Japan International Cooperation Agency (JICA)
Tehran Disaster Mitigation and Management Center (TDMMC)

No.

THE COMPREHENSIVE MASTER PLAN STUDY ON URBAN SEISMIC DISASTER PREVENTION AND MANAGEMENT FOR THE GREATER TEHRAN AREA IN THE ISLAMIC REPUBLIC OF IRAN

FINAL REPORT
- MAIN REPORT -

December 2004

Pacific Consultants International
OYO International Corporation

GE
JR
04-039

Japan International Cooperation Agency (JICA)
Tehran Disaster Mitigation and Management Center (TDMMC)

THE COMPREHENSIVE MASTER PLAN STUDY ON URBAN SEISMIC DISASTER PREVENTION AND MANAGEMENT FOR THE GREATER TEHRAN AREA IN THE ISLAMIC REPUBLIC OF IRAN

FINAL REPORT

- MAIN REPORT -

December 2004

Pacific Consultants International
OYO International Corporation

The exchange rate applied in the Study is:

US $ 1.00 = Rls.8,500

(April, 2004)

PREFACE

In response to the request from the Government of the Islamic Republic of Iran, the Government of Japan decided to conduct a Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the Study Team headed by Mr. Itaru Mae of Pacific Consultants International, consisted of Pacific Consultants International and OYO International Corporation, to the Islamic Republic of Iran from August 2002 to August 2004. JICA set up an Advisory Committee chaired by Dr. Kimiro Meguro from the University of Tokyo, which examined the study from the specialist and technical points of view.

The Study Team held discussions with the officials concerned of the Government of the Islamic Republic of Iran and conducted the Study in collaboration with the Iranian counterparts. Upon the last return to Japan, the Study Team finalized the study results for delivery of this Final Report.

I hope that this report will contribute to the promotion of relevant projects for urban seismic disaster prevention and management and to the enhancement of friendly relationship between the two countries.

Finally, I wish to express my sincere appreciation to all the officials concerned of the Government of the Islamic Republic of Iran for their close cooperation extended to the Study.

December 2004

Estuo KITAHARA
Vice President
Japan International Cooperation Agency

Mr. Estuo KITAHARA
Vice President
Japan International Cooperation Agency
Tokyo, Japan

December 2004

Letter of Transmittal

Dear Mr. KITAHARA,

We are pleased to formally submit herewith the final report entitled “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran”.

This report compiles the results of the study which was undertaken in the Islamic Republic of Iran from August 2002 to August 2004 by the Study Team organized jointly by Pacific Consultants International and OYO International Corporation under the contract with the JICA

The Final Report is composed of the “Executive Summary”, “Main Report”, and “Sector Report”. In the Main Report, mitigation countermeasures for pre-earthquake, emergency response just after earthquake, and post-earthquake rehabilitation and reconstruction are prepared in the form of comprehensive master plan on urban seismic disaster prevention and mitigation, including the project profiles for urgent action projects. In addition, the Sector Report compiles overall procedures of the master plan formulation in each sector. It is truly hoped that the outcomes of the Final Report will contribute to reducing the risks of earthquake occurrence in the Islamic Republic of Iran.

Finally, we would like to express our sincere gratitude and appreciation to all the officials of your agency, the JICA advisory Committee, the Embassy of Japan in the Islamic Republic of Iran, and Ministry of Foreign Affairs. We also would like to send our great appreciation to all those who have extended their kind assistance and cooperation to the Study Team, in particular, relevant officials of Tehran Disaster Mitigation and Management Center (TDMMC), the Iranian counterpart agency.

Very truly yours,

Itaru Mae
Team Leader, JICA Study Team
The Comprehensive Master Plan Study on
Urban Seismic Disaster Prevention and Management for the
Greater Tehran Area in the Islamic Republic of Iran

Executive Summary

THE COMPREHENSIVE MASTER PLAN STUDY ON URBAN SEISMIC DISASTER PREVENTION AND MANAGEMENT FOR THE GREATER TEHRAN AREA

EXECUTIVE SUMMARY

General

Subsequent to the previous study on the Seismic Microzoning of the Greater Tehran Area conducted by Japan International Cooperation Agency (hereinafter referred to as "JICA") in 1999-2000, this study for the Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area (hereinafter referred to as "the Study") was initiated again by JICA as agreed upon between the Centre for Earthquake and Environment Studies of Tehran (hereinafter referred to as "CEST") and JICA on 16 April 2002. In February 2003, the Mayor's Decree of Tehran was issued, declaring the establishment of "Tehran Disaster Mitigation and Management Center (hereinafter referred to as "TDMMC"), in which two disaster-related organizations of Tehran, CEST and Tehran Comprehensive Emergency Management Plan Secretariat (hereinafter referred to as "CEMS") were merged. According to the establishment of TDMMC, the authorities as a counterpart agency to the JICA Study Team were transferred from CEST to TDMMC.

The Study commenced in August 2002 and will complete in July 2004, taking the study period of 2 years. The conduct of the Study proceeds in 3 phases to achieve the following sequential study objectives.

Phase 1 (August 2002-March 2003)
Comprehensive Diagnosis of Disaster Prevention and Management Situation in Tehran

Phase 2 (April 2003-October 2003)
Preparation of the Master Plan for Urban Seismic Disaster Prevention and Management in Tehran

Phase 3 (November 2003-July 2004)
Preparation of an Action Plan for the Implementation of Urgent Priority Projects and Programs

1. Introduction

Laws and Regulations

In response to requirements of the Iranian Constitution, which stipulates the Government's responsibility for providing assistance to Iran's population in coping with disaster related effects, the Government of Iran has adopted over the past decade or so policies and implemented measures that are intended to establish an adequate and suitable country-wide disaster management system. The system is to address the whole range of natural and man-made disasters with special emphasize on earthquake induced catastrophes, and it is to comprise disaster mitigation, preparedness, emergency response and reconstruction and rehabilitation plans.

At Tehran Municipality level, the "Tehran Disaster Mitigation and Management Center – TDMMC", which was formed in 2003 as a merger of two earlier disaster management related entities, forms the core institution for overall disaster management within Tehran. At present, TDMMC falls under the direct control and guidance of Tehran's Mayor. The mandate of the Center, though still under further review and discussion, covers all relevant natural disasters and the disaster management areas of mitigation, preparedness, emergency response and reconstruction and rehabilitation.

Implementation of the Tehran-specific disaster management system is tailored around the "Tehran Comprehensive Emergency Management Plan". The plan is an emergency response plan that organizes 24 central, local government and NGO organizations under the umbrella of 22 committees with three core functions. The core functions are: relief and rescue management, settlement management, and logistics management.

The early establishment of an independently fully functional "Emergency Communication System" and an "Emergency Operations Center" at TDMMC is needed. Particular emphasize has to be placed at the hardware and software integration of both components, if possible, in combination with a fully functional "Disaster Management Information System" that incorporates all relevant national and Tehran level disaster response and management entities

Full integration of community based disaster response capabilities into the existing emergency response system is also one of the core issues that Tehran has to cope with.

Basic Policy of the Study

Goal

The lives and properties of the citizens of Tehran are being made safer from a potentially devastating earthquake by formulation and implementation of a comprehensive disaster management plan. The goal of the master plan is to establish a safe and secure urban environment against a potential earthquake.

Planning Period

The implementation plan should be divided into three phases:

Short term	2004-2006
Medium term	2007-2010
Long term	2011-2015

The master plan will cover the years 2004 to 2015, or a total of 12 years.

Objectives

In order to achieve the goal, the Master Plan sets three objectives to accomplish by the year 2015. The objectives are:

- to secure lives and properties of the citizens of Tehran;
- to protect citizen's life after the event; and
- to prepare rehabilitation and reconstruction.

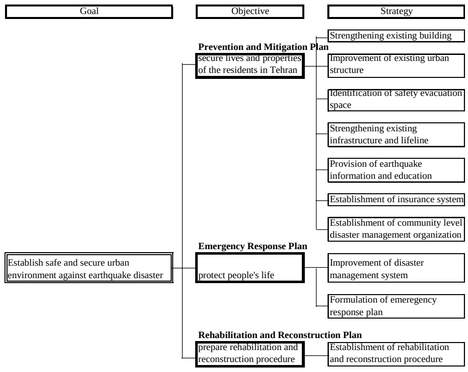
Strategies

To achieve the objectives, ten strategies are selected as follows:

- Strengthening existing buildings
- Improvement of existing urban structure
- Identification of safety evacuation space
- Strengthening existing infrastructure and lifeline
- Provision of earthquake information and education
- Establishment of disaster mitigation policy
- Establishment of community level disaster management organization
- Improvement of disaster management system
- Formulation of emergency response plan
- Establishment of rehabilitation and reconstruction procedure

Framework of the Master Plan

The framework of the master plan study can be organized as shown below.



The three objectives are in correspondence with three plans: prevention and mitigation plan, emergency response plan and rehabilitation and reconstruction plan. The ten strategies are classified dependent on earthquake countermeasures.

2. Conditions for the Master Plan

Objective Earthquake

Three types of scenario earthquakes, namely Ray Fault Model, North Tehran Fault (NTF) Model, and Mosha Fault Model were adopted for seismic microzoning analyses. Among the three scenario earthquakes, Ray Fault Model is estimated to cause the most serious damage in Tehran Municipality. Therefore, Ray Fault Model is the objective earthquake in the master plan study.

	Ray Fault	NTF	Mosha
Length (km)	26	58	68
Magnitude (Mw)	6.7	7.2	7.2
Peak Ground Acceleration (gal)	North<200 South>400	North>400 South<200	<200
Intensity (MMI)	North: 8 South: 9	North: 9 South: 7-8	7

As a result of the damage estimation, damages to residential buildings and human casualties are summarized below.

	Ray	NTF	Mosha
Bldg Damage	483,000	313,000	113,000
Damage Ratio	55%	36%	13%
No. of Deaths	383,000	126,000	20,000
Death Ratio	6%	2%	0.3%

Note: The number of existing buildings and population were assumed at 876,000 and 6,360,000, respectively.

Economic Damage Analysis

The effects of an earthquake event can be broken down into three: the economic cost, the human cost including loss of life and personal injuries and the ecological cost among other damage to ecosystem. The economic loss caused by the earthquake can be categorized into three items: direct loss, indirect loss and secondary effects of the earthquake.

Direct Loss

In order to estimate direct loss, previous study results are used. As for the building damage, the replacement costs of each building type are estimated based on the existing building construction practice. The total direct damage by the heavily collapsed buildings is Rial 191,977 billion, or US$ 22.6 billion. The total direct damage by the bridges and lifelines is Rial 238 billion, or US$ 28.0 million, and Rial 70.7 billion, or US$ 8.3 million, respectively.

Indirect Costs and Secondary Effects of Earthquake Damage

Those costs are estimated using available statistical data and the experience of other countries. The indirect damage is estimated at US$ 9.2 billion. Secondary effects of the earthquake damage are estimated at 1.0 percent to 1.2 percent of total GNP, or approximately US$ 1.2 billion.

Total Damage

Total economic impact of earthquake of Ray fault model is summarized as follows:

Direct loss	US$ 22.6 billion
Indirect loss	US$ 9.2 billion
Secondary loss	US$ 1.2 billion
Total Loss	US$ 33.0 billion

Total damage of the earthquake is 56 percent of the GNP.

Emergency Response Costs

Emergency response costs include emergency response costs to Tehran residents, removal of debris and temporary shelter provisions. The total costs are estimated at US$ 2.9 billion.

Rehabilitation and Reconstruction Costs

The rehabilitation and reconstruction costs are estimated to cover 31,000 ha, or 44 percent of the Tehran Municipality. In financial terms, it is about US$ 195 billion, or 3.4 times of the GNP.

Economic Analysis of Earthquake Damage Estimation

Target of damage reduction level is one-tenth of Ray Fault Model's estimated building damage, as indicated in Chapter 1 of this report. In order to achieve this goal, the government and private sector should spend money on earthquake damage mitigation measures. When the damage amount is reduced, emergency response and rehabilitation and reconstruction costs are reduced as well. The following table shows the preliminary analysis results.

		Case 1 (Do Nothing case)	Case 2 (30 percent decrease of damage)	Case 3 (90 percent decrease of damage)
Earthquake Damage	Building Damage	483,000	330,792	51,058
	Human Casualty	383,000	265,572	57,071
	Homeless Victims	3,126,000	2,167,563	465,809
	Debris (1,000 ton)	124,000	85,981	18,477
Costs (US$)	Building Damage	23.5 billion	16.5 billion	3.5 billion
	Building Strengthening	-	14.5 billion	63.0 billion
	Emergency Response	2.9 billion	2.1 billion	0.4 billion
	Rehabilitation and Reconstruction	195.3 billion	130.9 billion	19.5 billion
	Total	221.7 billion	164.0 billion	86.4 billion
Remarks		The damage of earthquake is derived from estimation results in Ray Fault Model.	This case is decrease of damage about 30 percent. This alternative is target reduction level within the period of master plan.	The ultimate case for the damage reduction. It will be 90 percent of damage reduction level. In this case, the damage level can be handled in emergency response.

Note:
In case 1 earthquake damage is derived from "The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, November 2000."
Building Damage Cost is calculated based on the replacement costs of the building.
Building Strengthening Cost is calculated by the building analysis results, using GIs value to determine reconstruction and retrofitting. The unit cost of strengthening building is determined based on the actual conditions and applied to the number of the objective buildings.
Emergency response cost is calculated at US$ 57 per victim per month and it will continue for six months.
Rehabilitation and reconstruction costs are estimated at US$ 6.3 million per hectare based on area development calculation in Appendix 4-3.

SECURE LIVES AND PROPERTIES OF THE CITIZENS OF TEHRAN (DISASTER PREVENTION AND MITIGATION PLAN)

3. Strengthening Existing Buildings

Building Investigation

In order to gauge the seismic resistance of buildings in Tehran, building investigation was conducted on a sub-contracted basis. The sample buildings for investigation were selected as follows, and pertinent design drawings were collected upon obtaining permission for investigation.

Building Type		Sample Nos.
Public Facility	Major public facilities	70
	Hospitals	80
	Schools	100
	Other public facilities	10
Residential buildings	South	10
	Central	40
	North	40
Total		350

Notes: Major public facilities include municipality, fire brigades and police offices. Other public facilities include libraries, museums and theaters.

Method of Analysis

The diagnostic method adopted for analyzing seismic resistance was the "Code of Comprehensive Diagnosis and Renovation of Government Buildings" enacted in Japan in 1996, which is expressed by the Seismic Index of Structure "GI_S" obtained from the following equation.

$$GI_S = Q_U / (\alpha \cdot Q_{UN})$$

Where,
- GI_S : Seismic Index of Structure
- Q_U : Seismic force level for ultimate capacity check
- Q_{UN} : Required seismic force level for ultimate capacity check
- α : Correction coefficient

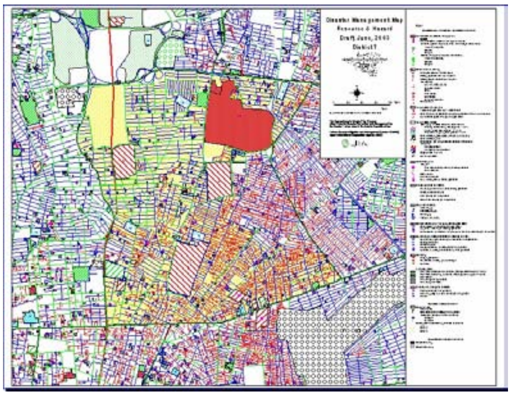
Results

By using GI_S, it was estimated that 50% of existing buildings in Tehran would take heavily damage by the target earthquake. It was also revealed that Masonry structure, which is a dominant structure type in Tehran, is particularly weak.

4. Improvement of Existing Urban Structure

Disaster Management Map and District Diagnosis Sheet

In order to assess the availability situation of existing disaster preventive resources, a Disaster Management Map was prepared by district based on the collected data from district level. District disaster diagnosis sheet is prepared to show the resources and vulnerability level of each district.



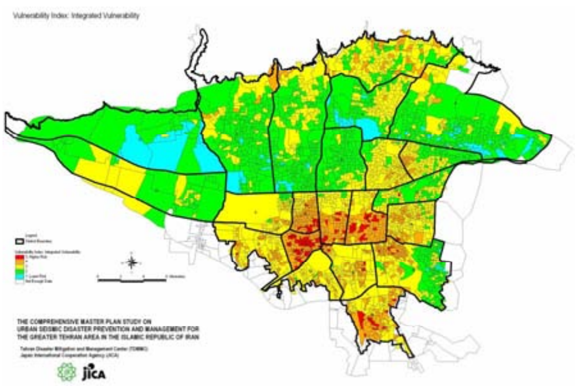
District-wise Diagnosis for Earthquake Vulnerability

In order to evaluate the vulnerability for earthquakes district-wise, three indices, which are Building Damage Index, Evacuation Index, and Secondary Damage Index, are used for the evaluation.

- Building Damage Index:
  Possible highest rates of collapsed buildings to the total buildings resulted from the previous study under the three scenario earthquakes.
- Evacuation Index:
  The evacuation includes open space area, narrow road ratio, number of evacuees and number of disaster weak.
- Secondary Damage Index:
  The variables include hazardous facility, gas pipeline damage and electric power cable damage.

Results of Diagnosis

Integrated vulnerability is assessed on the sum of the estimated three vulnerability indices of building collapse, people's evacuation and secondary disaster. The results of the analysis are shown in the next figure.



Regional Characteristics of Urban Vulnerability

It would be appropriate to evaluate the relative vulnerability of Tehran Municipality in an integrated manner as a whole, yet it is insufficient to indicate the specific problems. To understand specific vulnerability, the Study Team reorganized each vulnerability index into eight categories as shown below.

Evaluation Index	Characteristics of Disaster Management
AAA	Relatively less vulnerable urban structure
AAB	High risk on secondary disaster
ABA	High risk on evacuation possibility
BAA	High risk on building collapse
ABB	High risk on evacuation possibility and secondary disaster
BAB	High risk on building collapse and secondary disaster
BBA	High risk on building and evacuation possibility
BBB	High risk on all variables

The results of analysis show that districts 10 and 17 are the most vulnerable districts.

In order to mitigate existing urban structure in Tehran, the following mitigation measures could be applied based on the analysis above.

1. Urban redevelopment
2. Road and urban infrastructure improvement
3. Area-based building reconstruction and retrofitting
4. Individual building retrofitting and reconstruction

From the aspect of creating a more earthquake resistant urban structure, area-wide urban redevelopment projects are preferred in the context that they would accrue diverse benefits such as the improvement of urban environment and the value-added land use to enhance financial viability of the projects. However, the implementation of urban redevelopment projects should be supported by necessary institutional and legislative arrangements to enable the following systems.

- Public-Private-Partnership (PPP) system
- Dedicated fund for urban redevelopment
- Designation and legislation of "Special Urban Redevelopment Zones"
- Practical land readjustment and right conversion systems
- Financial cross-subsidization system
- Legal process for formulating consensus among residents
- Cadastre-based land registration and appropriate property assessment systems
- Taxation systems to capture accrued benefits from beneficiaries
- Enforcement of earthquake-resistant design codes and inspection system to secure design-compliant building acts

5. Identification of Safety Evacuation Space

The evacuation system mentioned in the Study is proposed as follows:

Regional Evacuation Place

It is an open space such as a large-scale park or green place having a space that is necessary to protect lives of evacuating persons from dangers such as spreading of fire or others that arise at the time of a large-scale earthquake.

Community Evacuation Place

It is a place for neighboring evacuating persons to temporarily assemble and to watch the situation before evacuating to the Regional Evacuation Place. It is a place for evacuating persons to form a group temporarily to evacuate to the Regional Evacuation Place. The place shall be such as urban parks, sports field, school, religious facility, etc. in which the safety of assembled persons can be secured.

Evacuation Route

In this Study, regional evacuation place is identified from public space such as parks and open space. The Study Team identified 136 candidates. Primary evacuation place will be identified by each district.

Emergency road network has been identified in this Study. Emergency road system is proposed as follows:

Primary Emergency Road, linking with Disaster Management Centers of national, provincial, municipality, district, and sub-district municipalities and major airport and seaport as for transportation nodes. In order to set-up the network, all of centers have to be clearly identified and categorized on the base map.

Secondary Emergency Road, linking with all the identified emergency response centers of rescue/fire fighting/security, emergency road, and medical care. Also, all emergency response centers have to be clearly identified and categorized on the base map.

The following figure shows the proposed emergency road network, but it should be reviewed in future.

6. Strengthening Existing Infrastructure and Lifeline

Bridges

The previous Microzoning study estimated six bridges as "Collapsed" and five bridges as "Unstable." Compared with building damage in Tehran, bridge damage is relatively low. Most of those bridges are not reinforced or rebuilt so far. In order to reinforce the existing bridges, a detailed investigation of those bridges is required before any work is carried out. There are several methodologies for reinforcement work.

Water

The previous microzoning study showed the pipeline damage points. The damage analysis on other water supply facility has not been done. It is required to assess the vulnerability of the water supply facility and improve it according to the analysis results.

Gas

The previous microzoning study showed the damage analysis on gas pipeline but not on other related facilities. Based on the previous study results, Gas company has carried out further vulnerability study on gas facility.

Electricity

Damage analysis on electrical power cable damage was done by the previous microzoning study. The other facilities should have been evaluated based on the assessment results.

7. Provision of Earthquake Information and Education

In order to mitigate the damages from an earthquake and prepare for disaster management and emergency response, this plan establishes to increase the knowledge on disaster management and to implement drills to the local government staff and related organizations and also to disseminate the knowledge of disaster preparedness to local residents in various occasions and to try to increase their awareness and capacity of self-disaster-preparedness and responses continuously.

Education for government staff

The following items will be included as necessary information.

- Basic knowledge of earthquake
- Prediction of earthquake breakout in Tehran
- Results of the estimated damages and vulnerability of earthquake in Tehran
- Plan, laws and regulations related to earthquake in Tehran

Disaster -related Organization

- Causes of disaster outbreak
- System and structure of disaster preparedness and duties and functions to be managed by each organization
- Plan of staff responsibilities in case of emergency
- System of coordination and communication with and roles of related organizations
- The past disasters and issues for emergency responses, etc.

Education for School Students

Tehran Municipality and district offices will provide education with the following in mind:

- To consider the contents of guidance and approaches based on the development levels of students, types of schools and location of schools, etc.
- To utilize educational materials such as supplementary readers and audio-visual aids in accordance with students' development levels
- To instruct "importance of life," "family ties," "mutual cooperation", etc. through implementation of learning by experience of nature life, welfare and voluntary activities, etc.

Education for the General Public

As knowledge of daily preparation for earthquake and what to do in case of earthquake, the following items will be enlightened:

- Measures of disaster preparedness regulated by Tehran Municipality and district offices
- Basic knowledge of earthquake and the past earthquake in Iran
- Preparation before occurrence of earthquake and necessary items after occurrence of earthquake

Social Education

Knowledge of earthquake will be disseminated and enlightened through various seminars and trainings with some target groups (NGOs and CBOs) such as women's groups, environmental groups, youth association and PTA, etc., so that local residents can have consciousness as members of society and increase awareness of their contribution to local disaster preparedness.

8. Establishment of Disaster Mitigation Policy

Insurance

It is the primary responsibility of the Government to promote and motivate insurance coverage for natural disasters, including earthquakes. The fact that the Government doesn't even insure its own assets, including cultural assets of the country, sends the wrong signal to society.

At present, since premium rates are determined "across-the-board" by the "Iran Central Insurance Co." , other actors in the insurance sector can not use rebates, discounts and any other price mechanism to improve their competitive position within the market , thereby limiting their capacity to broaden their client-base

There are many examples of countries, such as Japan, the United States, New Zealand, France, Spain, Caribbean and Latin American countries that have in place one or the other form of disaster insurance scheme.

Governmental Assistance Policies

Three political measures to assist in promoting private building strengthening are possibly considered; low-rate loan, subsidy and insurance. Each of those policy or options by mixture can be applied case by case.

- Low-Rate Loan
  Low-rate loan scheme with an annual interest rate of 8% and 10 years of payback period is applied to the cost for building strengthening, considering an annual open market rate of 15% in Tehran.
- Subsidy
  Subsidy will be applied to the cost of building diagnosis and a part of building strengthening cost.
- Insurance
  Government can utilize the insurance system in obtaining investment cost of area development or fund for low-rate loan scheme described above, by taxing on private insurance companies. The insurance policy shall indirectly contribute to the promotion of private building strengthening.

Considering building characteristics of steel or RC frame and masonry, it is recommended to apply different policy settings to steel or RC frame building owners and masonry building owners, for both strengthening and reconstruction cases. The total amount of yearly required cost is estimated as approximately US$ 122.8 million, including the cost for seismic diagnosis covered by subsidy.

Management of Revenue

It takes a vast amount of capital investment cost for the promotion of private building strengthening. This amount shall be covered by earthquake disaster related fund, which can be created by use of revenue of Tehran Municipality, interest from return back by loan program and taxing on privatized insurance companies.

Sustainability and public consensus are the key factors for the selection of policy for the assistance in promoting private building strengthening.

9. Establishment of Community Level Disaster Management Organization

Community-Based Activities for Disaster Preparedness

In order to protect life and property of the local people from earthquake damages, it is important for all disaster-related organizations at national to community levels to take measures as best as they could. At the same time, individual local resident has to get a concept of self-protection, have enough knowledge of earthquake, accumulate training, learn countermeasures of disaster by experience and implement these activities at home, in the community and workplaces, etc. Furthermore, these measures for disaster preparedness can be effective if the local community cooperate, collaborate with existing community organizations such as youth association and women's groups and establish community-based groups of disaster preparedness. For this purpose, local government will indicate the standard and regulations for appropriate and effective activities for disaster preparedness.

Roles of Workplace

The role and contents to be implemented by industries and workplaces for local disaster management activities are described here. The persons who manage or operate the workplaces and facilities will protect and keep safe the employers and users and implement appropriate activities for disaster preparedness in order to prevent the area from expanding the disaster. Additionally, the workplaces will make efforts to participate in the activities for disaster preparedness such as rescue of the affected people as a member of the community. For this purpose, the workplaces will make groups of self-disaster-preparedness, contact with other groups of self-disaster-management in the related area and try to secure the safety of the workplaces and the related area actively.

Support and Guidance from Tehran Municipality

Tehran Municipality and district offices will promote involvement of the existing CBOs and NGOs and establishment of groups for self-disaster-management in Tehran and support for the vitalization of their activities. Areas to be considered with attention are areas (a) with high population density, (b) with many disaster weak, (c) with high vulnerability of housing and facilities, (d) with less collaboration among the residents, and (e) with shortage of water for fire extinguishing.

Community Level Organization

As to administrative level, there exists sub-district under district. Since mahale is not an administrative division, there is no formal links between district office and local residents. In considering the disaster preparedness and emergency responses, the bridge between district offices and individual local resident is indispensable.

The candidate places are:

- housing complex
- mahale council
- school
- office, factory and bazaar
- mosque
- cultural center
- health center
- sports center
- NGOs and CBOs
- Red Crescent Society
- Public participation center, etc.

These places can be a center for disseminating information and collecting people for training and seminars provided by district offices. And the people in these places will be able to respond to emergency as a group if they are provided with information and training. Since the social structure in Tehran is very complex and diversified, these networks should be combined accordingly for the purpose to cover all area of Tehran.

PROTECT CITIZEN'S LIFE AFTER THE EVENT (EMERGENCY RESPONSE PLAN)

10. Improvement of Emergency Response System

Emergency Response Scenario

Ray Fault Model is taken as the scenario earthquake. However, the damage considered to be caused by the Ray Fault Model is extraordinarily huge and sometimes beyond imagination. Therefore, some description might not demonstrate the real situation.

Emergency response scenario of 1) Municipality Emergency Response Headquarters, 2) Rescue, Relief and Medical Treatment, 3) Evacuation, 4) Traffic and 5) Lifelines are assumed.

Legal Background of Emergency Response

According to 29th Act of the Constitution, the Iranian governments regulate themselves to provide social security services for health and treatment services and medical care, etc. The governments should prepare emergency response plan and procedure to cope with the situations. At the national level, the Red Crescent Society of Iran has a responsibility for rescue and relief activities.

Upon the request from the Mayor of Tehran, the National Committee for Natural Disaster Reduction asked the relevant organizations to formulate a disaster management plan at Tehran Municipality level. Tehran Comprehensive Disaster Management Plan was formulated by the Tehran Municipality. Therefore, the Study covers whole disaster management fields and this section deals with emergency response based on the existing disaster management efforts.

Organization and Management System

Organization

The Tehran Comprehensive Disaster Management Plan proposed the establishment of an emergency response organization based on Incident Command System (ICS), which is a model for command, planning and coordination after emergency.

Commanding system

The comprehensive disaster management plan proposed to have an ICS together with Standard Emergency Management System (SEMS). Standard Operation Plan is established in Tehran Municipality.

Organization for Initial Action

According to the existing laws and regulations, the organization for the emergency response is shown as follows:

11. Formulation of Emergency Response Plan

Information and Communication System

If the disaster and rescue network will be newly installed, all desirable functions will be equipped in this occasion.

Necessary Information in Disaster and Rescue Network

The necessary information is divided into two categories, one is for victims and public and the other is for rescue and relief operations.

The information is summarized in three.

- Information of next earthquake and fire as after shock
- Safety information of family, friends and relatives
- Detail earthquake information such as hypocenter and seismic intensity

While, the following information should be required for rescue and relief operations.

- Information of number of victims to be nursed in each area

- Road blockade information
- Notification of designated evacuation route and place
- Information of commodity supply such as water and food

Configuration of Disaster and Rescue Network

The backbone of the network is newly established with microwave system connected between TDMMC and 22 district buildings. TDMMC is a hub station, and all the necessary information are collected and analyzed, and sub-disaster management center is also provided for security reason.

The core network is very stable and has large capacities, so it is recommended to use the core network in routine works during office hours.

- New mobile radio system operated by TDMMC
- Satellite network with small terminal station
- GSM network as a part of public network

Radio LAN network and private PHS mobile system is also to be studied (it is the access network in Japan).

The most important role in the management center is to prepare the optimum formation for rescue and relief operations to meet the damage size judging from obtained daily observation data.

Search and Rescue

Resources for search and rescue operation in Tehran is expected totally short to meet exploding needs after the earthquake. Given the circumstances, some important strategies to fulfill the overall objective will be to:

Move promptly based on the simplified command and coordination mechanism

Search and Rescue operation is commonly understood to be critically effective until 72 hours after the building destruction by the earthquake. Only simplified system to make decisions, which might be realized by uniting local Task Force Organizations with national organizations, can make it possible to mobilize the resources over the country and concentrate them on Tehran in the shortest time.

Utilize the community resources for disaster response to the fullest extent

It will be impossible to put Search & Rescue teams into countless collapsed buildings. Rescue operations will not reach the people in any other way but by counting on community people's help for the trapped in ruins of residential buildings with three or less stories.

Establish Mass Casualty Management as a part of systematic response

Tertiary level hospitals need to be protected from being overwhelmed by massive light cases. Establishment of control system of victims' flow from community to hospitals is crucially important for effective disaster management.

Search and rescue teams

Search and rescue teams at three levels defined in table below will be deployed over the affected area. In principle, one District Rescue Team and ten Community Rescue Teams may be thrown in a district impartially, while two to three Hyper Rescue Teams, which are equipped with advanced search devices, will be dispatched to the highest priority facilities

Field Care

Casualties will be managed through the standardized in It consists of four vital emergency elements: community-based response activity, AMPs at sites, Hospital care and Logistics. Among them one of key components is AMP, which will play a role of checking point before sending the injured to hospitals to control their flow.

Role of team at AMP

Time, Place & Job principles
A. During emergency period – for first 5 to 7 days after the impact
Target: community people who are injured by impact or fire Place: At the entrance of health center, hospital and in evacuation places Major roles are to: 1) Provide first aid at collecting points 2) Carry out triage, minimal treatment and transfer severe cases to hospitals after stabilization 3) Open for 24 hours 4) Have drugs, consumables and equipment for trauma cases mainly
B. Post emergency period – from 6 to 8 day onward
Target: evacuated people at shelters and camps, and patients who need care at sites Place: not always AMP but at fixed- shelters/camps and affected area on visiting base Major roles are to: 1) Transfer severe cases to hospitals 2) Provide 12 hours service for injured cases as well as acute internal and chronic cases 3) Have medical necessities for internal, chronic and mental cases mainly

Community-based Rescue and Treatment Activities

Rescue- and Relief- related players in community are categorized into two: One is Local authority, personnel and groups, and the other is Local Health Personnel (LHP). Community people will be organized and mobilized on voluntary basis to assist Community Authority and Local Health Personnel.

Player	Role in the Urgent period
Community*	Set up of Emergency Committee Dissemination of information Search and Rescue operations Fire Extinguish operations Transfer of casualty Assistance of Reception at Health Centers or Hospitals
Local Health Personnel	Organizing Health Centers or Hospitals Triage On site treatment

Note: * local authorities and persons or groups who concern themselves in the localities with rescue work, communications, transport, shelter and food supply

Evacuation

It is necessary to let residents in the disaster area evacuate quickly to the safe place in following cases:

- When it is estimated that danger to human lives has seriously increased;
- When it is estimated that human lives in wide area will face the danger caused by flowing-out and diffusion of gas, etc.;
- When a lot of fire arise at the same time caused by an earthquake and they spread and expand; and:
- When it is deemed necessary to protect lives and bodies of residents from disaster.

TDMMC and District Municipality

When a danger is imminent in an area of jurisdiction, the District Municipality shall, upon communicating with TDMMC, recommend or instruct evacuation after evacuation needed area and evacuation place are specified.

When disaster has arisen or is about to arise and it is deemed necessary to protect human lives or bodies, District Municipality shall establish a warning area and restrict or prohibit the entry into such area and order to move-out from such area.

Even in an ordinary time, it is necessary for each area or community (residents association) to grasp the actual condition of the area in respect of forming a group or of self-governing situation at the time of evacuation.

Regional Firefighting Department

Firefighting Department shall recommend or instruct residents to evacuate when it judges that spreading of fire or diffusion of gas is rapid and that the danger to human lives is seriously imminent. On such occasion, it shall immediately notify the District Municipality.

Evacuation Guidance

The role and measure for the evacuation guidance in each organization shall be defined by respective agencies.

TDMMC and District Municipality

When recommendation or instruction is issued TDMMC shall quickly distribute the contents of recommendation or instruction by following measures:

- Announcement using speaker at mosques or schools
- Oral communication to residents or community leaders directly
- By utilizing mass media
- By utilizing publicity activity by Police Department or Fire Fighting

At the Community Evacuation Place, staff of the District Municipality shall formulate groups of respective areas, communities or companies by obtaining assistance of a Police Department and a Firefighting Department. After that, they shall organize a group leader of communities or persons in managerial position of companies and shall guide them to the Regional Evacuation Place. On such occasion, it shall cause persons who are vulnerable to disaster such as sick persons, senior citizens or disabled persons to evacuate on top priority

It shall allocate necessary number of guides at the Regional Evacuation Places. They engage in collection of information relating to damage and public relations activity and getting hold of missing people. They also shall take measures of re-evacuation when it judges dangerous and shall make efforts to keep the order at the evacuation place.

Firefighting Department

Firefighting Department shall notify TDMMC and the District Municipality about most safe route and directions of evacuation taking into account the size of disaster, situation of roads and bridges, diffusion route of fire and operation of fire fighting.

When evacuation begins, Firefighting Department shall engage in evacuation guidance by activities of firemen.

Firefighting activity after the point when recommendation or instruction is issued shall endeavor to secure the safety of evacuation places and evacuation roads.

Traffic

Control from Space Aspect

Route Control

The route control covers road sector and route. Total prohibition or partial prohibition on traffic in which passage of vehicles other than designated ones are prohibited, is implemented. Designation of emergency road or emergency transportation routes falls under this category.

Area Control

The area control is to regulate the traffic, in a uniform manner, not only for disaster-affected areas but also surrounding areas. One can imagine possible cases in which it becomes impossible to go through roads because of collapse of structures along roads such as roads houses, buildings, power poles or fences and so on and road traffic function is paralyzed in the surrounding blocks of areas.

Control from Time Aspect

Detailed regulation by a unit of time is unrealistic in a state in which traffic is confused at the time of disaster, and rough regulation, which takes into account the actual situation of traffic in daytime or night time or on weekdays or weekend, is appropriate. However, it would be better to avoid, as much as possible, changing the regulation time depending on the traffic situation. The reason being that, if the regulation is changed frequently, it becomes difficult to make information concerning regulation fully understood, mistrust to the regulation arises and it is feared that the traffic situation becomes even unstable by contrast.

Traffic Enforcement and Provision of Information

Whether or not the traffic regulation can achieve its objectives largely depends on the implementation system of the traffic enforcement. If, although emergency transportation routes are proposed, number of entry point on crossing roads and areas along roads are enormous, it is quite difficult to restrict the inflow of ordinary vehicles only by means of barrier, cone or allocation of police officers. And it can be well imagined that illegal parking or abandoned vehicles on emergency transportation roads cause traffic jam. Therefore, in order to enhance the effect of traffic regulation, it is necessary to provide information quickly by using any and all means.

Health and Medical Service Operation

Medical resources available in Tehran is expected totally short to cope with enormously surging needs after the earthquake. Given the circumstances, some important strategies to fulfill the overall objective will be:

To place first priority on life-saving care throughout the medical care operations

Treatments must be selectively provided to the injured who will be judged savable through triage at every treatment point.

To mobilize and utilize available resources fully regardless of locations, ownership and source

Government commitment is crucially important to mobilize private sector totally by endorsing monetary compensation for their expenses to treat the injured unconditionally.

To make systematic response by establishing treatment level tiered-system over the country

Establishment of system to provide care, from community first, then to transfer to hospitals in local network, and to hospitals in metropolitan and national network, is crucially important.

To provide health care to fit people's needs which change over time

Health resources must shift from treatment for surgical cases during first several days to care for acute internal cases followed by patients with chronic diseases.

