THE TEHRAN DISASTER MITIGATION AND MANAGEMENT ORGANIZATION,
TEHRAN MUNICIPALITY (TDMMO)
ISLAMIC REPUBLIC OF IRAN

THE PROJECT FOR CAPACITY BUILDING FOR EARTHQUAKE RISK REDUCTION AND DISASTER MANAGEMENT IN TEHRAN IN THE ISLAMIC REPUBLIC OF IRAN

PROJECT COMPLETION REPORT

JANUARY 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
OYO INTERNATIONAL CORPORATION

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PHOTOS

1st JCC [June 2012]

CP training for Output3 in Japan [December 2012]

Output2: Seminar on Planning and Operation of DRR Museums [February 2013]

Output3: Site investigation of seismograph observation candidate location [February 2013]

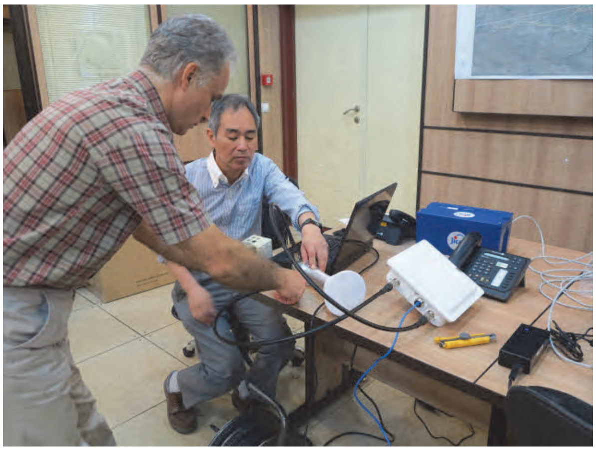
Output1: Discussion on the Emergency Road Network [April 2013]

Output2: Introduction of disaster management education tools [December 2013]

Output2: Evacuation Drill [January 2014]

CP training for Output2 in Japan [February 2014]

Output1: Site investigation of Bridge [May 2014]



Output3: Communication system test [June 2014]

Output1: Command Post Exercise [September 2014]

4th JCC [February 2015]

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LIST OF ABBREVIATIONS

ADSL	Asymmetric Digital Subscribe Line
BHRC	Building and Housing Research Center
BRT	Bus Rapid Transit
C/P	Counterpart
CPX	Command Post Exercise
DAVAM	Neighborhood Emergency Response Volunteers
DES	Damage Estimation System (a subsystem of QD&LE System)
DIG	Disaster Imagination Game
DIW	Disaster Imagination Workshop
DMM	Disaster Management Museum
EEWS	Earthquake Early Warning System
ERCC	Emergency Response Commanding Centre
ERN	Emergency Road Network
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GNI	Gross National Income
GPS	Global Positioning System
HAZUS	HAZards U.S
HP	Home Page
ICS	Incident Command System
ICT	Information and Communication Technology
IGUT	Institute of Geophysics, University of Tehran
IIEES	International Institute of Earthquake Engineering and Seismology
ISDN	Integrated Services Digital Network
IUST	Iran University of Science and Technology
JCC	Joint Coordinating Committee
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
JMA	Japan Meteorological Agency
LAN	Local Area Network
M/M	Minutes of Meetings
MMI	Modified Mercalli Intensity scale
MPLS	Multi-Protocol Label Switching
NGO	Non-Governmental Organization
PDM	Project Design Matrix
PGA	Peak Ground Acceleration
PO	Plan of Operation
O&M	Operation and Maintenance
QD&LE	Quick Damage and Loss Estimation
OJT	On the Job Training
RCS	Red Crescent Society of the Islamic Republic of Iran
R/D	Record of Discussion
SMS	Short Message Service
S/N	Signal to Noise ratio
SOP	Standard Operation Procedure
SRTM	Shuttle Radar Topography Mission
TDMH	Tehran Disaster Management Headquarter
TEDES	Tehran Earthquake Damage Estimation System
TOT	Training of Trainers
TTCC	Tehran Traffic Control Company
TTX	Table Top Exercise
TDMMO	Tehran Disaster Mitigation and Management Organization, Tehran Municipality
UNDP	United Nations Development Programme
WCDRR	World Conference on Disaster Risk Reduction
WiMAX	Worldwide Interoperability for Microwave Access

1. INTRODUCTION

1.1. Background

Tehran Municipality, with a population of 11 million, is the capital city of the Islamic Republic of Iran (hereinafter referred to as “Iran”), a country that has a land area of 1.65 million km^2, population of 73.86 million and a per capita GNI of 4,530 US dollars (World Bank 2010). The city is located at the foot of Alborz Mountains and has a high seismic potential with many active faults. Based on historical seismic data, Tehran has suffered from major earthquakes roughly every 150 years. Since the 20^{th} century, Tehran has experienced rapid urbanization without an appropriate system for disaster management and when the next major earthquake hits, it is expected that it will be a catastrophe of a scale unprecedented.

Against such background, JICA implemented two development studies and one technical cooperation project. “The Study on Seismic Microzoning of the Greater Tehran Area” (1999-2000) (hereinafter referred to as the “Microzoning Study”) estimated that the number of casualties could reach up to 380,000. “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management of the Greater Tehran Area” (2003-2004) (hereinafter referred to as the “Master Plan Study”) followed to formulate a systematic seismic disaster management plan in the three phases: normal situation, emergency situation, and reconstruction and to identify priority projects. During the Master Plan Study, Bam Earthquake took place, invoking awareness in the Tehran Municipality of the need to promote an emergency response system and hence The “Project for Establishment of an Emergency Response Plan for the First 72 Hours after an Earthquake” (2006-2010) (hereinafter referred to as the “Emergency Plan Project”) was implemented. The Emergency Plan Project aimed at improving the capacity of Tehran to respond swiftly and properly under emergency through three Outputs: the emergency response command system is improved; a quick damage and loss estimation (QD&LE) system is developed and operated; and the emergency evacuation plan and capacity are improved.

The capacity of TDMMO has improved as a result of the above development studies and technical cooperation. However, while the Tehran Municipality needs to establish a structure for taking initial action based on the information from the QD&LE system and secure an emergency transport route for the transportation of emergency aid supply and that of emergency vehicles, there is no specific manual for road management and no training has been carried out either. Further, the existing emergency road network does not reflect the road conditions in an emergency situation such as a road blockage due to damage of bridges. People in Tehran would need to take actions on their own based on the information of the earthquake provided by the media etc. until the government could takeover, but the level of civil participation in the community disaster management activities such as rescue is insufficient and awareness-raising is not moving forward. Construction of the Disaster Management Museum is planned, yet they lack experience in displaying such goods and in providing education using such goods. In addition, the early warning system adopted is the QD&LE system that has been recently introduced and needs improvement for the government and citizens to initiate an effective emergency response in case of an earthquake.

Against such background, the government of Iran has requested the government of Japan to conduct the next technical cooperation project, the Project for Capacity Building for Earthquake Risk Reduction and Disaster Management in Tehran (hereinafter referred to as “the Project”), aimed at: increasing the capacity of the emergency road network; improving public understanding of an earthquake; and upgrading the QD&LE system. JICA implemented the Preliminary Study from September to November 2013. The contents and area of cooperation was agreed between JICA and the counterparts, and the minutes of meeting (M/M) was signed and exchanged. Record of discussion (R/D) was also signed and exchanged on 18 December 2011.

1.2. Project Description

(1) Name of the Project

The Project for Capacity Building for Earthquake Risk Reduction and Disaster Management in Tehran

(2) Overall Goal of the Project

Integrated preparedness for response of Tehran Municipality against earthquake disaster is improved.

(3) Purpose of the Project

In the three areas of road disaster management, community disaster management and early warning, preparedness for response against earthquake disaster of Tehran Municipality is improved.

(4) Outputs of the Project and their Activities

【Output 1】

Capabilities of TDMMO for formulation, operation, maintenance, and management of plans related to road management against earthquake disaster are improved.

(Activities)

1-1 To upgrade the emergency road networks in consideration of an expansion of Tehran, the location of important facilities inside and outside of Tehran and others

1-2 To prepare multiple and alternative plans of the main emergency road network in conjunction with other transportation systems such as air transportation, railways and subways

1-3 To assess the vulnerability of the emergency road networks based on the aspects including lifeline facilities such as stations and water, gas, electricity and telecommunication lines, etc. and their interactions

1-4 To prepare a seismic resistant plan for the vulnerability of the emergency road networks including bridges and tunnels

1-5 To prepare an operation and maintenance plan of the emergency road networks including methodology of clearing the roads after an earthquake, and methodology of revising and expanding the emergency road networks in the future

1-6 To prepare a draft instruction for design and construction of structures, lifelines and buildings adjacent to the emergency road networks, to be included in the urban development plan

1-7 To hold seminars and workshops on the plans related to the emergency road networks

To hold Simulations (Drills) utilizing disaster scenario based on the result of the damage estimation and in consideration of the emergency road networks

【Output 2】

Capabilities of TDMMO for formulation, operation, maintenance, and management of plans related to community-based disaster management against earthquake disaster are improved.

(Activities)

2-1 To study current public awareness of the earthquake disaster

2-2 To study the contents and effectiveness of the disaster education for the public in the past

2-3 To review and improve the existing master plan on public training and awareness for the earthquake disaster management including short term (from 2 to 3 years) action plans

2-4 To prepare public education training tools and materials

2-5 To prepare and finalize the basic concept, display plan, circulation scenario, floor plan, spaces required, and equipment plan for each space and drawing of each section for the disaster management museum

2-6 To prepare a public education plan and program conducted at the disaster management museum

2-7 To prepare an operation and management plan for the disaster management museum

2-8 To hold workshops on the community-based disaster management

2-9 To conduct emergency evacuation drills in designated Mahalle

【Output 3】

Capabilities of TDMMO for formulation of plans related to early warning and operation, maintenance and management of the system including the QD&LE system installed in the previous Project are improved.

(Activities)

3-1 To prepare an improvement plan for the early warning including the QD&LE system

3-2 To prepare an improvement plan for the existing seismograph network in and around Tehran considering future implementation of the earthquake early warning system (EEWS[1])

[1] EEWS is the system to issue early warning by estimating magnitude and epicenter (distance and direction) using P-wave.

3-3 To develop a pilot scale earthquake early warning system and prepare an action plan for further development of the system including necessary measures to be taken by related organizations such as water, electricity, gas, and fuel pipes, and fire and safety services, and subways

3-4 To strengthen data the communication systems for the QD&LE system based on investigation of communication systems, recommendation of suitable systems and development of backup lines

3-5 To increase items of the QD&LE system in addition to buildings and casualties

3-6 To install a seismic intensity early warning system for emergency response and public awareness

3-7 To improve the current multi-layered warning system for more effective emergency response activities

3-8 To prepare a plan to introduce a post-earthquake (secondary events) information and warning system

(5) Project Site

The project site consists of a total of 22 districts of the legal territory of Tehran and the surrounding area (Greater Tehran Area). A map of the Project site is shown in Figure 1.2.1 on the following page.

(6) Responsible and Implementing Authorities and Organizations

Tehran Disaster Mitigation and Management Organization (TDMMO）

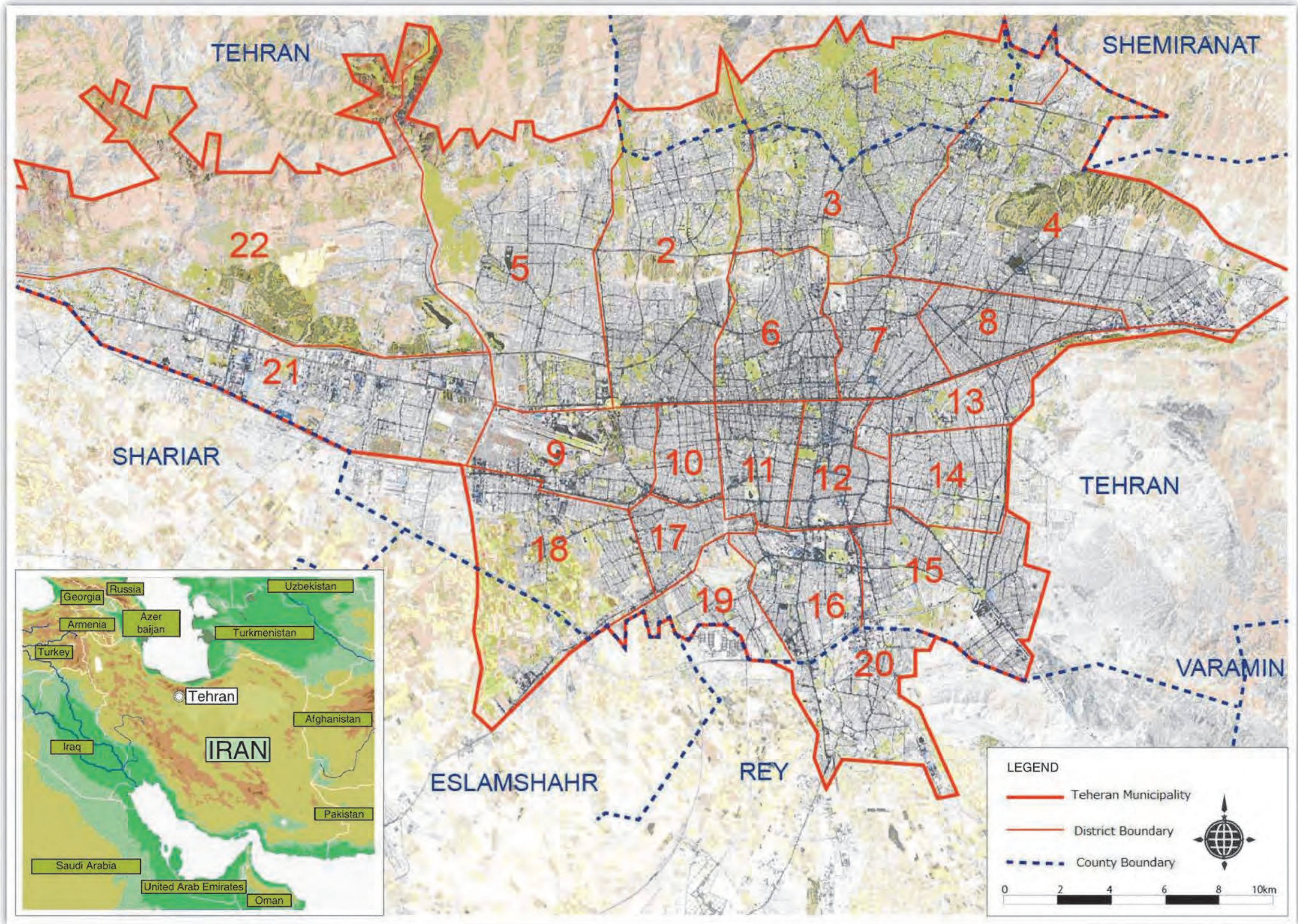


Figure 1.2.1 Map of the Project Site (Greater Tehran Area)

2. CONTENTS OF ACTIVITIES

2.1. Activities related to the whole project

The activities corresponding to PDM of the Project are as follows and the work flow chart is shown in Figure 2.1.1.

Table 2.1.1 Activities corresponding to PDM

No.	No. in PDM	Activity
Activities related to the whole project		
【1】	-	To prepare, discuss, and finalize the Work Plan
【27】	-	To prepare the Progress Reports
【28】	-	To prepare the Project Completion Report
【29】	-	To provide counterpart training in Japan
【30】	-	To hold a joint seminar
Activities related to Output 1		
【2】	1-1	To upgrade the emergency road networks in consideration of the expansion of Tehran, the location of important facilities inside and outside of Tehran and others
【3】	1-2	To prepare multiple and alternative plans of the main emergency road network in conjunction with other transportation systems such as air transportation, railways and subways
【4】	1-3	To assess vulnerability of the emergency road networks based on the aspects including lifeline facilities such as stations and water, gas, electricity and telecommunication lines, etc. and their interactions
【5】	1-4	To prepare a seismic resistant plan for the vulnerability of the emergency road networks including bridges and tunnels
【6】	1-5	To prepare an operation and maintenance plan of the emergency road networks including methodology of clearing the roads after an earthquake, and methodology of revising and expanding the emergency road networks in the future
【7】	1-6	To prepare a draft instruction for design and construction of structures, lifelines and buildings adjacent to the emergency road networks, to be included in the urban development plan
【8】	1-7	To hold seminars and workshops on the plans related to the emergency road networks
【9】	1-8	To hold Simulations (Drills) utilizing the disaster scenario based on the result of the damage estimation and in consideration of the emergency road networks
Activities related to Output 2		
【10】	2-1	To study current public awareness on the earthquake disaster
【11】	2-2	To study the contents and effectiveness of the disaster education for the public in the past
【12】	2-3	To review and improve the existing master plan on public training and awareness for the earthquake disaster management including short term (from 2 to 3 years) action plans
【13】	2-4	To prepare public education training tools and materials
【14】	2-5	To prepare and finalize the basic concept, display plan, circulation scenario, floor plan, spaces required, and equipment plan for each space and a drawing of each section for the disaster management museum
【15】	2-6	To prepare a public education plan and program to be conducted at the disaster management museum
【16】	2-7	To prepare an operation and management plan for the disaster management museum
【17】	2-8	To hold workshops on the community-based disaster management
【18】	2-9	To conduct emergency evacuation drills in designated Mahalle
Activities related to Output 3		
【19】	3-1	To prepare an improvement plan on early warning including the QD&LE system
【20】	3-2	To prepare an improvement plan of the existing seismograph network in and around Tehran considering future implementation of the earthquake early warning system (EEWS)
【21】	3-3	To develop a pilot scale earthquake early warning system and prepare an action plan for further development of the system including necessary measures to be taken by related organizations such as water, electricity, gas, fuel pipes, fire and safety service, and subways

No.	No. in PDM	Activity
【22】	3-4	To strengthen data communication systems for the QD&LE system based on investigation of communication systems, recommendation of suitable systems and development of backup lines
【23】	3-5	To increase items of the QD&LE system in addition to buildings and casualties
【24】	3-6	To install a seismic intensity early warning system for emergency response and public awareness
【25】	3-7	To improve the current multi-layered warning system for more effective emergency response activities
【26】	3-8	To prepare a plan to introduce a post-earthquake (secondary events) information and warning system

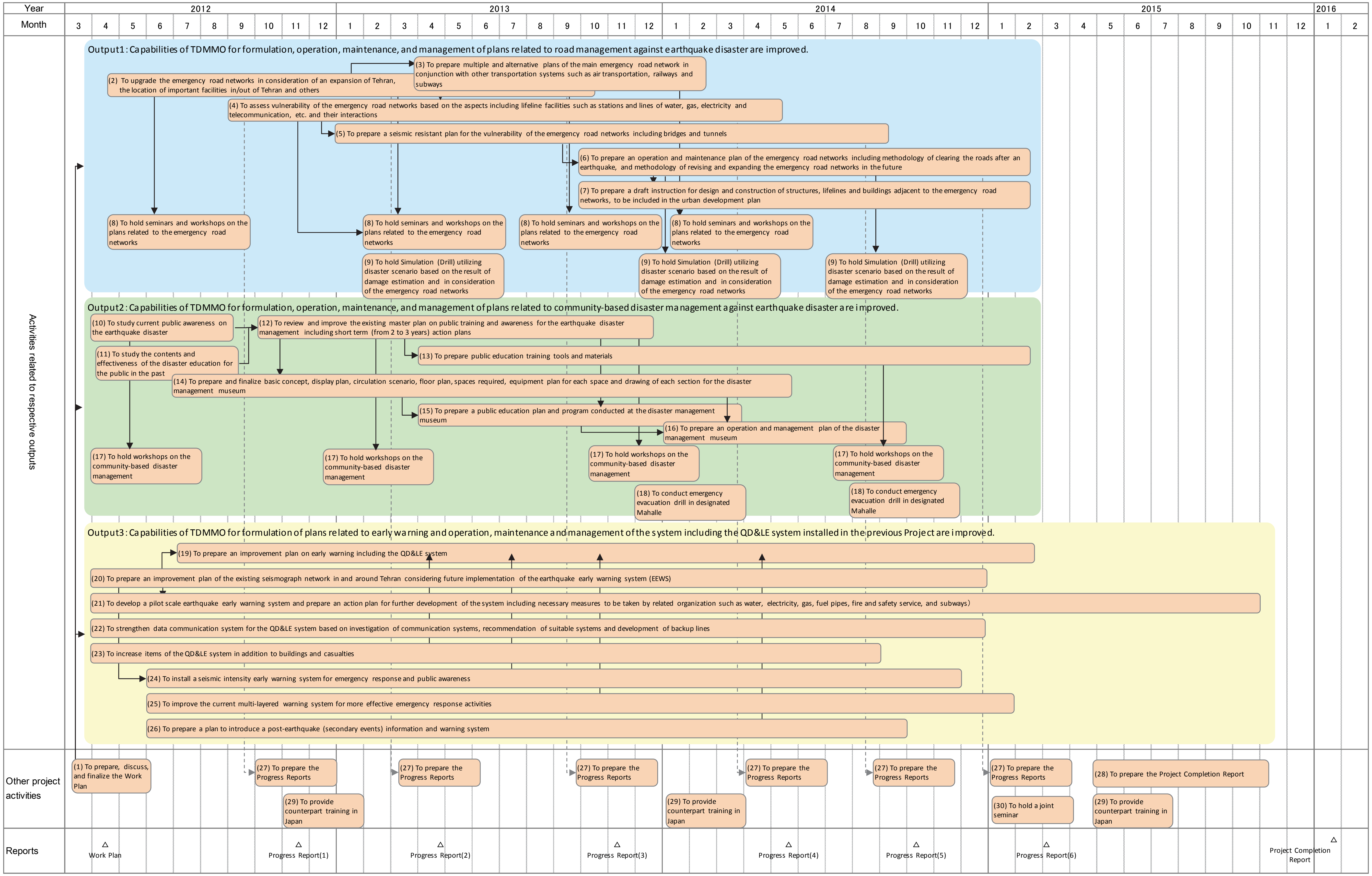


Figure 2.1.1 Work Flow Chart

2.1.1 【1】To prepare, discuss, and finalize the Work Plan

The JICA Expert Team formulated implementation policies and activities, as well as the work plan and incorporated them into the Work Plan (draft). Then, discussions were held with the Iranian side based on the Work Plan (draft) and the overall description of the Project was shared. Also, the Persian version of the work plan (tentative translation) for better discussion with the stakeholders in Iran was prepared. Based on the discussions above mentioned, the Work Plan (draft) was revised and finalized upon discussion with the stakeholders in Iran. The WORK Plan was agreed to and adopted at the first Joint Coordination Committee (JCC) on 2 June 2012.

