13th World Conference on Earthquake Engineering
Vancouver, B.C., Canada
August 1-6, 2004
Paper No. 2082

EARTHQUAKE PROTECTION: THE NEED FOR LEGISLATION TO STRENGTHEN HIGH-RISK BUILDINGS

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SUMMARY

Lives continue to be lost in earthquakes in European countries – more than 20,000 in the last decade - and there are several high-risk areas where there is now known to be a potential for death tolls much higher than those recently experienced. It is widely agreed that the risk to human life is concentrated among the occupants of buildings not constructed to the present generation of codes, either because they were built before those codes were in force, or because the codes have not been implemented. This paper looks at earthquake risk in Europe from the perspective of human casualties, offers a preliminary review of action in the major European earthquake-prone countries to reduce this risk – primarily through intervention in the existing building stock – and notes some progress. Experience of legislation in other countries is discussed. The paper argues that progress in reducing earthquake risks will be slow unless legislation to require building owners to take action is put into place and is effectively enforced.

INTRODUCTION

The recent terrible tragedy in Bam was a shock to the world, and especially affects all those who are concerned with protecting lives against earthquakes by better design of buildings and structures. What can be done to reduce the recurrence of earthquake disasters and the loss of life which they entail? The recent earthquake tragedies in Italy, Algeria, Turkey, and most recently Iran, have been clearly identified, by the press, politicians and the general public, as being the result of the collapse of buildings which could have been and should have been built to withstand the level of shaking they experienced. So why is it that we still do not have a system in place for evaluating, assessing and strengthening buildings, even the public buildings such as schools and hospitals, in earthquake areas? This may not perhaps be so surprising in relatively poor countries like Iran, but surely it is not an acceptable state of affairs in the richer countries, such as those of the European Union. And yet even in the EU countries with the highest level of seismic risk (Italy, Greece, Portugal, Austria, Spain and France), there is not yet a regulation that requires all existing public buildings to achieve an acceptable level of life safety for their occupants or users (only newly-built ones).

Whose responsibility is it to formulate and enact the legislation needed to ensure that school buildings, and indeed all other buildings used by the public, are earthquake safe? Both the European Commission and national governments have some powers in this area. Many regulations already exist at a European

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and at national levels in areas affecting the health and safety of the public, and particularly the workforce, and are seen as a necessary means to ensure a uniform level of protection for the citizen and a level playing field for business throughout Europe. Regulation has a special validity in circumstances where decisions affecting the risks to peoples' life and health are taken by others (for example their employers); where individuals are not readily aware of the risks associated with their actions; and where action to mitigate the risks must be taken at a community, regional or even international level. All of these circumstances are true of earthquake risk, and this is of course recognised in the regulations covering the design of new buildings, which are now in the process of being unified at EU level through the adoption of the Eurocodes. And there is a special validity, which can be widely supported, in legislation to protect the lives of schoolchildren who can have no choice over which buildings they use, and little awareness of the risks involved.

It is not surprising, though, that neither the European Commission nor the European national governments favour the idea of new regulations on this issue. Among the possible tools for government action to achieve desirable social and environmental goals, regulation tends to be losing popularity in the advanced economies of the world in favour of various other kinds of incentives. Supporting underpinning research, demonstrating best practice, voluntary codes and even tax incentives are today preferred to regulation, because of the perceived costs to the economy and the additional problems of enforcement that new regulations often bring with them. In this kind of regulatory climate, the necessary action for earthquake protection can easily get overlooked. For the building stock at large, regulation would impose obligations on property-owners to strengthen their buildings, thus increasing rents and reducing the stock of cheap accommodation; and this would certainly be opposed by many of those owners, and maybe by the business community at large. For publicly-owned buildings, the introduction of such regulations would impose additional burdens on national budgets, which would have to be met by increasingly tax-averse electorates.

This paper argues that, conversely, the logic which applies to the protection of life in the design of new buildings should also apply to the much more difficult issue of the protection of life in existing older buildings. All kinds of activities are needed at an EU and at a national level to support this, including research, public awareness raising, and the drafting of model documents. But experience from other countries, especially the USA and New Zealand, suggests that unless these activities are underpinned by legislation – primarily concerned with the strengthening or demolition and replacement of existing high risk buildings - resistance will be strong, and little progress will be made. Without underpinning legislation, in other words, other supporting actions will simply lack the "teeth" to be really effective in bringing about reduction in the highest risks.