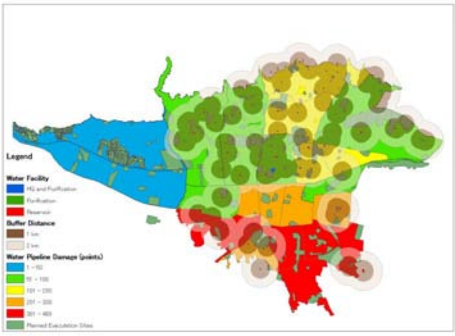
Lifeline

In Tehran Municipality, by initiation of TDMMC, each Sub-committee, including Water Committee, Natural Gas Committee, Power Committee, prepared a Standard Operation Plan for emergency response. Furthermore, based on the Standard Operation Plan, Greater Tehran Gas Company, and Tehran Regional Electric Company prepared a more detailed Emergency Response Plan. Especially, GTGC is revising their plan by reviewing the Emergency Response Plan of Osaka Gas, which covers all the necessary part of emergency response. It is necessary to prepare such a plan and each staff must be aware and well understand the purpose and importance of such a plan. According to the meeting with Tehran Water and Sewage Company, they have not prepared a detailed emergency response plan yet; however, in March 2000, "A Study on Seismic Risk, Impact by Service Interruption and Earthquakes Preparedness in Tehran Water Supply System" was completed, and important recommendations are given in the study. Therefore, utilizing the information, it is necessary to prepare a detailed emergency response plan in the near future. In the later section, tentative emergency response plan is prepared for the reference.

Water Supply

Potable water is indispensable resource for human life. After the event of earthquake, it is easy to imagine that lack of water will be occurred and, therefore, establishment of emergency water supply plan in advance will be extremely important to avoid a disorderly situation.

Distribution and the capacity of Water Reservoirs



Emergency Water Capacity by District

District	Population	Area (ha)	Total amount of water in Reservoirs (m3)	Amount of water available (liter/person)	No of Days to be no supply of water (days)
1	229,143	3,454	332,200	1,450	21
2	464,773	4,956	278,800	600	14
3	237,301	2,938	137,300	579	14
4	647,207	7,243	357,900	553	14
5	424,960	5,901	317,200	746	16
6	242,049	2,144	240,100	992	18
7	300,212	1,537	314,500	1,048	19
8	332,005	1,324	37,000	111	8
9	173,482	1,955	63,500	366	12
10	282,308	806	0	0	0
11	234,251	1,206	0	0	0
12	189,625	1,358	0	0	0
13	238,735	1,389	0	0	0
14	367,472	1,456	153,500	418	12
15	595,856	2,846	53,700	90	7
16	289,999	1,655	0	0	0
17	287,367	796	20,000	70	6
18	272,534	1,785	52,500	193	10
19	202,994	1,149	56,000	276	11
20	293,100	2,028	0	0	0
21	131,202	5,196	0	0	0
22	57,230	6,140	0	0	0
Total	6,493,805	59,262	2,414,200	372	12

Source: TWSC, 2003

It shows that after 11 days, people with access to water will be half of the population in Tehran, and after 21 days, no one will have access to water. However, as mentioned before, this figure assumes that no water transmission is supplied from dam and purification plants. It is hard to estimate all the transmission pipes will be damaged. Therefore, this is the worst case and it can be said that total volume stock of water by water reservoirs is comparatively large even if compared with other countries.

Foods Provision

The following measures are the necessary requirements for Tehran Municipality.

To provide storage facility for foods and primary living requirements in relevant institutions in each of 22 Districts

Emergency response related institutions in each of 22 districts such as district office, traffic police, Basij, and military installations are preferable to provide storage facility, taking into account the capability of provisions to go through, which depends on the accessibility to emergency road network.

To make an agreement on foods provision with retailers and wholesalers

The emergency foods should be put in storage facilities at any time. However, given the limitation of storage capacity, emergency foods will be run out in the long disaster recovery term. The relevant institutions should have a contract with retailers and wholesalers for additional provision by order in the case of lack of foods.

To establish a cooperative setup and define the sphere of responsibility and roles with Red Crescent

For the effective foods provision in the event of disaster, the responsible areas to Red Crescent and Tehran Municipality should be clarified.

PREPARE REHABILITATION AND RECONSTRUCTION (REHABITITATION AND RECONSTRUCTION PLAN)

12 Establishment of Rehabilitation and Reconstruction Procedure

The process for urban rehabilitation and reconstruction can be divided chronologically into five stages from the moment the earthquake disaster.

Stage 1: Establishing the Preliminary Framework for Urban Reconstruction

(Within one week from the time of the earthquake)

This is the period for confirming the initial framework for the reconstruction of the city, and during this time the basic mechanism will be established by the Municipality for tackling urban reconstruction swiftly, including setting up a post-disaster reconstruction headquarters.

Stage 2: Formulation of Basic Policies for Urban Reconstruction
(From one week to one month after the earthquake)
During this period the basic policy regarding the reconstruction of the city will be drawn up at the post-disaster reconstruction headquarters in order to make clear the fundamental approach to be taken towards the rebuilding work, and when this has been determined the residents will then be notified of it.

Stage 3: Formulation of Basic Plan for Urban Reconstruction
(From one month to six months on)
During this period a basic plan will be drawn up a basic plan for rebuilding the town and with this clarify the both the fundamental plan for the regeneration of the whole of the Tehran City and/or each area that has suffered damage and also the methods for achieving this.

Stage 4: Confirmation of the Work Program for Urban Reconstruction
(From six months to a year on)
In this stage the work will be conducted towards getting the agreement of the local residents and create a program of work for the reconstruction based on the basic plan that was formulated.

Stage 5: Implementation of Urban Reconstruction Projects
(One year and onwards)
In this stage, rebuilding the town will be forwarded based upon the work program for urban reconstruction drawn up in Stage 4. In order to carry this out rapidly, endeavors to secure financial resources will be indispensable.

It is a fundamental aim to recover the citizen's life to the original conditions. However, it is also the principal objective to reconstruct new living style for the victims who suffer huge damages onto their minds, bodies and properties. The new style shall conform with new reality of the situation of the disaster and living.

14 Implementation Plan

The implementation agency for the projects will be the governmental sector as shown in the long list. It can be divided into four hierarchal organizational systems: national government, Tehran Municipality, district government and community level as well as semi-governmental agency. The lifeline company, falling into semi-governmental organization, should take responsibility for implementation of their facility.

The long list prepared in this study includes the entire projects aiming to achieve goal and objectives for the master plan. The long list is compiled by the strategies of the master plan and re-grouped into the priority program

The total cost for all projects proposed in the long list is estimated at US$ 1,931 million, excluding the project cost for promotion of private building strengthening, amounting to US$ 940.9 million

The cost for private building strengthening promotion project is omitted.

Allotment of Investment Cost by Organization Level

Organization Level	Investment Cost (Million US$)
National	Sub Total 541.7
Ministry of Housing and Urban Development	1.4
Ministry of Interior	3.0
Ministry of Defense	0.8
Ministry of Health and Medical Education	156.7
Ministry of Transportation and Traffic	15.3
Ministry of Education	338.1
Other Ministries	26.6
Tehran Municipality	Sub Total 978.3
TDMMC	178.9
District Affairs Deputy Office	58.2
City Service Deputy Office	190.2
Transportation and Traffic Deputy Office	159.4
Urban Development and Architecture Deputy Office	51.8
Social and Cultural Affairs Deputy Office	0.8
Others	339.2
District Municipality	51.9
Government-Owned Lifeline Companies	350.6
Red Crescent Society	8.4
NGOs, Private Sectors	0.2
	Total 1,931.1

Total investment cost of Tehran Municipality is almost double of national level investment cost. In particular, TDMMC will take a vital role in implementing the earthquake disaster management projects.

The individual projects in the long list are measured by the assumed evaluation indicators as follows:

(1)	Master Plan Objective Aspect
(1-1)	Contribution to Securing Lives and Properties (Contribution to Mitigation: Physical Measures)
(1-2)	Contribution to Securing Lives and Properties (Contribution to Preparedness: Software Measures)
(1-3)	Contribution to Protection of Citizen's Life after the Event
(1-4)	Contribution to Preparation of Rehabilitation and Reconstruction
(2)	Performance Aspect
(2-1)	Governance Improvement
(2-2)	Neighborhood Consciousness Enhancement
(2-3)	Beneficiaries
(2-4)	Basic Human Need
(3)	Implementation Aspect
(3-1)	Urgency
(3-2)	Estimated Project Cost
(3-3)	Financing Potential
(3-4)	Implementing Maturity

Based on this criteria, the Study Team selected priority project as shown below:

No.	Title of Priority Project
1	Strengthening and Replacement of Existing Public Buildings
2	Promotion of Strengthening of Existing Private Buildings
3	Improvement of Building Quality
4	Promotion of Urban Redevelopment for Disaster Prevention
5	Provision of Regional Evacuation Sites and its Facility
6	Strengthening and Replacement of Bridges along Major Road Network
7	Strengthening of Water Supply Facility and Network
8	Installation of Central Control System for Natural Gas Distribution System
9	Establishment of Model Schools for Disaster Education with Different Characteristics at Tehran Municipality Level
10	Designation of Model Communities for Organization of Community Level Disaster Management Group and System
11	Tehran Disaster Mitigation and Management Center - Institutional Capacity Building
12	Establishment of Emergency Traffic System in Tehran
13	Installation of New Disaster Information and Telecommunication Network
14	Strengthening of the Emergency Response Capability and Capacity of the Tehran Fire Fighting and Safety Services Organization
15	Strengthening of Emergency Response Capacity for the Governmental Health Organization

Table of Contents

Executive Summary

List of Tables

List of Figures

Abbreviations and Acronyms

3C-S	Command-Control-Communication Structure
ADPCM	Adaptive Differential Pulse Code Modulation
AEO	Atomic Energy Organization; Office of the President
AMP	Advance Medical Post
BHRC	Building and Housing Research Center
BOR	Bed Occupancy Ratio
BSCSRA	Bureau for Studies and Coordination of Safety and Recovery Affairs
BTS	Base Transmitting Station
CAR	Contractors All Risk
CBO	Community Based Organization
CDE	Council for Determination of Exigencies (see also SEC)
CDMA	Code Division Multiple Access
CEAAAO	Civil Employment And Administrative Affairs Organization; Office of the President
CEMS	Tehran Comprehensive Emergency Management Plan Secretariat
CEST	Center for Earthquake and Environmental Studies of Tehran
CGC	Council of Guardians of the Constitution
CIC	Commander-in-Chief
CP	Collecting Point or Command Post
CPMR-SCCR	Council of Policy Making for Reconstruction – The Supreme Council of Cultural Revolution
CRO	Civil Retirement Organization; Office of the President
DAMA	Demand Assignment Multiple Access
DEG	Diesel Engine Generator
DEMP-NL	Disaster Emergency Master Plan at National Level
DHC	District Health Center
DM	Disaster Management
DMG	Disaster Management Group
DMH	Disaster Medical Hospital
EAR	Erect All Risks
ECS	Emergency Communications System
EMS	Emergency Medical Service
EMT	Emergency Medical Treatment
EMTFM-DL	Emergency Management Task Force – District Level
EMTFM-ML	Emergency Management Task Force – Municipality Level
EMTFM-SDL	Emergency Management Task Force – Sub-district Level
EOC	Emergency Operations Center
EPO	Environmental Protection Organization; Office of the President
ER	Emergency Response
ER	Emergency Room
ERP	Emergency Response Plan
FEMA	Federal Emergency Management Agency
FWA	Fixed Wireless Access
GIS	Geographic Information System
GNP	Gross National Product
GOI	Government of Iran
GOJ	Government of Japan
GSM	Global System for Mobile communications
GTA	Greater Tehran Area
GTGC	Greater Tehran Gas Company
GTMA	Greater Tehran Municipality Area
HDPE	High Density Polyethylene
HLR	Home Location Register

H&S	Health & Sanitation
I.R.I.	Islamic Republic of Iran
ICA	Islamic Consultative Assembly (also “Majlis”)
ICB	International Competitive Bidding
ICS	Incident Command System
ICU	Intensive Care Unit
IIEES	International Institute of Earthquake Engineering and Seismology
INDMP	Integrated Disaster Management Plan
INGC	Iran National Gas Company
ITU	International Telecommunication Union
IUMS	Iran University of Medical Science
JICA	Japan International Cooperation Agency
KDD	Kokusai Densin Denwa Corporation
LHP	Local Health Personnel
LOS	Length of Stay
LS	Local Switch
MCM	Mass Casualty Management
MDF	Main Distributing Frame
MMI	Modified Mercali Intensity
MOAJ	Ministry of Agriculture Jihad
MOC	Ministry of Commerce
MOCHE	Ministry of Culture & Higher education
MOCO	Ministry of Cooperatives
MODAFL	Ministry of Defense & Armed Forces Logistics
MOE	Ministry of Energy
MOEAF	Ministry of Economic Affairs & Finance
MOET	Ministry of Education & Training
MOFA	Ministry of Foreign Affairs
MOH	Ministry of Health (and Medical Education)
MOHUD	Ministry of Housing & Urban Development
MOI	Ministry of Interior
MOIC	Ministry of Information & Communication
MOICG	Ministry of Islamic Culture & Guidance
MOIM	Ministry of Industry & Mines
MOIS	Ministry of Intelligence & Security
MOJ	Ministry of Justice
MOLSA	Ministry of Labor & Social Affairs
MOP	Ministry of Petroleum
MORT	Ministry of Roads & Transport
MPO	Management & Planning Organization, Office of the President
MU	Medical University
NCNDR	Law of Foundation of National Committee for Mitigation of Natural Disaster Effects
NDOI	National Documents Organization of Iran; Office of the President
NDTF	National Disaster Task Force
NDTFOrg	National Disaster Task Force Organization
NGO	Non-Governmental Organization
NIGC	National Iranian Gas Company
NPWG	National Preparatory Working Group
NTF	North Tehran Fault
NTT	Nippon Telegraph and Telephone Corporation
ODA	Official Development Assistance
OM	Operation & Maintenance
PAHO	Pan American Health Organization
PDC	Personal Digital Cellular telecommunication system
PDTF	Provincial Disaster Task Force
PDTFOrg	Provincial Disaster Task Force Organization

PE	Polyethlene
PEO	Physical Education Organization; Office of the President
PGA	Peak Ground Acceleration
PHS	Personal Handyphone System
PO	The President's Office
PP	Participation Papers
PPP	Public-Private-Partnership
PPWG	Provincial Preparatory Working Group
PR	Public Relations
PTA	Parents Teachers Association
PTFOrg	Provincial Task Force Organization
QPSK	Quadrature Phase Shift Keying
R&R	Reconstruction & Rehabilitation
RCS	Red Crescent Society of Islamic Republic of Iran
RRCP	Rescue & Relief Comprehensive Plan
SCI	Statistics Center of Iran
SEC	State Exigency Council (also referred to as CDE)
SMTCI	State Management Training Centre of Iran; Office of the President
SNG	Satellite News Gathering
SOP	Standard Operation Plan
SPV	Special Project Vehicle
STD	Subscriber Trunk Dial
SUMS	Shahid Beheshti University of Medical Science
TCEMP	Tehran Comprehensive Emergency Management Plan
TCI	Telecommunication Company of Iran
TCIP	Turkish Catastrophe Insurance Pool
TCT	Telecommunication Company of Tehran
TCTTS	Tehran Comprehensive Traffic and Transportation Study
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TDMMC	Tehran Disaster Mitigation and Management Center (Merged CEST and CEMS)
TDMO	Tehran Disaster Management Organization
TERMOP	Tehran Emergency Response Management and Operations Plan
TETCO	Tehran Engineering Technical Consulting Organization
TF	Task Force
TFFSSO	Tehran Fire Fighting and Safety Services Organization
TFOrg	National Task Force Organization
TGIS	Tehran GIS Center
TM	Tehran Municipality
TMCSO	Tehran Municipality Computer Service Organization
TMN	Total Management Network
TPWG	Township Preparatory Working Group
TREC	Tehran Regional Electric Company
TTTO	Tehran Traffic and Transportation Organization
TUMS	Tehran University of Medical Science
TWSC	Tehran Water and Sewage Company
UBC	Uniformed Design Code
UNDP	United Nations Development Program
VSAT	Very Small Aperture Terminal
WB	World Bank
WHO	World Health Organization
WLL	Wireless Local Loop
WTO	World Trade Organization

General

GENERAL

1. Introduction

In response to the official request of the Government of Islamic Republic of Iran (hereinafter referred to as “GOI”), the Government of Japan (hereinafter referred to as “GOJ”) has decided to conduct “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran” (hereinafter referred to as “the Study”).

The Japan International Cooperation Agency (hereinafter referred to as “JICA”), the official agency responsible for the implementation of technical cooperation programs of GOJ, undertook the Study in accordance with the relevant laws and regulations in force in Japan.

On the part of GOI, the Center for Earthquake and Environmental Studies (hereinafter referred to as “CEST”) acted as the counterpart agency to the Japanese Study Team (hereinafter referred to as “the Study Team”) and also as the coordinating body in relation with other governmental and non-governmental organizations concerned with the smooth implementation of the Study.

In February 2003 the Decree of the Mayor of Tehran was issued, declaring the establishment of “Tehran Disaster Mitigation and Management Center (hereinafter referred to as “TDMMC”), in which existed two disaster-related organizations of Tehran, CEST and Tehran Comprehensive Emergency Management Plan Secretariat (hereinafter referred to as “CEMS”) were merged. The establishment of TDMMC was confirmed through the official letter from TDMMC to JICA with reference to 190/2452 dated 8 September 2003. According to the establishment of TDMMC, the authorities as a counterpart agency to JICA Study Team were transferred from CEST to TDMMC.

This Final Report is compiled to summarize all the Study contents.

2. Background of the Study

Tehran City is located at the foot slope of the Alborz Mountain Ranges that form part of the Alpide-Himalayan Orogenic Zone, which is a high potential earthquake zone having many peculiar active faults. According to the historical seismic data, Tehran has suffered from strong earthquakes at 150-year return period; Manjil City, which is located 200 km northwest from Tehran, was hit by a strong earthquake in 1990. Seismologists predict a strong earthquake will hit Tehran in the near future, because the City has not experienced any disastrous earthquake since 1830.

"The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran" was conducted with the cooperation of JICA and Tehran Municipality between 1999 and 2000. As a result of this study, it is pointed out that a strong earthquake caused by the fault activity of the Ray Fault will largely affect Tehran City. Huge seismic damages to both buildings and people are estimated, especially in the Southern part of Tehran City where dense populations and traditional non-seismic-resistant buildings are dominant.

Tehran Municipality does not yet have a comprehensive and firmly approved disaster management master plan, though there are various important activities and documents toward that end. The Red Crescent Society of Islamic Republic of Iran (RCS), for example, is preparing a rescue and relief plan that will cover the immediate "ex-post event" emergency response measures. Master plans for prevention, preparation and rehabilitation still need to be completed.

Taking those circumstances into consideration, GOI requested GOJ to conduct the Study as a technical cooperation program. The Study commenced in August 2002.

3. Scope of the Study

3.1. Study Objectives

The objectives of the Study are:

1) To formulate a master Plan and its implementation plan for urban Seismic Disaster Prevention and management for Tehran City; and

2) To transfer skills and technical knowledge on urban seismic disaster prevention and management to counterpart personnel of CEST (subsequently TDMMC) in the course of the Study.

3.2. Study Area

The study area covered the entire area of Tehran City, which is composed of 22 districts and boundary zones as shown in Figure G. 1

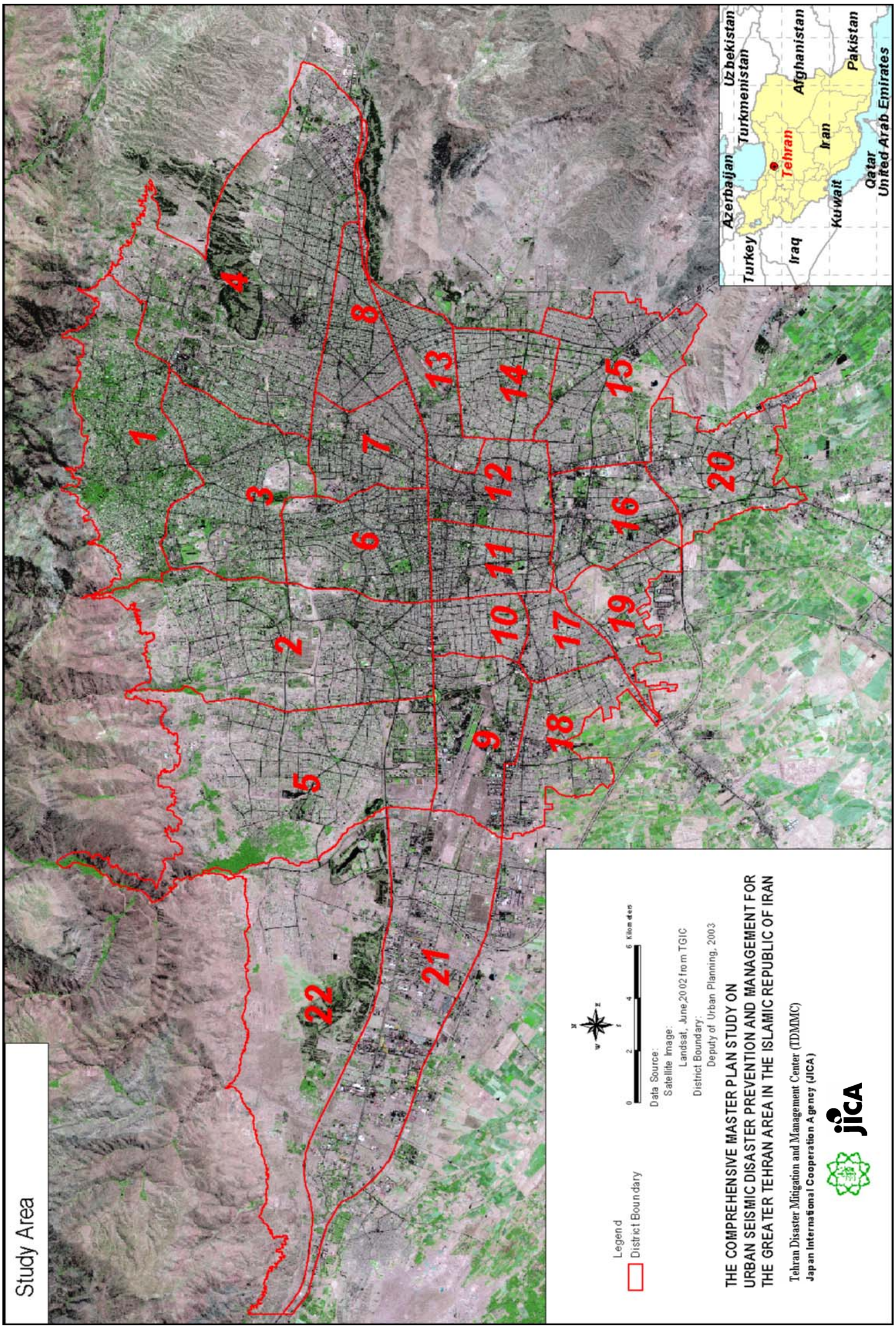


Figure G. 1 Study Area

3.3. Schedule of the Study

The Study consisted of a variety of tasks. Figure G. 2 shows the work schedule, interrelations among the tasks and the logical flow of the Study.

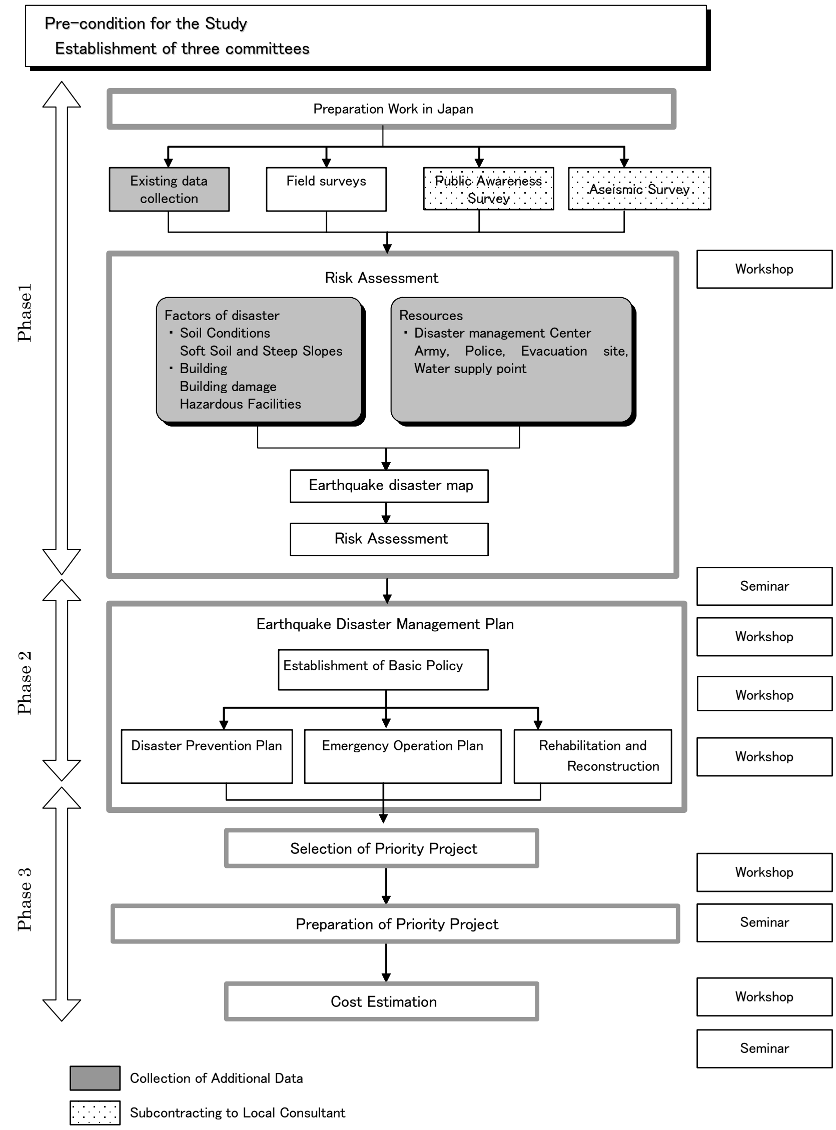


Figure G. 2 Flow Chart of the Study

3.4. Implementing Organizations

The Study was carried out through the joint efforts of the JICA Study Team and Iranian counterpart personnel, who formed the study implementing body. The JICA Study Team was comprised of members from Pacific Consultants International (PCI) and OYO International (OYO). The Iranian counterparts were delegated from CEST and subsequently TDMMC.

In Tehran, many agencies including governmental organizations, universities and research institutes have been conducting seismic research and disaster management activities.

Considering the necessity of involving relevant Iranian agencies and organizations in the Study, Iranian side established three kinds of committees, namely, Steering Committee, Technical Committee and Implementation Committee. The responsibility of Steering Committee is to guide whole of the Study in the proper direction as a highest-level committee. And that of the Technical Committee and the Implementation Committee, allocated under the Steering Committee, is to advise to CEST (subsequently TDMMC) and the JICA Study Team on appropriate technologies to be applied in the Study, and to provide the relevant information and to advise CEST (subsequently TDMMC) and the JICA Study Team from the viewpoint of project implementation.

Figure G. 3 shows the relationship of study organizations, followed by the member lists of Japanese side study organizations shown in Table G. 1. Members of the Steering Committee, Technical Committee and Implementation Committee are shown in Table G. 2 and Table G.3.

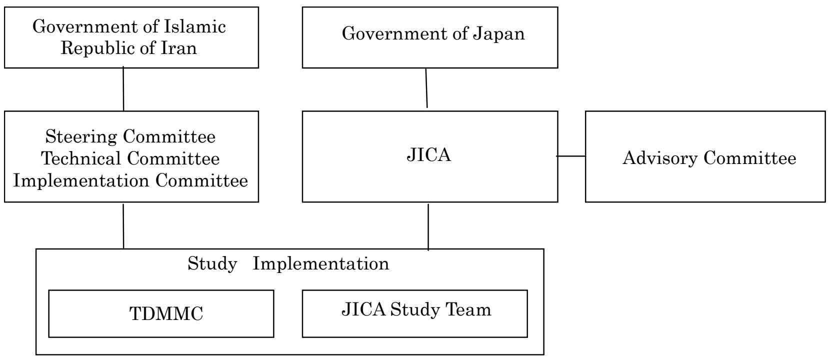


Figure G. 3 Study Organization

Table G. 1 Member Lists of the Japanese Side Study Organizations

JICA Advisory Committee

Dr. Kimiro Meguro	Leader	The University of Tokyo
Dr. Shuichi Takeya	Member	Ministry of Land, Infrastructure and Transport
Dr. Shingo Nagamatsu	Member	Disaster Reduction and Human Renovation Institution
Mr. Katsunori Ishida	Observer	Hyogo Prefectural Government

Study Team

Mr. Itaru Mae	Team Leader
Mr. Ichiro Kobayashi	Deputy Team Leader / Urban Disaster Management
Mr. Osamu Nishii	Deputy Team Leader / Disaster Prevention and Management
Mr. Kanao Ito	Urban Planning (1)
Ms. Mihoko Ogasawara	Urban Planning (2)
Dr. Akio Hayashi	Building Structure
Mr. Ryoji Takahashi	Infrastructure and Lifeline
Dr. Nahoko Nakazawa	Community Disaster Prevention and Management (1)
Ms. Junko Okamoto	Community Disaster Prevention and Management (2)
Ms. Tomoko Show	Social Analysis
Mr. Masatoshi Kaneko	Economic Analysis
Mr. Schneider Klaus-Dieter	Organization and Institution for Disaster Management (1) / Project Implementation
Mr. Makoto Nakamura	Organization and Institution for Disaster Management (2)
Mr. Kazumi Akita	Disaster Rescue and Medical Response
Mr. Hiroyuki Maeda	GIS Specialist
Mr. Masahiro Satake	Disaster Information and Communication Management
Mr. Shukyo Segawa	Seismology
Mr. Toshitsugu Shimodaira	Coordinator
Mr. Kazushige Mizui	Coordinator

JICA Tokyo Headquarters

Mr. Itsu Adachi (April 2003-) Mr. Senichi Kimura (August 2002 – March 2003)	Group Director	Group III (Water Resources and Disaster Management), Global Environment Department
Mr. Masafumi Nagaishi (December 2003 -) Ms. Katsura Miyazaki (August 2002 – November 2003)	Team Director	Water Resources and Disaster Management Team II, Group III (Water Resources and Disaster Management), Global Environment Department
Ms. Ai Yamazaki (September 2003 -) Mr. Kotaro Taniguchi (August 2002 –August 2003)	Staff	Water Resources and Disaster Management Team II, Group III (Water Resources and Disaster Management), Global Environment Department

JICA Expert

Mr.Junji Wakui (June 2004 -) Mr. Izumi Tanaka (August 2002 –May 2004)	JICA Expert	ODA Advisor in Iran

Table G. 2 Member Lists of the Three Committees from August 2002 to May 2004

Steering Committee Members

Mr. Rasool Zargar	Advisor to Tehran Mayor/Tehran Municipality
Mr. Javad Haghani	Deputy for City Services/Tehran Municipality
Mr. Javad Sharbaf	Deputy for Technical and Development Affairs/Tehran Municipality
Mr. Gholam Hossein Pordeli	Deputy for Urban Planning & Architecture/Tehran Municipality
Dr. Ali Akbar Moinfar	Senior Advisor/Center for Earthquake Studies of Tehran
Mr. Abbas Jazayeri	Director/National Disaster Task Force/Ministry of Interior
Mr. Amir Farjami	General Manager, Rural and Urban Development/MPO
Dr. Mohsen Ebrahimi	Director/Tehran Disaster Management Center
Mr. Farid Mehdian	Director/Center for Earthquake Studies of Tehran
Mr. Ahmad Naderzadeh	Head/Center for Earthquake Studies of Tehran
Dr. Ghasem Heidarinezhad	Director/Building and Housing Research Center
Dr. Mehdi Ghalibafian	Professor/School of Engineering, Tehran University

Technical Committee Members

Dr. Ali Akbar Moinfar	Structural and Earthquake Engineering
Prof. Mehdi Ghalibafian	Structural Engineering
Prof. Hossein Bahraini	Urban Planning and Environment
Prof. Behrooz Gatmiri	Geotechnical Engineering
Prof. Mohsen Ashtiani	Earthquake Engineering
Mr. Ahmad Naderzadeh	Structural and Earthquake Engineering
Dr. Nemat Hasami	Lifeline Engineering
Dr. Firooz Tofigh	Management and Planning
Mr. Farid Mehdian	Architecture and Urban Planning

Implementation Committee Members

Mr. Javad Sharbaf	Deputy for Technical and Development Affairs/Tehran Municipality
Mr. Gholam Hossein Pordeli	Deputy for Urban Planning & Architecture/Tehran Municipality
Mr. Javad Haghani	Deputy for City Service/Tehran Municipality
Mr. Mohammad-Mehdi Khorsandnia	Deputy for Transportation and Traffic/Tehran Municipality
Mr. Mehdi Moeini	Tehran GIS Center
Mr. Yoosef Khosroshahi	Computer Service Organization/Tehran Municipality
Mr. Mohsen Ebrahimi	Director/Tehran Disaster Management Center
Mr. Farid Mehdian	Director/Center for Earthquake Studies of Tehran
Mr. Ahmad Naderzadeh	Head, Earthquake Studies and Research/CEST
Mr. Abbas Jazayeri	Director/National Disaster Task Force/Ministry of Interior
Mr. Ali Ahmadi	Deputy for Security/Ministry of Interior
Mr. Amir Farjami	Urban and Rural Housing/Management and planning Organization
Mr. Ali Jahanbakhshi	Disaster Task Force/Tehran Province
Dr. Mahmood Fatemi Aghda	Center for Natural Disasters Research and Studies
Mr. Khosravi	Housing and Urban Organization of Tehran Province
Mr. Fereydoon Esfandiari	Fire Fighting Organization/Tehran Municipality
Mr. Bizhan Daftari	Red Crescent Society of Tehran Province
Mr. Ghamami	Deputy for Urban Planning/ Ministry of Housing and Urban development
Mr. Mohammad-Taghi Araghi	Iran National Gas Company
Mr. Reza Jamal	Tehran Electric Company
Mr. Asad Balakhesal	Tehran Water and Sewage Company
Mr. Kamran Khosravi	Iran Telecommunication Company
Mr. Hamid Damavandi	Technical Department/Tehran and Suburbs Railway Company
Mr. Ghavam Shafati	Fire Fighting and Safety Depertment/Petroleum Products Distribution Company
Dr. Fayyazi	Emergency Response Management/Ministry of Health

Table G. 3 Member Lists of the Three Committees from May 2004

Steering Committee Members

Dr. H. Shakib	Member of City Council and Advisor to the Mayor
Mr. M. Aliabadi	Deputy for Technical & Civil Affairs/Tehran Municipality
Mr. M.J. Mohammadi Zadeh	Deputy for Urban Services/Tehran Municipality
Mr. GH. Pordeli	Deputy for Urban Planning & Architecture/Tehran Municipality
Mr. M. Hashemi	Deputy for Districts Affairs/Tehran Municipality
Dr. M. Hosseini	President/TDMMC
Dr. M. Ebrahimi	Deputy for Disaster Management/TDMMC
Dr. K. Amini	Advisor to the President of TDMMC
Mr. S.A. Jazayeri	Ministry of Interior (National Committee)
Dr. Rohani Manesh	Tehran & Suburb Urban Railway Co.
Dr. Nogol	Professor, Geological Survey of Iran
Mr. Habibollahian	Head of Tehran Planning Organization and Advisor of the Mayor

Technical Committee Members

Dr. Maziar Hosseini	Structure and Earthquake Engineering/President of TDMMC
Dr. M.T. Kazemi	Structure and Earthquake Engineering/Professor of Sharif University
Dr. K. Amini	Engineering Geology/Advisor to the President of TDMMC
Dr. H. Shakib	Earthquake Engineering/Member of City Council
Dr. Motamedi	Psychology/Welfare Org., General Manager of Bureau Social Damages
Dr. A. Shariat	Lifelines/Professor of Science & Tech. University
Ms. F. Saleh	Urban Planning/TDMMC
Dr. M. Ebrahimi	Disaster Management/TDMMC
Dr. H. Pedram	Infrastructures
Mr. S. Montazer Ghaem	Geotechnique and Structure/TDMMC
Dr. V. Hosseini Jenab	Rescue & Relief/TDMMC
Dr. B. Abdi	Rescue & Relief/TDMMC
Dr. A. Tarighi Rasekhi	Rescue & Relief/TDMMC
Mr. R. Radnia	Media and Public Relations/TDMMC
Mr. A.R. Sabeti	Environment/TDMMC
Mr. M. Novin	Information and Communication/Head of Telecommunication Center, Tehran Municipality

Implementation Committee Members

Mr. M. Aliabadi	Deputy for Technical & Civil Affairs/Tehran Municipality
Mr. M.J. Mohammadi Zadeh	Deputy for Urban Services/Tehran Municipality
Mr. GH. Pordeli	Deputy for Urban Planning & Architecture/Tehran Municipality
Dr. H. Behbahani	Deputy for Transportation and Traffic/Tehran Municipality
Dr. M. Hosseini	President/TDMMC
Dr. M. Ebrahimi	Deputy for Disaster Management/TDMMC
Dr. H. Shakib	Member of City Council
Dr. K. Amini	Advisor to President/TDMMC
Mr. S.A. Jazayeri	Ministry of Interior (National Committee)
Mr. A. Azarifar	Deputy for Security-Disciplinary/Tehran Governorship
Dr. Farshbaf Maherian	Head of Management and Planning Organization of Tehran Province
Mr. A. Jahan-bakhshi	Taskforce HQ of Tehran Province
Dr. Fatemi Aghda	President of Iran Natural Disaster Research Center
Mr. Hagh-shenas	Deputy for Islamic Revolution Housing Foundation
Mr. A. Ziaie	President of Fire Fighting and Safety Services Organization
Mr. B. Daftari	Deputy for Rescue and Relief/Red Crescent Society
Dr. H.R. Dehghan	Managing Director/Tehran Red Crescent Society
Mr. Habibollahian	Head of Tehran Planning Organization
Mr. M.T. Araghi	Managing Director/Gas Co. of Tehran Metropolitan
Mr. M. Jannatian	Managing Director/Tehran Regional Electric Co.
Mr. S. Mahmoodi	Managing Director of Tehran Water and Sewage Co.
Mr. M. Khosravi	Iran Telecommunication Co.
Dr. Rohani Manesh	Tehran & Suburb Urban Railway Co.
Mr. GH. Shafati	Oil Products Distribution Co.
Dr. V. Kianpour Atabaki	Disaster HQ of Ministry of Health
Dr. H. Abbasi	IIEES
Dr. M. Ghafoori Ashtiani	President/IIEES

Table G. 4 Member Lists of Counterparts

Dr. Maziar Hosseini	Project Manager
Dr. Kambod Amini Hosseini	TDMMC President's Advisor
Dr. Mohsen Ebrahimi Mojarad	Emergency Traffic System
Ms. Fatemeh Saleh	Urban Planning and Community-based Disaster Management, Training
Ms. Forough Basirat	GIS
Ms. Mitrana Mokhtari Tirani	Coordination Affairs and Training
Ms. Leila Talebi	GIS
Mr. Koosha Sina	GIS
Mr. Alireza Sabeti	Lifelines
Dr. Bahram Abdi Farkoosh	Disaster Management, Organization and Institutionalization
Ms. Zahra Sadat Hosseini	Social Studies
Mr. Saeed Montazer Ghaem	Structure
Dr. Ali Tarighi Rasekhi	Disaster Management, Rescue and Relief
Mr. Shahin Mohammadi Yeganeh	Community-based Disaster Management, Emergency Network
Mr. Bijan Yabar	Urban Planning and Community-based Disaster Management
Mr. Moezedin Babakhani Teymori	Infrastructure and Lifeline
Mr. Ramin Radnia	Mass Disaster and Training

4. Major Activities of the Study

The major activities of the Study are summarized in Table G. 5.

