5.3 Safe building construction and protection of critical facilities

Some of the earliest types of vulnerability associated with disaster risk reduction concern the physical conditions of where and how people live. Ever since people have been building structures to live and work in, and the critical elements of infrastructure systems that support the economic and social bases of all societies, there has been some attention and investment provided to protect these valued facilities.

"Earthquakes don't kill people, buildings do." Charles Richter, inventor of the Richter Scale of earthquake magnitude measurement

As populations grow and expand into more inherently vulnerable locations, and as economic pressures result in even more construction and infrastructure, the necessity of risk reduction applied within the built environment becomes more pressing. However, given the magnitude of the problem, it must also be noted that positive work is being done to reduce people's exposure to risks in the built environment. This section focuses on some of these elements and accomplishments:

- *a safer built environment;*
- *structural measures for disaster-resistant construction;*
- *codes, policies and procedures;*
- *improving the resistance of non-engineered buildings;*
- *developing appropriate methodologies;*
- *protection of critical facilities;*
- *the role of engineering and technical abilities in protecting critical facilities;*
- *multiple aspects of protecting urban infrastructure and other forces at work;*
- *protection of health systems; and*
- *protection of educational facilities.*

A safer built environment

The skills of construction workers whether sophisticated or basic, and the professional abilities of engineers have a particularly important role to play in create and maintaining safer societies. Protecting critical facilities involves many other types of people too, including government officials at various levels of responsibility. However, successful risk management related to the built environment also includes people that are involved in planning in both urban and regional contexts, and the considered use of land and other dimensions of the natural environment. Investors and agents of development who seek to spur growth and development also need to be aware of the physical landscape, to ensure that the rush to create greater value and more physical assets does not end up increasing the exposure of the built environment to disaster risks.

The public needs to be highlighted as a primary contributor to the expectation and the realization of safer buildings and physical infrastructure. In the interest of protecting their families and property, individuals need to ensure that their homes are as safe as possible, both in where they are located and how they are built. Failing this, the potential risks multiply as populations become more concentrated in the rapid urban sprawl experienced around the world.

The mushrooming informal settlements and substandard housing are frequently located in inherently vulnerable locations. Unfortunately, this is too often tolerated for the migrant, the impoverished or transient populations.

It becomes even more critical politically and socially if governing authorities are at all attentive to reducing disaster risk factors in the built environment.

There are three distinctive contexts for introducing physical risk management measures in buildings or infrastructure:

- reconstruction or repair of buildings, particularly following the losses or damage from a major hazardous event;
- construction of new buildings in normal circumstances; and
- retrofitting existing building stock through strengthening programmes.

Each of these possible approaches also possesses different levels of opportunities that can be utilized to ensure safer conditions in the built environment – given the will and commitments to do so.

Good opportunity

Reconstruction, with the introduction of mitigation measures, is always likely to be possible, even in countries with resource limitations. It is particularly beneficial given both the evident public interest as well as the significant resources available following a disaster. This is on account of high levels of political will and public demand for enhanced safety immediately following disasters. Therefore, officials can benefit from drawing on the excellent opportunities presented by adversity to introduce mitigation measures during periods of reconstruction.

Moderate opportunity

Introducing mitigation into new construction is feasible if there are funds available to pay for the improvements and if codes are in place with adequate enforcement. However, the introduction of mitigation measures into non-engineered buildings is fraught with social, economic and cultural obstacles and remains a global challenge. It should also be noted that in most developing countries vulnerable buildings and existing infrastructure lifelines will continue to comprise more than 95 per cent of the vulnerable facilities that exist.

Box 5.22
Strategies to achieve a safer built environment

Strategies to achieve a safer built environment, need to be:

- ambitious, grasping unique post-disaster possibilities to improve building;
- focused on lifeline buildings and infrastructure;
- stimulated by a range of incentives;
- inclusive, with the attention of engineers being devoted to the creation of safe engineered, as well as non-engineered buildings; and
- inclusive, with public interest, involvement, expectations and support.

As such, the possibility of investment in retrofitting needs to be considered. If more widely shared and employed, technology provides ever more efficient and effective means of protection, especially as the cost often can be justified when compared with realistically calculated expected losses. The more vulnerable a specific locality is to a possibly severe hazardous event, the more justifiable investment in retrofitting could be.

Limited opportunity

The introduction of retrofitting for existing buildings will always be difficult given the scale of building stock in urban areas. For example, in the United States, the average turnover in the nation's building stock is only 1 to 2 per cent per year. Thus there is a vast potential cost associated with implementation in terms of securing the necessary finance and the cost of social and economic disruption.

Structural measures for disaster-resistant construction

The design and construction of hazard-resistant structures are some of the most cost-effective means of reducing risks. Urban planners, architects, engineers, construction contractors and building inspectors are all responsible to ensure that planning and construction are technically sound and account for potential hazards.

The engineering standards of buildings, lifelines and housing are determined through research and technical decisions. But they must be applied by building professionals. It is they who must determine how effective a particular engineering solution will be in respect to stress or hazard.

However, much less attention is given to the important roles of investors, local political authorities and community leaders to fulfil their own professional and civic responsibilities. Together they have important roles to play in assuring building compliance implied by their investment, enforcement of legislation or adherence to local standards. Codes are only as good as the extent to which they are employed and enforced.

It is worth emphasizing the wide diversity of causes identified in this preceding example. They embrace technical elements, economic realities, and conditions of public administration, education, legislation, public awareness, as well as criminality and other social factors. As none of these features is limited to any single, individual country or location, to counter such patterns of vulnerability broad, well-integrated risk reduction strategies are required to meet the distinctive requirements of any economic and socio-cultural environment.

The state of Florida was regarded as having one of the most rigorous building codes in the United States until Hurricane Andrew stripped away pretences of compliance. Similar realizations often occur after disasters, whether they happen in Japan, Turkey, Egypt, Taiwan, India, United States, Mexico, Algeria, Iran or elsewhere.

Fortunately, there are dedicated institutional efforts of collaboration that are working to promote a wider understanding and more effective application of various measures that can make communities safer. Two examples follow.

"The reality that somewhere between 75 and 90 percent of all earthquake fatalities result from building failures, highlights the importance of implementing mitigation measures specifically associated with building design and construction."

Professor Ian Davis, United Kingdom

Box 5.23
Vulnerable building stock

Following the earthquakes in Turkey in 1999, earthquake specialists from Istanbul's Bogazici University summarized the reasons why Turkish building stock proved to be so vulnerable:

- Rampant code violations led to disastrous results.
- The system was conducive to poor construction.
- High inflation meant very limited mortgage and insurance, an impediment to large-scale development, resulting in limited industrialization of residential construction.
- High rate of industrialization and urbanization led to a need for inexpensive housing.
- There was very little professional qualification of engineers.
- There was ineffective control and supervision of design and construction.
- Corruption was common.
- There were regulations with limited enforcement and no accountability.
- Ignorance and indifference were widespread.
- Government was a free insurer of earthquake risk.

Source: M. Erdik and M. Aydinoglu, 2000

Earthquake Engineering Research Institute and International Association of Earthquake Engineering

In an effort to address some of these and similar issues, the Earthquake Engineering Research Institute (EERI) in Oakland, California, United States is conducting a joint project with the International Association of Earthquake Engineering (IAEE) in Tokyo, Japan. Together they are building an Internet-based encyclopedia of housing construction currently used in seismically active areas of the world.

The endeavour links more than 160 volunteer engineers and architects from 45 countries, enabling them to consolidate and share data, as well as to access tools that can reduce the vulnerability of housing in earthquakes. The goal is to create a professional resource that is useful not only for design and construction professionals but also for housing authorities, community planners and other agencies concerned with hazard reduction and sustainable development.

