hazard potential

6.2 Possible EU actions to support Civil Protection

The possible actions of DG Environment to pursue the above principles are mainly related to Member States initiatives (points 1 and 2), and actions with direct involvement of the Civil Protection Unit in DG-ENV (point 3):

1.Risk reduction

- More careful land-use planning in view of seismic risk aspects and sustainability. Among other actions it is urgent to develop, improve, and disseminate products for design and construction practices and land-use planning, as well as to improve professional practice. Education and training for engineers, practicing design and construction professionals, planners, facility managers, should be involved in continuing education programs
- Promotion of activities for vulnerability and risk evaluation of existing structures (strategic and public buildings, dwelling private buildings, lifeline structures), by

supporting improvement of loss estimation and risk assessment tools and development of next generation databases. EU Member States should be encouraged to provide detailed data on local geology, building inventories, and utility and transportation systems to enable more accurate planning and establishing of priorities.

- Incentives for risk reduction (strengthening existing structures – strategic buildings, dwelling buildings, lifeline structures). Earthquake loss-reduction activities should be promoted and local governments which adopt, implement, and enforce such policies and practices should be supported.

2. Mitigation of earthquake effects after an event

- Improving preparedness in emergency operations. In this respect it is worthwhile to mention a sentence drawn from (DG ENVIRONMENT - Directorate A – ENV.A.5 - Civil Protection Consultation - on the future instrument addressing prevention of, preparedness for and response to disasters: Issues Paper): *Training is a cornerstone of emergency preparedness and response. Within the framework of the Community Mechanism, a training programme has been developed consisting of three components: <u>courses</u>, <u>simulation exercises</u> and an <u>exchange of experts system</u>.* Education and training for engineers, emergency managers and other personnel should be involved in continuing education programs.
- Improving monitoring and early warning systems as well as implementing scenario preparing tools, in order to provide rapid, reliable information about earthquakes and earthquake-induced damage and take immediate Civil Protection countermeasures.
- Improving survey methods for after-event operability assessment of buildings and lifelines (methods, training, etc.) in order to reduce the social and economic impact of seismic disruption.

3. Inter-government collaboration

The simultaneously occurrence of large earthquakes, or other catastrophes of similar dimensions, is extremely unlikely. Therefore when a large earthquake takes place in Europe it is reasonable to use a large part of the resources available for use in Emergency situations in the EU to help the affected region. This requires a large effort of coordination for the efficient use of those resources. This requires preparedness both at National and EU level, involving (i) the knowledge (prior to the occurrence of earthquakes) of the potentially available resources in the Member States by the DG Environment Civil Protection Unit, (ii) knowledge of the time necessary for their deployment on the affected zones and (iii) preparedness of national Civil Protection agencies to provide coordination and guidance on the best possible allocation of the human and material resources received from other Member States. The preparedness of both the DG Environment Civil Protection Unit and National Civil Protection agencies should be tested and improved simulating the response of all these bodies for several potential seismic scenarios in different European regions. It is also suggested that this activity is extended beyond EU borders, and includes coordination and cooperation with Civil Protection agencies of other countries close to the EU, namely Turkey, other European countries not members of the EU, countries of North Africa and others that may wish to participate. The large capacity of response in emergency situations that would result from this coordination effort should also be used to help people in need due to large catastrophes anywhere in the world.

7. SUMMARY OF RECOMMENDATIONS

In order to enhance the process of risk mitigation in Europe, we believe that the following actions may be considered, involving interactions between the European Commission, Member States and the scientific community.

7.1 A review of the Role of DG-RTD to create a new longer-term support structure for European Research, with associated changes in funding mechanisms, relationship between EU-funded and nationally-funded research activities, and administrative arrangements (Section 4 and Appendix 1).

7.2 An enhanced research programme at a European level covering aspects of earthquake hazard, better construction and communication of seismic risks to the general public and within the construction industry, and means to reduce the earthquake risk in existing buildings and infrastructure (Appendix 2).

7.3. Enhanced activity by DG-ENV to support the ability of Civil Protection agencies in Member States to respond after a major earthquake, and to ensure that land-use planning and urban development for sustainability incorporates provision for minimising seismic risks, alongside those from other more obvious natural hazards (Section 6.2)

7.3 Further support to the development of Eurocode 8 by DG-ENT, in order to bring the fruits of new research into practice, to improve its applicability by the construction industry, and to strengthen its effectiveness for use in retrofit strengthening programmes, especially for the old urban centres of European cities (Section 5.5, 5.6).

