

## Chapter 7

### CONCLUSIONS AND RECOMMENDATIONS

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Earthquakes are common occurrences in the Philippines, and those of larger magnitude near population centres have proven destructive and deadly. The lethal earthquake of 16 July was the twenty-fourth in this century. It followed severe earthquakes in southern Mindanao in 1976 and in 1968, and brought the total of resulting deaths to 10,235.

The earthquake of 16 July demonstrated the severe impact that such an event can have on the economy of a region. As the population grows, and investment accumulates in infrastructure and the built environment, the threat of ever-larger losses being inflicted by earthquakes also grows. The recent disaster has highlighted the need to do more to protect the nation's population and investment from future strong earthquakes.

The science of protecting cities and regions from earthquake damage has developed rapidly over the past three decades. Techniques have been developed in other countries that could be used in the Philippines. Few of these techniques, however, are currently being employed locally.

Reconstruction after the earthquake of 16 July raises a number of issues for the rapid recovery of the affected areas, and for protecting both the affected area and other regions of the country from future earthquake damage. The issues fall into three categories:

- Reduction of Earthquake Consequences
- Reconstruction Planning
- Programme Implementation

Conclusions and recommendations, including recommendations for technical assistance, are given for each issue.

#### REDUCTION OF EARTHQUAKE CONSEQUENCES

##### 7.1 Preparedness for Future Earthquakes and Other Natural Hazards

**Issue:** How can the lessons of this earthquake be used in other parts of the Philippines and beyond, and how can the impetus for protection that this earthquake has generated be maintained into the future?

The disaster has illustrated the need for a national capa-

bility to design and implement strategies to mitigate the effects of future earthquakes and other natural disasters. There is a need to establish a programme of systematic data collection to enable mitigation projects to be designed effectively and to understand more fully the hazards faced by the community. Support to national institutions and increased interchange of information and expertise internationally, particularly with other seismically-prone countries of Southeast Asia, would improve the national capability to reduce the effects of future earthquakes and other natural hazards such as typhoons, volcanic eruptions, landslides, tsunamis and floods. The strategies to mitigate the effects of the future earthquakes and other natural disasters should be generated on the following conceptual approaches:

- A shift in emphasis to pre-disaster planning and preparedness and improvement of postdisaster relief and management capabilities;
- An acceptance of an integrated approach to multi-hazard disaster mitigation and development of programmes linking prevention, hazards identification and warning research and preparedness;
- Integration of disaster prevention and preparedness into the national and local planning process;
- Enhancement of organizational strengths and training of specialists to improve disaster mitigation resources;
- Promotion of available technologies and knowledge transfer with continuous implementation in disaster mitigation process taking into account culture and economic capacity of the country; and
- Public education to shift society perspective from passive acceptance of disaster consequences to awareness of the opportunities for disaster mitigation and the role of individuals in protecting themselves.

**Recommendations:** A national institution or administration should be established, either by creating a new body or by expanding the powers of the present National Disaster Coordinating Council to cover physical planning, engineering standards and professional education standards related to earthquake impact mitigation. This body should be capable of providing support and guidelines to regional development councils, national authorities, rapid development of existing and establishment of new research and educational institutions. Particular attention should be given to the establishment of scientifically consistent data base on the effects of the earthquake of 16 July 1990 and rapid training of the practicing engineers, national and local government specialists and decision-makers for rational execution of the reconstruction programme and risk mitigation of earthquakes and other natural hazard in the earthquake stricken region and gradually entire country considering its inten-

sive and frequent exposure to natural /disasters.

## **7.2 Strategy for Earthquake Disaster Management:**

**Issue:** How to create rational and efficient strategy in earthquake disaster management by strengthening of existing capabilities in the country and transfer of developed technologies and knowledge available on international level.

Based on the conceptual approach for multi-hazard and integrated risk mitigation process for natural disaster, earthquake disaster management should be based on the following steps:

- Earthquake Monitoring;
- Earthquake Hazard Analysis and Mapping;
- Vulnerability and Earthquake Risk Assessment;
- Earthquake Risk Mitigation Through Implementation of Engineering Measures, Land Use and Development Planning, Legislation, Quality Control and Insurance;
- Public Information and Education.