To support this argument, the paper first looks at the scale of earthquake risk in the EU and neighbouring countries, and then at actions taken or already in progress in some of the EAEE countries to achieve risk mitigation. It then looks at some experiences in other countries, from which conclusions are drawn.

EARTHQUAKE RISK IN EUROPE

Because earthquake risk combines information about seismicity, exposure and vulnerability, useful comparative measures of earthquake risk are notoriously difficult to construct. Seismicity must be measured over a long time period to give a useful indication of the most severe event which may occur; but over such a long time period populations change, administrative boundaries shift, and the building stock changes too, usually tending to lower vulnerability over time. The type of risk which is being examined will also considerably influence relative risks, as will the scale of the region which is being considered.

One uniform way to measure earthquake risk is through the loss of human life. Table 1 is an attempt to compare the relative risks to human life in European countries. It lists all the 29 countries whose Earthquake Engineering Associations are members of the European Association for Earthquake Engineering, and records the number of fatal earthquakes, the number which have killed more than 1,000, the number which have killed more than 10,000 people, and the total number of human casualties recorded over the whole of the 20th century. It then records the 2001 population of the country concerned, and calculates the long-term fatality rate in terms of the number of fatalities per year per head of 2001 population. Finally, it ranks and categorises the countries according to this long-term fatality rate. A world rank is given, in terms of the total number of casualties experienced by each country in the 20th century. The data are taken from the Martin Centre's database of fatal earthquakes [1], and may be incomplete for some countries.

World Rank	Country	No of fatal eqs	No of eqs killing more than 1000 people	No of eqs killing more than 10,000 people	Total fatalities	Population 2001 (millions)	Fatalities per 2001 million of population per year
Risk of major national significance							
3	ITALY	45	6	2	128031	57.7	22.19
4	IRAN	89	16	4	121513	66.1	18.38
5	TURKEY	111	17	2	99391	66.4	14.97
Nationally significant risk							
22	GREECE	50	2		6629	10.6	6.25
7	former USSR	45	9	3	77802	269	3.21
24	ALGERIA	22	2		5339	31.7	1.68
49	CYPRUS	4			94	0.76	1.24
29	ROMANIA	3	2		2578	22.3	1.16
31	former YUGOSLAVIA including Croatia, Slovenia, Bosnia, Macedonia	17	1		2013	23	0.88
Locally significant risk							
40	BULGARIA	5			317	7.7	0.41
45	PORTUGAL	3			122	9.4	0.13
36	EGYPT	4			576	69.5	0.08
79	ICELAND	1			1	0.28	0.04

Table 1 The earthquake fatalities suffered during the 20th century by the countries of the EAEE; and relative long-term fatality rates, in the countries with a significant national earthquake risk.
Note: in addition to the countries listed above, member countries France, former Czechoslovakia, Hungary, Belgium, Spain Poland and the Netherlands also had one or two deaths in the 20th century; while Denmark, Israel, Norway, Switzerland, Austria and the UK had no fatal earthquakes during the 20th century.

Even if we accept the data, there are of course many objections and inadequacies in this table as a measure of comparative present-day risk. Populations have grown hugely over the century, and at a rate which is very uneven. Some of the countries listed have had population growth of 40% or more over the last 20 years, others are declining in population; borders and administrative boundaries have shifted; large earthquakes have often affected more than one country; building stock has changed dramatically over the century, from single-family and rurally-based housing, to city apartment blocks, with significant effects on vulnerability; and in all countries, the seismicity is very unevenly distributed, with local levels several times higher than the national averages. Another objection is that 100 years is not a long enough period of time to consider, since several major cities (e.g. Lisbon and Istanbul) known to be prone to seriously damaging earthquakes did not experience one in the whole of the 20th century. Yet, in spite of its inadequacies, the table may be useful in two ways. First by clearly identifying the most earthquake-prone countries and showing the enormous difference that exists between these countries and the least earthquake prone countries of the European area; and secondly, by enabling us to compare the risks from earthquakes to other risks which people experience in their daily working and non-working lives.

