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POLITICAL ACTIVITIES OF EARTHQUAKE ENGINEERS FOR SEISMIC RISK MITIGATION ?

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SUMMARY

The earthquake community – consisting of engineers, seismologists and scientists – has developed and accumulated an immense knowledge about earthquake protection - mainly by structural measures - and hence also about seismic risk mitigation. However, this knowledge is still widely ignored by many public authorities, public opinion, and by numerous individuals. Thus the questions arise: Is the earthquake community doing the right things? Are technical and scientific activities enough? Or shouldn't other activities such as powerful media and political activities also be pursued? What would be an appropriate strategy? Such questions are discussed and some basic principles are postulated. For illustration and as examples, relevant activities undertaken in recent years in Switzerland and corresponding results – successes and failures – are described.

1 HIGHLY QUALIFIED KNOWLEDGE

The "earthquake community" - consisting of engineers, seismologists and scientists who concern themselves with the causes and effects of earthquakes - knows that in many countries a considerable seismic risk exists and that it can be effectively reduced, mainly by means of modification of structures, i.e. by structural measures. We[2] have gained a wide knowledge regarding which measures have to be applied to provide new and existing buildings and other structures with greater resistance to earthquakes. Here, on the technical side, we know well enough what has to be done and what has to be avoided for obtaining a better seismic performance of the built environment. Some important principles, for example, are the following:

- create ductile structures by capacity design and relevant constructional measures and detailing
- avoid soft storeys and unsymmetrical bracing of the structure
- avoid short columns and parapet walls in frame structures
- reinforce masonry structures or brace unreinforced masonry structures by means of RC structural walls
- protect foundation using capacity design principles
- investigate possibility of soil liquefaction
- secure installations and equipment
- etc.

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[2] Note, as a structural engineer belonging to this community the author has adopted the 'we' form to emphasize personal involvement.

These are well known and well proven protective structural measures. The relevant knowledge and methods belong to our core competences.

When we are using these competences we are of course finding some gaps. Therefore, we – the leading experts in this field – are devoting all our energy to improving and perfecting our technical and scientific knowledge. And in this process we are always developing more advanced and more complex methods both for the analysis and for the structural design and detailing. And as a consequence, we are writing more advanced and more complex codes. These activities belong to our core activities. They are fascinating and we are happy to carry them out, because here we feel ourselves "at home" and truly in our element ….

2 WIDESPREAD IGNORANCE

However, if we look outside to the real world, we observe that our highly qualified knowledge and our sophisticated methods and even our advanced codes are often not taken notice of by public authorities, by owners, architects and even by some "normal" engineers. Our knowledge and our methods are often not being applied out there in the real world or are even deliberately ignored. And also our warnings on the damage potential of probable future earthquakes are ignored by society at large, despite the fact that actual earthquakes reveal a structural behaviour just as we have predicted. And this despite the fact that we observe again and again just the damage we expected, and we always recognize the same causes of damage, which could be eliminated if only our proposals were applied.

In fact it is true that in many places and on numerous occasions we – the members of the earthquake community – have to note great deficiencies in the realization or even great ignorance of our knowledge and our recommendations. In the following some examples of deficiencies and ignorance, representative of many more, are described.

Disregard for codes
World-wide the state of development of the structural engineering seismic codes is generally of a high standard. But in many countries and regions often the provisions of the codes are not being fulfilled. The reasons may be a lack of knowledge, indifference, laziness or pure ignorance. To exacerbate the situation, effective mandatory conditions and checks by building authorities are missing. Therefore, new structures often exhibit a considerable seismic vulnerability, and even for relatively small earthquakes they constitute a high risk. For example, in Switzerland most residential buildings are traditionally built in brick masonry without any other vertical structural elements. With such "purely" masonry structures it is impossible to guarantee a code-conform verification of seismic safety. Furthermore, again and again structures with soft storeys are being built. And this list concerning the disregard for code provisions could be easily extended.

No education of architects in seismic conceptual design
In many universities and other places of higher education the students of architecture are not taught the seismic conceptual design of buildings, i.e. both for the structural and the non-structural elements (partition walls and facades). This is the case even though the conceptual design plays a central role in determining the behaviour of buildings regarding seismic safety and sensitivity to damage; and although many architects often carry out the general conceptual design themselves without the expertise of an earthquake engineer.

Renovation of historic monuments without improving seismic safety

In many countries there are valuable historic monuments: churches, castles, secular buildings, groups of historical buildings, etc. Fortunately, in many cases great efforts are being made to preserve them. This involves – and justifiably so – a considerable investment: frescoes and paintings are restored, stuccoes repaired, plasterwork renewed and often structural rehabilitation is undertaken. However, in most cases only the former state is restored and no decisive measures to improve seismic safety are implemented. This could be done however with just minimum extra cost, i.e. at just a small fraction of the costs for the restoration of the cultural parts, the seismic safety could be vastly improved.

Not upgrading dangerous existing structures

Often the assessment of an existing structure reveals a completely inadequate seismic safety. For example, in the case of a fire station it is shown that even for a relatively small earthquake the building would collapse and the fire engines could not drive out. Thus an upgrade project is planned. But despite the proved urgency of the situation the project is filed away for years or maybe for decades or forever without being implemented by the relevant authority, i.e. it is unlikely that it will ever be realized. And this happens, even though in the case of a seismic event this building has a vital lifeline function.

Inappropriate developments in the properties of reinforcing steel

It has been common knowledge for some time now that for the ductility of RC structures the strain-hardening ratio of the reinforcing steel – i.e. the ratio of tensile strength to yield strength – is of great importance. Generally it should be at least 1.15. Despite this, in many countries and regions reinforcing steel is continually being further developed to achieve as high a yield strength as possible. This usually leads to a reduction of the strain-hardening ratio, often much below the required minimum value. The result is that the plastic zones in the structural elements are too small, resulting in an early fracturing of the reinforcing steel, i.e. giving an inadequate ductility of the elements and thus of the relevant RC structures.

Insufficient detailing

In the planning of structures often a lot of effort is put into the analysis. By contrast, important constructional measures, which are essential to the ductile behaviour of the structure, are neglected. For example, in RC columns the ties are provided with 90° instead of 135° hooks. The result is a premature anchorage failure of the ties. Another fault is to choose too large a spacing between ties so that the bars of the axial reinforcement buckle between the ties and in the next load cycle they fracture in tension. Both can lead to a failure of the column and a collapse of the whole structure.