### **Recommendations:**

**a. Earthquake Monitoring:** Further improvement of existing seismological stations network by implementation of telemetered and computerized systems. Planning and installation of strong motion instruments network in the country. Urgent operational upgrading of the existing strong motion instruments in the country and installation of strong-motion instruments arrays in Baguio, Dagupan and small size network in the affected area by the earthquake of 16 July 1990.

**b. Earthquake Hazard Analysis and Mapping:** The segment of the Philippine/Digdig Fault system which ruptured to produce the July 16, 1990, Luzon earthquakes is not likely to produce an earthquake of comparable magnitude for many years. However, other segments of the same fault system, and of subduction zones beneath the Philippines, will produce earthquakes of various magnitudes in future years. To estimate the likelihood of earthquakes themselves, the historical record needs to be supplemented by geologic studies of prehistoric ruptures. Such work would define segments of the Philippine Fault system that are likely to produce individual earthquakes and estimate the recurrence frequency of various size earthquakes along each segment. To assess seismic wave propagation and local site effects, topography and local geology need to be related to the distribution of damage and to strong motion ground acceleration during earthquakes.

All of the preceding information can be incorporated into seismic hazard maps--indicating expected intensities and accelerations of future ground shaking, plus areas subject to liquefaction and earthquake-induced landslides. Such maps provide the basic information needed by engineers and planners to strengthen buildings, infrastructure, and life-

lines to withstand future earthquakes, and needed to focus efforts to increase public awareness of earthquake hazard and how earthquake losses can be minimized. Earthquake hazard mapping usually begins on a national scale (earthquake sources have already been mapped by PHIVOLCS), and then shifts to more detailed mapping of individual provinces, cities and municipal areas. Mapping at a scale of 1:250000 would be a useful and practical scale at which to prepare the first comprehensive seismic hazard maps of the Philippines.

It is recommended urgent elaboration of preliminary seismic zoning map of Luzon and preliminary seismic land capability maps\* for the Baguio City and Dagupan City and their surrounding area of interest for their development planning (e.g. BLIST). Full support should be given to the national institution (PHIVOLCS and other) and assured international assistance for this rather urgent and very important task in order to assure adequate protection level of the new investments allocated for realization of the reconstruction plan.

Further elaboration of seismic zoning map of the country and seismic land capability maps of the most affected and other cities and metropolitan areas should be elaborated in accordance with the capacity of the existing and newly created national institutions and recognized needs by national and local

- c. **Vulnerability and Earthquake Risk Assessment:** Collected earthquake damage data on transportation systems and some of the lifelines are well documented. In most of the affected towns and cities available damage data on buildings and structures are not consistently documented. Their presentation is suitable only for implementation of safety measures and making decisions for demolition of hazardous buildings.

It is recommended to collect detail data implementing adopted uniform methodology for earthquake damage assessment and established data base on earthquake damage buildings and structures at least for Baguio, Dagupan and other most affected cities and towns by the earthquake of 16 July 1990. This is particularly important for development of vulnerability functions of buildings by structural types for specific site conditions and their implementation in earthquake risk analysis and assessment of earthquake damage potential in urban areas as discussed under 7.b recommendation.

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\* Seismic land capability map should be synthesis map of the expected vibrational effects, land instabilities (e.g. liquefaction potential, landslides, rockfalls, subsidence) and earthquake damage potential of existing elements at risk for a return period of 200 years. The map elaboration should be based on engineering geology, hydrogeology and geotechnical maps of the considered area, detail seismic zoning map and vulnerability analysis of existing elements at risk (buildings, transportation systems, lifelines, etc).

**d. Earthquake Risk Mitigation:** In order to assure implementation of uniform level of safety as acceptable level of seismic risk within execution of the reconstruction plan it is recommended to prepare urgently an Emergency Interim Building Code with guidelines for repair and strengthening of earthquake damage buildings. Revision of existing National Building Code should be considered within short period of time (including CE structures, e.g. roads, bridges, lifelines) and elaboration of seismic zoning map of the country.