Table G. 5 Major Activities of the Study

Study Stage	Date	Topics and Contents
Phase I	August, 2002	Commencement of the Study in Iran
	September 3, 2002	1st Joint Steering Committee Meeting, agreeing upon the Inception Report between CEST and the JICA Study Team
	September 4, 2002	Signing on Minutes of Meeting on Inception Report
	September 16, 2002	Technical Committee and Implementation Committee Meetings, presenting and discussing the master planning study for seismic disaster prevention and management
	October 2, 2002	Technical Transfer Workshop (1), presenting major results of the previous Microzoning Study
	February 4, 2003	2nd Joint Steering Committee Meeting, presenting the study progress in Phase I
	February 9, 2002	1st Seminar at Esteghlal Hotel, presenting study result in Phase I
	February 10, 2002	Signing on Minutes of Meeting on the Progress Report (1)
Phase II	May 3~13, 2003	Technology Transfer Training Course, exercising microzoning technique for further comprehension and utilization targeting on counterpart personnel in CEST
	June 24, 2003	Meeting with Mayor of Tehran City, presenting the Study and discussing the cooperative backup of Tehran Municipality for the Study
	July 2, 2003	Community Workshop (1), holding a meeting on community-based disaster preparedness activities
	August 5, 2003	Community Workshop (2), orienting community-based disaster map creation in selected area (District 17)
	August 6, 2003	Community Workshop (2), orienting community-based disaster map creation in selected area (District 2, cooperative housing area)
	August 7, 2003	Community Workshop (2), orienting community-based disaster map creation in selected area (District 2, housing complex)
	August 13, 2003	Community Workshop (2), orienting community-based disaster map creation in selected area (District 10)
	August 18, 2003	District Meeting on Selected Pilot Study in District 10, explaining the pilot study and establishing close relationship between District 10 and the JICA Study Team
	August 18, 2003	Community Workshop (3), preparing community-based disaster map for disaster preparedness planning
	August 19, 2003	District Meeting on District Level Disaster Prevention and Mitigation Plan, explaining the idea to all Mayors from 22 Districts in Tehran Municipality
	August 20, 2003	3rd Steering Committee Meeting, presenting progress of Phase II Study and agreeing upon its contents between TDMMC and the JICA Study Team
	August 21, 2003	Signing on Minutes of Meeting on 3rd Steering Committee Meeting
	August 26, 2003	Structure Workshop at TDMMC building, presenting and discussing building diagnosis and strengthening
	September 14, 2003	Community Workshop (4), examining existing community organizations
	September 15, 2003	Community Workshop (4), enlightening and enhancing awareness of seismic disaster for school children
	September 16, 2003	Technology Transfer Workshop at TDMMC Building, guiding a preparation of master plan for seismic disaster targeting on counterpart personnel in TDMMC

	September 21, 2003	4th Steering Committee Meeting, explaining the study progress and basic principles of the Master Plan and agreeing upon its contents between TDMMC and the JICA Study Team
	September 22, 2003	Signing on Minutes of Meeting on 4th Steering Committee Meeting
	September 22, 2003	Community Workshop (4), examining on-going community activities
	December 23, 2003	2nd Seminar at Laleh Hotel, presenting study result in Phase II
	December 24, 2003	Signing on Minutes of Meeting on the Submission of the Interim Report
Phase III	June 6, 2004	5th Steering Committee Meeting, presenting and agreeing upon the contents of Interim Report
	June 6, 2004	Signing on Minutes of Meeting on 5th Steering Committee Meeting
	June 9, 2004	Community Workshop (5), enhancing awareness of seismic disaster for school children by creating disaster map
	June 16, 2004	Community Workshop (5), promoting community-based disaster activity for Basij
	August 8, 2004	6th Steering Committee Meeting
	August 10, 2004	3rd Seminar

5. Other Publications of the Study

The publications other than Reports prepared in the course of the Study are as follows.

1) Newsletter

For the purpose of developing the network, heightening of consciousness of disaster mitigation and management activities and sharing the information among all the governmental organizations, research institutes, NGOs and communities relating to disaster management activities, newsletters presenting any topics relating to the Study were published in the course of the Study. Total six(6) series with 300 sets each of newsletter detailed below were distributed aforementioned entities through TDMMC.

- Newsletter No.1, Inaugural Issue, published in October, 2002
- Newsletter No.2, Featuring Citizen Participation, published in February, 2003
- Newsletter No.3, Featuring Building Vulnerability, published in June, 2003
- Newsletter No.4, Featuring GIS, published in September, 2003
- Newsletter No.5, Featuring Bam Earthquake, published in March, 2004
- Newsletter No.6, Contribute Articles to the JICA Study, published in August, 2004

2) Video Program for the Promotion of Community-based Disaster Management Activities

In order to promote community-based activities in Tehran by the own effort of citizens, the Study Team prepared a video program, in which concept, managing techniques and contents of a series of workshops held in the course of the Study are presented. This video program was distributed to organizations relating to community-based disaster management activity in Tehran including TDMMC.

3) Maps for District-based Assessment of Vulnerability to Earthquake Disaster

Study team carried out intensive data collection during Phase 1 and Phase two of the study. The collected data were input into the GIS database, which developed by this study, to formulate district level disaster management map. The map includes the disaster management resources and earthquake hazards for each district. Together with disaster management map, Study Team prepared the disaster management sheet for each district, which contains the disaster management resources and earthquake risk in number. In order to formulate disaster management plan for each district, Study team proposed countermeasures for each district.

In order to understand the Tehran municipality's earthquake disaster risk, Study Team prepared the vulnerability analysis in Tehran municipality. Study Team distributed vulnerability map in Tehran municipality for the district to prepare the disaster management plan for the city.

4) Pilot Study for District 17 to support district-based disaster management plan formation

In order to promote a formulation of the plan at district level, a pilot study was carried out for District 17, which has a high potential of earthquake damage and a high social awareness on earthquake disaster. In the course of the Study, Study Team selected two district, district 17 and 10, for pilot study, yet district 10 could not be produced the output of the study.

5) Poster competition

In order to increase awareness of disaster preparedness and mitigation not only among the children but also among school staff, families of the children and the general public as a whole, TDMMC and Study Team organized a poster competition in cooperation with the Institute for the Intellectual Development of Children and young Adults (Kanoon). The target children for the competition are third and fifth grades of elementary school and first grade of secondary school students in Tehran. There were 125 entries screened and 13 children are awarded.

6) Attitude survey for building strengthening

Study team carried out survey for preference of the residents for strengthening the their buildings. The number of sample is 200 from municipality, special emphasis on masonry building. The results show the there is clear difference in willingness to pay for structure strengthening by type of the building. Based on the results, Study team proposed policy options for private house strengthening.

Chapter 1
Introduction

CHAPTER 1 INTRODUCTION

1.1 Existing Disaster Management System

1.1.1 Existing Laws and Regulations

1) National Level

The legal and administrative foundations, including the prevailing policy directions, for the regulatory frameworks governing at national and Tehran Municipality levels of the disaster management system as a whole, including the system's major features, components, functions and procedures, are codified in few legal, policy and/or administrative documents as listed in Table 1.1.1.

Table 1.1.1 Regulatory Framework - Policy Directions & Executive Orders

Regulatory Framework	Primary Function & Level of Relevance	Fundamental Character
The 1979/1989 Constitution	Governs the basic principles and establishes the responsibilities of the Government	Fundamental Legal Basis
"Law of Foundation of National Committee for Mitigation of Natural Disaster Effects"(NCNDR)	The documentation available contains the text of the law as well as a cover letter signed by the then President. The law establishes the Committee and relevant sub-committees.	Law & Executive Regulation
Council of Minister's Decree (s)	Of concern here mainly: The decision of April 06th, 2003 approving the "Rescue & Relief Comprehensice Plan". The plan stipulates the basic disaster management system structure and major functions of the systems.	Policy Direction & Executive Order
Decisions of the "State Exigency Council - SEC"	This entity has provided guidelines in its early 2004 decision "Basic Policies for Disaster Mitigation and Prevention"	Policy Direction & Executive Order
Decree of the Major of Tehran	Of concern here mainly: The decree of early 2003 that regulates the establishment and functions of TDMMC	Executive Order
Resolution by Disaster Related Committee(s)	Of concern here mainly are the resolutions of those of the "National Disaster Task Force - NDTF"	Planning Guideline

Note: Reference to the relevant texts is made in the main text of the Sector Report.
Source: JICA Study Team compilation.

The national and Tehran levels disaster management systems including organizational set-up and mandate are tailored around four principal functions (refer to Table 1.1.2); mitigation, preparedness, emergency response, and reconstruction & rehabilitation (R&R). The system is clearly mandated at both national and Tehran Municipality levels to address, in principle, most potential types of disasters. A general typology of disaster types as identified by World Bank research is presented in Table 1.1.3.

The 1979 Constitution of the Islamic Republic of Iran (I.R.I), effective since 3 December 1979 and amended on 28 July 1989, contains two articles indirectly relevant for disaster management. Article 29 [Welfare Rights][1] and Article 31 [Housing][2] of the Constitution implicitly refer to the Government's responsibility for providing assistance to Iran's population in coping with disaster-related effects. The term "disaster" is not explicitly referred to in the Constitution.

Table 1.1.2 Principal Functions of the Disaster Management System in I.R.I.

Disaster Mitigation	Disaster Preparedness	Emergency Response	Reconstruction and Rehabilitation
Is defined as "Being the aggregate operations which shall be carriet out prior to, at the time of, and after occurrence of crisis with the objective of preventing or mitigating the adverse effects of crisis."	Is defined as "Being the aggregate operations which shall result in enhancement of the social abilities of the government and the people in carrying out the various phases of crisis management. Preparedness shall include collectionof data and information, research activities, planning, creation of management structures, education, supply of resources, exercise, drills, and comprise public and expert training through civil foundations, industries and vocations, mass media and radio	Is defined as "… the supply of urgent services after occurence of crisis with the objective of salvation of the lives and property of the people and creation of relative welfare for them and preventing expansion of damamges. ER includes rescue operations, supply of hygiene, treatment, creation of security, transportation, communication, burial of the dead, solid waste removal, sewage control, fire control, hazardous material control, supply of fuel, supply of	Is defined as "… the restoration of conditions in an effected and damamged area, after the occurrence of crisis, back to normal with due consideration of the characteristics of sustained development and all safety standards."

Note: The definitions are based on an unofficial translation of Article 2 of the "Rescue & Relief Comprhensive Plan", adopetd in April 2003 by Council of Ministers' decision.
Source: JICA Study Team.

Table 1.1.3 World Bank - General Typology of Disasters

Water Related Events	Geology Related Events	Other Events
WRE 1: Winds WRE 2: Storms WRE 3: Floods WRE 4: Droughts WRE 5: Forest Fires	GRE 1: Eartquakes GRE 2: Volcano Eruptions GRE 3: Landslides	OE 1: Pest Infections OE 2: Industrial Accidents OE 3: Epidemics (Infectious Diseases) OE 4: Human Conflict

Source: Roy Gilbert/Alcira Kreimer: "Learning from the World Bank's Experience of Natural Disaster Related Assistance"; The World Bank; Urban Development Division; Washington D.C.; 1999; p. 6

[1]) The article reads according to a 1992 translation by the Iranian Embassy in London as follows: "(1) To benefit from social security with respect to retirement, unemployment, old age, disability, absence of a guardian, and benefits relating to being stranded, accidents, health services, and medical care and treatment, provided through insurance or other means, is accepted as a universal right. (2) The government must provide the foregoing services and financial support for every individual citizen by drawing, in accordance with the law, on the national revenues and funds obtained through public contributions."

[2]) The article reads according to a 1992 translation by the Iranian Embassy in London as follows: "It is the right of every Iranian individual and family to possess housing commensurate with his needs. The government must make land available for the implementation of this article, according priority to those whose need is greatest, in particular the rural population and the workers."

The Islamic Consultative Assembly or Majlis approved on 31 July 1991 a law titled "The Law of Foundation of National Committee for Mitigation of Natural Disaster Effects."[3] This proposed law in turn was signed into binding law by the President of I.R.I. on 13 August 2002.

This law, which was complemented in 2003 by a Decree of the Council of Ministers, establishes the fundamentals of Iran's disaster management system in the following manner:

- The law establishes the Ministry of the Interior (MOI) as the supervisory body for disaster management related entities and activities.
- It explicitly identifies the following disasters that need to be addressed, namely: storm, flood, drought, cold stroke, botanic pests, air pollution, earthquake and landslides, and reflux of seas, lakes and rivers.
- It identifies 14 individual line ministries, government entities and NGOs as the principal entities in disaster management and it delegates the authority to include and/or call on the assistance of any other entity to the Head of the National Committee (the Minister of the Interior).
- It passes the authority to establish the required sub-committees to the National Committee and it empowers this Committee to announce any emergency situation;
- It delegates the authority to the National Committee to approve the budget (credit) needed by the above entities for the realization of their responsibilities.
- It charges the Ministry of the Interior to issue the necessary instructions for the establishment of provincial level committees to be under the supervision of the governor of each province.
- It charges the Ministry of the Interior to inform all Islamic Consultative Assembly Commissions about the results of the activities of all involved entities at a six months cycle.

Execution of the above law is further detailed by Council of Ministers' decision on 12 April 2003, which comprises 14 individual articles and one attachment that deals with the individual duties of the Sub-committee for risk assessment. Article 1 of this Council of Ministers' Decree identifies the core-function(s) for nine specialized Sub-committees established by the Decree as summarized in Table 1.1.4. The duties of the nine Sub-Committees are defined as:

"The overall and general duties of subcommittees are implementation of studies and research to provide resolutions that intend to prevent the natural incidents happening or that mitigate their effects. The details of duties of subcommittees will be prepared by the members of the

[3]) The JICA Study Team translated the formal title of this law into English. It is not an official translation.

relevant committee and will be approved by the National Committee for Mitigation of Natural Disaster Effects."

Table 1.1.4 Core Functions of Nine National Level Disaster Sub-Committees

Core Functions of Sub-committee	Members & Operational Direction(s)
Risk Assessment for Earthquake and Landslides	Responsible entity: Ministry of Housing and Urban Development Sub-Committee Members: the committee has twelve (12) members, overwhelmingly ministerial and non-ministerial level entities. Tehran Municipality is a member.
Pest, Botanic Disease & Frost-bite Control	Responsible entity: Ministry of Agriculture Jihad Sub-Committee Members: the committee has ten (10) ministerial and non-ministerial level entities.
Restorаution of Pastures & Drought Mitigation	Responsible entity: Is the Affiliate to the Ministry of Agriculture Jihad: Construction Crusade (this organization is now merged into the Ministry) Sub-Committee Members: there are eight (8) ministerial and non-ministerial member organizations.
Flood, sea-flux, reflux, and river overflow mitigation	Responsible entity: Ministry of Energy Sub-Committee Members: the committee has eleven (11) ministerial and non-ministerial level entities.
Air Pollution Control Measures	Responsible entity: Environment Protection Organization; Office of the President Sub-Committee Members: the committee has fourteen (14) ministerial and non-ministerial level entities. Tehran Minicipality is a member.
Mitigation of Storm risks	Responsible entity: Meteorology Organization Sub-Committee Members: the committee has seven (7) ministerial and non-ministerial level entities. Tehran Minicipality is a member.
Relief & Rescue Operations	Responsible entity: Red Crescent Society (RCS) (under the Ministry of Health & Medical Education Sub-Committee Members: the committee has nine (9) ministerial and non-ministerial level
Loss & Damage Compensation	Responsible entity: Management & Planning Organization (MPO); Office of the President Sub-Committee Members: the committee has nine (9) ministerial and non-ministerial level entities.
Health & Treatment	Responsible entity: Ministry of Health, Treatment and Medical Education Sub-Committee Members: the committee has seven (7) ministerial and non-ministerial level entities.

Note: Some of the entities identified above, such as the previous Ministry of Construction Crusade, have been merged with other government entities. Hence, titles for the presently prevailing system may not in all cases be identical.
Source: JICA Study Team compilation based on an unofficial translation of the Farsi document.

The Government of Iran (GOI) in a further step approved and put into force by the Council of Ministers' Decree dated 12 April 2003 the national level "Rescue & Relief Comprehensive Plan" (RRCP),[4] which is a legally and fully binding executive order. Article 4 of the RRCP establishes the six fundamental functions of the plan as identified in Table 1.1.5.

[4]) The discussion on the RRCP is based on the text of an unofficial English translation prepared by a Tehran law firm.

Table 1.1.5 Core Functions of the RRCP

Core Function	Descriptions
1	To realize scientific study and research that transfers modern and advanced disaster management methods from inside and outside of the Islamic Republic of Iran (I.R.I.) to the administrative system
2	To implement national and district level plans and investment with priority attached to prevention and mitigation
3	To provide a unified management and to outline the duties and responsibilities of all executive branch organizations
4	To attract people's participation and to organize and train volunteer forces of a disaster management network
5	To ensure efficient utilization of government and non-government resources
6	To ensure the required support of line ministries, other organizations and the Armed Forces, in particualr the "Resistance Mobilization Force"

Note: Based on Article 4 of the April 06th, 2003 RRCP.

Source: JICA Study Team compilation based on an unofficial translation of the oroginal Farsi document.

2) Tehran Municipality

There are two principal sources for understanding the Tehran-specific regulatory framework and related organizational set-up for disaster management. The two sources are the Tehran Comprehensive Emergency Management Plan (TCEMP) and the Tehran Mayor’s Decree of May 2003 that establishes in formal terms the Tehran Disaster Mitigation and Management Center (TDMMC). A third important document is the recent decision by the Tehran City Council to change the status of TDMMC into an organization and re-name the institute into Tehran Disaster Management Organization (TDMO). The City Council decision also re-defines the mandate and core functions for the designated TDMO. However, this document, though far reaching in consequences, was not made available and its contents and implications are, therefore, excluded from this discussion.

The Tehran Comprehensive Emergency Management Plan (TCEMP) is an emergency response plan or ERP that organizes 24 organizations under the umbrella of 22 committees to address an emergency situation that may arise within the Tehran Municipality covering all types of disasters as defined by the TCEMP itself and other related national level disaster management policy and planning documents. This ERP is tailored around three major functions as summarized in Table 1.1.6 and its implementation is on-going. TDMMC is currently the responsible entity for the ERP, fully in charge of supervising and coordinating the realization of the TCEMP.

Table 1.1.6 Tehran Municipality – TCEMP Planning Framework

Core Functon of TCEMP	Description of Individual Tasks by Sub-Committee
Core Function 1: Relief and Rescure Management	The individual planning functions are undertaken under the umbrella of four (4) sub-committees for: (a) waste & debris removal; (b) health & treatment; [c] relief & rescue; and (d) burial affairs
Core Function 2: Settlement Management	The individual planning functions are undertaken under the umbrella of nine (9) sub-committees for: (a) settlement issues; (b) gas issues; [c] fixed communications issues; (d) electricity issues; (e) water issues; (f) sewage issues; (g) mobile and satellite communications; (h) oil products & fuel supplies; (i) transportation and traffic issues
Core Function 3: Logistics Management	The individual planning functions are undertaken under the umbrella of nine (9) sub-committees for: (a) legal affairs; (b) provincial adjustment affairs; [c] safety issues & police department; (d) loss evaluation; (e) public contribution affairs; (f) information dissemination; (g) budget insurance and financial affairs; (h) fire brigade and safety services; (i) mental and social health affairs

Source: JICA Study Team compilation based on interviews with staff members of the previous CEMS institution.

The Mayor of the Tehran Municipality on May 2003 establishes in formal legal and institutional terms TDMMC as the entity responsible for disaster management, including emergency response, in the Tehran Municipality. The Mayor's Decree defines the center's functions in 21 individual articles and one explanatory footnote.[5] TDMMC's functions can be grouped into three distinctly different categories that vary in terms of character, implied expertise and manpower, and executive authority. The three groups are:

- Coordination functions, including supervisory authority and power over other entities of the Municipality and to a certain extent national level line Ministries,
- Direct formulation and preparation functions, and
- Direct executive function, such as the case for the preparation, conduct and evaluation of drill exercises and the coordination among the 24 committees that are involved in the preparation of the individual emergency response plans.

1.1.2 Disaster Management Organization

1) National Level

The national level organizational set-up reflects the structure and management approach required in response "Rescue & Relief Comprehensive Plan" (RRCP), of April 1 2003, which has broadened and deepened the organizational disaster management structure and increased the level of complexity of the whole system to a significant degree. The RRCP stipulates the following mandate and core functions for the various entities at hierarchical levels of the revised system configuration as depicted in Figure 1.1.1.

[5]) The complete text of the Mayor's Decree in an unofficial English translation is attached in Appendix IV to the Sector Report.

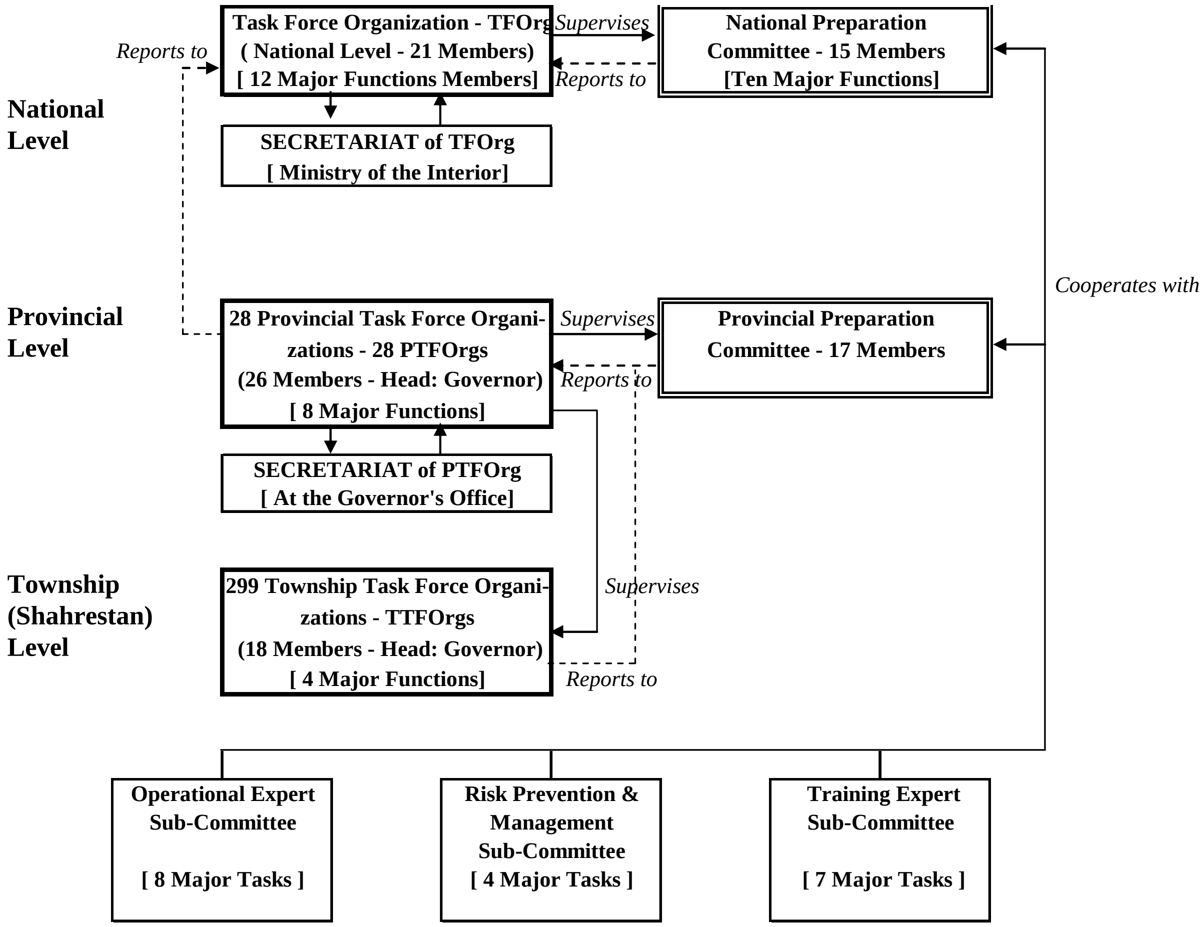
- The principal functions, Article 5 of the RRCP, of the National Task Force Organization (TFOrg.) are national policy formulation, national level planning, and overall supervision of disaster management in I.R.I. It is important to highlight that the RRCP states explicitly that, with its approval and the subsequent establishment of the TFOrg., all previously issued responsibilities and authorizations to other organizations have been effectively transferred to the TFOrg.

- TFOrg., which is at ministerial level and chaired by the Minister of the Interior, comprises 21 members, out of which 13 are ministers of line ministries[6] and eight are heads of various organizations. TFOrg. should convene under normal circumstances four times a year.

- TFOrg. has 12 principal functions, the important ones of which are: national policy formulation and national level planning for the disaster management system as a whole; determining the functions, duties and responsibilities of all sectors and governmental and non-governmental organization in that system, drafting legal bills, rules and procedures to be submitted for approval to the Council of Ministers through the Minister of the Interior, advising, supervising and appraising disaster management plans of governmental and non-governmental organizations involved in disaster management, approving requests for ODA assistance, announcing the national and/or provincial level disaster situation, and preparing the budget outline and/or budget request for the disaster management system in I.R.I.[7]

[6]) The line ministries are: Minister of the Interior, Minister of Health & Medical Education, Minister of Information and Communication, Minister of Education and Training, Minister of Defense & Armed Forces, Minister of Roads & Transport, Minister of Energy, Minister of Housing & Urban Development, Minister of Agricultural Jihad, Minister of Islamic Culture and Guidance, Minister of Economic Affairs & Finance, Minister of Foreign Affairs, Minister of Science, Research & Technology, Head of Management & Planning Organization, Head of Red Crescent Society, Head of Radio & Television Organization, Head of the Armed Forces Organization, Head of Iran Municipalities' Organization, Head of Police Department of Iran, Head of Islamic Revolution Housing Foundation, and Commander of Resistance Mobilization Force (Basidj). A principal overview of the line ministries and affiliated organizations is attached as Appendix VI.

[7]) In accordance with items 1 to 12 of Article 7 of the RRCP.



Source: JICA Study Team based on the RRCP.

Figure 1.1.1 Simplified National Level Structure of the "Rescue & Relief Comprehensive Plan"

- In the event of a real disaster, all line ministries, governmental organizations and police forces fall under the authority and command of the head of TFOrg., that is, the Minister of the Interior, who is the commander-in-chief (CIC).
- A Secretariat, established in the Ministry of the Interior, is to support the activities of the TFOrg. The composition and membership of the Secretariat is not identified in the RRCP. The Secretariat has, however, 15 principal functions, the major one of which are to undertake research and applied research in support of the mandate and activities of TFOrg including relations with relevant institutions within and outside of the I.R.I.and the supervision of research undertaken by sub-organizations, to manage the information network for disaster management, including the public disaster announcement system to manage financial affairs within approved credit ceilings to evaluate activities undertaken by entities supporting TFOrg. to follow up on the proper execution of rules, procedures and so on established by TFOrg. to inspect and audit the

required credit ceilings of the task force organizations for the four main disaster management areas; [8] and to undertake public-relations (PR) activities geared at increasing public awareness and promoting a culture of safety.

As illustrated in Figure 1.1.1, the organizational structure at national level is mirrored at Provincial level. The RRCP requires the establishment of 28 Provincial Task Force Organizations (PTFOrgs.). Those are headed by the Governor and are to comprise 26 members[9] each. Each 28 PTFOrg. is mandated with eight identical principal functions, the most important of which are:

- To formulate and adopt disaster management policies at provincial level;
- To manage disaster prevention, emergency response and reconstruction & rehabilitation, including the practice of drills;
- To manage disaster preparedness in close cooperation with the Provincial Preparation Committee;
- To manage the allocation of credit ceilings and financial means; and
- To announce the provincial disaster situation to the TFOrg.

The Secretariat for each of the PTFOrgs. must be established in all offices of the Governors of the 28 Provinces. The principal functions of the Provincial level Secretariat are not identified in the RRCP, but it can be assumed that they are the same or similar to those attached to the national level Secretariat. Articles 16 to 20 of the RRCP regulate the establishment of task force organizations at Township level,[10] which is not relevant at this point.

2) Tehran Municipality

The Tehran Disaster Mitigation and Management Center (TDMMC) was formally established with the merger of the previous CEST and CEMS. It status within the Municipality has been upgraded from falling under the responsibility of a Deputy Mayor to now falling directly under the supervision and responsibility of the Mayor of Tehran. In the absence of any new policy decisions and information on the new decree decided by the City Council, it must be assumed that the mandate and core functions are still determined by the May 2003 Mayor’s Decree, the stipulations contained in the RRCP as they directly or indirectly refer to the Municipality of

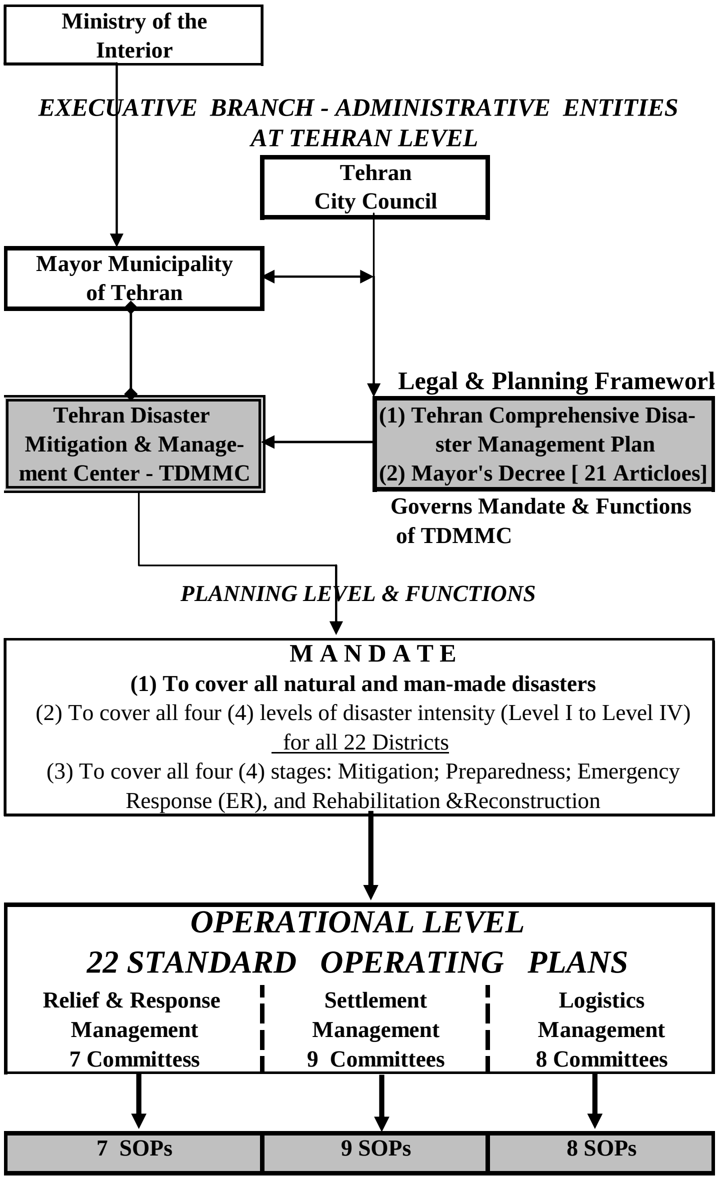
[8]) As introduced in Table 2.1.2, Chapter 2 of the Sector Report.
[9]) These members are: The Governor, the Manager of Red Crescent Society, the Dean of the Medical Science University and Health and Treatment Services of the Province, the Manager of the Telecommunication Company, the Manager of the Water & Sewage Company, the Manager of the District Electricity Company, the Head of the Management & Planning Organization, the SEPAAH High Commander of the district, the Military High Commander of the District, the Commander of the Resistance Mobilization Force (Basij), the Head of the Trading Organization, the Manager of IRIB, the Head of the Housing and Urban Construction Organization, the Head of the Road and Transport Organization, the Head of the Agricultural Jihad , the Head of the Islamic Council, the Head of the Welfare organization, the Director of Economic Affairs and Finance, the Director of Islamic Culture, the General Manager of the Judicial Office, the Head of the Education Organization, the Mayor of the Provincial Capital, the Head of the Islamic Revolution Housing Foundation, the General Manager for Environmental Protection, the Head of the Municipalities’ Organization, and the Commander of the Police Department.
[10]) For a brief presentation of the principal administrative structure of I.R.I. kindly refer to Appendix V.

Tehran,. In fact, the RRCP states explicitly that the TCDMP is and remains "in-force" unless otherwise decided by TFOrg.

The Tehran Municipality is so far the only local Government entity in I.R.I. that is, though embedded in the national system, somewhat outside the main stream of the disaster management system, with the Mayor as Commander-in-Chief of the Tehran-system The City Council as a regulatory body that may call for adjustments in the Tehran level system, as long as they do not bypass and/or contradict national level stipulations.

Figure 1.1.2 provides a stylized overview of the existing Tehran Municipality disaster management system configuration and its core mandate. The key features are:

- The core mandate of TDMMC remains in line with Article 1 of the RRCP to cover all natural and man-made disasters;
- TDMMC is responsible for appropriate measures that address all four areas of disaster management, that is, mitigation, preparedness, emergency response, reconstruction and rehabilitation and at all defined levels of disaster intensity I to IV; and
- TDMMC continues to implement the requirements of the "Emergency Response Plan" (ERP) by establishing the definition and introduction of Standard Operating Procedures (SOPs) and the Incident Command System (ICS) in all relevant participating organizations for a unified management structure.



Source: JICA Study Team.

Figure 1.1.2 Tehran Municipality Disaster Management System and Mandate

CEMS, one of the two predecessor-organizations to TDMMC, has sourced standard operating plans from similar organizations in other countries, the selection criteria being “best-practice.” All 22 Standard Operating Plans (SOPs) have been finalized and distributed to the participating organizations for application. All SOPs are quite general in nature covering the following typical headlines and explanations, introduction, objectives of the plan, purpose of preparing the plan, policy-making; (v) hypothesis; (vi) disaster levels; (vii) chart of main activities; (viii) action plan for different disaster levels; (ix) organizations in-charge, partners and backup; (x) diagram of activities related to disaster resolution, and (xi) table of level of participation among organizations. Table 1.1.7 shows, for illustrative purposes, an example for the level of participating organizations in “debris removal.”

Table 1.1.7 SOP Example – Organizations Responsible for "Debris Removal"

Organization	Production of Waste Material					Temporary Storage					Collection					Transfer Station					Recycling & processing					Disposal				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
Recycling Organization	p					ic	ic					p				ic	p	p	p	p	ic	ic	ic	ic	ic	ic	ic	ic	ic	ic
Tehran Disaster Management Center	b	b			b			b																						
Private companies active in management of solid waste material					p	p	p	p	p			p	p		p					p										
Environment Protection Organization	b	b	b	b	b																b	b	b	b	b					
Ministry of Industries and Mines	b	b	b	b	b																	b	b	b	b					
Min. of Health, Treatment & Medical Education	b	b	b	b	b																	b	b	b	b					
Min. of Sciences, Research & Technology	b	b	b	b	b																									
NGOs (*Basij* and NGOs)	b		b	b	b																									
Deputy for Urban Services/Tehran Municipality and affiliated organizations						b	b	b	p	p	ic	p	ic	ic	p	b	b	b	b	b	b	b	b	b	b	b	b	p		p
Deputy for District Affairs of Tehran Municipality						b																								
Mass Media					b	b	b	b	b	b						b														
Basij Forces						b	b	b								b														
Disciplinary (police) forces						p	p	p	p																					
Workers in construction sites						p	p	p	p	p																				
Deputy for Training & Research and Public Relation in Recycling Org.	ic	ic	ic	ic	p																									
Service sector of major centers and units producing solid waste material (factories, hospitals, hotels , …)						p	p	p	p	p																				
Other urban producers						ic	p	p	p	p																				
Deputies for Urban Services in District Municipalities						ic	p	p	p	p	p	p	p	p	p			p	b	b										p
Motorized Services Org. in Tehran Municipality							p					ic				p	p	p	p	p										
Deputies for Social & Cultural Affairs in district municipalities		p	b	p	p																									
Private suppliers of machineries											b	b	b	b	b			b	b	b	b									
Relevant organizations and agencies											p																			
Relevant governmental and private organizations and agencies																					p	p	p	p	p					
Contractors (transportation, storage, etc.)											p	p	p	p	p	p	p	p	p	p			p		p	p	p	p	p	p
Producers of solid waste material											p	p	p	p	p															
Tehran Emergency Center																b	b	b	b	b										
Fire Brigade and Safety Services																b	b	b	b	b										
Transportation & traffic Org.																b														
Relevant Governmental Organizations for site selection and land cession including Natural Resources Gen. Office, Environment Org., Army																										b	b	b	b	b
Min. of Education & training		b	b	b	b																									
IRIB (Radio-TV Org.)		b																			p									
Temporary daily paid workers through urban services contractors												p			p			p	p	p										
Companies and organizations that have necessary facilities and equipments												b	b	p	b			b	b									b	b	b
Traffic Police General Office												b	b	b	b							b	b	b	b					
Min. of Commerce																						b	b	b	b					

Notes: 1) ic = in charge; b = back up; p = participating.
Source: Debris Removal SOP, TDMMC.