More examples of ignorance of our knowledge and our recommendations could, in fact, easily be given.

However, based on these sad facts some urgent questions must be put: Why? Why are our knowledge and methods and codes often ignored? Why are our warnings ignored?

The author is convinced that we – the members of the earthquake community – have to seek the answer in ourselves. We think we have accomplished our task when we put all our energy into extending our knowledge and refining our methods and perhaps get as far as their implementation in codes of practice. And we believe it is not our job to ensure that the results of our traditional activities are translated into action. We believe this is the responsibility of politicians, public authorities, legislators, the owners of structures, insurance companies, etc. But then we discover that these institutions and persons usually remain in a passive state. Often they are hardly interested in our statements and our expertise. And, as a consequence, seismic risk is steadily increasing.

3 CHANGE IN STRATEGY

Thus the author is pleading for a change in strategy by the earthquake community including the national and international societies for earthquake engineering. He is pleading that – beside of our traditional activities – we exert ourselves much more to seeing to it that the existing knowledge is actually applied in practice, and that we deploy our resources less exclusively for accumulating new and more sophisticated but hardly applied knowledge.

This will mean that the following new non-technical and non-scientific measures and activities will be undertaken by the earthquake community:

(i) Clarifying aims and arguments:
Systematic *elaboration of the need for action* for a substantial reduction of the seismic risk.
(ii) Creating public awareness:
Systematic *activities in the media*, i.e. in the press, radio and television, to make people more aware of the need for action.
(iii) Mobilizing politicians and public authorities:
Systematic, so to say, *political activities* with the aim of a substantial improvement of the legal and financial basis for protective measures.

Since these non-technical and non-scientific measures and activities have usually been greatly neglected in the past by the earthquake community, even small efforts can have a big beneficial effect. The effect is usually much greater than if the same amount of energy were invested in the perfecting of our knowledge and methods and codes.

Certainly, it is clear that if we engineers, seismologists and scientists were to undertake such primarily non-technical and non-scientific activities, then we would find ourselves on unfamiliar ground, where in general we would not feel “at home”:

- we prefer to work with the computer or in the laboratory
- we think in technical and scientific terms, not politically
- many of us are not particularly skilled at meeting and discussing with lay persons
- we prefer to engage in discussion among experts rather than with the general public
- we often have great difficulty in simplifying and presenting ideas and interrelationships in a way that is understood by lay persons.

Nevertheless, the author is convinced that it is urgent that we force ourselves to undertake the new activities!

In the following three chapters a systematic overview of the general need for action is given and effective media activities and possible political activities are suggested. In each of the chapters firstly basic principles are outlined and then explained, drawing on experience gained in recent years in Switzerland.

4 NEED FOR ACTION

4.1 Basic Principles

The basis for the primarily non-technical and non-scientific activities (ii) and (iii) of the earthquake community is a clear idea of the need for action regarding the seismic design and upgrading of structures and hence of the seismic risk mitigation. Such activities will only be successful if they rest on clear aims and arguments. This necessitates the following work:

- analysing the existing situation, and finding out important deficiencies
- establishing the aims
- defining the necessary political, administrative and technical measures
- assessing the measures and assigning them to priority classes
- clarifying and stating more precisely the relevant arguments

This work has to be done in a number of areas with a need for action, which, of course, can be identified and grouped in different ways. Here we follow the classification scheme shown on the next page (SIA D 0150 [1]).

The *Phenomena* are the following: Seismic waves propagate from the source (focus, hypocentre) to the Earth's surface and act on structures and facilities, which respond in the form of vibrations, deformations and damage, possibly leading to collapse. Damaged structures endanger human life directly or indirectly through released substances.

The three *General Areas* can be distinguished as follows:

- Seismic Actions
- Behaviour of Structures and Facilities
- Disaster Management

The general area Seismic Actions deals with Hazard Evaluation (see the lower part of the scheme). The general area Behaviour of Structures and Facilities is the key area of earthquake defence. Here Protective = Primary Measures lead to a decisive reduction of human casualties and damage to property. The general area Disaster Management deals with accompanying measures.

The *Fields of Knowledge* belonging to the three general areas are:

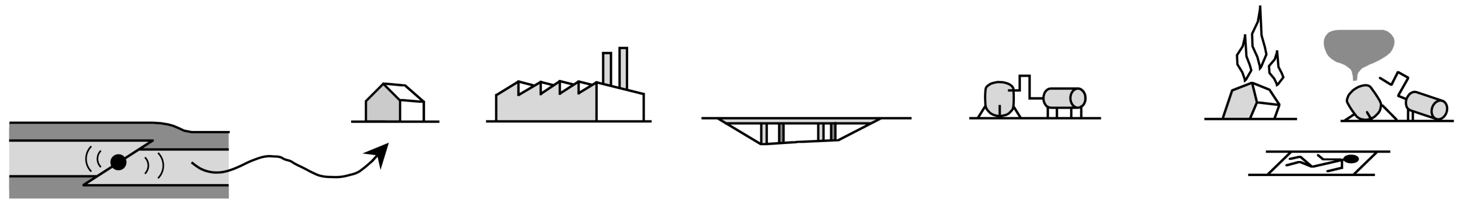
- Seismology and Soil Dynamics
- Structural Dynamics and Planning = Conceptual Design, Preliminary Design, Analysis, Member Design and Detailing
- Survival Aids

The *Areas with Need for Action* are:

(a) Seismic Hazard
(b) Seismotectonics
(c) Wave Propagation Effects
(d) Site Effects
(e) Dynamic Soil-Structure Interaction
(f) Legal Basis
(g) Code Provisions
(h) Seismic Design of New Structures
(i) Seismic Upgrading of Existing Buildings
(j) Seismic Upgrading of Existing Bridges
(k) Seismic Upgrading of Historic Structures

Overview Need for Action – National Earthquake Risk Reduction Program (NAPER)

