United Nations Centre for Human Settlements (HABITAT)

Expert Mission to Assist in Reconstruction and Development After the Philippines Earthquake of 16 July 1990

PHI/90/F01

Appendix I

MISSION DIARY

Monday 26 Nov	Morning - meetings UNDP, set up office for mission team. Afternoon - meeting NEDA 15:00 Evening - meeting PAGASA (Roman Kintanar, et.al.)
Tuesday 27 Nov	Morning - meeting HUDCC 09:00 Afternoon - Meeting PHIVOLCS 13:30 Evening - meeting World Bank (Brian Taylor,et.al.)
Wednesday 28 Nov	Morning - meeting DPWH 09:00 Afternoon - meeting Presidential Task Force 14:00 (Mr. Singson)
Thursday 29 Nov	Review literature, data and information. (see Appendix IV - References and Reports)
Friday 30 Nov	Public Holiday Review literature, data and information. (see Appendix IV - References and Reports) Brian Taylor, World Bank 12:30
Saturday 1 Dec	09:00 Drive Manila to Baguio through affected area Burnham Hotel, Baguio
Sunday 2 Dec	Tour of Baguio DL Arrives Manila 22:45

Monday 3 Dec	DL drives Manila to Baguio with Arturo Corpus Review of Baguio Masterplan Tour area surroinding Baguio
Tuesday 4 Dec	Breakfast NEDA and Baguio planning officials Training Seminar Baguio a.m. Travel to San Fernando through affected area p.m. Meet with NEDA officials in San Fernando
Wednesday 5 Dec	Dagupan Tour Meeting with Mayor
Thursday 6 Dec	Review of Dagupan Masterplan Tour San Fernando Port facilities
Friday 7 Dec	Training Seminar Dagupan a.m. Return to Manila p.m.
Saturday 8 Dec	Identification of potential technical assistance needs
Sunday 9 Dec	Begin Preparation of Technical Report
Monday 10 Dec	Meetings with Potential Project Counterparts to discuss possible technical assistance support
Tuesday 11 Dec	9:00 NEDA Training Seminar Manila 15:00 Meeting with NEDA Officials
Wednesday 12 Dec	Meeting with UNDP Resident Representative Report chapters by IA/AC completed Draft technical assistance proposal (PFF) AC Departs 13:15 CX900
Thursday 13 Dec	Complete discussion draft technical assistance Proposal IA departs 17:30

Friday 14 Dec	Collect statistical data Draft maps and figures for report
Saturday 15 Dec	Process statistical material
Sunday 16 Dec	Coordinate drafting of inputs to Technical Report and annexes
Monday 17 Dec	Writing of Technical Report
Tuesday 18 Dec	JP to Dalton Pass area Finalization of data Writing of Technical Report
Wednesday 19 Dec	Completion of Technical Report
Thursday 20 Dec	Presentation of Technical Report to NEDA
Friday 21 Dec	Discussion of Technical Report with NEDA and incorporation of suggestions
Saturday 22 Dec	DL Departs 08:00 PR300 JP Departs 20:25 LH745

IA = I. Armillas
JP = J. Petrovski
AL = A. Coburn
DL = D. Lewis

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Appendix II

PERSONNEL DIRECTORY OF MISSION

PROFILE OF MISSION MEMBERS

Ignacio Armillas, Project Leader
Coordinator, Unit III, Asia and Pacific TCD
United Nations Centre for Human Settlements (HABITAT)

Urban Planner specializing in physical planning in earthquake-prone areas and currently Coordinator of the Asia and the Pacific Unit, Technical Cooperation Division. Previously Chief Technical Advisor on the United Nations project 1986-88 on reconstruction and mitigation planning in Mexico City following the 1985 earthquake.

UNCHS (HABITAT) has been involved in providing international technical assistance in earthquake reconstruction and seismic risk mitigation projects since its inception in 1978. Reconstruction and earthquake mitigation projects carried out through HABITAT include assistance after earthquakes in Yemen, Algeria, Mexico, Ecuador and more recently in Iran.

Prof. Jakim Petrovski
Institute of Earthquake Engineering and Engineering Seismology
Skopje University, Yugoslavia

Earthquake Engineer with 27 years of experience in urban and regional seismic risk assessment and mitigation planning. An eminent international figure in the field of earthquake risk mitigation, he is now one of the expert group members planning the International Decade of Natural Disaster Reduction. Currently Rector of Skopje University, and Executive Vice President of the International Association of Earthquake Engineering, he is involved in many international consultancy projects on regional seismic risk and earthquake reconstruction.

The Institute of Earthquake Engineering and Engineering Seismology at Skopje University, Yugoslavia is one of the leading international institution in the field of earthquake engineering and seismic risk analysis. Founded in 1963 with assistance from UNCHS following the earthquake in Skopje that year, the Institute now provides training for students, professionals and disaster managers from around the world and carries out international consultancy projects.

Dr. Andrew Coburn
The Martin Centre for Architectural and Urban Studies
University of Cambridge, United Kingdom

Architect/Planner specializing in earthquake protection planning and vulnerability of non-engineered buildings. Past experience of earthquake recovery in Italy (1980), Turkey (1983), Yemen (1982), Mexico (1985), Greece (1986), Iran (1990). Earthquake damage survey experience in a large number of events. Dr. Coburn's Ph.D. is in Housing Policy for Earthquake Mitigation. He is currently working on the book Earthquake Protection Planning, due for publication by John Wiley & Son in 1991.

The Martin Centre for Architectural and Urban Studies is a research institute of the University of Cambridge, England, specializing in land use and and built form studies, building materials and earthquake protection planning. The Martin Centre has developed considerable expertise in regional planning for earthquake protection, developing worldwide databases on earthquake damage and empirical vulnerability of housing and non-engineered buildings. The Martin Centre provides consultancy through Cambridge Architectural Research Ltd., a private consultancy company of which Dr. Coburn is a Director.

Dr. Arturo G. Corpuz
School of Urban and Regional Planning
University of the Philippines

Regional Planner specializing in regional transportation and land use in developing countries. Dr. Corpuz's Ph.D. is in transportation and regional development in Luzon. Consultant of the National Land Use Committee in the formulation of Regional and National Physical Framework Plans for the Philippines. Expertise in housing policies, Southeast Asian urban and regional histories, and statistical analyses of population distributions.

The School of Urban and Regional Planning at the University of the Philippines is the leading urban and regional planning institution in the Philippines. The school provides training for students and professionals engaged in various fields of planning and consultancy services to public sector development- and planning-oriented programs.

Dr. David Lewis
Associate Professor and Chairman, Department of City and Regional Planning,
Cornell University, USA

Regional Development planner specializing in project design and program management in developing countries. Previous experience in the Philippines on community development program and village self-help projects in rural areas. Long term advisory responsibility for regional development planning in Jordan, Pakistan, and Kenya. Expertise in small industry development, housing finance, technology transfer, and quantitative analysis for regional planning.

The Department of City and Regional Planning at Cornell University, Ithaca, New York, USA, has extensive international experience in development planning and in planning for hazard and risk mitigation.