In line with the requirements of the Tehran Comprehensive Disaster Management Plan (TCDMP), the emergency response (ER) employs an Incident Command System (ICS) that is divided into six principal phases and that is still under implementation. These stages and their status in implementation are summarized in Table 1.1.8.

It may be said in summary, according to information provided by TDMMC, that (i) step 3 is completed to over 50% and (ii) steps 4 and 5 are currently under realization in line with the ICS approach.

Table 1.1.8 Stages of Emergency Response System Realization and Current Status

ERP Phases	Tasks to be Performed	Implementation Status
Phase 0	Definition of organizations; lead; supporting organizations and entities	**Completed**
Phase 1	Design of operational plans by the twenty-two committees	**Completed**
Phase 2	Determination of "key-people", that is top-level persons in the chain-of-command	**Completed**
Phase 3	Determination of human and non-human resources, that is a resource assessment under the twenty-two committees	**On-going (About 70% complete)**
Phase 4	Determination of other "key persons" in the established chain-of-command	**On-going**
Phase 5	Definition of duties & responsibilities of all personnel within the given chain-of command	**On-going**
Phase 6	Determination of sufficient resources needed for enabling TDMMC to carry out its mission efficiently and effectively	**Not yet started**

Source: JICA Study Team, based on information from TDMMC.

The rationale for using an Incident Command System (ICS) is to introduce among the various participating entities a common language that uses standardized terms, and to realize within the participating organizations a uniform command structure in terms of functional assignments. The responsibilities would facilitate inter-agency communications.

TDMMC's institutional capability and capacity to respond to its mandate manner is obviously a direct function of the institute's endowment in terms of skills, personnel (quantity and quality) and financial resources. The history of personnel development at the predecessors of TDMMC[11] does not need to concern us here and figures for previous years are for illustrative purposes only. Table 1.1.9 summarizes the number of professional personnel and supporting staff that works presently at TDMMC as of March 2004.

The staffing level of some 29 professionals in 2004 should be interpreted, at this point in time, keeping in mind the following circumstances:

- TDMMC lacks so far, except for the un-revised 2003 Mayor's Decree, proper statutes that have been approved by the relevant authorities and are, therefore, binding. It is assumed that these issues will be remedied through the recent City Council decision.
- TDMMC still operates on ad-hoc annual budget requests, though the City Council appears to have approved an expenditure ceiling for the coming Fiscal Year from 21 March 2004 to 20 March 2005 of approximately US$ 10 million.[12]
- Most of the staff increases and some of the expertise (for example, in earthquake engineering and GIS) result from either the personnel changes at TDMMC, or are

[11]) For a discussion of this matter, please see Section 3.4.2 in Progress Report (1).
[12]) The figure represents a ceiling up to which TDMMC may incur expenditures during the coming FY; it is not a regular budget figure.

transfers from the old CEMS entity and/or are staff members currently attached to the on-going JICA project, but not yet regular TDMMC staff members.

- Pending a proper definition of the institutional core functions, it may be premature to draw any conclusions on the adequacy and suitability of the staffing.

Table 1.1.9 TDMMC Actual Manning Situation By Area of Expertise (March 2004)

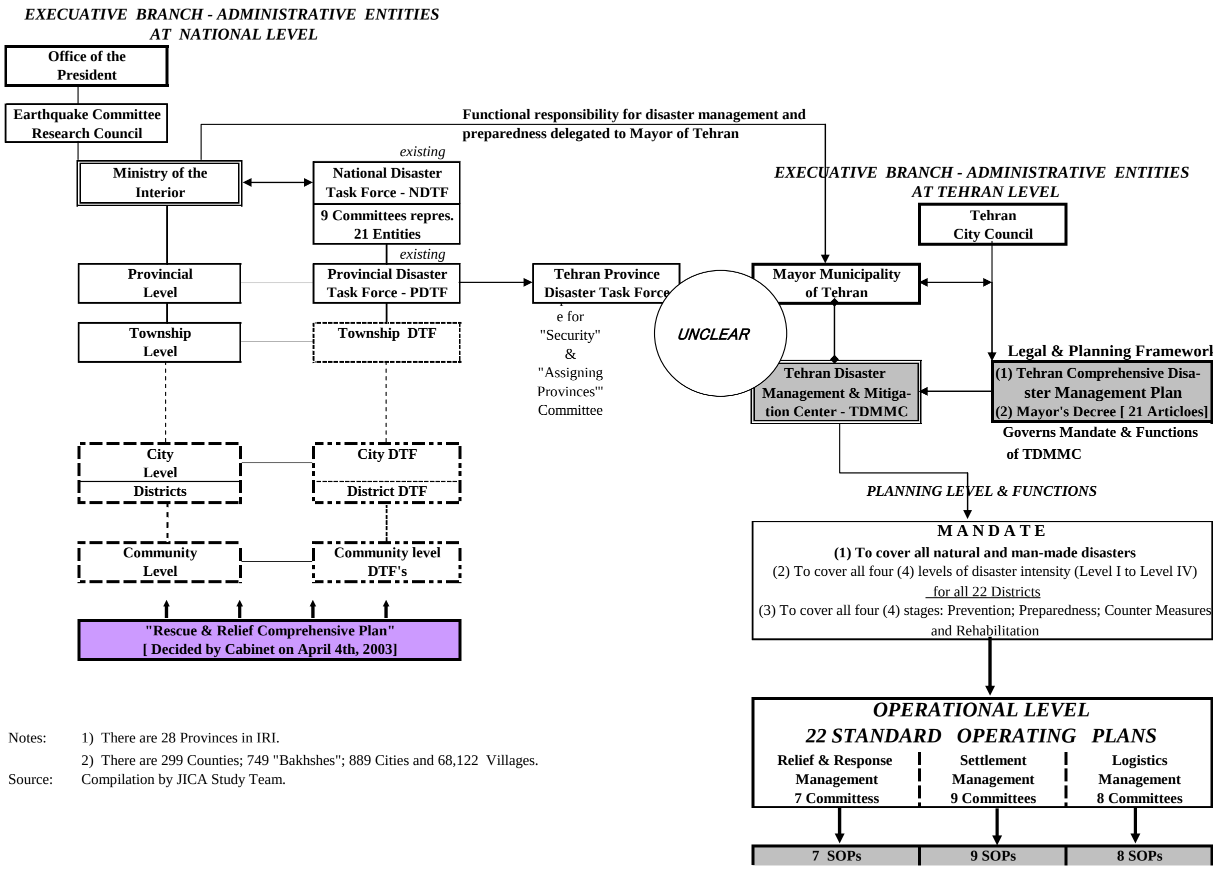
Category/ Parameter	Calendar Year	2000	2001	2002	2003	2004 (March)
Professional Staff	Level					
Architecture	n.a.	n.a.	n.a.	n.a.	1	0
Civil Engineering	B.S.	n.a.	n.a.	n.a.	1	4
Computer Science	B.S.	n.a.	n.a.	n.a.	1	1
Earthquake Engin.	Dr.	n.a.	n.a.	n.a.	n.a.	2
Environmental Health	B.S.	n.a.	n.a.	n.a.	n.a.	1
Geophysics	n.a.	n.a.	n.a.	n.a.	n.a.	1
GIS Experts	B.S.	n.a.	n.a.	n.a.	n.a.	2
Medical Doctors	M.D.	n.a.	n.a.	n.a.	2	4
Public Relations	M.S.	n.a.	n.a.	n.a.	1	1
Search & Rescue Mgmt.	B.S.	n.a.	n.a.	n.a.	n.a.	4
Structural Engin.	B.S.	n.a.	n.a.	n.a.	n.a.	3
Transportation	PhD	n.a.	n.a.	n.a.	1	1
Urban Planning	M.S./B.S.	n.a.	n.a.	n.a.	2	2
Languages	B.S.	n.a.	n.a.	n.a.	1	1
Sub-Total		n.a.	n.a.	n.a.	10	27
Supporting Staff	n.a.	n.a.	n.a.	n.a.	2	2
Other Staff	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
TOTAL		6	9	12	12	29

Notes: 1.) The number are only indicative, since not all personnel shown in 2004 is on the permanent payroll of TDMMC yet.
2.) The manning table has not yet been approved by the relevant authorities.
3.) The term other staff refers to drivers, cleaners, gardeners, and cafeteria staff.

Source: JICA Study Team compilation based on information provided by TDMMC.

It is useful to provide a snapshot overview as of March 2004 of the Tehran Municipality disaster organization and management system as it presents itself within the context of the overall national level system. Figure 1.1.3 provides a panoramic overview of that position. The essential issues for further concern about the inter-relationship between Tehran Municipality and the national level system are:

- Tehran Municipality is the only administrative entity in I.R.I. in which the Mayor and not the Governor of the Province is the Commander-in-Chief who would direct, under the overall control of the Ministry of the Interior, in an emergency situation, resource deployment and use. Such a set-up has naturally its merits and de-merits. However, the system designer should take a close look at the practical implications, in particular, for a disaster situation as predicted.



Notes: 1) There are 28 Provinces in IRI.
2) There are 299 Counties; 749 "Bakhshes"; 889 Cities and 68,122 Villages.
Source: Compilation by JICA Study Team.

Figure 1.1.3 Tehran Disaster Management System Within the National Context

- The mandate and core functions of TDMMC need to be scrutinized with a view to establishing firmly whether TDMMC should remain a local institution or, over the long run, develop into a national level entity.
- The RRCP, which is legally binding for all government and non-government entities and therefore also for any local level disaster management entities, contains many stipulations that need to be reviewed and, if necessary, be integrated into the mandate and/or functions of TDMMC. One example would be that of training Government official at various levels for disaster management related activities.
- There is a well recognized need for a fully functional Emergency Operations Center (EOC) at Tehran and perhaps also at national level. It needs to be further scrutinized as to whether the two centers should be combined, taking into account all technical and financial implication.

1.2 Basic Policy of the Study

1.2.1 Background

1) Objective Earthquake

The Greater Tehran Area is located at the foot slope of the Albors Mountains, which form part of the Alps-Himalayan Organic Zone. This zone is of high seismic potential with many peculiar active faults. The urban area of Tehran has been developed on alluvial layers, accumulated on hard rock through complex geological formations. According to historical seismic data, Tehran has suffered from several strong earthquakes with a return period of 150 years. The city of Manjil, located 200 km west of Tehran, suffered from a strong earthquake in 1990, which killed approximately 14,000 people. Seismologists believe that a strong earthquake will strike Tehran in the near future because the city has not experienced a strong earthquake since 1830.

The previous study[13] done by JICA developed three types of scenario earthquakes, namely Ray Fault Model, North Tehran Fault (NTF) Model, and Mosha Fault Model, and these were adopted for seismic microzoning analyses. Scale, peak ground acceleration, and seismic intensity of each scenario earthquake are summarized in Table 1.2.1.

Table 1.2.1 General Features of Scenario Earthquake Models

	Ray Fault	NTF	Mosha
Length (km)	26	58	68
Magnitude (Mw)	6.7	7.2	7.2
Peak Ground Acceleration (gal)	North<200 South>400	North>400 South<200	<200
Intensity (MMI)	North: 8 South: 9	North: 9 South: 7-8	7

Source: Seismic Microzoining of the Greater Tehran Area, 2000 JICA

The damage estimation produced the following damages to residential buildings and human casualties.

Table 1.2.2 Damages of Scenario Earthquake Models

	Ray	NTF	Mosha
Bldg Damages	483,000	313,000	113,000
Damage Ratio	55%	36%	13%
No. of Deaths	383,000	126,000	20,000
Death Ratio	6%	2%	0.3%

Note: The number of existing buildings and population were assumed at 876,000 and 6,360,000, respectively.

Source: Seismic Microzoining of the Greater Tehran Area, 2000 JICA

[13]) The Study on Seismic Mcrozoning of the Greater Tehran Area in the Islamic Republic of Iran, November 2000, Japan International Cooperation Agency.

The above results show that Ray Fault Model seems the most disastrous scenario that would generate worst damages to Tehran.

2) Responsibility of Formulation of Disaster Management Plan

TDMMC is established in Tehran Municipality by the merger of CEMS and CEST into one organization. According to Article 5 of the Mayor’s Decree of 2003, regarding functions of the TDMMC, TDMMC has responsibility for preparation, formulation and supervision of plans for prevention and reduction of the disaster effects, preparedness, encountering the events and rehabilitation. Therefore, this Study will be direct input for the Tehran Comprehensive Emergency Management Plan.

3) Implementation of the Disaster Management Master Plan

The basic concept of the disaster management is: the responsibility to save yourself is your own. Based on this concept, the government sector should provide assistance and support to residential organizations. The government should support the citizen’s activities and promote mitigation and preparedness for disaster management. The private organizations, such as private company, governmental organization and other organizations should participate in implementation of this plan.

The plan covers all subjects related to the earthquake disaster management in Tehran and includes many organizations in public and private sectors. The government in national sector should provide framework among the governmental agencies, including laws and regulations for the disaster management. In order to provide funds for the disaster management area, the national government should establish budgetary process for acquisition of the funds. Tehran Municipality is the primary agency for implementation of the master plan.

The community organization should involve disaster management plan in the area of cooperation and coordination among the citizens and responsibility for rescue and relief after the event. Community level disaster management includes formulation of disaster management maps and disaster management plan. Training activities based on the community level disaster management plan should be carried out periodically.

The disaster management organizations include lifeline companies and TV, radio broadcast organizations and the financial sector. Other private organizations include private cooperation, professional organization, etc. Those organizations should participate in implementation of the disaster management plan.

1.2.2 Goal

The lives and properties of the citizens of Tehran are being made safer from potentially devastating earthquake by formulation and implementation of a comprehensive disaster management master plan.

Urban development has been rapidly progressing in Tehran without the development of a proper disaster prevention system against potential earthquakes. It is clear that Tehran has not prepared for earthquake disaster. Therefore, the goal of the master plan is:

To establish a safe and secure urban environment against a potential earthquake.

In order to have a more concrete mitigation target, the Study Team proposes to reduce the number of damaged buildings to one-tenth of the estimated damage in Ray Fault case. Ultimate target damage caused by the Ray Fault Model is 48,000 buildings, which should be strengthened or rebuilt.

1.2.3 Planning Period

The implementation plan should be divided into three phases:

- Short term (2004-2006)
- Medium term (2007-2010)
- Long term (2011-2015)

The master plan will cover years 2004 to 2015, a total of 12 years. However, ultimate goal of the mitigation target cannot be achieved within the planning period. It will take 80-100 years to achieve this goal.

Within the planning period, more than 100,000 buildings should be strengthened to reduce the earthquake damage.

1.2.4 Objectives

The master plan is composed of three plans: disaster prevention plan, emergency response plan and rehabilitation and reconstruction plan. These plans can be defined as the disaster management cycle: disaster prevention plan deals with the before earthquake measures, emergency response plan lays out the procedures and rules of the governmental response, and rehabilitation and reconstruction plan shows the after earthquake damage. These plans together with implementation schedule of the proposed project will determine future actions for disaster management in Tehran Municipality.

In order to achieve the goal, the Master Plan sets three objectives to accomplish by the year 2015. The objectives of the master plan are:

- to secure lives and properties of the citizens of Tehran;
- to protect citizen's life after the event; and
- to prepare for rehabilitation and reconstruction.

The first objective addresses the before earthquake situation. The objective focuses on the mitigation and preparedness of the governmental agency. The most important measures are the strengthening and reinforcement or rebuilding of the existing buildings and infrastructures. Urban redevelopment, demolishing and rebuilding of the most vulnerable area, is another way of addressing the issue. Public awareness improvement is also an important aspect for this period.

The second objective focuses on from just after earthquake until the reconstruction phase. The government should improve its organized action after the earthquake to save lives and provide services to the victims.

The third objective is the reconstruction and rehabilitation phase, which has not considered existing laws and regulations; rather decision would be made based on the situations. The basic procedure should be determined before the event.

1.2.5 Strategies

In order to reduce the damage in Tehran Municipality, emphasis should be given on the mitigation and preparedness. Upgrading of existing vulnerable buildings, use of the appropriate technique, better designs and construction practice in new building development will be the most effective way to reduce earthquake damage. At the same time, increasing preparedness in all areas is the important point.

Increased emergency response capacity within the governmental organization is also important to control earthquake damage. The government sector should take care of after earthquake situations.

The Study Team examines measures, structural and non-structural, to achieve the goal and objectives. The Team selected those measures and determined 10 strategies in order to achieve the goals by considering experiences of Japan. Those strategies include structural and non-structural measures.

The 10 strategies are as follows:

- Strengthening existing buildings
- Improvement of existing urban structure
- Identification of safety evacuation space
- Strengthening existing infrastructure and lifeline
- Provision of earthquake information and education
- Establishment of disaster mitigation policy
- Establishment of community level disaster management organization
- Improvement of disaster management system
- Formulation of emergency response plan
- Establishment of rehabilitation and reconstruction procedure

Those ten strategies are re-organized into disaster prevention and management plan formulation, emergency response plan and rehabilitation and reconstruction.

1) Disaster Prevention and Mitigation Plan

The plan covers a wide range of disaster management efforts. Building strengthening and area development are the most important measures for mitigation because buildings in Tehran are weak against earthquake. As the results of previous study indicate, the damage ratio of the building is more than 55% in case of Ray fault model so that building strengthening and rebuilding are the most important measures in Tehran. Strengthening public buildings is the most urgent work item and the promotion of private building strengthening is the next step.

Building strengthening in Tehran has not been popularized because of its relatively high cost. The most effective way to mitigate the huge earthquake damage estimation is to strengthen the buildings, which contributes to reduce the physical damage directly and to save the resources and efforts paid before and after disaster event. In this sense, research and development of inexpensive building strengthening, in particular for Masonry structure, is quite essential and cost-effective. The government should promote those research and development activities and its popularization. Application of inexpensive building strengthening method to existing weak buildings reduces the total mitigation cost.

The community level disaster management activity is also one of the important aspects. Without community participation in disaster management, it is difficult to carry out whole disaster management. Formulation of disaster resistant society is important but it is time-consuming work.

2) Emergency Response Plan

This plan focuses on emergency response activities after the event. Urgent and efficient response makes it possible to minimize spread of damage. Formulation of disaster management organization is the first step. Emergency response manuals should be established in each responsible organization. In this plan, guidelines are provided to promote formulation of such manual because most of the organizations have not prepared emergency response manuals.

3) Rehabilitation and Reconstruction Plan

In Tehran, rehabilitation and reconstruction procedure has not been established as yet. This plan focuses on laws and regulations and institutional aspects of rehabilitation and reconstruction. Especially, urban rehabilitation and reconstruction should be started before the event and included in normal urban planning process.

1.3 Framework of the Master Plan

1) Framework for the Master Plan

The framework of the master plan study can be organized as shown in Figure 1.3.1. The three objectives are in correspondence with three plans: prevention and mitigation plan, emergency response plan and rehabilitation and reconstruction plan. Ten strategies are classified depending on earthquake countermeasures.

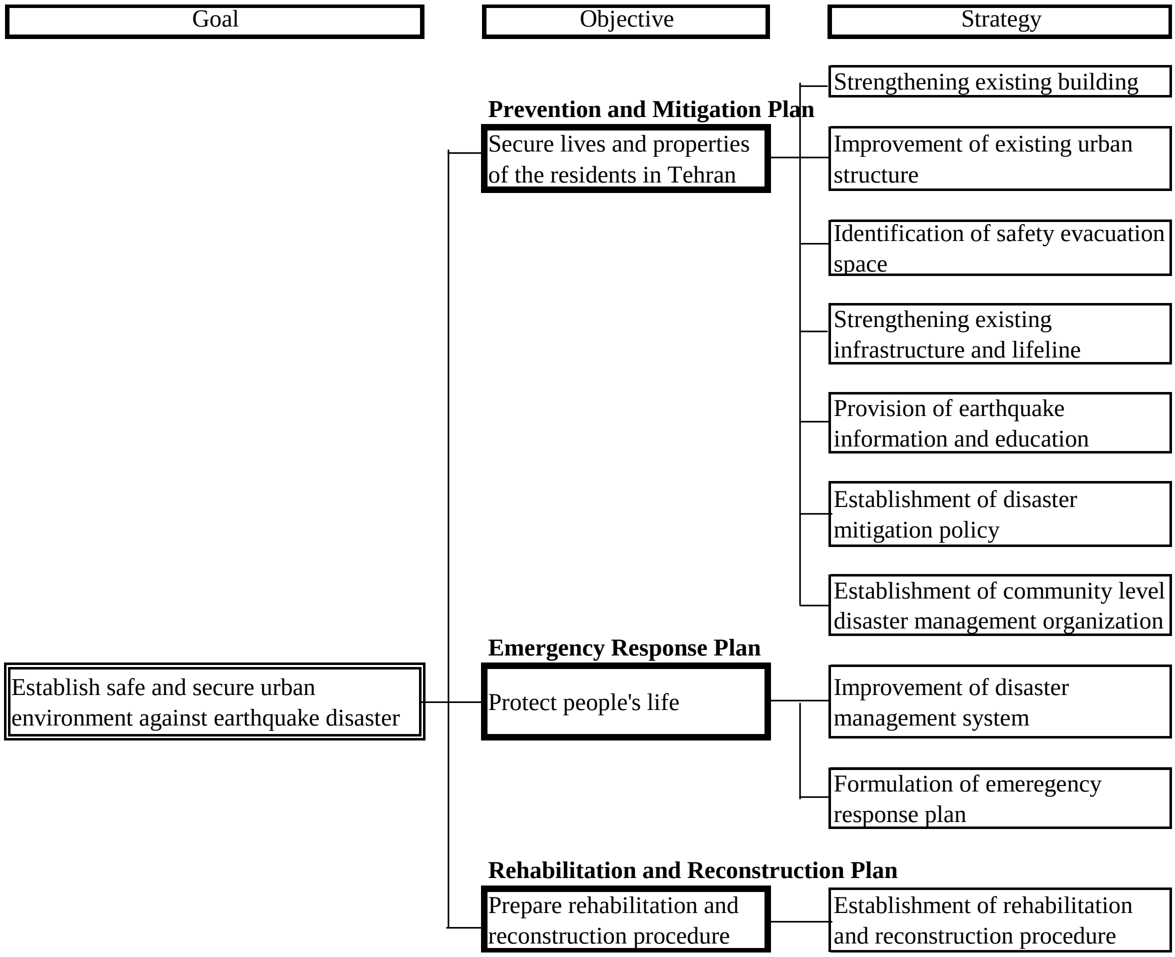


Figure 1.3.1 Framework of the Master Plan

2) Implementation Plan

The Study Team compiled long lists, which included all projects in order to implement the master plan. Based on the list, the Study Team selected priority projects and programs. The priority projects and programs have been formulated by inter-sector approach to achieve the stated goals, and corresponding project profiles drawn up. The responsibility of each project is shown for easy implementation of the project.

The Study Team has prepared the total investment costs for each responsible organization and compared its budgets for the realization of the project. There is a problem of the resource mobilization to the disaster management field, because of low recognition by the governments. Each organization should start preparing their disaster management plans in accordance with the recommendation of the master plan.

Reference to Chapter 1

Japan International Cooperation Agency. 2000. *The Study on Seismic Mcrozoning of the Greater Tehran Area in the Islamic Republic of Iran*. Tokyo.

Chapter 2
Conditions for the Master Plan

CHAPTER 2 CONDITIONS FOR THE MASTER PLAN

2.1 Damage Estimation

2.1.1 Objective Earthquake

Three types of scenario earthquakes, namely Ray Fault model, North Tehran Fault (NTF) model and Mosha Fault model were established in the previous study. Fault models for each earthquake were constructed for numerical calculation. Scale, peak ground acceleration and seismic intensity for each scenario earthquake are summarized as shown in Table 2.1.1.

Table 2.1.1 Summary of Three Scenario Earthquakes

	Objective Earthquake		
	Ray Fault model	NTF (North Tehran Fault) model	Mosha Fault model
Length (km)	26	58	68
Moment Magnitude (Mw)	6.7	7.2	7.2
Peak Ground Acceleration (gal)	Northern Area: 200 and less Southern Area: 400 and over	Northern Area: 400 and over Southern Area: 200 and less	200 and less
Seismic Intensity MMI	Northern Area: 8 Southern Area: 9	Northern Area: 9 Southern Area: 7 to 8	7

Source: The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, November 2000

2.1.2 Damage

In order to estimate seismic damage, in the previous study, a total of 34,805 census blocks are identified and these blocks are aggregated into 3,173 census zones. Statistical data on population and buildings are accumulated based on these census units. The census boundary is used as the base unit for the special data analysis.

Seismic intensity of each census zone was calculated based on the three scenario earthquakes. Then, seismic damage was estimated together with database, population, building and infrastructure and lifeline. The damage estimation was done in each zone.

The Table 2.1.2 shows the results of the estimation.

Table 2.1.2 Damage Estimation Results

Item	Unit	Amount
Heavily Damaged and Collapsed Residential Building		
Ray	nos	483,000
North Tehran	nos	313,000
Mosha	nos	113,000
Human Death		
Ray	nos	383,000
North Tehran	nos	127,000
Mosha	nos	20,000
Water Pipeline		
Ray	point	3,900
North Tehran	point	800
Mosha	point	10
Gas Pipeline		
Ray	point	540
North Tehran	point	140
Mosha	point	2
Electricity Cable		
Ray	m	18,500
North Tehran	m	2,700
Mosha	m	0
Telephone Line		
Ray	m	12,800
North Tehran	m	2,200
Mosha	m	0

Source: The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, November 2000

Note: ☐ Objective Earthquake

Based on the previous study results, the Study Team estimates heavily damaged and collapsed floor area, debris removal and homeless victims.

- Heavily damaged or collapsed floor area

In Building Census, floor area and structure of each dwelling unit are surveyed. Then, total floor area of each structure in each district is obtained. Floor area of heavily damaged or collapsed building is calculated by multiplying total floor area by damage ratio for each structure.

- Debris of heavily damaged and collapsed building

Amount of debris of heavily damaged or collapsed building was estimated by the following assumption:

[debris (ton)] = 0.75 (ton/m^2) x [heavily damaged or collapsed floor area (m^2)]

- Debris of emergency road

Amount of debris on emergency road was assumed as follows:

[debris on emergency road] = 0.03 x [total debris]

- Homeless victims

Number of homeless victims is calculated in each census zone based on the population in each structure. Population in each structure multiplied by the damage ratio of each structure derived the number of people living in the heavily damaged or collapsed buildings. From this number, number of deaths is subtracted in each district.

Table 2.1.3 summarizes the damage estimation based on the results of the previous Microzoning Study.

Table 2.1.3 Damage Estimation Based on Microzoning Study

Item	Unit	Amount
Heavily damaged and collapsed floor area		
Ray	Ha	17,000
North Tehran	Ha	15,000
Mosha	Ha	6,000
Debris of heavily damaged and collapsed building		
Ray	1000 ton	124,000
North Tehran	1000 ton	109,000
Mosha	1000 ton	46,000
Debris of heavily damaged and collapsed building on emergency road		
Ray	1000 ton	3,700
North Tehran	1000 ton	3,300
Mosha	1000 ton	1,400
Homeless victims		
Ray	Nos	3,126,000
North Tehran	Nos	1,999,000
Mosha	Nos	763,000

Source: The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, November 2000

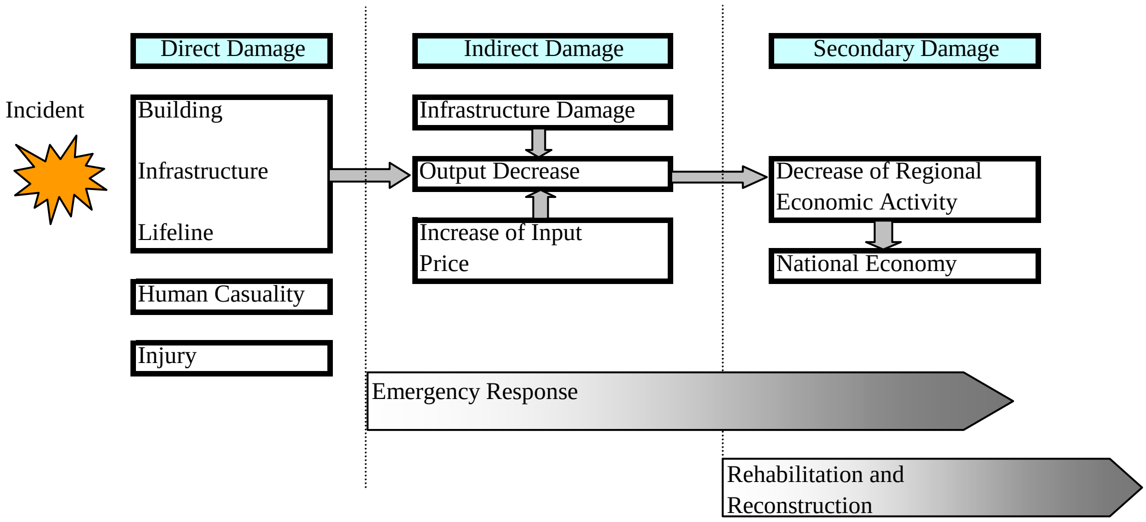
Note: ☐ Objective Earthquake

2.2 Economic Analysis

2.2.1 Economic Damage Analysis

The effects of an earthquake event can be broken down into three; the economic cost, the human cost including loss of life and personal injuries, and the ecological cost among other damage to ecosystem. Economic cost can be expressed in monetary terms, yet the other effects are difficult to quantify. In this section, focus is on economic cost estimation.

The economic loss caused by the earthquake can be categorized into three items: direct loss, indirect loss and secondary effect of the earthquake. Figure 2.2.1 shows the links of those damage items. Direct cost relates to the physical damage to capital assets, including building, infrastructure, industrial plants, and inventories of finished, intermediate and raw materials destroyed or damaged by the earthquake. Indirect cost includes lower output from damaged or destroyed assets and infrastructure and loss of earnings due to damage to infrastructure such as roads and ports. Secondary and macroeconomic effects take into account the short and long-term impacts of a disaster on aggregate economic variables.



Source: JICA Study Team

Figure 2.2.1 Damage Link

The previous study shows the possible physical damages of an earthquake in Tehran. Damage is not clear, however, in monetary terms. Monetary value of the damage would direct overall disaster management alternatives in the coming master plan. For example, in order to reduce the earthquake damage, strengthening of the existing buildings is the most important, yet the retrofitting requires financial resources. After the earthquake, the Government should spend money to cover post-earthquake operation and rehabilitation and reconstruction of Tehran.

The economic analysis would tell which policy decision makes sense in terms of economic costs. However, there is difficulty in evaluation of earthquake damage in cost-benefit analysis in monetary terms. The reasons are that: 1) placing a monetary value on life has not reached acceptance; 2) placing a monetary value on speculation of damage and disruption of economy is still an inexact process; 3) prediction when and how earthquake will impact any particular building cannot be done accurately, so the earthquake damage on building is unclear and 4) real-life testing before and after mitigation is not possible. In this analysis, costs side of the disaster losses should be clarified in monetary terms.

2.2.2 Direct Loss

In this Study, the only available economic costs are a part of direct loss. The other economic costs, such as indirect costs and secondary effects of the earthquake damage, are estimated based on assumptions and other studies because of limitation of data. The Study Team utilizes the previous study results of damage estimation to estimate direct loss of the earthquake damage.

1) Building Damage

The previous study by JICA estimated residential building damage. The term “damaged building” means that buildings are heavily damaged or collapsed and that these are unfit for living without proper repair. The cause of damage is limited to earthquake and secondary damages are not included. Floor area is used for estimation of the damage costs.

Data used for the analysis derived from the cadastral database, which is managed by computer service organization. Damaged floor area is calculated for each building structure using same damage ratio, which is derived from previous study. Damaged loss is calculated by using unit replacement costs by each structure type. Assumed replacement costs of each building structure type are shown in Table 2.2.1.

Table 2.2.1 Unit Price of Building Structure

Structural Type	RC Structural	Weak Masonry	Unreinforced Masonry	Semi-reinforced Masonry	Steel
Unit Costs (Million Rial/m^2)	1.9-2.4	1.5	1.5	2	1.9-2.3
Structural Type	Adobe	Hangars and Canopies	Mix of above structure	Others	
Unit Cost (Million Rial/m^2)	1.0	1.5	1.0	1.0	

Source: JICA Study Team

Table 2.2.2 shows damage loss caused by building collapse.

Table 2.2.2 Damage Loss from Building Collapse (Ray Fault)

District	RC	Masonry	Steel	Adobe	Hangars and Canopies	Mixes of above 1-6	Others	Damaged Total Floor Area (ha)	Damaged Total Loss (billion Rials)
1	51	276	352	2	2	1	2	685	11,928
2	105	327	408	1	3	7	1	852	14,892
3	59	274	406	1	5	11	1	758	13,209
4	42	538	456	1	17	69	0	1,124	18,529
5	105	191	277	1	2	9	0	585	10,358
6	49	360	408	1	8	5	1	831	14,322
7	20	361	261	1	8	3	0	654	10,934
8	9	318	204	0	3	6	1	542	8,941
9	2	165	51	0	4	38	0	261	3,924
10	6	278	103	2	4	4	0	399	6,367
11	10	307	186	6	8	2	1	520	8,549
12	10	357	172	64	9	6	0	618	9,658
13	4	283	173	4	6	15	0	484	7,892
14	3	352	194	3	4	3	0	560	9,146
15	4	348	209	1	3	18	19	602	9,696
16	6	225	117	2	11	32	0	392	6,223
17	2	219	67	1	3	6	0	298	4,713
18	6	179	89	3	8	47	0	332	5,116
19	2	76	107	1	2	4	0	192	3,293
20	9	215	118	4	7	39	0	392	6,182
21	4	148	85	1	20	285	0	544	7,075
22	3	25	25	0	0	2	10	63	1,030
Total	1,015	11,027	8,916	20	27	1,221	67	11,692	**191,977**

Source: JICA Study Team, 2003

Remark: Utilized hypothetical unit cost is shown in Table 2.2.1. Damaged floor areas are estimated using the building damage ratio of the JICA Microzoning Study and the floor area of Property Tax Database from Tehran Computer Service Organization.

The direct damage loss of the building is RIAL 191,977 billion or USD 22.6 billion.

2) Bridge Damage

In the previous study, 164 bridges located within the Study Area were evaluated. The evaluation is classified into three types: 1) collapsed, 2) unstable, and 3) stable. For the calculation of Direct Loss caused by bridge damages, approximate cost is applied temporarily. This unit cost for bridge construction will be updated when most updated unit cost information is received from TETCO. Table 2.2.3 shows damage loss caused by bridge collapse.

Table 2.2.3 Damage Loss from Bridge Collapse (Ray Fault)

District	No. of Evaluated Bridge	No. of Collapsed Bridge (Ray)	No. of Unstable Bridge (Ray)	Damaged Total Loss (billion Rials)
1	8	0	0	0
2	26	0	1	17
3	21	0	0	0
4	10	0	0	0
5	11	0	0	0
6	6	3	0	79
7	5	0	0	0
8	0	0	0	0
9	1	0	0	0
10	4	0	0	0
11	1	1	0	35
12	3	1	2	28
13	0	0	0	0
14	0	0	0	0
15	2	0	0	0
16	4	0	1	51
17	7	0	1	4
18	5	0	0	0
19	1	1	0	25
20	1	0	0	0
21	5	0	0	0
22	3	0	0	0
Total	124	6	5	**238**

Source: JICA Study Team, 2003
Remark: Utilized hypothetical unit cost is Rial 3.5 million per square meter. Area of collapsed and Unstable bridges is calculated from 1:2,000 digitized maps, TGIS, 1997. Damage loss is calculated for collapsed bridge as 100% and unstable bridge as 50%.

3) Lifeline Damage

Lifeline consists of 1) Water, 2) Gas, 3) Electricity, and 4) Telecommunications. For each lifeline, since damage is estimated in the previous study, the Study Team attempted to estimate damage loss from lifeline network damage and the result is shown in Table 2.2.4.

Table 2.2.4 Damage of Lifelines

Items		Damaged Points	Costs (million Rial)	Total (billion Rial)
Lifeline	Water	3,900	15.5	60.5
	Gas	540	9.0	4.9
	Electricity	18,500	0.13	2.4
	Telecommunication	12,800	0.23	2.9
Total				70.7

Source: JICA Study Team

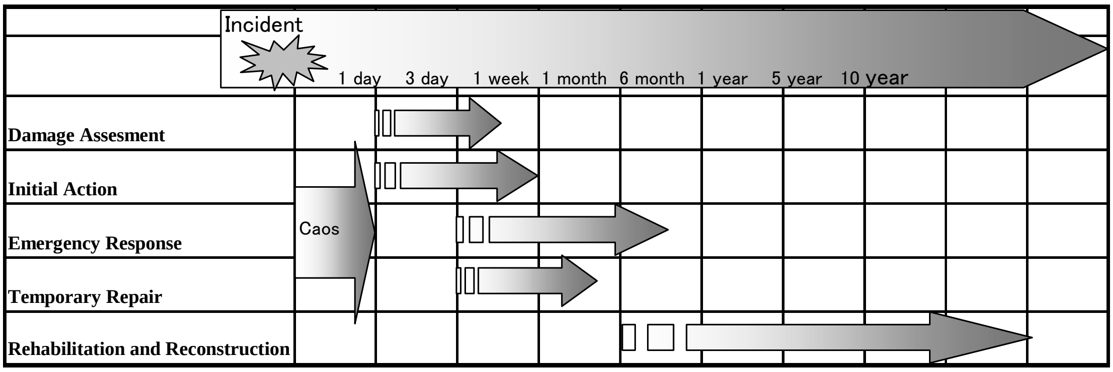
The amount of damage is RIAL 70.7 billion or USD 8.3 million in total lifeline damage.

4) Total Direct Loss

The analysis of the earthquake economic loss shows the amount of direct loss is RIAL 191,977 billion or USD 22.6 billion. It is equivalent to 37% of national GDP, RIAL 520,000 billion, or 106% of the annual municipality revenue. The preliminary analysis included only part of direct loss.

2.2.3 Indirect Costs and Secondary Effects of Earthquake Damage

Indirect damage costs and secondary effects of the earthquake are difficult to estimate in Tehran with limited statistical data and without proper assumptions after earthquake response activities. In order to estimate indirect costs, the data for destroyed assets and infrastructure and loss of earnings due to damage to marketing infrastructure such as roads and ports[1] are required. The only available statistical data in Tehran are found in the Iran Statistical Yearbook. The Study Team makes use of those data to estimate indirect and secondary earthquake damage. The following emergency response assumptions are made in order to estimate indirect costs (see Figure 2.2.2).



