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5.3. Protection of critical facilities

"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

All societies need to be highly selective in the identification and protection of their key resources and service facilities. These lifeline elements need enhanced protection from hazard impact so they can remain functional at the time of crisis or following a major disaster. Typical critical facilities and infrastructure include:

- Key infrastructure and utilities, such as communications, water, electricity and fuel supplies.
- Primary transportation links, such as main roads, rail links, harbours and airports.
- Public administration facilities, government offices, police, fire and emergency service facilities.
- Medical facilities performing critical public health and life saving functions.
- Schools and buildings with social value, important for public assembly or local identity.
- Key economic assets related to finance, commerce and manufacturing.
- Cultural monuments, museums and historic structures.

The discussion and examples shown in this section will focus on:
- The role of engineering and technical abilities in protecting critical facilities
- Protection of urban infrastructure
- Structural means, disaster-resistant construction
- Codes, policies and procedures
- Government examples, public demonstration of best practices
- Development of appropriate methodologies

The role of engineering and technical abilities in protecting critical facilities

Buildings, critical facilities and infrastructure are necessary for the effective functioning and well being of any society. It is therefore necessary to consider what has to be done to promote the development and application of appropriate standards of design and construction within what is often called the built environment.

In technical terms, the expertise and methodologies are available within the scientific and technical communities to generate appropriate standards of design and construction for damage resistant structures and critical facilities. The fact that they are spread across countries and individual fields of experience limits their use.

In many developing countries, people with the right training, skills and motivation are in short supply. At the same time, professional structures may be weak so that nationally recognised standards of professional qualification and conduct are lacking.

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

The pressures of growing population and poverty, finance, corruption, inadequate skills and weak administration often combine to produce woefully inadequate standards of building control. There are other problematic areas, as well, in translating current knowledge into practice. Buildings erected by incoming or migrant segments of the population are usually constructed without specific permission and are not regulated by any building control procedures. Public authorities are hard pressed enough to provide basic water and drainage

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Vulnerable building stocks

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

- Rampant code violations that 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, limited industrialization of residential construction.
- High rate of industrialization and urbanization lead to a need for inexpensive housing.
- No professional qualification of engineers.
- Ineffective control/supervision of design and construction.
- Corruption.
- Regulations with limited enforcement and no accountability.
- Ignorance and indifference.
- Government was a free insurer of earthquake risk.

services to serve the new population, much less to attend to how they house themselves.

The construction industry world-wide also has special characteristics, 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 one-off or unsupervised nature of much of the work, the risks in relation to the rewards, the ability to cut corners by covering up bad work and the lack of adequate training. Where the prevailing culture is lax or corrupt, local contractors will usually reflect it.

Local people can do something to protect themselves from the possible effects of disasters if simple advice is given and heeded. The extent to which this advice is provided is often limited and too often the professional communities themselves are not directly involved. 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 are reviewed in the light of such studies and have gained much from them, particularly when they have been undertaken in the early stages of post-disaster activity.

Lack of rewards for mitigation measures

A glaring omission in the newly crafted system in Turkey is, of course, the fact that no rewards have been worked out for mitigation measures. If homeowners decide to upgrade their buildings, this is currently not recognised in reduced [insurance] premiums, or increased benefits. … too much emphasis has been placed on the purely technical measures of earthquake protection, but this has occurred at the expense of improved settlement and spatial planning policies.

Source: Gulkan, P., 2000

Aside from the common disregard for prevailing conditions of risk, improper design, poor construction and inadequate maintenance figure again and again as major causes of building failure and loss of life. Poor engineering, ineffective building control by officials and bad building practices within construction concerns produce a grim harvest, long after those people responsible have moved on to other projects. Much of the older building stock may have been constructed before the adoption of modern construction standards, but there should be no excuse for the failure of modern buildings.

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 international engineering organizations. They are thus 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.