INDIVIDUALS CONTACTED

UNDP, Manila

Mohammed Farashuddin
Deputy Resident Representative
United Nations Development Programme

Khalid Bouzerda
Assistant Resident Representative
United Nations Development Programme

Christian Newman
Country Director
United Nations Industrial Development Organization

Edwin Sangoyo
Programme Officer
National Office
United Nations Development Programme

Ms. Fe Tupas
Programme Officer
United Nations Development Programme

National Economic Development Authority

Dr. Romeo A. Reyes
Assistant Director-General
National Economic Development Authority

Remigio A. Mercado
Land Use and Physical Planning Division
Regional Development Coordination Staff
National Economic Development Authority

Meeting Monday 26 November at NEDA

Dr. Romeo A. Reyes
Assistant Director-General
National Economic Development Authority

Marcelina E. Bacani
Director III, Regional Development Coordination Staff
National Economic Development Authority

Remigio A. Mercado
Land Use and Physical Planning Division
Regional Development Coordination Staff
National Economic Development Authority

Joseph Alabanza
Regional Director
Cordillera Administrative Region

Leo Quito
Regional Director
NEDA Region 01

Catalano S. Boquien, jr
Regional Director
NEDA Region 02: Cagayon Valley

Brian H Taylor
World Bank Consultant

Marilu Alferez
Director, Housing and Urban Development Coordinating Council

Crispin B. Banaag jr.
Planning Officer IV, Planning Service
Department of Public Works and Highways

Raymundo S. Punongbayan
Director, Philippine Institute of Vulcanology and Seismology
Department of Science and Technology

Ernesto M. Serote
Assistant Professor
School of Urban and Regional Planning, University of Philippines

Arturo G. Corpuz
National Land Use Committee
School of Urban and Regional Planning
University of the Philippines
(Consultant to National Economic Development Authority)

Evening Meeting Monday 26 November

Roman L. Kinitar
Director-General
Philippine Atmospheric Geophysical and Astronomical Services Administration

Rolando G. Valenzuela
Philippine Atmospheric Geophysical and Astronomical Services Administration

Lolita Garcia
Philippine Atmospheric Geophysical and Astronomical Services Administration

Meeting at HUDCC Tuesday 27 November 09:00

Elpidio G. Damaso
Secretary-General
Housing and Urban Development Coordinating Council

Alistair Blunt
Chief Technical Advisor
Project on Shelter Strategy for Low-Income Housing
UNCHS

Meeting at PHIVOLCS Tuesday 27 November 13:50

Raymundo S. Punongbayan
Director
Philippines Institute of Volcanology and Seismology

Ronnie C. Torres
Senior Science Research Specialist
Philippines Institute of Volcanology and Seismology

Jesse V. Umbal
Senior Science Research Specialist
Philippines Institute of Volcanology and Seismology

Ronaldo A. Arboleda
Senior Science Research Specialist
Philippines Institute of Volcanology and Seismology

Rolly E. Rimando
Senior Science Research Specialist
Philippines Institute of Volcanology and Seismology

Gemme F. Ambubuyos
Seismic Instrumentation Specialist
Philippines Institute of Volcanology and Seismology

Arturo S. Daag
Geologist
Philippines Institute of Volcanology and Seismology

Ma. Leonila P. Bautista
Geologist
Philippines Institute of Volcanology and Seismology

Glenda M. Besana
Geologist
Philippines Institute of Volcanology and Seismology

Meeting with World Bank Tuesday 27 November 19.30

Brian H Taylor
World Bank Consultant

Basilis Dimitriou
Desk Officer, Education Sector
World Bank

Kirkland Abrams
Architect, Education Sector
World Bank Consultant

Meeting at DPWH on Wednesday 28 November 09:00

Manuel M. Bonoan
Assistant Secretary for Planning
Department of Public Works and Highways

Leonardo Nunez
Director, Bureau of Maintenance
Department of Public Works and Highways

Francisco N. Pascual
Director, Bureau of Design
Department of Public Works and Highways

Meeting at Presidential Palace, Wednesday 28 November 14:00

Rogerio Singson
Assistant Secretary
Presidential Task Force for Earthquake Reconstruction

Field Trip to Earthquake-Affected Regions, 1-7 December

Remigio A. Mercado
Land Use and Physical Planning Division
Regional Development Coordination Staff
National Economic Development Authority

Ruben Mercado
Land Use and Physical Planning Division
Regional Development Coordination Staff
National Economic Development Authority

Ernesto M. Serote
Assistant Professor
School of Urban and Regional Planning, University of Philippines

Arturo G. Corpuz
National Land Use Committee
School of Urban and Regional Planning
University of the Philippines
(Consultant to National Economic Development Authority)

Baguio City, 1-4 December

Joseph Alabanza
Regional Director, NEDA
Cordillera Administrative Region

Jaime R. Bugnosen
City Mayor, Baguio City

Antonio Tabora jnr.
Vice Mayor
Baguio City

Mac B. Flores
City Planning and Development Coordinator
Baguio City

Leo Bernardez jnr.
Building Official
Baguio City

Leonardo De La Cruz
City Administrator
Baguio City

Arturo L. Orig
Planning Officer III
Zoning Officer, Deputy Zoning Administration
Baguio City

Juan M. Espinosa jnr.
Engineer II
City Engineers Office
Baguio City

Alberto A. Mayo
Engineer II
Dept of Public Works and Highways
Baguio Sub-District

Carmel P. Chammag
Senior Economic Department Specialist
NEDA Regional Office, Cordillera Administrative Region

Meeting at NEDA Regional Office, San Fernando, La Union 4 Dec.

Leo Quito
Officer In Charge,
NEDA Regional Office, Region 01

Inspection of San Fernando Port, Thursday 6 December

Silverio D. Mangaoang
Manager, Port Services Division
San Fernando Port

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Appendix III

TRAINING SEMINAR ON
EARTHQUAKE RECONSTRUCTION,
SEISMIC RISK AND VULNERABILITY REDUCTION
Presented:
BAGUIO CITY, 4 December 1990
DAGUPAN CITY, 7 December 1990
MANILA, 11 December 1990

Materials Prepared for Distribution to Participants

TRAINING SEMINAR FOR REGIONAL OFFICIALS IN CHARGE OF EARTHQUAKE RECONSTRUCTION

SCHEDULE

09.00 Introduction and Welcome
Regional Director of NEDA

09.15 Integrating Seismic Mitigation Concepts into the Planning Process

Dr. Ignacio Armillas, Project Leader
Coordinator, Unit III, Asia and Pacific TCD
United Nations Centre for Human Settlements (HABITAT)

10.00 Earthquake Damage, Seismic Hazard and Vulnerability

Prof. Jakim Petrovski
Institute of Earthquake Engineering and Engineering Seismology, Skopje University, Yugoslavia

10.45 Coffee Break

11.00 Earthquake Reconstruction and Future Protection

Dr. Andrew Coburn
The Martin Centre for Architectural and Urban Studies
University of Cambridge, United Kingdom

11.45 Regional Planning Issues in Earthquake Mitigation

Dr. David Lewis
Associate Professor and Chairman Urban and Regional Planning
Cornell University, USA

12.30 Discussion

13.30 Demonstration of SISMA Seismic Risk Computer Information System

14.30 Close of Session

LECTURE NOTES

INTEGRATING SEISMIC RISK MITIGATION CONCEPTS INTO THE PLANNING PROCESS

Ignacio Armillas, Ph.D.
United Nations Centre for Human Settlements (HABITAT)

INTRODUCTION

<u>An earthquake in Antarctica is a seismic event,
an earthquake in the island of Luzon is a natural disaster.</u>

This statement is quite self evident. Natural events become natural disasters when they result in loss of life and affect the man built environment. This message should be the quintessence of reconstruction and rehabilitation efforts. In fact, this message should underlie all physical development plans.