Appendix7：Minutes of Meeting of JCC

2.1.2 【27】To prepare the Progress Reports

The JICA Expert Team prepared progress reports (1-6) about the project activities. A Persian version of the report was also prepared so as to discuss and revise the contents with local stakeholders. The progress reports were submitted to JICA as shown in the following table.

Table 2.1.2 Submission of Progress Report

Name of Report	Term	Submission day	Number of copies
Progress Report 1	From April to September 2012	20 November 2012	Japanese 5 books English 10 books (5 books for local government) Persian 35 books (32 books for local government) CD-R (English and Persian) 3 CDs (2 CDs for local government)
Progress Report 2	From October 2012 to March 2013	30 April 2013	Japanese 10 books English 10 books (5 books for local government) Persian 35 books (32 books for local government) CD-R (English and Persian) 3 CDs (2 CDs for local government)
Progress Report 3	From April to September 2013	8 November 2013	Japanese 10 books English 10 books (5 books for local government) Persian 35 books (32 books for local government) CD-R (English and Persian) 3 CDs (2 CDs for local government)
Progress Report 4	From October 2013 to March 2014	28 May 2014	Japanese 10 books English 10 books (5 books for local government) Persian 35 books (32 books for local government) CD-R (English and Persian) 3 CDs (2 CDs for local government)
Progress Report 5	From April to September 2014	8 October 2014	Japanese 10 books English 10 books (5 books for local government) Persian 35 books (32 books for local government) CD-R (English and Persian) 3 CDs (2 CDs for local government)

Name of Report	Term	Submission day	Number of copies
Progress Report 6	From October 2014 to February 2015	End of February 2015	Japanese 10 books English 10 books (5 books for local government) Persian 35 books (32 books for local government) CD-R (English and Persian) 3 CDs (2 CDs for local government)

2.1.3【28】To prepare the Project Completion Report

The JICA Expert Team prepared the Project Completion Report (this document) in which not only the Project activities but also the activities in Tehran of the Advisory Committee members were included. The Persian version of the report was also prepared for discussion with local stakeholders. The report was revised based on the result of the discussions, and it was reported in the 4th JCC on 18 February 2015. For activities 3-3, the contents were revised and updated based on the activities that were carried out in the extension period, and the report was finally completed in the end of January, 2016.

2.1.4【29】To provide the counterpart training in Japan

The counterpart training was carried out in Japan. The two weeks training was conducted for each of the three Outputs. A total of 15 personnel (five for each of the three Outputs) participated in a two-week training exercise. Training exercises were planned so that participants could understand the techniques used in Japan and could utilize the experience in the project activities after the training. Concretely, the training for Output1 included learning about the planning and management of the emergency road network in Japan, management and maintenance of eliminating road obstacles, and the technology of improvement of seismic resistant infrastructure. Output2 included the planning and management of disaster museums in Japan, and community engagement and disaster management education. Output3 included the technology of early warning systems and the role of media.

The training plan was prepared and got the approval from JICA before the training. The contents of the training were discussed among the JICA Expert Team, TDMMO and JICA, and the program including experiences and field tours was prepared. Participants were selected from the discussions with JICA and TDMMO.

The training also included site visits to disaster stricken areas in Tohoku in order to learn of the misery and lessons from the Great East Japan Earthquake. For instance, the lecture from a storyteller, a visit to temporary houses and the disaster stricken area were included.

This project organizes the Assistance Committee in Japan which has its main organization in Hyogo prefecture in order to obtain advises for the project. The training was also prepared in cooperation with the committee. The training in “Hyogo Prefecture” and “The Great Hanshin Awaji Earthquake Memorial Disaster Reduction and Human Renovation Institution” was positively utilized.

The abstract of each training is shown on Table 2.1.3, and the detailed schedule is shown from Table 2.1.4 to Table 2.1.6. The training for Output1 and Output2 was implemented at the same time.

Table 2.1.3 Abstract of Counterpart Training

Output	Name of Training	Term	Number of Participants
Output1	Counterpart Training (Output1 : Road Disaster Management) in Japan	From 21 February to 7 March 2014 (from 22 February to 6 March in Japan)	TDMMO 4 people Tehran Traffic Control Center 1 person
Output2	Counter Part Training in Japan 2014 (Output 2)	From 21 February to 7 March 2014 (from 22 February to 6 March in Japan)	TDMMO 3 people District One of Tehran municipality 1 person Tehran municipality 1person
Output3	Schedule of Counterpart Training (Output3:Early Warning) in Japan	From 9 to 22 December 2012 (from 10-21 in Japan)	TDMMO 5 people

Table 2.1.4 Schedule of Counterpart Training Output1

Date			Visit / Training Theme	Location
22-Feb	Sat	AM	↓	
		PM	Arriving Osaka, Osaka-Kobe	-
23-Feb	Sun	AM		-
		PM		-
24-Feb	Mon	9:30-12:00	Briefing	JICA Kansai
		14:00-16:00	Program Orientation(Explanation of this Training)	JICA Kansai
25-Feb	Tue	10:00-12:00	Lecture on Lessons learned, recovery and reconstruction from Great Hanshin-Awaji Earthquake by former Official of Kobe municipality	JICA Kansai
		13:10-13:20	Visit to Pier with the bared steel frame caused by the Great Hanshin-Awaji EQ	Near Kyobashi ramp of Hanshin express way
		14:00-16:00	Visit to Hyogo Prefectural Government(Kobe) / Lecture on countermeasures on disaster management of Hyogo Prefecture	Hyogo Prefecture
26-Feb	Wed	10:00-11:30	Visit to Hyogo Earthquake Research Center (E-defense) / Visit to see large laboratory equipment for seismic resistance	Hyogo Earthquake Research Center
		14:00-16:00	Visit to Hyogo Prefectural Emergency Management and Training Center / Lecture on setting the wide area network for preparation of widespread disaster	Miki Disaster Management Park
27-Feb	Thu	10:00-12:00	Visit to West Nippon Expressway Company /Visit to Traffic control center, Lecture on Disaster Countermeasures for highways and Clearing roads	West Nippon Expressway Company
		13:30-16:00	Visit to Osaka Gas Engineering Co.,Ltd / Lecture on countermeasures of gas facilities for earthquake, Visit to Central Operation Room at Osaka Gas Co., Ltd	Osaka Gas Engineering Co.,Ltd
28-Feb	Fri	8:30-12:30	Transferr(Plane) Kobe → Itami → Sendai→Ishinomaki	
		14:00-17:00	Lecture on Community based Reconstruction Visit to NeeSee Site Visit to Disaster Stricken Area in Great East Japan Earthquake	Downtown Creative Reconstruction Committee Ishinomaki city
1-Mar	Sat	10:00-14:00	Talk with Story teller Site Visit to Disaster Stricken Area in Great East Japan Earthquake	Ishinomaki city
		14:00-19:00	Ishinomaki → Sendai Transfer(Shinkansen) Sendai → Tokyo	
2-Mar	Sun	AM	Holiday（Arrangement of Documents and Data）	JICA Tokyo
		PM		JICA Tokyo
3-Mar	Mon	9:30-12:00	Interim Discussion	OC office
		14:00-16:00	Lecture on countermeasures for securing road network of metropolitan area by Official of Tokyo Metropolitan Government	OC office
4-Mar	Tue	9:30-11:00	Discussion on Seismic Retrofitting Plan	JICA Tokyo
		13:00-14:30	Visit to National Police Agency / Lecture on emergency road network and traffic control	National Police Agency
		15:00-16:00	Visit to Traffic Control Center at Metropolitan Police Department	Metropolitan Police Department
5-Mar	Wed	9:30-11:00	Waterbus Cruise (Tokyo Mizube Cruising Line) around Tokyo for viewing several Bridges 9:50 Ryogoku → 10:45 Odaiba	Around Tokyo
		14:00-17:00	Visit to Tokyo National Highway Office(Ministry of Land, Infrastructure, Transportation and Tourism Kanto Regional Development Bureau) / Lecture on maintenance and retrofitting of roads, visit to seismic retrofitting site of bridge and pipe utility conduit	Tokyo National Highway Office
6-Mar	Thu	9:00-10:00	Lecture on Disaster Management Countermeasures and Administration in Japan by Official of Cabinet Office	JICA Tokyo
		10:00-12:00	Preparation for Final Presentation	JICA Tokyo
		13:00-14:00	Final Presentation	JICA Tokyo
		14:00-15:30	Evaluation, Closing Ceremony	JICA Tokyo
			Leaving Japan（Tokyo(Narita) - Dubai - Tehran）	-
7-Mar	Fi	AM	Arriving Tehran	-
		PM		

Joint Training with Output1

Table 2.1.5 Schedule of Counterpart Training Output2

	Date			Activity Project Counter Part	Place
1	22-Feb	Sat	AM	↓	
			PM	Arriving in Japan（Arriving at Osaka [Kansai Airport]）、 Move to（Kansai Airport-Kobe）	
2	23-Feb	Sun	AM		
			PM		
3	24-Feb	Mon	9:30-12:00	Briefing	JICA Kansai
			14:00-16:00	Orientation	JICA Kansai
4	25-Feb	Tue	9:30-12:00	Disaster Reaction and Human Renovation Institute	Disaster reduction and Human Renovation Institute
			14:00-16:00		JICA Kansai
5	26-Feb	Wed	10:00-12:00	Introducing Bosai Community (BOKOMI) by Kobe city fire department	JICA Kansai
			13:30-16:30	Flog Caravan by Plus arts	JICA Kansai
6	27-Feb	Thu	10:00-12:00	Planning and Reality of Disaster Museum by Prof. Murosaki Emeritus Prof. Kobe Univ.	JICA Kansai
			14:00-16:00	Hokudan Earthquake Memorial Park	Hokudan Earthquake Memorial Park
7	28-Feb	Fri	8:30-14:00	Move （Kobe→Itami(ANA733/10:00-11:10)→Sendai→Ishinomaki 12:30）	
			14:00-17:00	Observation of Disaster Affected Site of East Japan Earthquake Visiting NewSee (local NGO)	Ishinomaki City
8	1-Mar	Sat	10:00-14:00	Observation of Disaster Affected Site of East Japan Earthquake	Ishinomaki City
			14:00-19:00	Move（Ishinomaki→Sendai→Tokyo）	
9	2-Mar	Sun	AM	Holiday	JICA Tokyo
			PM		JICA Tokyo
10	3-Mar	Mon	9:30-11:00	Mid-term reporting and Discussion Session	Oriental Consultants
			12:50-17:00	Honjyo Bosai Kan (training center)	Honjyo
11	4-Mar	Tue	10:00-12:00	Educational contents for promoting safer constructions by Prof. Fukuwa, Nagoya Univ.	JICA Tokyo
			13:00-15:00	Rescue now	JICA Tokyo
			14:00-16:00	Edo Tokyo Museum (Museum Team）	Ryogoku
12	5-Mar	Wed	9:30-10:30	Sona AREA	Tokyo Bay Area Regional Disaster Management Park
			14:00-16:00	Transferring Scientific Knowledge of Disasters by Dr. Nouguchi	NIED (National Research Institute for Earth Science and Disaster Prevention,Tsukuba)
			14:00-16:00	National Museum of Emerging Science and Innovation (Miraikan)	Odaiba (Tokyo Bay Area)
13	6-Mar	Thu	9:00-10:00	Lecture on Disaster Management Countermeasures and Administration in Japan by official of Cabinet Office	JICA Tokyo
			10:00-12:00	Preparation of Presentation	JICA Tokyo
			13:00-14:00	Final Presentation	JICA Tokyo
			14:00-15:30	Evaluation, Closing Ceremony	JICA Tokyo
			PM	Leaving Tokyo	
14	7-Mar	Fri	AM	Arriving Tehran	

Table 2.1.6 Schedule of Counterpart Training Output3

	Date			Training Theme / Visit	Location
1	9, Dec	Sun	AM		
			PM	✈Leaving Iran (Tehran-Dubai-Narita)	-
2	10, Dec	Mon	AM	↓	-
			PM	Arriving Narita, Transfer Narita-Tokyo	-
3	11, Dec	Tue	9:30-12:00	Briefing	JICA Tokyo
			13:00-15:00	Program Orientation（Explanation of the Training（Purpose、Expected Outcome、Presentation of Outcome, etc.）)	JICA Tokyo
4	12, Dec	Wed	10:30-12:00	Lecture on Earthquake Early Warning System, Seismic Intensity Information	Japan Metrological Agency
			14:30-16:30	Lecture on Development, Operation and Management of Seismograph Network, and Technical Contents of Earthquake Early Warning System	NIED(National Research Institute for Earth Science and Disaster Prevention)
5	13, Dec	Thu	10:00-12:00	Utilization of Earthquake Early Warning System (Seismic Information System and Observation System)	Kogakuin University
			13:30 - 14:30	Summary of the first half and the aim of the second half of the training Transfer Tokyo - Sendai	OC (Oriental Consultants)
6	14, Dec	Fri	10:00-12:00	Lecture on Current status of the Utilization of Earthquake Early Warning System during the Great East Japan Earthquake, Lessons of the Great East Japan Earthquake by Professor Motosaka	Tohoku University
			PM	Transfer Sendai - Ichinoseki - Kesennuma Visit to Kesennuma City Transfer Kesennuma - Ichinoseki	-
7	15, Dec	Sat	10:00-13:00	Lecture on Experiences of the Great East Japan Earthquake Site Visit to Disaster Stricken Area in Kesennuma City	Kesennuma City
			PM	Transfer Kesennuma - Ichinoseki - Tokyo	
8	16, Dec	Sun	AM PM	Holiday	-
9	17, Dec	Mon	10:00-12:00	Lecture on the Examples and the Role of the Media about the disaster information dissemination	NHK (Japan Broadcasting Corporation)
			15:00-17:00	Lecture on the Utilization of Earthquake Early Warning System in Hospitals	National Disaster Medical Center
10	18, Dec	Tue	10:00-12:00	Efforts on Utilization of Earthquake Early Warning System in a Municipality	Minato municipal office(Minato City)
			13:30-15:30	Lecture on Public Information Utilizing Earthquake Early Warning System by a Mobile Operator	NTT(Nippon(Japan) Telegraph and Telephone Corporation) DOCOMO INC.
				Transfer Tokyo - Kobe	-
11	19, Dec	Wed	9:00-11:00	Earthquake countermeasures f Waterworks	Kobe City Waterworks Bureau
			11:00-12:00	Visit to Kobe City Crisis Management Center	Kobe City Crisis Management Center
			14:00-16:00	Discussion about Earthquake Early Warning System installed in Tehran and the Utilization Plan	JICA Kansai
			16:00～	Preparing for Presentation	
12	20, Dec	Thu	10:00-12:00	Lecture on Quick Damage and Loss Estimation System "Phoenix Disaster Management System"	Hyogo Prefectural Office
			13:30-16:00	Presentation of Outcome, Evaluation, Closing Ceremony	JICA Kansai
13	21, Dec	Fri	AM	Preparation for Leaving	
			PM	✈Leaving Japan（Osaka-Dubai-Tehran）	
14	22, Dec	Sat	AM	Arriving Tehran	
			PM		

Additionally, Training for Disaster Managers of Megacities in Iran was implemented according to the request from TDMMO in May 2015. Terms of training and trainees are as follows. The abstract of the training is shown on Table 2.1.7.

・ Term：From 17th May 2015 to 28th May 2015
・ Trainees：11 persons
  TDMMO 3 persons

Tehran municipality 2persons
Disaster Managers of Megacities 6 persons

Table 2.1.7 Schedule of Counterpart Training for Disaster Managers of Megacities

				Activity	Place	Stay at	Purpose	Contents
-	16-May	Sat	AM					
			PM	Leaving Iran (Tehran-Dubai-Osaka)	-	Plane		
1	17-May	Sun	AM	↓	-	Kobe		
			PM	Arriving Osaka, Osaka-Kobe	-			
2	18-May	Mon	AM	Briefing	JICA Kansai	Kobe	Understanding schedule and contents of trainings. Identifying learning outcomes of the training by themselves.	Explaining outlines of trainings
			PM	Program Orientation(Expalanation of this Training)	JICA Kansai			
3	19-May	Tue	AM	Visit to Hyogo Earthquake Research Center (E-defense) / Visit to large laboratory equipment for seismic resistance	Hyogo Earthquake Research Center	Kobe	Understanding the earthquake-proof facilities and devices by visiting the large experimental device and other facilities	Lecture and Facility tour
			PM	Visit to Hyogo Prefectual Emergency Management and Training Center / Lecture on setting the wide area network for preparation of widespread disaster	Miki Disaster Management Park		Understanding the preparation for wide area disaster by structuring the wide-area disaster mitigation network	Lecture and Facility tour
4	20-May	Wed	AM	Visit to Hyogo Prefectural Government(Kobe) /Lecture on Damage overview and Lessons Learned & Reconstruction situation from Great Hanshin-Awaji Earthquake	Hyogo Prefecture	Sendai	Learning on Damage overview and Lessons Learned & Reconstruction situation from Great Hanshin-Awaji Earthquake	Lecture and Q&A
			PM	Visit to Disaster Reduction and Human Renovation Institute	Disaster Reduction and Human Renovation Institute		Knowing actual situations of disasters Learning on the disaster museums	Observation and experiencing of facilities
				Transfer Kobe → Osaka(Itami)→Sendai				
5	21-May	Thu	AM	Talk with Story teller Site Visit to Disaster Stricken Area in Great East Japan Earthquake	Ishinomaki city	Tokyo	Knowing actual situations of disasters	Lecture and Site visit
			PM	Visit to NeeSee	NEWSee Ishinomaki city		Knowing actual situations of disasters	Lecture and Site visit
				Lecture on Community based Reconstruction Visit to NeeSee	Downtown Creative Reconstruction Committee Ishinomaki city		Knowing actual situations of disasters Learning on Reconstruction situation from Great East Japan Earthquake	Lecture and Site visit
				Transfer Sendai → Tokyo				
6	22-May	Fri	AM	Lecture on National Level Disaster Management Measures in Japan Lecture on Role of Wide Area Disaster Management Base	Tokyo Rinkai Disaster Prevention Park	Tokyo	Learning on National Level Disaster Management Measures, History & System in Japan, Role of Wide Area Disaster Management Base	Lecture and Q&A
			PM	Tokyo Metropolitan Government /Lecrure on Metropolitan(Provincial) Level Disaster Management	JICA HQ		Learning on Metropolitan(Provincial) Level Disaster Management	Lecture and Q&A
				Courtesy call to JICA	JICA HQ			
7	23-May	Sat	AM	Holiday（Arrangement of Documents and Data）	JICA Tokyo	Tokyo		
			PM					
8	24-May	Sun	AM			Tokyo		
			PM					
9	25-May	Mon	AM	Visit to Sumida City Government /Lecture on Municipal Level Disaster Managenet	Sumida City Government	Tokyo	Learning on Municipal Level Disaster Managenet, Regional Disaster Management Plan, Hazard Map, Disaster Management Drill, Community Based Disaster Risk Management	Lecture and Q&A
			PM	Visit to Honjo Bosai Kan (Life Safety Learning Center) /Simulate Experiencing of disaster	Honjo Bosai Kan		Knowing contents of disaster education facilities Simulate Experiencing of disaster	Observation and experiencing of facilities
10	26-May	Tue	AM	Visit to Japan Meteorogical Agency (JMA) /Lecture on Weather forecast & Seismic Observation System in Japan at JMA	Japan Meteorogical Agency (JMA)	Tokyo	Learning on Weather forecast & Seismic Observation System in Japan at JMA	Lecture and Q&A
			PM	Visit to Fire and Disaster Management Agency/ Metropolitan Fire Department/ Emergency response in case of eathquake	Fire and Disaster Management Agency		Studying the method of emergency response, cooperation with other organizations, supporting large areas, and so on	Lecture and Q&A
11	27-May	Wed	AM	Preparation for Final Presentation	JICA Tokyo	Tokyo		
			PM	Final Presentation, Evaluation, Closing Ceremony	JICA Tokyo			
12	28-May	Thu	AM	Arrangement of Documents and Data, Preparation for leaving	JICA Tokyo	Plane		
			PM	Leaving Japan（Tokyo-Dubai-Tehran）	-			
-	29-May	Fri	AM	Arriving Tehran	-			
			PM					

Appendix5：List of participants of counterpart training in Japan

2.1.5 【30】To hold a joint seminar

(1) Joint seminar

The JICA Expert Team held several seminars and workshops with the counterparts to widely advertise the activities and Output of the Project to the stakeholders. The progress of Outputs, and the knowledge and examples in Japan were introduced. The details are described on 0【8】and 2.3.8【17】.