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Ways to achieve a safer built environment need to be:

- Ambitious, grasping unique post-disaster possibilities to improve building.
- Stimulated by a range of incentives.
- Inclusive, with the attention of engineers being devoted to the creation of both safe engineered as well as safe non-engineered buildings.
- Focused on lifeline buildings and infrastructure, rather than on unrealistic projections addressed to all structures within all settlements.

Many national institutions maintain high standards of professional competence, but the extent to which those standards are reflected in pressure on government to improve the enforcement of building regulations, or in the professional supervision of engineers on the ground is not necessarily so evident. They sometimes use the situation to their advantage and do little to encourage better standards. However, national engineering institutions are important agents for a safer built environment and high professional integrity, and this position must be maintained over the long term. Again, encouragement for the development of more effective national professional institutions and their increased influence in civic expressions of disaster risk management could become a more common area of interest among international agencies concerned with development.

Protection of urban infrastructure

Most cities experience natural hazards such as earthquakes, volcanic eruptions, floods, cyclones, and tidal waves, on a relatively infrequent basis. Yet, mounting losses to life and property, point to the fact that determining the risk to natural disasters is a dynamic process. It

What about 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, *'non-engineered building is outside the engineer's scope or mandate'*. The obvious follow-up question: "*therefore, in such a situation, **whose** responsibility is it to devise ways to create safer vernacular buildings to protect their occupants from earthquakes?*" remained unanswered, other than a vague suggestion that this problem was probably - *'the province of local builders'*.

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 in earthquakes in Japan, and at a global level that certainly needed the attention of his profession. However, he believed that there was regrettably no money in Japan to fund the necessary research or implementation of improved structural measures for such low-cost structures. A rather sad case of *'no money on the table, - no action on the ground'*"

"Fortunately there are notable, yet isolated exceptions to such negative attitudes or approaches including important work in Peru (Giesecke, 1999), Colombia, China and Bangladesh (Hodgson, Seraj, and Choudhury, 1999). One key center for research and development is the *Central Building Research Institute*, and the *Department for Earthquake Engineering at the University of Roorkee* in the State of Uttar Pradesh, India led by the pioneering work of Professor A.S. Arya on the strengthening of non-engineered construction. The groundbreaking World Bank-supported programme to retrofit village housing in Maharashtra, India following the Latur earthquake is an example of a programme that secured the technical support of Roorkee. (Government of Maharashtra, 1998)."

Source: I.Davis, 2002

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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 the elements it affects, but also upon the economic value of those elements. As communities grow larger, are more established and become more complex, the level of risk they face also increases.

Rapid urbanization in developing countries particularly, has led to the exponential growth of non-regulated housing. Population growth along coastal areas is exposing a greater number of people to the effects of severe weather. While these risks may be considered moderate in and of themselves, the rapid growth in population, investment and increasingly complex infrastructure associated with cities is thrusting an ever-greater number of urban citizens into higher categories of risk. With per capita city product exceeding 10 to 30 per cent of GNP, the challenge of making cities safer can no longer be regarded as merely a local or altruistic concern.

Disasters are only one of the many risks that urban dwellers face. Naturally occurring hazards are commingled with other equally pressing urban issues, such as decaying infrastructure, poor housing, homelessness, hazardous industries, inadequate services, unaffordable and poor transport links, pollution, crime, insecurity, and conflict. The built environment is deteriorating at a rate that most cities cannot afford to address. Vulnerability of the building stock to earthquake damage in one large centre has been estimated at 170,000 older poorly maintained buildings, 320,000 non-engineered buildings and 400,000 newer buildings with inadequate lateral resistance.

There are examples that illustrate both a growing awareness to these issues in cities and communities alike and what is necessary to protect their essential services and related infrastruc-

Building Measures

There is a need to recognize the three distinctive contexts for the introduction of physical risk reduction measures into buildings or infrastructure, (each possessing different levels of opportunities for application):

- *Reconstructing* new buildings or through the repair of buildings
- *Constructing* new buildings, in normal circumstances
- *Retrofitting* existing building stock through strengthening programmes.