Other measures for earthquake risk mitigation considering legislation, design and construction quality control, development planning, etc. should be developed as well in order to assure proper implementation of the considered strategic approach (7.1).

### **7.3 Professional Familiarity with Earthquake Protection Techniques**

**Issue:** How can the appropriate professionals be made aware of earthquake risk to encourage the use of protection methodologies in reconstruction planning and implementation?

The awareness of earthquake risk and an understanding of the effects of earthquakes are prerequisites for successful design of future protection. A knowledge of techniques that have been applied elsewhere is critical to the design of appropriate measures. Many Filipino professionals (city administrators, engineers, building contractors) have not had an opportunity to become familiar with earthquake risk and established protection techniques. Furthermore, the general public is relatively unaware of earthquake risk. A broad understanding of the issues is critical to public endorsement for risk mitigation activities.

**Recommendation:** A Technical Assistance programme should be used to help professionals in the Philippines acquire information and benefit from the experience of their counterparts from other countries. A general public information and education project should be undertaken to provide content and coverage guidance for news and entertainment media.

### **7.4 Capabilities for Implementation of Protection Plans**

**Issue:** How to maximize capability for implementation of protection plans given current legal and administrative structures?

Even the best disaster protection plans will be useless without effective implementation. The damage in Baguio City and elsewhere indicates that despite the earthquake building codes, the design and construction standards were not utilized as effectively as they might have been. The policing of building permits, construction quality, and other ele-

ments of municipal regulations are critical to the protection of the city.

**Recommendation:** The government (body recommended in 7.1 above) should undertake a full review of methods and resources needed to implement disaster protection plans. Baguio and Dagupan should be used as case studies. This review should include legal structures, building permit authorization procedures, staffing levels, and skill availability. Recommendations should be made as appropriate, for revisions to procedures, manpower authorizations, and legal regulations.

### **7.5 Multi-Hazard Mitigation**

**Issue:** The earthquake-affected area also suffers from typhoon hazards, flooding risks and other natural disasters. How can the reconstruction and development make the region safer against all hazards?

In addition to being hit by earthquakes, the area is also subject to typhoons, flooding and other natural hazards. The reconstruction should create a physical environment that is less prone to damage from such threats. An integrated approach to multi-hazard protection should be adopted.

There are a number of differences in the effects and protection measures that are needed to combat the different agents of hazard. For example, earthquake forces typically damage masonry and poorly constructed reinforced concrete buildings. Strong earthquakes also damage infrastructure. Typhoons, by contrast, wreak their strongest havoc on lighter structures, lifting off roofs and pulling away cladding, with their greatest impact on the housing sector. Flooding is principally a site-related hazard.

An integrated approach to risk reduction would define each of the agents of natural hazard and their associated effects, and the appropriate protection strategy. The vulnerability to each hazard would be defined for the building stock, infrastructure and economic systems of the region. A database of building stock, physical infrastructure and economic systems in the region could be designed to allow protection measures against each hazard to be evaluated so that an integrated plan for multi-hazard protection could be developed.

**Recommendation:** A multi-hazard protection plan should be developed using a database of the building stock, physical infrastructure and economic systems in the region. The vulnerability to each element at risk to each of the hazards should be defined. The risk (probability of loss) should be defined for each sector and geographical area. Protection plans should be drawn up prioritizing investment for maximum reduction in threat to life, structures, and economic production.

## **RECONSTRUCTION PLANNING**

### **7.6 Strategic Policy for Reconstruction and Development**

**Issue:** How can the reconstruction efforts be used to revitalize economic productivity?

The government reconstruction plan recognizes the importance of revitalizing the economy of the region as a prerequisite for full recovery. A strong economy with the financial capacity to build strong structures is the best defense against major losses in future earthquakes. It is important to establish a coherent strategy with explicit objectives for prioritizing reconstruction projects, and for dealing with the conflicting demands on limited resources. The assumption that resources should be used to repair elements that were damaged - i.e. to rebuild the pre-earthquake status quo - should be balanced against the option of using the available resources to restructure the system in a manner that solves old problems and supports new development.