Source: JICA Study Team

Figure 2.2.2 Disaster Management Activities

It assumes that it takes three months for economic activities in both industrial and commercial sectors to start anew, and from then on economic activities are gradually increased to reach 80% of their previous situations in a year's time.

The gross national product (GNP) of the Tehran is assumed to be 26% of the national economy of USD 59.6 billion in 1999. In 1999, Tehran's GNP reached USD 15.5 billion, of which USD 4.5 billion was industrial outputs. Commercial output was assumed to be 62% of total GNP in Tehran and primary sector is USD 1.4 billion per year..

[1]) Catastrophes and Development, Integrating Natural Catastrophes into Development Planning, April 2002.

Emergency response after an earthquake is a yearlong process. Temporary repairs start after a month and could last up to three months. Rehabilitation and reconstruction starts after six months from the incident. Earthquake damage to the secondary and tertiary sector continues for one year. Industrial sector completely stops production for one month and afterwards, it will recover to normal situation in 11 months. Tertiary sector is also assumed to have indirect damage for one year. Based on those assumptions, industrial output will drop USD 4.5 billion to USD 1.7 billion. Commercial output will drop USD 9.6 billion to USD 3.9 billion. Primary sector will be USD 1.4 billion to USD 0.7 billion. GNP in Tehran will be 6.3 billion after the earthquake. Therefore, indirect lost is USD 9.2 billion.

Secondary effects of the earthquake damage are difficult to estimate. The research study done by the World Bank in Marmara Earthquake shows damage at 1.0% to 1.2% of total GNP in the first year and 0.8% to 1.0% the following year. The damaged area in Turkey is placed at a cost of 34.4% of GNP and 46.7% of industrial output, while in Tehran municipality, it is 25% of GNP and 24% of industrial outputs. Therefore, 2% of GNP, which is USD 1.2 billion, would be estimated as cost of secondary damage in Tehran.

Total economic impact of earthquake damage of Ray fault model is summarized as follows:

Direct Loss	USD 22.6 billion
Indirect Loss	USD 9.2 billion
Secondary Effect	USD 1.2 billion
Total	USD 33.0 billion

Total damage of the earthquake is 56% of the GNP of the nation.

2.2.4 Emergency Response Costs

After the earthquake, the governmental and other organizations will implement emergency response activities. The past experience in Iran is not available to estimate emergency response costs. The World Bank has carried out damage estimation and emergency response cost estimation in Marmara Earthquake in Turkey. Based on the experience of the past earthquake in Turkey, emergency response cost is ranged between USD 150-200 per victim, which includes personal compensation for death and injury.

There is no reliable data available to estimate the emergency response costs in Tehran. Interviews done by the Study Team with knowledgeable persons at RCS show USD 19 /victim/month only for direct personal cost. Inclusion of other costs, equipment, materials, administration and management etc., would increase to three times as much as the direct personal costs. Emergency response taking six months for 3 million victims will cost USD 1.0 billion.

The removal of debris from the site will cost USD 15,400 per 1,000 ton. Total debris on the ground is estimated at 124 million tons only from the building. It will cost USD 1.9 billion for debris removal in Tehran.

Temporary shelter, including tents, will require 200,000 units for 1 million victims. The total cost will be USD 24 million.

Emergency response cost is estimated at USD 2.9 billion.

2.2.5 Rehabilitation and Reconstruction Costs

After the earthquake damage, it is estimated that more than 400,000 buildings will be collapsed. The inclusion of other damaged buildings would increase the number of buildings needing repair. The distribution of damaged building can be found in the southern part of Tehran. The previous microzoning study shows the building damage distribution as a percentage of each zone. It is assumed that the more than 50% of building collapse area would require area development after the earthquake. Total area for area development is about 31,000 ha, which is 44% of Tehran municipality.

The cost of area development is estimated as USD 6.3 million per hectare, including housing development and infrastructure development. Total development costs will be USD 195 billion in total, which is 3.4 times of the country's GNP.

2.2.6 Analysis of Existing Building

There is not specific building diagnosis method that has the force of law in Tehran at this stage. Some case examples were carried out referring to US specification "FEMA356."

In this Study a main concept of Japanese building diagnosis system called "Specification on Earthquake Resistant Diagnosis and Strengthening for Governmental Buildings (Building Maintenance and Management Center of Japan, 1996)" is relied on. An index obtained by utilizing "Specification on Earthquake Resistant Diagnosis and Strengthening for Governmental Buildings" is seismic index of structure $\boldsymbol{GI_s}$ (hereafter referred to as "$\boldsymbol{GI_s}$ system").

Design earthquake, which is prescribed in "Iranian Code of Practice for Seismic Resistant Design of Buildings" Standard #2800", is also interfaced with (hereafter referred to as "Standard #2800").

There are some specifications for building diagnosis in Japan, but only $\boldsymbol{GI_s}$ system can evaluate earthquake-resistant capacity of steel frame structure and RC structure from a unified point of view, and these two are major structure types in Tehran. This is the reason why a main concept of $\boldsymbol{GI_s}$ system is relied on.

Regarding masonry structure, a method that is described in Standard #2800 similar to US code UBC is reflected because descriptions in Japanese code are too strict for Iranian situation.

Regarding steel frame structure, some detail discussions are needed because steel frame structures in Tehran are quite different from Japanese ones. Therefore, *incremental loading method* is utilized in analysis.

Regarding RC structure, a simplified method developed in Japan is utilized because there is no essential difference between structures in Tehran and Japan. A similar simplified method is utilized for masonry structure.

Some representative buildings, each of which can be a disaster-prevention facility, are selected (i.e. School buildings, Hospitals, Public buildings and Lifeline facility). Some ordinary residential buildings are also selected. Building diagnosis was carried out utilizing GI_s system.

Result of building diagnosis was summarized in a table, which is prepared referring a classification in tax database from Tehran Computer Service Organization. Average GI_s value for each building type is referred to Table 3.2.1.

It is inherent in definition that GI_s value is a physical quantity that is obtained by structure capacity divided by required capacity. Therefore GI_s value can be converted to damage ratio of buildings because the damage ratio is defined as probability of damage. So this conversion was carried out in this Study. Main concepts of this conversion are probability theory and reliability method.

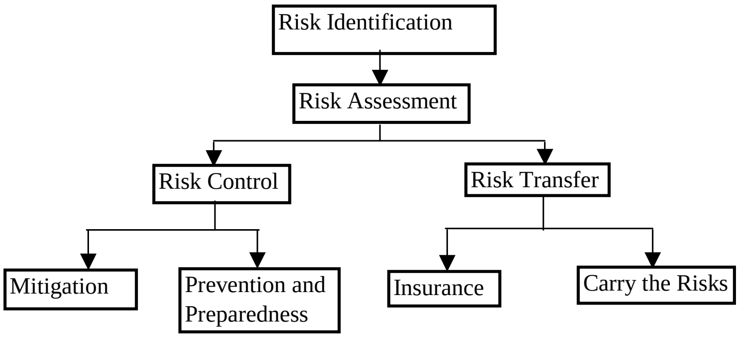
The probability in which buildings reach heavily damaged threshold, the floor area of damaged buildings and the number of damaged buildings were estimated by analysis based on average value GI_s of each building type and database of tax book of Tehran. The earthquake motion in this analysis is the design earthquake, which is prescribed in Standard #2800.

The extent of building damage assessed by above analysis exceeds the extent possible for emergency response activity. Therefore, draft countermeasures under the condition that is possible for emergency response activity was generated (i.e. strengthening and replacement of building).

2.2.7 Economic Analysis of Earthquake Damage Estimation

1) Risk Management of Natural Disaster

Risk management of the natural disaster can be broken down as shown in Figure 2.2.3.



Source: Kiyoshi, Kobayashi, Japan Society of Civil Engineering, Vol. 85, July 2000

Figure 2.2.3 Risk Management of Natural Disaster

The first step is to identify risks. This work was done by the previous study, Seismic Microzoning of the Greater Tehran, in November 2000. Based on the identified earthquake risks, an assessment of their potential impacts and magnitudes has been clarified in this Study. Those are shown in number or volume and monetary terms of damages in this section. The building damage is large, and earthquake impact is serious in the Tehran area. Therefore, risk control measures on building are considered in the next section.

The third step is to determine risk control methods and clearly identify measures to disaster management. As for risk transfer, this is discussed in Chapter 8 of this report.

2) Economic Analysis on Mitigation

Target of damage reduction level is one-tenth of the Ray Fault Model, as indicated in Chapter 1. In order to achieve this goal, the Government and private sector should spend money on earthquake damage mitigation of the buildings, infrastructure and lifeline structure. The outcomes of the mitigation works can reduce the following costs:

(1) Reduction in direct losses

The mitigation measure for building and infrastructure will avoid damage on structure, loss of human lives and injuries.

(2) Reduction in indirect losses

The long-term effects of economic loss associated with earthquake damage can be avoided with mitigation measures.

In this section, the Study Team compares the earthquake damage and required investment in three cases: Do Nothing, Reduced Damage at 30% and Reduced Damage at the Ultimate Level (90%). The three cases are compared as shown in Table 2.2.5

Table 2.2.5 Comparison of Damages and Costs for Three Cases: Do Nothing, 30% Damage Reduction, 90% Damage Reduction

		Case 1 (Do nothing case)	Case 2 (30% decrease of damage)	Case 3 (90% decrease of damage)
Earthquake Damage	Building Damage	483,000	330,792	51,058
	Human Casualty	383,000	265,572	57,071
	Homeless Victims	3,126,000	2,167,563	465,809
	Debris (1,000 ton)	124,000	85,981	18,477
Costs	Building Damage Costs	US$ 22.6 billion	US$ 15.9 billion	US$ 3.4 billion
	Building Strengthening	-	US$ 14.5 billion	US$ 63.0 billion
	Emergency Response	US$ 2.9 billion	US$ 2.1 billion	US$ 0.4 billion
	Rehabilitation and Reconstruction	US$ 195.3 billion	US$ 130.9 billion	US$ 19.5 billion
	Total	US$ 220.8 billion	US$ 163.4 billion	US$ 86.3 billion
Remarks		The damage of earthquake is derived from estimation results in Ray fault model.	This case is decrease of damage about 30%. This alternative is target reduction level within the period of master plan.	The ultimate case of 90% damage reduction. In this case, the damage level can be handled in emergency response.

Source: JICA Study Team

Note:

1. In case 1 earthquake damage is derived from "The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, November 2000."
2. Building Damage Cost is calculated based on the replacement costs of the building.
3. Building Strengthening Cost is calculated by the building analysis results, using GIs value to determine reconstruction and retrofitting. The unit cost of strengthening building is determined based on the actual conditions and applied to the number of the objective buildings.
4. Emergency response cost is calculated at US$ 57 per victim/ month and it will continue for six months.
5. Rehabilitation and reconstruction costs are estimated at US$ 6.3 million per hectare based on area development calculation.
6. The calculation of other case could be derived from assumption made from building sector report.

The preliminary analysis on building risk management assumes the same scenario earthquake. The analysis on the damage reduction shows the building damage cost, building strengthening cost, emergency response cost and rehabilitation and reconstruction cost in monetary terms, yet the cost of human life is excluded from the analysis. The analysis also has not taken into account the time factor of the earthquake, because it is very difficult to predict when the earthquake will hit Tehran Municipality.

The analysis shows that the money spent before earthquake would result in minimizing total damage cost, if all costs were included. Reducing earthquake damage as much as possible will lead to the most efficient way for the earthquake disaster management. The emphasis should be given to the strengthening of the existing weak buildings before the event. This will continue efforts towards achievement of the ultimate goal.

References to Chapter 2

Japan International Cooperation Agency. 2002.*The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran*. Tokyo.

Paul K. Freedman et al. 2002. *Catastrophes and Development Integrating Natural Catastrophes into Development Planning*, Disaster Risk Management Working Paper Series No. 4. The World Bank. Washington.

The World Bank. 1999. *Turkey Marmara Earthquake Assessment*. Washington

Chapter 3
Strengthening Existing Buildings

CHAPTER 3 STRENGTHENING EXISTING BUILDINGS

3.1 Analysis of Existing Buildings in Tehran

3.1.1 Building Database

The number of existing buildings in Tehran is summarized in Table 3.1.1, according to the taxation data obtained from Tehran Municipality Computer Service Organization (TMCSO) in 2002.

Table 3.1.1 Number of Existing Buildings in Tehran by Structural Type and Usage

Abbrev. of Structure	Description	Usage	Building Numbers
RC	Reinforced Concrete Structure	Educational	443
		Health	33
		Residential	35,863
		Governmental	272
		Other	1,360
Sub Total			**37,971**
WM	Weak Masonry (Brick or cement block or stone skeleton with middle steel columns/Brick skeleton with middle steel or concrete columns with 3 stories and up)	Educational	567
		Health	59
		Residential	166,433
		Governmental	242
		Other	5,508
Sub Total			**172,809**
URM	Unreinforced Masonry	Educational	3,810
		Health	374
		Residential	413,748
		Governmental	936
		Other	33,963
Sub Total			**452,831**
SEM	Semi-Enginerred Masonry	Educational	423
		Health	0
		Residential	0
		Governmental	0
		Other	0
Sub Total			**423**
ST	Steel	Educational	1,286
		Health	115
		Residential	235,239
		Governmental	888
		Other	16,535
Sub Total			**254,063**
AD	Adobe	All	6,770
HAN	Hangars and Canopies	All	11,054
MIX	Mix of 1~6	All	6,769
OT	Others	All	894
Total			**943,584**

Source: TMCSO, 2002

The building type Masonry was divided into three categories in the above table. "Weak Masonry" stands for the building structure composed of brick wall and partial frames, which consist of a few posts with saddle-supported main beams (locally called Khorjini) attached to them by using angle profiles as support. The posts usually run along the middle of the building. "Unreinforced Masonry" is a simple masonry building type composed of bricks, natural stones or concrete brocks. "Semi-Engineered Masonry" stands for the masonry structure with common RC frame, in which earthquake resistance capacity is ignorable.

Total number of buildings in Tehran is 943,584, in which an approximate percentage of each structural type in the total is as follows; 4% for RC, 18% for Weak Masonry, 48% for Unreinforced Masonry, 1% for Semi-Engineered Masonry, and 27% for Steel. Approximately 90% of all buildings in Tehran are used for Residential purpose.

Table 3.1.2 shows the number of permits for new construction and reconstruction issued by Tehran Municipality in 2001.

Table 3.1.2 Numbers of Building Construction Permits issued in 2001

	Semi-Steel	Steel	RC	Other	Total
Number of Permit	3	15,802	7,417	996	24,218

	New Construction	Demolition & Reconstruction
Number of Permit	3,420	20,798

Source: Tehran Municipality Performance in 2001, TMCSO, 2004

Due to the less availability and lack of information, the above statistical information was the only source relating to the construction permit issued in 2001. It is difficult to grasp how many masonry buildings have been converted to steel or RC frame buildings.

Approximately 626,000 of Masonry buildings exist in Tehran as shown in Table 3.1.1. This implies that the issue of vulnerability of Tehran due to the dominance of Masonry buildings remains, since swift conversion from Masonry to Steel or RC frame structures has not been observed.

3.1.2 Building Investigation

In order to gauge the seismic resistance of buildings in Tehran, building investigation was conducted on a sub-contractual basis. The prearranged target numbers of buildings for investigation are shown in Table 3.1.3.

Table 3.1.3 Target of Building Investigation

Building Type		Sample Nos.
Public Facility	Major public facilities	70
	Hospitals	80
	Schools	100
	Other public facilities	10
Residential buildings	South	10
	Central	40
	North	40
Total		350

Source: JICA Study Team

Buildings of strategic importance in the event of disaster such as schools, hospitals and public and lifeline facilities were selected for building investigation and diagnosis, as those facilities should be utilized as a hub center of evacuation and disaster mitigation. However, due to the veto for site inspection from authorities or property owners, or the fact that property owners seldom kept the original drawings, the number of investigated buildings were different from the prearranged target numbers at the beginning of the Study. The investigated buildings amounted to 287, in which 118 buildings were counted as Steel structure, 62 were RC and 107 were Masonry.

The following data and items were collected for each building.

- General configuration of the building (location, usage, structure types, construction year, outlook, number of stories, etc)
- Pertinent structural drawings

Throughout the site inspection, the following items were checked.

- Aging deterioration (crack, rust)
- Quality of construction materials (composition, brick, grout)
- Workmanship (welding)

The above data and information were gathered in several kinds of sheet and used as a basis of building diagnosis.

As to Masonry buildings, however, it was often the case that structural drawings were not prepared in the designing stage, or a structural basis was changed throughout the construction even if structural drawings were properly prepared.

3.1.3 Characteristics of Existing Buildings

Buildings in Tehran have a quite particular aspect compared with that of Japan and international standard as well. The aspect from an earthquake resistance point of view can be summarized as follows.

1) Common aspects

(1) Building type is masonry

Tehran buildings are 66% masonry building type, the great majority of which has very low earthquake resistance capacity.

The catastrophic damage of earthquake disaster would be triggered by the weakness of Masonry building. The priority for building strengthening should be placed on the countermeasures for Masonry building.

(2) Trend of RC and Steel Frame structure construction

As described earlier, 96% of permits on new construction and reconstruction were for RC and Steel Frame structure. This proportion is higher than that of decades ago because of the technical renovation and the decrease in the material prices, and thus this trend is expected to continue. However, although a considerable number of buildings are reconstructed in Tehran, their building types are not clearly comprehended. In addition, even if they are of RC and steel frame structure, there is possibility that their structures have insufficient earthquake resistance. In fact, the Study Team found out that, in particular cases, structural plan was often changed from original design. For example, RC building was constructed on the contrary to the original plan designed as Steel Frame structure. In conclusion, whether reconstruction promotes earthquake resistance of building is not comprehensible.

(3) A defect exists in the shape of frame for frame structure buildings

Many irregular shapes of frame are often observed in frame structure buildings in Tehran, such as the cases of uneven framing in the middle of story, absence of crossbeam, extremely low rigidity at some particular story and discontinuity of column from top to bottom of the building. These irregularities reduce the seismic resistance capacity of the building, apart from the matter of aesthetics.

(4) Infill wall of frame structure buildings is less reliable for seismic force

Steel frame and RC structure both have infill wall between frames, which is composed of hollow brick or porous brick. These materials do not have reliable resistance capacity in spite of large mass. Exterior cladding has also large mass, which induces large inertia force of lateral direction and vertical force. These are main reasons of poor earthquake resistance.

(5) Problems related to the ground and foundation of building

The ground in Tehran is comparatively stable; hence there can be found some examples which depend on the stability excessively, such as excavated slope that is left for a long time. However, the stability can be maintained only in the limited condition that ground does not contain much water; otherwise, stability is not guaranteed. In fact, destruction of an old qanat causes settlement and building collapse. The same kind of damage frequently occurs when sewage well or underground septic tank collapses or water leakage from pipe scours the ground. The foundation of building can be affected by evacuation near the building. It is thought that these accidents are caused by overconfidence about ground stability, and consequently potentiality of building collapse is arisen.

There can be seen many other deficiency in building foundation, such as bolt defect at plinth. Most of foundation of masonry building is usually made of compound of lime and sand; hence these types of foundation do not have sufficient strength.

2) Steel Structure

The characteristics of the majority of steel frame structure in Tehran are quite different from those of Japan. The most glaring difference between the two countries' steel frame structure is the column-beam connection, in which bending and shear capacity of the connection is less than base material of each frame member in almost all cases. Design concept, which makes the earthquake resistance depend on the ductility of steel, seems to be the same as Japanese design concept, but most of steel frame structure in Tehran does not actualize enough ductility since the column-beam connection would be destroyed before non-linear behavior effect is obtained.

A poor execution of welding is the main cause of the weakness at column-beam connection. In Tehran, on-site welding for column-beam connection is popular for the most case in which insufficient length of welded part or poor welding quality can be frequently observed. In most cases, steel is composed of multiple cast steel using splice plate by fillet welding, because the availability of cast steel is quite limited in Iran. The spliced plate does not cover the whole length of the steel, and it is welded discretely. Many engineers in Iran think that steel frame section of buildings is not poor compared with international standard; most of buildings, though, fall way below Japanese standard. Those characteristics are seen in most of steel frame structure buildings in Tehran. However, some excellent buildings exist in particular office or high-class residential buildings.

3) RC Structure

RC structure in Tehran does not have fundamental difference from that of Japan. Although for some cases the specification of RC structure or the amount of reinforcement bars is insufficient, it can be said that there is no fundamental difference between RC structures in Tehran and that of Japan in terms of design. Many engineers are conscious of forming reinforcing bar and confining effect of hoop bar, which prevents a serious problem of structural weakness of RC building.

On the other hand, there can be observed many deficiencies of workmanship, such as low quality concrete, insufficient overlapping of rebar and inadequate shape of rebar.

4) Masonry

Most of masonry structure is not designed by appropriate procedure. The most serious problem is found at foundation. Foundation is composed of sand and lime, and bricks are directly piled on the surface. Grout material is also composed of sand and lime for the most case, which have little shear capacity. In addition, tie and beam are not fixed to vertical part sufficiently in many cases. Round wood is used as tie and beam in some cases.

3.2 Evaluations of Earthquake Resistance

3.2.1 Objectives

Objectives of building diagnosis are as follows:

- To comprehend earthquake resistance capacity of buildings in Tehran theoretically;
- To estimate earthquake damage quantitatively on the basis of building investigation and diagnosis;
- To comprehend structural weakness, which in turn provides useful information and offers suggestions for specific method of strengthening;
- To estimate the improved effect of strengthening quantitatively, and
- To make suggestions for building diagnosis method and its application to Iranian system.

3.2.2 Diagnosis Methodology

There is not specific building diagnosis method that has the force of law in Tehran currently. For some cases, US specification "FEMA356" has been referred.

For the Study, a main concept of Japanese building diagnosis system called "Specification on Earthquake Resistance Diagnosis and Strengthening for Governmental Buildings (Building Maintenance and Management Center of Japan)" is adopted, and the design earthquake is given based on "Iranian Code of Practice for Seismic Resistance Design of Buildings Standard #2800" (hereafter referred to as Standard #2800).

There exist some specifications for building diagnosis in Japan, but only GI_s system has capability to evaluate earthquake resistance capacity of both steel frame structure and RC structure from a unified point of view. Since Steel Frame and RC structure types are of particular importance in predicting a construction trend in Tehran, the main concept of GI_S system was adopted for the Study.

The Japanese Specification provides the seismic index of structure, GI_S, in order to evaluate the seismic resistance capacity of building structure. GI_S is given as follows:

$$GI_S = \frac{Q_u}{\alpha \cdot Q_{un}}$$

Where, GI_S : Seismic Index of Structure

Q_u : Seismic force level for ultimate capacity check

Q_{un} : Required seismic force level for ultimate capacity check

α : Correction coefficient

The detail of diagnosis methodology is presented in Sector Report.

Regarding masonry structure, a methodology introduced in Standard #2800, which is similar to the U.S. code UBC, is referred because regulations of Japanese code are too rigorous for Iranian situation.

Regarding steel frame structure, careful approach is called for, since Steel Frame structures in Tehran are quite different from Japan's. *Incremental loading method* is applied to the analysis of Steel Frame structure.

Regarding RC structure, a simplified method developed in Japan is applied, considering no essential difference between structures in Tehran and Japan. A similar simplified method is also applied to Masonry structure.

Average GI_S value for each building type obtained by building diagnosis is summarized in Table 3.2.1. The classification of the building type accords with the taxation data. There are two reasons for the application of this data. Firstly, this database counts each single building. In the previous Microzoning Study, the used data was modified from census data, which did not represent the number of buildings strictly. Another reason is the necessity of qualitative estimations of building damage and effect of strengthening by structural type. For the categories that have no data, a predicted value was applied.

Table 3.2.1 Average GI_s Value for Each Building Type

Structure	Usage	Number of Story	GI_s
Reinforced Concrete Structure	All	1～3	0.50
		4～7	0.40
		More than 7	0.50
Weak Masonry (Brick or cement block or stone skeleton with middle steel columns / Brick skeleton with middle steel or concrete columns with 3 stories and up)	All	All	0.16
Unreinforced Masonry	All	1～2	0.14
		More than 2	0.19
Semi-Engineered Masonry	Educational	All	0.20
Steel	Educational	All	0.25
	Health		0.25
	Residential		0.21
	Governmental		0.25
	Other		0.25
Adobe	All	All	0.02
Hangars and Canopies	All	All	0.15
Mix	All	All	0.15
Others	All	All	0.15

Source: JICA Study Team

The reflection of actual circumstances of building structure in Iran is attempted in this diagnosis methodology. Further study to improve this methodology is required in the future.

Classification of building type, shown in Table 3.2.1, is prepared as a prototype for draft assessment of building vulnerability in Tehran. Therefore, needless to say, it is required to conduct further examination from a viewpoint of structural engineering.

For instance, with regards to steel frame structure, there are a considerable number of buildings in which column-beam connection does not have sufficient moment resistance as “moment resisting frame” and there is no bracing, namely, “steel frame buildings without bracing or moment resisting column-beam connections”. In this case, this kind of building does not have sufficient lateral resistance against inertia force caused by earthquake motion. Therefore, obviously, this type of building does not have any earthquake resistance. On the other hand, there are some advanced examples of steel frame buildings in which all welding parts are undertaken at the factory and all site work is undertaken by method of friction bonding using high-tensile bolts.

In terms of RC structure, there can be seen many examples that do not have sufficient quality, and on the contrary, some buildings that are designed with advanced consideration. Pre-cast RC structure is developed with the objective of labor saving of construction work. However, connecting parts of pre-cast elements should be designed with sufficient attention; without sufficient attention, defect in connection causes damage. Typical example can be seen in the damage of the Armenia Spitak Earthquake on December 7th, 1988.

The Study Team did not see pre-stressed concrete in the study area, but it is considered that building systems using pre-stressed concrete elements exist in Tehran. It is thought that the accurate application of this technique contributes to reducing mass of elements, which leads to reduction of inertial force in the event of earthquake.

In terms of masonry structure, its capacity mostly depends on quality of grout materials. In most case, the grout materials of old masonry buildings are made of not cement mortars, but bastard (lime and soil) mortars. These kinds of building can not be expected to have sufficient earthquake resistance. On the contrary, masonry structure buildings constructed with appropriate consideration have earthquake resistance to some extent. For instance, there are some buildings consisted of floors and ceilings that have adequate stiffness for a diaphragm; in the building, walls are appropriately allocated, which are combined with the grout materials that have sufficient resistance against shearing force. In addition, walls are confined by connecting each wall of orthogonal direction utilizing reinforced elements called tie or lintel band.

Moreover, appropriate database is essential to conduct systematic study on building structure. For example, building type, usage, construction year, area and floor height should be comprehended for research on building as an independent structure. Especially, if information about construction year is accurately recognized, it greatly contributes to understanding general detail of building type that is constructed in the corresponding year.

However, “the data obtained from Tehran Municipality Computer Service Organization (TMCSO) in 2002”, used in this Study, is not prepared for study related to structural engineering; therefore, it does not perfectly serve as statistical information for building structure. In fact, information that gives more information than the above-mentioned data was not provided by the previous counterpart. Therefore, it is recommended that census for building structure should be conducted in the future.

Furthermore, the problem for earthquake-resistant diagnosis of each individual building stems from insufficient residents’ awareness about building diagnosis itself in Tehran. For building diagnosis, the essential matter is information about the concerned building as well as permission for entry into it. Information about the building must include design drawings and as-built drawings. However, most of residents in Tehran usually do not keep them, and moreover there is lack of recognition about importance of keeping them even in the archive of Tehran. The residents of Tehran do not also have sufficient recognition about partial destruction required for building diagnosis such as peeling off exterior cladding and taking samples. Therefore, it is considered that, in order to completely carry out earthquake-resistant strengthening, it is indispensable to enhance fundamental comprehension about building strengthening, including understanding about study that needs such partial destruction. If the above-mentioned problems are solved, more accurate study than this Study becomes possible, which contributes to more effective activity for disaster mitigation. There must be careful approach to carry out the investigation that needs destructive test. This kind of approach is explained with use of flowchart in Sector Report.

3.3 Application of Building Diagnosis

3.3.1 Meaning of *GIs* Value

It is inherent in definition that GI_S value refers to the physical quantity that is obtained by dividing structure capacity by required capacity. The required capacity in this context is defined as equivalent linear intensity of response sector by means of equal-energy principle. When the structure satisfies the requirement of the response spectrum defined in Standard #2800, the value of GI_S is defined as 1.0. On the other hand, some countermeasures should be provided for the building when the GI_S value is less than 1.0.

There could be many historical buildings that do not meet present earthquake resistance code in urbanized area. It is understandable that the buildings which had been designed to meet the past design code do not satisfy the present code, because the design code is updated reflecting the newest engineering findings. This can be seen commonly in any country. The important thing is to find the buildings of a high collapse potential and to take the practical countermeasures for them. Therefore, it is essential to understand the relationship between the GI_S value and the actual building damage.

GI_S value can be converted to "*damage ratio of buildings **P***" as explained in the following section, because the damage ratio is defined as probability of damage. Main concepts of this conversion are based on "Probability theory" and "Reliability design method." When major samples remain at low value of GI_{S}, this indicator offers more effective development than the criterion in which 1.0 is defined as a base line simply. This is the reason for the conversion of GI_S value to *damage ratio of buildings **P***, carried out in this Study.

3.3.2 Damage Ratio

1) Definition of Damage Ratio

Damage Ratio, which is defined as probability of heavy damage, can offer effective information to represent the actual damage of building by converting the GI_S value. "Heavily damaged" is a damage state defining the building condition of obvious destruction with large cracks and so on or no serviceability, without any fundamental chance of restoration. It is inherent in definition that 0.5 of damage ratio means that 50 out of 100 buildings suffer from heavy or more serious damage. If a building is heavily damaged, a considerable number of dead and injured people might be anticipated. That is why the damage ratio and "heavily damaged" should be linked.

2) Relationship between *GIs* value and Damage Ratio

The damage ratio is represented by the following equation.

$$P = \Phi\left[-\beta\left\{ 1 + \frac{\ln\left(GI_S\right)}{\ln(S_f)} \right\} \right]$$

Where;

P : damage ratio

Φ : standard normal cumulative distribution function

β : index of reliability

S_f : safety factor

The theory and algorithm to reach the damage ratio, *P*, is presented in Sector Report.

3) Damage of Buildings in Tehran

The amount of anticipated building damage for Tehran is estimated by using damage ratio converted from GI_S value (see Sector Report). The number of damaged buildings, floor area and damage cost are estimated, based on the building data from tax database from Tehran Computer Service Organization and GI_S values for each structure type, assuming the earthquake motion prescribed in Standard #2800 (see Table 3.3.1).

Table 3.3.1 Damage Summary of Existing Buildings

(Unit: Million Rial)

Number of Existing Building	Number of Damaged Building	Damaged Property by Cost
943,584	473,399	188,101,557

Source: JICA Study Team

4) Effects of Strengthening and Reconstruction

Using the same concept of damage estimation for existing buildings in Tehran explained in the above sections, the effect of strengthening and reconstruction on a reduction of vulnerability of buildings in Tehran can be estimated. Following strategies are adopted for the effect estimation of strengthening and reconstruction.

- Number of existing buildings to be strengthened or reconstructed is selected
- A proportion for strengthening and reconstruction in selected buildings is set, considering the importance and seismic resistance level of the building
- Method of strengthening and its effect are set for each structure type

- Reconstruction is applied to the building whose GI_S value is too low to achieve required seismic resistance level by strengthening.

Table 3.3.2 shows the estimation result for the case that damage is reduced to the level of realistically coping with an earthquake disaster event.

Table 3.3.2 Number of Damaged Buildings After Strengthening and Reconstruction

	Number of Building	Number of Damaged Building
Number of Not Strengthened nor Reconstructed Building	21,583	6,440
Number of Strengthened Building	89,512	25,679
Number of Reconstructed Building	832,489	18,939
Total	943,584	51,058

Source: JICA Study Team

Table 3.3.3 shows the estimated cost for strengthening and reconstruction.

Table 3.3.3 Estimated Cost for Strengthening and Reconstruction

(Unit: Million Rial)

Cost for Strengthening	Cost for Reconstruction	Total
33,412,050	470,609,722	504,021,773

Source: JICA Study Team

3.4 Strengthening Countermeasure

3.4.1 Criteria for Countermeasures

There are three types of countermeasures for earthquake-proofing as follows:

- Strengthening of existing building
- Demolition and reconstruction
- Redevelopment of city block

Many buildings in the study area do not have sufficient GI_S value. For such a case demolition and reconstruction is ideal, if absolute countermeasures are called for. However, strengthening the existing structure is another effective solution. For the selection whether strengthening or reconstruction is reasonable, the resulting GI_S value and findings throughout the GI_S calculation both offer effective information, as structural weakness reflects on GI_S value.

1) Strengthening

It goes without saying that strengthening is the most cost-effective countermeasure; it has, however, a practical limitation in obtaining a 1.0 GI_S value. It has been said that strengthening has substantial advantage of preventing a pancake-like collapse of building.

Additional mass caused by strengthening increases an inertia force of the story where strengthening is executed. Consequentially, resistance capacity of lower story would certainly decrease. Therefore, unnecessary over-strengthening in order to pursue the 1.0 GI_S value must be avoided. Reasonable and practical target is to decrease probability of collapse as much as possible.

2) Demolition and reconstruction

The best countermeasure in order to obtain the 1.0 GI_S value is to demolish and reconstruct the building. For reconstruction, RC or Steel frame structure should be chosen in order to secure high seismic resistance capacity.

3) Redevelopment

Strengthening a single building is not effective for the city block that is composed of buildings standing side by side, because adjacent unreinforced buildings would push down the adjacent strengthened building by inertia. For such a case, area-wide redevelopment is a reasonable solution for not only building strengthening but also securing safety of the city.

3.4.2 Masonry

The most critical problem of strengthening masonry buildings is caused by the failure to obtain any engineering drawing in many cases. In particular, any countermeasure would not be discussed if the information of the foundation were not obtained.

The seismic resistance capacity of many masonry buildings is too small to be strengthened to the level of GI_S =1.0, and property owners would be reluctant to spend on that serviceability. However, the historically or monumentally important buildings are worth strengthening for some cases, even though a large amount of money is needed. An innovative engineering such as “seismic isolation” is required in order to decrease the inertia effect itself.

The following are recommended for Masonry buildings:

- To select the important buildings that could be utilized as a resource facility for disaster prevention; and
- To increase seismic resistance capacity as much as possible in order to prevent a pancake-like collapse.

There are some commonly observed features in masonry structure, and some handbooks or manuals concerning building strengthening are distributed in Tehran. It is important to discuss an application for each individual building in Tehran and to systematize the procedure. A well-educated engineer should diagnose each building to identify the structural weakness for an effective solution.

The following methods are recommended for masonry building:

- Increasing shear capacity of the part of weak area by installing additional wall or steel frame, steel frame with bracing
- Reducing excessively large openings
- Reinforcing the part of wall surrounding an opening
- Reinforcing the part of wall by FRP
- Cutting upper part of story if the building is more than 2 stories
- Reinforcing floor by “steel mesh+ mortar” or “steel tie,” if the floor stiffness is not sufficient
- Fixing joist-end and beam-end by steel bolt
- Increasing stiffness of foundation and capacity of foundation

The weakest parts are the focus of the above countermeasures. However, it must be understood that good sense of proportion might be lost if excessive add-ons are made.

3.4.3 RC

Regarding RC buildings there exist many examples of excessively thin parts and defect of reinforcing bar, though on the other hand there are also some carefully designed buildings. It is thought that these characteristics may be caused by discordance with design specification or non-compliance of construction execution with designing. The following must be checked:

- The existence of engineering drawings is critically important. If engineering drawings do not exist, discordance with design specification might happen.
- It is worth paying attention to the construction age. There is a turning period concerning constitution of specification, which is the 1970s. It is likely that the buildings were designed without any theoretical consideration if those buildings were built before that period.
- It is useful to compare section area of vertical parts to mass of upper part. GI_S system offers help for this comparison.

- If engineering drawing exists, the dimension of reinforcing bar should be checked. Checking points are the lap length of axial direction bar, and appropriateness of the shape of bar-end.
- It should be checked whether the column-beam connections have sufficient seismic resistance capacity to give the structure sufficient ductility. Brittleness may occur when the column-beam connections are not resistant enough or confinement of column by hoop bar is insufficient.

Countermeasures should be adopted case by case as follows, considering the above checkpoints.

- If the engineering drawings do not exist and serious designing error is found, the building should be demolished and reconstructed.
- If defect is found by checking the dimension of reinforcing bar from engineering drawings, that particular bar should be increased or reinforcing bar should be added.
- If some insufficiency of shear reinforcing or confinement is found by checking the engineering drawings, additional reinforcing should be done, by applying steel plate or FRP reinforcing.
- If sufficient reinforcing cannot be obtained by above measures, installing “shear wall,” “Steel Frame” or “Steel Frame with Brace” should be discussed in order to decrease story drift.

The following methods are recommended for reinforcing of RC building:

- Steel plate jacketing of column
- Steel plate jacketing of beam
- FRP reinforcing of column
- FRP reinforcing of beam
- Increasing column section
- Adding stirrup
- Installing RC shear wall
- Installing steel shear wall
- Installing Steel Frame with Brace
- Reinforcing column by adding wing wall

3.4.4 Steel

Some steel structure designed with advanced concept exists in Tehran for some office buildings and high-class residential buildings. However, most of Steel Frame buildings in Tehran involve plenty of partial structural problems that decrease the seismic resistance level of the building structure as a whole. Therefore, finding and analyzing the critical point of structural weakness by building diagnosis and conducting the strengthening to the weak point are an effective procedure to increase the seismic resistance level of the structure.

Following are the typical pattern of structural weakness of existing Steel Frame buildings in Tehran. As shown in Figure 3.4.1, all of bonding part is welded by fillet welding, not groove welding, that is done on site.

