Case 4
Geology, Planning, and Geologic Hazards of Coastal Cities in Asia and the Pacific

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Impact of geology on the development of coastal cities in Asia and the Pacific

Introduction

Some parts of Asia and the Pacific are located in areas frequently affected by damaging geological disasters. A geological disaster or catastrophe is the occurrence of a severe hazardous event. A geologic hazard is defined as a geological condition, process, or potential event that poses a threat to the health, safety, or welfare of a group of citizens or to the functioning or economy of a community or larger governmental entity. The part of Asia extending from the Himalayas through the Pacific rim is particularly vulnerable to earthquakes and volcanic eruptions because of the constant movement and collision in the region of lithospheric plates just beneath the surface of the earth. The circum-Pacific "ring of fire" has been the source of more than 50 percent of the earth's eruptions. The volcanoes in this belt tend to erupt explosively and cause more fatalities and property damage than volcanoes in the interior of continents. There seems to be a relationship between the length of preceding inactivity and the volume and violence of the ensuing eruption: the less frequent the eruption, the greater the violence. Most of the region's active the potentially active volcanoes are in densely populated areas where few people living near them are protected by any form of early warning system or contingency plan. The endangered residents may be unaware that a risk exists. Recent work has shown that eruption forecasting can save many lives, since, fortunately, volcanoes in these areas have been shown to behave in a predictable manner. Many potentially dangerous and known violent volcanoes have histories of providing warning signals shortly before they erupt. Volcano specialists can interpret these signals. Volcanic hazard and seismo-tectonic maps have been shown to be useful in the region, although more work needs to be done in this area.

The coastal cities of Asia also have many physical characteristics in common and share the problems of low-lying terrain, such as flooding, extensive and poorly drained backswamp areas, and soft clay soils. Moreover, many of these cities have overexploited their groundwater reservoirs and have introduced sea water into aquifers which once supplied fresh water to city wells. Since groundwater levels have been severely lowered, many of these cities have suffered regional lowering of the land surface or subsidence[1] in response to dewatering and compression of the underlying soft sediments. Cities of Asia continue to experience explosive growth and have outpaced any plans that were originally made for them to supply water, provide drainage, and treat sewage.

Many coastal areas of the region consist of unconsolidated sands and clays, which contain no economic mineral deposits. Geologists have tended to ignore these areas of surficial sediment in favor of the study of hard rocks containing economic mineral deposits. Only in areas of rich alluvial and beach tin placers have detailed studies of these sediments been undertaken, and these few studies are limited in their application to the needs of coastal cities.

Although nearshore and offshore waters have been the focus of intensive studies for decades, coastal plains[2] and deltaic regions have not been mapped in detail. Geology may be only one part of the complex coastal ecosystem, but it affects urban development more than any other single factor. Yet geology is perhaps the most ignored and least understood of the elements of the physical environment of the city—probably because geological data have not been presented in a form that urban decision-makers can use. Also, extensive subsurface investigations in these areas would be relatively costly time-consuming because of the mostly flat areas covered with a thick sequence of soft sediment. Because of the cost, urban development generally proceeds in piecemeal fashion, and geologic data are assembled as needed; no overall detailed geologic assessment has been made. It is only later after the city has sprawled over several hundred square kilometers and suffered flooding, subsidence, groundwater depletion, sea water intrusion, etc., that the geologist is asked to help solve its problems. It is often too late for anything other than partially effective remedial measures.

Elements of coastal urban geology

In assessing the impact of geology on the development of coastal human settlements in the Asian-Pacific region, following are some useful generalizations:

- An assessment of the geologic constraints to development in coastal cities should be considered a progress report. To be effective, the assessment should be updated regularly to account for regular variations in data and their interpretation.
- Many of the world's large human settlements are found in coastal areas of Asia and the Pacific and include the following: Adelaide, Bangkok, Bombay, Brisbane, Busan, Calcutta, Colombo, Chittagong, Dhaka, Fushou, Guangzhou, Hangzhou, Hanoi, Hobart, Ho Chi Minh City, Hong Kong, Jakarta, Karachi, Kobe, Madras, Manila, Melbourne, Nagasaki, Osaka, Perth, Rangoon, Seoul, Shenyang, Singapore, Surabaya, Tianjin, Tokyo, Wellington, Yokohama.
- Most of the larger cities of the South Pacific are located on coastal plains or atolls.
- Several schemes can be used to classify coastal areas: (1) based on the dominant sediment type (for example, rocky, muddy, or sandy); (2) based on the geomorphology (for example, atoll, coast plain, plateau, or mountain); (3) based on the origin of the dominant rock or sediment type (for example, deltaic, alluvial, lacustrine, volcanic, marine, or complex); or based on whether the coastline has been advancing or retreating.
- Any development activity in the coastal area, offshore or onshore, is a potential source of stress to the coastal environment.
- Essential inputs for land use planning in the coastal zone include a knowledge of the baseline conditions in each ecosystem, along with a knowledge of the principles of socioeconomics.
- The effects of geologic processes can be predicted, although the times and magnitude of impact are rarely known in advance.