7.4 Use of European Regional Development Funds (ERDF), (DG-REGIO) to support essential strengthening and upgrading for key infrastructure and public buildings such as schools and hospitals in areas of moderate and high seismicity. Ensuring construction to satisfactory antiseismic standards wherever ERDF or the Cohesion Funds (CF) is used for other construction work (Section 3.2).

7.5 Use of the European Social Fund (ESF) to support training and public awareness campaigns for earthquake-preparedness on the part of populations at risk (Section 3.2).

7.6. To examine the scope for new mechanisms of funding to support actions to preserve historical monuments and buildings and artefacts of cultural importance from future earthquake damage (Section 3.2).

APPENDIX 1. Earthquake Risk Reduction and Natural Disaster Mitigation in FP7.

Introduction

1. This document was originally written in response to the EU Document "Thematic Priorities in FP7", and submitted to the EU on 28.12.04. Its purpose was to propose a Research Theme for FP7 on Natural Disaster Mitigation, with Sub-themes to include:

- Geological hazards – earthquakes, volcanic eruptions, landslides and avalanches
- Climatic hazards – floods, windstorms, heat-waves and cold weather
- Wildfires

This document was drafted by and was supported by the Executive Committees of the European Association for Earthquake Engineering and the European Seismological Commission. Membership of both these bodies extends to countries in the European/Mediterranean area outside the present EU, but each is able to speak for the research community across the EU.

2. Since the document was submitted, the EC has published (COM, 2005, 440 and 441) its proposals for Research Programmes during FP7, including a detailed list of themes to be considered on Environment and Climate Change. The EAEE and ESC are pleased to note that the mitigation of natural disasters has a prominent place in many of the research activities proposed; but there remains much to do to bring these rather generally defined aims to the definition of specific research programmes and modes of research management. The views of the European earthquake research community expressed in the following pages therefore remain relevant, and we hope they will be considered by DG-RDT in its future task of formulating detailed research programmes.

Justification

3. Natural disasters of all types – earthquakes, floods, windstorms, volcanic eruptions, wildfires result in average annual losses across Europe of around Eu15-20bn. In addition they cause significant numbers of human casualties, loss of homes and livelihood, and cause a set-back to economic development wherever they occur. There is also the potential for a single loss – from an earthquake, flood or volcanic eruption - of the order of Eu100bn, greater than any which has occurred in the past.

4. The EU has supported research on all these topics for more than two decades, and much has been achieved during that time, especially in enhancing the understanding of the basic mechanisms involved and in limiting the future impacts by better design practices. But much remains to be done in understanding and reducing the vulnerability of EU communities and built environment, and in building our capacity to deal with the hazards we face. Research budgets have been neither sufficient in quantity, nor effectively enough targeted, to achieve a real breakthrough. In this respect the EU lags very far behind our industrial competitors in Japan and the United States.

5. The eastward expansion of the EU already in place, and that envisaged for the future, will both bring in new territories with grave natural hazards threats, highly vulnerable infrastructure and recent experience of terrible losses, and at the same time enlarge the EU existing pool of research expertise.

6. The FP7 period 2007-2013 therefore represents an unprecedented opportunity to harness emerging knowledge and technology to bring losses from natural hazards under control throughout the European area in order to improve the safety of its citizens and to safeguard their economic security.

Research approach

7. To achieve a decisive breakthrough towards natural disaster mitigation will require

- A programme of research at the EU level
- A programme which integrates research on all types of disaster
- A substantial increase in resources
- A multi-disciplinary approach involving physical scientists, engineers and social scientists
- Better collaboration between the research community, government and industry
- A managed programme

8. ***A programme of research at the EU level is needed***:

- to create and coordinate a critical mass of research expertise
- to create (or improve/further development) the necessary research infrastructure, including large scale research facilities
- because the phenomena being studied and their effects are truly transnational
- because national budgets alone are inadequate.

The goal of disaster mitigation is consistent with many existing EU policy goals – in environmental protection, in protection of the cultural heritage, in transport, in health, and in social affairs. If it is the aim of the EU that citizens throughout Europe should enjoy comparable living standards, this must include comparable levels of protection from known natural hazards.

9. ***A programme which is integrated across the whole field of disaster mitigation is highly desirable*** for effective management because:

- a multidisciplinary research approach involving physical and social sciences and engineering is common to all fields
- there is much overlap in methods, approaches, and research facilities
- in the design of facilities, a multi-hazard approach is likely to be cost-effective
- the user-community is the same in each case, consisting of designers and builders, urban authorities, estates managers, insurers and civil protection agencies.

10. ***A substantial increase in resources is essential*** because current funding of disaster mitigation research in the EU is at a much lower level than our industrial competitors in the USA and Japan. One result is that we are lagging behind those countries in bringing losses under control. Another result is that the development of technologies for scientific monitoring, for improvement in the performance of structures and for experimental and simulation studies is increasingly concentrated in the USA and Japan, leading to a loss of technological leadership and of export markets to the huge disaster-prone countries in Asia and the rest of the world.