The three countries which been identified in this Table 1 as having experienced the highest fatality rate (Italy, Iran and Turkey) all have calculated rates greater than 15 per million, and may be said to have risk levels of *major national significance*; while 13 EAEE countries not shown in the Table have fatality rates between zero and 0.01 per million, and may be said to have a risk which is either *insignificant or very localised*. Interestingly a factor of more than 1500 in the calculated long-term fatality rate separates these two groups of countries. This statistic alone makes it clear where effort should be directed if we wish to reduce the human life loss from earthquakes. Between these two extremes, we have two groups of countries, the first of which has a long-term fatality rate of between 1 and 15 per million and could be said to have a *nationally significant risk* (Greece, Romania, Russia, former Yugoslavia); and the second of which (Bulgaria, Portugal, Egypt, Iceland) have long-term fatality rates between 0.04 and 0.4 per million, and may be said to have a *locally significant risk.*

The long–term fatality rates calculated may also be used, with some caution, for comparison with fatality risk levels in other activities. Table 2 lists some fatality rates from a variety of activities in different locations, expressed in deaths per million of population.

TYPE	*Annual risk of death per million*
Smoking 10 cigarettes a day	5000
All natural causes aged 40	1200
Road accident (Europe)	125
Accident at home	38
Accident at work, manufacturing industry (UK)	13
Murder, living in Europe	10
Railway accident (Europe)	2
Hit by lightening	0.1
Wind storm, Northern Europe	0.1

Table 2 *Annual risk of death from industrial accidents for various sectors [1,2]*

If, given the balancing effects of changes in population and changes in building stock vulnerability, we take the view that, nationally, the figures are of about the right order of magnitude, we can see that

1. the risk of earthquake fatality is everywhere considerably lower than the risk of death from traffic accidents
2. the countries with the highest national average risk level have about the same average annual level as the risk of death from accidents at work.
3. the next group of countries have a level of earthquake risk about the same level as the risk of death in a railway accident or by murder
4. the third group of countries have a level of risk, nationally, no greater than that of death by windstorm or lightening strike.

The database of earthquake fatalities has also been used to compile an estimate of the causes of death in earthquakes. These are shown in Figure 1, which compares causes of death worldwide over the first and second half of the 20th century.

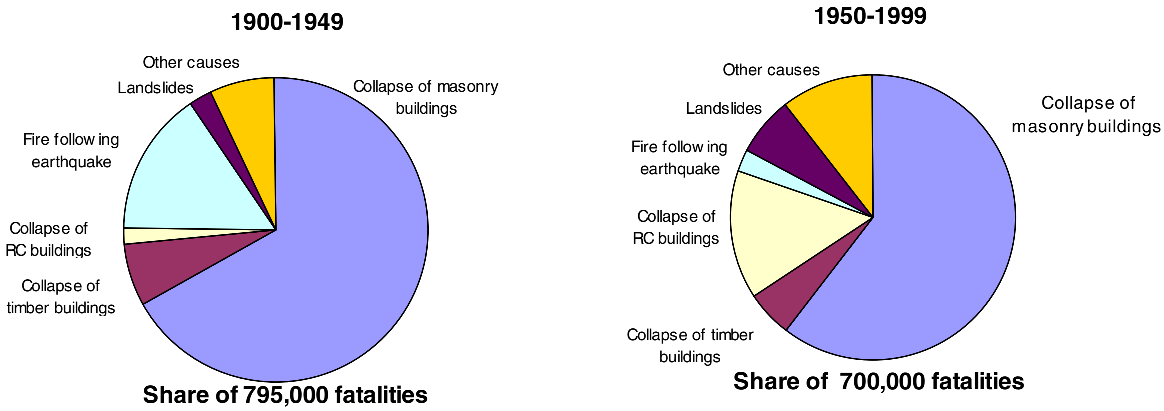

Figure 1 Share of 20th century fatalities by cause[1]