Phenomena



	Seismic Actions	Behaviour of Structures and Facilities	Disaster Management
General Areas	Seismic Actions	Behaviour of Structures and Facilities	Disaster Management
Fields of Knowledge	Seismology Soil Dynamics	Structural Dynamics Planning = Conceptional Design, Preliminary Design, Analysis, Member Design and Detailing	Survival Aids
Areas with Need for Action	(a) Seismic Hazard (b) Seismotectonics (c) Wave Propagation Effects (d) Site Effects (e) Dynamic Soil-Structure Interaction	(f) Legal Basis (g) Code Provisions (h) Seismic Design of New Structures (i) Seismic Upgrading of Existing Buildings (j) Seismic Upgrading of Existing Bridges (k) Seismic Upgrading of Historic Structures (l) Seismic Design of Nonstructural Elements (m) Seismic Design of Installations and Equipment (n) Seismic Design of Chemical Plants (o) Seismic Design of Lifelines (p) Seismic Design of Dams (q) Seismic Design of Nuclear Power Plants (r) Research on Seismic Behaviour of Structures and Plants (s) Putting Research Results into Practice (t) Education and Further Education of Engineers and Architects	(u) Rescue Operations (v) Safety Assessment of Damaged Structures and Facilities (w) Earthquake Insurance
	← Hazard Evaluation →	← **Protective = Primary Measures** →	← Accompanying Measures →
Previous Efforts of Authorities	▪ Swiss Seismological Service ▪ National Measurement Network	▪ Seismic Design of Nucl. Power Plants ▪ Sporadic Seismic Ass. of Public Buildings	▪ Civil Defense ▪ Disaster Management of the Cantons ▪ Army
Necessary Efforts		← **Urgent Need for Action !** →	

(l) Seismic Design of Non-structural Elements
(m) Seismic Design of Installations and Equipment
(n) Seismic Design of Chemical Plants
(o) Seismic Design of Lifelines
(p) Seismic Design of Dams
(q) Seismic Design of Nuclear Power Plants
(r) Research on Seismic Behaviour of Structures and Plants
(s) Putting Research Results into Practice
(t) Education and Further Education of Engineers and Architects
(u) Rescue Operations
(v) Safety Assessment of Damaged Structures and Facilities
(w) Earthquake Insurance

The *Measures* (not shown in the scheme) express the need for action in a concrete way. For each area with a need for action several measures may be involved. It is convenient to group the measures under the following 4 topics:

I MEASURES FOR THE LEGAL BASIS AND CODES
II OBJECT-SPECIFIC MEASURES
III MEASURES FOR EDUCATION AND PUBLIC AWARENESS
IV MEASURES FOR RESEARCH AND PRACTICAL APPLICATION

Object-specific measures (II) effect an immediate reduction of earthquake risk for certain objects (structures, facilities, systems). All other measures have an indirect effect by enabling or supporting the implementation of object-specific measures.

All defined measures are important for the reduction of seismic risk, though there are naturally differences with respect to general importance, costs, cost-benefit ratio and time scale for completion. It follows that the measures have to be evaluated and classified within a priority scale.

A thorough analysis of the existing condition, the specification of aims and the clear definition of the concrete measures, as well as their assessment and the setting of priorities are an essential prerequisite for further activities. Above all, media and political activities will only bring success if they are based on sound and proven, and thus also credible, precise arguments. Such arguments result from a clear evaluation of the need for action.

4.2 Example

In 1997/98 the Swiss Society for Earthquake Engineering and Structural Dynamics (SGEB) formulated and published the "Need for Action" to effectively reduce seismic risk in Switzerland (SIA D 0150 [1]). In total 23 *Areas with Need for Action* (see (a) to (w) on scheme) were systematically identified. For each area a comprehensive problem description was elaborated and in general 2 to 4 substantial individual measures were precisely formulated. In all, more than 60 measures were defined.

Then, in a subsequent process, an assessment and prioritization of the measures was carried out. The measures were assessed on the basis of the following criteria:

1) General importance (decisive, very important, important)
2) Costs (low, moderate, considerable, high)
3) Cost-benefit ratio (very good, good, acceptable)
4) Time scale for completion (immediate, short-term, medium-term, long-term)

On the basis of their assessment the measures were classified under 3 priority levels. About ¼ of the measures were assigned to the 1st Priority, a further ¼ to the 2nd Priority and the rest to the 3rd Priority. Details on the assessment and prioritization are given in the publication (SIA D 0150 [1]).

In the following the measures in the first and second priority levels are briefly described. The measures were classified according to the four groups of topics given in section 4.1.

I MEASURES FOR THE LEGAL BASIS AND CODES

Legal Basis (f)

- Preparation of the legal basis (above all, federal constitution article and federal law) for a "National Earthquake Risk Reduction Programme (NAPER)" and for its financing and realization.
- Ensuring that compliance of new structures with the earthquake regulations set out in the Swiss Codes is legally binding.
- Imposing time limits and creating financial incentives for the seismic upgrading of existing structures.

Code Provisions (g)

- Financing the preparation of earthquake codes by public funding (collaboration on and introduction of Eurocode 8, National Application Document, new Swiss map of seismic zones, new design spectra, use of microzonation, etc.).
- Execution of pilot projects on seismic design of public structures according to the pre-codes of Eurocode 8 to obtain the required practical experience for the National Application Document and for the final draft of Eurocode 8.
- Preparation of codes and guidelines for the seismic upgrading of existing buildings and bridges.

Seismic Design of New Structures (h)

- Improved enforcement of code provisions by the authorities and administration at all levels with their own structures, public structures and those in private hands based on a legally binding regulation.

Seismic Upgrading of Existing Buildings (i)

- Enforcement of the regulations of the Swiss Code SIA 462, according to which for all changes to existing buildings checking the seismic safety and if necessary carrying out a seismic upgrading is mandatory.

Seismic Design of Chemical Plants (n)

- Supplementing the inadequate guidelines of firms as well as laying down procedures to follow in the case of an incident with legally-binding earthquake regulations. Enactment of additional regulations for the layout of plants with extremely high damage potential.

II OBJECT-SPECIFIC MEASURES

Seismic Upgrading of Existing Buildings (i)

- Identification of existing public and private buildings of the most important building class (Class III), checking the seismic safety and if necessary carrying out a seismic upgrading.
- Checking the seismic safety and if necessary carrying out a seismic upgrading of especially vulnerable types of existing private buildings, e.g.:
  - buildings with a soft storey
  - buildings with highly eccentric stiffening
  - buildings with unreinforced masonry
  - frames "braced" by means of masonry walls
  - valuable natural stone structures

Seismic Upgrading of Existing Bridges (j)

- Identification of selected highways and railway lines of the most important building class (Class III), checking the seismic safety and if necessary carrying out a seismic upgrading of existing bridges.