Initial efforts of the project are devoted to compiling relevant information about all aspects of housing construction in seismic areas. These include architectural features, structural details, strengths and deficiencies under seismic loads, performance of materials in previous earthquakes, local construction practices, and common building materials used. Data is also compiled about the availability and use of insurance.

An important feature of the database is that it accommodates information about construction features ranging from the basic aspects of non-engineered rural housing through sophisticated engineering practices employed in urban high-rise construction.

As the information is on the Internet, users can search the database using various criteria. In addition to basic country profiles, information can be retrieved on the basis of urban or rural construction practices, seismic hazards, building functions, type of building materials or structural systems employed. The information also gives ratings of seismic vulnerability and describes community economic levels.

It is possible to compare the strengths and weaknesses of various construction techniques that have been used in different countries. Likewise, comparisons can be made of building materials, as well as indicating each country's experience with the performance of different types of construction.

The encyclopedia will also include country-specific information, including background information about seismic hazards; codes and building standards; the size, relative densities and rate of change in urban and rural housing; general weather patterns; and information about housing losses in past earthquakes. Users are able to generate graphs, tables, photos and drawings, and freely download any of the information provided. <http://www.eeri.org/>

Multi-disciplinary Center for Earthquake Engineering Research

Similar goals, but with different focus are being pursued by the Multi-disciplinary Center for Earthquake Engineering Research (MCEER) at the State University of New York at Buffalo, United States. The center strives to enhance the seismic resilience of communities by providing improved engineering and management tools for critical infrastructure systems. This relates to water supply, electrical utilities, hospitals and health facilities, and transportation systems.

MCEER works toward its goal by conducting integrated research, outreach and education activities in partnership with the users of the centre's products. MCEER unites a group of leading researchers from numerous disciplines and institutions throughout the United States to integrate their knowledge into the fields of earthquake engineering and socio-economic studies. The result is a systematic programme of basic and applied research that produces solutions and strategies to reduce the structural and socio-economic impacts of earthquakes.
<http://mceer.buffalo.edu/>

Codes, policies and procedures

The enforcement of standards to protect public safety is a responsibility of government. Codes should apply to new construction as well as for retrofitting existing structures. Surprisingly, given the large number of towns and cities within reach of volcanic eruptions, few efforts have been made to develop building codes which increase the resilience of buildings to ashfall, the most widespread of all volcanic hazards. Some other circumstances are less easily observed.

Development of standards is easy but implementation often proves to be more difficult. Land use, planning and construction standards are most often decided and enforced at the local level. It requires both prudent decisions to be taken and the expression of public confidence in the perceived value of their application and affordability. The use of mechanisms and tools for enforcing existing building codes and zoning by-laws must be central to creating a culture of prevention among officials and within the local communities.

Box 5.24
"We didn't know"

In October 2002, a moderate earthquake of a magnitude of 5.4 on the Richter Scale occurred in Molise, Italy. The only building which collapsed was the village school, killing 26 children and three adults. While the school had been built in 1953, it had been recently renovated. The resulting emotion swept across Italy, and was followed by public anger that led to the opening of a criminal investigation. Central authorities, local officials and building contractors were all accused of corruption and not adhering to building codes and regulations. In defence, it was claimed that although the region was classified as a zone of seismic risk, nobody had been so informed and such information did not appear on risk maps. Some of the local officials also were accused of not complying with the obligations of the seismic-resistance law adopted in Italy in 1982.

Case: South Africa

For some years, South Africa has enforced legislation pertaining to building codes and construction within vulnerable areas. Recently the Council for Scientific and Industrial Research (CSIR) published the *Red Book*, which stipulates guidelines for the planning and design of human settlements.

The planning and management of informal settlements are now matters of considerable interest for government. Also, greater attention is being given to tertiary educational qualifications to deal with these issues. The establishment of sustainable built environments is an important factor that will contribute to the development of South Africa and address the needs of its growing population.

Governments can set examples by insisting on the adherence to codes and by-laws in all public buildings. Similarly, government authorities can be required to build earthquake-resistant offices in seismic zones and locate other facilities in accordance with the best land-use practices to set a public example. In all countries around the world, places of public assembly and schools should be built to life safety standards.

Case: Bangladesh

Another example demonstrates how easily government practice can be employed to encourage positive change. After analysing successful survival techniques in small outlying villages during a devastating cyclone in 1990, the government of Bangladesh instituted a simple but straightforward policy modification. The ministry of public works issued an instruction that all new official government buildings in outlying locales subject to the hazardous forces of a cyclone would be built of properly engineered concrete construction and would consist of two stories. Experience demonstrated that with these two technical requirements, local government buildings could serve as viable places of temporary public refuge from storms and flood.

Experience from around the world demonstrates that there is a need to establish a system of planning controls and building by-laws that are:

- realistic, given economic, environmental or technological constraints;
- relevant to current building practice and technology;
- updated regularly in light of developments in knowledge;
- understood fully and accepted by professional interest groups;
- enforced, to avoid the legislative system being ignored or falling into disrepute;
- adhered to, with laws and controls based more on a system of incentives rather than on punishment; and
- integrated fully in a legal system that takes account of potential conflicts between the different levels of administration and government.

"The Federated States of Micronesia has passed building code laws and regulations but has not fully implemented the codes due to difficulties in meeting the financial requirements called for in the building code laws."

Micronesia response to ISDR questionnaire, 2001.

"One of the most important issues to be addressed in Zimbabwe is the enforcement of laws and regulations that relate to building by-laws and the conservation of natural resources such as stream bank cultivation, deforestation etc., causing the siltation of rivers and dams."

Zimbabwe response to ISDR questionnaire, 2001.

"One of the most important issues to be addressed in India is the strict implementation of laws including building codes."

India response to ISDR questionnaire, 2001.

"Building codes and other regulations are in existence, however the issue is enforcement. The matter is under discussion at various forums within Bangladesh, and the government is actively considering this issue."

Bangladesh response to ISDR questionnaire, 2001.

"The Cook Islands Building Control Unit has been stepped up to improve compliance with building codes and enforcement procedures by the introduction of experienced personnel drawn from commercial building construction."

Cook Islands response to ISDR questionnaire, 2001.

Box 5.25

Different perspectives of hazard resistant building codes (only slightly exaggerated)

A **seismologist** usually criticizes the stipulations of existing building codes that were prepared several years before because there is later evidence, which suggests redefinition of the earthquake hazard.

Engineers want to incorporate their recent research findings and press for stricter building codes. They are less concerned with stronger buildings themselves than with the adoption of their professional endeavours.

An **investor or owner of a building** does not want to spend the additional 2-5 per cent of the building cost to provide additional hazard risk protection for an extreme event that "probably will not happen, anyway".

Contractors cannot be bothered with extraneous regulations and troublesome building inspectors, especially if their demands are going to reduce the profit margin of the construction.

The **government** has not been able to implement even the existing building code because of the lack of suitable implementation mechanisms, including building inspectors.

Decision makers are afraid that the implementation of building codes may result in cost increases. They do not press implementation of building codes even for public construction. Public administrators are preoccupied with other pressing or important matters.

Politicians do not risk diminishing their popularity, as thje enforcement of codes is considered to be an unpopular and restrictive process of control. Besides, there are other important aspects of the construction industry to attend to, like contracts.

The **community** does not understand the process and is confused, especially after a disaster.

The **media** recognizes a controversial topic when it sees one, particularly if people have been killed as a result.