This joint seminar was held on 18 February 2015 to share the results of the whole project. Approx. 50 people from not only TDMMO but also from Teheran City, technical committee, universities and so on participated in the seminar. In the joint seminar, the results of each output were presented, and the JICA Expert Team introduced the debris management system in Japan according to the request from TDMMO.

A description of the joint seminar is presented on Table 2.1.8.

Table 2.1.8 Description of the joint seminar

	Joint Seminar
Type	Seminar
Date	18 February 2015
Participants	Organizations and people who are concerned with the Project
Number of Participants	Approx 50 people
Contents	Presentation of all results, Sharing information, Discussions, Future development and so on

(2) Joint Presentation at Third UN World Conference on Disaster Risk Reduction (WCDRR)

C/P and JICA Expert Team jointly made the presentation entitled “Safe Emergency Evacuation Program in Tehran Neighborhood Units” on the ignite stage of Third UN World Conference on Disaster Risk Reduction (WCDRR) held in Sendai on 16th March 2015.

The ignite stage is the occasion of 15 minutes presentation about the topics and projects for disaster management and more than 50 government officials observed this presentation. In the first half of this presentation, Mr. Taghizadeh, advisor of TDMMO president at that time, made a presentation about the introduction of TDMMO and the history of JICA's assistance. Then, the JICA Expert Team made a presentation about the JICA project, mainly “Emergency Plan Project” implemented in 2007-2010 such as showing the evacuation map and the result of evacuation drill. Human resource development and capacity building of TDMMO has been proceeded through the continuous project by JICA. At the end of presentation, video of evacuation drill was introduced. Mr. Taghizadeh could share the result of JICA’s assistance with other countries, furthermore, was able to realize the effect of JICA’s assistance through the participation of WCDRR.

Figure 2.1.2 Photos of joint presentation at Third WCDRR

2.2. Output 1

The flow of activity related to Output1 is as shown in the following figure.

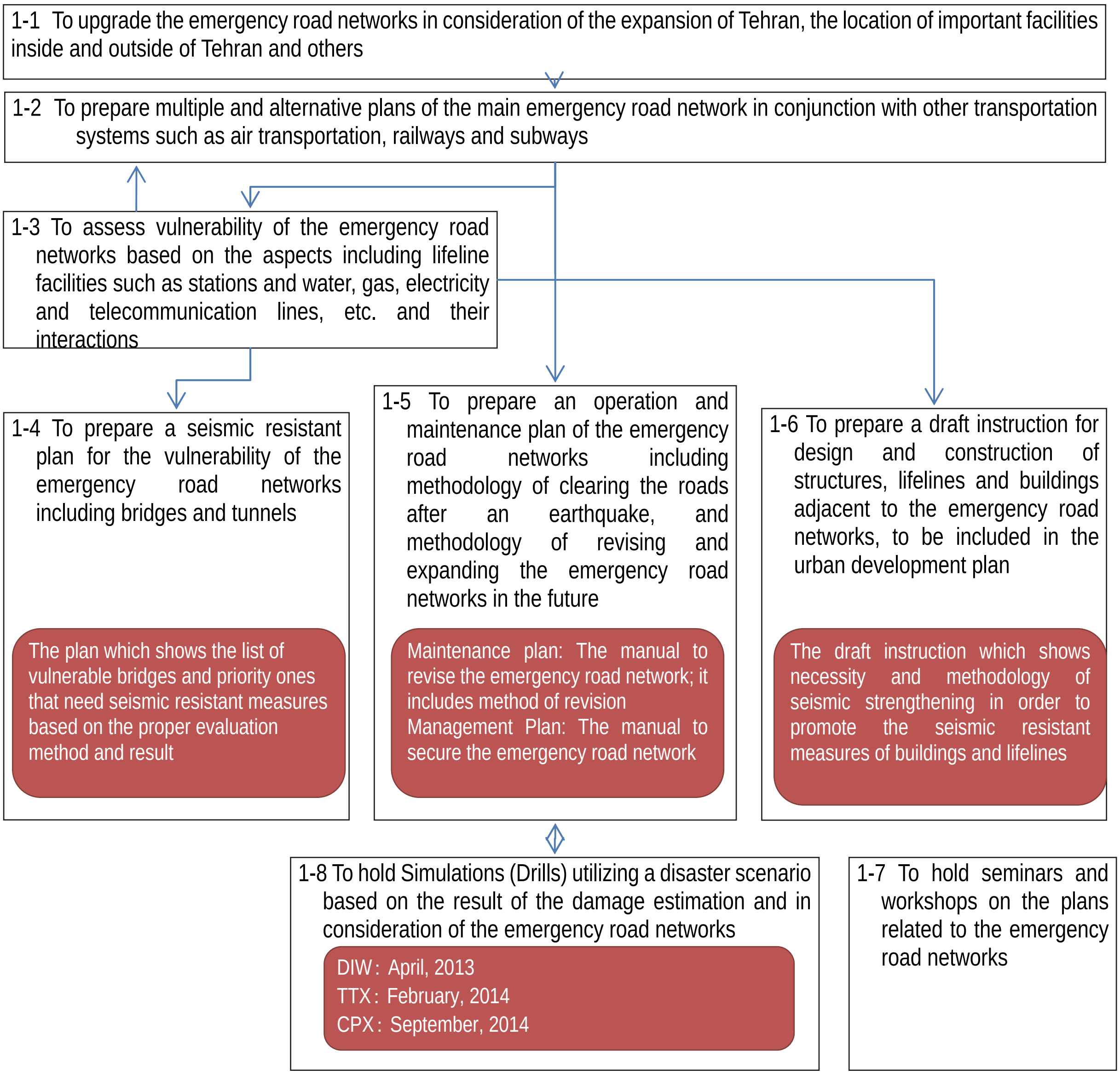


Figure 2.2.1 Output1 Flow of Activities

2.2.1 【2】To upgrade the emergency road networks in consideration of the expansion of Tehran, the location of important facilities inside and outside of Tehran and others (Activity1-1)

The emergency road network is to be specified in order to eliminate road obstacles preferentially for the smooth initial emergency response and emergency transportation.

The emergency road network currently utilized in the Tehran Municipality is the network suggested in the Master Plan Study that was completed eight years ago(Figure 2.2.2). The changes that took place in the urban structure since then such as the road networks and the location of important facilities including TDMMO need to be updated.

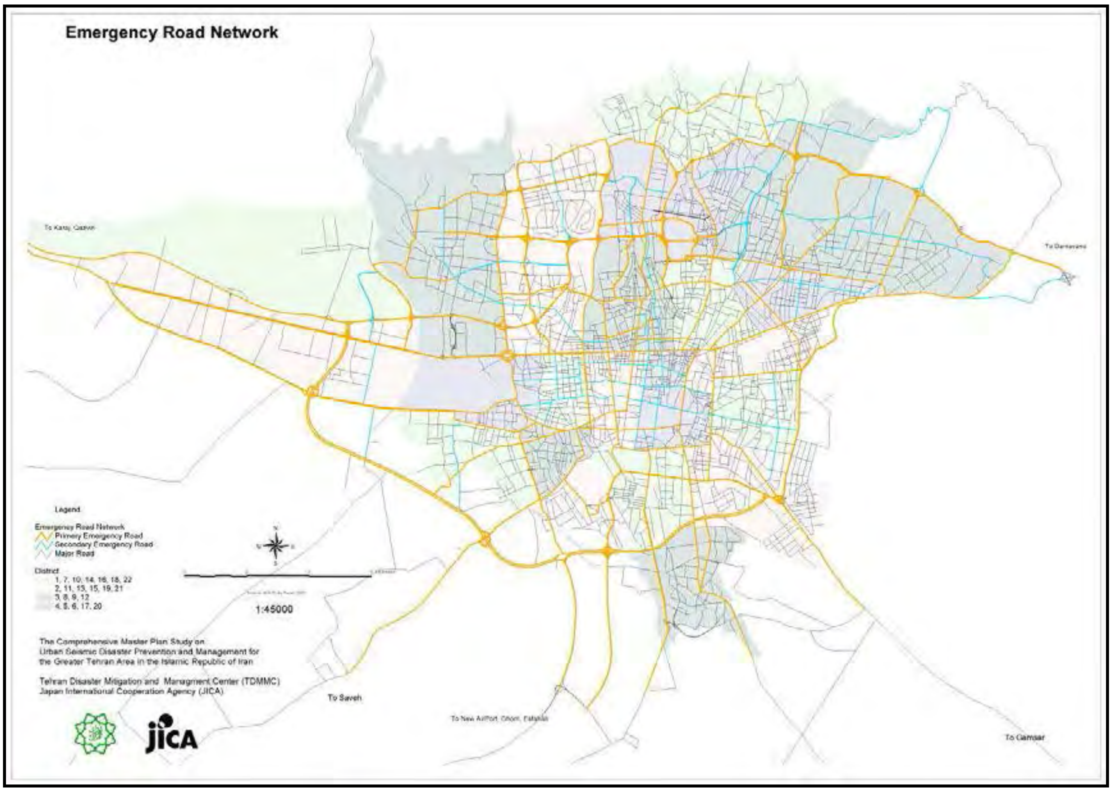


Figure 2.2.2 Emergency Road Network in Master Plan Study

Source: JICA, 2004. Report of "The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management of the Greater Tehran Area" (2003-2004).

The JICA Expert Team supported upgrading the current emergency road network. The details are as follows.

(1) Flow of Upgrade

The flow for upgrading the emergency road network is shown on Figure 2.2.3

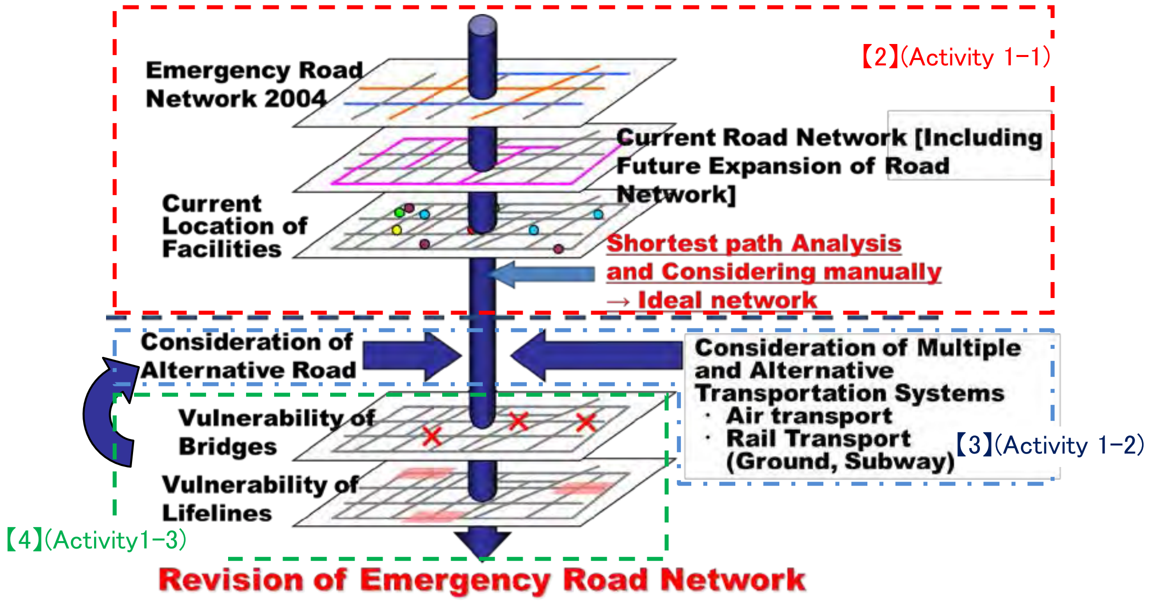


Figure 2.2.3 Flow of improving the emergency road network

(2) Update of road network data

In order to upgrade the emergency road network, the update of road network data in Teheran City and setup for its analysis was implemented. The road network data is based on the current data of TDMMO, and the data from other organizations are included. The future road plan is also considered, and the data was summarized in GIS format.

Total extension of the road network in Teheran city is shown on Table 2.2.1. The image is shown on Figure 2.2.4.

Table 2.2.1 Total Extension of road network in Teheran City

Passage type	Total (km)
Highway	1,521
Foot path	5
Main road	1,760
Branch road	2,501
Alley	5,699
Total of all passages	11,487

Figure 2.2.4 Road network plan of Teheran city

(3) Selection of important facilities

The important facilities which have to be connected by the emergency road network were considered. The methodology to choose them was basically based on the discussions. The JICA Expert Team introduced some examples in Japan. As a result of the discussions, two levels of important facilities are set, and defined as follows.

- Primary facility：The most important facilities for the emergency response and emergency transportation such as TDMMO, National Government, and Teheran municipality, and also main traffic nodes which connect with other cities such as railway station and airport. The redundancy of the traffic network is considered. By connecting these facilities, it can be carried out the smooth and effective emergency response, coordination of command and emergency transportation.
- Secondary facility：All base facilities for emergency response such as first aid, firefighting, maintenance, emergency road, medical treatment and so on.

The list of primary facilities is shown on Table 2.2.2, and the list of secondary facilities is shown on Table 2.2.3.

Table 2.2.2 List of first priority facilities

Number of centers	Name of Center
1	Presidential office
1	Ministry of Interior & Disaster management organization of the country (NDMO)
1	Governor general of Tehran
1	Municipality of Tehran
1	Deputy of traffic & transportation
1	TDMMO
1	IRIB
1	Civil & technical Deputy of Tehran municipality
4	Airport
12	Routes of entrance to the city of Tehran
3	Railway stations
4	Bases/headquarters for aiding provinces (supporting disaster management)
31	

Table 2.2.3 List of second priority facilities

District	Telecommunications	Electricity	Water & sewage	Water	Gas	Terminals (Bus stations)	Red Crescent	Traffic control centers	Traffic police center	Police station	Multi-function base	Special base	Blood transfer	Firefighting	EMS	Clinic	Hospital
1	0	0	0	0	0	0	1	1	3	7	1	1	1	5	8	0	12
2	0	0	0	0	0	0	2	0	4	5	6	1	1	5	7	0	8
3	0	0	0	0	0	0	0	0	1	4	2	1	0	5	3	0	14
4	0	0	0	1	1	0	0	1	1	6	5	1	0	8	7	0	8
5	0	0	0	0	0	1	0	1	3	7	7	1	1	7	11	0	3
6	0	0	1	0	1	0	0	0	1	5	1	1	5	3	5	0	30
7	0	0	0	0	0	0	0	0	1	3	0	1	1	3	2	0	10
8	1	1	0	1	1	0	0	0	2	2	2	1	0	3	5	0	1
9	0	1	0	0	0	0	0	0	1	1	1	0	0	1	3	0	1
10	0	1	0	1	0	0	0	0	1	1	1	1	0	2	4	1	6
11	0	0	0	0	0	0	1	0	1	5	2	1	0	6	6	0	11
12	0	0	0	0	0	0	0	0	1	4	3	1	0	6	0	0	15
13	0	0	0	0	0	1	0	0	1	2	3	1	0	3	3	0	3
14	0	2	0	0	0	0	0	0	0	4	4	1	0	2	5	0	3
15	0	0	0	0	0	0	0	0	0	4	7	1	0	5	4	0	1
16	0	1	1	0	1	1	2	0	0	4	5	1	0	5	5	0	4
17	0	0	0	0	1	0	0	0	1	1	2	1	0	3	1	0	1
18	1	1	0	1	0	0	0	0	1	2	5	1	0	4	3	0	3
19	0	0	0	0	0	0	0	0	1	1	4	1	0	4	0	0	0
20	0	1	0	1	1	0	3	0	1	6	8	1	0	3	5	0	2
21	1	0	0	1	1	0	1	0	1	2	1	1	0	3	1	1	0
22	1	1	1	0	1	0	1	0	2	2	6	1	0	6	3	0	2
total	4	9	3	6	8	3	11	3	28	78	76	21	9	92	91	2	138
									Total: 582 places								

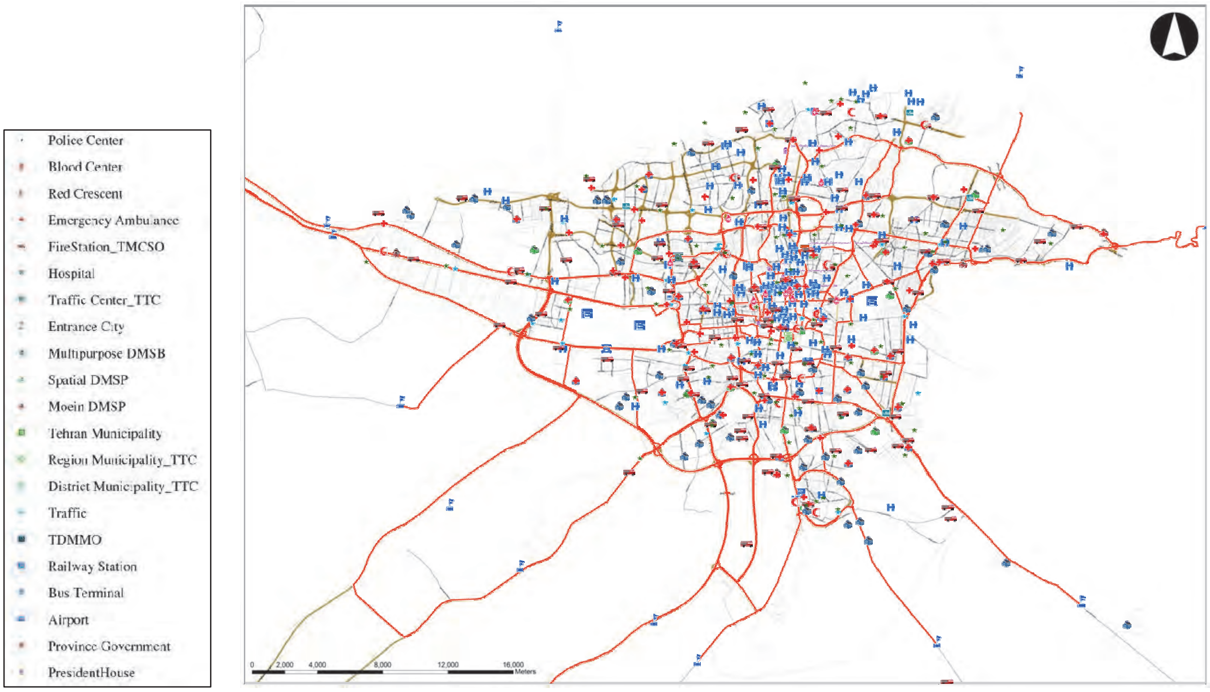


Figure 2.2.5 Location of Priority facilities on Emergency road network

(4) Implementation of shortest path analysis

The network analysis was implemented based on the road network and facilities data on (2) and (3). The methodology of analysis adopted the shortest pass analysis the same methodology of “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management of the Greater Tehran Area”. For the methodology of setting an emergency road network, there are no established methodologies. The fact is that almost of all is selected by manually from arterial road. However, though the discussion, as the first stage of analysis, the shortest pass analysis as one of network analysis methodologies was implemented. Thus, it is possible to be carried out the both quantitative evaluation and qualitative evaluation by revising the result of shortest pass analysis manually after the shortest pass analysis. The shortest path analysis finds the shortest path between two facilities. In this analysis, all intervals of all facilities are analyzed. The methodology of analysis with GIS was transferred from the JICA Expert to C/Ps in charge of GIS. The manual for analysis was also prepared.

As input data, network data is the set road network, and facility data is for the primary facilities. This is the reason that it is not realistic since it takes times to calculate between all two facilities (it is required approx. 360,000 analysis of 600 facilities * 600 facilities). The speed of cars is set as 60 kilometers per hour for expressways, and 30 kilometers per hour for main roads.

The result of the analysis is shown on Figure 2.2.6. The extracted network does not cover the whole area of Teheran city due to the location of primary facilities.