Additional resources are needed to provide for

- Much enhanced monitoring networks (including satellite monitoring)
- The development of research infrastructure and large scale facilities
- Creation of a directed long-term research programme
- The formation of networks and centres of excellence on a variety of topics
- The mobility of researchers

11. ***A multi-disciplinary approach is needed*** because effective action to reduce disasters requires coordination across several overlapping disciplines. Earthquake risk mitigation for example requires:

- Understanding seismic hazards – developing models of earthquakes based on geophysics and observation
- Assessing and reducing earthquake impacts – developing tools to simulate behaviour of buildings and urban systems, and devising technologies to build more earthquake resistant structures and strengthen existing ones
- Enhancing public understanding and community resilience – developing the means to communicate effectively about the options available, and to enable communities to devise their own protection strategies

These three areas are traditionally the domain of physical scientists, earthquake engineers and social scientists respectively. But none of these groups can operate effectively or achieve goals of value to society unless they interact closely and understand each others methods and problems.

12. ***Better collaboration between the research community, government and private companies is needed*** to ensure that the research supported by the EU makes the most impact possible on its intended users. Governments stand to benefit enormously from the reduction in future losses which should flow from this research; insurers will benefit from a better understanding of risk as well as reduction in losses; and the construction industry will benefit from the exploitation of the new techniques developed. A closer involvement of both government agencies and private companies in the formulation, execution and financing of natural disaster research is therefore easily justified. The mechanism of a "technology platform" (as proposed in paragraph 20 of *Science and Technology, the Key to Europe's Future* COM (2004) 353), would be an excellent vehicle for such a collaboration at a European level.

13. ***A managed programme is needed*** to achieve coordinated outputs and a long-term strategy. Research effectiveness in previous Frameworks has been hampered both by the short time-horizons of each Framework (enough for a single round of projects to be formulated, commissioned and executed), and by the lack of a coordinated scientific management. An attempt to improve the latter has been the introduction of Integrated Projects in FP6, but this has the unintended and very unfortunate result of creating too large and unwieldy research groupings, and of converting some of Europe's most able researchers into managers in order to offload the management from the Commission. The Commission has the opportunity, in FP7, to set up a programme with long term goals such as the very effective National Earthquake Hazards Reduction Programme (NEHRP) in the USA. Much could be learnt from a detailed examination of the structure and management of NEHRP and other US managed programmes such as that of the California Applied Technology Council.

Earthquake Risk Mitigation Sub-theme

14. As an element of an overall Natural Disaster Mitigation Research Theme, the EAEE and ESC envisage that it will be essential to address at least the following topics under FP7:

- Better fundamental seismological databases and instrumental networks (regional and local to specific buildings- test sites) for earthquake monitoring
- Improved hazard mapping
- Vulnerability assessment of buildings, lifelines, infrastructures etc Protection of historic buildings and centres
- Common standards of protection for existing public buildings, highways and other infrastructure
- Improved methods for intervention in the existing fabric to increase earthquake resistance
- Better design of structures and foundations
- Understanding human behaviour in earthquakes and public response to risk

- Building community resilience and response capability

More detail on some of these topics is given in Appendix 2 or will be provided in due course.

Fit with the EU criteria for identifying thematic domains

15. Contribution to European Policy Objectives.

The proposed research theme will make a vital contribution to Europe's aim of achieving sustainable economic growth. Societies which are constantly coping with the consequences of natural disasters do not achieve sustained growth. This has been shown by the impact of storms and floods in the EU countries in 2000. The research theme will contribute to policy objectives in many areas – in environmental protection, in protection of the cultural heritage, in transport, in health, and in social affairs. The creation of a uniform level of protection of the citizen from death of injury or loss of livelihood though natural disasters is clearly consistent with EU policy objectives.

16. European Research Potential.

The proposed research theme clearly has potential both for the creation of research excellence and for converting the results into social and economic benefits. At a scientific and technical level, natural hazards research in Europe leads the world in many areas. This has been achieved partly through previous EU funding, and future funding at an increased level is needed to maintain that status in the face of growing international competition. The potential now exists to convert that research into social and economic benefits to a much greater extent than has been achieved so far, and this is the challenge that must drive the research activity in FP7.

17. European Added Value

The arguments for research to be carried out at a European level are set out in Para 8. These are essentially to create a coordinated approach, a critical mass of researchers, and an adequate research infrastructure. Each of the phenomena of this proposed theme are common to many EU countries, and their threats and effects cross national boundaries. Through EU support over the last 2 decades the research culture is genuinely European. In natural disaster research European Centres of Excellence already exists and must be fostered and promoted. Europe is seen by the rest of the world as being a single entity. Fragmented national efforts are now unthinkable.