As you sadly observed a few months ago, the destructive effects of earthquakes concentrate, on the most part, in human settlement systems. This is to say the concentrations of human activity (cities, towns and villages), and the communication, transportation and distribution networks that link them. It is here that the greatest risk to human life and property exist, simply as a function of density. It is also because of the concentration of social and economic activities in cities, that when they are impacted by a disaster the overall social and economic fabric of the country as a whole suffers negative consequences. Thus, if we are to consider reducing the effects of earthquakes on the social and economic well being of a country, we must focus on reducing the levels of seismic risk in human settlement systems.

The major responsibility for reducing seismic risk, from a <u>technical</u> point of view, rests on engineers, architects and urban and regional planners, for these are the professionals that shape the physical environment. Engineering has provided methods and techniques for reducing the vulnerability of buildings, infrastructure and other civil works. These methods have been assimilated, to a large extent, into the work of engineers and architects. In urban planning the picture is far less positive. While planners have learned to integrate economic, social and, more recently, environmental factors into the planning process, they have yet to do the same regarding seismic vulnerability and risk reduction. The reason for this deficiency is partly the lack of methodologies which can be applied to this purpose. Clearly, there is a need to develop seismic risk mitigation techniques and methodologies, that can be integrated into the work of the planner.

Some isolated efforts at developing techniques and methodologies for integrating natural disaster mitigation concepts into physical planning and development are being made. Notably, the work of seismic engineers finds its way, more and more, into building codes and regulations. Concepts such as seismic zonation are becoming better understood by urban and regional planners. But overall, seismic vulnerability concepts are at best paid only lip service in the planning jargon. If we add to this the difficult political realities and expediencies of the private sector we come to realize that we are a long way from vulnerability awareness in so far as physical planning and development is concerned.

Ironically, it is after a natural disaster that the interest in mitigation is most intense. Having just witnessed the effects of the forces of nature, we are more inclined to think about the advantages of mitigation. So if this is the best time to reach the professionals, influence the decision makers and convince the private sector, so be it. The opportunity must not be lost. Moreover, it is now, during the reconstruction and rehabilitation phase that major investments will be made. Investments several times those that would otherwise have been made in the normal course of events. These investments will result in building and construction that will be in place for many decades to come. This infusion of investment and the physical heritage that it will create represents both an opportunity to regenerate the economic and social fabric of the region and the quality of the built environment we will leave to future generations.

These are convincing arguments, but, how do we go about it? How can we reflect disaster mitigation concerns into physical development plans? We do not have a set formula. In the rest of this paper will review some ideas for integrating seismic considerations into the planning process and physical development in general.

GENERAL CONSIDERATIONS

First of all we must recognize that disasters create conditions that require fast and massive mobilization of emergency aid. In the case of earthquakes almost simultaneously with the search and rescue operations we must start providing shelter, re-establish communication networks, and start planning the reconstruction of schools, hospitals and other essential facilities. At the same time we must be rehabilitating the social and economic fabric that has been torn by the disaster. It would seem irrational to propose that rehabilitation and reconstruction should wait for all the studies to be well and exhaustively completed. It is also wasteful to build temporary shelter which will have to be replaced, within a short time, with permanent shelter. But it is just as senseless to disregard the studies that would be the foundation for a safer environment because "there was no time for them". Clearly, both issues, need for quick response and need for sound information for decision making, must be addressed as they are not mutually exclusive. After all no planning exercise ever has complete perfect data. Planning after disasters must be done on the basis of the data available at that particular point in time -- while we strive all the while to acquire more and better data for future decisions.

It should also be noted that the safest stop-gap measure that must be taken after an earthquake is to assess if the building codes were adequate for the seismic conditions apparent in the area. Generally, building codes embody guidelines and restrictions for the assumed seismic conditions in the area. But the time period for which seismic data is available is relatively short compared with typical return periods of major earthquakes. The most recent earthquake may well add to the data base levels of activity beyond those that were expected maximums. It is therefore advisable to review the building codes immediately after the disaster and if necessary issue an interim code to ensure that reconstruction is carried out well within the margin of safety. Under an interim code building regulations can be greatly enhanced, including the strengthening of structural requirements for new buildings and those in need of repair. The interim code may well be too restrictive and increase construction costs significantly. This will bring a consequent slow-down in building activity but this must be accepted as a temporary measure. Meanwhile the Government must set out to prepare a new building code and development by-laws. In the preparation of the new code academic and research institutions should be consulted, as well as the professional societies concerned.

It is within the context of these general considerations that the following schematic framework is proposed.

METHODOLOGICAL APPROACH FOR DETERMINING RISK PARAMETERS

Geomorphological characteristics

In order to develop strategies aimed at mitigating risk, the first step is to determine or at least estimate, the hazard parameters. In the case of seismic hazard, this requires an appraisal of the nature of the seismicity of the area of interest. Given the make-up of seismic events, such an appraisal implies studies of vast geological provinces and the dynamics of their structural characteristics. Such studies must be aimed at determining the occurrence of telluric activity in the region and the typical levels and motion characteristics of ground movement in the area. Studies of this type include compiling of catalogues of seismic activity, defining tectonic zones, seismic source modeling, statistical probabilities of earthquake occurrence, and ground motion attenuation and surface geology amplification effects. From these studies, the return probability of ground motion for explicit periods (of say 50, 100 or 200 years) within a particular range of magnitudes and characteristics can be calculated.

In order to carry out these studies for Luzon, a data bank on the geomorphology of the island is indispensable. This bank must contain up to date accurate data on geological conditions beyond the island to the subduction zones to the East and West, as these have a strong bearing on seismic hazard throughout the island. Geophysical and geotechnic data on the structure and characteristics of the subsoil of the region must also be assembled. Known sources of seismic activity must be cataloged with reference to their nature and origin. All of these data is no doubt existing and perhaps it is already in an integrated data bank. If it does not exist such a data bank should be created.

A unit of measure which is most often used in the evaluation of seismic hazard is the peak ground acceleration (PGA). This measure is extracted directly from strong motion earthquake records and represents the maximum amplitude of acceleration as a percentage of the force of gravity. We understand that such strong motion records were not obtained during the Luzon Earthquake. Since this information is essential every effort should be made to make the existing set up of strong motion instruments operational and if possible more extensive.

Seismic hazard intensity, frequency and distribution of damages.

A useful data base is the so called "historical data base". This data, although not rigorous, is helpful since the time period covered through instrumentation is too short in the framework of geological time. Such a data base typically contains descriptive records of earthquakes which occurred within recorded history, but before seismic instruments were available. The sources of this data base are historical records, books and newspapers.

A second data base, and the most important, is that of data on telluric activity obtained through seismic instruments. This data base needs only contain information on tremors in the range which can cause some physical damage and include notation of the epicenter, intensity and duration of each event. It is desirable that the data in this base be corroborated with information from at least three seismic stations, at least one being outside the country.