Applying geology to city and land use planning

From experience, planners can predict which areas of the urbanizing fringe will be most rapidly developed. Corridors (highways and railways) undergo strip development first. Geologists can use traditional techniques to identify which areas of the developing corridor offer the least physical constraints (for example, the right depth to bedrock to avoid potential foundation problems). They can help direct development into areas with adequate water supplies and good drainage. The terrain on which a project is going to be constructed will ultimately affect the cost. The most economical solution should include as much geologic data as necessary to assure the proper design and planning of the project.

Assessing and analyzing available data

In the preliminary stages of project planning and design, the investigation of the area begins with a field reconnaissance and review of all available geologic information from previous studies, boreholes, geophysical investigations, soil engineering tests, and groundwater studies (including logs of existing and abandoned water wells). A documentation map is prepared that shows all sources of available data and the location of the data points and areas already mapped. A complete bibliography of published and unpublished geologic reports is prepared.

If no geologic map yet exists, the area should first be mapped, since this is the single, most import source of geologic information. More time devoted to collecting and synthesizing available data can help avoid costly mistakes and revisions later. Critical analysis of field data relating to bedrock and surficial geology, hydrogeology, and urban mineral deposits is useful for choosing appropriate construction materials.

Geologic data for sites in urban areas

A preliminary report of the site should consider the following information:

- types and locations of bedrock and their structural relationship;
- presence of soluble rocks;
- presence of conditions resulting from intense tropical weathering;
- Quaternary history;
- presence of major faults and their age;
- depth of the bedrock surface;
- depth to the geologic unit suitable for founding piling if no strong units occur at the surface;
- general groundwater conditions in the various terrains and the potential for subsidence and salt water intrusion;
- history of damaging earthquakes within a 100-km radius of the proposed urban development;
- presence of active or Quaternary volcanoes, historic ash deposits, and lahars;
- location of historic soil-flow failure areas within and adjacent to the proposed project activity;
- areas affected in the past by tsunamis, storm surges, landslides, urban floods, and other hazards;
- areas of previous dike failure and tidal flooding, and the probability of various floods in the proposed urban development;
- areas affected by damage from parent materials that yield expansive soils, along with an evaluation of their effect on various types of structures;
- areas with potential for developing building materials, sand and gravel, mineral extraction, and the location of economic placer deposits; and
- location of areas with old mines and abandoned shafts and pits.

Geologic data for mapping urbanizing areas

Thematic mapping and application of basic geology to planning is one method for analyzing and evaluating terrain on an urban basis, so that all unsuitable locations for projects can be eliminated.

Urban geology of four cities in Asia and the Pacific

Bangkok: geotechnical problems of development

Bangkok, the capital of Thailand, has a population of over 5 million. It is situated in the southern part of the Central Plain of Thailand, about 25 km north of the Gulf of Thailand. As of 1980, the metropolitan area covered 472 sq km on the flood plain east and west of the Chao Phraya River where the land is only 0.5-1.5 m above sea level. The explosive growth of Bangkok is evident: in 1900 it covered only 13.33 sq km and in 1958 96.37 sq km. The city relies on a drainage system consisting of canals that were constructed over the last 200 years. Since the 1950s, the growth of the city has led to a rapid lowering of the water table and compression of the clay. This subsidence began to affect drainage, so that during high tides, floodgates were closed on all the major canals to keep salt water out of the klong network. The drainage system could not discharge the water from the floodplain when high tides were combined with heavy rains and strong onshore winds, which made for frequent floods that created health hazards, produced profound damage, and made living and working in the city difficult for one to three months every few years. The city attempts to control urban runoff with a vast system of portable pumps that gradually move the water from one drain or canal to another. Eventually, the water is pumped over the floodgates (during high tides) in the Chao Phraya River.