None of the primary stakeholders seems to be discussing the problem in any common forum.

So, more vulnerable buildings continue to be built…

What is required to break this cycle?

Courtesy of the Asian Disaster Preparedness Center (ADPC)

Improving the resistance of non-engineered buildings

It remains something of a paradox that the failures of non-engineered buildings that kill most people in earthquakes attract the least attention from the engineering profession. At least two explanations for the neglect have been offered. One leading earthquake engineer explained that while the failure of non-engineered building construction was certainly a major problem, it should not be regarded as a problem for engineers. He believed that by definition, "a non-engineered building is outside the engineer's scope or mandate".

The obvious follow-up question of such a perception about whose responsibility it is then to devise ways to create safer vernacular buildings to protect their occupants from earthquakes, remains unanswered. Too often, there is little consideration other than possibly a vague suggestion that this issue is probably "the province of local builders". Some recent examples tend to suggest that this has now become an unacceptable response.

Comments from another experienced earthquake engineer, this time in Japan, indicated a similar withdrawal from the subject. The engineer deeply regretted the serious problem associated with the poor performance of non-engineered buildings to earthquakes in Japan, and he acknowledged that at a global level the matter certainly needed the attention of his profession. However, he believed that there was regrettably no money regularly allocated to fund the necessary research or to pursue the implementation of known and improved structural measures for such low-cost structures. This represents a rather unfortunate, not too say limited viewpoint of no money on the table, no action on the ground – especially if the objects are low-cost.

Fortunately there are notable, yet isolated exceptions to the more limited perspectives or negative approaches. These include important work in Peru focusing particularly on adobe structures. Similar work related to vernacular housing has been carried out in Colombia, China and Bangladesh. Noteworthy centres for research and development in this area of vernacular building protection are the Central Building Research Institute, and the Department for Earthquake Engineering at the University of Roorkee in the State of Uttar Pradesh, India.

Pioneering work in the strengthening of non-engineered construction earned the Roorkee University Emeritus Professor A.S. Arya India's highest civilian honour in 2001 for his lifetime achievements in the field. The World Bank-supported programme to retrofit village housing in the Indian state of Maharashtra following the 1993 Latur earthquake is another example of a programme that emphasized basic means of providing low-cost protection for vernacular housing.

Case: St Lucia

Throughout the Eastern Caribbean, most families live and many also work in individual houses. These dwellings represent substantial assets for those families who own their own homes, particularly for low-income home owners. With few other resources available to rebuild or repair houses affected by hazards, the damage or loss of a home can render a family unemployed and in financial peril, in addition to being homeless.

In such a hazard-prone and environmentally sensitive region, it is essential to take full account of these factors in the siting and construction details of homes to ensure the safety of the structure and its occupants. It is equally important to minimize the impact and use of the building on the surrounding environment. While property insurance can limit the financial impact of hazard-related damage, low-income residents rarely have sufficient resources to avail of such insurance.

In Saint Lucia, the National Research and Development Foundation (NRDF) offers a hurricane-resistant home improvement programme (HRHIP) for low-income earners. This programme trains local builders in safer construction and offers small loans to families wishing to upgrade the safety of their homes. In 1996, NRDF established the HRHIP with support from the USAID/OAS Caribbean Disaster Mitigation Project, and has operated it continuously since then.

The HRHIP assists low-income homeowners in retrofitting their homes to make them more resistant to the effects of tropical storms. The programme provides training in safer building techniques for builders and artisans who construct lower income housing. It has also developed minimum building standards for both homeowners and builders. Assistance is provided for estimating building material quantity and assuring quality control.

Between 1996 and 2002, NRDF disbursed 345 loans under this housing programme, with an average loan size of approximately US$ 4,100. Two thirds of these loans were for extensions to existing structures or to construct new buildings. The remainder, were used for repairs and renovations, purchases or the relocation of

The problem

"The occupants of houses of rubble stone masonry for example are many thousand times more likely to be killed in an earthquake, given the same severe ground shaking, than the occupants of a reinforced concrete structure designed and built to modern code standards. A major problem for earthquake protection is how to reduce the often extreme earthquake vulnerability of such dwellings."

Source: Coburn and Spence, 2002

A solution

"The replacement of existing dwellings with 'earthquake-resistant houses' is neither feasible nor, perhaps, desirable. It has been found more realistic to think, rather, in terms of low-cost upgrading of traditional structures, with the aim of limiting damage caused by normal earthquakes and giving their occupants a good chance of escape in the once-in-a-lifetime event of a large earthquake."

Source: Coburn and Spence, 2002

homes. While these loans are considered risky by traditional financial institutions because of the borrower's limited income or lack of collateral, repayment rates have been strong in the NRDF housing loan programme.

By making homes stronger, these properties become a more acceptable risk to property insurers so low-income homeowners who have strengthened their homes through the HRHIP can obtain property insurance. Working through a local insurance broker, NRDF has established a group insurance programme that is able to spread the risk over all the participants in the HRHIP programme. In addition to providing coverage for damages, group insurance programmes promote safer house construction by requiring the use of hurricane-resistant retrofit measures as a prerequisite for participation in the insurance scheme.

During 2003, the NRDF safer housing programme was reviewed and strengthened by refining loan procedures and enhancing its quality control mechanisms. It further developed its outreach efforts by producing two guidance documents, *Guidelines for the Implementation of a Safer Housing and Retrofit Program for Low-income Earners* and *Minimum Building Standards and Environmental Siting Guidelines*. The minimum building standards update earlier requirements and include a new section about environmentally sensitive siting criteria for island housing. The programme review and resulting improvements also reflected a joint effort of the supporting organizations that included the OAS, the World Bank and the government of Brazil. Additional information is available at <http://www.oas.org/cdmp/hrhip/>.

Developing appropriate methodologies

There are a number of initiatives and professional coalitions that have been developed to encourage greater national and technical capacities to protect critical infrastructure. Because of the strong engineering components involved, much of the motivation has come from seismic engineering specialists. One such example is the RADIUS methodology developed during IDNDR to assess urban seismic risk and currently being expanded through the Safer Cities MINNADE project led by ISDR. The examples below illustrate other initiatives that relate to different conditions experienced in various locations.

World Seismic Safety Initiative

The World Seismic Safety Initiative (WSSI) was formed in 1992 as an informal initiative of members of the International Institute of Earthquake Engineering. It later became an IDNDR demonstration project. It is a model example of dedicated professionals working together with minimal organizational structure to stimulate seismic risk reduction programmes in developing countries in Asia, the Pacific and Africa. WSSI has four goals:

- Disseminate state-of-the-art earthquake engineering information globally.
- Incorporate experience and apply research findings through standards and codes.
- Advance engineering research by concentrating on problem-focused needs.
- Motivate governments and financial institutions to establish policies that anticipate and prepare for probable future earthquakes.

During its initial activities in Asia and the Pacific, WSSI emphasized better public awareness and government attention for earthquake safety. It sought to develop information networks that could serve as catalysts for action in earthquake awareness, education and risk management.

WSSI has focused on well-defined and modest regional projects in support of local emerging technical institutions. These have included very productive associations with Nepal's National Society of Earthquake Technology (NSET) and Uganda's Seismic Safety Association, among others.

Additionally, WSSI supported regional and national initiatives in the transfer and sharing of technology; extending the application of professional engineering practices related to risk reduction; and increasing public knowledge for the improvement of structural response to earthquakes.