The order of opportunities to address each context is as follows:

Good Opportunity:
Reconstruction, with the introduction of mitigation measures, is always likely to be possible, even in countries with resource limitations. This is on account of high levels of political will and public demand for enhanced safety in immediate post-disaster contexts. Therefore, officials need to be sensitive to the excellent opportunities posed by reconstruction to introduce mitigation measures.

Moderate Opportunity:
Introducing mitigation into ***new construction*** is certainly attainable, if there are the additional 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 surrounded by social, economic and cultural obstacles and thus remains an unsolved global challenge of major proportions.

Limited Opportunity:
The introduction of retrofitting for ***existing buildings*** will always be the most difficult context given the scale of building stock in any urban areas. For example, in the USA, the average turnover in the Nation's building stock is only 1 to 2 percent a year. Thus there is a vast potential cost associated with implementation in terms of securing the necessary finance as well as the cost of social and economic disruption.

Source: I. Davis, 2002

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ture. The following cases demonstrate that while each involves technical and specialist inputs, a major key to the success has to be a greater degree of official interest and wider public participation if the commitment is to proceed beyond the stages of initial conception. An additional point that should not be overlooked is that there are often vital roles that need to be played by international organizations or development agencies in stimulating or supporting such initiatives.

Case: Disaster risk reduction in health facilities, water and sanitation systems in Latin America and the Caribbean.

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

During the past 15 years of work on this subject, a growing number of professionals and academics have participated in the compilation of technical manuals about disaster reduction 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 elaborate the retrofitting of several hospitals to withstand earthquakes.

While a particular emphasis had already been placed on the development of disaster prevention initiatives for large health centres from the effect of earthquakes and hurricanes, subsequent events of the El Niño phenomenon in 1997-1998, as well as the floods in Venezuela showed an increased necessity to analyse water-related disasters and their impact on the health sector facilities.

The impact of disasters on infrastructure has considerable environmental and health consequences, in particular given the very specific 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 related mortality. There is also now 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 bodies.

Retrofitted hospital
Photo: Osorio, PAHO

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Guiding vulnerabilty studies and mitigation measures in the the health sector

In order to ensure that technical knowledge is passed to other countries, PAHO will continue to promote an exchange of ideas between professionals and governments in order to advance the idea of preventing avoidable losses in the health sector from natural disasters. Despite technical advances that have been available to support health sector initiatives against natural disasters, many have not been implemented in new or existing health facilities. This has been due to either the lack of planning, insufficient resources or simply the lack of apparent 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. Although nothing has changed drastically from these efforts, 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. Moreover, many hospitals have decided to reinforce their facilities in light of the risks of disasters. In order to further develop this successful approach of disaster risk reduction, there is a need to continue the promotion and organization of studies about vulnerability of the built environment and facilities essential to public health with the joint participation of the academic, private and health sectors.

Source: PAHO, 2002

PAHO has promoted this topic since the beginning of the 1990's in Latin America and the Caribbean. Nevertheless, vulnerability reduction in the services for water and sanitation systems yet has a long way to go. They so far have concentrated mainly on the immediate needs of the population without encouraging a wider analysis and application of disaster prevention initiatives. This is due to several reasons, with some related to the considerable number of institutions involved with water and sanitation and the absence of leadership at national or local level. It is also partially a result of the great geographical extent of these services and the complexity of the technical solutions involved.

Photo: Osorio, PAHO

Advances have been made in the development of technical manuals for disaster prevention and in the capacity to reduce the vulnerability of water treatment facilities against natural disasters, based on the experiences of individual countries. On the other hand, technical publications that fully list criteria for building or protecting critical facilities from damage by natural disasters have not yet been developed. A list of such criteria is vital for the construction, as most of those considerations are only available in the literature for building methods but they are not more widely elaborated for general awareness or utilization.