Seismic Design of Chemical Plants (n)

- Classification of existing chemical plants on the basis of their damage potential, checking the seismic safety and if necessary carrying out a seismic upgrading, setting clear priorities and time limits.

Seismic Design of Lifelines (o)

- Identification, as part of the lifelines infrastructure, of structures, facilities and equipment, whose survival is important in a catastrophe, with definition of minimum functionality for earthquakes of different intensity. Checking seismic safety and where necessary seismic upgrading, setting clear priorities and time limits.

Seismic Design of Dams (p)

- Checking the seismic safety of existing large dams and where necessary carrying out a seismic upgrading, including the gates, bottom outlet, electro-mechanical components, etc., and evaluation of potential failure zones in the region of the foundations. For this purpose, the regulatory authority should define the necessary evaluation criteria.

III MEASURES FOR EDUCATION AND PUBLIC AWARENESS

Seismic Design of New Structures (h)

- Financing of leaflets and booklets on the importance of seismic actions and on the appropriate design of buildings and bridges, to be distributed to architects and engineers as well as public authorities and administrative bodies.

Seismic Design of Non-structural Elements (l)

- Financing of leaflets and booklets on the importance of seismic actions and on the appropriate arrangement of non-structural elements of buildings with the aim of reducing damage and increasing safety, to be distributed to owners, architects, engineers and insurance companies.

Seismic Design of Installations and Equipment (l)

- Financing of leaflets and booklets on the importance of seismic actions and on the appropriate arrangement of installations and equipment with regard to damage reduction and increasing safety, to be distributed to owners, architects, engineers, but especially to heating, ventilation and air-conditioning engineers.

Education and Further Education of Engineers and Architects (t)

- Creation of a chair of structural dynamics and earthquake engineering at the Swiss Federal Institute of Technology, both in Zurich (ETHZ) and Lausanne (EPFL), to advance the technical education of civil engineers both in theoretical and practical (conceptual design, detailing) aspects.
- Education of students of architecture at ETHZ and EPFL as well as students of architecture and civil engineering at technical colleges in conceptual design and detailing measures for the seismic protection of structures.
- Financing of regular further education courses for practising civil engineers and architects on the seismic protection of structures.

Rescue Operations (u)

- Modifying existing rescue services including civil defence to enable them to cope with an earthquake catastrophe, especially preparing an appropriate seismic rescue operation concept with the corresponding training and a contingency action plan with the setting of priorities for the different rescue phases.

IV MEASURES FOR RESEARCH AND PRACTICAL APPLICATION

Seismic Hazard (a)

- Carrying out archaeological and palaeo-seismological investigations to enlarge the database on historical earthquakes and their return periods.

Site Effects (d)
- Extension of microzonation, which at present has only been carried out in some areas, to all seismically endangered regions in Switzerland, with measurements and data on the expected frequency-dependent ground accelerations and ground displacements (response spectra) for different soil types.

Dynamic Soil-Structure Interaction (e)
- Equipping some typical structures in Swiss seismic areas with networked strong-motion accelerometers.

Seismic Design of Dams (p)
- Application of modern research results in practice by the provision, updating and supervision of the use existing computer programs simulating the seismic behaviour of concrete dams with the inclusion of reservoir and ground.
- Extension of the network of strong-motion devices to all large dams and systematic evaluation of the recorded data as well as making it available to interested experts.

Research on Seismic Behaviour of Structures and Plants (r)
- Research on the seismic behaviour and development of fundamentals for seismic design of buildings and bridges, with respect to:
  - ductility of reinforcing steels
  - seismic behaviour of unreinforced and reinforced masonry
  - seismic design of new and seismic upgrading of existing buildings
  - seismic design of new and seismic upgrading of existing bridges
  - seismic upgrading of historic structures
- Research on the seismic design and development of fundamentals for the seismic design of other items:
  - non-structural elements in buildings
  - installations and equipment
  - chemical plants
  - lifelines
  - dams
  - nuclear power plants

Putting Research Results into Practice (s)
- Support of projects dealing with the application of research results in practice.
- Support of the practice-orientation of research results by involving practising engineers in an advisory capacity.

The definition, assessment and prioritization of the more than 60 measures for the reduction of seismic risk formed the basis for the planning of media and political activities by the earthquake community.

5 ACTIVITIES IN THE MEDIA

5.1 Basic Principles

Creating a much greater public awareness for questions of earthquake protection and seismic risk mitigation has to be achieved primarily through the media, i.e. press, radio and television. Therefore, it is of the utmost importance that the earthquake community takes every opportunity to have a media presence, just as “constant dripping wears away the stone”. Of great importance too are direct contacts with lay persons in public lectures, panel discussions and scientific demonstrations. The following are possible ways which have generally proved to be worthwhile:

- organisation of media conferences in connection with
  - specialist conferences
  - publications
  - political initiatives in parliaments

  - demonstration of research findings
  - opening of exhibitions
- distribution of media releases in connection with
  - media conferences
  - earthquakes abroad causing large damage
  - other suitable occasions without media conferences
- periodic submission of general articles to a large number of newspapers and journals, countrywide or regionally
- publication of special articles and, if the editors are in agreement, of articles expressing particular views, in leading opinion-forming newspapers, as well as in popular newspapers and magazines
- giving lectures or talks for lay persons, e.g. in universities, adult education centres, societies, clubs, etc.
- organisation of public panel discussion with experts at which the public is invited to participate
- organisation of public scientific-technical demonstrations
- organisation of public exhibitions

Today many institutions, interest groups and individuals are competing for attention in the media. Anyone who wants to spread a particular "message" in the media first has to win the interest of the media people (journalists) themselves. For this purpose a "peg" is needed, i.e. something which journalists find sufficiently exciting to arouse the interest of the general public. Such a peg could be an event like the one listed above under 'organisation of media conferences'. With such events one might be successful in attracting journalists. However, this can be extremely difficult, because the message of the earthquake community usually involves fairly complicated technical-scientific material, and for most people today this is not very exciting. People have become accustomed to technology and take it more or less for granted. They use the fruits of technology without bothering to understand them. They profit greatly from technology, but are still not interested in what lies behind the technologies.