Figure 1 reveals that over 75% of all earthquakes deaths are caused by the collapse of buildings, and that collapse of masonry construction remained, over the last 50 years, worldwide, the major cause of death. Much of the masonry building stock is old, or of traditional construction; however, reports from recent earthquakes affecting urban areas indicate that an increasing proportion of the deaths are caused by the collapse of reinforced concrete frame buildings; and that collapsed buildings are largely those either built before the present generation of aseismic design codes was adopted, or built more recently in violation of these codes. A particularly alarming feature of recent earthquake experience (true of the recent earthquakes in Turkey, India and Taiwan), is the extent to which urban housing has developed in the form of reinforced concrete apartment blocks, built by developers without the involvement of earthquake engineers, using substandard materials, detailing practices and with inadequate building control by the local authorities. In the 1999 Kocaeli earthquake, collapse rates for reinforced concrete apartment blocks were higher than those for masonry buildings, and most of the deaths occurred in such buildings, an alarming trend which suggests that high death tolls will continue.

RISK MITIGATION ACTION IN EUROPE

Inevitably, risk mitigation action at a national or city level tends to follow the occurrence of a major damaging earthquake. Thus it is not surprising to find that the European countries currently most active in earthquake risk mitigation are those which have had recent experience of a damaging earthquake.

In Turkey, where the tragedy of the 1999 earthquakes in Kocaeli and Düzce which killed about 18,000 people, are still vividly remembered, some notable action has been taken towards improved building control. A study of the causes of poor quality construction in Turkey [3] pointed to deficiencies in both the nature and implementation of laws and regulations concerning the planning system, the project supervision at the design stage, and the system of supervision on site. Among these the most serious were the following deficiencies in the in building construction supervision system :

- no requirement for adequate expertise on the part of the supervising engineer
- supervising engineer has little contact with the process on site
- lack of personal liability insurance on supervisors
- no mechanisms for municipalities to become aware of, to refuse utility connection to, or to demolish unpermitted buildings
- no adequate system for prosecuting negligent builders
- no requirement for registration of builders or contractors.

Since 1999, serious efforts have been made to overcome these deficiencies in Turkey through new legislation and through setting up new training programmes. One particular innovation proposed, which has international significance, is the establishment of a new role of building supervision specialist. Private building supervision firms will be offered, in return for a fee, the responsibility for supervision of building projects, both in the design and construction phases; and that responsibility will carry with it the liability for offsetting any losses which might occur to the owner, during 10 years, resulting from poor construction. This liability will be backed by indemnity insurance on the part of the supervising firm. This measure in effect removes to the private sector from the municipalities the task of building control which they have failed (or been unable) to undertake adequately. Unfortunately, to date the legislation to introduce the new system for building control has not been passed, having run into constitutional difficulties about the removal of the responsibilities of local authorities. Other aspects of the recommended new provisions for building control in Turkey include:

- requirement for a resident site engineer for all substantial projects
- proper registration of contractors as well as engineers and architects taking responsibility for all buildings
- compulsory testing of materials used in all construction projects
- establishment of a compulsory national earthquake insurance system

The principal purpose of the compulsory insurance scheme is to create a financial pool (backed by international reinsurance) which can be used to support repair and reconstruction following future damaging earthquakes, replacing the increasingly unsustainable burden on the government for compensation payments under the current system. But this system has potentially huge implications for building control. By requiring householders to purchase insurance, premiums for which depend on the quality and location of construction, they are forced to consider and to some extent pay for the risks they face. This will in turn bring pressure to bear on the builders and designers to demonstrate that construction standards are being maintained. To date, more than 2 million policies have been taken out under the scheme.