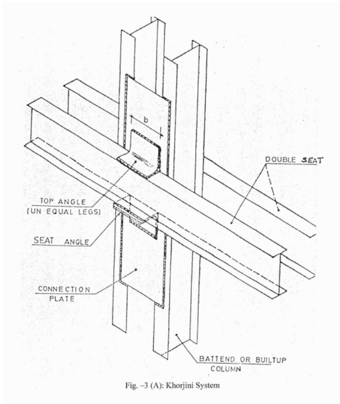


Figure 3.4.1 Typical Example of Khorjini Connection

This procedure is common to almost all steel buildings. Quality of welding is not always acceptable. In the worst case, beam is simply put on the bracket and there can be found no direct welding between column and beam. For almost all cases, bending capacity and shear capacity of column-beam connection are less than base metal, because length of welding is insufficient.

At designing stage, the connection part is assumed as a hinge (not Moment Resisting Frame). Consequently, horizontal resistance of the building is offered by bracing. Such a type of structure does not have ductility, since the structure would have a limit due to the bracing.

In addition, inappropriate arrangement of bracing is often seen. In the worst case, very few or no bracing is allocated to resist the inertia force in the longitudinal direction for the reason that bracing might be obstructive for the building façade to have windows or openings. As a result, the buildings would bump or lean against the next building when earthquake occurs.

Cross-sections of steel frame show a combination of cast steel (H section or I section) by splicing steel plate. Since spliced plates are welded at discrete part, the cross sections show a change at each part. Therefore, a number of sections create enormous variation. This may cause some errors in analysis and allocation of parts in construction. As a matter of fact, no sufficient splice plate at necessary part was found in the investigation of some buildings.

As to the Steel Frame structure, many defects were found throughout the building investigation and diagnosis. Careful investigation and diagnosis can point out those defects and offer the solution for obtaining original earthquake resistance capacity as designed. However, if the capacity of originally designed parts is insufficient, a capacity impact of strengthening on the increase in capacity is quite limited.

The analysis of Steel Frame structure needs relatively high engineering knowledge and skill; therefore, an experienced engineer should conduct building investigation henceforth.

The following methods are recommended for fitting each aspect of defect in Steel building:

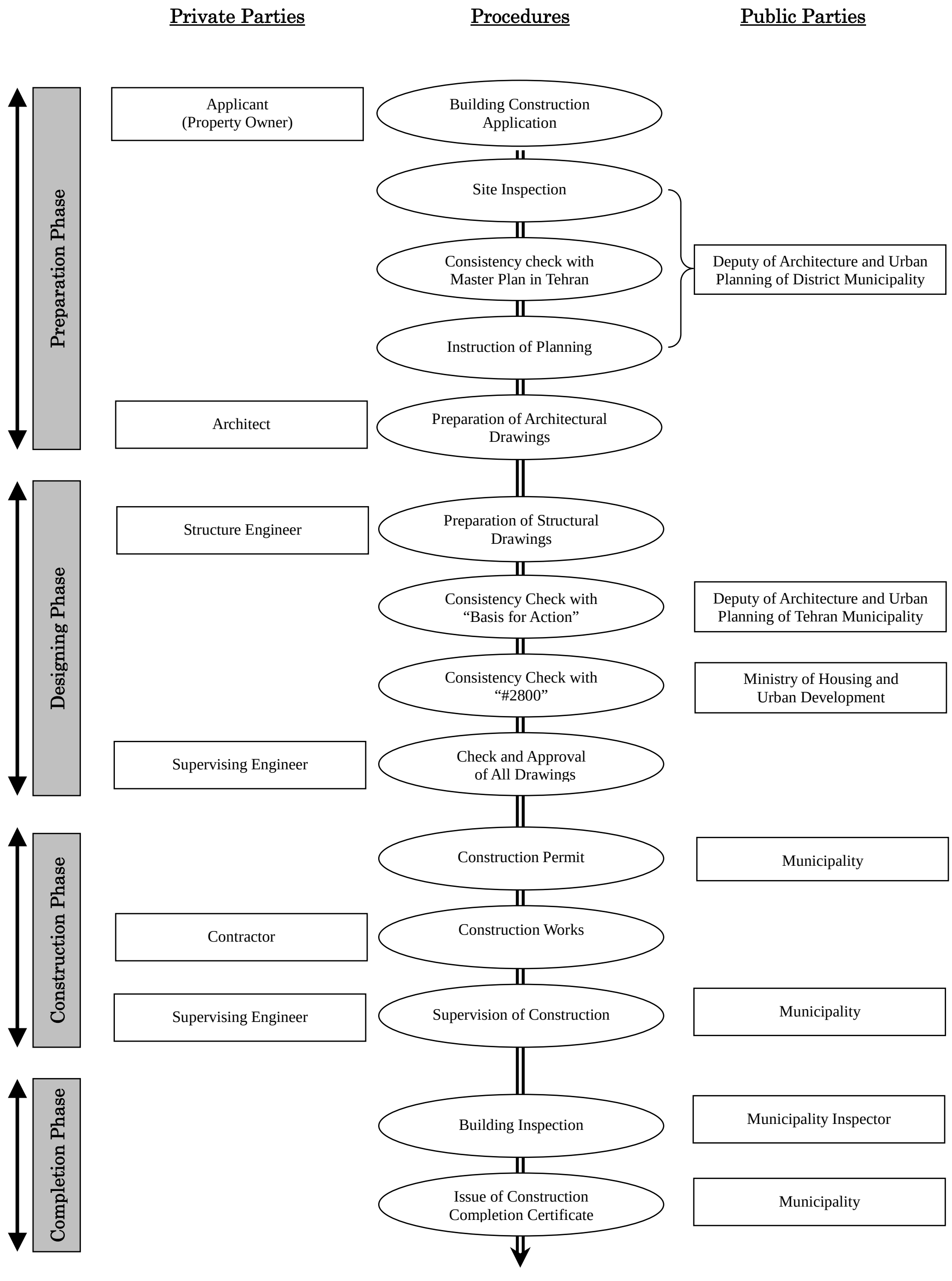
- Reinforcing column-beam connection by adding splice plate and welding
- Reinforcing brace end
- Setting additional panels of bracing
- Setting additional column for the purpose of increasing stiffness
- Adding splice plate and welding
- Adding rib and stiffener
- Adding T-shape section splice
- Concrete injection to square-shape section column

3.5 Building Construction Application and Procedure

3.5.1 Overview of Current Procedure on Building Construction

For the building construction in Tehran, Tehran Municipality issues construction permit and certificate of construction completion. According to “Performance Statistics of Secretariat of Commission, Article 5,” a total of 2,847 certificates of building construction completion in Tehran were issued in Year 2000. The Department of Urban Planning and Architecture of Tehran Municipality published the guideline for building construction, “Basis for Action,” in September 2002, in which all the regulations, procedures and standards related to building construction are described, namely, “Issuing Construction Permit,” “Division of Lands and Properties, Business,” “Issuing Non-Offense and Construction Completion Certificates, Duties” and “Supervising Engineers Affairs.”

According to the guideline, the procedure of building construction can be divided into four phases: appraisal phase, designing phase, construction phase and completion phase. The schematic flow of building construction practice is shown in Figure 3.5.1.



Source: JICA Study Team

Figure 3.5.1 Schematic Flow of Building Construction Practice

The fundamental issues for the existence of low seismic resistance of buildings in Tehran are inappropriate appraisal system, lack of strict regulation and observation ability in Tehran

Municipality. The loose regulation for the employment of engineers hired by property owner allows the construction of buildings with poor seismic resistance due to financial constraint. In addition, Tehran Municipality does not have a capability of appraising the seismic resistance of building, which in turn resulted in relying on the judgment of appropriateness in issuing permit mainly on compliance with architectural plans, city planning regulations and the documents prepared by property owner's employees.

In recent years Tehran Municipality established the Office of Building Design Control, whose duty is to double-check the design accuracy of important buildings. However, this office lacks the proper legal power and entity, and therefore does not have the authorized enforcing power to control the building construction. Table 3.5.1 summarizes the problems in building construction procedure.

Table 3.5.1 Problems and Consequent Effects in Building Construction Procedure

Procedures	Problems		Consequential Effects
	Private Parties	Public Bodies	
Building Construction Application	The Property Owner hires Architect, Structural Engineer, Supervising Engineer and Construction Contractor by him/herself.		The duties of those engineers tend to be dependent on Property Owner's preference, not on regulations and theories.
Issue of Construction Permit		Municipality does not have a capability to check structural aspect of building designing. Construction permit is usually given based on architectural drawings.	The emphasis of building construction has been made on architectural and city planning regulations and aspects, resulting in the existence of many low seismic resistant buildings.
Supervision of Construction		Municipality relies its supervising duties of building construction on the reports of Supervising Engineer, who is hired by Property Owner.	As-built construction has been made as a result of persuring freedom and low cost of construction. Not a small numbers of private masonry buildings has been constructed with over two stories, being opposite to regulation in Standard #2800.
Construction Works	Property Owners have usually hired non-engineering construction workers.		The use of poor quality materials and poor execution of welding would be induced.
Building Inspection		Building inspection is made by Municipality Inspector, who usually check only external apperence of building.	Property Owner spends less for structural materials and construction qualities in order to obtain cost effectiveness.

Source: JICA Study Team

3.5.2 Reformation of Construction Appraisal System

For the establishment of a functional building construction appraisal system, Tehran Municipality should conduct the following reforms in the appraisal system.

1) Legal empowerment capacity development of the newly established Office of Building Design Control

The fragmented appraisal responsibility causes the loose check and control. The Office of Building Design Control should have capability of handling the entire appraisal and a legal power to control building construction. The Office should have the function and human resources to check in particular the structural appropriateness to be consistent with Standard #2800.

2) Ensure that only licensed individuals are involved in building construction

Every engineer involved in building construction should be a registered engineer of Tehran Municipality. In addition, a supervising engineer should be assigned by Tehran Municipality.

3.6 Action Plan

3.6.1 Implementation of Building Diagnosis

A fundamental issue for building strengthening and securing city's safety is to identify the poor earthquake resistance building and to examine the effect and validity of strengthening. In order to do so, building diagnosis is indispensable.

1) Discussion about a specification on building diagnosis

No specific building diagnosis method that has the force of law in Tehran currently exists. However, a unified indication that has the force of law is needed in order to implement effective action for earthquake-proofing.

A committee should be formed to discuss a specification on building diagnosis in Tehran. Purposes of this committee are providing a certain procedure for the particular situation of Tehran and providing the force of law to this specification.

The main body of this committee should be Tehran Municipality, and members should be selected from public research organization (BHRC, IIEES, Tehran University, etc.) and some engineers who belong to construction or consulting firms.

2) Experimental research on existing buildings

There is a need to recognize characteristics of existing building structures by experimental study in order to certify reliability of diagnosis method.

Some researches have been already carried out by public research organization in Tehran, but the samples of the experiments do not target the low quality buildings. It is very important to evaluate the earthquake resistance capacity of the low quality buildings, because diagnosis system must point out the insufficient capacity by quantitative accuracy. There are a lot of misunderstandings about earthquake resistance of the buildings because of few quantitative evidence obtained from inspection.

Without modeling experiments and analyses that reflect the real situation of existing buildings in Tehran, no calibration of mathematical analysis is obtained. Practical specification should be provided for all the engineers in Iran.

3) Implementation

Firstly, building diagnosis should be carried out targeting public facility by utilizing the specification prepared by above-mentioned committee. This implementation should be conducted as a case study of diagnosis, considering that many of property owners do not understand the significance of building diagnosis.

The standard to judge a building as “sufficient,” “strengthening is needed” or “demolish and reconstruct” should be based on the result of this implementation.

In this Study, “seismic index of structure GI_S” is recommended. The relationship between damage ratio and GI_S value is explained to give the information about Judgmental standard in the sector report. If this quantitative indicator is utilized, a practical way of judgment can be given for each particular building.

Remaining tasks are to calibrate this system and to give the evidence of accuracy to the system. Sufficient discussion should be done in the committee to obtain a consensus about the system.

3.6.2 Implementation of Strengthening

1) Strengthening concept

If complete achievement of earthquake resistance is required, the ultimate solution of strengthening is to “demolish and reconstruct.” However, partial strengthening provides an effective cost performance. The ratio between cost of structure and other parts is 1:2.5 to 1:4. Almost 4 times of structural cost is dissipated as amenity building services and outer/inner layer. On the other hand, it should be noted that the building made by previous construction concept cannot be improved to the level which the newest design code requires.

2) Implementation

The trial of implementation should target public buildings given the difficulty in conducting strengthening of private buildings, though a need of strengthening for private buildings is comparatively high because of their high potential of causing casualties in the event of earthquake.

Low-interest loan and favorable treatment for insurance system can be effective for relatively high-income property owners or small retailers. This system would work if authorities such as Tehran Municipality offer subsidy for building diagnosis and if effective strengthening is realized.

On the other hand, for low-income property owners or small retailers, it is difficult for them to get subsidy, since their properties have quite low seismic resistance. In addition, the accumulation of low seismic resistant buildings in certain area makes the situation worse.

For such a case, redevelopment would be the reasonable solution. Within the redevelopment scheme, reasonable extent of city block is selected for reconstructing a high-rise building. A problem of this alternative is that the same floor area as before the reconstruction is hardly allocated to property owners. Authorities such as Tehran Municipality should offer low-interest loan and compensation.

Necessary activities for implementation of strengthening are as follows:

- Establishing system by relevant authority
- Providing public information of system
- Devising screening method carried out before conducting a detailed diagnosis
- Establishing authority in charge of implementing detailed diagnosis
- Setting up of information desk for citizens
- Developing computer software to help diagnosis

References to Chapter 3

Building Department, Minister's Secretariat. 1996. *Specification on Earthquake Resistance Diagnosis and Strengthening for Governmental Buildings*

Building code, Japan

Enforcement order of Japanese building code

Amendment of Japanese building code

Building Research Institute, Ministry of Land, Infrastructure and Transport. 2001. *Engineering Background of structural provision in Japanese amended building code*.

Architectural Institute of Japan. 1981. *Deformation-based design concept in capacity design*.

Yukio Maeda, etc. 1999. *Building Structural Design Handbook*.

Uniform Building Code (US)

Chapter 4
Improvement of Existing Urban Structure

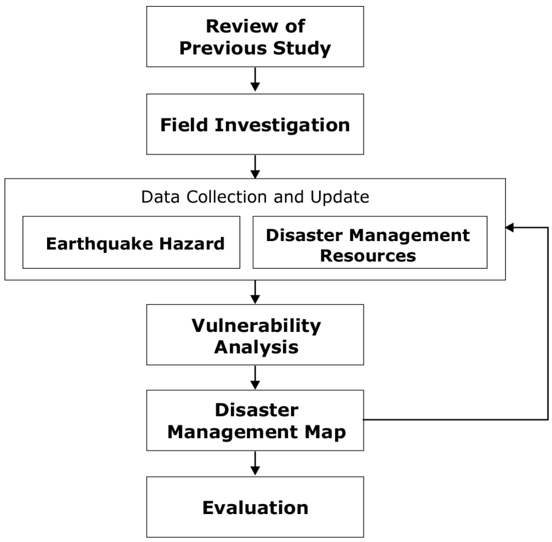
CHAPTER 4 IMPROVEMENT OF EXISTING URBAN STRUCTURE

4.1 District Diagnosis Analysis

4.1.1 Earthquake Hazard Analysis

In order to evaluate district earthquake hazard and response, the Study Team carried out a district earthquake disaster diagnosis analysis. The purpose of the analysis is to keep each district informed about disaster hazard and resources, so that they understand the existing situations. The results of analysis are presented as both a GIS map and a district disaster diagnosis sheet. The GIS map, called "Disaster Management Map," shows the earthquake hazard and disaster management resource. A district disaster diagnosis sheet shows the basic information of district and hazard, disaster resources and vulnerability of the district. Based on this analysis, each district should formulate a disaster management plan.

The Study Team took the following steps to conduct the analysis:



Source: JICA Study Team

Figure 4.1.1 Procedure of District Diagnosis Analysis

The Study Team utilizes the previous study results for disaster diagnosis analysis. *The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, 2000,* shows the detailed and comprehensive earthquake hazard in Tehran. Basic idea of this study makes use of previous study results and integrated data and information as a GIS database. Table 4.1.1 below shows data used for the analysis.

Table 4.1.1 Data Used for Earthquake Hazard Analysis

Items	Data Review and Update
Area of Liquefaction	In the previous study, only one borehole among 52 boreholes was identified to have a "relatively high" potential of liquefaction. No additional information for liquefaction potential was collected. Therefore, it is presumable that the area of liquefaction is quite limited in the study area.
Area of Landslide	The previous study showed that the unstable areas exist at the edge of the Alborz Mountains. However, these areas are not in residential areas. The analysis concluded that there is not high slope-failure risk in the residential and commercial area generally prevailing in hill, terrace and fan areas in Tehran. On the other hand, many small-scale slope failures and stone falls would occur at cut slopes during an earthquake. However, there is no detailed date for such small scale cut slopes.
Building Damage	Previous study used census data for building damage estimation. During Phase 1, the Study Team obtained cadastral data from TCSO. For the diagnosis analysis, previous study results are applied.
Bridges	Previous study results show that five bridges have high possibility of collapse. The Study found one new bridge (see Section 6.3, Chapter 3 in this report or Chapter 6, Sector Report, Volume 3 of Final Report for more detail)
Lifeline	As for lifeline damage, the data update is not continued after the previous study. In this analysis, previous study results are applied.
Lifeline Facility	Lifeline facility is collected by the previous study. In this study, the building for lifeline facility is evaluated.

Source: The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, 2000, JICA.

4.1.2 Disaster Management Resource

There are two sources of information on disaster management resource. One is land use data from Tehran GIS Center (TGIS) database and the data collection efforts by the Study Team. The following section explains the details of the data and data collection situations.

1) TGIS Database

The previous study collected the data on disaster management resources for each district. Since land use data in Tehran in 2002 from TGIS is obtained, the Study Team uses this database to identify the disaster management resource locations by facility name, which is identified from the database information.

2) Data Collection by the Study Team

For the required emergency response tasks, emergency response centers and resource data were requested to the related agencies since the beginning of the project.

(1) Parks and Open Space

Park data is almost established with the required attribute data for evacuation planning study by the park organization of Tehran municipality and 22 district offices.

(2) Public Educational Facilities

Public educational facility list is compiled from the previous educational facility list of JICA's previous study and the categorized educational facility land parcel data on the land use database of TGIS. The compiled educational facility list was requested to check and add required attribute data to the Ministry of Education's.

(3) Disaster Management Facility

Data on other disaster management facilities are collected from other organizations, such as Ministry of Health, Fire Brigade, Red Crescent Society and Police department. The identified information on disaster management facility is shown as follows:

Table 4.1.2 Identified Disaster Management Resources and Locations

			District																					
		Total	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
NCNDR	Total	33	1	1	2	1	0	18	2	0	2	0	1	5	0	0	0	0	0	0	0	0	0	0
Local Government	Total	139	9	10	4	11	8	10	7	4	2	5	1	9	5	9	7	8	4	6	4	8	3	3
	Tehran Municipality	7	0	0	1	0	0	3	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	District	32	1	1	1	1	2	1	1	1	0	2	1	2	1	4	3	3	1	2	1	2	0	1
	Nahiyeh	100	8	9	2	10	6	6	5	3	2	3	0	5	4	5	4	5	3	4	3	6	3	2
Disaster Management Center of Local Government	Total	126	9	11	1	11	8	7	6	4	2	5	1	6	5	6	7	7	4	6	4	8	3	3
	Tehran Municipality	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	District	23	1	1	1	1	1	1	1	1	0	2	1	1	1	1	1	1	1	2	1	2	0	1
	Nahiyeh	102	8	9	0	10	7	6	5	3	2	3	0	5	4	5	6	6	3	4	3	6	3	2
Police	Total	106	9	8	7	5	8	8	3	3	2	1	8	6	3	6	5	6	2	2	2	6	3	2
Fire Fighting	Total	73	3	5	5	6	3	4	2	2	0	3	5	3	4	2	3	1	2	3	2	2	3	2
	Emergency Response (Office)	4	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	Emergency Response (Station)	52	1	4	3	3	3	4	2	2	0	1	5	3	3	2	2	1	1	1	2	2	2	2
	Other (Station)	6	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
	Other (Under Construction)	11	2	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0
Red Crescent	Total	11	1	0	0	0	0	0	1	0	0	0	1	2	0	0	0	2	0	0	0	2	1	1
	District Relief and Rescue Base	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
	Other	9	1	0	0	0	0	0	1	0	0	0	1	2	0	0	0	1	0	0	0	1	1	1
Ambulance Service	Total	44	1	2	3	5	6	2	1	2	3	0	3	2	4	1	2	3	0	1	1	2	0	0
Health Center	Total	127	3	7	1	7	7	11	4	6	8	4	5	5	4	4	5	6	7	8	4	5	6	3
	Center	99	3	4	1	7	6	2	4	6	5	2	5	5	4	4	5	6	6	4	4	5	3	1
	Post	28	0	3	0	0	1	9	0	0	3	2	0	0	0	0	0	0	1	4	0	0	3	2
Traffic Police	Total	16	1	5	2	0	1	0	2	1	0	1	2	0	0	1	0	0	0	0	0	0	0	0
Hospital	Total	255	10	10	20	9	5	37	26	7	6	12	27	17	9	5	2	8	8	5	6	13	3	2
	Regional Hospital	45	4	2	6	1	0	9	1	0	1	1	4	5	2	0	1	1	1	1	0	2	0	0
	Other hospital	210	6	8	14	8	5	28	25	7	5	11	23	12	7	5	1	7	7	4	6	11	3	2
Park	Total	5,283	524	817	235	531	516	248	81	82	21	73	36	25	36	66	629	231	71	99	179	267	273	189
	Potential Regionnal Evacuation Place	11	0	1	1	1	0	1	0	0	0	0	1	0	0	0	2	1	0	1	0	0	0	1
	Potential Primary Evacuation Place	364	18	17	13	29	39	11	3	10	7	14	8	12	8	22	31	16	6	25	14	36	12	3
	Small Place	533	35	19	18	96	51	28	50	31	6	7	7	10	13	14	13	15	37	15	2	39	6	7
	Only from LPM	4,375	471	780	203	405	426	208	28	41	8	52	20	3	15	30	583	199	28	58	163	192	255	178
Primary School	Total	1,454	91	94	74	96	88	59	86	72	27	70	76	81	69	75	77	58	48	61	25	76	30	12
Secondary, High and Other School	Total	2,365	169	209	167	200	153	145	112	97	50	75	116	111	124	85	124	77	62	69	44	103	44	15
Water Supply	Total	76	10	9	5	13	8	6	4	1	1	0	0	0	0	3	1	0	1	3	2	0	0	0
	HQ and Purification	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Purification	4	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Reservoir	71	10	9	5	10	7	5	4	1	1	0	0	0	0	3	1	0	1	3	2	0	0	0
Electricity Supply	Total	127	8	13	11	8	7	8	6	2	1	6	4	8	6	5	2	3	1	1	3	5	4	3
	HQ and Main Offices	17	0	3	3	0	3	0	3	0	0	1	0	0	2	2	0	0	0	0	0	0	0	0
	Power Plant	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Reginal Emergency Services	20	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	1
	High Voltage Sub Station	86	6	7	7	7	3	7	2	1	0	4	3	7	3	2	1	2	1	1	2	4	4	2
Petrol Station	Total	117	7	6	9	5	2	9	8	3	6	3	7	10	9	4	5	6	1	2	0	6	2	5

*1: SELECT DISTINCTROW DISTRICT, Sum(COVERAGE_AREA) AS [Total_COVERAGE_AREA] FROM JICA2 GROUP BY DISTRICT;

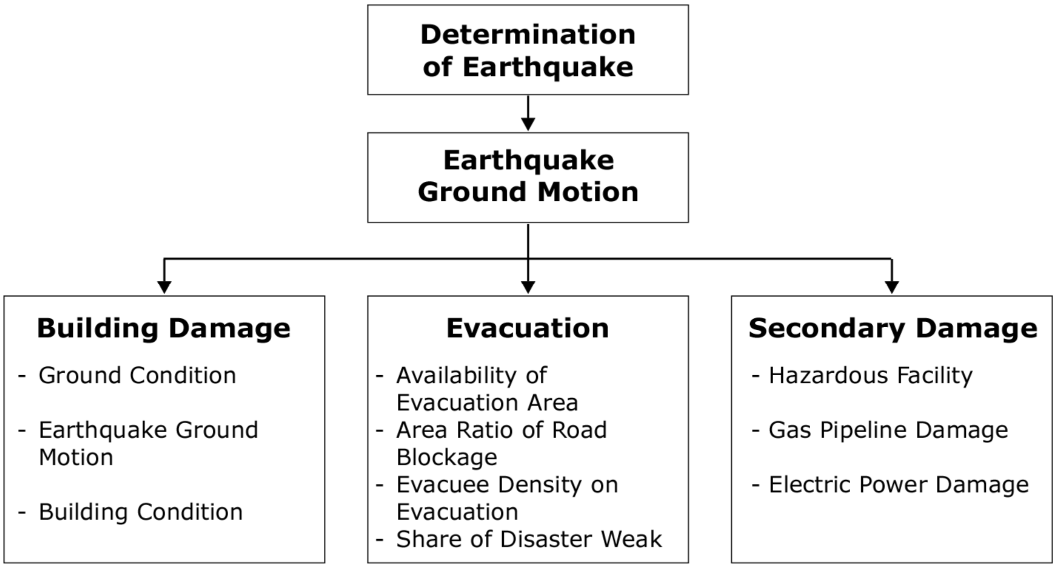
Source: Data Collected from various organization and Compiled by JICA Study team

4.2 Vulnerability Analysis in Tehran Municipality

4.2.1 Methodology

The previous study quantified the damage caused by earthquake in terms of building, human casualty, bridge and lifeline by microzone. In this study, the area's vulnerability to the earthquake should be clarified. In order to evaluate the area's vulnerability to earthquake, the Study Team carried out area vulnerability analysis.

The analysis takes the following steps:



Source: JICA Study Team

Figure 4.2.1 Procedure of Vulnerability Analysis

To analyze an area's vulnerability, the Study Team selects three variables; building damage, secondary damage and evacuation, and indices are used to represent each variable. The variables and indices are summarized as shown below:

Table 4.2.1 Variables used for Vulnerability Analysis

Items	Index	Items included in the index
Building	Ground condition	Based on the previous study
	Earthquake ground motion	
	Building condition	
Evacuation	Availability of evacuation area	By regional evacuation place
	Area ratio of road blockage	By collapsed building
	Evacuee density on evacuation	Road wider than 15 meters
	Share of disaster weak	Population of over 65 years old and less than 5 years old
Secondary Damage	Hazardous Facility	Major fuel/ gas tank, Petrol station, and Chemical facility
	Gas Pipeline damage	Pipeline damage, and Inner pipe of damaged gas supply building
	Electric power damage	Network damage, and Inner cable in damage building

Source: JICA Study Team

Each variable is independent each other and is analyzed separately. After ranking each variable, all the ranks are integrated to identify the vulnerability of Tehran.

4.2.2 Data Used for the Analysis

1) Determination of Earthquake

The previous study established scenario earthquakes to estimate earthquake damage. Three scenario earthquakes are selected for analysis: Ray fault, NTF and Mosha models. Among the scenario earthquake, two models, Ray fault and NTF model, would have a great impact on Tehran municipality. Therefore, the Study applied either of the earthquakes.

2) Earthquake Ground Motion

In order to analyze the most plausible areas to seismic vulnerability, the Study Team has considered the largest PGA in each microzone. The NTF model is applied for the northern part of the city, while the Ray fault model is for the southern part of the city. Therefore, the earthquake ground motion for the analysis is the largest earthquake in each microzone.

3) Building Damage

The building damage is estimated by the previous study. The building damage ratio, the number of the damaged buildings in each microzoing per total number of building, is used for the analysis. The building damage ratio is calculated from earthquake ground motion, building structure type, the year of construction and number of stories of the buildings.

4) Evacuation

The following data are used for the evaluation of the evacuation possibility. Three variables are used for the analysis.

(1) Evacuation Space

Data from the evacuation space and open space is used to evaluate the availability of the evacuation space. The Study Team collected those data from Tehran Municipality.

(2) Road Network

Road network data are derived from the Tehran Comprehensive Transportation and Traffic Studies and the Study Team collects their errors based on the data from Traffic and Transportation Organization. Road centerline data is supplied by the TGIS.

(3) Evacuation Route

Road network is the same data as collected in (2) above, and then more than 15 meters width road are selected for safety evacuation route.

Width of evacuation route is determined by an actual measure used in Japan. Appropriate width is more than 15 meters, which is calculated from required space for rescue activities, blocked space with roadside hazard and evacuee’s space (more detail is provided in Chapter 5 in this report).

(4) Disaster Weak

In previous study, census data are collected for the analysis. From the census data, aged population, those more than 65 years old, and children less than 5 years of age are identified. Handicapped persons are not identified in this Study.

5) Secondary Damage

The previous microzoning study results are used to evaluate vulnerability on gas and electricity damage. Data for hazardous facility are collected from the district government, fire department, industrial reorganization and relocation organization. Those data included gasoline stations and other hazardous facilities.

4.2.2 Analysis

1) Building Collapse

Almost all human casualties and loss were caused by collapsed weak structure buildings in the past urban earthquake disaster. Vulnerability to building collapse in each microzone is assessed on the estimated maximum building damage ratio of the three earthquake scenarios of Ray Fault, North Tehran Fault and Mosha Fault from the previous JICA Microzoning Study.

2) Evacuation

After an earthquake event, more serious human casualties will be caused by hazards of aftershocks and secondary disasters, when people could not be properly evacuated to safe evacuation place through proper evacuation route. Vulnerability to people's evacuation is assessed on the four sub-fields as follows.

(1) Availability of Evacuation Place by District

Available existing parks and open space (data obtained from Park Organization of Tehran Municipality) are assessed and classified into five categories, according to semi-gross evacuation area per capita. Detail regarding evacuation place by district is provided in Chapter 5 in this report.

(2) Population Share of Disaster Weak by District

Handicapped persons, those more than 65 years old, and children under 5 years of age are categorized as disaster weak, which means they cannot evacuate by themselves. Population share of those persons is assessed and classified into five categories.

(3) Road Blockage Ratio by Microzone

Debris of collapsed and heavily damaged buildings on roads will disturb people's evacuation and emergency vehicle operation. The estimated road area covered by debris ($30m^2$/collapse and heavily damaged building) is assessed and classified into five categories.

(4) Evacuee Density on Evacuation Route by Microzone

Population density (evacuee) on the wider than 15m width roads, which are categorized as safe evacuation route without influence of roadside hazard, is directly related to evacuation speed. High evacuee density will reduce evacuation speed as follows:

Table 4.2.2 Relationship Between Evacuee Density and Evacuation Speed

Density	Daytime speed	Night time speed	Reduced ratio
1.2person/m^2 and less	5.4km/hour	3.6km/h	Ordinary speed
3 person/m^2	1.6km/h	1.1km/h	30%
4 person/m^2	0.5km/h	0.3km/h	Less than 10%

Source: The 5th study on regional vulnerability measurement for earthquake, 2002, Bureau of Urban Planning, Tokyo Metropolitan Government Office, Japan

Evacuation conditions with high density and slow speed will generate serious situation and panic.

Areas classified under Index-5 means most seriously vulnerable area and are mainly located on the part of old town areas without urban renewal in the past half century, where safe evacuation place and proper wider evacuation road are lacking. They have a 1% (5.2 km^2) share of the urbanized district area and 3% share of the municipal population (176,000 pop.).

Areas classified under Index-4 are more widely located on the old town areas and old villages, where they have a 6% (around 40 km^2) share of the urbanized district area and 13% share (842,000 pop.) of the municipal population.

Areas classified under Index-3 are more widely spreading in the urbanized area, where they have a 12% share (around 88 km^2) of the urbanized district area and 28% share (1.8 million pop.) of the municipal population.

Areas classified under Index-2 have a comparatively safe evacuation area, a high 47% share (around 331km^2) of the urbanized area and 44% share (2.9 million pop.) of the municipal population.

3) Secondary Disaster

After an earthquake event, more serious human casualties will be caused by secondary disasters, which will be generated by hazardous facilities and damaged hazardous infrastructures as follows:

(1) Identified Hazardous Facility

The estimated number of the identified facilities of high pressure gas filling and refilling facility, chemical materials/products storage and factory, and petrol station

(2) Damaged Point of Natural Gas Supply Pipe

The estimated number of damaged points of pipeline and number of collapsed/heavily damaged buildings with natural gas supply

(3) Damaged Point of Electric Power Supply Cable

The estimated number of damaged length of cable and number of collapsed or heavily damaged buildings.

4.2.3 Integrated Vulnerability

Integrated vulnerability is assessed by the sum of the estimated three vulnerability indices of building collapse, people's evacuation and secondary disaster. Three variables are weighted as shown below.

- Vulnerability to Building Collapse: 2
- Vulnerability to People's Evacuation: 2
- Vulnerability to Secondary Disaster: 1

The weighted sum of the estimated vulnerability indices in each microzone is classified into five ranks of 1 to 5.

The Index-5, categorized as most vulnerable area, is concentrated in the central districts of 10, 11 and 12, the eastern district of 14, and the southern districts of 17 and 20, where there are comparatively old town areas.

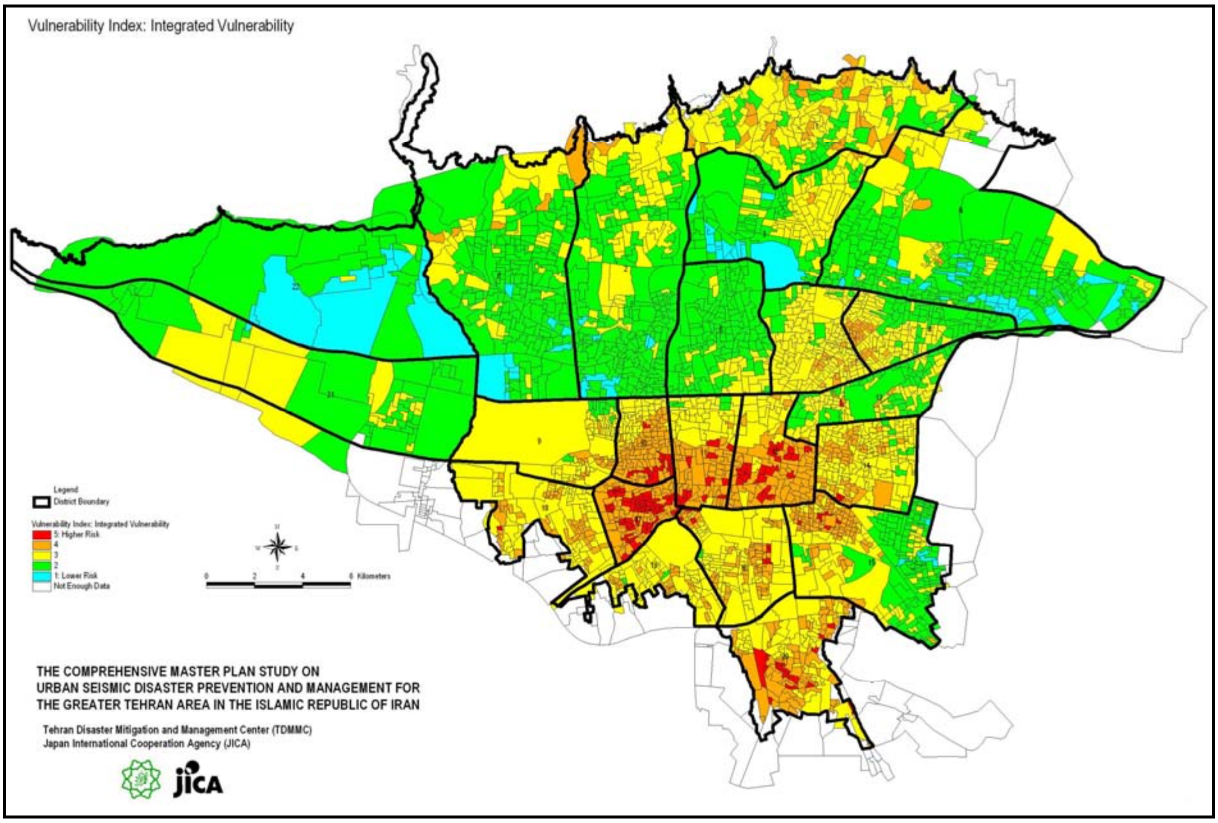
The Index-4, categorized as secondary vulnerable area, is concentrated in the northern mountain skirt district 1, the central districts of 10, 11 and 12, the eastern districts of 8/14, the southern districts of 15, 16, 17, 18 and 20 and the western district of 9.

The Index-3 is widely spreading in the urbanized districts except district 17 and all the area is classified to index 5 or 4.

The Index-2 is concentrated in the northern, eastern and western districts.

The Index-1 is very limited in the districts of 3, 4 and 22.

The figure below shows the result of this analysis.



Source: JICA Study Team, 2004

Figure 4.2.2 Integrated Vulnerability Index

4.2.4 Regional Characteristics of Urban Vulnerability

Integrated vulnerability, which combined three variables of building collapse, evacuation possibility and secondary damage, would be appropriate to evaluate the relative vulnerability of the Tehran Municipality. However it is insufficient to indicate the specific problem for urban disaster management and introduction of project and program to solve the problems.

In order to understand specific vulnerability, the Study Team reorganized each vulnerability index into eight categories. A five-ranked evaluation has been carried out in the previous section. In this section, those evaluation indices are used, but are re-categorized into "A" and "B." Risk levels 1 to 3 are re-grouped under "A" and risk levels 4 and 5 are under "B." Under this evaluation, there are three letters given, for ex., AAA. The first letter is applied to building, the second, evacuation, and the third, secondary disaster.