Instead of creating the "peg" oneself, occasionally one can "jump on the bandwagon". An example of this is the event of a strong earthquake that has occurred abroad. The media will have already brought it to the attention of the public whose interest will be directed towards the phenomenon of earthquakes, so that people may then be interested in the question of seismic risk in their own country. This is the time for the earthquake community to act, to "strike while the iron is hot", so to speak, by means of media releases, interviews, etc. This may bring success, provided one has prepared a good technical foundation and is equipped with convincing arguments. The arguments need to have been thoroughly worked out beforehand in the "Need for Action" programme.

For most of the earthquake community's activities in the media it is essential to involve relevant media specialists. Although newspaper articles have, firstly, to be drafted by members of the earthquake community, it is absolutely necessary that they are polished up (i.e. put into a suitable form) by professional journalists. An important aspect of an article is also the professional selection of photographs. Panel discussions have to be led by a skilful and if possible well-known (television) presenter. It is our task to provide the journalists with good documentation and to offer our help in the preparation. Qualified specialists, of course, have also to be involved in the planning of exhibitions. And the same applies to the design of printed matter, which has to be directed towards particular target groups. Here the help of a professional graphics designer is also essential.

It is of great importance that the contents and form of the "messages" of the earthquake community are oriented towards the specific target groups. This means, an article has to be written differently for, say, a newspaper for home owners, a journal for managers or a consumer magazine. The same is true for the contents of lectures, panel discussions and exhibitions, which need to be adapted to the audience.

In all these media activities of the earthquake community it must always be emphasized and kept in focus that a significant reduction of seismic risk is usually only possible by means of structural measures. However, in the public view the interest in the question of earthquakes is still primarily a more or less “scientific” interest in the tectonic source (focus) and in the ground surface movements at a particular place. Networks of ground motion instruments or risk assessments, among other things, are of course important and necessary, but in the case of an earthquake no single human life is actually saved with these, and there is no damage reduction. Thus in public activities it has to be stressed again and again that the design and detailing of structures is decisive and that today we know very well how, by means of a few specific measures, to make structures much more resistant to earthquakes. And it is always necessary to refute the erroneous idea that construction measures to protect seismic damage are very costly. For, as we all know: if seismic effects are taken into account from the very beginning of planning the structure (seismic conceptual design) and modern design methods (e.g. the deformation-oriented capacity design method) are employed, in general insubstantial extra costs are involved compared with the case where seismic effects are not taken into account from the beginning. In most cases the extra costs could amount merely to less than 1 percent of the total building costs (see section 7.1).

5.2 Example

In Switzerland the “Need for Action” (SIA D 0150 [1]) was published in 1998. In it an essential foundation was laid and the appropriate arguments for use in activities in the media (press, radio and television) were formulated. In the last few years the earthquake community in Switzerland has either initiated or participated in the following media activities:

- organisation of about 6 media conferences (partly combined with radio and television programmes)
- distribution of about 10 press releases (also in cases of damaging earthquakes abroad)
- submission of about 8 general articles for the newspaper press (having differing success with the printed copies depending on the topic and moment in time; the press cuttings however fill several thick files)
- publication of special articles (expressing particular views) in about 8 newspapers and periodicals (total circulation figures around 1.5 million)
- giving about 20 lectures and talks for lay persons in universities, adult education centres, societies and clubs (with between 40 and 200 in the audience in each case)
- organisation of 2 controversal public panel discussions (in total around 500 people taking part)
- organisation of about 6 public scientific technical demonstrations with the earthquake simulator at the ETHZ “Seismic effects on a 3-storey building with reinforced concrete structural walls” (visited by more than 1000 personally invited key persons)
- organisation of the exhibition “The Earth is shaking – with us too” at the Natural History Museum in Basle (March to November 2002, seen by about 30,000 visitors)

These activities were rather time-consuming and for several members of the earthquake community they involved a lot of hard work. But it also resulted in a “domino effect” within the earthquake community, i.e. in an increasing number of colleagues and other persons becoming involved and so in the end the load was carried on many shoulders.

The media activities either initiated or supported by the earthquake community in Switzerland were very useful and even in some cases decisive for clearing the ground of public opinion for political activities. Sometimes, fortunately, media and political activities could be coordinated.

6 POLITICAL ACTIVITIES

6.1 Basic Principles

To achieve a substantial reduction of seismic risk the creation of an effective legal basis (relevant constitutional mandate, laws, regulations) stands in the foreground. As long as this basis is missing it has to be effected by political means. In a federative state initiatives have to be undertaken on the levels of the Confederation and of the states. This work has to be initiated primarily by the earthquake community. Proposed important political activities are:

- encouraging individual politicians to start initiatives in the parliaments of the Confederation and the states or of certain municipalities (e.g. large towns)
- supplying pertinent information to the members of a parliament before a relevant initiative is debated (e.g. through personally addressed circular letters including supplements), augmented by personal contacts with key people like party leaders, etc.
- direct petitions to the governments (executive) of the Confederation, the states and possibly certain municipalities
- creating awareness in administrative bodies (civil servants) of the Confederation, the states and possibly certain municipalities, with the purpose of starting own initiatives

For all these political activities a well-structured concise but short documentation containing the most important arguments is essential. To do this the facts and the interrelationships, which are often complicated, have to be simplified, but still presented in such a way that no false information is passed on and no contradictions creep in. Further, the members of the earthquake community, if requested, should give assistance to the politicians, e.g. by helping to formulate the text and the reasons for initiatives, to write the speeches, etc.

6.2 Example

In recent years in Switzerland the political activities of the earthquake community were undertaken above all at the level of the Confederation but also in some states (cantons). The activities have led, thus far, to important successes as well as to an unfortunate failure. The activities took the form mainly of encouraging individual politicians and representatives of administration to start initiatives in their respective parliaments or administrative bodies, respectively. In these efforts the relevant persons received considerable support from the earthquake community. In the long run there was again a kind of "domino effect", in this case involving more and more persons. Some of them then started initiatives by themselves and this finally gained a certain momentum of its own. But mostly the careful preparation of information and often also supporting the politicians and civil servants was important. So far (state of affairs in February, 2004) the political activities of the earthquake community have led among others to the following results.