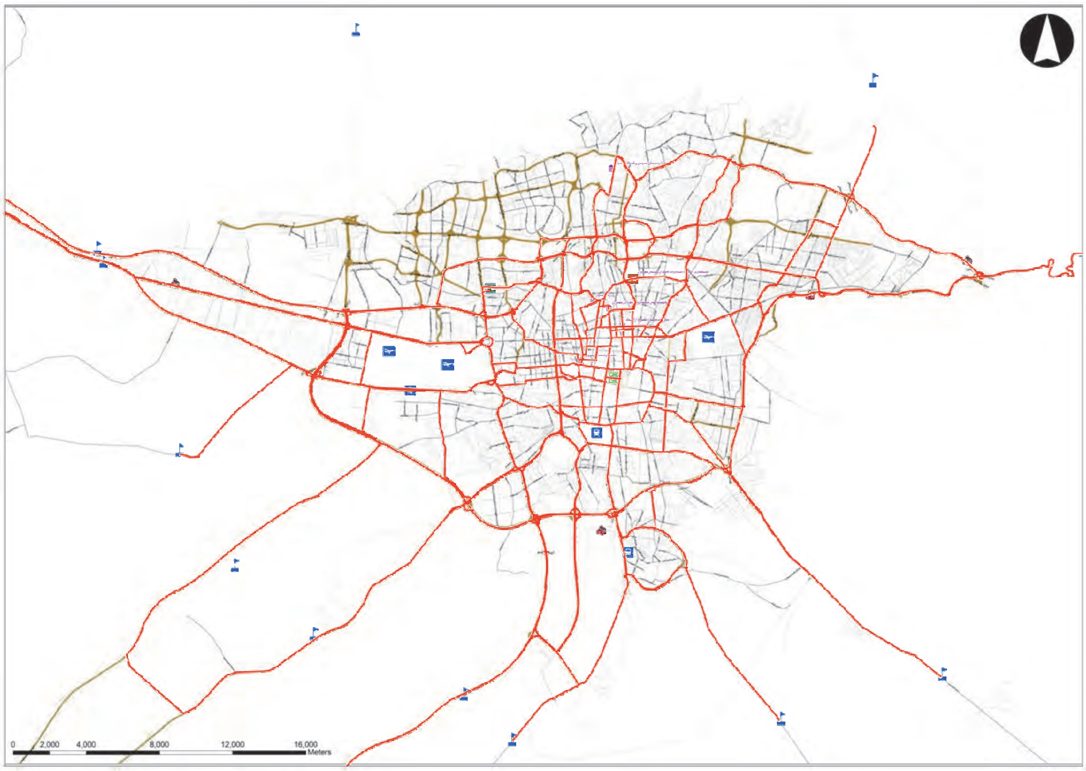


Figure 2.2.6 Result of analysis of shortest path (choice of network)

(5) Classification of the emergency road network

In Japan, the emergency road network is often set so as to run from the Primary network to the tertiary network in consideration of redundancy, provision of alternatives, and the classification of facilities. The case of Japanese emergency traffic and transportation roads was introduced. In Japan, there are 2 emergency road networks, the emergency traffic road is designated by Police and the emergency transportation road is designated by local government. The emergency traffic road is carried out the traffic control and the emergency transportation road is connected the disaster management facilities for emergency transportation. The JICA Expert Team explained these differences and discussed with C/Ps. Through the discussion, since this is the first time to operate the emergency road network in Tehran Municipality, in order to be simplified, it was determined the classification divided 2 categories of traffic control roads and Priority road for elimination of road obstacles without traffic control as following table.

Table 2.2.4 Classification of emergency road network

Classification			Definition
1	Traffic control road **Road with police control**		Crux road to connect important facilities. Traffic control is examined in order to achieve smooth response.
2	Priority road for elimination of road obstacles（without traffic control） **Road with priority for reopening**		Elimination of road obstacles is preferentially examined at this road for emergency vehicles.
		with special line	Special lane such as BRT (Bus Rapid Transit) lane is utilized for emergency vehicles.
		suggestion for creating special line (divided line)	Special lane is prepared with barricades in case of emergency.
		without special line (divided line)	Special lane is not prepared.

(6) Revision of the emergency road network by the result of discussion

The emergency road network was revised by the discussion between C/Ps and the JICA Expert Team. The discussion was based on the result of (4), and the following points were mainly discussed.

- To secure the access to secondary facilities selected at (3)
- To separate into 2 classifications determined on (5)
- To consider the comprehensive network of the whole Teheran city

Revision of the emergency road network is shown on Figure 2.2.7. The next chapter considers more about the redundancy and alternatives for the network.

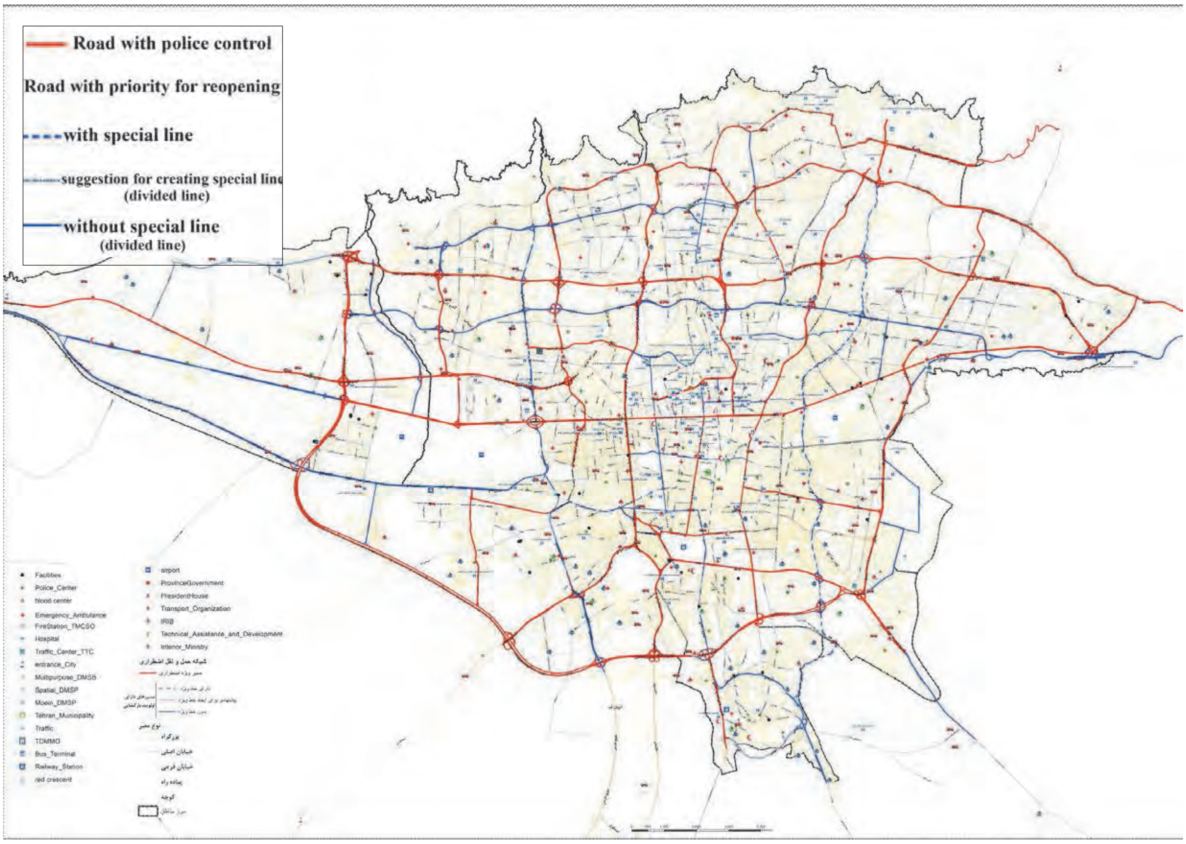


Figure 2.2.7 Revised emergency road network on【2】

2.2.2 【3】To prepare multiple and alternative plans of the main emergency road network in conjunction with other transportation systems such as air transportation, railways and subways (Activity1-2)

This session examined (1) Check of redundancy and alternatives for the emergency road network and revision, and (2) Alternative transportation methodology such as air transportation, railway, and subway transportation. The details are discussed as follows.

(1) Check of redundancy and alternatives of the emergency road network and revision

It is required to secure the redundancy of the emergency road network in order to make the emergency response and transportation available when some part of the network happens to be damaged.

Ordinary congestions are seen especially at commute time in expressways and main roads in Tehran city. One of the reasons is the bad manners of the drivers. When an earthquake strikes, this kind of congestion could interrupt the emergency response. Also, though the infrastructures and lifelines of Teheran city are more resistant than houses, the damage to infrastructures and collapse of buildings along the network could cause road blockages. Therefore, the emergency road network is required to plan in consideration of redundancy and alternatives.

The emergency road network set on 2.2.1 basically includes redundancy because the network is determined by the shortest path analysis in consideration of the important facilities in the whole area of Tehran city and was checked manually by observation. Therefore, the JICA Expert Team and C/Ps checked the previously set network, and added some networks as necessary. The check of redundancy and alternatives was prepared using the following process. Firstly, set the hypothetical damaged point. Secondly, analyze the shortest passage. Finally, the alternative roads are added as necessary.

1) To set the hypothetical damaged point based on the assessment of vulnerability

The hypothetical damaged point was determined based on the result of a temporary assessment of vulnerability of lifelines and bridges with possibility of collapse of structures, which is shown on 2.2.3. In regard to the lifelines, hypothetical damaged points were set on points in each district, and the shape of the network was also considered. The JICA Expert Team lectured and mentored C/Ps to set the hypothetical damaged points such as at the points vertically crossing pipes, etc., which may cause road closure. Regarding bridges, vulnerable ones are identified based on the result of a simplified evaluation.

2) Re-implementation of shortest pass analysis with GIS

The shortest pass analysis was re-implemented with hypothetical damaged points as interruptions. The methodology of analysis was transferred from the JICA Expert Team to C/Ps. The manual for analysis was also prepared. Figure 2.2.8 shows one part of the manual.

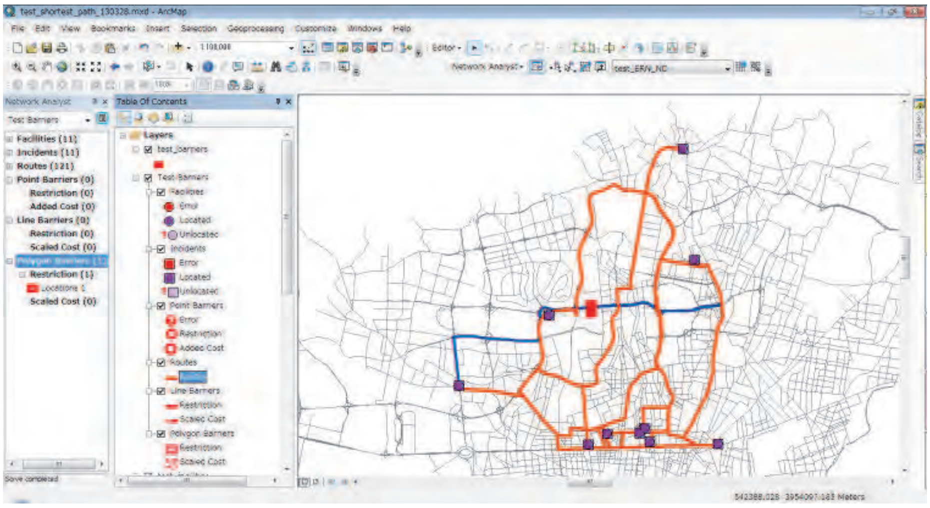


Figure 2.2.8 Example of shortest pass analysis method manual in consideration of hypothetical damaged points

The actual analysis was implemented by C/Ps with the manual. As input data, network data is the emergency road network set on 2.2.1, and the facility data includes both primary and secondary facilities. The result of the analysis is shown on Figure 2.2.9.

Figure 2.2.9 Result of shortest pass analysis in consideration of hypothetical damaged points

3) To add alternative routes

Based on the result of Figure 2.2.9, the JICA Expert Team and C/Ps verified the emergency road network from the following viewpoint.

- Accessibility to each facility (Result of analysis)
- Extended time to reach each facility comparing with one without hypothetical damaged points (Result of analysis)
- Redundancy (Discussion)

There was no problem with accessibility and extended time. However, some routes were added to the sparse areas based on the discussions in consideration of redundancy. The updated emergency road network is shown on Figure 2.2.10.

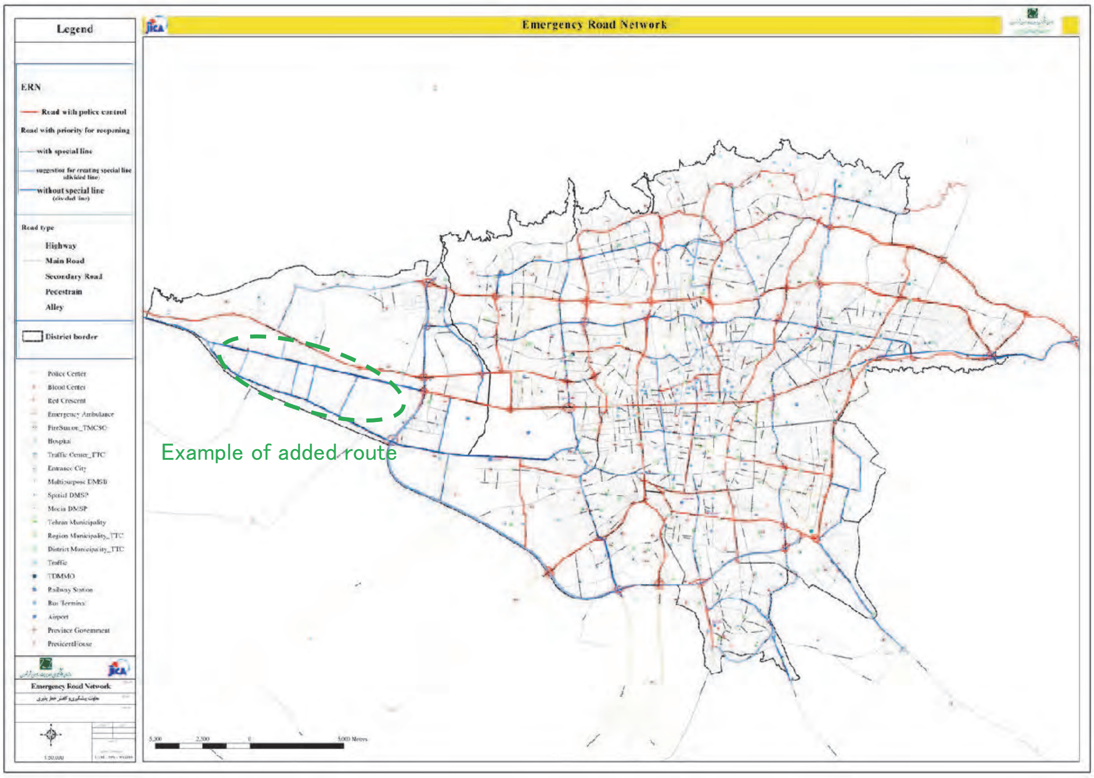


Figure 2.2.10 Emergency road network including redundancy and alternatives

(2) Study about alternative transportation such as air transportation, railway and subway

Various means of transportation such as air transportation utilizing helicopters, and subways are included in multiple and alternative plans on the emergency road network in Japan. The JICA Expert Team introduced Japanese examples, then advised and discussed multiple and alternative transportation methods which considered characteristics of transportation in Teheran city. The details are as follows.

1) Research of means of transportation

<u>a.BRT</u>

Figure 2.2.11 shows the route map of BRT. A BRT lane is utilized as a priority road for elimination of road obstacles as shown on 2.2.1. It is also expected to be utilized as transportation for people and items. Therefore, it has to be superimposed on the emergency road network.

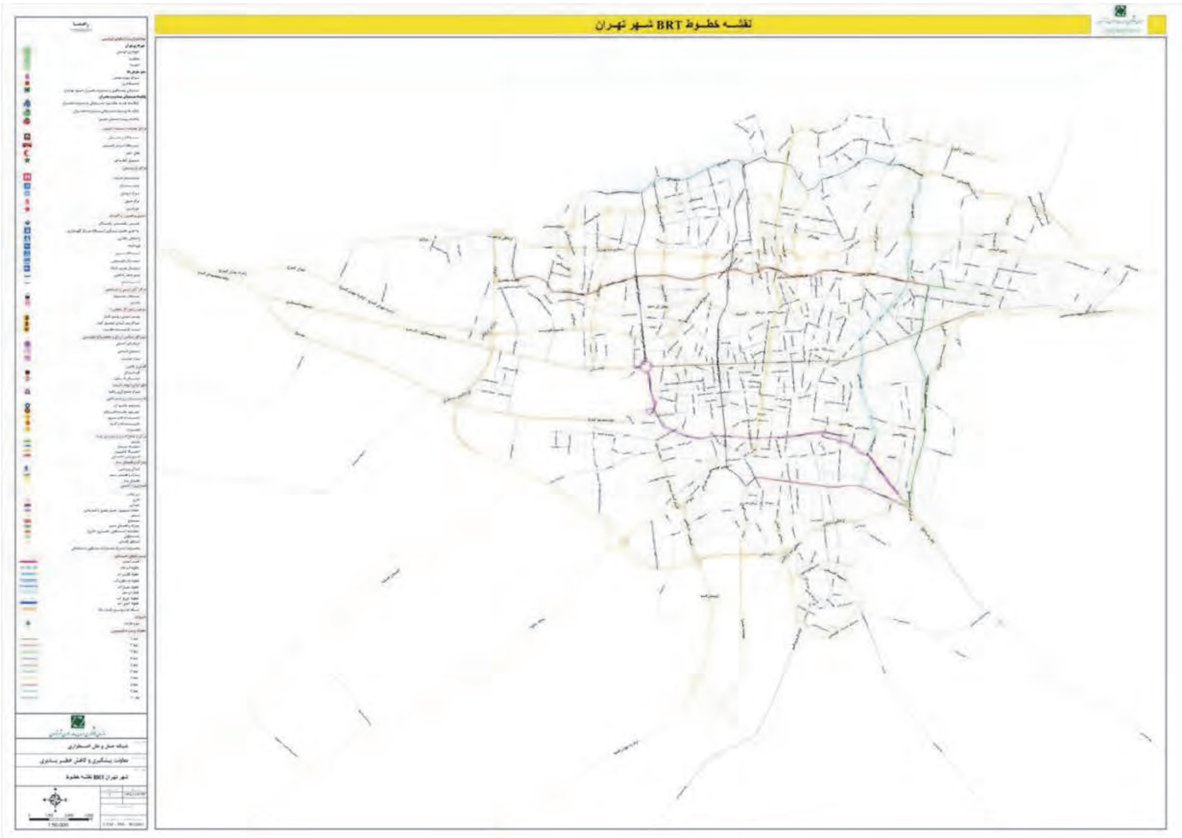


Figure 2.2.11 Route map of BRT

<u>b.Subway</u>

Generally, a subway is a resistant form of transportation because it is constructed as an underground structure. The JICA Expert Team and C/Ps discussed Japanese experiences such as damage to the subway which damage level was very limited in the Great Hanshin-Awaji earthquake, and quick return to operation of the Tokyo metro having no damage after the Great East Japan Earthquake. Consequently, the Subway is included in the emergency road network in Teheran city because it can play a role as an alternative or complementary form of transportation by understanding from past experiences that Subway system having high seismic resistance against Earthquake.

Table 2.2.5 and Figure 2.2.12 show the current and future subway plans. More route network will be constructed in the future, even though currently metro has a comprehensive route network connecting main areas. Figure 2.2.13 shows overlayered figure of the road network and subway network.

Table 2.2.5 Current and Future Plan for the Subway

Line	Number of stations		Line length (km)	
	Expansion	Existing (Mehr 1391)	Expansion	Existing (Mehr 1391)
1	29	29	39	39
2	26	22	35	26
3	28	2	35	7
4	19	17	21	21
5	11	10	42	42
6	27	0	31	0
7	25	0	27	0
8		0	34	0

9		0	32	0
Total	165	80	296	135

Figure 2.2.12 Future Plan for the Subway network (2030)

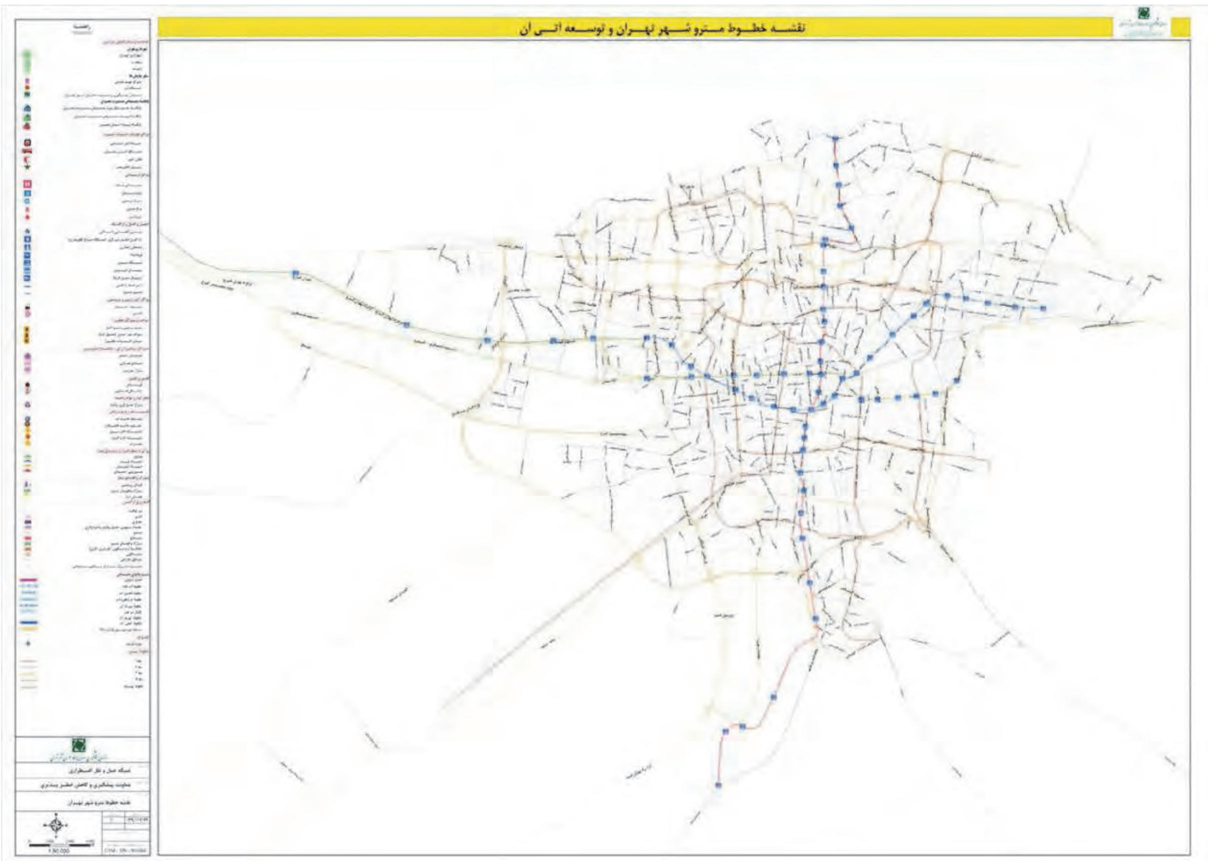


Figure 2.2.13 Road network and Subway network

c.Airport and railway

Airports and main railway stations are precious transportation hubs for wide area transportation and support. Therefore, these facilities are included in the primary facilities, and connected by the emergency road network.