WSSI was also instrumental in the establishment of the Earthquakes and Megacities Initiative

(EMI) and worked together with the International Association of Seismology and Physics of the Earth's Interior (IASPEI) to prepare a global hazard map. On a global basis it also contributed to the development of the Global Disaster Information Network (GLO-DISNET). <http://www.geic.or.jp/glodisnet/dis/network/partner>

Earthquakes and Megacities Initiative

The Earthquakes and Megacities Initiative (EMI) was created following the First Earthquakes and Megacities Workshop conducted in Seeheim, Germany in 1997. EMI's scientific agenda promotes multidisciplinary research to evaluate the effects of earthquakes on large urban areas and to develop technologies and methods for the mitigation of those effects.

Within its programme, EMI promotes the establishment of comprehensive city-wide disaster management systems. It encourages the development of tools for disaster risk assessment and management. This includes information technology that enables megacities to understand their risks and then to take actions to reduce their exposure to hazards. Spreading knowledge about hazards, urban vulnerability and associated risks builds institutional strength, increases accountability and triggers new initiatives.

In addition to supporting scientific research, EMI focuses on projects expected to accelerate earthquake preparedness, mitigation and recovery. Projects encourage knowledge sharing among scientists, practitioners and end-users. Activities are aimed primarily at building and sustaining professional and technical capacities in the mega-cities of developing countries.

EMI has focused its capacity-building action plan on three main projects. The Cluster Cities Project (CCP) aims to create a network of large metropolises exposed to the threat of earthquakes so that they can share their experiences and coordinate their activities. The main objective is to enable them to increase their capacities for disaster preparedness, response and recovery. EMI facilitates exchanges within the network and coordinates joint activities for participants.

The other two projects are the Regional Centers Project, an extension of the CCP, and the Training and Education Program which involves knowledge sharing across professional interest groups to build local and regional capacities.

In 2001, EMI held three regional workshops in connection with the CCP. At the Third Americas Cluster Project Workshop in Ecuador, three areas of cooperation were identified: community-based vulnerability reduction; population needs and health care delivery in disasters; and promoting a culture of prevention.

The Oceania Cluster Cities Meeting took place in the form of a China-New Zealand workshop devoted to urban development and disaster mitigation. It resulted in a cooperation agreement between the cities of Tianjin and Wellington.

The Euro-Mediterranean Cluster Cities Meeting was part of the 2001 Med-Safe Network meeting held in Naples. An ad hoc coordination group was put in place to develop a framework for further Euro-Mediterranean cooperation involving EMI cities and partners in the region.

In 2002, three more workshops were held by the Americas, Oceania and Euro-Mediterranean clusters. In October 2002, the Third International EMI Workshop was hosted by the China Seismological Bureau in Shanghai. Significantly, it served as a starting point to launch a new programme. This new Cross-Cutting Capacity Development Program is conceived as a long-term multidisciplinary programme that establishes a framework for the EMI capacity-building agenda. It is to be implemented in partnership with EMI Cluster Cities Partners, mainly city partners in Asia, working through selected institutions sharing EMI's disaster reduction agenda.

The programme focuses on four activities: the development of toolkits to deal with disaster scenarios; support for the creation of disaster scenarios in selected rural areas and urban systems; promotion of disaster-resilient building designs and land-use planning; and capacity-building in raising awareness and increasing community involvement.

EMI is also participating in the development of an interdisciplinary research programme on hazard reduction and response in metropolitan regions. The initiative was planned by the University Center for International Studies at the University of Pittsburgh in the United States. This programme works closely with the Americas Cluster Cities Project and was launched at its workshop in Mexico City in 2002. <http://www.megacities.physik.uni-karlsruhe.de>

While not directly related to EMI, the Megacities 2000 Foundation was established in December 1994, in the Netherlands. This followed a request by UNESCO to the International Academy of Architecture (IAA). The foundation collects and disseminates information on the development of megacities. The foundation has an active Internet site, organizes lectures and produces publications to further this aim. <http://www.megacities.nl>

GeoHazards International

GeoHazards International (GHI) is a non-profit organization based in California, United States, dedicated to improving earthquake safety in developing countries. Working together with UNCRD, GHI has pioneered a method to assess and reduce earthquake risk in urban areas. The Global Earthquake Safety Initiative (GESI) has been applied in 21 urban areas around the world and plans are under way for further expanded use of the methodology in India.

Following the major earthquake in Gujarat, India in 2001, GHI worked in cooperation with the Indian NGO, Sustainable Environment and Ecological Development Society (SEEDS) and the Gujarat State Disaster Management Authority. Together, they assessed earthquake risk and evaluated risk management options for three cities.

GHI has also signed an agreement with the Regional Emergency Office of the Ministry of the Interior in Antofagasta, Chile and the Center of Scientific Investigation and Higher Education, in Ensenada, Mexico to strengthen collaboration in those seismic-prone areas.

As a measure of the organization's innovative applications and dedication, GHI's founder and director, Dr. Brian Tucker was awarded a prestigious John D. and Catherine T. MacArthur Foundation Grant in 2002. This recognized his work through GHI in designing low-cost methods to minimize structural failure and human injury from natural disasters in the developing world. It will allow further work on the development and application of a global earthquake risk index designed to estimate risk and to motivate risk-reduction measures. <http://www.geohaz.org>

Case: Greece

Like several other European countries, Greece manages emergency and preparedness plans under the framework of civil protection responsibilities. A new law on civil protection was passed in 2002 taking account of experiences from recent disasters in the country. The law increases the responsibilities of municipalities in disaster management; emphasizes the role of volunteers in civil protection; and promotes the integration of scientific and technical knowledge pertaining to hazards and the risks they pose to the population.

Nevertheless, there are some specific national prevention measures, mainly directed towards earthquake risk. The Greek Seismic Design Code was originally enacted in 1959 and updated several times. A later seismic design code was established in 1995 and revised in 1999. Still more recent, the Greek earthquake design code and the reinforced concrete code both date from 2000 and complete the main legal instruments for earthquake prevention. The application of these codes is mandatory for all new construction.

A national effort for land-use and urban planning was undertaken under a law dating from 1983. According to the planning standards that were set, disaster protection and specifically earthquake safety were considered as a requirement. Nevertheless, the degree of implementation of the plans was lower than expected in some areas, mainly due to the pressures of rapid urbanization.

Despite these legislated instruments, important lessons were learned from the severe earthquake that occurred in 1999. Striking heavily populated areas in Athens and the Attica region, it killed 143 people, injured 750 and made hundreds of thousands of people homeless. It was also the most expensive earthquake in Greece, with losses estimated at 3 per cent of the country's GNP.

Although the Athenian buildings performed relatively well in the earthquake, other consequences demonstrated that more effort needs to be placed in land-use and urban planning with respect to providing a greater degree of seismic safety. The earthquake also confirmed that seismic safety is very dependent on the overall design of the buildings. Thus, requirements in respect to seismic safety should be included in the general building code as well as the code for the design of other forms of infrastructure.

A project to establish criteria and effective procedures for conducting vulnerability assessments of public buildings and bridges was in progress when the earthquake occurred. The earthquake only confirmed the need for seismic retrofitting of buildings. The reconstruction of the damaged buildings was done according to a new reinforcement code, with modern repair techniques such as the use of fibreglass introduced for the first time by the ministry of environment, planning and public works. Instructions about the repair of buildings were also published and training seminars were conducted for engineers.

Subsequently, additional vulnerability assessments are being accomplished. Initially, rapid macroscopic inspections of existing critical buildings, those designed for public use, or which represent high density of occupancy in all of the Greek prefectures. A database is being created regarding the characteristics of these 200,000 or more buildings. The next step will be to undertake an estimation of relative vulnerability and then to plan for a progressive retrofit programme.