The result of these initiatives has been to familiarize certain organizations such as the *Pan-American Engineering Association for the Public Health and Environment – la Asociación Interamericana de Ingeniería sanitaria y Ambiental (AIDIS)* with prevention issues. In the same way, improvements have been made in the promotion of the topic in different sectors such as in the management of water facilities. This has allowed the topic of disaster risk reduction to be included in the legislative measures related to disaster management issues.

Some countries like Peru have 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 knowledge to carry out these guidelines. For the future, it is vital that the universities, academic institutions and professionals assume the responsibility to promote the spread of this technical knowledge in order for these obstacles to be overcome.

With the exception of Costa Rica and Ecuador, there are presently very few countries that can show the execution of special projects to reduce the vulnerability of facilities against natural disasters. For instance, water purification facilities and related systems generally remain exposed to different types of hazards, even though many of these facilities supposedly have been upgraded to withstand their damaging effects. Only water treatment facilities have been improved to some extent, as the public availability of clean drinking water has been a top priority for disaster management emphasis in the wake of disasters.

Case: Canada

Canada's new *Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP)* was established to enhance the protection of 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 such as energy and utilities, communications, services, cybernetic systems, transportation, safety and government comprise as the backbone of the nation's economy.

Structural means, disaster-resistant construction

The design and construction of hazard-resistant structures constitute some of the most cost-effective means of reducing risks. The technical design and authoritative enforcement of building codes and related standards of construction are essential to protect the built environment from unnecessary loss or damage from natural hazards. Urban planners, architects, engineers, construction contractors and building inspectors all have important responsibilities to ensure that the physical aspects of planning and construction are technically sound and are suited to the circumstances of potential hazards in a specific location.

The engineering standards of buildings, lifelines, and housing are determined by the degree to which technical decisions are made, and followed through in practice, by construction professionals. It is they who must determine how effective a particular engineering solution will be in respect to an expected degree of stress or hazard.

However, much less attention is given to the equally 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 expected compliance of standards implied by their investment, enforcement of legislation, or adherence to local procedures, regulations and standards. Even when assuming that codes have been based on current knowledge and developed experience, they ultimately are only as good as the extent to which they are employed and enforced. The state of Florida was regarded as having one of the most rigorous building codes in the US until Hurricane Andrew stripped away all pretences of compliance. Similar disclosures have arisen with unerring frequency *after* disasters have occurred, whether they happened in Japan, Turkey, Taiwan or India.

"In Turkey, the building construction supervision scheme is directed mostly to checking designs, when in fact violations occur at the construction site."
Gulkan, P.

In an effort to address some of these issues, the *Earthquake Engineering Research Institute (EERI)*, a non-profit professional association headquartered in Oakland, US, is conducting a joint project with the *International Association of Earthquake Engineering (IAEE)* located in Tokyo, Japan. Together they are building an interactive, dynamic, Internet-based *encyclopaedia of housing construction* used in all seismically-active areas of the world. The endeavour links more than 160 volunteer engineers and architects from over 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

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useful not only for design and construction professionals but also for housing authorities, community planners, or 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 or other associated factors. 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 all other ranges of intermediate technical consideration up to the sophisticated engineering practices employed in urban high-rise construction.

As the information is placed on the Internet, users can search the database by various criteria. In addition to basic country profiles, information can be retrieved on the basis of specific types of urban or rural construction practices, seismic hazards, building functions, type of building materials or structural systems employed. The information also relates to ratings of seismic vulnerability and even describes economic levels of inhabitants. It will be possible to compare the strengths and weaknesses of various construction techniques and strengthening technologies that have been tried in different countries. Likewise, comparisons can be displayed with the various types of building materials used, as well as indicating each country's perception about the performance of different types of construction.

The encyclopaedia will also include country-specific information, including background information about seismic hazards, codes and building standards, the size and rate of change in urban and rural housing, relative densities of urban and rural housing, general weather patterns and specific information about housing losses in past earthquakes. Users will be able to generate graphs, tables and presentations, view photos and drawings, and print either short or long descriptions from any of this information.