The urban geology of the city is influenced by a soft, thin (10-16 m), highly compressible marine clay termed Bangkok Clay. Its geotechnical properties present an important geologic constraint to the development of the city. Bangkok is now the most rapidly sinking metropolis in the world, and is approaching a rate of 13 cm per year in some areas of heavy groundwater pumpage. The construction of roads, canals, and rail lines increases the load on the clay. Bangkok has utilized the expertise of various government institutions to assess and mitigate the geotechnical problems associated with development. For example, builders have avoided the problem of compression by preloading the clay before roads and rail lines are constructed or by sinking piling to more stable sand substrata.

Although field evidence of subsidence exists, no estimates of damage can be made yet. Direct evidence was noted when casings for water wells were found to protrude above the ground surface from 0.5-1 m, even though they has been founded in deep sands). Structural damage is evident where city pavement and sidewalks meet buildings that are constructed on deep piling. One cosmetic solution to this problem has been to add a step periodically to the stairs leading into the buildings. Buildings that are connected, but supported by piling driven to different depths, suffer differential subsidence, as evidenced in the cracks in walls and floors where they are linked. Bridges do not subside, but ramps leading to them do, since they are not founded on deep piling. A sharp break in slope occurs where bridge ramps meet streets, which causes a bump to be felt in vehicles using the bridges. This bump becomes worse with time.

With the awareness of Bangkok's geotechnical problems, the Department of Mineral Resources (DMR) is mapping the Quaternary geology in several areas of the lower Central and Coastal Plains of Thailand. This mapping program will provide the necessary geologic input for investigating the problems associated with urban development and land use. Studies are planned on the environment, the geotechnical and geological properties of Quaternary sediments, and the groundwater regime and aquifer characteristics of surficial sediments. DMR will be able to assess subsoil conditions, groundwater availability, mineral resources, drainage patterns, and natural hazards.

In the early 1980s, strict controls on groundwater use were enacted to reduce pumpage. Also, groundwater fees for consumers were introduced. Both actions contributed to lower pumping rates and higher piezometric levels in Bangkok within the first year—both promising signs.

Kuala Lumpur: geological problems of development in the urban center

The geological hazards affecting the development of Kuala Lumpur include the properties of the material beneath the city, such geologic processes as deep chemical weathering or downslope movement, and recent activities in the mining industry. The geological problems related to the development of Kuala Lumpur have been the focus of several geological investigations by the Geological Survey of Malaysia, including hazard investigations which first began in 1917. The tropical climate and high rainfall of Malaysia result in rapid weathering of geologic materials. Natural rock exposures are extremely rare. In Kuala Lumpur,the dominant rock types are (a) the Kuala Lumpur Limestone (containing minor intercalations of phyllite); (b) granites of Mesozoic or younger age; and (c) the Kenny

Hill Formation (consisting of interbedded quartzite and phyllite). Each of these rock types gives rise to a different set of geotechnical problems.

In addition to the thick sequence of weathered material above the bedrock, the lowlands of the city are covered with river alluvium of Quaternary age that masks the bedrock and older weathered regolith. Also, extensive open-cast alluvial mining has left behind ponds and mine pits. The ponds are filled with slime, which must be removed before the pits can be refilled and the land reclaimed. Improper compaction of the material used to refill the ponds is a potential cause of geotechnical problems in some areas.

Cavities and sinkholes are common in the highly irregular bedrock surface developed on the Kuala Lumpur Limestone. Tropical weathering in Malaysia has created some of the most spectacular and extensive networks of caves seen anywhere in the world. Half the city is situated over limestone, which lies at a depth of less than 100 meters. The foundations for older, low-rise structures are footed in the alluvium or in stiff layers within the regolith. The foundations for more recently built, higher-rise structures had to be placed in the bedrock, which called for accurate knowledge of the depth and exact location of the top of the Kuala Lumpur Limestone. Research is under way to develop a methodology for identifying the location, depth, size, and orientation of the cavities by using such techniques as seismic reflection, microgravity, downhole radar, and electromagnetic methods. So far, these techniques have not been refined enough to formulate a precise picture of the top of the bedrock in the limestone area. This information will be useful for planning the growth of the city around this unique and complex set of problems.

As an example of the difficulty in (and necessity for) assessing the depth and location of the top of the limestone, in some building sites, up to 20 holes have been drilled (an expensive and time-consuming program) to define the bedrock surface, although this number is insufficient to locate surface cavities just below the top of the limestone. Several structures have been severely damaged when they were near completion because their loads could not be supported by the cavernous limestone. Construction costs and schedules are often underestimated because of these problems.