2) To set up multiple and alternative network routes in consideration of characteristics of each mode of transportation

As discussed above, BRT, subway, airport and railway play precious roles to compliment the established emergency road network to operate emergency response activities after occurrence of disasters. Thus, these networks and bases are set up in the emergency road network to cooperate with each other.

(3) Upgrade of the emergency road network

In accordance with the result of (1) and (2), the upgrade of the emergency road network with multiple and alternative plans was finalized. The finalized network is shown on Figure 2.2.14. Also, Table 2.2.6 shows the total extension of the emergency road network, Figure 2.2.15 shows the total extension of each district.

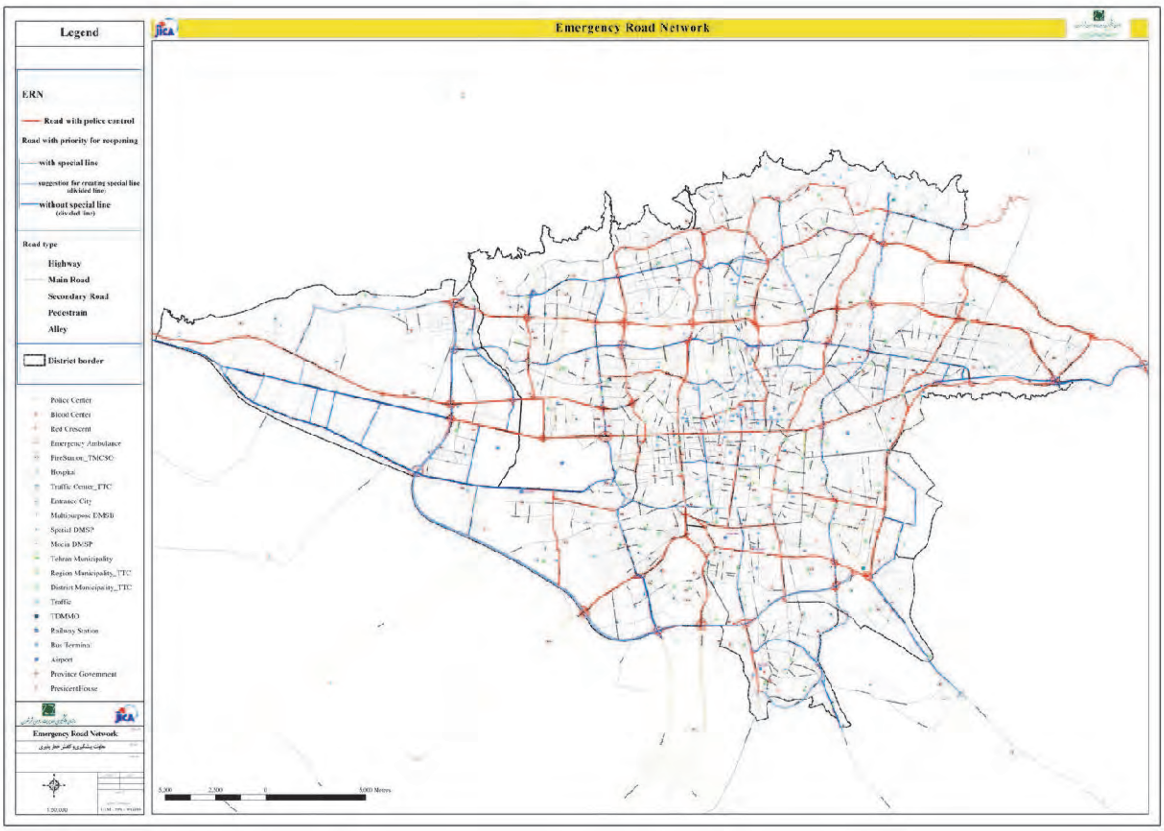


Figure 2.2.14 Finalized emergency road network

Table 2.2.6 Total extension of emergency road network

Classification		Extension(km)	Total Extension(km)
1	Traffic control road	300.5	541.4
2	Priority elimination road (no traffic control)	240.9	

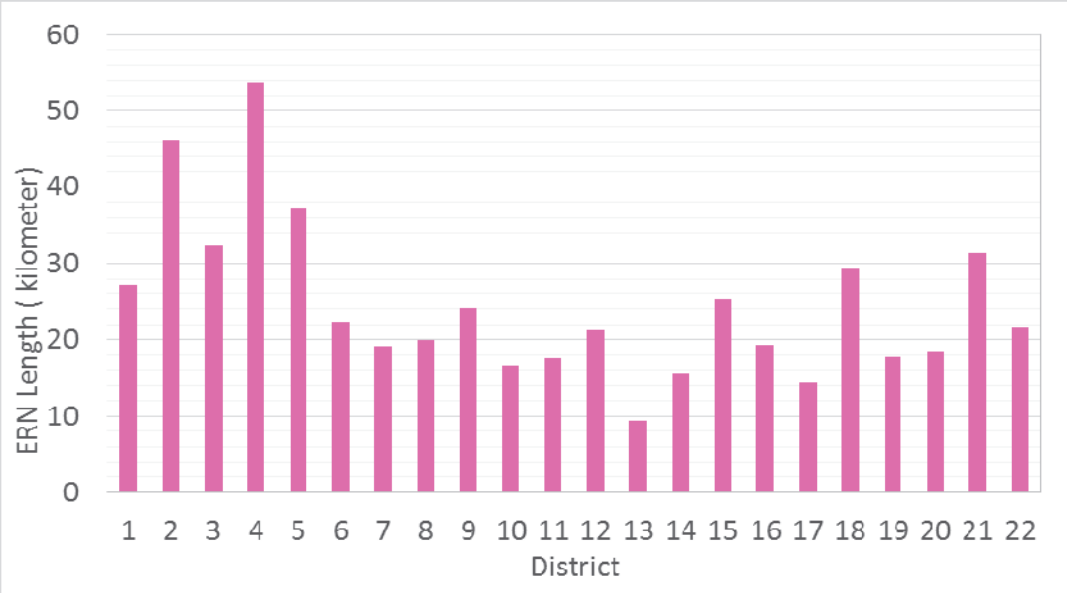


Figure 2.2.15 Total extension of emergency road network in each district

Hereafter, the emergency road network has to be known to residents, and the bridges, lifelines, buildings along the emergency road network have to be resistant. Seismic resistance of those facilities is described later.

2.2.3 【4】To assess the vulnerability of the emergency road networks based on the aspects including lifeline facilities such as stations and water, gas, electricity and telecommunication lines, etc. and their interactions (Activity1-3)

As most of the Lifeline facilities (line network) are placed close to or intersect the road, the damage of lifelines caused by the earthquake has a possibility to affect the road damage or the interruption of the traffic function. Therefore, the JICA Expert Team and TDMMO assessed the vulnerability of the lifelines and the effect of the emergency road network.

(1) Vulnerability assessment of lifelines

1) Investigation of the current conditions of Lifeline facilities (water, gas, electricity, communication, oil pipelines, etc.)

Lifelines, except for the water, etc., are managed by a public company under the direct control of the government. In addition, the water and sewer are managed by Tehran Province Water and Wastewater Company[2]. Electricity is managed by Great Tehran Electrical Distribution Co.[3], Communication is managed by Telecommunication Company of Iran[4], and the oil pipeline is managed by the National Iranian Oil Company[5]. These lifelines have formed networks in Grater

[2] Tehran Province Water and Wastewater Company http://www.tpww.ir/en/inter

[3] Great Tehran Electrical Distribution Co. ,Power Distribution Company of Tehran, Power distribution company areas (South and East) Tehran Province, West Power Distribution Company of Tehran

http://www.tbtb.co.ir/en/home

[4] Telecommunication Company of Iran http://tci.ir/default.aspx?lang=En

[5] National Iranian Oil Company http://en.nioc.ir/Portal/Home/

Tehran metropolitan area and some lifeline networks are close to or cross the Emergency Road Network.

Current conditions of each pipeline are shown as follows.

a.Waterworks and Sewage

The current condition of water pipelines which were obtained from the Water and Sewerage Company is shown in Table 2.2.7, the extension of the district main water pipeline is shown in Table 2.2.8. The relationship between the water pipelines and the emergency road network is shown in Figure 2.2.16.

Table 2.2.10 shows the length of sewage pipeline in each district, Figure 2.2.17 shows the relationship of the sewage pipelines and Emergency Road Network. Population furnished with water supply in Tehran in 2012 is about 14 million people and this is over 20% of the entire Iran[6]. Water pump capacity is about 220,000 m^3 per hour, the total length of water pipeline is about 15,000km.

[6] Tehran Province Water and Wastewater Company http://www.tpww.ir/en/aboutus

Table 2.2.7 Information on water pipelines according to the district

district	gravitational water pipelines(m)	Multi-purpose Pipelines (m)	Pumping water pipelines (m)	Raw water pipelines(m)	district	gravitational water pipelines (m)	Multi-purpose Pipelines(m)	Pumping water pipelines(m)	Raw water pipelines (m)
1	16,404	11,463	21,407	905	12	2,907	—	—	—
2	13,298	1,184	19,802	2,301	13	12,906	—	—	—
3	13,238	—	19,283	—	14	22,890	—	2,352	—
4	65,042	2,313	4,607	7,847	15	19,230	—	2,504	—
5	15,264	—	30,897	5,371	16	7,652	—	—	—
6	21,868	—	10,945	4,152	17	7,559	—	7	—
7	16,413	—	3,084	—	18	753	—	5,355	—
8	9,777	—	—	—	19	9,618	—	188	—
9	6,812	—	9,426	—	20	6,488	—	—	—
10	2,775	—	—	—	21	—	—	—	30,576
11	539	—	—	—	22	—	—	—	36,861

Source: JET（TDMMO）

Table 2.2.8 Main water pipelines according to the district, diameter and material

District	Diameter (mm)	Length (m)	Material	District	Diameter (mm)	Length(m)	Material
1	700	4,841	Steel	7	800	199	Steel
1	800	377	Steel	7	900	1,198	Cast -iron
1	900	3,624	Steel	7	900	474	Steel
1	1000	593	Steel	7	1000	865	Steel
2	700	4,126	Steel	7	1125	2,087	Cast -iron
2	800	2,365	Steel	7	1200	940	Steel
2	900	1,501	Steel	8	700	312	Steel
2	1000	1,142	Steel	8	800	2,098	Steel
2	1200	3,761	Steel	9	700	2,527	Steel
2	1400	775	Steel	10	900	466	Steel
4	700	607	Steel	11	700	321	ductile
4	800	139	Steel	1	900	835	Steel
4	900	320	Steel	13	700	591	Steel
5	700	10,181	Steel	14	700	1,788	Steel
5	700	805	Ductile	14	800	640	Steel
5	800	792	Steel	15	700	217	Steel
5	800	530	ductile	15	800	968	Steel
5	900	3,188	Steel	15	900	2,020	Steel
5	1000	1,302	Steel	15	1000	416	Steel
6	700	928	Cast -iron	17	700	1,556	Steel
6	700	425	Steel	18	700	361	Steel
6	750	824	Cast -iron	18	700	416	ductile
6	900	148	Cast -iron	19	700	1,092	Steel
6	900	589	Steel	19	800	460	Steel
6	1000	1,102	Cast -iron	20	700	298	Steel
6	1000	1,603	Steel	20	900	210	Steel
7	700	644	Steel				

Source: JET（TDMMO）

The number of intersections between the water pipelines and the Emergency Road Network, which may cause road closure at the time of disaster occurrence, is 124 points and the number of crossings of the water pipelines and the fault line is 43 points.

Table 2.2.9 Number of cross points of water pipelines with ERN and Faults in each district

District	Number of cross points with ERN	Number of cross points with the Fault line	District	Number of cross points with ERN	Number of cross points with the Fault line
1	8	13	12	0	0
2	9	4	13	3	1
3	15	4	14	4	0
4	8	4	15	9	1
5	8	5	16	4	0
6	10	1	17	3	0
7	10	4	18	3	0
8	7	0	19	6	0
9	5	0	20	5	4
10	1	0	21	2	0
11	2	0	22	2	2
Total				124	43

Source: JET（TDMMO）

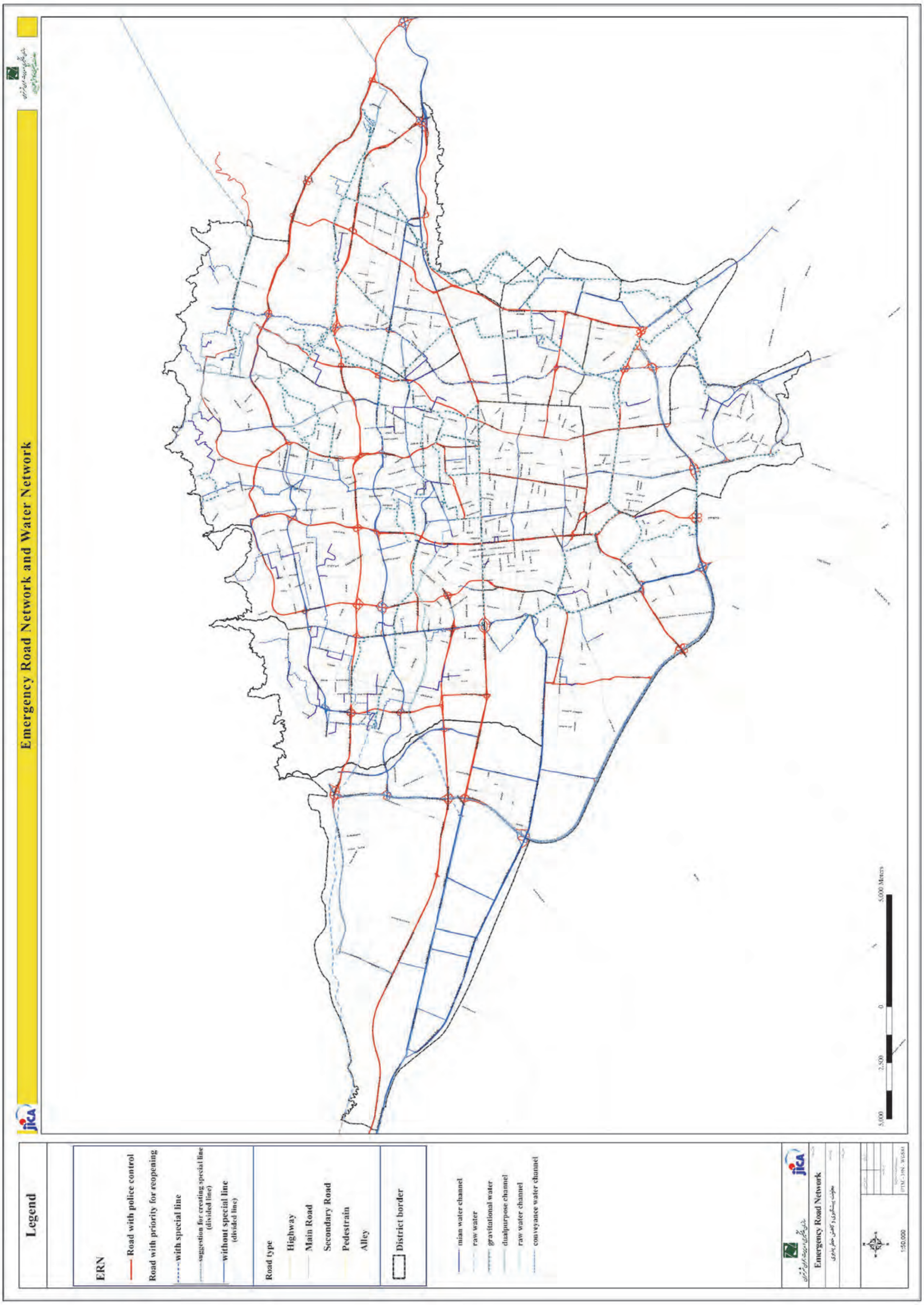


Figure 2.2.16 Overview of water pipe laying and Emergency Road Network

Table 2.2.10 Length of Sewage pipeline for each district

District	Length(m)	District	Length(m)
1	183,312	12	76,330
2	155,656	13	106,646
3	122,568	14	138,108
4	1,446	15	300,575
6	147,170	16	210,358
7	39,406	17	143,143
8	17,310	18	88,557
10	61,570	19	133,253
11	76,052	20	207,418

Source: JET（TDMMO）

The number of intersections between the sewage pipes and the Emergency Road Network is 48 points in total as shown in Table 2.2.11.

Table 2.2.11 Number of sewage crossings of the emergency road network (ERN)

District	Number of intersections	District	Number of intersections
1	3	12	2
2	1	13	3
3	3	14	3
4	0	15	9
6	2	16	8
7	0	17	2
8	1	18	1
10	1	19	3
11	2	20	4

Source: JET（TDMMO）

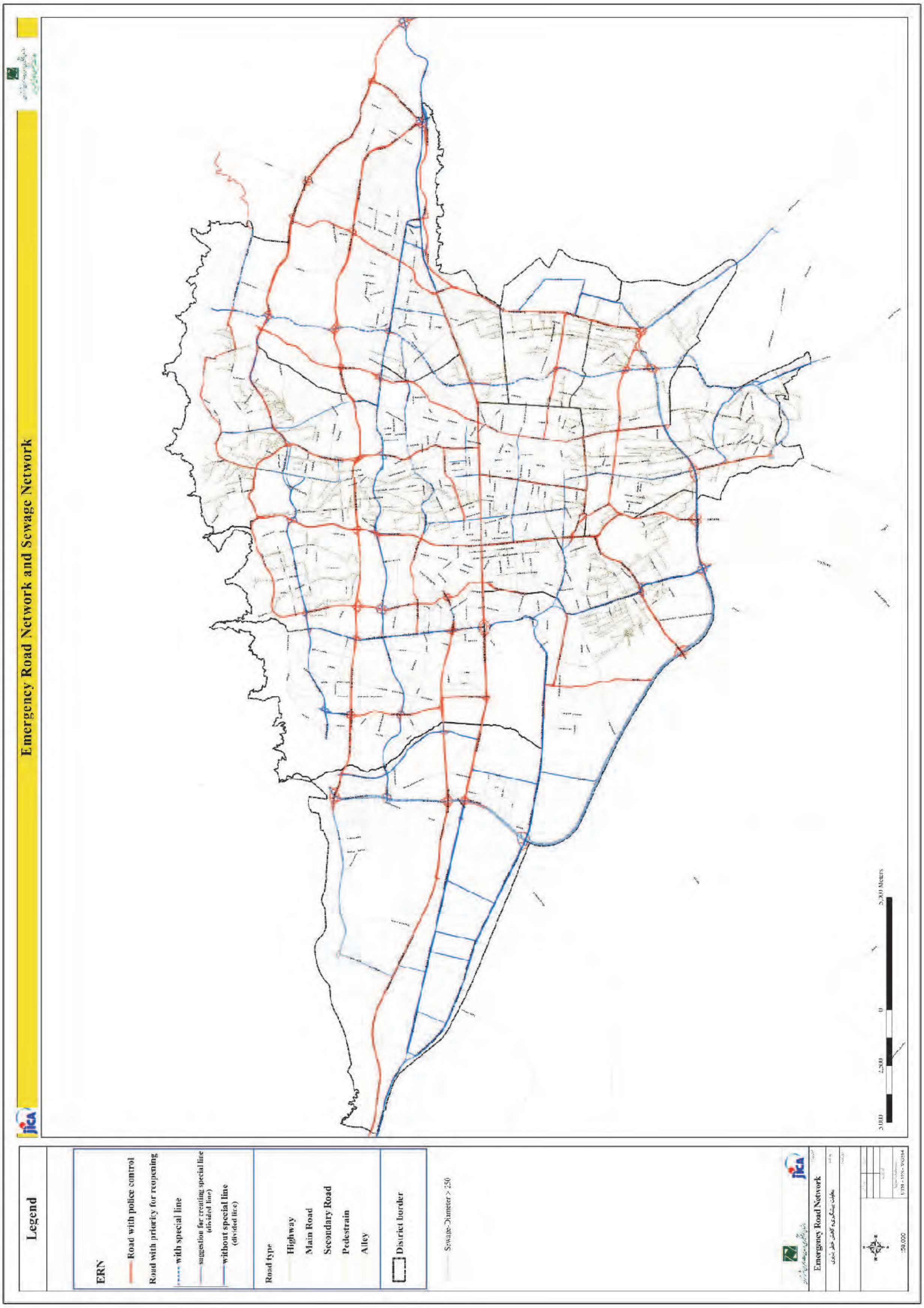


Figure 2.2.17 Overview of sewage pipe laying and Emergency Road Network

b.Gas

Table 2.2.12 and Table 2.2.13 show the length of gas pipelines that were obtained from the gas company through TDMMO. Figure 2.2.19 shows the relationship of the gas pipelines and the Emergency Road Network.