At the Level of the Confederation:

- Setting up of a “National Platform for Natural Hazards”. This is an advisory committee comprising high level civil servants and external experts. Its aim is to develop a balanced risk culture to combat natural hazards, in place of a sum of individual measures which has been common practice up to now. This platform for natural hazards has accepted that compared to the other natural hazards like floods, storms, avalanches, mud slides, forest fires, etc. there is an enormous deficit in seismic protection and that this must above all be reduced by measures directly related to building and bridge structures.
- On the 11.12.2000 the Federal Council (Swiss Government) decided on the following 7 measures in its own sphere of responsibility (own public structures etc. and those which are supported by money of the Confederation):
  - Systematic application of the building codes for new structures

- ▪ Careful seismic control of renovation projects
  - ▪ Inventory of existing buildings
  - ▪ Examination of the threat to the cultural heritage
  - ▪ Improvement of the legal basis
  - ▪ Clarification of insurance questions relating to earthquake damage
  - ▪ Preparation of a detailed disaster response plan
- On the 1.1.2001 the Federal Council set up the "Coordination Centre for Seismic Risk Mitigation" as part of the Federal Office for Water and Geology FOWG. At present it consists of a geologist, an earthquake engineer (civil engineer) and a secretariat. It has been assigned the following tasks:
  - ▪ Development of a cohesive policy of the Confederation on seismic risk mitigation
  - ▪ Coordination of the measures of all bodies of the Confederation on seismic risk mitigation
  - ▪ Setting up and constant updating of an inventory on the seismic safety of the existing structures of the Confederation.
  - ▪ Elaboration and publication of guidelines and aids for professionals involved in the planning and construction process, owners and authorities
- The Coordination Center of FOWG has already initiated many useful measures, for example:
  - ▪ Development of a three level procedure for the seismic assessment of existing buildings. The first level is based on a risk assessment, the second level – if necessary – on carrying out a modified FEMA-310 procedure, and the third level – if necessary – on carrying out a detailed seismic evaluation of a building.
  - ▪ Publication of a booklet on the seismic conceptual design of buildings stating basic principles for engineers, architects, building owners and authorities on an elementary level (Bachmann [2]).
  - ▪ Development of a procedure for the elaboration and application of micro-zoning studies in Switzerland (FOWG [3]).
- By November 2003 about 300 federal buildings were assessed on the first level and about 90 on the second level.
- The Federal Office for Roads FOR initiated the development of a three level procedure for the seismic assessment of existing road bridges (Wenk [4]). The procedure shall be used primarily for the assessment of about 3500 bridges of the national highway road network. In 2004, as a testing phase, a total of 630 bridges of 3 cantons will be assessed (level 1).
- By own initiatives of concerned persons numerous task groups were established. The name, aim and number of members (experts) of the groups are shown in Table 1.

Concerning all these results at the level of the Confederation the political activities of the earthquake community were successful. However, concerning the very important goal of improving the legal basis for seismic risk mitigation, so far the earthquake community has experienced an important failure. This is as described below.

The parliamentary Committee for the Environment, Regional Planning and Energy (UREK) of the Swiss National Council (Federal Parliament), has studied the problem of seismic protection. For this purpose the UREK was provided with (SIA D 0150 [1]) and other material by the SGEB, and some relevant discussions took place. The UREK recognized the existing large deficits and the primary requirement of structural measures. In Switzerland the legal competence and responsibility for planning and building inspection lies mainly with the states (cantons). UREK however wanted the Confederation to take over more of the responsibility especially in the area of seismic protection but also in general for protection against natural hazards. Therefore, in a first approach, UREK agreed to a parliamentary initiative for creating a new article in the federal constitution with the wording “The legislation on protection against natural hazards is the responsibility of the Confederation”. The initiative was published in May 2002. Government offices, cantons and associations – also the SGEB – could express their opinions on this in writing up to October 2002.

As a matter of fact, a substantial majority of the cantons opposed to the “too centralistic” wording of the article. Therefore, a sub-committee of UREK reduced the wording to “The Confederation defines basic principles for the protection of humans against natural hazards. The Confederation can support measures for the defense against natural hazards”, which might be accepted by a majority of the cantons. However in the year 2003 the political climate in Switzerland changed considerably. The yearly financial deficit increased dramatically. As a serious consequence, in its meeting of November 18, 2003, by a nearly balanced vote result, UREK declined its own initiative for creating a new article in the federal constitution, mainly to avoid increased costs for the Confederation. Thus for the present the legal competence and responsibility especially for seismic design and upgrading of most public and private structures will remain with the cantons.

Table 1: Task groups at the level of the Confederation with members and aims (by courtesy of FOWG)

Task group	Aims
Seismic safety of dams (7 experts)	Elaboration of guidelines according to relevant dam provisions
Historic monuments and earthquake protection (7 experts)	Seismic safety of historic monuments
Operation concept in the case of an earthquake (9 experts)	Disaster management concept for seismic risk mitigation
Seismic safety of existing federal buildings (7 experts)	Realization of a relevant inventory of federal buildings
Lifelines and earthquake protection (10 experts)	Definition of “Lifelines”, “size of event”, “inventory”, “commensurability of costs”
Soil profile classes of EC 8 (8 experts)	Elaboration of response spectra and soil classes according to EC 8 and Swisscodes SIA 261
Damage protection of standing tanks (11 experts)	Elaboration of recommendations for the seismic safety of existing tanks
SIA 261-1 Seismic assessment of existing structures (11 experts)	Preparation of SIA recommendations for protection aims and seismic safety of existing buildings
Procedure for construction permission by building insurance companies (4 experts)	Elaboration of a procedure for the general construction permission for new buildings at cantonal level
Seismic damage prevention of buildings by insurance companies (11 experts)	Elaboration of a working aid for seismic damage prevention
PEGASOS (3 expert groups)	Probabilistic seismic hazard analysis for nuclear power plants: Sources, decay functions and site effects
UREK (25 members of the federal parliament)	Elaboration of an article on “Natural Hazards” for completion of the constitution

That was in fact an important set back with respect to seismic risk mitigation and hence for the earthquake community. The general opinion is that – concerning a constitutional article – we have to wait some years until the political and financial "ice age" will hopefully be over – or an important earthquake will occur.