There are, however, important choices to be made regarding the various earthquake reconstruction policies to be pursued. An earthquake opens a window of opportunity to upgrade the built environment and to advocate for greater measures of seismic safety, but there are also pressures to reconstruct buildings quickly in a rapid return to the same pre-earthquake conditions of vulnerability. What has become clear is that municipalities with previously existing plans and projects to address risk reduction are much better equipped to realize the positive opportunities following a severe hazardous event.

It became evident that more geological and geotechnical studies are required leading to seismic microzoning endeavours that can determine better use of land and urban planning. Seismic risk assessment would also be a useful tool in order to obtain a clear view of the possible effects of future earthquakes in the economically important and heavily populated area of Attica and to support decision-making about earthquake protection. Additional special measures for land-use planning and the protection of industries and businesses have been implemented, including geotechnical studies of the Attica Basin, urban planning, and a relocation scheme.

Public awareness programmes have also been utilized to inform the public and to train special groups about earthquake protection. Since an earlier earthquake in Kalamata in 1986, leaflets and posters were disseminated and information campaigns have been conducted, especially through schools.

Earthquake education provides dividends. It is commonly understood now that in many cases children reacted better than their parents during the aftershocks, thanks to the training they obtained at school. New information technologies provide additional opportunities for wider education and should be used more. As has been experienced elsewhere, in Greece too, many training and awareness initiatives were set up only after the earthquake. These include training seminars for teachers and for volunteers, the production of informative CD-ROMS for teenagers, and handbooks and web sites for wider access by the general public.

The wider use of media representatives, particularly to encourage closer working relationships with the scientific community before a crisis arises, may prevent the perpetuation of inaccurate messages during the critical stages of an emergency. Such prior relationships can also provide encouragement for more deliberate and safer reconstruction afterwards.

Protection of critical facilities

All societies need to be particularly selective in the identification and protection of their key infrastructure and service facilities. As these critical lifelines are essential to the effective functioning of a society, they should first of all be built and maintained to life safety standards. This equally implies the importance of maintaining their protection from hazard impacts so they can remain functional at all times, and particularly at the time of crisis or severe community need.

There are at least five excellent reasons for protecting critical facilities:

- Protect as many lives as possible by emphasizing places of public assembly or refuge, such as religious buildings, theatres and sports stadiums.
- Safeguard the younger generation that is the future of all societies, and the facilities essential for their growth and development, by ensuring safe schools, colleges and other educational institutions.
- Maintain the economy and protect livelihoods, by ensuring the protection of local factories, means of transportation and communication, markets, vital crops or economically important natural resources.
- Maintain the viability and operational capabilities of facilities and key resources needed to address the population's safety and well-being at the time of crisis, such as hospitals and local health facilities, clean water systems, evacuation centres, police and fire service facilities, emergency operations centres and airports.
- Protect irreplaceable monuments of cultural heritage or collective identity, or unique environmental habitats that define a community's economic worth or social basis.

At the same time, it must be realized that no society can protect all of its people and resources from all potential harm or loss. Neither the inhabitants nor leaders of Tokyo or California command sufficient wealth to protect everything in their midst. The concept of determining acceptable losses may at first seem to be a luxury of richer communities. Quite to the contrary, it is much more important that poorer societies dependent on fewer assets be more selective in deciding which critical facilities and key resources must be protected at all costs.

This requires deliberate and prior considerations that can only be undertaken in a methodical process that involves the full participation of the people most immediately affected. It also underlines the important fact that commitments to the protection of critical facilities are only driven in part by technical knowledge or structural measures identified with construction and engineering abilities.

The role of engineering and technical abilities in protecting critical facilities

Critical facilities and infrastructure are necessary for the effective functioning of any society. It is therefore necessary to consider what has to be done to promote the application of appropriate standards within the built environment.

By way of example, Canada's Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP) was established specifically to enhance the protection of the nation's critical infrastructure from disruption or destruction, and to act as the government's primary agency for ensuring national civil emergency preparedness. This underlined the importance of critical infrastructure as the backbone of the nation's economy.

It is important to keep in mind that the value of critical facilities and the systems they support, far exceeds the cost of their physical structures or facilities alone. Their true value is the sum of the cost of the building or physical facility, the contents and pertinent equipment, supplies and inventory, and the value of the activities or services they provide. This total value has to be considered in all calculations of relative costs incurred or investments made in protecting these assets.

Technical expertise is widely available to generate appropriate standards of the design and construction for damage-resistant structures and critical facilities. The political commitment to engage and more often the allocation of funds to implement known techniques and practices are wanting. The fact that specialist knowledge is spread across countries and individual fields of experience can also limit a wider familiarity and its more effective use.

Nonetheless, in many developing countries, people with the right training, skills and sometimes motivation are in short supply. At the same time, professional organizations may be weak, so nationally recognized standards of professional qualification and conduct also may be lacking.

The pressures of growing population, poverty, corruption, inadequate skills and weak administration often combine to produce woefully inadequate standards of building control. There are also problems in translating knowledge into practice.

Many countries have adopted building codes requiring disaster-resistant design and construction. The problem is not so much that codes are inadequate but that often they are not enforced effectively. Their provisions and adequacy vary but where they are rigorously applied buildings are more disaster-resistant than they might otherwise be. Equally important but more expensive, is the need to retrofit exposed critical facilities and older buildings where practical.

Informal or spontaneous settlements of buildings erected by incoming or migrant segments of the population are usually constructed without permission and are not regulated by building control procedures. Public authorities are hard pressed to provide basic water and drainage services to serve new or rapidly expanding populations, much less to attend to how they house themselves.

The construction industry worldwide also has special characteristics of high competition and small profit margins, many of which militate against the achievement of high quality in the built environment. Contributing factors include the high proportion of small local firms; the often one-off or unsupervised nature of much of the work; the large financial risks in relation to the more moderate rewards; an ability to cut corners by covering up bad work; and the lack of adequate training. Where the prevailing culture of an official sense of public safety is lax or corrupt, there is a good chance that this will be reflected in the work of local contractors.

As one experienced engineer in a heavily earthquake affected country commented, "At least part of the problem stems from the fact that much of the supervision of building construction is concentrated on checking and approving designs, whereas in fact most violations occur at the construction site."

While engineering knowledge on disaster-resistant construction has to be enhanced on a national level, this process involves two distinct levels. One relates to important international partnerships and programmes that support education and additional opportunities to exchange experience. This leads to the establishment of well-regarded engineering schools and a few key players in the field. Turkey, India and a number of Latin American countries are examples for this.

These well-qualified engineers do not need any transfer of knowledge from abroad. The problems rather hinge on the professional commitment and means to disseminate this developed professional knowledge to the many ordinary practicing engineers working more routinely throughout the country. Incentives from national governments and international donor agencies can foster this process.

On the other hand, it is sufficiently evident that local people can do something to protect themselves from the possible effects of hazards if simple advice is given and means are available for it to be heeded. The extent to which this advice is provided is often limited and too often the skilled professional communities are not directly involved.

Aside from a common disregard for prevailing conditions of risk, there are many examples of improper design, poor construction and inadequate maintenance that figure again and again as major causes of building failure and unnecessary loss of life. Much of the older building stock may have been constructed before

"In Turkey, it is the national authorities that enact legal frameworks for disaster reduction. In the area of land-use planning and building code enforcement, responsibility lies with the local governments. Many deficiencies exist in both because local governments lack the necessary technical manpower for effective enforcement, and short-term populist tendencies are strong at that level. Unfortunately, university curricula in these disciplines do not make explicit reference to disaster reducing concepts and measures."