Table 2.2.12 Length and tube diameter of the gas pipe in each district（250Psi）

district	Length(m)	diameter	district	Length(m)	diameter	district	Length(m)	diameter
1	1,920	8	11	8,868	12	20	429	16
1	7,867	10	11	2,120	16	20	5,351	20
1	4,917	12	11	7,049		20	149	22
1	6,915	16	12	10,518	12	20	2,287	30
1	2,459	24	12	3,127	16	20	27,132	
1	23,725		12	11,177		21	16,384	36
2	14,516	12	13	5,749	12	21	345	
2	130	22	13	3,763	16	22	31,828	30
2	16,994	24	13	4,025	24	22	2,292	36
2	1,439	30	13	10,173		22	1,463	
2	36,010		14	7,447	12			
3	13,745	12	14	3,875	22			
3	5,111	24	14	4,953	24			
3	21,764		14	10,935				
4	1,274	10	15	3,067	12			
4	20,023	12	15	4,096	16			
4	11,012	24	15	4,538	22			
4	32,622		15	8,117	24			
5	13,066	12	15	1,472	30			
5	12,545	24	15	20,873				
5	1,717	30	16	2,113	4			
5	4,257	36	16	334	12			
5	28,411		16	2,904	16			
6	18,346	12	16	1,389	20			
6	2,301	16	16	5,231	24			
6	897	24	16	12,515				
6	15,515		17	3,113	12			
7	15,036	12	17	79	22			
7	1,836	16	17	10,948				
7	145	24	18	334	8			
7	9,536		18	13,524	12			
8	1,942	12	18	2,233	22			
8	1,708	16	18	321	24			
8	4,431	24	18	13,809				
8	10,916		19	2,798	22			
9	3,708	12	19	10,620	24			
9	3,838	22	19	530	30			
9	5,200		19	6,799				
10	6,848	12	20	478	6			
10	5,900		20	4,671	12			

Source: JET（TDMMO）

Table 2.2.13 Length and pipe diameter of the gas pipes in each district（100Psi）

district	Length(m)	diameter
5	4,264	12
9	5,160	24
18	2,995	12
20	202	12
20	2,831	4
21	18,620	12
21	2,298	16
21	14,010	18
21	4,077	24
21	3,599	30
22	734	30

Source: JET（TDMMO）

Tehran province Gas Company is supplying gas to about 2.2 million households. The number of intersections between the gas pipeline and Emergency Road Network, of the 100Psi pipes is 20 points and 250 Psi pipes is 385 points.

Figure 2.2.18 Regulator for pressure control attached to a house

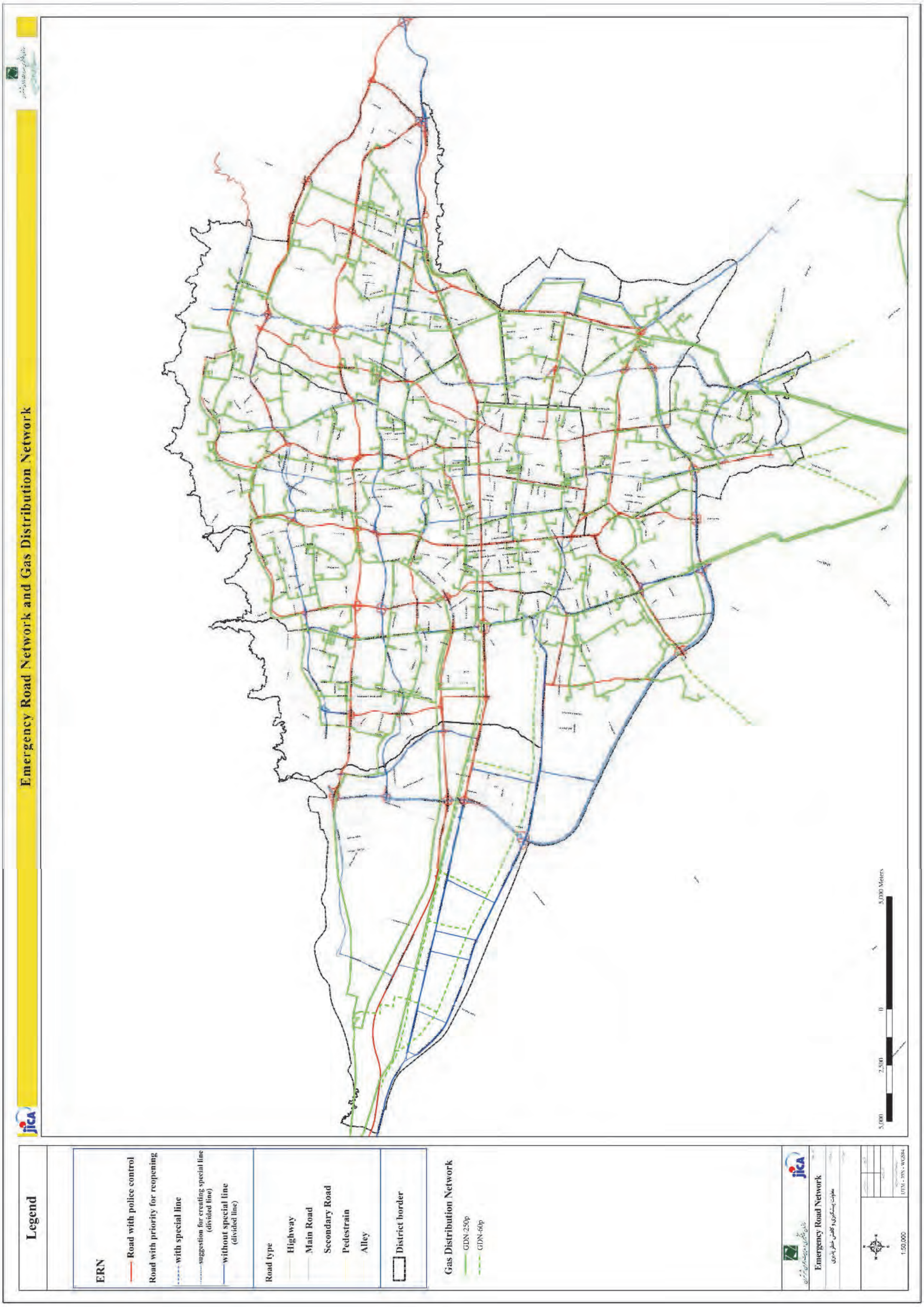


Figure 2.2.19 Overview of Gas pipe laying and Emergency Road Network

c.Electricity

The length of the electricity power line that was obtained from the electricity company through TDMMO and the number of intersection points between the power line and the Emergency Road Network is shown in Table 2.2.14.

The number of electricity contracts was about 3.3 million in 2008 including households, agriculture and commerce, etc. Figure 2.2.20 shows the relationship between the power line and Emergency Road Network.

Table 2.2.14 Lengths of the power line and the power line intersects with the ERN in each district

district	Length of underground line(m)	Length of Aerial line (m)	Number of intersections (underground)
1	33,214	14,616	11
2	46,557	28,236	22
3	29,147	5,163	9
4	25,710	37,850	8
5	11,960	53,532	1
6	42,755	6,492	25
7	26,292	478	10
8	5,462	13,988	1
9	9,996	7,280	8
10	6,072	24,124	5
11	24,622	14,963	5
12	54,663	8,118	24
13	16,213	6,145	2
14	15,560	24,635	5
15	5,351	23,111	2
16	25,510	54,154	9
17	3,738	14,616	3
18	13,137	28,236	2
19	74	5,163	0
20	480	37,850	1
21	15,396	53,532	3
22	7,481	6,492	2

Source: JET（TDMMO）

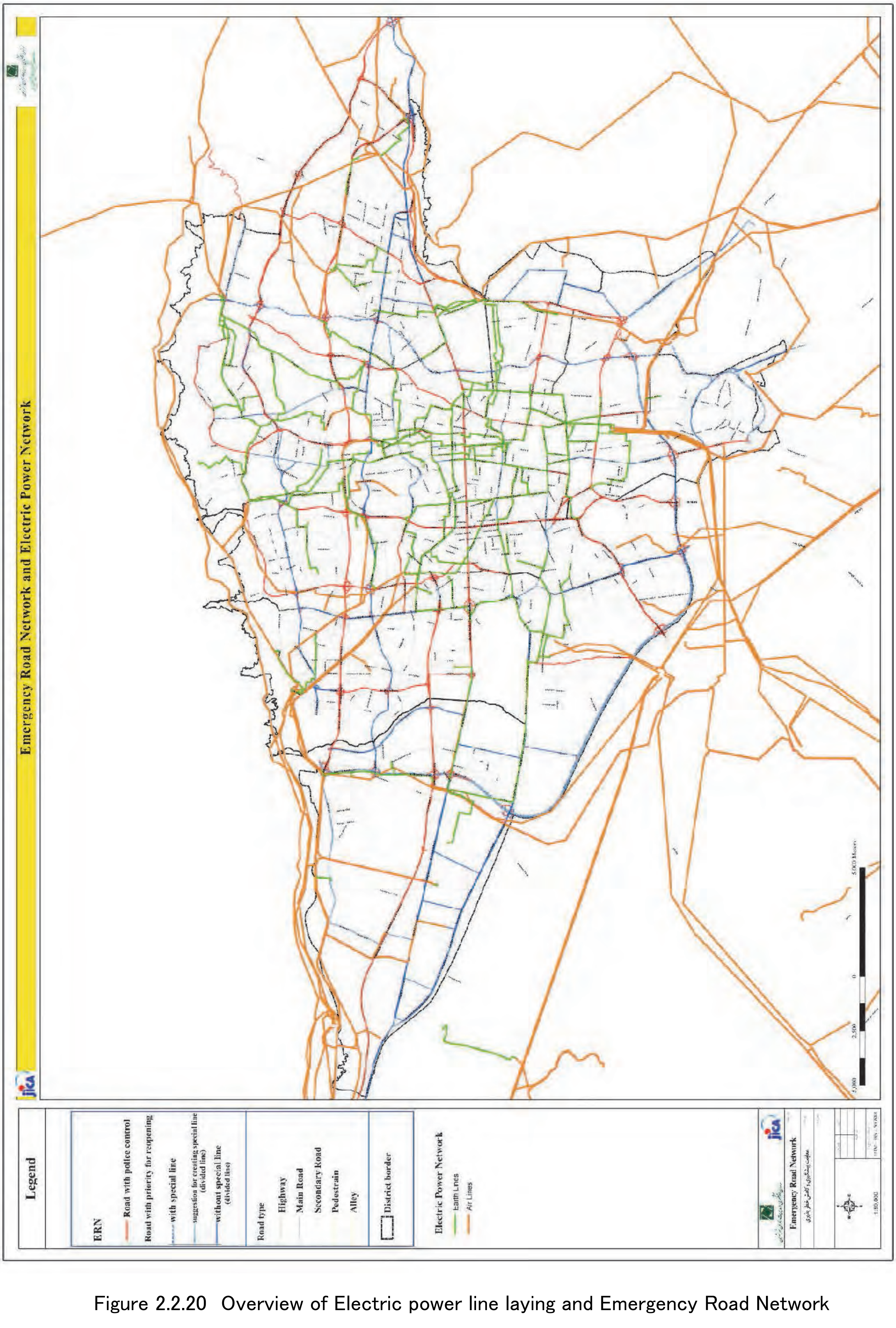


Figure 2.2.20 Overview of Electric power line laying and Emergency Road Network

d.Telecommunications

Table 2.2.15 shows the current condition of the telecommunication line which was obtained from the telecommunication company through TDMMO. About 7.7 million telephones are installed. The length of the optical fiber line is about 11,000km. The number of intersections between fiber optic lines and the Emergency Road Network is 150 points in total. The relationship of the telecommunication lines and the Emergency Road Network is shown in Figure 2.2.21. For waterworks, due to leakage of water by pipe damages caused by displacement of ground at fault line may affect to road network, however, for telecommunications, cause of ground displacement is not considered because only aerial cable lines may cause road blockage to its network.

Table 2.2.15 Length of the telecommunication lines of each district, Number of intersections with the Emergency Road Network

district	Length(m)	Number of intersections	district	Length(m)	Number of intersections
1	26,023	13	12	23,766	10
2	28,600	13	13	11,921	3
3	29,608	12	14	9,785	4
4	30,680	6	15	16,910	5
5	36,308	8	16	9,511	3
6	28,597	17	17	5,762	4
7	23,054	14	18	18,369	3
8	11,525	7	19	4,430	2
9	11,229	1	20	17,461	5
10	10,623	7	21	26,895	4
11	17,455	9	22	6,140	1

Source: JET（TDMMO）

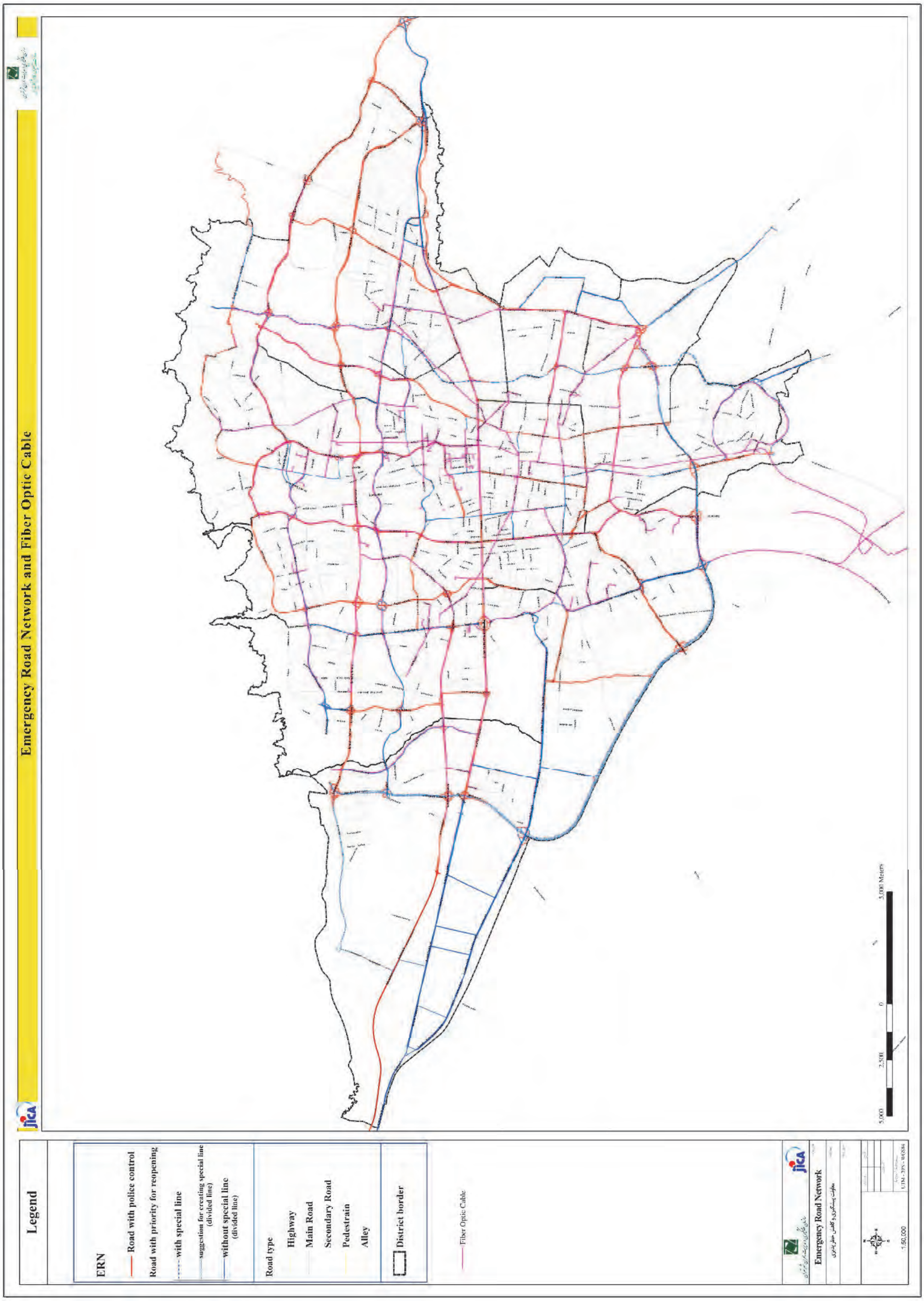


Figure 2.2.21 Overview of Fiber Optic cable laying and Emergency Road Network

2) Study of vulnerability assessment method for Lifelines

In this project, it is necessary to consider the impact of the road closure due to lifeline damage which causes malfunction to ERN, and carried out vulnerability assessment to evaluate the impact. JICA Expert Team provided necessary information to C/Ps through presentations and meetings for each lifeline based on most recent vulnerability assessment method referring committee, research institute coordinated by central and local governments in Japan.

a.Water

According to the "Guide for water pipe damage by earthquake prediction "[7] published in recent years, estimated damage rate (the number of damage points per pipe extension) is assumed to take into consideration the standard damage rate, pipe materials and fittings, diameter, terrain, and the possibility of liquefaction.

Rm(v)= Cg×Cp×Cd×R(v)

R(v)=9.92×10-3×(v-15)1.14 (point/km) v: Ground surface maximum speed of ground motion (cm/s)（However,15≦v<120）

Cp is pipe material of, 7.5 to 0.0 for each joint (restraint joint), Cd is 2.0(ϕ 50mm-80mm) ~ 0.1 (ϕ 500mm-900mm), Cg is set to 0.4 (hills, etc.) to 6.0 (liquefaction) differentially.

The standard of damage estimation is different by the scenario earthquake of disaster management council as following cases.

【Damage Estimation of Tokyo Metropolitan Earthquake（March, 2006）】
Standard damage rate =$2.24\times10^{-3}\times(v-20)^{1.51}$ (points/km)

【Expert Committee on Eastern Nankai and Nankai earthquakes, etc.（May, 2008）】
Standard damage rate =$3.11\times10^{-3}\times(v-15)^{1.30}$ (points/km)

b.Gas

Damage estimation to gas lines caused by an earthquake disaster in Japan has mainly been investigated and researched by the operator.

For high-pressure gas facility, sufficient seismic measures have been implemented such as gas supply stop system to prevent secondary disasters, such as fire by the operators, which will function if measured seismic intensity 6 (SI[8] value 60cm / s) or more is observed, it will stop the supply automatically, and refer total housing units which stop distribution are considered as result of vulnerability assessment.

c.Electricity

The Damage Estimation for the number of houses suffering a power outage in the Tokyo Metropolitan Earthquake（March, 2006）, was calculated for two separate groups of houses, those that were in an area that would be subject to the spread of fire and those that were not .

7 Guide for water pipe damage by earthquake prediction（March 2011 Foundation Water Research Center）

8 SI value: spectral intensity (an index indicating the degree of damage caused by the shaking of up to general building)

The number of damaged Utility pole = utility pole number ×utility pole breakage rate

Utility pole breakage rate, seismic intensity 7: 0.8%, seismic intensity 6-7: 0.056%, seismic intensity of 5-6: 0.00005%

d.Telecommunication

The Damage Estimation for the number of houses suffering loss of telecommunication links in the Tokyo Metropolitan Earthquake（March, 2006）, was calculated for two separate groups of houses, those that were in an area that would be subject to the spread of fire and those that were not.

Utility pole damage number is the same for Electricity.

In addition, for comparison of damage estimation methods between the existing study "Micro zoning" as a reference, which is a standard damage estimation method in Japan and evaluation by HAZUS is shown in Table 2.2.16 and Table 2.2.17.

Table 2.2.16 Comparison of damage estimation methods

<table>
<tr><th></th><th>Overview of study and damage estimation method in Micro Zoning (2000) Note)</th><th>Standard damage estimation method in Japan</th><th>HAZUS®MH MR4 Technical Manual</th></tr>
<tr>
<td>Waterworks (Sewage)</td>
<td>Damaged points per conduit length are calculated by multiplying each coefficient of the ground, pipe diameter and materials of pipes.
Rfm=Rf×Cg×Cp×Cd (points/km)
However, Cg = 0.5 and Cp = Cd = 1.0 are fixed since detailed information cannot be obtained, therefore damage estimation depends on Rf.
Rf=1.7×A6.1×10-16
Rf is not to exceed 2.0.</td>
<td>Basically the same as on the left, the standard damage rate by the research study, the coefficients are different.
【Guide of water pipe damage prediction by the earthquake（March, 2011 Foundation Water Research Center）】
$Rm(v)=Cg×Cp×Cd×R(v)$
$R(v)=9.92×10^{-3}×(v-15)^{1.14}$ (point/km)
v:Ground surface is maximum speed of ground motion (cm/s)
（However,15 ≦ v<120）
Cp is tube material, 7.5 to 0.0 for each joint (restraint joint), Cd is 2.0 (φ50-80) ~ 0.1 (φ500-900), Cg is set to 0.4 (hills, etc.) to 6.0 (liquefaction).

【Damage Estimation of Tokyo Metropolitan Earthquake（March, 2006）】
Water pipe damage point number = standard damage rate × liquefaction risk rank correction coefficient × tubing species and correction coefficient × length of pipe
Standard damage rate $=2.24×10^{-3}×(v-20)^{1.51}$ (point/km)
v: Ground surface speed (cm/s)、PL value rank=1.0～3.0
【Expert Committee on Eastern Nankai and Nankai earthquakes, etc.（May, 2008）】
Standard damage rate $=3.11×10^{-3}×(v-15)^{1.30}$ (point/km)</td>
<td>8.1.6.2 Definition of Damage States for Pipelines
For pipelines, two damage states are considered. These are leaks and breaks. Generally, when a pipe is damaged due to ground failure (PGD), the type of damage is likely to be a break, while when a pipe is damaged due to seismic wave propagation (PGV), the type of damage is likely to be joint pull-out or crushing at the bell. In the loss methodology, it is assumed that damage due to seismic waves will consist of 80% leaks and 20% breaks, while damage due to ground failure will consist of 20% leaks and 80% breaks. The user can override these default percentages.