The top of the bedrock is difficult to locate in granitic terrain because of the effects of intense weathering that has left huge, residual boulders embedded in the unconsolidated debris derived from the decay of the granite. These blocks are called floaters because they are found well above the bedrock surface. Since construction engineers are seeking firm substrata to anchor the foundations of tall structures, the problem of distinguishing a floater from the real bedrock surface is particularly acute. Buildings that have piling sunk only to the top of a floating boulder may tilt or be structurally damaged as the piling founded on the boulder begins to sink.

The alluvial plain upon which Kuala Lumpur is built was formerly mined extensively for tin placer deposits. Many mining ponds were left behind in the depressions created by the dredges. Reclamation has been carried out in many part of the city, although some of the fill was evidently not properly compacted, since some houses have continued to settle after they were built.

Mining close to populated centers poses several problems in Malaysia. When pits for the mines are dug, the alluvium is dewatered, which draws down the water table in the adjacent limestone areas. This dewatering lowers the strength of the sediment that fills the sinkholes and causes the alluvium in the sinkhole to drain out through the base, which then causes the land surface to collapse. In 1984, this problem caused a row of nine two-story townhouses under construction on reclaimed mine tailings to collapse.

Many other geological characteristics present problems for Kuala Lumpur. On some of the steeper hillsides and beneath cuts, rockfalls and soil flow have occurred. Careless blasting in nearby quarries also contributes to slope instability. Intense rainstorms often cause soil flowage. Heavy rainfall also saturates colluvium and generates semicircular failure planes where cut slopes are more than 10 meters high. Subsidence often occurs in Kuala Lumpur for the following reasons: (a) reduced volume of soil by compaction (air removal) or consolidation (water expulsion); (b) collapsed limestone cavities because of removal of support; and (c) swelling and shrinking clays (because of changes in their water content). Erosion has also caused problems, especially near areas where sand was quarried from the river bottom.

Manila: geological and geotechnical problems of the urban center

The City of Manila, with an area of only 38.56 sq km (6 percent of metropolitan Manila), had a population 1.6 million in 1980. Flooding has always been a major problem in Manila, but since a P 1.5 billion flood control drainage program was launched in 1976, only 4.43 sq km (0.7 percent of the metropolitan area) are floodprone. These areas, however, are heavily populated, and many of Manila's residents annually face substantial losses from flooding.

Manila faces problems associated with overpumping of ground water and intrusion of salt water from Manila Bay into the main aquifers that supply water to 96 wells. Like Bangkok, the groundwater level has dropped below sea level through most of the metropolitan area, and is declining at a rate of 4-10 meters per year. The problems faced by Manila are not unique; well-known techniques are available for modeling groundwater flow systems in cities and evaluating and predicting changes in water quality, declines and water level, and subsidence that occur in heavily exploited areas.

Studies of the geotechnical properties and engineering geology of the metropolitan Manila are just now beginning with detailed mapping of the city conducted by the Philippine Institute of Volcanology. Routine investigations of specific sites of construction in Manila are currently conducted by the Bureau of Mines and Geo-Sciences, Ministry of Natural Resources.

The western edge of the city adjacent to Manila Bay lies on modern deltaic deposits, consisting primarily of unconsolidated silts, sands, and clays. The uppermost unit consists mostly of silty clay with a low shear strength. All these units range from soft to very soft, with low shear strength, and present problems if foundations are improperly designed. Engineers have so far been reluctant to found larger structures on the soft unit of the upper sequence in western Manila. Heavy structures mostly have been founded on piling driven to sands of the deeper and older delta units. Smaller structures can be founded on the soft topset deposits by using a shallow raft, spread, pad, or floating type foundation. Invariably, piling is used where the soft and compressible clay units are very thick.

Sydney: geological problems

The most costly natural hazard in New South Wales is recurrent flooding, followed by damage from landslides and coastal erosion. Sydney lies on a deeply weathered crust covered in placed with younger windblown or fluvial sediments. In other places, the weathered rocks have been stripped away, exposing fresh bedrock. The result is that the rocks of Sydney have a patchwork of geotechnical properties that reflect their various lithologies as well as their weathering and tectonic history. This has affected their rippability and, in turn, construction costs.

Another geological problem stems from the varying permeability of weathered rocks. A large landfill at Lucas Heights, sited on weathered sandstone, has leached polluted water rapidly into the weathered part of the sandstone. The unweathered zone has low permeability and prevents deep migration of the toxic water from the landfill, which restricts such water to shallow depths in the vicinity of the landfill. The geotechnical solution involved placing drains in the weathered zone to collect the undesirable water for treatment.