Turkey response to ISDR questionnaire, 2001.

the adoption of modern construction standards but there should be no excuse for the failure of modern buildings.

The lessons based on experience are clear. Engineering studies of disaster damage are regularly undertaken and constitute a vital element in the design process. Codes and standards in many countries are reviewed in the light of such studies and have gained much from them, particularly when they have been considered in the early stages of post-disaster activity.

Where they exist, national engineering institutions are committed to maintaining appropriate standards of professional ethics and competence among their members and to discipline those who deliberately break professional codes of conduct. By virtue of their national standing, they have contacts at senior levels of government and with international engineering organizations.

They are therefore in a strong position to promote the importance of technical integrity, learning the lessons of disasters, identifying and assessing risks and employing disaster-resistant design and construction practices. They are also in a position to work for a better-trained and more risk-conscious construction industry.

Many national institutions maintain high standards of professional competence. Yet institutional pressure on governments to improve the enforcement of building regulations is not so evident. National engineering institutions are important agents for a safer built environment and high professional integrity. Encouragement for the development of more effective national professional institutions and their increased influence in disaster risk management could become more explicit among international agencies concerned with development.

Multiple aspects of protecting urban infrastructure and other forces at work

Most cities experience natural hazards on a relatively infrequent basis. It will not be long before 50 per cent of the world's population is located in urban areas, with many people living in vast cities at risk of natural hazards. This is an inevitable development and the implications are profound.

The level of risk depends not only on the nature of the hazard and the vulnerability of elements exposed to it, but also upon the economic value of the elements at risk. As communities grow larger, are more established and become more complex, the level of risk they face also increases.

Population growth along coastal areas is exposing a greater number of people to the effects of severe weather. While these hazards may be considered moderate, the rapid growth in population, unregulated housing, investment and the increasingly complex infrastructure associated with cities are thrusting an ever-greater number of urban citizens into higher categories of risk. With cities producing 10-30 per cent of GNP, the challenge of making cities safer can no longer be regarded as merely a local concern.

Disasters are only one of the many risks faced by people living in urban environments. Naturally occurring hazards are combined with other equally pressing urban issues all compounded by poverty. These include aging or decaying infrastructure, poor housing, homelessness, hazardous industries, unaffordable and poor transport links, pollution, crime and conflict. This is also an area for gender analysis as women-headed households in informal urban settlements are often at very high risk in natural disasters.

The built environment is deteriorating at a rate that most cities cannot afford to address. One can cite the example of Mumbai, India among many other similar cases. According to the government of Maharashtra's Greater Mumbai Disaster Management Plan, Risk Assessment and Response Plan, 2.76 million buildings of the city were registered in the 1991 census. Not more than nine per cent of them were constructed with reinforced concrete, while another 31 per cent of the structures were made of brick masonry. The remaining 60 per cent of the structures were built of informal masonry or were non-engineered buildings constructed of light material widely used in slum areas. The vulnerability of these latter structures is so evident that an earthquake of intensity VII (Modified Mercalli Scale) would likely damage between a half and three quarters of them significantly.

There are other examples that illustrate a growing awareness of the need to protect essential services and infrastructure. They also indicate that the problems are not so simply identified as being strictly technical. The following cases demonstrate that while each one involves technical and specialist inputs, additional forces often complicate the realization of effective solutions.

In most instances though, major keys to success emerge as a combination of the exercise of official responsibilities and a wider measure of public participation in reducing the risks. Vital roles need to be played by public and private entities, international organizations and development agencies, to motivate joint and collaborative initiatives for mutual benefit. Neither the insistence of good and responsible governance, nor the assumption of civic responsibilities, can be discounted as essential measures of successful disaster risk reduction

Case: Algeria

In May 2003, the biggest earthquake since 1980 struck north-central Algeria, only 50 kilometres from the national capital, Algiers. With a magnitude of 6.8 on the Richter Scale, at least 2,300 people were killed, more than 10,000 injured, with more than 200,000 people left homeless. Many buildings collapsed like playing cards, and the prevailing perception of immediate emergency relief was that it was neither timely nor adequate.

Driven by a frustration of some people digging in the ground with their bare hands to rescue trapped people, some citizens quickly converted their suffering into anger against the national government, local authorities, property developers and constructions firms. When the president visited the impact zones the following day he was met by an angry and unruly crowd demanding to know how these conditions had been “allowed to happen”.

The explanation is neither unique nor simple, when one considers that the origins of such a disaster lay in many layers of socio-economic vulnerability and political decisions taken or avoided. However, because the country is situated in a highly seismic area, one could foresee with certainty that a strong earthquake would hit the region, even if it were not possible to predict exactly when.

Certainly one among the many reasons for such a high impact was the widespread if erroneous belief that local standards of construction were sufficient, to provide an adequate measure of earthquake resilience for conditions known to exist. They clearly proved to be inadequate or were not rigorously applied.

There were probably other contributing factors. There was a sudden increase in demand for many new dwellings to house the rapidly growing population of workers, accompanying rapid economic liberalization and deregulation during the 1980s.

Under such conditions, one can speculate on the extent to which land allocation, land-use planning and building controls were considered or managed. However, following the devastation of the earthquake it was evident that people had clearly constructed recklessly, without the full benefit of professional responsibility or adequate safety standards in risky areas.

The additional contexts of unemployment, poverty, social inequality, economic dependence, and a difficulty to sufficiently use local knowledge further contributed to acceptance of vulnerability for potential losses. A dense background of risky practices and the absence of attention devoted to either the prevention or mitigation of risks is behind many disasters. Disclosure often comes with disaster.

While the complex issues of reducing inequalities and poverty, or promoting employment and public services have many roots, some shorter-term solutions for better prevention and mitigation are still possible. Increased public awareness of local hazards and risks is essential. Potential homeowners can then become a self-motivated group of building inspectors. If governments have responsibilities, so do citizens.

Case: Turkey

In May 2003, an earthquake in the Turkish city of Bingol destroyed 300 buildings and damaged more than 5,000 others. No damage was so

"If people showed as much interest in the earthquake safety of their apartments as they show in the type of tiles, doors and taps used, then it is more likely that building contractors would stick to the rules and regulations."

Source: Alpaslan Özerdem, 1999

"Hazard 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...Advocates for risk mitigation strategies must develop political as well as technical solutions."

Source: Coburn and Spence, 2002.

grievously felt as the collapse of a school dormitory, killing 84 children. A modern, engineered structure, the dormitory had only been built in 1998.

This event occurred four years after the terrible 1999 earthquake in Izmit, Turkey, which killed 20,000 people. It also relaunched the loud public debate on the prevailing standards and building codes that are applied, or not applied, as the case may be. An analysis of 12 types of debris in Bingol revealed that some of the concrete used was less than required norms and contained improper types of sand and gravel. Moreover, iron reinforcement bars were linked improperly, if not carelessly. A subsequent inquiry by the Turkish judicial system noted that the company that constructed the school dormitory had been forbidden previously to operate in the public sector because of overpricing.
<http://www.info-turk.be>

Many countries have outlying or isolated regions, not infrequently mountainous or subject to seismic activity. Reflecting the rugged physical geography, the inhabitants of such areas often lead a precarious life. By being distant from the political and economic concentration in major urban areas, these people often suffer national and global trends that concentrate wealth elsewhere, widening inequalities of class, ethnicity, beliefs or community. These forces can potentially fuel a process of underdevelopment that encourages corruption and leaves people to focus solely on their rudimentary survival.