At the Level of the State (cantons):

- In Canton Valais and Canton Basle the permission for the construction of new private buildings was made to depend on the proof that the seismic provisions of the SIA building codes are fulfilled. In Canton Berne this restriction is intended to be introduced in the near future.
- Several cantons initiated a seismic assessment of their own existing public buildings, which (including the buildings of the municipalities) represent on average about 3% of the whole public and private building stock in Switzerland, using the three level procedure developed by FOWG. Table 2 shows the number of public buildings of the cantons which were assessed on the first level by November 2003. As an example and a preliminary result, in Canton Berne 25 buildings corresponding to 6% of its own public building stock have to be upgraded by means of structural measures.
- Canton Nidwalden performed a seismic risk study for the case that the 1611 central Switzerland earthquake (M = 6.2) could happen again today. The study is based on a seismic micro-zoning of the whole canton according to the soil classes of (SIA 261 [5]), the real classified building stock according to the detailed inventory of the state assurance company of Nidwalden, and on relevant tentative damage functions. The study resulted in a loss depending on the community of between 13% to 40% and on average (whole canton) of 27% of the value of the total building stock. In these numbers, the damage to the building content, to lifelines, bridges, etc. and of course the costs of industrial production interruption and other costs are not included.

At the Level of the Municipalities:

- Some larger towns have started to implement measures similar to those of the above mentioned cantons.
- In the city of Zurich the Department of Industry has undertaken a study on the seismic behaviour of potentially vulnerable industrial plants
- In the city of Basle all chemical plants have to be checked for their seismic vulnerability
- etc.

Table 2: Existing cantonal public buildings assessed by the FOWG procedure (first level) by November 2003 (by courtesy of FOWG)

Canton		Number
AR	Appenzell Ausserrhoden	130
BE	Berne	410
BL	Baselland	?
BS	Baselstadt	70
GR	Graubünden	100
LU	Lucerne	160
NW	Nidwalden	10
SG	St. Gall	210
SZ	Schwyz	40
VS	Valais	100
ZG	Zug	40
In total (approx.)		1300

7 "STRUCTURAL" RESULTS

The previous considerations concerned some rather unusual activities of the earthquake community: the elaboration of the "Need for Action" (SIA D 0150 [1]), well planned media activities and substantial political activities. These activities and relevant results are extremely important and urgent. The aim is to improve the overall situation regarding the reduction of seismic risk. However, the reduction of the seismic risk itself – and here we deliberately want to reiterate – can only be achieved by means of relevant, actually implemented structural measures. What counts in the end are the measures that are effectively put in place. Therefore the question is what are the immediate and substantial results of the said activities on real structures? We can denote these results as “structural” results.

7.1 Numerical representation of substantial results

One could attempt perhaps to quantify the “structural” results in numerical terms. For example, the following questions could be posed:

1) At present, in how many new structures are the earthquake code requirements being correctly implemented, as a percentage of the newly built structures? (This thanks to an increased “seismic awareness” of the responsible persons involved in the planning process and to relevant checks)
2) What are the extra costs due to a code-conform seismic design of new buildings, as a percentage of the construction costs?
3) At present how many existing structures (mainly buildings and bridges) annually are being seismically upgraded?
4) What are the costs for a seismic upgrading of existing buildings, as a percentage of the value of the building?

In general, it would be difficult to make statistically-based statements. With regard to question 1), in countries without a mandatory check by public authorities, it seems to be difficult to give an answer, because the corresponding processes are hidden from sight. As for question 2), on the other hand, in the case of some typical objects relevant data can be obtained. And for question 3) it is possible to make some rough estimates. Finally, regarding question 4), there may be initially few experience values.

Figure 1: Just a few RC structural walls for bracing URM structures: 3-storey dwelling house (left) and 4-storey residential building (right)

In Switzerland, exhibiting a low to medium seismic hazard, some provisional opinions and numbers are available. Concerning question 1), some experts think that in less than 10 % of all cases the earthquake code requirements are fully and correctly considered. With regard to question 2), experience shows that the extra costs usually lie between 0 and 1% (2% in extreme cases) of the construction costs. Here it is necessary to differentiate between the construction methods. In the case of a sound seismic conceptual design, for RC structures there are practically no extra costs. For unreinforced masonry (URM) structures, by contrast, the extra costs may be around 1%, provided that just a few masonry walls are replaced by RC structural walls (Figure 1). Other construction methods lie in between. With regard to question 3) it is estimated that at present annually about 10 to 15 buildings are being seismically upgraded. This may not seem to be many, but one must not forget that the relevant activities of the earthquake community were only started a few years ago and that many groups of buildings are currently in the assessment phase (see 6.2). The actual number will certainly increase however in the near future. And with regard to question 4) initial experience indicates that the costs of upgrading existing buildings may vary considerably, i.e. in general between 2 and 10 % (up to 20 or 30 % in extreme cases) of the value of the building.

7.2 Innovative solutions for upgrading

The results of the activities of the earthquake community described above cannot be expressed only in numerical terms, since there are also very welcome benefits in the area of innovation. New ideas, new materials and modern technological solution methods and relevant experience also form important parts of the picture.

In Switzerland there are a number of examples of upgraded existing buildings, in which innovative solutions have been applied. Some interesting cases and innovative projects already completed are briefly described below.

Stabilisation of an existing building by adding on a new part

A 9-storey building houses the police headquarters for the Canton Valais in Sion. The Valais is an area that experiences periodically (every 50 to 100 years) earthquakes of magnitude 6 to 6.5. In the case of a strong earthquake the building is the nerve centre for disaster management. The building was shown to exhibit a grossly inadequate seismic safety for excitation in the longitudinal direction. The safety in the transverse direction however proved to be adequate.

Figure 2: Addition of a new 9 m long building part (left side) with internal RC structural walls for stabilising of an existing 9-storey police headquarters building

After detailed studies and the consideration of alternative solutions it was decided to stabilize the existing building by the addition of a new part of 9m length (Figure 2). Within the new part two capacity-designed, ductile RC structural walls of I-section were specified. The walls are fixed to a raft foundation supported on tension and compression piles and run the whole height of the building. At the level of each floor the old and new parts of the building are connected by prestressed tendons.

External inclined truss to upgrade an existing building for earthquake action and gravity loading
One of the buildings of the Swiss Federal Institute of Technology ETH in Zurich with several lecture theatres seating up to 500 people was only braced on the rear side by means of RC structural walls. The front and the central part of the building exhibited a typical soft storey at ground floor level with few non-ductile RC columns. This resulted in large eccentricities between the centre of resistance or the centre of stiffness and the centre of gravity. Even in the case of a relatively weak earthquake the building would twist and the columns at the front of the building would fail. In addition, on the first floor there are large cantilevers, which were unsafe under gravity loading.