Several expressways in Sydney have 50- to 100-meter high vertical cuts in the Hawkesbury sandstone. Without proper geotechnical analysis, the steep walls of the highways would have collapsed periodically. The differences in the properties of weathered and unweathered bedrock and the abundance of subsurface openings made construction of the first dams in the Sydney area in the 1950s and 1960s difficult because of the extra excavation and extensive grouting programs that were needed. Hence, few concrete arch dams have been built in Australia since then.

Various problems encountered with tunnels in Sydney relate also to the differences in drainage of the rock at various points along the shafts. Tertiary weathering was so extensive in one case that when access shafts were constructed to reach a tunnel beneath the Sydney rail yards, so much water drained from the weathered shale that pumps had to be installed in the shafts.

Some suburbs and nearby towns have periodic landslides because they are situated on shale of low shear strength and highly slakeable clay. The clay contains a disordered illite that become unstable in the presence of water. Regoliths and colluvium are both unstable in parts of Sydney and are slowly slumping or flowing down the sides of valleys. The weathered material at the surface is lubricated by groundwater leaking from fractures and joints in the underlying bedrock.

Urban geology of some major cities of Asia

Urbanization of Asia and the Pacific

Among the 25 cities of the world with populations expected to exceed 10 million by the year 2000, 14 are likely to be in the Asian-Pacific region: Bangkok, Beijing, Bombay, Calcutta, Dhaka, Hong Kong, Jakarta, Karachi, New Delhi, Seoul, Shanghai, Tianjin, Tehran, and Tokyo. During the last decade, the cities in the region have gone through a period of profound and accelerated transformations, not the least of which were the radical changes in the environment and the hectic pace of life that now exists. The encroachment of the cities onto lands that are unsuitable, even hazardous, has been an unfortunate result of urban growth. Most of the growth has been unplanned and has affected both the national environments and ultimately human life. (For an example from the region, see the case history of Bombay in the box.)

Bombay

Bombay is India's richest and second largest city with a population of 8.2 million (1981 census) and a growth rate of 4 percent a year. It has one of the finest harbors in the world and handles 21 percent of the total exports of India. In its early years, Bombay was situated on a rock island. After its first spurt of growth in 1770, the area between the seven islands was filled in, resulting in the present site of the city. A new area on the mainland—New Bombay—has grown rapidly along the coast since 1970. The water on the island and in New Bombay is insufficient; sources of water have had to be tapped farther and farther away from the city, at greater cost.

After many years of suffering from water shortages and rationing, the Government of Maharashtra constructed two great dams that supply 325 million gallons of water a day to Bombay. Demand was expected to grow to 730 million gallons a day by 1991, again to outstrip the supply. Geology has been used to locate new reservoirs, and to provide the appropriate data and mapping for such activities in the volcanic rock, since it has many permeable zones. The Government of India was the first country in the region to apply the concepts of environmental geology to the planning and development of its large urban areas.

Conclusion

Urban and engineering geologists are needed to help plan human settlements so that geologic hazards can be assessed before development begins. To understand the geological foundations of areas where cities will expand in the next few decades, detailed mapping of Quaternary or surficial sediments is needed. Urban planners will be better able do their jobs with maps that clearly show the hydrologic and geologic constraints to development. The contributions of geologists can be expected to ease the burden on the poor who tend to live in areas more vulnerable to extreme geophysical events, such as earthquakes and volcanic eruptions. Geologists should learn how to present their technical data in a more appropriate way so that nonspecialists can use them. The wise use of geologic information can help improve the quality of life of urban dwellers only if decision-makers recognize its importance.

Notes

1. Subsidence is the gentle lowering of the surface due to the removal of water from the underlying sediments and the subsequent compression of clays in the sequence. This problem is related to the exploitation of groundwater and to the geological characteristics of the underlying sediments. A city founded on rock cannot experience subsidence of this type. A city situated on soft sediments, mostly sand and clay, has a geologic framework that favors profound subsidence.
2. Coastal areas referred to in this case study include the area extending from the shore to about 50 km inland, as well as nearshore coastal waters.