Such a wider perspective of vulnerability that hinders the mitigation and prevention of risk is acutely conveyed in discussion in Radical Interpretations of Disaster (RADIX), an online discussion forum about public perceptions of risk and activist solutions.
<http://online.northumbria.ac.uk/geography_research/radix>

Protection of health systems

Following the 1985 earthquake in Mexico City, PAHO began work on vulnerability and disaster reduction for health facilities in Latin America and the Caribbean, with an emphasis on hospitals. This experience made it clear that it was not sufficient for medical and support staff alone to be prepared to attend to emergency situations. It was equally important for the political establishment and the public to undertake mitigation measures to reduce the vulnerability of the public health infrastructure.

During the past 15 years, a growing number of professionals and academics have worked to compile technical manuals about disaster risk management measures that should be applied in the construction, maintenance and retrofitting of health facilities. Additional work has been undertaken to conduct vulnerability studies and to retrofit several hospitals to withstand earthquakes.

Disaster events that occurred during the El Niño phenomenon in 1997-1998, showed an increased need to consider the impacts of water-related disasters on health sector facilities. In addition, the impact of disasters on infrastructure demonstrates considerable environmental and health consequences, in particular given the vulnerability of domestic water supplies and the physical infrastructure necessary for sanitation.

Health risks related to the disruption of water distribution and sewage systems in the aftermath of disasters, and particularly during floods, contribute greatly to mortality rates. There is growing appreciation of the importance of ensuring proper maintenance and protection of systems for industrial water and wastes, so that they do not result in toxic or chemical pollution of water resources.

Box 5.26
Vulnerability studies and mitigation measures in the health sector

In order to ensure that technical knowledge is passed to other countries, the Pan-American Health Organization (PAHO) promotes an exchange of ideas between professionals and governments in order to advance the idea of preventing avoidable losses in the health sector from natural hazards.

Despite technical advances that have been available to support health sector initiatives against natural hazards, many have not been implemented in health facilities. This has been due to lack of planning, insufficient resources or a simple lack of interest on the part of government authorities or potential financial supporters. Unfortunately, many of these projects have failed more from a lack of interest to do things responsibly than from a lack of resources.

This topic has provoked considerable interest in Latin America and the Caribbean. An attempt has been made to move the agenda of disaster reduction forward by the publication and distribution of relevant information by PAHO and other institutions. This is being realised most effectively through the joint participation of the academic, private and health sectors.

Many hospitals have taken steps to reinforce their facilities in light of the risks of disasters. In order to develop this approach further, there is a continuing need to promote and organize studies about vulnerability in the built environment, particularly facilities essential to public health.

Source: PAHO, 2002.

PAHO has promoted this topic since the early 1990s. Nevertheless, vulnerability reduction in water and sanitation has a long way to go. So far, emphasis has been on meeting the immediate needs of the population without encouraging a wider analysis and application of disaster prevention initiatives.

This is partly due to the many institutions involved with water and sanitation and the absence of leadership at national or local levels. It is also partially a result of the geographical extent of these services and the complexity of the technical solutions involved.

Advances have been made in the development of technical manuals to reduce the vulnerability of water treatment facilities against natural disasters based on the experiences of individual countries. However, technical publications that fully list criteria for building or protecting critical facilities from damage by natural disasters have not yet been developed.

Peru has established legal guidelines for the health sector to encourage the inclusion of disaster reduction activities in its action plans. However, there has been very little elaboration on the technical skills to carry out these guidelines. It is vital that academic institutions and professional organizations assume the responsibility to promote technical knowledge.

The result of these initiatives has been to familiarize organizations such as the Pan-American Engineering Association for Public Health and Environment (AIDIS) with prevention issues. In the same way, there have been advances in promoting risk reduction in various sectors such as the management of water facilities. The wider professional involvement has further enabled these topics to be included in legislative measures related to disaster and risk management issues.

With the exception of Costa Rica and Ecuador, there are few countries in Latin America that can demonstrate the implementation of specific projects to reduce the vulnerability of facilities to natural hazards. For instance, water purification facilities and related systems generally remain exposed to different types of hazards, even though many of them supposedly have been upgraded and despite the widespread recognition that clean drinking water is a top priority in any disaster response activities.

Protection of educational facilities

Schools represent a particularly forceful example of a civic obligation to protect a common good. They are universally recognized in communities around the world for their inherent social value, a location for public assembly and often protection. They regularly serve as a symbol of local identity and many times define a community's worth, as well as representing its future. They embody the highly regarded social values of education and provide the basis for growth, understanding and experience between generations within a sense of community. This further underlines the importance of schools being built and maintained to what should be the highest standards of protection.

For many reasons in most countries, this is often not the case. Even in times of greatest need, when schools are used as emergency shelters during a crisis or for temporary accommodation following a severe disaster, the primary educational function of schools can be compromised seriously for long periods of time. Policies regarding public safety issues and the continuity of educational functions requiring the use of school buildings during and after a natural hazard event should be carefully considered, discussed and adopted by the community.

The need for such multi-stakeholder deliberation was aired and leadership displayed in an international seminar on Disaster Management and the Protection of Educational Facilities, organized by the OECD in conjunction with the Greek ministry of education and the national school building organization, in November 2001.

There are other examples which demonstrate commitments by which communities, technical specialists and educational authorities are seeking to place the importance of protecting schools, their community functions, and most importantly the children which they nurture at the heart of local disaster reduction programmes.

The OAS School Protection Programme: EDUPLANhemisférico

A comprehensive inter-American strategy was launched in 1993 to reduce the education sector's vulnerability to natural hazards by an initiative of the Unit for Sustainable Development and Environment of the Organization of American States (USDE/OAS), working with PAHO and ISDR. Known as EDUPLANhemisférico, the programme seeks to engage public and private institutions, national and international agencies, NGOs and private individuals to encourage member states to adopt an action plan for reducing the vulnerability of the education sector to natural disasters through a variety of international forums.

EDUPLANhemisférico works through eight technical secretariats with the cooperation of a variety of institutions in the Americas, including universities and development centres of school infrastructure. Together, they serve as implementing focal points located in Argentina, Costa Rica, Peru, Trinidad and Tobago, the United States and Venezuela. They conduct activities at a number of local, national and regional locations with their work divided into three areas: academic improvement, citizen participation, and physical infrastructure protection.

There is a commitment to improve the curriculum with the addition of more elements pertaining to understanding vulnerability and risk reduction in primary, secondary and higher education. This is done to encourage individuals and various professional interests to work more closely together for disaster reduction.

Regardless of international efforts to design and implement acceptable standards for building and retrofitting schools, EDUPLANhemisférico recognizes the values and needs for energetic local participation to reduce the vulnerability of school buildings to natural hazards.

EDUPLANhemisférico sees the enforcement of internationally accepted standards as a complementary but not essential component of disaster reduction of school infrastructure. The primary enforcement of standards should take place through societal mechanisms at the most local level of a society and in the most direct means possible.

Local enforcement means the participatory review and action regardless of any other technical or governmental requirements, and it is preferable to provincial or national levels of oversight. International enforcement is not recommended because local participation should demand accountability from the more immediate owners and operators of the vulnerable school infrastructure.

In this respect EDUPLANhemisférico works to accomplish more local participation and accountability in addressing all forms of vulnerability in the education sector until each successive administrative level of responsibility has no choice but to become more accountable itself. An internationally accepted standard ultimately must be that there is no loss of life from school facilities impacted by natural hazard events and that the buildings continue to function through times of disaster.

The declaration of the ministries of education during the meeting in Punta del Este, Uruguay, in September 2001, failed to include the issue of reducing the vulnerability of school buildings to natural hazards in the sectoral agenda. Accordingly, EDUPLANhemisférico will continue working to make this issue part of the ministries of education agenda.