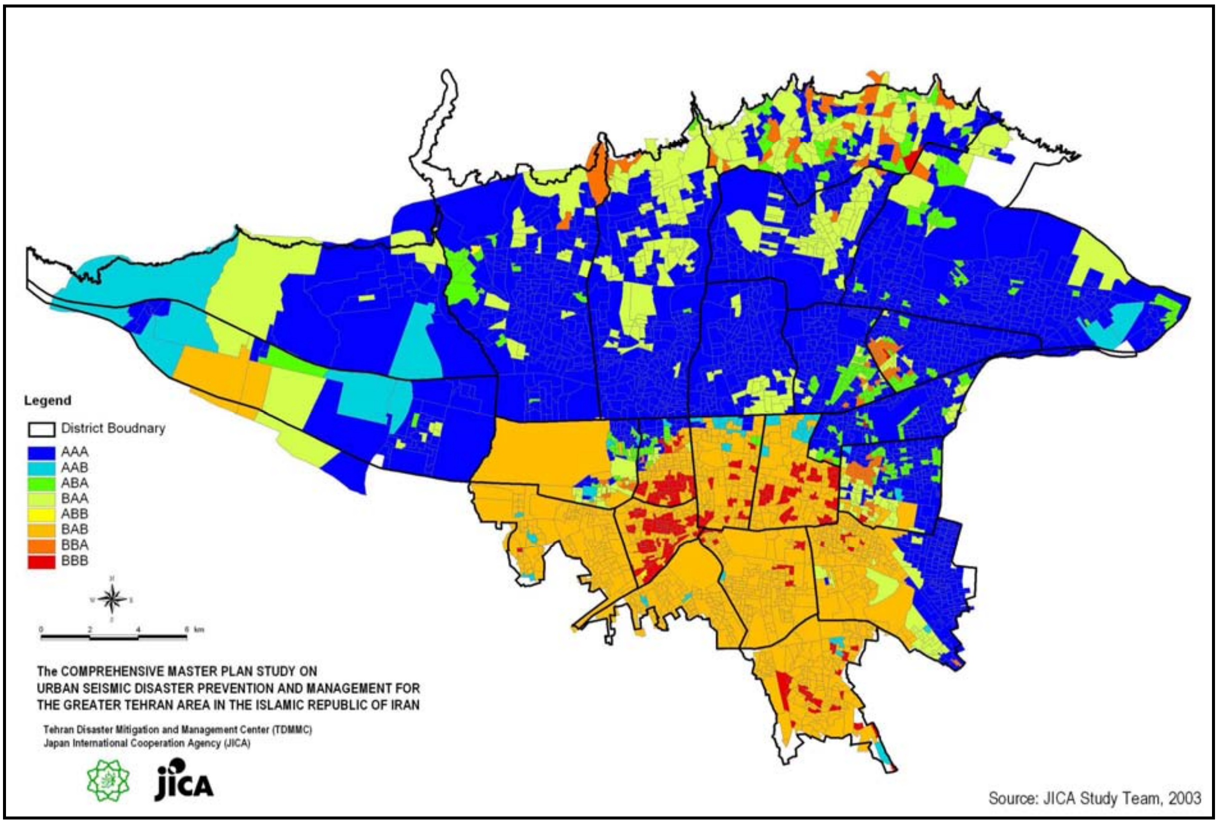
The evaluation of regional vulnerability is reorganized by district as shown in Table 4.2.4. Characteristics of risk can be identified in this table. It shows districts 10 and 17 as the most vulnerable districts in Tehran Municipality registering a vulnerability index of BBB.

Table 4.2.3 Evaluation Criteria and Urban Characteristics

Evaluation Index	Characteristics of Disaster Management
AAA	Relatively less vulnerable urban structure
AAB	High risk on secondary disaster
ABA	High risk on evacuation possibility
BAA	High risk on building collapse
ABB	High risk on evacuation possibility and secondary disaster
BAB	High risk on building collapse and secondary disaster
BBA	High risk on building and evacuation possibility
BBB	High risk on all variables

Source: JICA Study Team

The results of the vulnerability analysis are shown in Figure 4.2.3. The map is produced based on the evaluation criteria in Table 4.2.3.



Note: The map is produced based on the evaluation criteria in Table 4.2.3.

Source: JICA Study Team

Figure 4.2.3 Characteristics of Vulnerability

Table 4.2.4 Characteristics of Vulnerability by District Municipality

District		AAA	AAB	ABA	ABB	BAA	BAB	BBA	BBB	Unknown	Total
1	Area (ha)	980	0	384	0	1,479	0	457	40	113	**3,454**
	%	28.4%	0.0%	11.1%	0.0%	42.8%	0.0%	13.2%	1.2%	3.3%	
2	Area (ha)	3,272	0	18	0	1,523	1	68	0	74	**4,956**
	%	66.0%	0.0%	0.4%	0.0%	30.7%	0.0%	1.4%	0.0%	1.5%	
3	Area (ha)	2,031	0	1	0	884	0	22	0	0	**2,938**
	%	69.1%	0.0%	0.0%	0.0%	30.1%	0.0%	0.7%	0.0%	0.0%	
4	Area (ha)	5,167	249	417	0	761	0	37	0	612	**7,243**
	%	71.3%	3.4%	5.8%	0.0%	10.5%	0.0%	0.5%	0.0%	8.5%	
5	Area (ha)	4,446	0	304	12	546	2	167	0	424	**5,901**
	%	75.3%	0.0%	5.2%	0.2%	9.3%	0.0%	2.8%	0.0%	7.2%	
6	Area (ha)	1,838	0	0	0	306	0	0	0	0	**2,144**
	%	85.7%	0.0%	0.0%	0.0%	14.3%	0.0%	0.0%	0.0%	0.0%	
7	Area (ha)	1,210	0	219	0	71	0	37	0	0	**1,537**
	%	78.7%	0.0%	14.3%	0.0%	4.6%	0.0%	2.4%	0.0%	0.0%	
8	Area (ha)	1,049	0	102	0	53	0	115	5	0	**1,324**
	%	79.2%	0.0%	7.7%	0.0%	4.0%	0.0%	8.7%	0.4%	0.0%	
9	Area (ha)	169	41	78	0	179	1,452	36	0	0	**1,955**
	%	8.7%	2.1%	4.0%	0.0%	9.2%	74.2%	1.8%	0.0%	0.0%	
10	Area (ha)	168	8	59	0	28	308	13	221	0	**806**
	%	20.8%	1.0%	7.4%	0.0%	3.5%	38.2%	1.7%	27.4%	0.0%	
11	Area (ha)	46	86	15	0	0	946	0	113	0	**1,206**
	%	3.8%	7.1%	1.3%	0.0%	0.0%	78.4%	0.0%	9.3%	0.0%	
12	Area (ha)	0	117	0	0	0	973	1	266	0	**1,358**
	%	0.0%	8.6%	0.0%	0.0%	0.0%	71.7%	0.1%	19.6%	0.0%	
13	Area (ha)	1,125	0	147	0	76	0	7	4	30	**1,389**
	%	81.0%	0.0%	10.6%	0.0%	5.5%	0.0%	0.5%	0.3%	2.2%	
14	Area (ha)	743	25	138	0	254	158	125	10	2	**1,456**
	%	51.0%	1.7%	9.5%	0.0%	17.4%	10.8%	8.6%	0.7%	0.2%	
15	Area (ha)	920	7	0	0	402	1,414	6	19	77	**2,846**
	%	32.3%	0.3%	0.0%	0.0%	14.1%	49.7%	0.2%	0.7%	2.7%	
16	Area (ha)	0	7	0	0	0	1,589	0	59	0	**1,655**
	%	0.0%	0.4%	0.0%	0.0%	0.0%	96.0%	0.0%	3.6%	0.0%	
17	Area (ha)	0	0	0	7	0	451	0	338	0	**796**
	%	0.0%	0.0%	0.0%	0.9%	0.0%	56.7%	0.0%	42.4%	0.0%	
18	Area (ha)	0	29	0	0	0	1,675	0	4	77	**1,785**
	%	0.0%	1.6%	0.0%	0.0%	0.0%	93.8%	0.0%	0.2%	4.3%	
19	Area (ha)	0	16	0	0	0	1,069	0	1	64	**1,149**
	%	0.0%	1.4%	0.0%	0.0%	0.0%	93.0%	0.0%	0.1%	5.6%	
20	Area (ha)	0	53	0	0	0	1,549	0	172	255	**2,028**
	%	0.0%	2.6%	0.0%	0.0%	0.0%	76.4%	0.0%	8.5%	12.6%	
21	Area (ha)	2,295	1,298	174	0	674	679	0	0	76	**5,196**
	%	44.2%	25.0%	3.4%	0.0%	13.0%	13.1%	0.0%	0.0%	1.5%	
22	Area (ha)	3,133	1,503	14	0	1,281	0	0	0	209	**6,140**
	%	51.0%	24.5%	0.2%	0.0%	20.9%	0.0%	0.0%	0.0%	3.4%	
Total	Area (ha)	**28,600**	**3,440**	**2,073**	**19**	**8,520**	**12,275**	**1,091**	**1,252**	**1,994**	**59,263**
	%	**48.3%**	**5.8%**	**3.5%**	**0.0%**	**14.4%**	**20.7%**	**1.8%**	**2.1%**	**3.4%**	

Source: JICA Study Team 2003

4.3 Urban Development for Disaster Prevention

4.3.1 Issues from Aspect of Disaster Prevention

Based on the vulnerability analysis in the previous section, it is found that Tehran is not strong enough against earthquakes affecting following problems as follows;

- High density
- Inadequate evacuation facilities
- Structurally weak and old buildings

The most vulnerable area is typical of congested with weak and old buildings and lack of open spaces through the sight survey conducted by the study team. Those areas are distributed mainly in the central part of Tehran and the process of settlement and construction of residential units was supposed to start during years 1956 to 1969 and followed by immigration to this area that composed mainly of the northwestern part of the countries and large Azarbaijani tribes, the division of lands into small parcels started without any plan preparation. Most of the buildings in the area have not been rebuilt to date, that is, three to five decades have been passed already.

Source: JICA Study Team 2004

Figure 4.3.1 Examples of the Congestion Settlement in Vulnerable Area (District 17)

4.3.2 Basic Approach for Disaster Resistant City

1) Objectives of Upgrading Urban Condition

To be an earthquake resistant city, Tehran City has to make a breakthrough the current conditions, or to attain following things as objectives;

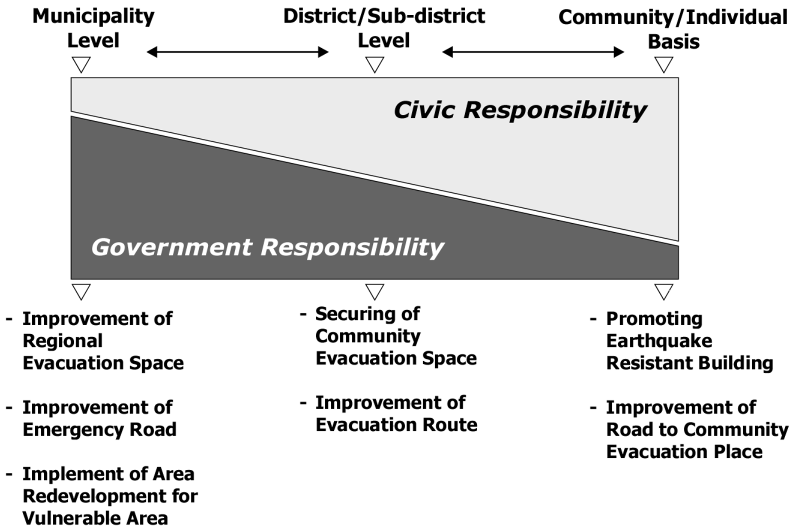
- To decrease density of vulnerable area
- To secure sufficient spaces for evacuation
- To increase and promote earthquake resistant buildings

2) Basic Strategies of Upgrading Urban Condition

To achieve the objectives above can bring about to lessen the disaster damage and to keep urban function when an earthquake happens as well as to make smooth evacuation and relief activities after the occurrence. Practical major strategies for achievement of those objectives are as follows;

- To implement area redevelopment
- To secure regional and community evacuation place
- To improve of emergency roads and evacuation route
- To review and revise the current building standard
- To enforce the regulation
- To introduce incentive systems for promoting quake-proof building

To pursue the strategies should be carried out depending on the degrees, that is, “municipality level”, “district/sub-district level” and “community/individual level”.



Source: Based on Urban Disaster Prevention Handbook, 1997, Gyosei, modified JICA Study Team

Figure 4.3.2 Responsibility of Improvement for Disaster Prevention

(1) Municipality Level

Activities for urban development in municipality aim at whole area of Tehran City. To be precise, improvement of regional evacuation places and emergency roads accordingly disaster prevention master plan should be mainly conducted by municipal government. Also area redevelopment in the most vulnerable areas should be done at municipality level because those projects need a large budget and participation and need to coordinate with other organizations.

(2) District/ Sub-district Level

Urban development activities at district and sub-district level are smaller scale improvement than the municipality level. In the concrete, to secure community evacuation place and to improve evacuation route should be conducted not only by district government but also in cooperation with local people and community.

(3) Community/ Individual Level

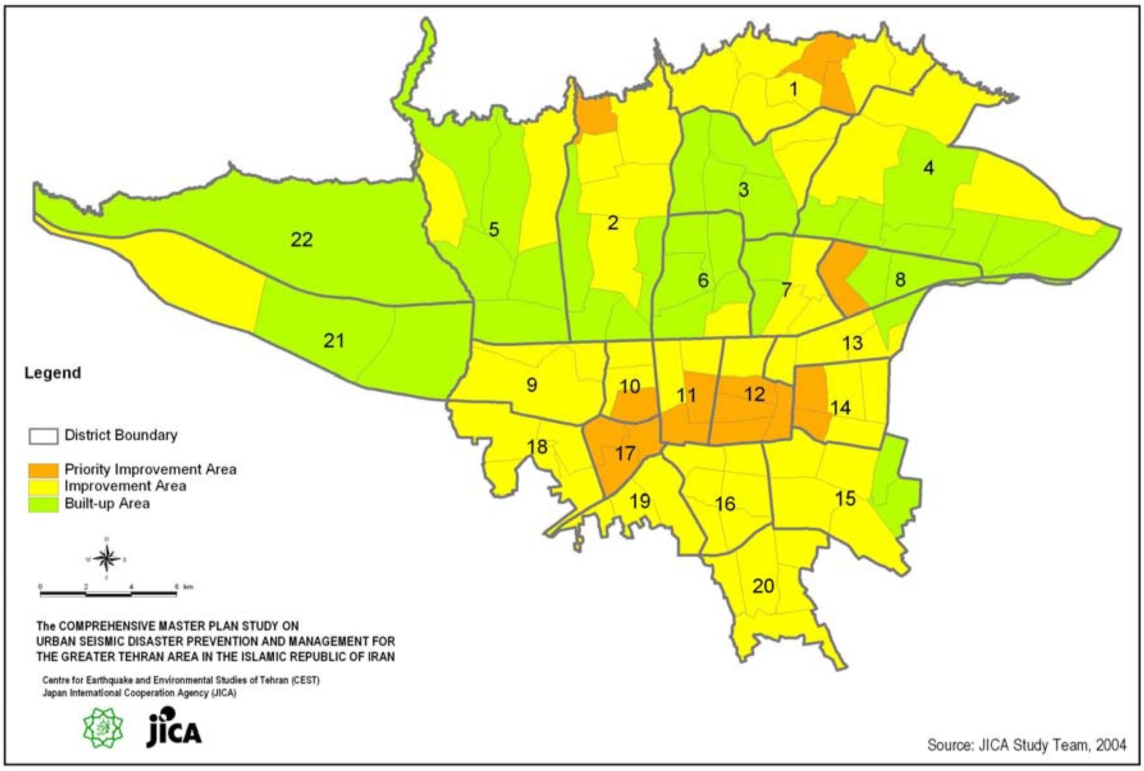
Disaster activities at community and individual level are principally to strengthen individual residence and to clarify the route from the residence to community evacuation place. With a view to support for such activities as legal system, it is necessary to consolidate the current system related to building and urban planning. In addition, public awareness of disaster prevention should be increased as well.

3) Disaster-proof Living Zoning System

In order to achieve those three objectives above, the study team proposes to employ "Disaster-proof Living Zoning" system which has been applied in Tokyo. The zoning is in general to divide area into small blocks as one unit and to improve a series of disaster prevention facilities for each block. For such developments, a disaster prevention plan and the implementation plan at community level should be prepared for every block. Appropriate size of the block is supposed to be from 65 to 100 ha, or elementary school district. Nahiye boundaries can be applied to the zoning in light of size of area and administrative jurisdiction.

4.3.3 Basic Policy of Urban Development

Based on the vulnerability analysis, the study team carried out analysis to classify Nahiye districts in the study area into three categories, namely "Priority Improvement Area," "Improvement Area" and "Built-up Area" in terms of undertaking urban improvements by priority. The criterion of these areas is based on the result of vulnerability analysis, distance of the regional evacuation place and sight surveys done by the study team (see Figure 4.3.3). The comparison of each area's characteristics is shown in Figure 4.3.3.



Source: JICA Study Team

Figure 4.3.3 Zoning of Improvement Area

Table 4.3.1 Major Features of Three Categorized Areas

Vulnerability/ Characteristics	Basic Approach	Supporting System	Institution Concerned
1. Priority Improvement Area			
Vulnerability • Building Collapse Index-B Evacuation Index-B Characteristics • Out of the coverage of regional evacuation place • High density • Old building	Regional Level • Large-scale area redevelopment • Designation and legislation of "Disaster-proof Living Zoning"	• Area redevelopment in right conversion system • PPP scheme • Dedicated fund for urban redevelopment system • Financial cross-subsidization system • Legal process for formulating consensus among residents • Cadastral-based land registration and appropriate property assessment system • Taxation systems to capture accrued benefits from beneficiaries	• TDMMC • Tehran Municipality • Ministry of Housing and Urban Development • Ministry of Interior
2. Improvement Area			
Vulnerability • Building Collapse Index-B Evacuation Index-A • Building Collapse Index-A and Evacuation Index-B Characteristics • Not all area inside the coverage of regional evacuation place • Middle to high density	District Level • Development for disaster prevention plan at community level • Securing of Community Evacuation Space • Improvement of Evacuation Route • Small-scale land redevelopment	• Dedicated fund for urban redevelopment • Practical land readjustment system • Legal process for formulating consensus among residents • Enforcement of earthquake-resistant design codes and inspection system to secure design-compliant building act	• TDMMC • District Municipality • Local Community
3. Built-up Area			
Vulnerability • Building Collapse Index-A Evacuation Index-A Characteristics • Inside of coverage of regional evacuation place • Low to middle density	Individual Level • Individual implementation for disaster prevention • Strengthening of individual buildings	• Enforcement of earthquake resistant design codes and inspection system to secure design-compliant building act • Introducing incentive system to promote strengthening buildings • Dedicated fund for urban redevelopment system	• District Municipality • Local Community • Ministry of Housing and Urban Development

Source: JICA Study Team

1) Priority Improvement Area

(1) Specification of Priority Improvement Area

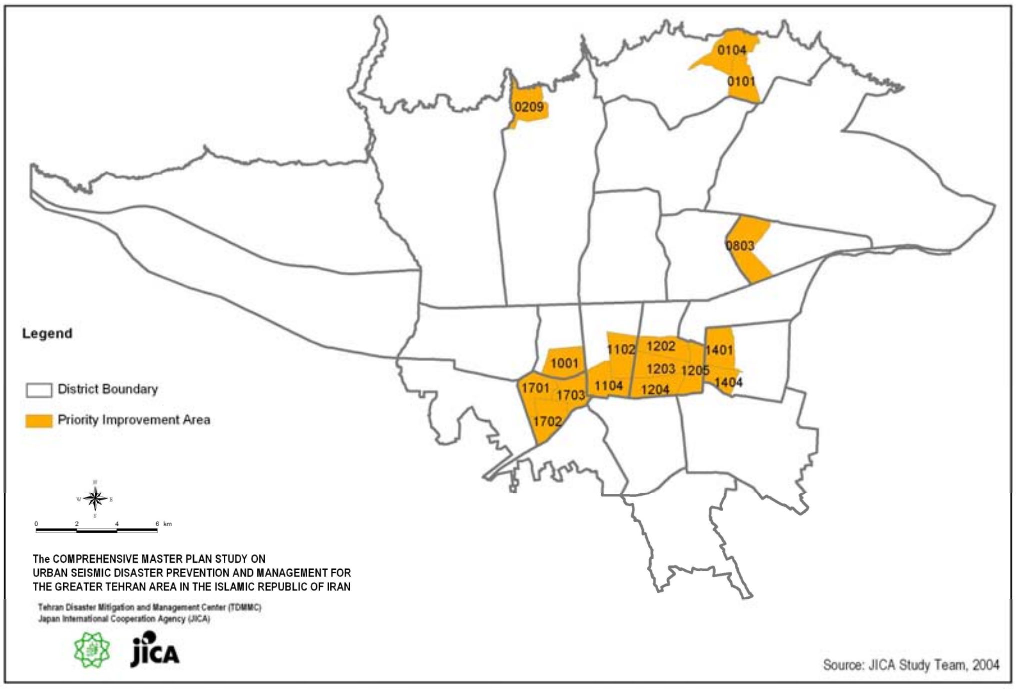
Priority Improvement Areas are selected from Improvement Areas which means most vulnerable area and need urgent actions with emphasis on area-based development.

The measures are the following items:

- Including many vulnerable zones of building collapse index - "B" (more than 60% of buildings will be heavily damaged or collapsed) and evacuation index – "B" (lack of evacuation place, proper evacuation road, and most of roads disturbed by debris and so on)
- Out of coverage of the regional evacuation area

- High-density area with old buildings

The priority improvement area is approximately 4,450 ha, included 16 sub-districts and the population is approximately 933,000 (see Figure 4.3.4 and Table 4.3.2).



Source: JICA Study Team

Figure 4.3.4 Distribution of Priority Improvement Area

Table 4.3.2 List of Priority Improvement Area

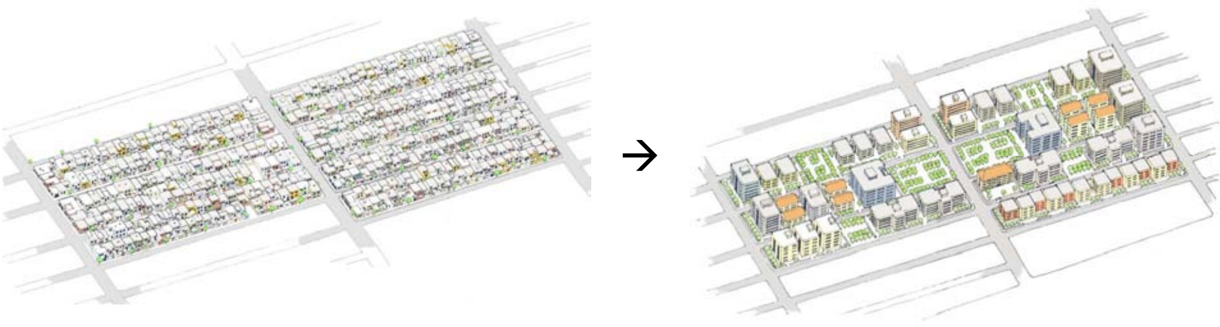
District	**Sub-district**	**Area** (ha)	**District**	**Sub-district**	**Area** (ha)
1	Nahiye 0101	242	12	Nahiye 1202	248
	Nahiye 0104	354		Nahiye 1203	262
2	Nahiye 0209	302		Nahiye 1204	258
8	Nahiye 0803	456		Nahiye 1205	227
10	Nahiye 1001	282	14	Nahiye 1401	285
11	Nahiye 1102	280		Nahiye 1404	176
	Nahiye 1104	282	17	Nahiye 1701	262
				Nahiye 1702	294
				Nahiye 1703	240

Source: JICA Study Team, 2004

(2) Basic Strategy

Area redevelopment is considered as one of appropriate countermeasures for priority improvement areas because for the most part those areas are characterized by old, high-density buildings, narrow streets occupied by parked cars and limited open spaces for evacuation. In particular, alleys in residential area are extremely narrow and cannot be widened because the housing units are too small to set back. Area redevelopment enables to decrease building density, to make open spaces and roads, and to strengthen the building structure against earthquake at once.

Area redevelopment is designated for demolishing the existing congested urbanized area and reconstructing new buildings with appropriate spaces (see Figure 4.3.5). With a view of utilization of the land due to making open spaces and reserved area for selling, if "right conversion system" is applied, floor area should be increased. In other words, new buildings in redeveloped area can be higher raised than current one. Furthermore, building method of earthquake resistant should be fully applied to reconstruction.



Existing Condition **Redeveloped Area**

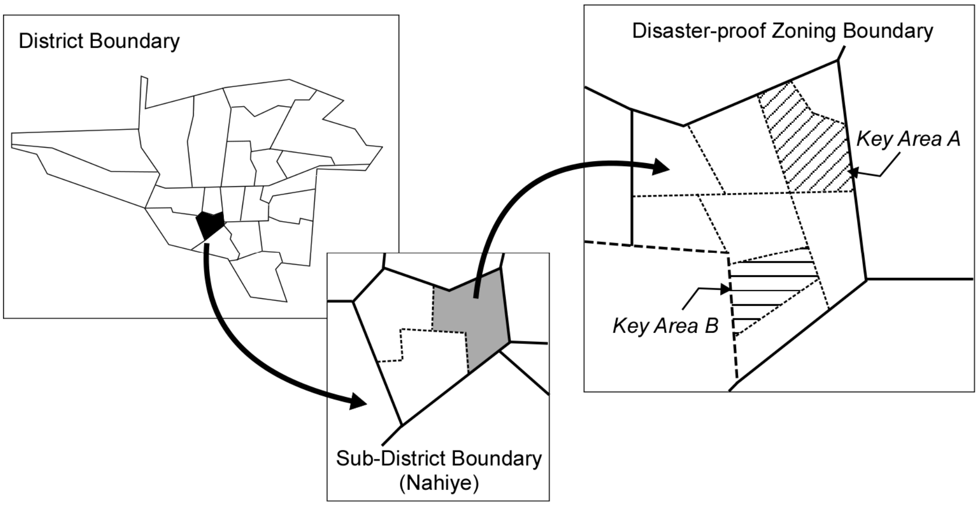
Source: JICA Study Team

Figure 4.3.5 Image of Area Redevelopment for Disaster Prevention

Area redevelopment project should be conducted in phase for the following reasons. One is financial, because this kind of project needs a huge amount of money even if "right conversion system" is applied. It totally depends on the selling price of the reserved floors area for outside people. The other reason involves obtaining the understanding and cooperation of the residents/communities. Thus, phasing method, redeveloping little by little, can be said to be the most practical way. Appropriate land size for redevelopment is from 20 to 50 ha in one phase.

It is preferable that one phase should be completed in a decade. The basic strategy includes a series of steps as follows:

- Make a disaster prevention plan in each sub-district , i.e. disaster-proof zone
- Select and prioritize the disaster-proof zones as designated priority improvement area from the viewpoints of vulnerability and urgency
- To identify small blocks as "Key Area" of which highest priority disaster-proof zones



Source: JICA Study Team

Figure 4.3.6 Image of Disaster-proof Zoning and Key Area

- Create implementation plan and conduct feasibility study on Key Area
- Implement engineering works

Also, it is vital to coordinate the project to fit local attributes and to obtain the residents/ communities' understanding during the course of activities.

2) Improvement Area

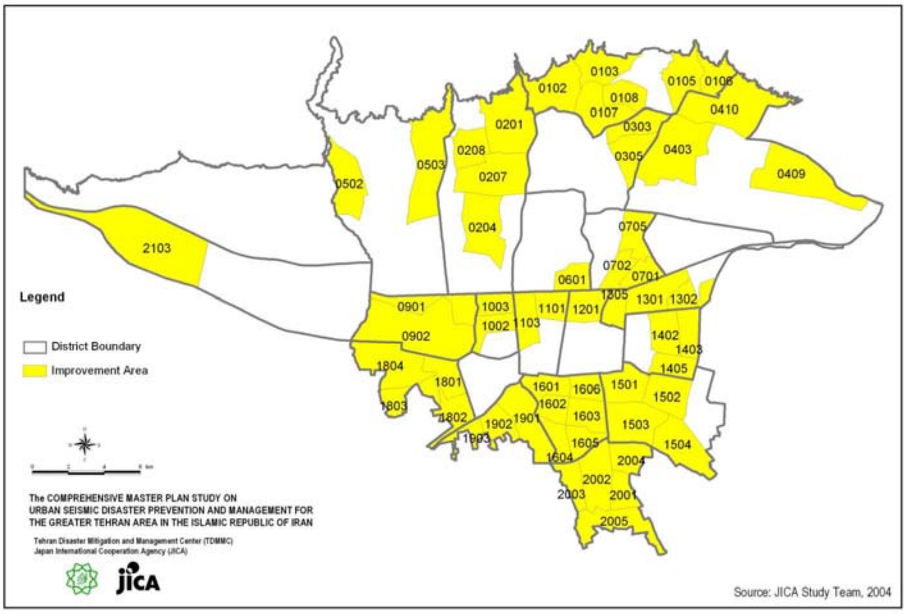
(1) Specification of Improvement Area

Priority Improvement Area designates high risk area which is expected to be seriously damaged by earthquake.

The measures proposed are for the following areas:

- Many vulnerable zones of building collapse index - "B" (more than 60% of buildings will be heavily damaged or collapsed) and assessed not so seriously vulnerable area of evacuation index - "A", or evacuation index – "B" (lack of evacuation place, proper evacuation road, and most of roads disturbed by debris and so on) and assessed not so seriously vulnerable area of building collapse index – "A".
- Out of coverage of the regional evacuation area
- High-density area with old buildings

The improvement area is approximately 28,900 ha, including 57 sub-districts and covering a population of approximately 3,675,000 (see Figure 4.3.7 and Table 4.3.3).



Source: JICA Study Team

Figure 4.3.7 Distribution of Improvement Area

Table 4.3.3 List of Improvement Area

District	**Sub-district**	**Area** (ha)	**District**	**Sub-district**	**Area** (ha)
1	Nahiye 0102	704	13	Nahiye 1301	498
	Nahiye 0103	487		Nahiye 1302	284
	Nahiye 0105	495		Nahiye 1305	244
	Nahiye 0106	319	14	Nahiye 1402	385
	Nahiye 0107	536		Nahiye 1403	318
	Nahiye 0108	316		Nahiye 1405	293
2	Nahiye 0201	949	15	Nahiye 1501	443
	Nahiye 0204	729		Nahiye 1502	485
	Nahiye 0207	817		Nahiye 1503	651
	Nahiye 0208	377		Nahiye 1504	649
3	Nahiye 0303	346	16	Nahiye 1601	296
	Nahiye 0305	313		Nahiye 1602	238
4	Nahiye 0403	1,094		Nahiye 1603	360
	Nahiye 0409	1,089		Nahiye 1604	255
	Nahiye 0410	1,120		Nahiye 1605	261
5	Nahiye 0502	612		Nahiye 1606	247
	Nahiye 0503	1,130	18	Nahiye 1801	341
6	Nahiye 0601	279		Nahiye 1802	351
7	Nahiye 0701	246		Nahiye 1803	306
	Nahiye 0702	245		Nahiye 1804	787
	Nahiye 0705	377	19	Nahiye 1901	660
9	Nahiye 0901	471		Nahiye 1902	311
	Nahiye 0902	1,485		Nahiye 1903	179
10	Nahiye 1002	281	20	Nahiye 2001	249
	Nahiye 1003	243		Nahiye 2002	580
11	Nahiye 1101	275		Nahiye 2003	276
	Nahiye 1103	370		Nahiye 2004	333
12	Nahiye 1201	362		Nahiye 2005	590
			21	Nahiye 2103	1,879

Source: JICA Study Team, 2004

(2) Basic Strategy

Based on the vulnerability analysis, the improvement area is not necessary to redevelopment but improvement of disaster prevention facilities is needed which are community evacuation place, evacuation route and so on.

In principle, disaster prevention activities for this area should be conducted at district/ sub-district level. Accordingly, it is necessary to prepare disaster prevention plans at community level which should well reflect community attributes, i.e., geological characteristics and social backgrounds.

Although the main players are district municipalities and community groups, supports from Tehran municipality and other government entities are also absolutely essential for the disaster prevention activities. Installation of incentive system, establishment of required regulation and provision of inducement system could be efficient and should be enforced by the different sectors of government.

3) Built-up Area

(1) Specification of Built-up Area

Other than both priority improvement area and improvement area is area designated as Built-up Area. This type of area is not considered to be in grave danger from two viewpoints of building collapse and evacuation.

The measures proposed are for the following areas:

- Many zones of building collapse index - “A” and evacuation index – “A”
- Most of the areas inside of coverage of the regional evacuation area

The built-up area is approximately 25,900 ha, included 36 sub-districts and the population is approximately 1,886,000.

(2) Basic Strategy

Built-up Area is not seriously vulnerable compared with other designated areas. But it needs to be improved by individual disaster prevention measures. Also those measures should be supported by government sector in such ways that to introduce incentives system for promoting safe buildings and to establish appropriate regulations would be effective.

4) Supporting System

In order to facilitate those projects explained in above section, appropriate supporting system in terms of financing and regulation should be considered. The following scheme can be applied:

- Public-Private-Partnership (PPP) system
- Dedicated fund for urban redevelopment
- Practical land readjustment and right conversion system
- Financial cross-subsidization system
- Legal process for formulating consensus among residents
- Cadastral-based land registration and appropriate property assessment system
- Taxation systems to capture accrued benefits from beneficiaries
- Enforcement of earthquake-resistant design codes and inspection system to secure design-compliant building act

References to Chapter 4

Tokyo Metropolitan Government. 1999. *Urban Disaster Prevention Plan of Metropolitan Tokyo*. Tokyo.

Bureau of Urban Development, Tokyo Metropolitan Government. 1999. *Implementation Plan for Creating Urban Disaster-prevention.* Tokyo.

Gyosei. 1997. *Urban Prevention Disaster Handbook*(in Japanese). Tokyo.

Keikokusha. 1995. *City Planning Textbook*(in Japanese). Tokyo.

Yasumichi Mifune. 1997. *Keyword Dictionary for Urban Planning.*

Chapter 5
Identification of Safety Evacuation Space

CHAPTER 5 IDENTIFICATION OF SAFETY EVACUATION SPACE

5.1 Evacuation System

5.1.1 Regional Evacuation Place

1) Evacuation System

It is vital that residents can evacuate to safe place through certain route when an earthquake happens. Accordingly, evacuation system, a wide area evacuation place and evacuation roads, should be provided. It is necessary to specify and secure open space which is large enough to accommodate residents and roads which are wide enough and linked with evacuation place. In addition to, the system should be well-known by residents.

(1) Regional Evacuation Place

It is an open space such as a large-scale park or green space without any slope and surface, which is for protection evacuees from any dangers such as falling of buildings and others when a large-scale earthquake hits. Gross open space in the regional evacuation place has to be bigger than 3 m^2 per person or net area more than 2 m^2/person in Tokyo. Appropriate coverage area of the regional evacuation place is less than 2 km-radius.

(2) Community Evacuation Place

It is a place for evacuating persons to form a group temporarily to evacuate to the regional evacuation place. The place shall be such as urban parks, sports fields, schools, religious facilities, etc. in which the safety of assembled persons can be secured. Gross open space in the community evacuation place has to be bigger than 2 m^2 per person or net area more than 1 m^2/person in Tokyo. Appropriate coverage area of community evacuation place is approximately 500 meter-radius.

(3) Evacuation Route

It is a road that leads from the community evacuation place to the regional evacuation place. It is designated in advance to enable residents living in an evacuating zone to evacuate quickly and safely to the regional evacuation place. Appropriate width of road as evacuation route is more than 15 meters.

Width of evacuation route is determined by an actual measure used in Japan. Appropriate width is more than 15 meters which is calculated from required space for rescue activities, blocked space with roadside hazard and evacuee’s space.

- Required space for rescue activities stands for passable space for emergency vehicles: 4 meters
- Road block by hazards are collapsed objects and parked or/and left cars: 3~4 meters
- Required road width for evacuation: 7~8 meters
  The method of calculation is as follows;

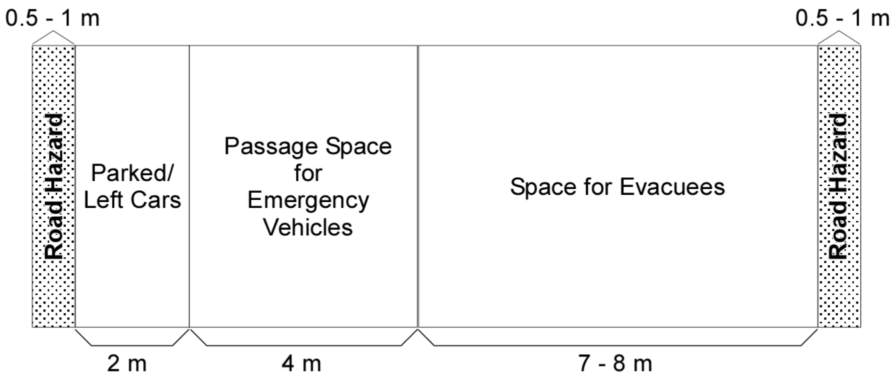
Space for Evacuation	=	No. of Evacuees	/	Evacuees Density	/	Evacuation Speed	/	Evacuation Time

Calculation in case of Iran

7.8 meters	=	22,000 * person	/	0.7 ** person/m2	/	2,000 km/hr.	/	2 hr.

*: (Coverage Area of Regional Evacuation Space / 4 direction) x Average Density= (2kmx2km/4)x110=22,000

**: 0.7 person/m2 is spacious compare with the case of Japan which is 1.0 person/m2 because of to take account of national character.



Source: Urban Disaster Prevention Handbook, 1997, Gyosei

Figure 5.1.1 Road Width of Evacuation Route

2) Selection of Evacuation Place and Route

Throughout the study, latest information about urban spaces such as vacant, cultural, sport, services, commercial, green spaces such as forest park, parks and recreational centers, fairs, terminals and other open spaces with more than 2,000 m^2 has been corrected as primary data. Approximately 1,030 locations are listed by municipality in which candidate regional evacuation places are selected by using certain software called “Tehran Temporary Housing Software”.

3) Screening of Regional Evacuation Place

Candidates for the place are selected from the list and combined area of those facilities by the criteria as follows:

- Public owned land and facilities for stability,
- Major park, open space and sport ground for flexible utilization,
- Public facilities with enough seismic resistant building structure,

- Without any natural hazardous area,
- Without any hazardous chemical facilities in and around the area, and
- Emergency potable water supply, toilet (tank), and emergency goods storage are proposed.