The better the economy of the region is understood, the better the decisions that can be made to facilitate economic recovery. It is particularly important to analyze the relationships between labour, the different economic sectors, regional development, and infrastructure investment.

**Recommendation:** The National Economic Development Authority should design a strategic plan for the reconstruction and development of Regions I, II, III and the CAR as an integrated area. The plan should provide guidelines to be used in assessing the priority of individual projects proposed from the individual regions. Technical Assistance should be used to acquire the benefit of experience in other countries in post-disaster development planning. The use of microcomputers in data processing for planning purposes would be particularly helpful.

### **7.7 Programme for Regional Transportation Network**

**Issue:** The proposed investment of \$32.25 billion in transportation infrastructure in the earthquake-affected region represents a major opportunity for regional economic development. How can it be targeted strategically to maximize benefit to the region?

Taking as an example the massive road reconstruction element of the recovery and development plan, it is important that this be planned within a strategic framework. If the reconstruction of the roads is planned from the outset with a full understanding of the regional transportation network, the distribution of traffic flows between markets and production centres, and how this is likely to evolve in the future, then the programme can be designed for maximum economic recovery and future development.

From this point of view, it is important that the terms of reference for the reconstruction planning - i.e. the prioritization of road repair and rebuilding projects - should reflect a strategic multi-regional perspective. The economic system that the damaged roads are serving connects the agriculturally productive regions of Northern Luzon with their major markets in Metro Manila via the industrial and service node cities of Baguio, Dagupan, San Fernando and others. The municipal of Kayapa in Nueva Vizcaya for example, produces vegetables for transport through Baguio to the Metro Manila market. The earthquake cut off local access as well as access out of the region. As a result, several months after the earthquake it still has not recovered. A strategic programme of road development for the entire area is needed. This will require more than just repair of earthquake damage; more than just combining the road repair needs of the separate regions involved. What is required is an integration of transport needs for the whole economic system.

**Recommendation:** Transportation infrastructure projects should be planned within the context of a regional development strategy, taking Northern and Central Luzon as the economic area to be considered. Urban growth, industrial expansion, agricultural production, and service sector development should be analyzed. Future traffic flows should be projected, and an overall plan for a transport system to support regional development should be proposed. Repair and new construction needs should be assessed within this regional development framework. During the planning phase (estimated duration 6 months) repair work for restoration of function should continue on vital linkages, but upgrading projects should await the design of the regional strategy.

#### **7.8 Planning Urban Development: Strategic Planning vs Master Planning**

**Issue:** The urban areas of the Philippines are growing rapidly. How can their development be planned in a manner that responds to changing conditions?

Earthquake hazard is regional in nature rather than localized to an individual town or city. The strategic approach needed to reduce the risk of a future earthquake disaster is necessarily regional rather than urban. The 16 July earthquake demonstrated the vulnerability of regional linkages and networks of transportation infrastructure. Prior to the earthquake, Baguio had evolved into a national centre for higher education. The concept of land use planning tends to be static in nature, and does not provide for evolving contingencies such as these. A more dynamic, responsive, strategic approach is required. The urban masterplan has to be seen as one element in a much broader strategy to reduce future earthquake impact on the region and to guide urban development.



**Recommendation:** Urban planning should be made a dynamic process guided by a set of strategic objectives. The objectives should be reviewed as part of the annual budget process, and thoroughly updated at least once every five years.

### **7.9 Managing Urban Development**

**Issue:** Earthquake-protection planning in urban areas requires more complex urban management techniques than conventional land-use masterplanning. How can these changes be incorporated into planning procedures?

The standard procedures for urban planning currently in use do not lend themselves very easily for disaster protection planning. The emphasis is on land-use zoning. Earthquake protection relies more heavily on building stock management processes in which the types of building and strength of the built environment are more important than the functional activities they house. Protection planning focuses on changing construction types. Some conventional planning concepts, such as density of land development, building height controls and siting of key installations are valid, but may be less effective than building stock management.