Repair Rate [Repairs/Km] ≅ 0.0001 x (PGV)(2.25)
(With PGV expressed in cm/sec.)

Repair Rate [Repairs/Km] ≅ Prob [liq] x PGD(0.56)
(With PGD expressed in inches.)

Table 8.10: Damage Algorithms for Water Pipelines
<table>
<tr><th></th><th colspan="2">PGV Algorithm</th><th colspan="2">PGD Algorithm</th></tr>
<tr><td></td><td colspan="2">R. R. ≅ 0.0001 x PGV(2.25)</td><td colspan="2">R. R. ≅ Prob[liq]xPGD(0.56)</td></tr>
<tr><td>Pipe Type</td><td>Multiplier</td><td>Example of Pipe</td><td>Multiplier</td><td>Example of Pipe</td></tr>
<tr><td>Brittle Pipes (PWP1)</td><td>1</td><td>CI, AC, RCC</td><td>1</td><td>CI, AC, RCC</td></tr>
<tr><td>Ductile Pipes (PWP2)</td><td>0.3</td><td>DI, S, PVC</td><td>0.3</td><td>DI, S, PVC</td></tr>
</table>
</td>
</tr>
</table>

Note) Micro zoning Final Report 4.4.2.Lifelines p226-p227

Note) Micro zoning Final Report 4.4.2.Lifelines p226-p227

Table 2.2.17 Comparison of damage estimation methods

<table>
<tr><th></th><th>Overview of study and damage estimation method in Micro Zoning (2000) Note)</th><th>Standard damage estimation method in Japan</th><th>HAZUS®MH MR4 Technical Manual</th></tr>
<tr><td>Gas</td><td>Basically damage estimation for gas is the same as for the water pipes.
The coefficient of the ground is fixed at Cg = 0.5, and Cp × Cd is set by the material and diameter of the pipes.（Steel pipes (250psi):0.1, Steel pipes (60psi):0.2, Polyethylene pipes: 0.1）
※ to be Mechanical Pipe joint type is assumed from the construction age (Screw type joint is 10 times more fragile than the mechanical type)</td><td>【Damage Estimation of Tokyo Metropolitan Earthquake（March, 2006）】
The number of supply outages is defined as the number of hindrances of supply.
Area of SI values 60cm / s or higher is assumed as the outage area, the total customer number contained therein is calculated as the number of outages.</td><td>The same two damage algorithms proposed for potable water pipelines are assumed to apply for crude and refined oil pipelines. These are listed again in Table 8.21. Note that mild steel pipelines with submerged arc welded joints are classified as ductile pipes, while the older gas welded steel pipelines, if any, are classified as brittle pipes. In Table 8.21, R.R. stands for repair rates or number of repairs per kilometer, PGV stands for peak ground velocity in cm/sec, and PGD stands for permanent ground deformation in inches.
Table 8.21: Damage Algorithms for Oil Pipelines
<table>
<tr><th rowspan="2"></th><th colspan="2">PGV Algorithm</th><th colspan="2">PGD Algorithm</th></tr>
<tr><td colspan="2">R. R. ≅ 0.0001 x PGV(2.25)</td><td colspan="2">R. R. ≅ Prob[liq]xPGD(0.56)</td></tr>
<tr><th>Pipe Type</th><td>Multiplier</td><td>Example of Pipe</td><td>Multiplier</td><td>Example of Pipe</td></tr>
<tr><td>Brittle Oil Pipelines (OIP1)</td><td>1</td><td>Steel Pipe w/ GasWJ</td><td>1</td><td>Steel Pipe w/ GasWJ</td></tr>
<tr><td>Ductile Oil Pipelines (OIP2)</td><td>0.3</td><td>Steel Pipe w/ ArcWJ</td><td>0.3</td><td>Steel Pipe w/ ArcWJ</td></tr>
</table>
Same for Oil pipelines</td></tr>
<tr><td>Electricity</td><td>It is estimated that there will be no damage to aerial lines in the case of a seismic intensity 8 (seismic intensity (MMI)) or less, and estimated 0.55% damage of area in the case of seismic intensity 9 (seismic intensity (MMI)) or more. Underground lines are estimated to suffer no damage in the case of seismic intensity 8 (seismic intensity (MMI)) or less, and estimated 0.3% damage of area poles in the case of seismic intensity 9 (seismic intensity (MMI)) or more.</td><td>【Damage Estimation of Tokyo Metropolitan Earthquake（March, 2006）】
The number of houses that would loose electricity is calculated for two separate groups of houses, those that were in an area that would be subject to the spread of fire and those that were not.
The number of damaged utility poles = utility pole number ×breakage rate of utility poles by shaking
Breakage rate of utility poles is 0.8% for seismic intensity 7, 0.056% for seismic intensity 6 -7, 0.00005% for seismic intensity 5 - 6.</td><td>HAZUS evaluates the reduction of the power supply function.
HAZUS does not suggest a technique to assume loss or damage brought about due to the collapse of a power line steel tower becoming a traffic hindrance on the urgent road network.</td></tr>
<tr><td>Communication</td><td>Damage to the communication systems is estimated by the same method as for ground lines since the main communication line is a ground line except for the distribution line.</td><td>【Damage Estimation of Tokyo Metropolitan Earthquake（March, 2006）】
The number of homes that loose service is calculated for two separate groups of houses, those that were in an area that would be subject to the spread of fire and those that were not.The number of damaged utility poles is the same as for Electricity.</td><td>HAZUS evaluates the reduction of the power supply function.
HAZUS does not suggest a technique to assume loss or damage due to the collapse of a telephone pole becoming a traffic hindrance on the urgent road network.</td></tr>
</table>

3) Vulnerability assessment of Lifeline facilities (water, gas, electricity, communication, oil pipelines, etc.) facilities intersecting or close to the Emergency Road Network

In this project, as mentioned earlier, it is necessary to consider the impact of the road closure due to lifeline damage which causes malfunction to ERN, and carried out vulnerability assessment to evaluate the impact. And vulnerability assessment was carried out based on District, because pipeline and cable networks data of lifelines was developed, and damage points were evaluated in this unit.

C/Ps have conducted the general vulnerability assessment based on the American HAZUS[9]. Therefore the method for lifelines is HAZUS as well.

For making decision on priority of reinforcement, it should be decided not only considering number of damage points, but also considering socio-economic condition of each region. This decision shall be integrated into Draft Instruction, and improve seismic resistance of lifeline to reduce secondary damages to ERN.

a.Waterworks and Sewage

The damage function shown in HAZUS (8.1.8 Development of Damage Functions) was utilized. According to the data described above, the pipe characteristics are classified into five as follows. Pipe damage points per length (RR) were estimated by the peak ground velocity (PGV) of each district. (Table 2.2.18 to Table 2.2.23)

$$\mathrm{RR} = 0.3 \times 0.0001 \times PGV^{(2.25)}$$

[9] MH MR4 Technical Manual
http://www.fema.gov/media-library-data/20130726-1716-25045-6422/hazus_mr4_earthquake_tech_manual.pdf

Table 2.2.18 Damage Estimation for water pipes (gravity flow pipelines)

district	Pipe length(m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	16,404	564	87.09	2.317	38
2	13,298	534	82.45	2.049	27
3	13,238	550	84.92	2.189	29
4	65,042	550	84.92	2.189	142
5	15,264	534	82.45	2.049	31
6	21,868	483	74.58	1.635	36
7	16,413	477	73.65	1.589	26
8	9,777	537	82.92	2.075	20
9	6,812	590	91.10	2.564	17
10	2,775	543	83.84	2.127	6
11	539	487	75.20	1.665	1
12	2,907	464	71.65	1.493	4
13	12,906	535	82.61	2.057	27
14	22,890	484	74.73	1.642	38
15	19,230	556	85.85	2.244	43
16	7,652	560	86.47	2.280	17
17	7,559	592	91.41	2.584	20
18	753	599	92.49	2.653	2
19	9,618	591	91.26	2.574	25
20	6,488	776	119.82	4.750	31

Table 2.2.19 Damage Estimation for water pipes (multipurpose pipelines)

district	Pipe length(m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	11,463	564	87.09	2.317	27
3	1,184	550	84.92	2.189	3
4	2,313	550	84.92	2.189	5

Table 2.2.20 Damage Estimation for water pipes (pumping water pipelines)

district	Pipe length(m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	21,407	564	87.09	2.317	50
2	19,802	534	82.45	2.049	41
3	19,283	550	84.92	2.189	42
4	4,607	550	84.92	2.189	10
5	30,897	534	82.45	2.049	63
6	10,945	483	74.58	1.635	18
7	3,084	477	73.65	1.589	5
9	9,426	590	91.10	2.564	24
14	2,352	484	74.73	1.642	4
15	2,504	556	85.85	2.243	6
17	7	592	91.41	2.584	0
18	5,355	599	92.49	2.653	14
19	188	591	91.26	2.574	0

Table 2.2.21 Damage Estimation for water pipes (raw water pipelines)

district	Pipe length(m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	905	564	87.086	2.317	2
2	2,301	534	82.454	2.049	5
4	7,847	550	84.925	2.189	17
5	5,371	534	82.454	2.049	11
6	4,152	483	74.579	1.635	7
21	30,576	479	73.962	1.604	49
22	36,861	470	72.572	1.537	57

Table 2.2.22 Damage Estimation for main water pipes (according to district and material)

district	Diameter (mm)	Pipe length(m)	material	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	700	4,841	steel	564	87.086	2.317	11
1	800	377	steel	564	87.086	2.317	1
1	900	3,624	steel	564	87.086	2.317	8
1	1000	593	steel	564	87.086	2.317	1
2	700	4,126	steel	534	82.454	2.049	8
2	800	2,365	steel	534	82.454	2.049	5
2	900	1,501	steel	534	82.454	2.049	3
2	1000	1,142	steel	534	82.454	2.049	2
2	1200	3,761	steel	534	82.454	2.049	8
2	1400	775	steel	534	82.454	2.049	2
4	700	607	steel	550	84.925	2.189	13
4	800	139	steel	550	84.925	2.189	0
4	900	320	steel	550	84.925	2.189	1
5	700	10,181	steel	534	82.454	2.049	21
5	700	805	ductile	534	82.454	2.049	2
5	800	792	steel	534	82.454	2.049	2
5	800	530	ductile	534	82.454	2.049	1
5	900	3,188	steel	534	82.454	2.049	7
5	1000	1,302	steel	534	82.454	2.049	3
6	700	928	Cast-iron	483	74.579	1.635	2
6	700	425	steel	483	74.579	1.635	1
6	750	824	Cast-iron	483	74.579	1.635	1
6	900	148	Cast-iron	483	74.579	1.635	0
6	900	589	steel	483	74.579	1.635	1
6	1000	1,102	Cast-iron	483	74.579	1.635	2
6	1000	1,603	steel	483	74.579	1.635	3
7	700	644	steel	477	73.653	1.589	1
7	800	199	steel	477	73.653	1.589	0
7	900	1,198	Cast-iron	477	73.653	1.589	2
7	900	474	steel	477	73.653	1.589	1
7	1000	865	steel	477	73.653	1.589	1
7	1125	2,087	Cast-iron	477	73.653	1.589	3
7	1200	940	steel	477	73.653	1.589	1
8	700	312	steel	537	82.917	2.075	1
8	800	2,098	steel	537	82.917	2.075	4
9	700	2,527	steel	590	91.101	2.564	6

district	Diameter (mm)	Pipe length(m)	material	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
10	900	466	steel	543	83.844	2.127	1
11	700	321	ductile	487	75.197	1.665	1
11	900	835	steel	487	75.197	1.665	1
13	700	591	steel	535	82.608	2.057	1
14	700	1,788	steel	484	74.734	1.642	3
14	800	640	steel	484	74.734	1.642	1
15	700	217	steel	556	85.851	2.244	0
15	800	968	steel	556	85.851	2.244	2
15	900	2,020	steel	556	85.851	2.244	5
15	1,000	416	steel	556	85.851	2.244	1
17	700	1,556	steel	592	91.41	2.584	4
18	700	361	steel	599	92.49	2.653	1
18	700	416	ductile	599	92.49	2.653	1
19	700	1,092	steel	591	91.255	2.574	3
19	800	460	steel	591	91.255	2.574	1
20	700	298	steel	776	119.821	4.750	14
20	900	210	steel	776	119.821	4.750	1

Table 2.2.23 Damage Estimation for sewage pipes (according to district)

district	Pipe length(m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	183,312	564	87.086	2.317	425
2	155,656	534	82.454	2.049	319
3	122,568	550	84.925	2.189	268
4	1,446	550	84.925	2.189	3
6	147,170	483	74.579	1.635	241
7	39,406	477	73.653	1.589	63
8	17,310	537	82.917	2.075	36
10	61,570	488	75.351	1.673	103
11	76,052	440	67.940	1.325	101
12	76,330	421	65.006	1.200	92
13	106,646	535	82.608	2.057	219
14	138,108	404	62.381	1.094	151
15	300,575	368	56.822	0.886	266
16	210,358	346	53.425	0.772	162
17	143,143	395	60.991	1.040	149
18	88,557	415	64.079	1.162	103
19	133,253	384	59.293	0.976	130
20	207,418	286	44.161	0.503	104

Table 2.2.24 shows the estimated damage to the water supply in each district. The largest amount of damage is from districts 1 to 5. In addition, by summarizing water pipelines in types of pipe, it made clear result of vulnerability assessment in accordance with importance.

Table 2.2.24 Estimated damage location and number of the intersection number of the emergency road network and the fault with water pipes

district	Number of Intersections with ERN	Number of Intersections with the fault	Damage Estimation (Number of damage points)				
			gravity flow pipelines	multipurpose pipelines	pumping water pipelines	raw water pipelines	main water pipelines
1	8	13	38	27	50	2	21
2	9	4	27	-	41	5	28
3	15	4	29	3	42	17	-
4	8	4	142	5	10	11	14
5	8	5	31	-	63	7	36
6	10	1	36	-	18	-	10
7	10	4	26	-	5	-	9
8	7	0	20	-	-	-	5
9	5	0	17	-	24	-	6
10	1	0	6	-	-	-	1
11	2	0	1	-	-	-	2
12	0	0	4	-	-	-	-
13	3	1	27	-	-	-	1
14	4	0	38	-	4	-	4
15	9	1	43	-	6	-	8
16	4	0	17	-	-	-	-
17	3	0	20	-	0	-	4
18	3	0	2	-	14	-	2
19	6	0	25	-	0	-	4
20	5	4	31	-	-	-	15
21	2	0	-	-	-	49	-
22	2	2	-	-	-	57	-
total	124	43	580	35	277	148	170

On the other hand, for sewage, there are many points of intersection with the emergency road network in the southern districts 15 and 16, and in the northern districts 1 and 3. These areas should be improved to increase earthquake resistance of the water pipes.

Table 2.2.25 Sewage pipes and the number of intersections with the emergency road network and the fault, and the number of estimated damage points

district	Number of Intersections with ERN	Number of Intersections with the fault	Number of damage points
1	3	7	425
2	1	3	319
3	3	4	268
4	0		3
5	-	-	-
6	2	3	241
7	0		63
8	1		36
9	-	-	-
10	1		103
11	2		101
12	2		92
13	3		219
14	3		151
15	9		266
16	8		162
17	2		149
18	1		103
19	3		130
20	4	6	104
21	-	-	-
22	-	-	-

b.Gas

Damage function shown in HAZUS (8.1.8 Development of Damage Functions) was utilized. Estimated number of damage points for the gas pipe was evaluated by the above data. Damage points per pipe length (RR) was calculated by the following HAZUS formula (Table 2.2.26 to Table 2.2.27).

$$RR = 0.3 \times 0.0001 \times PGV^{(2.25)}$$

Table 2.2.26 Estimated number of damage points in the gas pipes in each district (Psi100)

district	diameter	Length of pipes (m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
5	12	4,264	534	82.454	0.615	3
9	24	5,160	590	78.594	0.552	3
18	12	2,995	599	64.079	0.349	1
20	12	202	776	44.161	0.151	0
20	4	2,831	776	44.161	0.151	0
21	12	18,620	479	73.962	0.481	9
21	16	2,298	479	73.962	0.481	1
21	18	14,010	479	73.962	0.481	7
21	24	4,077	479	73.962	0.481	2
21	30	3,599	479	73.962	0.481	2
22	30	734	470	72.572	0.461	0

Table 2.2.27 Estimated number of damage points in the gas pipes in each district(Psi250)

district	diameter	Length of pipes (m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points	Sub Total
1	8	1,920	564	87.086	0.695	1	
1	10	7,867	564	87.086	0.695	5	
1	12	4,917	564	87.086	0.695	3	
1	16	6,915	564	87.086	0.695	5	
1	24	2,459	564	87.086	0.695	2	
1		23,725	564	87.086	0.695	16	32
2	12	14,516	534	82.454	0.615	9	
2	22	130	534	82.454	0.615	0	
2	24	16,994	534	82.454	0.615	10	
2	30	1,439	534	82.454	0.615	1	
2		36,010	534	82.454	0.615	22	42
3	12	13,745	550	84.925	0.657	9	
3	24	5,111	550	84.925	0.657	3	
3		21,764	550	84.925	0.657	14	26
4	10	1,274	550	84.925	0.657	1	
4	12	20,023	550	84.925	0.657	13	
4	24	11,012	550	84.925	0.657	7	
4		32,622	550	84.925	0.657	21	42
5	12	13,066	534	82.454	0.615	8	
5	24	12,545	534	82.454	0.615	8	

district	diameter	Length of pipes (m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate （points/km)	Number of damage points	Sub Total
5	30	1,717	534	82.454	0.615	1	
5	36	4,257	534	82.454	0.615	3	
5		28,411	534	82.454	0.615	17	37
6	12	18,346	483	74.579	0.490	9	
6	16	2,301	483	74.579	0.490	1	
6	24	897	483	74.579	0.490	0	
6		15,515	483	74.579	0.490	8	18
7	12	15,036	477	73.653	0.477	7	
7	16	1,836	477	73.653	0.477	1	
7	24	145	477	73.653	0.477	0	
7		9,536	477	73.653	0.477	5	13
8	12	1,942	537	82.917	0.622	1	
8	16	1,708	537	82.917	0.622	1	
8	24	4,431	537	82.917	0.622	3	
8		10,916	537	82.917	0.622	7	12
9	12	3,708	590	91.101	0.769	3	
9	22	3,838	590	91.101	0.769	3	
9		5,200	590	91.101	0.769	4	10
10	12	6,848	543	83.844	0.638	4	
10		5,900	543	83.844	0.638	4	8
11	12	8,868	487	75.197	0.500	4	
11	16	2,120	487	75.197	0.500	1	
11		7,049	487	75.197	0.500	4	9
12	12	10,518	464	71.645	0.448	5	
12	16	3,127	464	71.645	0.448	1	
12		11,177	464	71.645	0.448	5	11
13	12	5,749	535	82.608	0.617	4	
13	16	3,763	535	82.608	0.617	2	
13	24	4,025	535	82.608	0.617	2	
13		10,173	535	82.608	0.617	6	14
14	12	7,447	484	74.734	0.493	4	
14	22	3,875	484	74.734	0.493	2	
14	24	4,953	484	74.734	0.493	2	
14		10,935	484	74.734	0.493	5	13
15	12	3,067	556	85.851	0.673	2	
15	16	4,096	556	85.851	0.673	3	
15	22	4,538	556	85.851	0.673	3	
15	24	8,117	556	85.851	0.673	5	
15	30	1,472	556	85.851	0.673	1	
15		20,873	556	85.851	0.673	14	28
16	4	2,113	560	86.469	0.684	1	
16	12	334	560	86.469	0.684	0	
16	16	2,904	560	86.469	0.684	2	
16	20	1,389	560	86.469	0.684	1	
16	24	5,231	560	86.469	0.684	4	
16		12,515	560	86.469	0.684	9	17
17	12	3,113	592	91.410	0.775	2	

district	diameter	Length of pipes (m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points	Sub Total
17	22	79	592	91.410	0.775	0	
17		10,948	592	91.410	0.775	8	10
18	8	334	599	92.491	0.796	0	
18	12	13,524	599	92.491	0.796	11	
18	22	2,233	599	92.491	0.796	2	
18	24	321	599	92.491	0.796	0	
18		13,809	599	92.491	0.796	11	24
19	22	2,798	591	91.255	0.772	2	
19	24	10,620	591	91.255	0.772	8	
19	30	530	591	91.255	0.772	0	
19		6,799	591	91.255	0.772	5	15
20	6	478	776	119.821	1.425	1	
20	12	4,671	776	119.821	1.425	7	
20	16	429	776	119.821	1.425	1	
20	20	5,351	776	119.821	1.425	8	
20	22	149	776	119.821	1.425	0	
20	30	2,287	776	119.821	1.425	3	
20		27,132	776	119.821	1.425	39	59
21	36	16,384	479	73.962	0.481	8	
21		345	479	73.962	0.481	0	8
22	30	31,828	470	72.572	0.461	15	
22	36	2,292	470	72.572	0.461	1	
22		1,463	470	72.572	0.461	1	17

Table 2.2.28 shows that there is high vulnerability in districts 1, 2, and 20 in the 250 psi lines.