Fresh impetus for mitigation action in Turkey has been provided by a forecast that a major earthquake (M>7.5) must be expected for the section of the North Anatolian fault closest to Istanbul - with a 60% probability of occurrence within 30 years [4]. A study of the effects of this scenario conducted by JICA [5] estimates that 7.1% (51,000) buildings in Istanbul will receive heavy damage, and casualties will reach 0.8% (73,000). While not all seismologists accept the assumptions behind this prediction, it has been a catalyst for consideration of the special risk problem of Istanbul, where an even higher proportion of the population (73%) live in the kind of apartment blocks which suffered so badly in the Kocaeli earthquake, and where perhaps 90% of which are not built to satisfactory earthquake resistant standards. A proposed Istanbul Rehabilitation Project being conducted for the Istanbul Metropolitan Municipality [6] will attempt to take action on this vast number of substandard buildings by a three-stage process. In the first stage street-surveys will identify the most likely high-risk buildings; these will then, at a second stage, be surveyed by dimensional measurements at ground floor, to determine action needed for the third stage, seismic rehabilitation of those in the highest risk category. In some cases, where high-risk buildings are scattered, this will take the form of simplified strengthening interventions; but in other cases, where whole housing estates are in a state of deterioration for social and economic reasons, it is envisaged that wholesale redevelopment will be undertaken either on existing or new sites.

In Greece, frequent damaging earthquakes in the last 25 years, including those of Thessaloniki (1978), Corinth (1981), Kalamata (1986), Aegion (1995), Kozani (1995) and Athens (1999) have created a highly-developed national consciousness of the earthquake problem, and improved economic performance has led to a general rise in the standards of building. Most of the buildings which collapsed in recent earthquakes were identified as older buildings, built prior to the present-day building code. But many such buildings remain: and in the last two years a framework for the pre-earthquake assessment of public buildings has been developed and approved by the national earthquake mitigation authority (OASP), strongly based on the US framework established by Presidential Decree in 1994 following the Northridge earthquake [7] It is recognised that the cost of bringing these buildings – which include public schools, hospitals, and public administration buildings - to a satisfactory standard of earthquake resistance will be substantial: for the schools in Thessaloniki alone, it was estimated that the cost would be equal to the entire budget of the Region for new schools over the next 6 years. Thus a lengthy programme for action is envisaged – perhaps 15 years. A three stage process is envisaged, beginning with a rapid visual screening procedure (RVSP), leading to a seismic score. This will be followed by an approximate seismic evaluation of those buildings with a low seismic score. For those buildings which do not pass this evaluation, a third, more detailed assessment will be performed, leading to recommendations for strengthening. An attempt to validate the RVSP for a large sample of buildings in Thessaloniki by comparing their seismic score with their actual performance in the earthquake of 1978 showed poor correlation building by building. Nevertheless a clear trend of reduced average repair costs with increasing seismic score was established for reinforced concrete buildings [7].

In Portugal, while there has been no mainland earthquake in recent years, the Azores islands of Faial and Terceira were badly affected by the earthquakes of 1997 and 1980 respectively, which claimed 70 lives; and the memory of 20th century earthquakes in 1909, 1941 and 1969 and the historical memory of the devastating 1755 Lisbon earthquake provide an incentive for risk mitigation activity. At a government level, the Regional Government of the Azores is at a relatively advanced stage with a policy to intensify efforts at rehabilitation and maintenance of the existing housing stock; creating credit lines (including earthquake insurance) aimed at strengthening of older housing while maintaining its architectonic characteristics; and special measures for protecting people living in high-risk locations. This is in addition to subsidies available to those repairing houses damaged in the 1998 earthquake. At a national level, the Portuguese Association of Earthquake Engineering (SPES) in association with the Portuguese Association of Companies for Preservation and Restoration of the Architectural Heritage (GECoRPA) has formulated a National Plan for Reducing the Seismic Vulnerability of Constructions modelled on the National Earthquake Hazards Reduction Program (NEHRP) in the USA, which envisages a series of activities including surveys of the housing stock to assess the risk; defining and developing intervention strategies; creating support legislation; training; preparing masterplans; and finally carrying out the rehabilitation [8]. A 25-year programme is envisaged, with a cost about 1% of national GNP over that period. The legislation envisaged has several dimensions including certification of designers; improvement of building control; definition of situations requiring compulsory seismic rehabilitation; and the creation of tax incentives. However, to date this plan remains a proposal, supported in terms of research work, but lacking the Government backing to bring it to fruition.