**Recommendation:** A set of guidelines for urban planners should be developed to incorporate building stock management techniques into the planning process. Such techniques include differential property taxation, planning dispensations, control of utilities supply, deconcentration of facilities, strengthening of key buildings, and disaster access route planning. These should be developed within a framework of seismic risk analysis in which building stock information, ground condition mapping, and expected earthquake shaking levels are used to assess areas and building types most at risk. A methodology for planning the most protection measures for various cities should be developed through pilot studies in Baguio and Dagupan.

### **7.10 Metropolitan Concepts in Urban Development Planning**

**Issue:** Several cities have outgrown their administrative boundaries and urban development is spilling over into adjacent municipalities. Given the autonomy of decision-making authority in each city and municipality, the issue is how to coordinate urban development over an area that covers several administrative units.

Urban development plans need to be carried out on the basis of urban systems which often cover more than one administrative unit. In the cases of Baguio and Dagupan and other towns in the earthquake affected areas, the urban areas of these rapidly developing cities have outgrown their administrative boundaries. The expansion of the planning framework to encompass a metropolitan area, involving several municipalities together, is needed. This approach is already being explored in the concept of BLIST involving Baguio City

and four adjacent municipalities. This is to be encouraged. Resistance to the metropolitan concept from the satellite municipalities arises from a fear of loss of sovereignty. This might be overcome by some sort of federal-type metropolitan administrative structure.

**Recommendation:** A system for metro-area development planning should be created to address needs that extend across administrative boundaries. The system recognizes the individuality of separate administrative units, while simultaneously providing for the development of large scale systems.

#### **7.11 Water Resource Development in Cities**

**Issue:** The continuous growth of urban areas, including the earthquake-stricken cities of Baguio and Dagupan, require an increasing supply of water. How can reconstruction be used to improve the obvious lack of water supply in these cities?

The insufficient water supply in Baguio and Dagupan as well as many cities in developing countries is caused, in part, by the constraints of planning within formal administrative boundaries. This has prevented the tapping of water resources in the immediate vicinities of these cities, those which are beyond the city governments' territorial jurisdictions. There is a need to plan integrated water supply and distribution networks for a greater functional settlement area. One network, for example, could include Dagupan and nearby municipalities and share water resources among them. These networks should avoid relying on one or two critical supply or distribution lines. They should be designed in a manner which minimizes the chances for total disruption in the event of an earthquake by spreading critical supply and distribution functions throughout the network.

**Recommendation:** The reconstruction effort should consider rebuilding the water supply and distribution network of Baguio, Dagupan and their immediate vicinities so that existing water resources are utilized more efficiently. The network should be designed in such a way that damages caused by future earthquakes or any single part of the network will not be totally disruptive.

#### **7.12 Emergency Interim Building Code**

**Issue:** Time pressures for reconstruction conflict with the need for careful study and planning for a safe future.

The City of Dagupan has placed a moratorium on the reconstruction of buildings that have been condemned. The objective is to prevent the building of unsafe structures before a decision has been made on the viability of the current city centre and alternative locations for development. This is also, however, preventing businesses from operating and is slowing the recovery of the economic activity in the town. The pressures on the municipality to allow rapid

reconstruction conflict with the/need to study the problem in order to make the city reconstruction safer in the long term. Studies of safety needs and protection planning will take time.

**Recommendation:** An emergency interim building code should be developed to allow individuals who wish to rebuild immediately to do so. The interim building code should be strict enough to ensure that regardless of the outcome of the subsequent planning process, the new buildings will be in compliance with the plan. This will give property owners who are willing to pay the premium for a superior grade of construction the opportunity to proceed immediately without prejudicing the future safety of the city. It will also allow planners to proceed with their work without being pressured by rapid reconstruction.

## **PROGRAMME IMPLEMENTATION**

### **7.13 Use of Local Building Companies**

**Issue:** How can local development be stimulated by the use of local building companies for government construction projects?

A large portion of the government reconstruction budget will be spent on construction contracts for small/medium sized projects. If awarded to local companies employing local labour, the funds will be recycled directly into the local economy. The labourer spends his wages at the local shops and the money invested in the reconstruction benefits both building labourer and shopowner.