4) Regional Evacuation Space

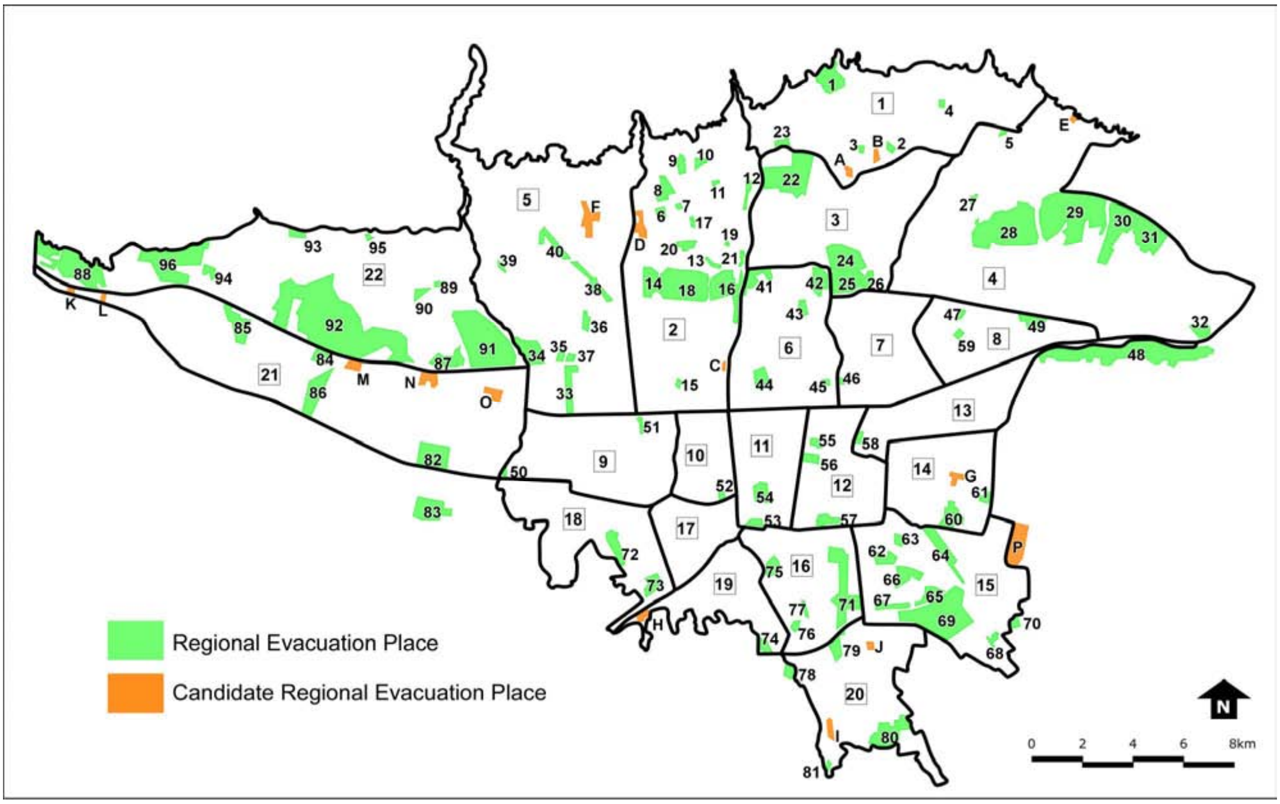
Based on the criteria as above, the study team identified 96 areas out of 136 identified locations for regional evacuation place.

Table 5.1.1 Summary of Evacuation Place Candidate

Type	Number	Area (ha)
Public Space (Park)	96	6,655
Private Land	16	373
Military	19	1,324
Unknown	5	271
Total	**136**	**8,623**

Source: JICA Study Team 2004

Identified regional evacuation places and candidate places are shown in Figure 5.1.2, and the list of the regional evacuation places are shown in Table 5.1.1.



Source: JICA Study Team 2004

Figure 5.1.2 Location of Regional Evacuation Place and the Candidate Place

Table 5.1.2 List of Regional Evacuation Place and Capacity by District

District	Regional Evacuation Place			Required Area for Evacuation (ha)
	Code	Name of Place	Area (ha)	
1	1	Saad Abad Garden	84.2	
	2	Qeytarieh Park	9.9	
	3	Green Space, Next to Qeytarieh Sub Station, TREC	7.5	
	4	Niavaran Park	6.1	
	23	Plan for National Parlement, Islamic Conference Place, North of Chamran Highway	16.8	
	Total		**124.6**	**45.8**
2	6	Surrounding of water reserviour, in Farahzad	16.4	
	7	Vacant for Food Science Faculty, in Farahzad	4.2	
	8	Forest in Farahzad	38.4	
	9	Parvaz Park, Farahzad	21.9	
	10	Vacant, North of Saadat Abad	14.2	
	11	Water Reserviour, Kaj Square	4.1	
	12	Vacant along Darake River	15.1	
	13	Vacant belong to Azad University, Shahrak Ghods	8.8	
	14	Western Part of Pardisan Park	52.1	
	15	Vacant, Water Company in Tarasht Area	4.9	
	16	Nasr Park and Sorrounding area	134.2	
	17	Kanoon Parvaresh Fekri, Shahrak Ghods	8.7	
	18	Main Part of Pardisan Park	219.1	
	19	Vacant, by the Hormozan St.	1.8	
	20	Civil Workshop in Shahrak Ghods	17.2	
	21	Forest Park along Chamran Highway, Surrounding Mollasadra St.	7.6	
	Total		**568.6**	**93.0**
3	22	Surroundings of I. R. I. B. Headquarters	225.9	
	24	Northern Part of Abbas Abad land	136.6	
	25	Northern Part of Abbas Abad land	104.2	
	26	Jahan Kodak Park (National Library in Plan)	25.5	
	Total		**492.1**	**47.5**
4	5	Park, South Eastern Part of Lashgarak St. and Ozgol St. Intersection	5.8	
	27	Javaherian Garden (related to Municipality), Lavizan Area	6.5	
	28	Lavizan Park	334.2	
	29	Narvan Park, Babaiee Highway	431.8	
	30	Pardis Green Land Park	188.5	
	31	National Forest Park, Babaiee Highway	135.3	
	32	Park, Vacant belongs to Municipality, South of Hakimiye	32.0	
	Total		**1134.0**	**129.4**
5	33	Ekbatan Rehabilitation and Renovation Co.	51.8	
	34	Eram Park	79.6	
	35	Ekbatan Rehabilitation and Renovation Co.	11.3	
	36	Green Space, Nour Sq.	14.0	
	37	Green Space, East of South Nour Blvd.	10.7	
	38	South Part of Vacant under Power Cable, Shahrak Gharb	44.6	
	39	Kan Garden	5.9	
	40	North Part of Vacant under Power Cable, Shahrak Gharb	54.8	
	Total		**272.7**	**85.0**

District	Regional Evacuation Place			Required Area for Evacuation (ha)
	Code	Name of Place	Area (ha)	
6	41	Atomic Energy Organization, Chamran and Hemat Highway Intersection	51.9	
	42	Abbas Abad Land, West of Modarres Higway	51.1	
	43	Saiee Park	16.5	
	44	Laleh Park	43.4	
	45	Tehran Garden (Cultural House)	6.5	
	Total		**169.5**	**48.4**
7	46	Shiroudi Sport Land	8.5	
	Total		**8.5**	**60.0**
8	47	Buildings belong to Municipality (Technical Workshop, Storages)	11.7	
	49	Tehran Metro Company and related storage and Technical Office, Between Dardasht and Bagheri St.	47.1	
	59	Sport Land, Storage belong to MOE and Polt National Company	8.0	
	Total		**66.8**	**66.4**
9	50	Workers Sport Complex	5.6	
	51	Almahdi Park, Daily bazar along Mehrabad Airport Zone	6.4	
	Total		**11.9**	**34.7**
10	52	22 Bahman Park, North of Ghazvin St., West of Arab St.	8.9	
	Total		**8.9**	**56.5**
11	53	Shahid Haji Zadeh Educational Complex, N. I. O. P. D. C.	16.8	
	54	Razi Park, Behind Razi and Farabi Hospital	42.3	
	Total		**59.1**	**46.9**
12	55	Open Space, between Hafez and Ferdosi St., along Sakhaiee St.	11.7	
	56	Parke Shahr	24.2	
	57	Boostan and Sport Complex under plan, West of Shoosh Square	31.2	
	Total		**67.0**	**37.9**
13	58	New place for National Parlement, Mojahedin Eslam Intersection	16.9	
	48	Sorkhe Hesar	396.8	
	Total		**413.7**	**47.7**
14	60	Cultivation, Between Nabard and Ahang Highway	57.1	
	61	Basij Park, between Basij and Mahalati Highway	12.4	
	Total		**69.5**	**73.5**
15	62	Daily Bazar, Sport Complex, North of Besat Highway	39.3	
	63	Valiasr Park, Attarbashi St.	16.3	
	64	Cultural House, Green Space along Khavaran St.	69.7	
	65	Northern part of Tooska Forest park	31.5	
	66	Forest Park, South of Besat Highway	57.3	
	67	North west part of Tooska Forest park	21.8	
	68	Mesgar Abad old Cemetry	8.0	
	69	Main Part of Tooska Forest Park	318.1	
	70	Vacant, East of Moshiriye Square	24.6	
	Total		**586.5**	**119.2**
16	71	Besat Poweplant and Surrounding area	159.2	
	75	22 Bahaman Boostan, Bahman Cultural House, Old Koshtargah	36.3	
	76	Shariati Educational Complex, ETKA Factory, South of Barbary Square	11.1	
	77	Shahid Rajaiee Park, long Rajaiee Highway, East of Barbari Square	6.9	
	Total		**213.5**	**58.0**
17	--	--	0.0	
	Total		**0.0**	**57.5**
18	72	Ghaem Boostan	51.4	

District	Regional Evacuation Place			Required Area for Evacuation (ha)
	Code	Name of Place	Area (ha)	
	73	Sepide Park, Sport Land, North of Saeedi Highway	37.0	
	Total		**88.4**	**54.5**
19	74	Cultivation, Intersection of Besat and Beheshte Zahra Highway	17.6	
	Total		**17.6**	**40.6**
20	78	Vacant, West of Shahrake 13 Aban	31.6	
	79	Green Space, Sport Land, South of Azadegan Highway	37.9	
	80	Vacant in ghaleh Gabri Area	97.8	
	81	Green Space along Anbare Naft St.	5.3	
	Total		**172.6**	**58.6**
21	82	Vacant belongs to Properties Org.	104.2	
	83	Norouz Abad Riding Club	99.4	
	84	Vacant belongs to Valiasr Cultural Complex	27.2	
	85	Vacant along Shahrak Cinemaie Ghazali	73.9	
	86	Shahrak Daneshgah Cooperation Company	91.4	
	Total		**396.1**	**26.2**
22	87	Khargoosh Darreh Forest	55.7	
	88	Western Part of Chitgar Park	232.1	
	89	Forest between Shahrak Cheshme and Nabovat Garrison	5.6	
	90	Forest between Nabovat Garrison and Shahrak Rahahan	13.8	
	91	Azadi Stadiuum	359.1	
	92	Chitgar Park	741.1	
	93	Vacant, North of Shahid Namjoo Garrison	19.0	
	94	Forest, North of Vardavard Metro Station	16.8	
	95	Green Space, West of Shahrak Rah Ahan	4.7	
	96	Vardavard Forest Park	52.5	
	Total		**1,500.4**	**11.4**

Source: JICA Study Team 2004

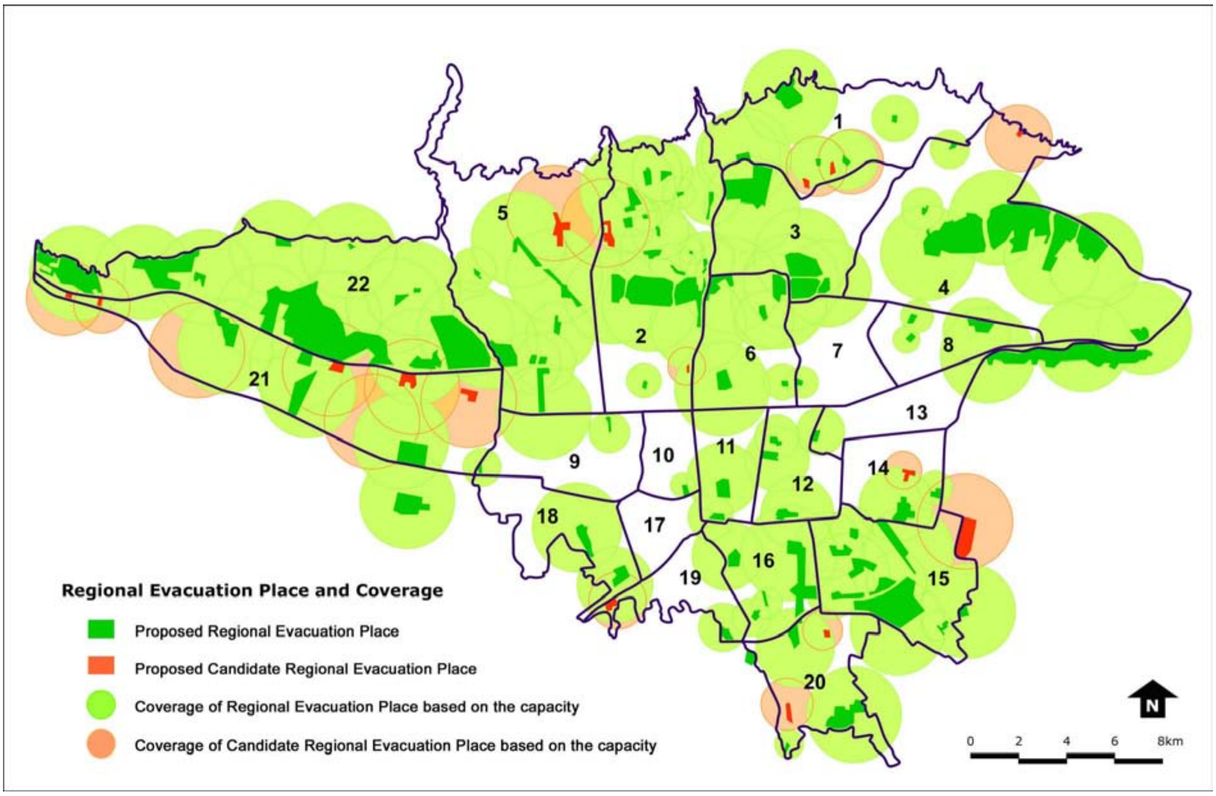
As the above table shows, regional evacuation spaces are not enough for District 7, 9, 10, 12, 14, 17, and 19 in term of the capacity. The study team proposed some private land as candidate regional evacuation area. The list of it is in the following table, Table 5.1.3.

Table 5.1.3 List of Candidate Regional Evacuation Place and Capacity

District	Candidate Regional Evacuation Place			
	Code	**Name of Place**	**Usage**	**Area (ha)**
1	A	Private Green Space, Sadr and Modarres Highway Intersection	Private	10.0
	B	Surroundings of Qeytarieh Building Complex	Private	11.6
	Total			**21.6**
2	C	Surrounding of water reserviour, in Farahzad	Private	5.5
	D	Vacant for Food Science Faculty, in Farahzad	Private	30.5
	Total			**36.0**
4	E	Farm, Soohanak	Private	16.5
	Total			**16.5**
5	F	Vacant, Shahrak Almahdi, Iran Pars	Private	41.8
	Total			**41.8**
14	G	Water Company, Armenia Cemetry, North of Shahid Mahalaty Highway and Soleymanie Shahrak	Private	14.8
	Total			**14.8**
19	H	Vacant, Green Space, Brick Factory, South of Saveh Road,West of Khalazair St.	Private	24.0
	Total			**24.0**
20	I	Cultivation along Shahid Rajaiee St.	Private	16.3
	J	Vacant, Storage, Company, along Fadaian Eslam St.	Private	9.5
	Total			**25.8**
21	K	Green Space, west of Sina Drug Production Factory	Private	6.0
	L	Green Space, East of Vilco Factory	Private	3.3
	M	Cultivation, west of Pars Electric Company	Private	21.7
	N	Pars Khodro Storage and Surrounding area	Private	35.3
	O	Iran Tire Factory, Ghods Arial Industry, Karaj Highway	Private	25.1
	Total			**91.4**

Source: JICA Study Team 2004

In light of capacity, seven districts are in shortage of the regional evacuation place, as mentioned already above. But in light of distance from those evacuation places, most of the districts hold certain areas outside of coverage of the evacuation place. Figure 5.1.3 shows that area in white spreads means more than 2 kilometers far from evacuation place or area of the nearest evacuation place is not enough to accommodate all evacuees who live within 2 kilometers-radius of the place. The coverage is calculated from capacity of the evacuation place and population density.



Source: JICA Study Team 2004

Figure 5.1.3 Regional Evacuation Place and the Coverage

5) Basic Approach for Improvement of Regional Evacuation Place

The study team proposed to establish a "Committee for Regional Evacuation Place" in TDMMC or Tehran Municipality Office. Major roles of the committee can be considered as follows;

- To review the regional evacuation place regularly in cooperation with Park and Open Space Organization,
- To coordinate with the private owners of candidate regional evacuation place to designate those areas as regional evacuation place, and
- To approach land use planning and redevelopment projects for securing open space as regional evacuation place.

Based on GIS data, there are some parks and open spaces belonging to the Military which are not included in the above list. It is one of possibilities to secure these Military areas as regional evacuation place depending on political issues.

The area outside coverage of the regional evacuation place, white area in Figure 5.1.3, has to be secure as regional evacuation place. In absence of those areas, to improve community evacuation place should be completed at least. Details of community evacuation place are shown in the following section 5.1.2.

6) Installation of Facilities in the Regional Evacuation Place

Based on size of each regional evacuation place, it should keep appropriate facilities and/or equipments for occurrence of an earthquake, that is, helicopter ports, toilets, telecommunication system, water tanks, food storages, and so on. Chapter 11 of this report provides more details. Accordingly, relevant signboards should be set up at the regional evacuation place. The following figure shows signboards at regional evacuation places in Japan as one of example.

Signboard for ”Regional Evacuation Place and Temporary Relief Place”

Signboard for ”Emergency Heliport”

Signboard for ”Relief Supplies Terminal”

Source: Official homepage of Odawara City, Japan

Figure 5.1.4 Examples of Signboard at Regional Evacuation Place

5.1.2 Community Evacuation Place and Evacuation Route

The study team recommends that a “Committee of Evacuation Place and Route” is established at District Municipality which can consist of district officers and volunteers from communities or local residence. As a pilot project in District 17, a district officer specified community evacuation places and evacuation route based on opinions from community’s representatives. Advantage of involvement with local people is not only to accumulate local information but also to promote growing awareness of disaster prevention activities.

1) Selection of Community Evacuation Place

Each district shall identify its community evacuation place. Community level evacuation place should cover the whole Tehran Municipality completely. The study team prepared a guideline regarding community level evacuation place identification and distributed it to each district through TDMMC.

2) Evacuation Route

Designation of evacuation route is proposed to link and connect community gathering and evacuation places with regional evacuation area safely, especially for the area as follows:

- Area in the zone located in the outside, 2 km from the regional evacuation place

- Hazardous facilities are identified in the zone
- Designated emergency road /or expressway, highway and railway are passing through the zone

In the selection of evacuation route, the following should be considered for safety reasons:

- Select roads wider than 15 m
- Do not select route adjacent to the identified hazardous facilities as much as possible
- Do not select route passing through vulnerable building area as much as possible
- Do not select designated emergency road network as much as possible

Maintenance and improvement of identified evacuation route should be done by district municipality and communities. For example, to carry out road markings on evacuation route is safe announcement for local people and to keep out illegal parking.

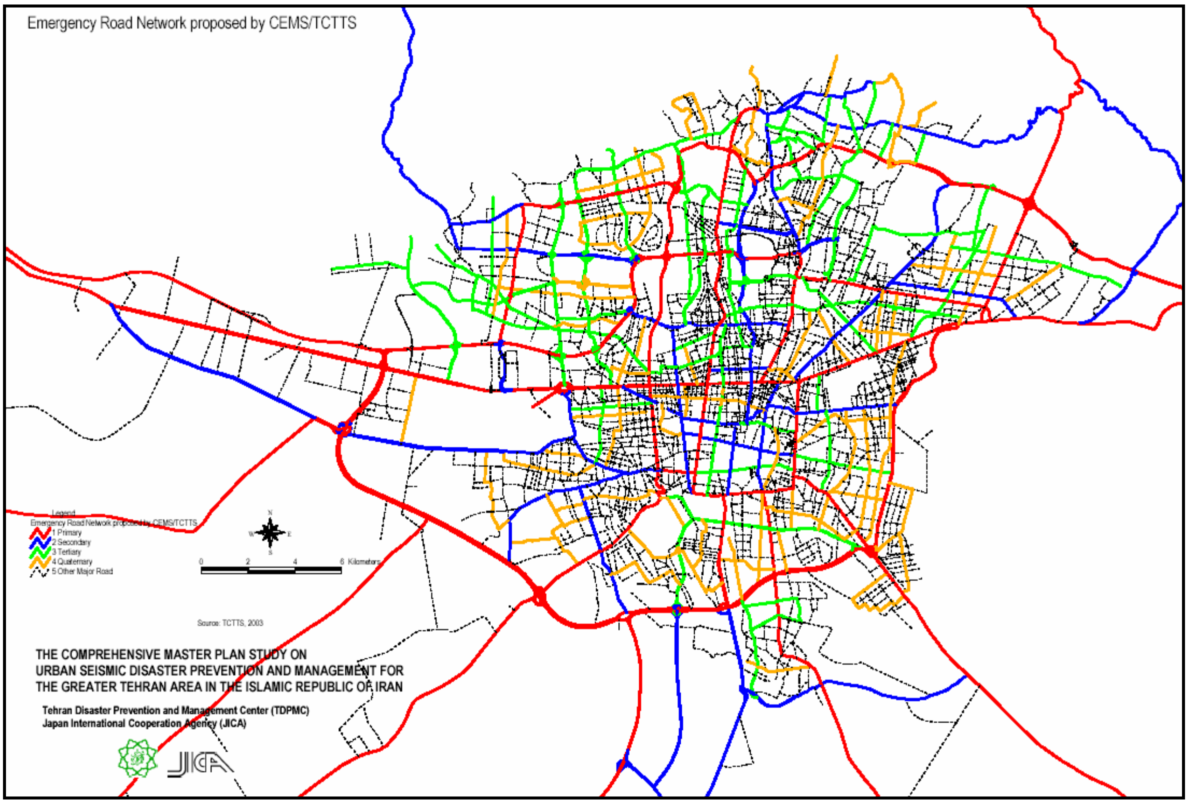
Source: Official homepage of Itabashi district municipality, Japan

Figure 5.1.5 Example of Road Marking on Evacuation Routes

5.2 Emergency Road Network

5.2.1 Review of Emergency Road Network Plan by TDMMC

Primary emergency road network has been made by TDMMC on September 2003 (see Figure 5.2.1). Based on the network, policy and approach of TDMMC are fairly different from that of the study team. The obvious differences are pointed out as follows:



Source: TDMMC

Figure 5.2.1 Primary Emergency Road Network by TDMMC

- Approach to obtain the emergency road network by the study team and TDMMC is different. In this study, government office is considered to be emergency response headquarters and traffic flows between these offices are given the first priority. This is the general procedure for emergency management control. On the other hand, TDMMC focuses on the road network specialized for rescue operation.
- It is not completely clear which network is superior or important. Comparison of these networks is not meaningful at this very preliminary stage.
- Both networks use the same road network data and similar calculation methods. However, the data itself are incomplete.
- There is common recognition that emergency transportation network shall be analyzed by the shortest pass analysis using GIS database and programs.
- It is indispensable to investigate and study what kind of origins and destinations of traffic flows have higher priority. Conditions of velocities and quantities of traffic flow shall be determined in order to obtain appropriate networks.

Taking the above circumstances into consideration, the basic policy and recommendations for traffic control are presented in the next section.

5.2.2 Proposed Emergency Road Network System

Emergency road network should be selected from the existing arterial road network, the roads of which are required to be wider than 15 m in order to avoid and minimize influences from roadside building damages and secondary disasters. Emergency road network should not be excessively designated. It should be set in coordination with actual capabilities of each emergency response taskforces of debris removal, traffic control, etc. Otherwise, the designated emergency road network could not work and be used within 3 days after an earthquake, which is the time limit for full operation of emergency response activities. The proposed Emergency Road Network System consists of two levels of road networks, which correspond to the required timing of emergency response activities as follows.

1) Primary Emergency Road

It is defined as linking with Disaster Management Centers of national, provincial, municipality, district, and sub-district municipalities and major airport and seaport as for transportation nodes.

In order to set-up the network, all centers have to be clearly identified and categorized on the base map.

2) Secondary Emergency Road

Secondary Emergency Road is linking with all the identified emergency response centers of rescue/fire fighting/security, emergency road, and medical care.

Also, all emergency response centers have to be clearly identified and categorized in the base map.

5.2.3 Approach and Method for Emergency Road Network

GIS-based Shortest Path Analysis Method is proposed and applied to identify the minimum time distance route to link with the identified centers for each level of emergency road. The shortest path is analyzed on the road inventory database of TCTTS. The Preliminary Emergency Road Network of JICA is selected by the sum of estimated trips on each road section between each center based on Shortest Path Analysis.

The following are required points for review of the proposed three levels of Emergency Road Network:

1) The identified center on the steps of 2), 3) and 4) as indicated below should be revised,

when the Emergency Response Plan is finalized.

2) Based on above finalized plan, identified Centers shall be replaced by the finalized center.

3) Shortest path analysis shall be applied for above new centers. And two levels of emergency road network shall be finalized.

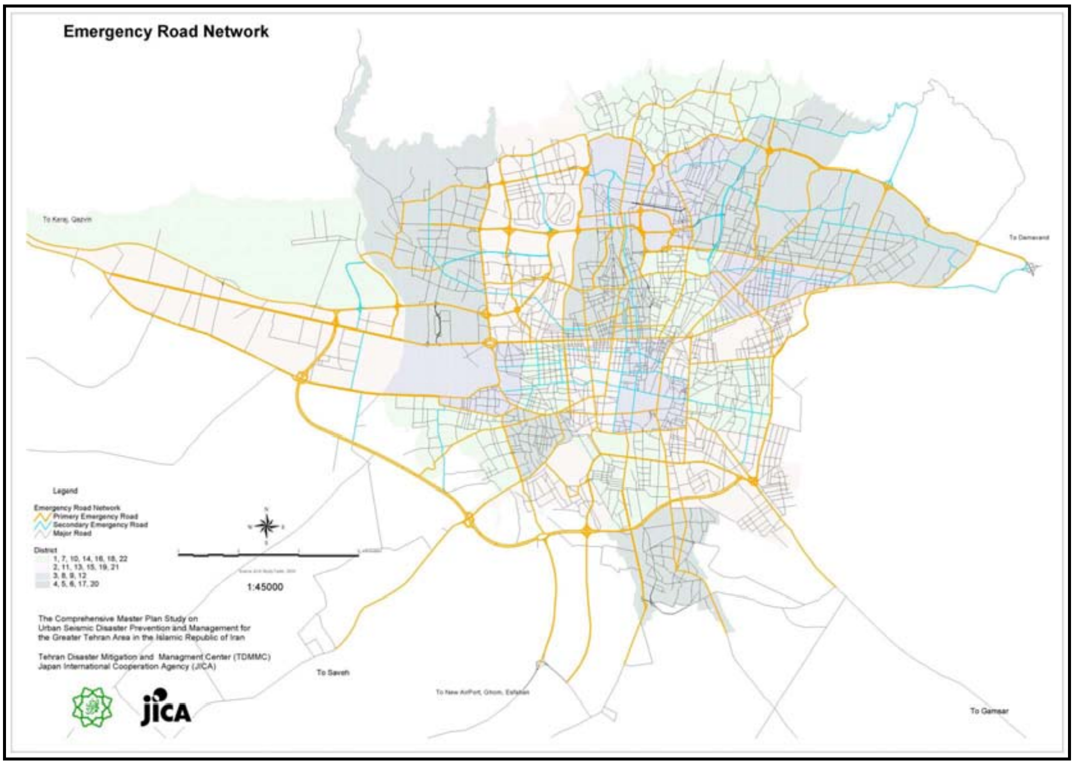
4) Seismic resistance diagnosis is proposed for all bridges on the selected emergency road. Structural strengthening and reconstruction program shall be formulated for the assessed vulnerable bridges.

5) Road improvement program is proposed to the following vulnerable sections:

- Road widening for narrow road section
- Preparation of buffer zone to mitigate influence for hazardous road section
- Retrofitting and reconstruction of assessed vulnerable buildings on the roadside.

5.2.4 Emergency Road Network

The Study Team identified the emergency road network by using shortest path analysis. The following figure shows emergency road network in the Study Area.



Source: JICA Study Team

Figure 5.2.2 Proposed Emergency Road Network

1) Primary Network

Identify Disaster Management Centers/Major Transportation Node for Primary Emergency Road (most of required data were provided by responsible agencies).

1. National Level: Ministry of Interior and all the members of NCNDR
2. Provincial Level: Provincial Disaster Management Center
3. Municipality Level: TDMMC
4. District Level: District Disaster Management Center or District Offices
5. Sub-District Level: Sub-District Offices
6. Air Transport Node: the existing and new international airports
7. Public Relation: <u>Radio/TV station</u> and <u>news agency</u>

List of Primary Road Network is shown in Table 5.2.1.

Table 5.2.1 List of Primary Road Network

No.	Name	No.	Name	No.	Name
1	17th. Shahrivar St.	36	Jenah Exp.way	71	Rajaee Exp,way
2	Abshenassan Exp.way	37	Karaj Highway	72	Ressalat Exp.way
3	Amin ol molk St.	38	Karaj Special Highway	73	Sadr Exp.way
4	Andisheh Blvd.	39	Kargar North St.	74	Saheb Jam St.
5	Asbdavani Exp.way	40	Karimkhan Zand St.	75	Saidi Exp.way
6	Ashrafi Esfahani Exp.way	41	Keshavarz Blvd.	76	Samadi St.
7	Azadegan Highway	42	Khavaran Exp.way	77	Shahid Ghayori St.
8	Azadi Sq.	43	Kordestan Exp.way	78	Shahid Rajabnia
9	Azadi St.	44	Latifi St.	79	Shahid Tondgoyan Exp.
10	Azari St.	45	Madani Exp.way	80	Shahid_e Gomnam Exp.way
11	Babaee Exp.way	46	Masil Bakhtar St.	81	Shahran Blvd.
12	Basij Exp.way	47	Mehran St.	82	Shariati St.
13	Basij Sq.	48	Meysami Blvd.	83	Sheykh Fazlollah Nouri Exp.way
14	Behdari St.	49	Milad Blvd.	84	Shoush St.
15	Behesht Zahra Highway	50	Misagh St.	85	Taavon Blvd.
16	Beheshti St.	51	Moallem Blvd.	86	Taleqani St.
17	Besat Exp.way	52	Modares Exp.way	87	Tehran_Qom Highway
18	Chamran Exp.way	53	Molavi St.	88	Tehran_Varamin Road
19	Damavand St.	54	Molla Sadra St.	89	Tello_Lashkarak Road
20	Darabad Exp.way	55	Monirieh Sq.	90	Valiasr St.
21	Dasht_e_Azadegan	56	Mostafa Khomeini St.	91	Yadegar_e Emam Exp.way
22	East Azadi Sportland Blvd.	57	Motahari	92	Yaftabad St.
23	Ebn_e Sina St.	58	Navab Exp.way	93	Zamzam St.
24	Emam Hosein Sq.	59	Nejatollahi St.	94	Zandieh St.
25	Enqelab_e Eslami St.	60	Niavaran St.	95	Ziba Shahr St.
26	Estadiom St.	61	Niayesh Exp.way		
27	Estakhr Blvd.	62	Noor St.		
28	Evin Exp.way	63	Parvin Blvd.		
29	Fadaeean_e_Eslam St.	64	Pasdarran St.		
30	Fath Exp.way	65	Pirouzi St.		
31	Haqqani Exp.way	66	Qaleh Morghi St.		
32	Helal_e_Ahmar St.	67	Qazvin St.		
33	Hemmat Exp.way	68	Qoddousi Blvd.		
34	Jahad Sq.	69	Qom Road		
35	Jalal_e Ale Ahmad Exp.way	70	Rah Ahan Sq.		

Source: JICA Study Team 2004

2) Secondary Emergency Road

Identify Emergency Response Centers for Secondary Emergency Road are shown as follows.

1. Fire Fighting/Search/Rescue/Security: Fire-fighting Stations, Red Crescent, Police Station, and Military force.
2. Medical/Health Care: Ambulance Center, Hospital, Health Center, Blood Center, and storage of medical equipment/medicine.

3. Emergency Road: Traffic police (GIS Data), Traffic Control Center, Road Maintenance Dept., City Service Center and Related Private Companies for Debris Removal,
4. Autopsy/Identification/Burial Service: Autopsy Organization, Beheshte, and Identification.
5. Building Inspection/Temporary Housing Supply: Responsible agencies could not be identified yet,
6. Debris Removal: City Service Center and Related Private Companies, contractors for Debris Removal, and Debris Disposal Site,
7. Lifeline-1 Water: Purification plants and Reservoir with emergency/ rehabilitation centers
8. Lifeline-2 Gas: All Emergency Response and Rehabilitation Centers
9. Lifeline-3 Electricity: All Emergency Response and Rehabilitation Centers
10. Lifeline-4 Telecom: All Emergency Response and Rehabilitation Centers

It should be noted that Data and information of underlined facilities could not be obtained from responsible agencies.

List of Secondary Road Network is shown in Table 5.2.2.

Table 5.2.2 List of Secondary Road Network

No.	Name	No.	Name	No.	Name
1	142 West St.	21	Golestan St.	41	Narenjestan 7th
2	15 Th Khordad St.	22	Golha St.	42	Nbovvat Sq.
3	30 m Jey	23	Hafez St.	43	Niayesh Exp.way
4	AbouSaeed St.	24	Hashemi St.	44	Nosrat St.
5	Alghadir Blvd.	25	Janbazan East St.	45	Ostad Hasan Banna St.
6	Amirkabir St.	26	Janbazan West St.	46	Ozgol Exp.way
7	Araqi Exp.way	27	Jeihoun St.	47	Paknejad Blvd.
8	Ayat St.	28	Jomhouri Eslami St.	48	Parvin Blvd.
9	Azizi St.	29	Kamali St.	49	Qanat Kosar St.
10	Badiei St.	30	Kashani Blvd.	50	Qarani St.
11	Bahar Blvd.	31	Khaled Estamboli St.	51	Ressalat Exp.way
12	Baharestan Sq.	32	Khalij St.	52	Rodaki South St.
13	Chogan Blvd.	33	Khayam St.	53	Sattar Khan St.
14	Dolat St.	34	Komail St.	54	Seraj St.
15	Emam Khomeini St.	35	Kordestan Exp.way	55	Sobhani St.
16	Esteqlal St.	36	Laleh Blvd.	56	Soleimani St.
17	Fajr Blvd.	37	Lashkarak Road	57	Vafadar Exp.way
18	Ferdosi St.	38	Mirza_ye Shirazi St.	58	Vahdat_e_Eslami St.
19	Gandi St.	39	Moayeri St.	59	West Azadi Sportland Blvd.
20	Golbarg West St.	40	Nabard St.	60	Zartosht East St.
				61	Zeyneddin Exp.way

Source: JICA Study Team 2004

3) Improvement and Maintenance of the Emergency Road

Improvement of identified emergency roads above, both of primary and secondary ones, should be carried out for the time of disaster. The preparation can be considered as the following items, which are done by TDMMC in cooperation with other organizations.

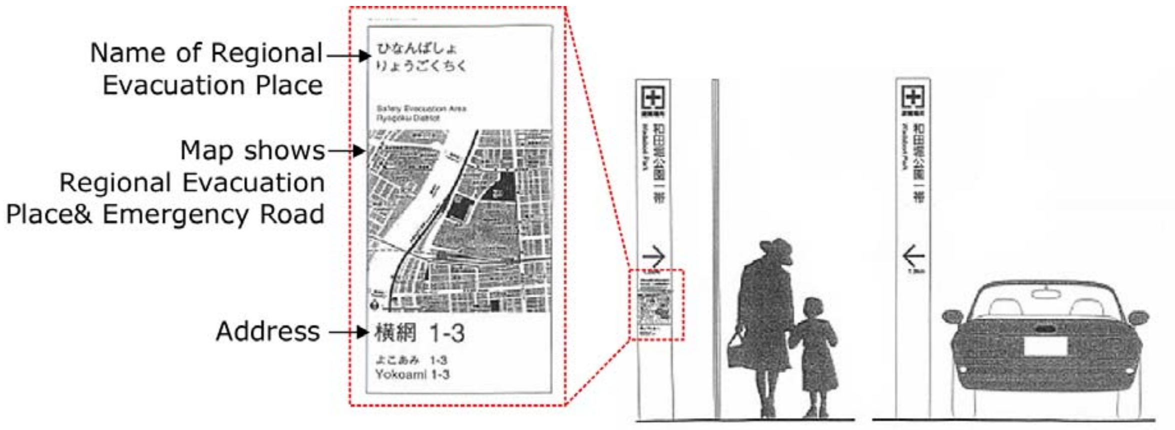
- To keep the building along the roads less than seven meters high as well as strengthening the building, in order to avoid blocking the emergency road by collapsed building
- To strengthen bridges and pedestrian decks cross the emergency roads
- To strengthen traffic light and to set up emergency power generating system in major intersections
- To set up emergency telephones and loud speakers along primary emergency road
- To put signboards for announcement of emergency road and for evacuees (see Figure 5.2.3 and Figure 5.2.4)

It is also necessary to maintain those facilities and equipments, and to inspect illegal parking on the emergency roads in cooperation with traffic police department.

Source: Metropolitan Police Department, Japan

Note: Catfish is a symbol of earthquake in Japan

Figure 5.2.3 Signboard of Emergency Road in Tokyo, Japan



Source: Tokyo Metropolitan Government, Japan and modified by JICA Study Team

Figure 5.2.4 Signboards on Emergency Road for Evacuees in Tokyo, Japan

References to Chapter 5

Tokyo Metropolitan Government. 1999. *Urban Disaster Prevention Plan of Metropolitan Tokyo*. Tokyo.

Bureau of Urban Development, Tokyo Metropolitan Government. 1999. *Implementation Plan for Creating Urban Disaster-prevention.* Tokyo.

Metropolitan Police Department of Japan. 2004. *What to do in case of an earthquake in Tokyo*. on Official Homepage.

Odawara City, Japan. 2004. *Disaster Prevention Plan in Odawara*(in Japanese) on Official Homepage.

Gyosei. 1997. *Urban Prevention Disaster Handbook*(in Japanese). Tokyo.

Keikokusha. 1995. *City Planning Textbook*(in Japanese). Tokyo.

Yasumichi Mifune. 1997. *Keyword Dictionary for Urban Planning*