APPENDIX 2 Research Themes and Topics for Future Earthquake Engineering Research in Europe under FP7

The following summary of research topics was formulated by the European Association for Earthquake Engineering following the Workshop "Earthquake Risk Reduction in Europe" held in Lisbon on 31.10.05, and submitted to the EC's Research and Development DG in December 2005. The emphasis is on improving understanding of the earthquake hazard, and the assessment and reduction of risk for Europe's unique building stock and infrastructure. There are two components, namely *research topics* and *support actions*.

A. Research Topics

1 Earthquake hazard.
Evaluation of position and probability of occurrence of future large earthquakes
The following themes of research should be encouraged: (a) the modeling of seismic activity; (b) the earthquake cycle on active faults; (c) the relationship between strong or large historical earthquakes and active faults; (d) the mapping of capable and active faults at the European scale. Part of the tools has been developed in previous projects. The existing capabilities to monitor earthquakes should be enhanced. (see support actions).

Development of a common methodology to evaluate hazard in Europe
Methods for evaluation and characterization of ground-shaking hazard, working at a regional scale. Selection of most appropriate return period for design purposes and for ultimate and damage-limitation limit states. Evaluation of tsunami hazard in Mediterranean and Atlantic.

Influence of local geology in large cities.
Methodologies to understand and map local hazards including the influence of local geology and subsoil, active faults and zones with potential for landslides, subsidence and liquefaction, with application to large population concentration.

Real time observation and warning systems for earthquake and related hazards
Monitoring and real-time reporting and impact analysis of earthquakes, and systems for automatic response to earthquake warnings. Tsunami warning systems.

2 Seismic risk assessment and mitigation for existing buildings and infrastructure
Simplified probabilistic methods for seismic risk analysis
Development of displacement-based methods suitable for European building typologies. Definition of unified approach for seismic risk evaluation using GIS tools. Mapping tools for proposed intervention to the buildings.

Development of a unified approach in rapid screening.
Common definition of rapid screening approaches to assess vulnerability of single buildings or groups of buildings.Rapid screening procedures for bridges

Methods for evaluation of the vulnerability of the existing built environment
Defining vulnerability relationships for national building typologies/materials, notably for masonry structures, lifelines and industrial plants and equipment and historical buildings. Evaluation of non-structural and economic losses and human casualties. Emphasis on evaluation techniques for public buildings especially schools and hospitals. Development of inventory databases; monitoring of the dynamic response of existing structures; post-event damage surveys and data-gathering.

Evaluation Of risk Protection Measures
Improvements in understanding of public perception of earthquake risk; evaluation and case-studies of risk-reduction and risk-transfer measures, including non-structural actions; cost-benefit studies for risk-reduction measures.

***3* Design of new facilities and strengthening of existing facilities**
Innovative approach to the design of rational earthquake-resistant structures
Analytical and experimental studies on new materials and building typologies and techniques such as: validation of partial plastic mechanisms as seismic design objective; energy dissipation systems and base isolation methods; non-continuous frames stabilised by relative rocking of structural components.

Development of strengthening techniques for existing buildings and infrastructure
Strengthening techniques for old buildings and low ductility reinforced concrete buildings, with emphasis on low-cost techniques for large scale interventions; emphasis on schools, hospitals and multi-storey multi-occupancy buildings; development of strengthening techniques of low intrusive effect for application in monuments, historical buildings and other structures; seismic design and upgrading of mechanical, electric and other types of equipment used in the lifelines and industry; cost-benefit studies.

B. Support actions

Support for networks to monitor earthquake
Development of Euro-wide networks for seismic monitoring, including sea-floor monitoring, and with emphasis on the seismically-active but poorly instrumented areas of South and South-Eastern Europe.

Support for existing earthquake test facilities
Facilities at both JRC and national laboratories will need continued support to enable them to be available to carry out necessary experimental studies.

Support for international meetings and exchanges
Support for meetings, exchanges and collaborative projects to facilitate transfer of knowledge and experience with researchers in countries with a highly developed earthquake protection culture, notably USA, but also Japan and New Zealand. Also support for knowledge transfer to and data acquisition from developing countries in high-risk zones.

Support for training workshops for young scientists and engineers
Support, under Marie Curie funding, for international workshop to transfer research results and good practice to young scientists and design practitioners, with emphasis on the new accession countries.

Development of educational tools
Simplified explanations of research outcomes design codes, suitable for design practitioners and the general public.