Another institution addresses some of the same issues but with an emphasis devoted to infrastructure and their related components. The overall goal of the *Multi-disciplinary Center for Earthquake Engineering Research (MCEER)*, State University of New York at Buffalo, USA, is to enhance the seismic resilience of communities, through improved engineering and management tools for critical infrastructure systems, such as those related to water supply, electrical utilities, hospitals, 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 USA to integrate knowledge, expertise, and interdisciplinary perspective with state-of-the-art facilities in the field 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.

Codes, policies & procedures

The development and enforcement of standards and codes to protect public safety is an expected responsibility of government. Codes should exist and 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 ash fall, the most widespread of all volcanic hazards.

Development of standards is easy but implementation is difficult because it requires prudent decisions and the accepted confidence in

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 the 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 Centre, Bangkok, Thailand.

"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, the university curricula in these disciplines does not make explicit reference to disaster reducing concepts and measures."

Turkey response to ISDR questionnaire, 2001

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"Yes, we have building codes and related regulations, but ..."

"The Federated States of Micronesia have passed building code laws and regulations but have 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

their applicability and affordability. Land use, planning and construction standards are most often decided upon and enforced at the local level. Promoting a culture of prevention within local authorities and communities must therefore be the central focus of any national disaster risk management strategy. The application of mechanisms and tools for enforcing existing building codes and zoning by-laws must be central to this effort.

For some years, South Africa has enforced legislation pertaining to building codes and construction within vulnerable areas, such as those based on a 50-year flood line. 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 receiving increased attention from all levels of government as well as a greater focus in the offerings of tertiary educational qualifications. The establishment of economically, physically, environmentally and socially integrated and sustainable built environments is one of the most important factors which will contribute to harnessing the full development potential of South Africa and addressing the needs of its growing population.
Experience 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.
- ☑ Regularly updated in the light of developments in current knowledge.
- ☑ Fully understood and accepted by the professional interests that relate to the legislation.
- ☑ 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.
- ☑ Fully integrated in a legal system that operates without conflict between the different levels of administration and government.

Hong Kong
Photo: Munich Re

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Government examples, public demonstration of best practices

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 of investing in risk reduction practices. The importance of such official leadership was emphasized 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 Greek School Building Organization* (SBO), in November 2001.

Development of appropriate methodologies

There are a number of initiatives and professional coalitions, which have been, developed to encourage greater national or technical capacity building to protect critical infrastructure. Because of the strong engineering components involved, much, but not all of the motivation has come from seismic experiences and earthquake engineering fields. The success of the examples elaborated below can serve as guidance for the further development of similar initiatives that relate to different types of hazards. A similar approach towards addressing floods and urban infrastructure is a suggested consideration for the future. One example, already described in chapter two (p. XX) is the RADIUS methodology developed during IDNDR to assess urban seismic risk.

The *World Seismic Safety Initiative (WSSI)* began in 1992 as an informal initiative of members of the *International Institute of Earthquake Engineering* (IIEE), and later became an IDNDR Demonstration Project active throughout the decade. It has since proceeded to become a model of dedicated professionals working together with minimal organizational structure to stimulate seismic risk reduction programmes in developing countries in Asia, the Pacific and Africa. Throughout its existence, WSSI has had four goals:

- Disseminate state-of-the-art earthquake engineering information globally.
- Incorporate experience and apply research findings in 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, and sought to develop information networks that could serve as catalysts for action in earthquake awareness, education and risk management. An element of WSSI's success has been to focus on well-defined and modest regionally-based projects, including *Nepal's National Society of Earthquake Technology (NSET)*, *Uganda's Seismic Safety Association (USSA)*, and the *Global Disaster Information Network (GLO-DISNET)*.

By means of its extended technical membership, WSSI was also instrumental in the establishment of the *Earthquake 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. 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. By focussing on the demands of the 21st century, this programme increasingly seeks to pursue the aim of evaluating the effectiveness of mitigation practices in its area of concentration.