Damage distribution patterns from previous earthquakes are also useful in determining hazard levels, therefore, a data base which incorporates data on damages to structures in recent earthquakes should also assembled. The data fields should include a description of each building which was reported as having suffered some damage, its location, and type of damage.

All of the above data bases are useful in refining hazard parameters for the planning region.

Seismic vulnerability

A second set of factors which must be considered in order to develop strategies aimed at mitigating risk are those concerning vulnerability. Vulnerability assessments should ideally be carried out in a number of fields, including physical, social, economic and environmental.

In human settlements, the potential casualties and the social and economic disruptions which can be expected for particular levels of seismic hazard are determined on the basis of the expected impact of an earthquake of a particular magnitude on the physical environment. This being so, theoretical and empirical physical vulnerability estimates, together with predicted hazard levels provide a reasonable base for the estimation of seismic risk levels and the construction of damage prediction models.

A VULNERABILITY MODEL WITH PLANNING APPLICATIONS

The critical issue for practicing planners is how to utilize the information on risk and vulnerability. The geologist, seismic engineers, and other scientists can provide us the information, but this information is of little use if we do not know how to apply it in our work. The task at hand is then one of learning to apply knowledge on seismicity. Here is where the earth scientists, engineers and planners must work together.

As an illustration of how seismic data can be transformed into usable information for planning we present the following model. This model is basically empirical and site specific, and could be easily calibrated for any planning area.

Vulnerability Model

The initial step is to survey all structures, or a representative sample, within the planning area in order to determine their physical vulnerability. Each structure is evaluated for a variety of characteristics which are considered to have a bearing on the physical integrity of the structure.

The physical vulnerability for each structure can be determined on the basis of the weighted computation of the factors which were considered in the survey. The weighted computation results in what is regarded as the vulnerability index for the structure. This index is then plotted as a vulnerability function curb for expected hazard levels. Utilizing the vulnerability function curves risk levels can then be approximated for individual structures, the study area as a whole or any portion of it.

The selection of the factors to be included in the model and their relative weights is, of course, critical to the validity of the model. Consequently, the utmost importance must be given to the method by which these factors are to be selected. This is best done by a group of highly qualified engineers and architects through open discussion in the course of several meetings. Initially a large number of factors should be included in the model, Slowly, through a process of testing the impact of each factor in the overall model, using field test data, the number of elements is reduced to the final dozen or so. The selected items must include aspects related to use, age, height, foundations, structural system, non-structural elements, upkeep, symmetry and relationship to surrounding structures.

The use of structures can follow the categories used for other planning purposes, or a simpler (and more relevant) categorization can be made. For example, a three level system can be adopted with each category corresponding to whether the building houses "life-line" functions such as hospitals, fire houses, etc., or whether large numbers of people are concentrated inside the building at any given time of the day or night. Thus, schools and department stores would be in one category, while warehouses would be in another.

Age is taken not only as a possible reflection of the condition of the building (including possible weakening from previous tremors) but also with specific reference to the particular building code that was in effect when the structure was erected.

More than any other item, the type of foundation and structural systems of a building will dictate how the building will respond to seismic movements. However, from evidence from a number of earthquakes, it is well recognized that a major part of the damage induced to buildings is directly due to high damagability of non-structural elements, such as infill walls and partitions. The high damagability of non-structural elements is mainly produced by the uncontrolled interstory drifts and rotations of the foundation, which are usually larger than the strength and deformability capacity that the non-structural elements can permit. Furthermore, in the case of small and moderate earthquakes where the structural systems will not in themselves fail, the non-structural elements may suffer damage and will cause loss of life and provoke damage to the structure. In this way, even low levels of seismic activity, can result in non-structural elements leading to functional and physical vulnerability of a building. Thus, foundations, structural systems and non-structural elements should be given given significant weight in the model.

Other relevant aspects are the symmetry of a building (asymmetrical and corner buildings generally suffer more damage during earthquakes), its proportions (height to floor area), separation from other structures, relative volume in reference to its neighbors (for example, a building may be structurally quite sound and able to withstand strong ground motion, but it may be seriously damaged by the motion of a more massive neighbor), and quality of the maintenance of the foundations and structure.

The weights to be assigned to each factor within the formula should also be arrived at through the same discussion and testing process as was recommended for the list of critical factors. Once the model has been finalized and calibrated through field tests, the limits of damage categories (i.e. acceptable, liable to minor damage, liable to major damage, and liable to collapse) should be established through empirical observations.

Applications of the Model

The proposed model provides the opportunity to evaluate alternative proposals for reducing seismic risk. At the level of individual structures a variety of options can be tested, say strengthening of the structural system, changing its use or reducing the number of stories. As each choice has a discreet price associated with it, we can evaluate the cost-effectiveness of the options under review. Likewise proposals at the scale of city block or planning area can be evaluated through simulating changes in the model.

The information compiled from expected levels hazard and the vulnerability assessment are combined to arrive at potential risk levels. Thus, we are able to provide estimates of structural damage, human casualties and economic losses likely to be incurred within certain planning time scales. Output is in terms of mapping risk, identifying areas of unacceptable levels of risk and quantifying the probability of loss. These results are the basic inputs required for planning and building human settlements which are less vulnerable to seismic events.

In terms of mitigating the effects of seismic activity, recommendations are possible at two levels. First, at the level of individual buildings, the vulnerability studies carried out for each and every building make it feasible to identify those buildings in need of special attention and, furthermore, which elements within the building are to blame for the high level of vulnerability registered. Moreover, with the model developed, it is possible to simulate the outcome and cost of alternative remedial actions which, in turn, permits the implementing of cost effective solutions.

At the planning level the hazard and vulnerability studies result in the creation of maps which display areas of different levels of risk. In addition, as is the case at the level of structures, alternative proposals should be able to be simulated in order to evaluate their desirability in relation to physical development plans.

Of course, if we do not wait for a disaster to strike, but incorporate disaster mitigation considerations into the planning process we will have the luxury of working with better data.

Models such as the one described in this paper can neither be exhaustive or definitive, but they can make a contribution towards the building of knowledge, techniques and methodologies that will assist the practicing planner in the making of safer human settlements, and, in doing so, help to reduce the loss of life and property to earthquakes.