In Latin America there are at least three other programmes that reflect concerted efforts to increase the resilience of school buildings against damage from natural hazards.

Seismic vulnerability analysis of school buildings, Santa Fe de Bogotá, Colombia

This programme of the education secretariat in the capital district was developed by Projects and Designs Ltd. in April 2000. Most of the school buildings were built before the standard of the Colombian code for seismic resistant buildings was in force. As a result, most of the buildings in Colombia, including many schools, were designed and built without any seismic-resistant criteria. The analysis developed a methodology to be used in all phases of the project, and the staff in the education ministry was trained to obtain information for the primary evaluation of seismic vulnerability. The primary evaluations were conducted in all schools, determining the seismic vulnerability of each. Priorities among individual schools were then assigned according to available budgets. In some cases more detailed vulnerability analyses and structural retrofitting studies were conducted.

Vulnerability evaluation and retrofitting of schools, Quito, Ecuador

This evaluation exercise was developed by the National Politechnic School and conducted in three typical structural systems used for schools in Quito. These included structures employing unreinforced masonry or adobe construction; two to five storey reinforced concrete buildings generally using frame and slab floors; and those with steel frames and unreinforced masonry infill walls generally found among more lightweight structures.

The study noted that there were no previous records about the extent or types of earthquake damage to schools. However, information gathered more recently shows the following common weaknesses:

- Short columns are a common architectural design in most of the reinforced concrete buildings and cause severe damage in an earthquake.
- Inadequate design features in construction joints can result in damage to adjacent buildings during earthquakes.
- Infilled walls of the light steel structures tend to fail due to inadequate connections with the steel frames.
- Lightweight roofs collapse because of the absence of tensile reinforcement.
- Adobe construction and unreinforced masonry are very vulnerable because of the absence of connecting beams and the presence of heavy roofing tiles.

The lack of appropriate maintenance was also identified as increasing the vulnerability of the structures. Experienced engineers visited each building, performed a short evaluation, and then recommended procedures to classify them according to the degree of vulnerability observed. Subsequently, a group of schools was evaluated in more detail using mathematical models.

The government of Ecuador has recently approved revised seismic provisions for structures based on regional standards, but there are no effective mechanisms in place to ensure the enforcement of these regulations. Under the new code, schools are classified as critical facilities, so it is expected that they will be engineered to a higher standard.

Retrofitting rural schools, Venezuela

This activity was developed by Fundación de Edificaciones y Dotaciones Educativas in 1998, to strengthen the most commonly used structures in rural areas. The lightweight structures have steel frames and unreinforced masonry with infilled walls, of one storey with a sheet metal roof. The fragility of the building components shows rapid deterioration. The objective of the retrofitting plan was to repair and improve the existing buildings so that they would be more durable, secure and comfortable.

First, the structure was reinforced. A thin concrete slab reinforced by a net of expanded metal was substituted for the metal roof, and a thermo-resistant cover was added. Then, the exterior walls, doors, and windows were modified to improve illumination, ventilation, and the security of the building. For each building, a cost-benefit analysis was considered to verify the advisability of either retrofitting or replacing the building.

A pilot project was implemented in a preschool building, and the methods employed solved the problems observed in most of the buildings evaluated. It was observed at first that the initial cost appeared high in comparison to an unmodified structure. However, the obvious benefits of the improvements in the quality of education that could be offered in a comfortable, secure, hygienic, and more aesthetic school convinced people that the expenditure was a good investment.

Future challenges and priorities

As essential components of any successful disaster risk reduction strategy, safe building construction practices and the protection of critical facilities present both important opportunities, but also areas for additional attention. In reflecting on the experience conveyed in this chapter, the following issues represent important challenges for the future.

Safe construction is rooted in risk assessment

The fundamental starting point for the effective engagement of engineering and construction measures for disaster risk management must proceed from a sustained and on-going commitment to risk assessments. Attention in this respect initially must take account of the intended physical locations of housing, facilities and infrastructure, guided by consideration of appropriate land use and related planning processes. The suitability and quality of construction as related to risk factors are inextricably linked to the judicious evaluation of physical aspects of vulnerability.

Need for a wide coalition of interdependent interests

Experience that demonstrates the value of structural measures in creating a safer built environment is grounded in the mutual recognition of many different interests. The constituency associated with the physical aspects of disaster risk management needs to include a growing coalition of investors, developers, planners, architects, engineers, builders and government officials. Educators in each of these professional disciplines, but especially in the fields of building trades, engineering and public administration are equally important. They are crucial for consolidating the knowledge and experience of the past and passing that knowledge along with professional skills to future generations. There is a need to bring the full range of technical, social and political considerations to bear on each of these responsibilities, with a fuller appreciation of their mutual inter-dependence if significant levels of physical resilience and protection are to be realized.

Responsibility starts at home

The most essential responsibility for a safe building environment must rest with the public and individuals in fulfilling their roles as owners, users and inhabitants of structures. It is only with their understanding and involvement that collective behaviour can be encouraged that leads to providing greater resilience within any community. Translation of such individual self interest into more persuasive advocacy rests upon the systematic efforts to spread information about hazards and associated risks. This builds a basis for institutional strength, increases accountability and can also trigger new initiatives.

A need for determining acceptable levels of risk

Even while the foundation of effective risk management in the built environment is tied to risk assessment, it is important to ensure that there is a related commitment to evaluating levels of acceptable risk. There is a need for institutional capabilities and also public dialogue to establish priorities of what structures, facilities or lifeline systems must be protected at all costs. Such priorities need to proceed beyond the identification of key facilities and systems and have to be carried through to the determination of priority applications of chosen technical procedures or processes. There is a need for technical analysis and understanding, but success will depend ultimately on the extent of negotiated agreement that takes account of economic, political, and social tradeoffs of what the society or community cannot afford to lose.

With regard to infrastructure and related lifeline services, it is particularly critical that a long-term perspective be adopted in consideration of collective well-being. This suggests that a particular relevance be given to protect the health and educational systems that underpin the social vitality of a community at least as much as the economic and natural resources that determine the viability of a population. For both of these reasons, it is important that the value of infrastructure be seen in terms of the service functions they provide in the context of sustainable development.

Continuing challenges in enforcement of safe practice

In all countries there are many continuing challenges to ensure the adherence and implementation of safe building standards and land-use regulations that contribute to a safer built environment. While continuous efforts to improve existing building codes are always desirable, and authorities are encouraged to devise them where none exist, the real and pressing need is to find means to apply and enforce those that have already been designed. It is widely accepted that incentives are more conducive to realizing normative standards in ones own self interest than the threat of punishment for the failure to do so, which seldom seems to be pursued with the vigour that should be expected.

As discussed, the reasons for non-compliance are many but official and commercial corruption, intentional oversight, and concentration on short-term advantages all contribute to a careless attitude towards public safety. Only continuous concerted public and private efforts to create a stronger sense of dedication to risk reduction can overcome these other more selfish attitudes. The goal needs to be one of creating sufficient critical mass in public expectations and political responsibilities through good governance to make risk reduction an accepted public value.

Professional training and applied knowledge

The construction and engineering professions, along with the commercial interests and educational institutions which sustain them, have special responsibilities in the teaching and promotion of values that contribute to successful disaster risk management in practice. It is they who must work with greater effort to instill professional integrity within their own ranks, but also to advocate for more sustained policies in the public interests for a safer built environment. Such an approach may seem to fly in the face of expected traditional relationships between business, academia and government. Nonetheless, it forms the basis of public-private collaboration that is increasingly being identified as the only viable, and economical, way to achieve safer construction and public infrastructure.