In Italy, a substantial programme of repair and strengthening of masonry buildings followed the 1976 Friuli, 1980 Irpinia and the 1997 Umbria-Marche earthquakes and a number of other post-earthquake projects have begun to tackle the problem of the existing building stock at risk in those areas. Progress towards reducing risks in Italy as a whole has been supported by a new system of tax incentives, introduced in 2001, for private owners upgrading their buildings**.** Most recently, following the tragic loss of the lives of schoolchildren which it involved, the October 31st 2002 San Giuliano di Puglia earthquake has provided a big stimulus to earthquake risk mitigation throughout Italy, with important implications for the older building stock. Within months, a new earthquake code was drafted and is now proceeding into law, which among other changes introduces a new seismic zonation (including the whole country within the seismic zonation for the first time), and will set out more detailed procedures than before for the evaluation and strengthening of existing structures. In parallel with this initiative, the 2003 allocation of funds from central government to the regions for the first time provides funds for the evaluation of public buildings, leading to the creation of a list of priorities for strengthening, and with an emphasis on school buildings at risk; and further legal instruments will set deadlines of a few years to carry out this huge programme of strengthening [9].

France and Romania also have in place programmes of evaluation and strengthening of important high-risk buildings. In Romania, this is limited to a relatively small number of multi-storey reinforced concrete buildings in the capital, Bucharest, which were shown by the 1977 earthquake to be highly vulnerable, and in some cases were very inadequately repaired afterwards, [10]. In France the programme is concerned with the protection of public buildings (schools and hospitals) in the high-risk Antilles islands of Guadeloupe and Martinique. In some parts of Austria and Switzerland evaluations of existing public buildings has been started though no systematic strengthening programme is yet in place in any of these countries.

INTERNATIONAL COMPARISONS

Some international comparisons are of relevance. Most large-scale strengthening programmes have taken place immediately after a major damaging earthquake, at a time when public concern and awareness of the risk is at its highest, when substantial building repair work is in progress, and when there may have been changes in the Code of Practice [1]. After the 1985 Mexico City earthquake, the lateral resistance requirements for buildings in the worst-hit parts of the city were substantially increased, and the new building code also specified that the increases should apply not only to all new buildings and all buildings damaged in the earthquake, but also to all existing buildings whose failure would put the public or essential services at risk, even where they had not been seriously damaged by the 1985 earthquake. This resulted in a very substantial programme of strengthening, affecting many thousands of existing buildings.

Strengthening of buildings in high-risk areas which have not recently experienced earthquakes is not yet happening very widely, although there has been some progress in California. According to a Hazardous Buildings Ordinance issued in 1981, the City of Los Angeles requires all buildings of unreinforced masonry constructed before 1934 to be brought up to a minimum standard of structural resistance. The standard required is somewhat lower than that required for new building, but sufficient to reduce the risk of loss of life or injury significantly. The rules were introduced as a consequence of the extent to which building damage and casualties in earthquakes in southern California in the 20th century were concentrated in these older buildings. A method of assessing the resistance of existing and strengthened buildings was specified, and all building owners were expected to have surveys carried out within nine months, and have completed any necessary strengthening within a specified period depending on the extent of the risk involved. However compliance with this Ordinance was slow, and has led to almost as many demolitions as strengthening projects.

More recently, following the 1994 Northridge earthquake, and after a long campaign by the Seismic Safety Commission, The California State legislature passed legislation (SB1953) requiring all hospitals, including the many that were built before 1972, to be brought up to acceptable standards of life safety by 2030. 90% of hospitals reported their structural condition by the deadline date of January 2001, and a surprising proportion (966 out of 2467) were found to be in the worst structural category, SPC1, “Pre-1972 buildings posing a risk of collapse” [11]. These will have to be upgraded, or may not be used for acute care purposes after 2008. Thus, in spite of their extreme public importance (and especially following a future damaging earthquake), and in spite of the fact that the risk to hospitals has been well-known since the failure of the Olive View Hospital in the 1971 San Fernando earthquake, without supporting legislation, very little has been done to deal with the risk. Even after the legislation, the complexity of the task and the serious financial problems of the hospitals (which will not be subsidised to undertake this work) have resulted in considerable resistance to the upgrading programmes it requires [12] and it is thought that a significant number will not comply.