EARTHQUAKE DAMAGE, SEISMIC HAZARD AND VULNERABILITY FOR EARTHQUAKE DISASTER MANAGEMENT

Prof. Jakim Petrovski
Scientific Advisor
Institute of Earthquake Engineering and Engineering Seismology
University "Cyril and Methodius", Skopje, Yugoslavia

Principal Topics of Presentation:

1. Basic Principles of Earthquake Disaster Management
2. Earthquake Damage Classification and Loss Assessment
3. Modelling and Asessment of Seismic Vulnerability and Risk
4. Measures and Activities for Reduction of Earthquake Consequences:
   Skopje, Yugoslavia Earthquake of July 26, 1963
5. UN International Decade for Natural Disaster Reduction

Submitted Publications

1. Building Damage Classification and Loss Assessment
2. Modelling and Assessment of Seismic Vulnerability and Risk
3. Assessment of Regional Seismic Losses - Case Study
4. Reduction of Consequaneces of the Major Catastrophic Earthquakes in Yugoslavia, and Seismic Hazard Assessment

   4.1 Skopje, Yugoslavia Earthquake of 26 July 1963

   4.2 Montenego, Yugoslavia Earthquake of 15 April 1979

   4.3 Methods and Data Applied in Seismic Hazard Assessment, Seismic Zoning and Microzoning

   4.4 Seismic Microzoning Studies for Land-Use Planning, Detailed Urban Planning and Design.

BUILDING DAMAGE CLASSIFICATION AND LOSS ASSESSMENT

Jakim PETROVSKI[1]

Skopje
June 15, 1990

[1] *Professor, Institute of Earthquake Engineering and Engineering Seismology University "Kiril and Metodij", Skopje, Yugoslavia*

BUILDING DAMAGE CLASSIFICATION AND LOSS ASSESSMENT

Jakim PETROVSKI

Professor, Institute of Earthquake Engineering and Engineering Seismology
University "Kiril and Metodij", Skopje, Yugoslavia

1 General

During the last two decades natural disasters, and earthquakes in particular, have tended to become increasingly destructive as they affect ever larger concentration of population and material property. Industrial development of seismic-prone regions, that is ordinarily accompanied by urban expansion and increased population becomes prohibitive unless investments in infrastructure, housing, other public and social activities, etc., are protected against damage at all stages of their development.

Although significant efforts have been put into assessment and mitigation of the possible consequences of the existing seismic hazard, major earthquakes which had occurred in this period induced enormous damage to the economy of the regions stricken and entire countries. Moreover, due to the rapid development of high concentration of material property in seismically active regions a significant increase of damage might be expected in future major earthquake events.

A damaging earthquake provides an opportunity to acquire unique technical information about the physical effects of ground shaking, surface fault rupturing, earthquake–induced ground failures, regional tectonic deformation, wave inundation from seiches and tsunamis, etc. The technical informations should primarily be acquired on the following scales:

- **global**, in order to obtain the large - overall picture of the global tectonic forces;
- **regional**, in order to define the physical parameters and the ranges of their values for providing the rational understanding of the spatial and temporal characteristics of the earthquake activity the region is exposed to;
- **local**, in order to determine the physical parameters and the range of their values that control the site–specific characteristics of the earthquake hazards; and
- **engineering**, in order to provide data that can be correlated with the spatial dimensions of specific structures, facilities, life-lines or any other element at risk being under the engineering relevance.

The information, facts, and lessons learned from postearthquake investigations provide a basis for identifying the present situation and give rise for necessary changes. The new information can be utilized in research studies, in assessment of earthquake hazards and risk for specific urban areas, in mitigation and preparedness actions, used in implementation of new and improved loss-reduction measures.

The focus of this paper is therefore to present uniform methodology and procedure for earthquake damage assessment (inspection, classification and reporting) or building in urban and/or rural regions, establishment and organization of damage data banks due to the earthquake effects, and to discuss the methodological highlights of damage data analysis necessary for reliable estimation of physical, functional and economic losses. The principal aim of developing this methodology and procedure for earthquake damage assessment is to assure, primarily, an adequate volume of data for the following needs:

- To reduce incidents of death and injury to occupants of buildings that have been seriously weakened or damaged by a strong seismic event and most probably will be exposed to series of aftershocks immediately after the main shock;
- To obtain realistic information on the magnitude of the disaster in terms of number of usable, damaged and dangerous buildings for the purpose of immediate protection of human lives, sheltering and housing of the citizens, urgent revitalization of the basic life and social activities, etc.;
- To improve the knowledge of the amplitude, spectral composition, temporal and spatial distribution of ground shaking and its causative relations with damage in buildings and triggering of other earthquake-induced physical effects;
- To assure data base for uniform estimation of economic losses for development of appropriate rehabilitation programme and assistance in the reconstruction and future development of the affected region on the basis of improved seismic design regulations, codes and construction standards;
- To create data base for prediction of earthquake consequences in the future earthquakes in affected and other seismic regions;
- To extend the state-of-knowledge on seismic zoning, in order to push the limits of seismic microzoning to bounds established by local and engineering scales;
- To provide data for planning and organization of civil defence system, elaboration of rescue operation plans, staff training, organization of emergency supplies, etc.;
- To record and classify damages for planning and performance of repair and strengthening of damaged buildings;
- To identify principal elements of earthquake damage and develop vulnerability relationships for different building categories indispensable for planning and performance of short-, intermediate-, and long-term priority actions for reduction of earthquake consequences and pre-earthquake assessments;
- To improve seismic design and construction codes and regulations, as well as design and construction practice;
- To improve scientific basis for physical, urban and general planning for reduction of earthquake consequences and mitigation of seismic risk pertinent to seismically active regions;
- To improve the state-of-practice on land use, engineering design and construction; and
- To initiate and activate new and revitalized programs of research, mitigation, preparedness, response, and recovery, as well as to call for change in public policy concerning earthquake hazards.

Post–earthquake damage evaluation and classification have to be organized by implementing a systematic methodology and rapid procedure in order to provide local and national decision making authorities with essential information for undertaking economically justified and technically consistent measures for reduction of earthquake consequences in n uniform manner over the entire country.

Principal elements incorporated int he uniform methodology and procedure for earthquake damage assessment such as: damage and usability prospection and classification of earthquake induced damage to buildings, procedure and organization for damage data collection, earthquake damage data analysis, organization of damage data bases, etc. as presented in the following are based upon experiences gathered from earthquakes that took place during the last two decades in Yugoslavia and other countries located in seismically active regions in the world. The methodology and procedure for earthquake damage assessment, originally proposed by IZIIS–Skopje and later accepted by other Balkan countries, as it is believed, will provide reliable and transferable data for practical elaboration of efficient pre–disaster risk mitigation and management or post–disaster reconstruction and revitalization programmes.

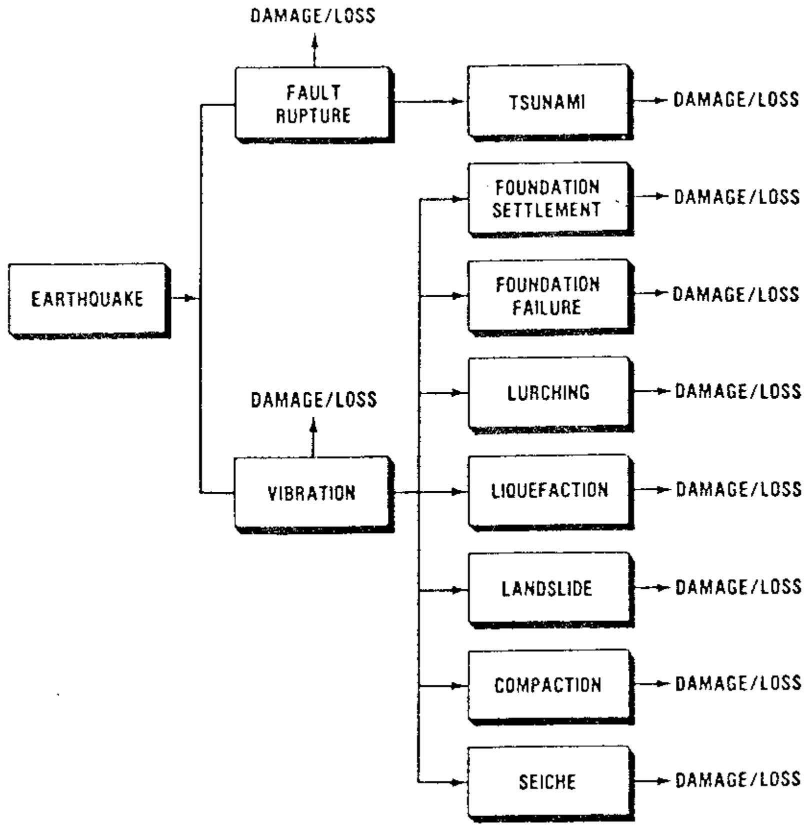
2 Earthquake Damage and Usability Classification