To simultaneously upgrade for earthquake action and gravity loading an external inclined truss consisting of steel tubes was proposed (Figure 3). The truss prevents the twisting of the building transmitting both the shear forces resulting from the earthquake action and the forces resulting from gravity loading of the cantilever structure to the foundation. Due to the chosen inclination of the truss no new foundation was necessary; the existing foundation could be used.

Figure 3: External inclined steel truss for upgrading an RC lecture theatre building for both, seismic actions and gravity loads

External RC walls in a residential building
In Fribourg an architectural rehabilitation, involving mainly installations and insulation work, of three 8-storey residential buildings (each with 28 apartments) built in the 1970s was carried out. The opportunity was taken to carry out at the same time a seismic upgrading according to current code provisions. The existing load bearing structure consists of a soft ground storey and of 7 storeys of unreinforced masonry (URM). For the purpose of seismic upgrading in both directions of the buildings two external RC structural walls reaching from the foundation to the roof were added (Fig. 4). This solution had the big advantage that during the construction work for this upgrading everybody could remain in their apartments. The walls were rigidly connected to the 7 RC floor slabs and provided with an external insulation. The costs for the seismic upgrading amounted 14% of the total rehabilitation costs or 7.4 % of the value of the buildings.

Figure 4: External RC structural walls for the seismic upgrading of three 8-storey residential buildings under construction (left) and after completion (right)

Internal RC walls in a children’s hospital

An extensive architectural rehabilitation was planned for a 4-storey children’s hospital in Aarau. An investigation of the seismic safety undertaken was only carried out after the commencement of the rehabilitation work. It was discovered that the building could fail under a relatively small earthquake. As a consequence the work was stopped. Finally, the cantonal parliament approved an additional amount of 6% of the rehabilitation costs for seismic safety. The seismic safety was achieved by installing a small number of capacity-designed ductile RC structural walls inside the building (Figure 5).

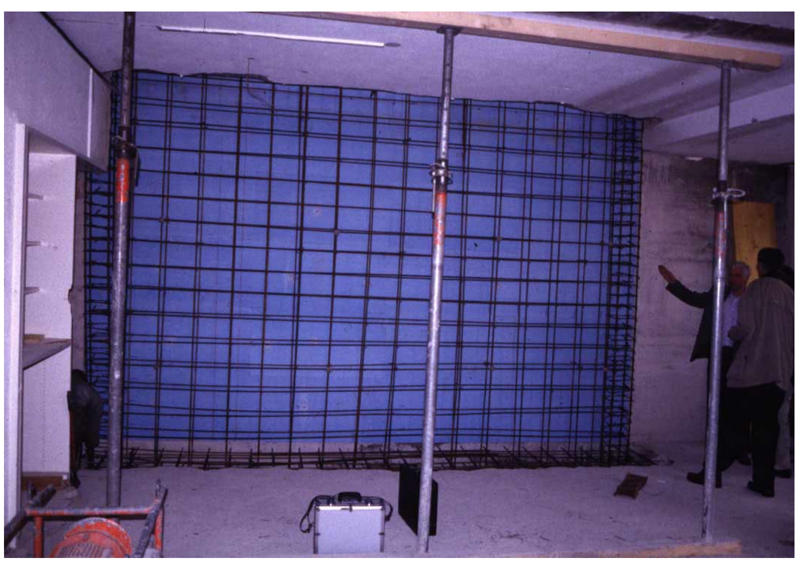


Figure 5: Internal RC structural walls for the seismic upgrading of a children's hospital

Truss-like CFP strips in an URM building

In a 7-storey residential building of a private grammar school near the town of St. Gall an extensive architectural rehabilitation was planned. It was discovered that the building, above all in the transverse direction, exhibited a big deficit in seismic safety. The walls around the stair-well and the facades on the front end of the building consisted of unreinforced masonry (URM) structural walls and no other vertical structural elements were present. Thus the building had to be seismically upgraded. On the URM walls the plaster was removed in carefully chosen strips and truss-like carbon fibre plastic (CFP) strips were glued on (Figure 6). The RC floors act as horizontal elements of the truss. In order to obtain a satisfactory flow of forces in the joints of the truss, the CFP strips were carefully anchored in the RC floor slabs. Tests performed as part of an extensive research project showed that by such a method of upgrading both the strength and the ductility of the URM walls were substantially improved to resist the seismic action.

Figure 6: Truss-like CFP strips glued to URM walls and carefully anchored in the RC floor slabs (right) for the seismic upgrading of a 7-storey residential building (left)

Base isolation of liquid gas tanks

If liquid gas tank structures were to fail in an earthquake, this could have catastrophic consequences. The liquid gas would escape, become volatile and could spread over large areas. It would have to be assumed that it could cause an explosion and devastating fires and secondary effects in chemical plants could result. In the case of such tanks in Visp (Canton Valais) a very inadequate seismic safety was discovered and efficient upgrading measures had to be implemented. For two tanks a solution involving base isolation was found.

In the case of a spherical tank (liquefying the gas by means of high pressure) containing 700 tons of liquid gas, the 8 RC columns of the structure were cut through and 0.4 m high pieces were extracted by tapping. High damping rubber bearings were inserted into the holes (Figure 7 left) and to reduce the remaining stresses in the columns truss-like bracing consisting of steel bars was installed.

In the case of a cylindrical tank (liquefying the gas by means of low temperatures) with a capacity of 1000 tons of liquid gas high damping rubber bearings were placed at the top of the RC columns (Figure 7 right). In this case the top of the columns as support for the bearings had to be enlarged but no bracing of the columns was necessary.

Figure 7: Insertion of high damping rubber bearings into RC columns for the seismic upgrading of liquid gas tanks: at column base (left) and at column top (right)

These examples of innovative solutions for the seismic upgrading of existing structures demonstrate that "political" activities of the earthquake community can lead to significant developments and substantial increase of professional experience in earthquake engineering.

8 CONCLUSIONS

The members of the earthquake community – engineers, seismologists and scientists – can no longer be complacent and satisfied simply to produce excellent work in their specialist areas, and in the development of sophisticated design methods and codes. Through this alone, only relatively little impact will be made on earthquake protection of new and existing structures.

With clear aims and arguments developed by the elaboration of the need for action, with well planned media activities and with substantial political activities, the earthquake community can achieve much more in effecting a significant reduction of the seismic risk. Both, specialist work as well as "political" work is necessary.

9 REFERENCES

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