EMI was created as an outcome of 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, and the development of tools for disaster assessment and disaster management such as information technology that enable megacities to understand their risk and take actions to reduce their exposure to disasters. The knowledge of hazards and risks is

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intended to build institutional strength, to increase accountability and to trigger new initiatives.

In addition to supporting scientific research, EMI focuses its efforts on specific projects expected to have a high impact in accelerating earthquake preparedness, mitigation and recovery. Its projects constitute mechanisms for knowledge building and information sharing among scientists, practitioners and targeted end-users. These activities are aimed primarily at building and sustaining professional and technical capacities in the megacities 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 overriding objective is to enable them to increase their capacities for disaster preparedness, response and recovery. EMI serves to facilitate exchanges within the network and to coordinate joint activities in the project. The Regional Centers Project is an extension of the CCP. The EMI Training and Education Program involves the sharing of knowledge and information across different professional interest groups to build local and regional capacities.

EMI held three regional workshop in 2001, in connection with its Cluster Cities Project. 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 in order to develop a framework for further Euro-Mediterranean Cooperation involving EMI cities and partners in the region.

EMI is also participating in the development of an interdisciplinary research programme on hazard reduction and response in metropolitan regions currently being planned by the University Center for International Studies at the University of Pittsburgh, in the US. This programme will work closely with the Americas Cluster Cities project and is planned to be launched during 2002 at the Americas Cluster Cities Workshop in Mexico City.

The Megacities 2000 Foundation was established in December 1994, in the Hague, the Netherlands, following a request by UNESCO to the *International Academy of Architecture (IAA)*. The foundation collects, processes and disseminates information on the development of big cities. To this aim the foundation uses an Internet site, organizes lectures and produces publications.

GeoHazards International (GHI), a California-based non-profit organization is dedicated to improving earthquake safety in developing countries. Working together with the *UNCRD*, GHI is pioneering a method to assess and reduce earthquake risk in urban areas. The *Global Earthquake Safety Initiative (GESI)* method has been applied in 21 urban areas around the world and plans are under way for it to be extended to 30 cities in India.

Following the major earthquake in Gujarat, India in 2001, GHI is working in cooperation with the Indian NGO, *Sustainable Environment and Ecological Development Society (SEEDS)* and the Gujarat State Disaster Management Authority (GSDMA) to assess earthquake risk and to evaluate the 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 their collaboration in similar activities in those seismic-prone areas.

The *Kathmandu Valley Earthquake Risk Management Project (KVERMP)* aims to project sound earthquake management policies for the Kathmandu valley in Nepal, and to begin the process of implementing them. The experiences gained in this project should be useful for other earthquake threatened cities in developing countries, and should further establish NSET Nepal as a focal point for earthquake mitigation activities in the Kathmandu valley.

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Future challenges and priorities

The primary challenge for enhancing risk management practices with respect to critical facilities is to place the value of the infrastructure in a broad context of sustainable development. Only then can the relative priorities be considered to provide an acceptable degree of protection to those assets. It is equally important that the full range of technical, social, and political procedures be brought to bear through measures of design and construction, land use and siting considerations, and the adherence to standards and regulatory measures.

The priority lays in the development and application of measures rather than in only understanding what should be done. The understanding and acceptance of procedures to encourage or enforce behavior that can provide a greater extent of resilience within a community, as well as the application of existing knowledge and techniques, remain a critical challenge.

Some specific challenges and priorities, which require further attention, include:

- How to deal with already existing, vulnerable building stock, which is impossible to improve or refurbish.
- Need to pay particular attention to informal settlements.
- Need for further efforts by training and academic institutions, supported among others by international development agencies, to support and train engineers and other professionals in disaster-prone countries as a means of enhancing disaster reduction efforts and the broader sustainable development process.
- Development of effective national engineering institutions to accompany governmental efforts in maintaining and enforcing appropriate standards
- Incentives to enforce existing building and construction codes and standards, as well as policies.