2.1 Nature of Damaging Earthquake Hazards

Earthquake damage to buildings, structures and utilities may be caused by different types of seismic hazard. The main hazards posed by earthquakes to rural and urban areas could be summarized as follows:

- Ground shaking of different severities;
- Differential ground settlement, land and mud slides, soil liquefaction, ground lurching and avalanches;
- Ground displacements along faults;
- Floods from dam and levee failure, tsunamis and seiches; and,
- Fires resulting from earthquakes.

In the past history of earthquakes, all types of seismic hazards are well known with dominant influence of ground shaking and hazards associated with soil instabilities. By far, the most important is the ground shaking, which causes buildings and structures to collapse partially or totally producing damage at large distances from the epicentral zone. Ground shaking affects the soil and foundation under structures, therefore a lot of earthquake-induced structural damage is a consequence of ground failure and differential ground settlements. Sometimes the ground will lurch, particularly along roadslides, culverts, river banks, and in low–lying areas producing fissures and unstable soil conditions. Ground shaking can also initiate devastating rock and mud slides, producing greatest disasters ever experienced from seismic causes (Peru earthquake, 1970). Very common earthquake hazard is liquefaction of sandy soils, especially in river valleys and coastal regions. During earthquake shaking, water saturated free grained soils and sands, take on liquidal characteristics due to rapid alternative action of sharing stresses. Water saturated sands are wide–spread, particularly in flat areas where population tends to concentrate, sot hat soil liquefaction and damage of buildings and structures due to this earthquake hazard are observable in almost every earthquake. Soil liquefaction effects are very frequently associated with rather low accelerations of ground shaking. A much more restricted hazard comes from surface rupturing of geological faults. Buildings that straddle fault displacements may be critically wrenched. Elimination of this hazard is difficult in practice and depends upon adequate building codes and the availability of special geological fault maps.



Schematic Illustration of the Primary and Secondary Hazards
Caused by an Earthquake Causing Damages and Losses

The other earthquake hazards are related to water and fire. Due to undersea faulting, gigantic waves - tsunamis, rush up along the coast-line and devastate coastal man-made facilities. Floods from sudden failure of dams in earthquakes is an ever present danger which could create enormous destructive effects; sometimes larger than ground shaking itself. Fires are potential secondary effects in modern urbanized areas with presence of chemical industry, oil and gas supplies. Ground shaking could cause breakage of pipe-lines, failure of oil or gas tanks, chemical industries and others; causing explosions, release of toxic chemicals and fire in quarts or entire towns (Kanto earthquake, Japan, 1923).

2.2 Earthquake Damage Inspection

Earthquake damage and usability classification after moderate or large-scale damaging earthquake should be performed on the basis of uniformly established methodology within the country or wider region in order to create uniform basis for assessment of physical damage, estimation of economic losses and to create uniform data basis for pre-earthquake studies and prediction of the effects in the future earthquakes.

Assessment of earthquake damage inspection and classification presented completely further in the text is developed under the UNDP/UNIDO project "Building Construction under Seismic Conditions in Balkan Region" (RER/79/015) and accepted for application by the Balkan countries. This methodology for earthquake damage and usability classification is synthesized in the Earthquake Damage Inspection Form which is developed on the basis of the experience gathered in earthquake damage and usability classification in the past earthquakes in the Balkan region and other countries in the world.

The earthquake Damage Inspection Form is prepared in a format suitable for easy and rapid field data collection. The presentation format is suitable for rapid transfer of data to computer media enabling detailed analysis of relevant damage and usability classification parameters. It comprises the basic information pertinent to each individual building. The following groups of parameters are considered:

- **IDENTIFICATION PARAMETERS (1–9):** Describing the location of the building within the town with corresponding section number or settlement, building number and number of inspection team; position of the building in the block and its orientation, gross area, number of storeys, usage, number of apartments and construction period. With drafting of the sketch of the building in plan and cross-section, writing the address of the building and determining the ownership (left side), the basic identification parameters are completed.

  Town code, section number of considered town area or settlement, number of the building, working team number and other identification parameters, together with suitable town and section maps could be prepared in advance during the training process of the inspection teams. Position of the building in the block and its orientation are important to separate possible collision effects or failure of adjacent buildings and dominant direction of earthquake action. Particular attention should be paid to classification of usage in accordance with the description of subcategories of the nine basic categories as given in the back side of the Inspection Form. Construction period is an identification parameter left to be defined by each country. It is usually connected with type of structure and quality of construction. For the Mediterranean region possible differentiation could be made as follows: (1) before 1920 - dominant traditional construction of adobe, stone masonry and brick masonry; (2) 1920–1950 - dominant construction of brick and stone masonry buildings with R.C. slabs; and (3) after 1950 - dominant construction of R.C. frame buildings and other modern types.

- **STRUCTURAL AND QUALITY PARAMETERS (10–17):** Describing the type of structure. The codes are given on the back side of the Inspection Form and they are separately defined for each subcategory out of 5 categories of masonry buildings, 4 categories of R.C. structures, 3 categories of steel structures and 2 categories of timber structures. Defined are also codes for identification of structural systems of floor and roof structures; roof covering; type of load carrying system (in accordance with the descriptions given on the back side for six basic categories); quality of workmanship; stiffness of the first floor relative to other floors; and possible repairs from the previous earthquakes. All these parameters are of basic importance for damage and usability classification of the buildings and extrapolation of these data for economic loss assessments as well as improvement of future design and construction practice and requirements. The main reason is that damage evaluations leading to empirical vulnerability and damage cost functions should be associated with structural types and usage categories. Particular attention could be given during the training process of inspection teams to assessment of the quality of workmanship and relative stiffness of the floors which will be based mainly on engineering experience and judgement. Repair from previous earthquakes is an extremely important parameter. Its evaluation for each building class should be elucidated during the training process of inspection teams. It may lead to improving of the general strategy for repair and strengthening of earthquake damaged buildings and, therefore to reduction of a large number of casualties which might occur due to failure of inadequately repaired buildings damaged in previous earthquakes (Romanian earthquake, 1977).

- **DAMAGE AND USABILITY CLASSIFICATION (18–24):** Describing damage of structural system, nonstructural elements and entire building in 5 basic categories; damage due to soil instabilities in 8 categories of the described seismic hazards and damage due to fire. Finally, on the basis of described damage, usability levels, classification and posting should be summarized in 3 categories out of 5 on damage description.