Case 5
International Collaboration for Local Earthquake Response and Recovery Planning

Shirley Mattingly and Valerie Melloff

Mexico City and Los Angeles—both cities vulnerable to earthquakes of major magnitude—have launched a program to exchange knowledge of their respective hazard mitigation, response, and recovery programs. Both cities have historical, cultural, and economic ties, in addition to sharing vulnerability to earthquakes. This vulnerability led policymakers in both cities to initiate hazard mitigation, earthquake response and recovery programs to reduce the threat to life and property from earthquakes. Officials in each city have also been actively seeking out information about such programs in other locales. These factors spurred representatives in the two cities to look to each other for further ways to improve preparedness for emergency response and recovery.

Informal fact-finding visits on the part of officials from both cities evolved into a formal commitment on November 14, 1990, binding both cities to an ongoing cooperative exchange of information from the research and experience of the other city. The agreement moves beyond the simple recognition of the need for an exchange and establishes a multidisciplinary and organizational basis for implementing the process. In a broader sense, the cooperative agreement is significant because it is the first tangible transfer of knowledge between local governments. Both the National Science Foundation and the Federal Emergency Management Agency are interested in the Mexico City-Los Angeles Exchange as a demonstration project for the United Nations International Decade for Natural Disaster Reduction.

A Bilateral Committee, co-chaired by the directors of the Emergency Operations Organizations (EOOs) of each city, was set up to identify and develop objectives, workshops, and programs relative to the needs of each city's EOO. Participants in the exchange will be drawn from a broad range of disciplines involved in planning or managing emergency response or recovery functions. They will be selected on the basis of their specialized skills and ability to contribute to specific exchange topics.

Topics selected for study with Los Angeles reflect Mexico City's determination to establish a cohesive organization for responding to future earthquakes and improving public education and training efforts in this area. Examples of the key preparedness topics for the exchange include the following:

- *Mitigating structural and nonstructural hazards.* What policies, laws, or educational programs are in place to mitigate the effects of earthquakes on seismically vulnerable buildings—including historical buildings—and their contents?
- *Designing and implementing exercises.* How should exercises be designed for testing components of the city emergency response plan, such as the functioning of the emergency operations center and building damage assessment teams, and the way in which the exercises are coordinated?
- *Planning for sheltering.* How does the city organize shelter operations? How are shelters managed?
- *Preparing government employees.* What is the status of the Building Emergency Coordinator Program, employee education and training, floor wardens, city employee response teams, business resumption planning and capabilities for government agencies?

- *Training by business and community organizations.* What are the purpose and function of business councils, such as the Business and Industry Council on Emergency Planning and Preparedness (BICEPP) and Downtown Emergency Preparedness Action Council (DEPAC). Are there training and organization of community and business emergency response teams, and development of systems to track and coordinate volunteers?

Examples of key topics in the area of emergency response include the following:

- *Organizing for preparedness and response.* How should multidisciplinary aspects of planning, coordination, and building be carried out?
- *Delivering medical services.* What emergency medical services are available? What plans are in place for activating and implementing hospital emergency responses?
- *Implementing urban search and rescue plans.* How is the urban search and rescue program set up?
- *Assessing damage.* How should information on damage and situation assessment be compiled and communicated?
- *Disseminating emergency information to the public.* What are the plans to ensure that the media provide the public timely and appropriate information? What is the concept and use of the Emergency Broadcast System?
- *Reestablishing lifelines.* What are the plans for reestablishing utilities and transportation systems, as well as for using and transporting heavy equipment to remove debris?

Mexico City is particularly interested in the multifaceted program Los Angeles has developed over the last two decades to reduce earthquake vulnerability. Highlights of the program include emphasis on developing seismic reinforcement legislation; creating a multidisciplinary emergency response organization; acquiring specialized equipment (such as a mobile emergency operations center; establishing planning partnerships with the private sector; and implementing numerous training programs for government employees, as well as for business and community groups.

In spite of the accomplishments of Los Angeles, the city does not claim to have all the answers. Los Angeles is still working on many basic issues—such as improved coordination, and communications and emergency backup power—some of which seem to afflict responses to disasters in well-prepared, as well as underprepared, cities. Los Angeles is also interested in planning for post-earthquake recovery and reconstruction, and has begun an unprecedented effort in this area. Some unresolved recovery and reconstruction planning issues remain:

- *Integrating the financial, technical, and social aspects of reconstruction and rehabilitation.*
- *Financing recovery privately or publicly.*
- *Coordinating recovery and reconstruction.*

Since Los Angeles is likely to encounter many of the same social problems experienced by Mexico City in the aftermath of the September 1985 earthquakes (for example, thousands of resident may be temporarily displaced), Los Angeles has much to gain from Mexico City's findings after the 1985 earthquakes.

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