In New Zealand, following bad experience with old unreinforced masonry buildings in the 1929 Murchison and 1931 Napier earthquakes, local authorities were given statutory powers to declare those unreinforced masonry buildings with less than 50% of the capacity needed to resist forces specified for design of new buildings as earthquake risk buildings, “potentially dangerous in an earthquake” and require the owner to strengthen or remove them according to a timetable set by the council [13]. This considerably reduced the number of high-risk old buildings, both through abandonment and strengthening, though a small number still remain.

Thus evidence from other countries suggests that legislation is necessary, but not sufficient, to reduce significantly the number of older high-risk buildings; that the legislation required is complex, and the engineering community needs to be involved over a long period of time in its development; and that the experience of damaging earthquakes provides the incentive and creates a “window of opportunity” for such legislation to be passed.. Alesch and Petak [14] conducted a valuable study of the legislation on earthquake risk mitigation of three communities in Southern California, which aimed to discover the reasons why such a long period had elapsed from the time at which the need for such programmes was widely recognised (after the 1933 Long Beach earthquake) until a mitigation ordinance was finally passed. This took place in 1972 in Long Beach, but only in 1981 in Los Angeles. The main conclusion of the study was that earthquake risk mitigation is not primarily a technical exercise; it is "inherently and often intensely political because mitigation usually involves placing some cost burdens on some stakeholders, and may involve a redistribution of resources". They maintain that advocates for risk mitigation strategies must develop political as well as technical solutions, and they argue that a decision on a policy for earthquake protection has four prerequisites:

1. A recognised and well defined problem, and a belief that something can be done about it which will be politically acceptable
2. A possible technical solution to the problem that non-technical policy-makers view as practical and effective
3. A group of policy advocates who believe in the policy, are seen by the policy makers as credible, and are persistent in their pursuit of the policy.
4. A window of opportunity for the policy to be enacted such as that which occurs when an earthquake that affects the community directly or indirectly has occurred.

It could be argued that of these conditions are now in place in at least some European countries which have recently experienced damaging earthquakes, and that the time is ripe for more concentrated action.

CONCLUSION

The argument put forward in this paper has been that:

1. There still exists in many parts of Europe a dangerously high level of risk of casualties from earthquakes.
2. We know both where the risk is highest (countries and regions), and which types of buildings are most vulnerable. There is no evidence that the risk is on its own diminishing with time.
3. There are national activities and programmes in several European countries directed towards identifying high-risk buildings and reducing their numbers over time; but there does not appear to be a law on the statute book anywhere in Europe which requires all buildings that are below a certain standard of earthquake-resistance to be strengthened, even when in use by the public or housing emergency services.
4. Although the protection of the public and the safety of the workforce makes this a matter for possible EU action, no such action is contemplated at the moment at the European level.
5. The experience of other high-risk countries seems to suggest that little will be achieved, in spite of repeated experience of damaging earthquakes, unless legislation is introduced to require owners to strengthen their buildings to a satisfactory standard of life safety. The legislation needs to be backed up by technical and financial support.
6. The techniques for carrying out this work are already available
7. Unless concerted action is taken leading to this kind of legislation at a national and/or EU level, the problem of high-risk buildings and life–loss in earthquakes in Europe will remain for many years to come.

However, such a programme would undoubtedly be expensive and resources for it would need to be drawn from other competing demands for public or private funds. Initially it may be that that the legislation proposed should apply exclusively to school buildings. There is a good precedent for this: the first earthquake legislation in the USA was the Field Act of 1933, which applied only to school buildings. Furthermore, few would argue against making children, the future of the European community, the highest priority. Such a relatively small-scale initiative that would nonetheless prove the feasibility of assessment and strengthening projects; would also raise the issue both amongst the next generation of European voters as well as the adult community.

Acknowledgements

The ideas of many people active in earthquake protection issues in Europe have contributed to this paper; particular thanks are due to Mihael Papagiannakis MEP, Panayotis Carydis, Andrew Coburn, Giulio Zuccaro, Antonios Pomonis, Julian Bommer, Mary Comerio, Carlos Oliveira, Artur Pinto, David Dowrick, Mauro Dolce and Haluk Sucuoglu for fruitful discussions and valuable comments on earlier drafts.

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