  All these parameters are of fundamental importance for any further damage and usability classification and analysis of the entire volume of data. In the major earthquake event, many buildings will be damaged to varying levels and possibly large number will collapse. The overriding consideration for usability classification will depend on the damage level of the structural elements and the integrity of the principal structural system. Earthquake damage of the structural system will depend upon the type of the load carrying system, lateral load resisting system, age and construction quality of the building, severity and duration of ground shaking and associated seismic hazards such as differential ground settlement, soil liquefaction, land slides, etc. the building is exposed to. Since severe aftershocks may occur after a major earthquake and cause further weakening of the already damaged structural system, it is of paramount importance to make an immediate damage inspection in order to assess the degree of damage and the potential of the structural system to resist further aftershock shaking. Other nonstructural elements may be damaged and removal of the hazard due to their failure could be done within a shorter period of time, but the structural system is of primary concern to the safety of the occupants, and if it has been damaged, warrant posting of the building as unsafe for occupancy should be made. Damage of structural elements and posting for all five categories is given in sufficient details on the back page of the Inspection Form with the comments on safety and usability of each category.

  Damage of nonstructural elements and installations should be estimated with equal care in 5 basic categories similar to those of the structural elements and integral structural system. Most of the nonstructural elements and installation damages will depend on damage degree of residual integrity of the structural system. Examples of nonstructural damages are cracks in the architectural elements and installations, partially destroyed, collapsed or shattered partitions, interior or exterior walls, cracked or fallen ceilings, fallen light fixtures, cracked and fallen down chimneys, attics and gable walls, broken glass, dislodged mechanical and electrical equipment, broken plumbing lines and water heaters, broken gas and water lines, and elevators coming out of their guide–rails. Damage of inoperative service systems in the buildings like supplying water, gas, electricity supplies, sanitary services, etc. may render a building unusable or dangerous as more dramatic than collapse of a structural system or architectural elements. The critical need for certain usage categories of buildings (hospitals, schools, gymnasiums, cafeterias, food warehouses, power stations, transformer stations, pumping stations for water and sewage, communication facilities, etc.) to be returned to operation as soon as possible makes early evaluation of service systems (installations) almost mandatory. Damage categories of nonstructural elements and installations should follow basically the same damage categories of structural elements due to their dependence on the dislocations created in the integrity of the structural system. In the case of pronounced flexible structures, nonstructural damage classification could be considered with one higher category in respect to the structural elements damage categories.

Damage of the entire building should be classified in the same 5 categories following both damage classification of structural and nonstructural elements and installations. Observed soil instabilities, if they are enough pronounced, could be classified by the regular inspection team. In the case of any doubts the regular inspection team should require reinspection by soil engineers and geologists. Damage due to fire is quite possible in modern urban regions but it could be significantly reduced with protective measures and training of people's behaviour after an earthquake.

Finally, on the basis of the performed damage classification, usability classification and posting should be performed in accordance with the description given on the back page of the Inspection Form. Not posting should be avoided in general and implemented only with strong reasons for posting categories 4, 5 and 7. Explanations of main reasons for usability classification and posting should be short and based on principal elements of structural and nonstructural damage classification.

- **EMERGENCY MEASURES AND HUMAN LOSSES (25, 27, 28):** Describing recommendations of the inspection team for emergency measures to be undertaken in removal of local hazards primarily of nonstructural elements, in order to make the building usable for occupants, and measures like demolition of severely damaged or partially collapsed buildings to protect streets and neighbouring buildings from their sudden failure. Identification of human losses - number of deaths and injuries - is usually performed during emergency operations by health departments, civil defence and army. Usually, earthquake damage inspection teams are organized and become operational several days after the major earthquake event. Thus they should use data on human losses supplied by health departments and there is no need for their involvement in the rescue operations. It is very important to collect data on human lives together with other data on damage and usability classification in order to develop more reliable data base for assessment of human losses and relate it to structural types and usage categories of the buildings as one of the most important vulnerability parameters.

- **PHOTOGRAPHS (26):** Requirement for photographs to be taken on damage of structural and nonstructural elements is very important in completing evidence and data set on earthquake damage since these data will disappear within a short period of time. The photographs will provide information to the supervisors and governmental authorities in the emergency and short-term operations, and will be of basic importance in data analysis for the needs of scientific and applied research. The back side of each photograph should comprise the code number of the sector (or settlement) and the building. Photographs of nonstructural and installation damage should be taken where such damage represents a hazard to building occupants.

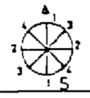
The described methodology on earthquake damage and usability classification is directly connected with the presented Earthquake Damage Inspection Form and the explanations given on its back side. These are basic instruction materials for the inspection teams in order to perform damage and usability classification in an uniform manner. In order to achieve mobile and effective performance of the inspection team, comprehensive training programmes should be continuously organized by the communal district and the national civil defence organizations. Special ordinances should be issued by local and national government authorities for implementation of the described methodology on earthquake damage and usability classification.

EARTHQUAKE DAMAGE AND USEABILITY INSPECTION FORM

1. Town: (name - code) : 1
2. Building identification :
   - 2.1. Code of Town Section or Settlement 7
   - 2.2. Working team code : 9
   - 2.3. Number of the building : 11
3. Principal Orientation of the Building :
   1. NS, 2. EW, 3. N45E, 4. N45W 14
4. Position of the Building in the Block :
   1. Corner, 2. Middle, 3. Free 15
5. Building Gross Area (m^2) : 16
6. Number of Stories :
   - 6.1. Basement : No /0/, Yes /1/ 20
   - 6.2. Stories : 21
   - 6.3. Mezzanine : No /0/, Yes /1/ 23
   - 6.4. Appendages : No /0/, Yes /1/ 24
7. Usage (see description on back page) :
   - 7.1. Building : 25
   - 7.2. Ground Floor : 27
8. Number of Apartments : 29
9. Construction period (To be defined by each country)
   1. 2. 3. 31
10. Type of Structure (see description on back page) : 32
11. Floors :
    1. R.C., 2. Steel, 3. Wood, 4. Other 35
12. Roof : 1. R.C., 2. Steel, 3. Wood, 4. Other 36
13. Roof Covering : 1. Tiles, 2. Lightweight asbestos cement, 3. Metal sheets, 4. Other (specify) 37
14. Type of Load Carrying System (see description on back page) :
    1. Bearing walls, 2. Frames, 3. Frames with infill walls 4. Skeleton with infill walls, 5. Mixed, 6. Other (specify) 38
15. Quality of Workmanship :
    1. Good, 2. Average, 3. Poor 39
16. First Floor Stiffness Relative to Others :
    1. Larger, 2. About equal, 3. Smaller 40
17. Repairs from Previous Earthquakes :
    1. No, 2. Yes, 3. Unknown 41
18. Damage of Structural Elements :
    1. None, 2. Slight, 3. Moderate, 4. Heavy, 5. Severe (see description on back page)
    - 18.1. Bearing Walls : 42
    - 18.2. Columns : 43
    - 18.3. Beams : 44
    - 18.4. Frame Joints : 45
    - 18.5. Shear Walls : 46
    - 18.6. Stairs : 47
    - 18.7. Floors : 48
    - 18.8. Roof : 49
19. Damage of Nonstructural Elements and Installations:
    1. None, 2. Slight, 3. Moderate, 4. Heavy, 5. Severe (see description in the manual)
    - 19.1. Interior Walls : 50
    - 19.2. Partitions : 51
    - 19.3. Exterior Walls (facade) : 52
    - 19.4. Electrical Installations : 53
    - 19.5. Plumbing : 54