There are, however, barriers to awarding contracts locally. These may include perceptions of limited local capability, skills and equipment. Standard government procurement methods typically require financial guarantees, or large volume performance experience that may make smaller operators ineligible. Larger contractors based in Manila or other large urban centres are likely to have more skills and be better placed to take advantage of contract awards. If, however, a large proportion of contracts are taken by outside contractors, the investment resources will flow out of the affected region, and the possibility of using the reconstruction budget to revitalize the local economy will be greatly reduced.

**Recommendation:** A practice should be established for the government to use locally-based contractors for reconstruction projects. Government procurement procedures may need adjustment. Also, assistance may need to be offered to expand local contractor capability. A compromise could be a requirement for larger contractors based outside the region to employ locally or use local sub-contractors, although such procedures are usually much less successful.

#### **7.14 Integrated Plan for Building Materials**

**Issue:** The planned reconstruction and development programme will require a large supply of building materials. How is this to be met without increasing the nation's balance of payments deficit?

The large volume of construction activity envisaged in the reconstruction and development programme, amounting to some P43.6 billion, implies a massive consumption of building materials. Part of the planning for the reconstruction effort must include a logistical examination of materials procurement. It would be preferable for building materials to be obtained locally where possible, and nationally where not. It is important that reconstruction exacerbate the national trade deficit as little as possible. There may be some flexibility in the choice of materials used for some projects, and a locally manufactured material should be used in preference to an imported if possible. Expansion of current manufacturing output of certain materials may be possible in existing plants, and it may be possible to establish new materials manufacturing plants to accommodate the expanded demand. Small-scale building materials manufacturing processes can often be established rapidly and may give additional benefits to the affected communities.

**Recommendation:** An integrated plan for building materials supply should be developed for reconstruction needs. The plan should examine the expected materials need, and explore the flexibility of demand, timescale, quality and choice of material for the proposed projects. The current production levels of each material regionally and nationally should be reviewed, and the possibility of increasing production from existing facilities and establishing new facilities should be explored. The potential for small-scale production of materials to satisfy some construction needs should be evaluated. Imported materials should be used only when national supply is not possible.

#### **7.15 Straightening Tilted Buildings Using Local Companies**

**Issue:** Several of the tilted buildings in Dagupan and other areas could be straightened and rehabilitated at a lower cost than demolition and reconstruction. The problem is how to acquire the technology.

There are many buildings in Dagupan City that have suffered differential settlement as a result of ground liquefaction or softening. They are now leaning, but otherwise structurally sound. Techniques exist for straightening tilted buildings by excavating below foundation level, reinforcing the foundation structure and jacking in stages. This technique is far less expensive than demolishing and rebuilding the structure. The skills and expertise are available in Japan and Europe, but it would be preferable for work to be carried out by Filipino companies for developmental reasons.

**Recommendation:** Technical assistance should be provided to help with technology transfer of engineering techniques for building straightening to selected Filipino construction companies.

#### **7.16 Special Training for Building Contractors**

**Issue:**

The earthquake caused very little damage to the traditional timber framed houses popularly found in the Philippines. The greatest damage was caused to poor quality concrete framed buildings. Significant intermediate levels of damage were inflicted on the more recent houses built in reinforced concrete by local contractors without engineering design. The building damage suggests that building contractors in the region have little experience in designing reinforced concrete for earthquake resistance, and that they need a better understanding of the engineering and construction principles involved. The gradual changes occurring in the residential building stock by increasing preference for concrete houses means that if contractors do not acquire the necessary knowledge, the building stock will become more vulnerable to future earthquakes.

There is a need for training programmes for building contractors to help them improve the quality of reinforced concrete design and construction. This should be practical training for supervisors in local construction companies, giving information on earthquake forces and basic guidelines on good practice for building earthquake-resistant structures. This could be coupled with contractor training courses on building typhoon-resistant structures and on siting guidelines to minimize structural damage from ground failures.

**Recommendation:** A programme to train small building contractors on disaster resistant construction techniques should be established. The programme would consist of very short (one to five days) courses on specific building techniques. Appropriate audio visual materials would be prepared and utilized in the training.