Sketch of Building

Plan | Cross Section



Address :

Owner :

20. Damage of Entire Building :
    1. None, 2. Slight, 3. Moderate, 4. Heavy, 5. Severe 55
21. Damage due to Fire After the Earthquake :
    No /0/, Yes /1/ 56
22. Site-Soil Conditions :
    1. Rock, 2. Firm, 3. Medium, 4. Soft 57
23. Observed Soil Instabilities :
    1. None, 2. Slight settlements, 3. Intensive settlements, 4. Liquefaction, 5. Landslide, 6. Rockfalls, 7. Faulting, 8. Other (specify) : 58
24. Usability Classification and Posting :
    Posted : 1. Green, 2. Yellow, 3. Red,
    Not posted : 4. To be posted after removal of local hazard, 5. Soil and geological problems, reinspection, 6. Unable to classify, reinspection, 7. Building inaccessible 59

Explain main reasons for your classification and posting :

25. Recommendations for Emergency Measures :
    1. None, 2. Remove local hazard, 3. Protect building from failure, 4. Protect streets or neighbouring buildings, 5 Urgent demolition 60
26. Photographs taken :
    No /0/, Yes /1/ 61
27. Trapped in the Building :
    No /0/, Yes /1/
    (If yes stop inspection and inform authorities) 62
28. Human Losses :
    No deaths and injures /0/, Possible deaths and injuries /1/ 63
    If information available, please indicate :
    Number of deaths : 64
    Number of injuries : 66
29. Date of Inspection : Month/Day 68
    Names of Inspection Engineers : Signatures
    1.
    2.
    3.

DESCRIPTION AND CODES OF USAGE CATEGORIES, TYPE OF STRUCTURE, LOAD CARRYING SYSTEM, STRUCTURAL DAMAGE CATEGORIES AND POSTING

7. BUILDING USAGE CATEGORIES :

10 Residential : 11 Family houses, 12 Apartment Buildings

20 Office : 21 Entire Building, 22 Partially

30 Economical : 31 Trade, 32 Finance, 33 Small industry, 34 Storage and ware houses, 35 Agricultural, 36 Fishing, 37 Forestry

40 Health an Social Welfare : 41 Hospitals and clinics, 42 Health services, 43 Social welfare (old people houses, invalides, day care centers)

50 Public Services : 51 Administrative – central or local government, 52 Police and Fire stations, 53 Transportation (buildings ground, rail, air, sea) 54 Communications (buildings, post, radio, TV)

60 Education and Culture : 61 Schools, 62 Universities and research centers, 63 Dormitories, 64 Historical and religious, 65 Cultural and entertainment, 66 Sports (gymnasiums, stadia)

70 Tourism and Catering : 71 Hotels, 72 Restaurants, Cafe, 73 Coffee shops, pastry shops etc.

80 Industry and Energy : 81 Industrial, 82 Energy (power plants, transformer stations, etc.)

90 Other Buildings (to be described)

10. TYPE OF STRUCTURE :

100 Masonry Buildings :

110 Adobe : 111 Adobe plain, 112 Adobe with timber belts

120 Solid brick : 121 With horizontal R.C. belts, 122 With horizontal and vertical R.C. belts

130 Hollow brick : 131 With horizontal R. C. belts, 132 With horizontal and vertical R. C. belts

140 Concrete blocks : 141 With horizontal R. C. belts, 142 With horizontal and vertical R. C. belts

150 Stone masonry : 151 Dry stone masonry, 152 Plain stone with low quality of mortar, 153 Plain stone with good quality of mortar, 154 Stone with timber belts, 155 Stone with steel ties, 156 Stone with R.C. horizontal belts, 157 Stone with horizontal and vertical R.C. belts

200 Reinforced concrete structures :

210 Cast in place frames : 211 With solid brick infill, 212 With hollow brick infill, 213 With light concrete blocks or panel infill, 214 With shear walls

220 Cast in place bearing walls : 221 With bearing walls in one direction, 222 With bearing walls in both orthogonal directions

230 Prefabricated structures : 231 Frames with hollow brick infill, 232 Frames with light concrete or panel infill, 233 Frames combined with shear walls, 234 Large panel structures, 235 Small panel structures

240 Mixed structures : 241 R.C. frames with load bearing masonry walls, 242 Combination of steel frames with load bearing masonry walls

300 Steel structures :

310 Heavy industrial steel structures : 311 Without cranes, 312 With cranes

320 Light industrial steel structures : 321 Without cranes, 322 With cranes

330 Multi story steel structures : 331 Frames without bracing, 332 Frames with bracing, 333 Steel frames with R.C. core, 334 Steel frames infilled with R.C.

400 Timber structures :

410 Baghdadi : 411 Baghdadi with ground floor of stone masonry, 412 Baghdadi only

420 Prefabricated : 421 Timber frames, 422 Timber small panel elements

14. TYPE OF LOAD CARRYING SYSTEM :

Vertical and lateral loads are carried by : 1. Walls, 2. Frames, 3. Frames with infill walls, 4. Skeleton with infill walls in which beams and columns are not forming frame system, 5. Mixed combination of walls, frames and/or shear walls and infills, 6. Other systems (to be described)

18. DAMAGE OF STRUCTURAL ELEMENTS AND POSTING :

1. None – Posted Green : Without visible damage to the structural elements. Possible fine cracks in the wall and ceiling mortar. Hardly visible nonstructural and structural damage

2. Slight – Posted Green : Cracks to the wall and ceiling mortar. Falling of large patches of mortar from wall and ceiling surface. Considerable cracks, or partial failure of chimneys, attics and gable walls. Distrubance, partial sliding, sliding and falling down of roof covering. Cracks in structural members

   Buildings classified in damage category 1 and 2 are without decreased seismic capacity and do not pose danger to human life. Immediately usable or after removal of local hazard (cracked chimneys, attics or gable walls).

3. Moderate – Posted Yellow : Diagonal or other cracks to structural walls, walls between windows and similar structural elements. Large cracks to reinforced concrete structural members : columns, beams, R.C. walls. Partially failed or failed chimneys, attics or gable walls. Disturbance, sliding and falling down of roof covering

4. Heavy – Posted Yellow : Large cracks with or without disattachment of walls with crushing of materials. Large cracks with crushed material of walls between windows and similar elements of structural walls. Large cracks with small dislocation of R.C. structural elements : columns, beams and R.C. walls. Slight dislocation of structural elements and the whole building.

   Buildings classified in damage category 3 and 4 are with significantly decreased seismic capacity. Limited entry is permited, unusable before repair and strengthening. Need for supporting and protection of the building and its surroundings should be considered

5. Severe – Posted Red : Structural members and their connections are extremely damaged and dislocated. A large number of crushed structural elements. Considerable dislocations of the entire building and deleveling of roof structure. Partially or completely failed buildings

   Buildings classified in category 5 are unsafe with possible sudden collapse. Entry is prohibited. Protection of streets and neighbouring buildings or urgent demolition required. In case of isolated or typified buildings decision for demolition should be based on economical study for repair and strengthening.