Table 2.2.28 Number of gas pipe Intersections with the Emergency Road Network and the fault in each district, and the estimated number of damage points

district	100psi			250psi		
	Number of Intersections with the ERN	Number of Intersections with the fault	Estimated damage points	Number of Intersections with the ERN	Number of Intersections with the fault	Estimated damage points
1	—	—	—	30	26	32
2	—	—	—	28	16	42
3	—	—	—	21	20	26
4	—	—	—	17	6	42
5	4	0	3	14	9	37
6	—	—	—	28	10	18
7	—	—	—	21	1	13
8	—	—	—	16	0	12
9	0	0	3	16	0	10
10	—	—	—	12	0	8
11	—	—	—	18	0	9
12	—	—	—	19	0	11
13	—	—	—	17	4	14
14	—	—	—	11	0	13
15	—	—	—	24	2	28
16	—	—	—	20	0	17
17	—	—	—	12	0	10
18	4	0	1	10	0	24
19	—	—	—	18	0	15
20	2	0	0	28	14	59
21	9	0	21	1	0	8
22	1	0	0	4	5	17
Total	20	0	28	385	113	465

c.Electricity

The damage function shown in HAZUS (8.1.8 Development of Damage Functions) was used. Damage points per pipe length (RR) were calculated by the following formula HAZUS (Table 2.2.29).

$$RR = 0.3 \times 0.0001 \times PGV^{(2.25)}$$

Table 2.2.29 Estimated number of points of damage to the underground cables in each district

district	Length of pipes (m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	33,214	87.086	564	0.695	23
2	46,557	82.454	534	0.615	29
3	29,147	84.925	550	0.657	19
4	25,710	84.925	550	0.657	17
5	11,960	82.454	534	0.615	7
6	42,755	74.579	483	0.490	21
7	26,292	73.653	477	0.477	13
8	5,462	82.917	537	0.622	3
9	9,996	91.101	590	0.769	8
10	6,072	83.844	543	0.638	4
11	24,622	75.197	487	0.500	12
12	54,663	71.645	464	0.448	24
13	16,213	82.608	535	0.617	10
14	15,560	74.734	484	0.493	8
15	5,351	85.851	556	0.673	4
16	25,510	86.469	560	0.684	17
17	3,738	91.410	592	0.775	3
18	13,137	92.491	599	0.796	10
19	74	91.255	591	0.772	0
20	480	119.821	776	1.425	1
21	15,396	73.962	479	0.481	7
22	7,481	72.572	470	0.461	3
Total					243

d.Telecommunications

Estimated damage number of telecommunication pipe has been calculated using the pipeline damage function shown in HAZUS. (Table 2.2.30)

$$RR = 0.3 \times 0.0001 \times PGV^{(2.25)}$$

Table 2.2.30 Estimated damage number of telecommunication pipes in each district

district	Length of pipes (m)	peak ground acceleration (gal)	peak ground velocity (cm/s)	Damage rate (points/km)	Number of damage points
1	26,023	564	87.086	0.695	18
2	28,600	534	82.454	0.615	18
3	29,608	550	84.925	0.657	19
4	30,680	550	84.925	0.657	20
5	36,308	534	82.454	0.615	22
6	28,597	483	74.579	0.490	14
7	23,054	477	73.653	0.477	11
8	11,525	537	82.917	0.622	7
9	11,229	590	91.101	0.769	9
10	10,623	543	83.844	0.638	7
11	17,455	487	75.197	0.500	9
12	23,766	464	71.645	0.448	11
13	11,921	535	82.608	0.617	7
14	9,785	484	74.734	0.493	5
15	16,910	556	85.851	0.673	11
16	9,511	560	86.469	0.684	7
17	5,762	592	91.410	0.775	4
18	18,369	599	92.491	0.796	15
19	4,430	591	91.255	0.772	3
20	17,461	776	119.821	1.425	25
21	26,895	479	73.962	0.481	13
22	6,140	470	72.572	0.461	3
Total					258

There are large number of damage points from districts 1 to 5 and 20. These areas should be improved to increase the seismic resistance with priority.

Table 2.2.31 Number of Intersections of communication pipes with the ERN and the fault and the estimated number of damage points in each district

district	Number of intersections with ERN (underground lines)	Number of intersections with the faults (underground lines)	Number of damage points
1	11	10	18
2	22	3	18
3	9	9	19
4	8	2	20
5	1	1	22
6	25	5	14
7	10	1	11
8	1	0	7
9	8	0	9
10	5	0	7
11	5	0	9
12	24	0	11
13	2	0	7
14	5	0	5
15	2	0	11
16	9	0	7
17	3	0	4
18	2	0	15
19	0	0	3
20	1	0	25
21	3	0	13
22	2	2	3
Total	158	33	258

(2) Vulnerability assessment of buildings

The collapse of buildings can block the emergency road network with scattered debris. This chapter studies the experience of the past disasters, and assesses the possibility of road blocks due to the collapse of buildings.

1) Damage occurred by building collapse

JICA Expert Team explained the damages due to the collapse of buildings with the experiences of Japan and Iran.

<u>a.Example in Japan</u>

In the Great Hanshin Earthquake, more than half of the deaths occurred because of suffocation. The second cause is crushing. The collapse of buildings block the road and ambulances and fire-engines cannot arrive at the damaged area. Because of this, issues regarding the spread of fire and the deterioration of the condition of victims cannot be solved, and then the number of casualties increases.

b.Example in Iran

The "Microzoning Study" in 1999 prepared by JICA estimated the damage to Teheran city based on the three different types of earthquake models.

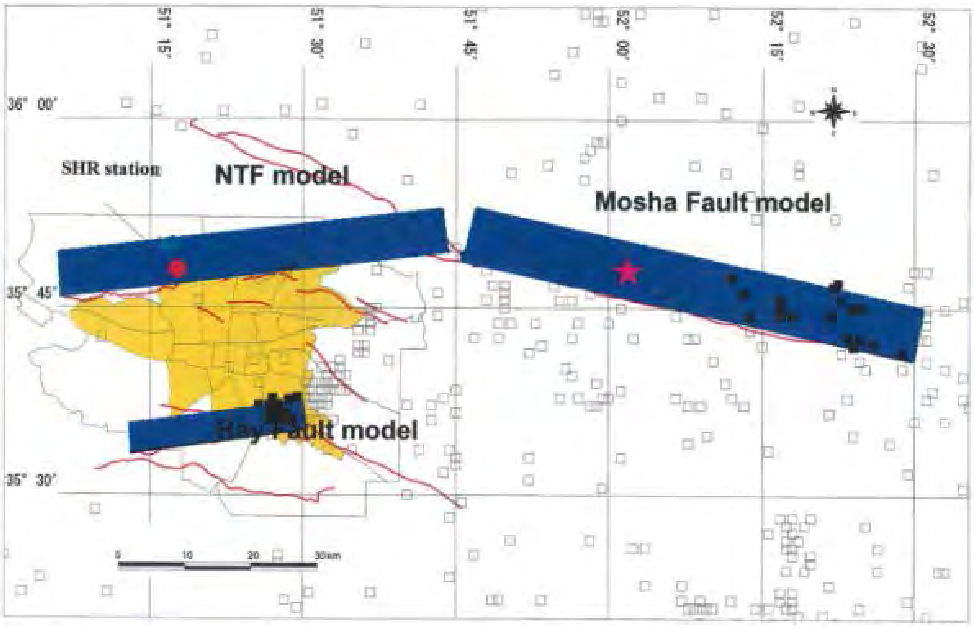


Figure 2.2.22 Three types of earthquake models (1999)

Table 2.2.32 Damage estimate of each model (1999)

	Ray Fault Model	NTF Model	Mosha Fault Model
Building Damage (Number)	483,000	313,000	113,000
Number of Death (Number)	383,000	126,000	20,000
Water Pipeline (Points)	3,864	776	13
Gas Pipeline (Km)	539	539	137
Electricity (Number)	18.7	2.65	0
Telecommunication (Km)	12.8	2.2	0

With the Ray Fault Model, 483,000 buildings in Teheran could be totally or partly collapsed. This is equivalent to about 55% of all the buildings. The characteristic of residential buildings in Iran is heavier structure comparing to Japan, because they are built with steel or stones in Iran, though they are constructed with wood in Japan. The walls are mainly built out of bricks and both confined masonry walls and sun-dried bricks exist.

2) Example of road block due to the collapse of buildings

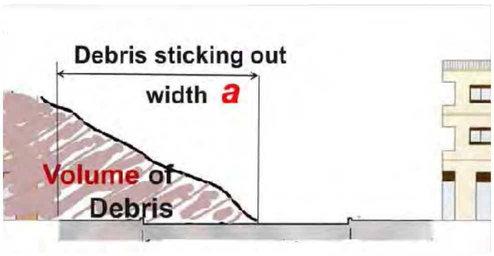
The JICA Expert Team explained the example of a road block due to the collapse of a building. Many roads had been blocked after the Great Hanshin Earthquake due to the collapse of buildings and infrastructures, and to the falling of window glass and signboards.

Many roads were blocked because of the collapse of buildings in 2002 in Iran as well.

Figure 2.2.23 Road Blocks in Iran (2002)

3) Assessment of the amount and width of Debris by collapse of buildings

Assessment of the width of debris by a collapsed building can be utilized in order to estimate the risk allowance of emergency road network. Also, it can be used to estimate the cost and manpower for clearance. Therefore, the estimation could be included in the disaster mitigation and reconstruction plan. The JICA Expert Team explained the research regarding assessment of the width of debris in Japan. The following formula was based on the result of the measurement of damages by aerial photography after the Great Hanshin Earthquake.



$a=2.32 \cdot X_1^{0.379} + 0.189 \cdot X_2^{2.23} + 4.41 \cdot X_3^{12.0}$

a : Debris sticking out width (m)

X_1 : **Damage ratio**
X_2 : gross floor area / building area
X_3 : building area / ground-floor area

Figure 2.2.24 Formula of assessing the width of debris

The counterpart understood the importance of the assessment with introduction of the formula. As a result of discussions between the counterpart and the JICA Expert Team, a different assessment method based on Thessalonians thesis has been adopted, considering difference of structure of buildings between Japan and Iran, and with strong suggestion from Iranian side. The methodology of calculation is as follows.

First of all, the rate of collapse of building is determined with the formula shown as follows.

Secondly, β and median are decided based on the type of structure, constructed year, and height of building as shown on Table 2.2.33. Finally, the width of debris is calculated with the graph shown on Figure 2.2.25. The indication of the width per story is summarized as shown on Table 2.2.34

$$P = NORMSDIST\left(\frac{1}{\beta}\ Ln\frac{PGA}{median}\right)$$

Table 2.2.33 Decision of β and median

β	*median*	Building year	height	Construction Type	Row
0/64	0/36	Before 67	short	steel	1
0/64	0/45	After 67			2
0/64	0/43	Before 67	medium	steel	3
0/64	0/53	After 67			4
0/64	0/47	Before 67	high	steel	5
0/64	0/58	After 67			6
0/64	0/35	Before 67	short	concrete	7
0/64	0/44	After 67			8
0/64	0/41	Before 67	medium	concrete	9
0/64	0/54	After 67			10
0/64	0/35	Before 67	high	concrete	11
0/64	0/44	After 67			12
0/64	0/37	Before 67	short	masonary	13
0/64	0/38	Before 67	medium		14

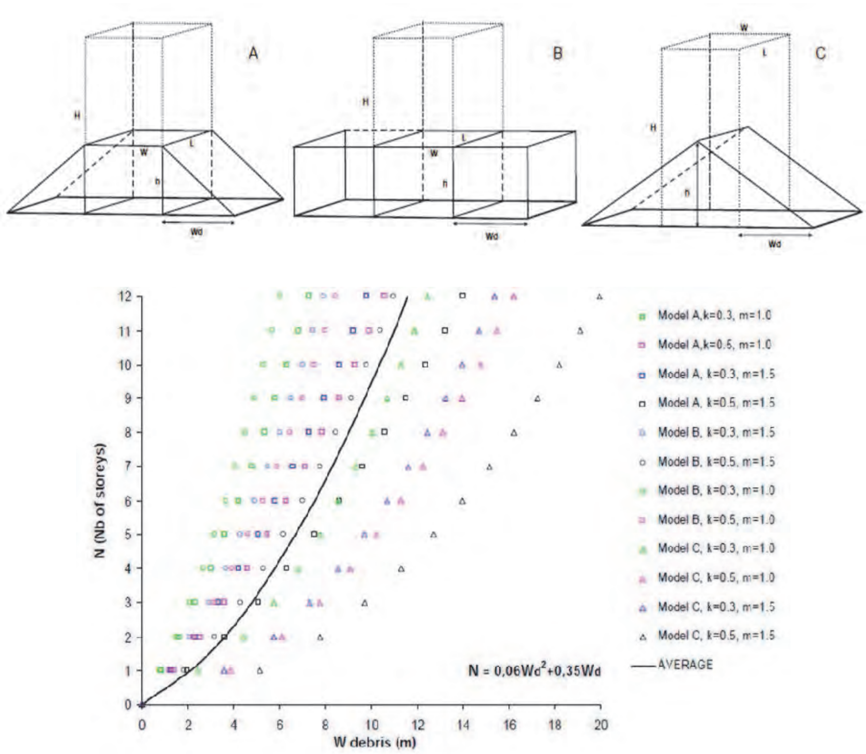


Figure 2.2.25 Assessment graph of the width of debris

Table 2.2.34 Indication of width of debris per story

blockage	Width of debris	number of Stories	row
SIDEWALK	2.1	1	1
SIDEWALK & 1 Line	3.6	2	2
	4.7	3	3
SIDEWALK & 2 Line	5.8	4	4
	6.7	5	5
	7.5	6	6
	8.3	7	7
SIDEWALK & 3 Line	9.0	8	8
	9.7	9	9
	10.3	10	10
	10.9	11	11
SIDEWALK & 4 Line	11.5	12	12
	12.1	13	13
	12.6	14	14
	13.2	15	15
SIDEWALK & 4 Line	13.7	16	16
	14.2	17	17
	14.6	18	18
	15.1	19	19
	15.6	20	20
	16.0	21	21
	16.5	22	22
	16.9	23	23
	17.3	24	24
SIDEWALK & 5 Line	17.7	25	25
	18.1	26	26
	18.5	27	27
	18.9	28	28
	19.3	29	29
	19.6	30	30

$$V=0.66\,LW_d\,(W_d-2)$$

W_d =debris width from building collapse

L= Width of building

4) Countermeasure to apply for the safety of the emergency road network

The JICA Expert Team advised the following.

<u>a.Quick removal of debris after the earthquake</u>

The JICA Expert Team suggests the agreements with the construction companies which obtain heavy equipment, and to ask them to respond quickly in case of earthquake. The example of an agreement in Japan is explained and TDMMO understood. Hereafter, the agreement will be prepared with reference to the service of snow removal.

<u>b.Alternative transportation</u>

Iran lists the subway as alternative transportation. The subsurface structure is comparatively quake-resistant, and damage to a subway is rare. The example of damage to a subway in the case of the Great Hanshin Earthquake is explained in the third seminar. Subways are effective as alternative transportation. However, once a collapse has occurred such as at Daikai station, the damage is severe. Therefore, the preparations for an emergency must include such things as submergence and collapse.

c.Seismic retrofit of buildings along the emergency road network

Seismic retrofit of buildings along the emergency road network before an earthquake can be one countermeasure. The details are discussed in Chapter 2.2.6.

2.2.4 【5】To prepare a seismic resistant plan for the vulnerability of the emergency road networks including bridges and tunnels (Activity1-4)

(1) Studied seismic standards and seismic resistant plans in Iran

The receipt of seismic criteria of Iran “Code463”

The seismic measures have been implemented sequentially with budget by the Technical deputy.

(2) Studied seismic measures that are already put in place in Iran

1) Inspection of seismic retrofitting construction site

The JICA Expert Team visited the seismic retrofitting construction site at Jalal Al Ahmad Bridge on April 10, 2013, and inspected the current state of the seismic retrofitting measures. In this site ground anchors were installed into the abutment from the surface of the abutment to the back of the abutment. This seismic retrofitting method inhibits the relative displacement generated between the superstructure and substructure in an earthquake by interconnecting the super structure and substructure.

Figure 2.2.26 Photo taken under the target bridge

Figure 2.2.27 Photos of construction situation, Anchor installed situation, Retrofitting situation at the bearing

2) Implementation of seismic retrofitting in other bridges

It is understood that on October 24, 2013, the other bridges had seismic retrofitting implemented.

Figure 2.2.28 Photo of bridge with seismic retrofitting implemented

To inhibit the deformation of the pier the top of the pier was connected to the ground with a steel bar. In another bridge, a retention device (the connection between superstructure and substructure by PC cable) is installed at the girder end, in addition, the bridge seats are widened.

Figure 2.2.29 Photos of Retention device(left) and Bridge seat widening(right)

Alternately, on a bigger bridge constructed recently, isolation dampers are installed at the girder end, and it has become a specification in consideration of the behavior during an earthquake.

Figure 2.2.30 The bridge with an isolation damper installed at the girder end

Figure 2.2.31 The isolation damper at the girder end

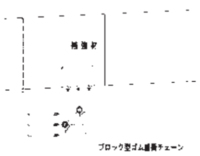
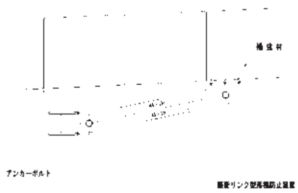
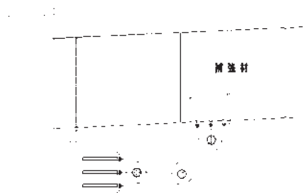
3) Generalization

There is still only a few of the bridges with seismic retrofitting measures, but gradually carrying out the seismic retrofitting has begun. It was confirmed that the counter measures against collapse of bridges are the same as those that are used throughout Japan, such as PC cable or edge widening and so on. Regarding the seismic performance of the piers, the methods for the wrapping of piers are usual in Japan because the cost is low, but it was confirmed that the restraining measures for relative displacement between superstructures and substructures were used extensively in Tehran city.

(3) Considered seismic measures that are applicable in Iran

It was confirmed that the counter measures against collapse of bridges using PC cable and the edge widening was carried out extensively in Iran. In addition, it was confirmed that the restrained deformation measures were also carried out extensively. It is thought that the counter measures against collapse of bridges (like the PC cable) used extensively in Japan is applicable in the bridges of Iran when the situation is considered. Therefore it is thought that the Japanese measures are applicable. The list of measures is shown below.

Table 2.2.35 The examples of the collapse of bridge prevention devices

	The block type buffer chain	Buffer link type	Buffered joint pin type
Image	 	 	 
Cost	37,500 USD	45,800 USD	54,200 USD

On the other hand, it cannot be confirmed that the pier wrapping method is in use now. A summary of the method, an approximate cost and the application procedure were explained for the methods applicable for Iran.

(4) Assess the seismic vulnerability of the emergency road network including multiple and alternative routes

1) Summary

Regarding the structures on an emergency road network, the tunnel structure is judged to be high in earthquake resistance because it moves in harmony with the ground in an earthquake.

The bridges that were suspected of having a particularly high seismic vulnerability were assessed.

If it is only for choosing the target bridges, a simple method is adequate. But it is necessary to suggest an appropriate seismic retrofitting method for each target bridge. Just a first screening may be able to determine the possibility of collapse of a bridge, but the weak points that could cause the collapse of a bridge cannot be determined. By performing a secondary screening it clarifies weaknesses that could produce collapse of a bridge, and it is necessary to suggest appropriate seismic retrofitting measures.

In implementing, TDMMO and the JICA Expert Team discussed the evaluation method for seismic performance and the procedure for evaluation, and first screening by the simple evaluation technique was carried out in order to choose the bridges which had high vulnerability, and those bridges were comprehensively evaluated for seismic performance. The simplified evaluation was carried out using the American "HAZUS" and Japanese "Katayama method" as the first screening. The comprehensive evaluation was carried out based on Japanese "Ductility design" that is one of the design methods for Japanese highway bridges. For carrying out the comprehensive evaluation, the bridges of Tehran city were grouped according to the bridge type, and the comprehensive evaluation was carried out for the typical bridge extracted from a bridge group evaluated to have high vulnerability by the first screening.

The outline of the American "HAZUS" and the Japanese "Katayama method" is as follows.

■HAZUS

HAZUS is the earthquake damage estimation system. It's developed by U.S. Federal Emergency Management Agency (FEMA). The bridge damage is estimated by the bridge spec and the position of the bridge in HAZUS

For bridge, the seismic damage of the target bridge can be calculated 4 type possibility of occurrence (Minor Damage, Moderate Damage, Extensive Damage, Complete Damage) based on the information of that the target bridge's specifications such as the seismic design type, number of span, structure type, bearing type and location of the bridge (longitude, latitude), spectrum acceleration, and so on.

If this method is applied to the bridge of the other countries, it is necessary to carefully determine the applicably, since the seismic design type and the structure type of the target bridge are defined based on the specifications of the U.S.

■Katayama method

Katayama method is the judgment technique for seismic damage possibility. It is based on the method proposed by Tsuneo Katayama. Katayama method has been used on the assumption that damage during an earthquake in Tokyo Metropolitan or other many local government in Japan. Microzoning Study* was carried out in 2000.

Katayama method is the technique for scoring the possibility of the bridge unseating risk depended on the target bridge specifications and the surrounding environment such as the girder type, bearing type, substructure type, soil type, etc. This technique is obtained by multi-dimensional quantification theory I based on the results of analyzing the relationship between the actual earthquake damage and bridge status.

In the Microzoning Study, Katayama method have been modified to apply to Tehran, since it was developed based on the Japanese seismic damage.

* Microzoning Study: The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of IRAN, 2000

2) First screening

For the all bridges in Tehran city, the first screening was carried out using the HAZUS and Katayama methods. Only TDMMO carried out the evaluation by HAZUS. For the Katayama method, the necessary information and the procedure for the evaluation were explained to CPs in TDMMO, and the CPs evaluated the seismic vulnerability of those bridges. The bridges of Tehran can be classified into 11 types and the risk of collapse was evaluated for each bridge type.

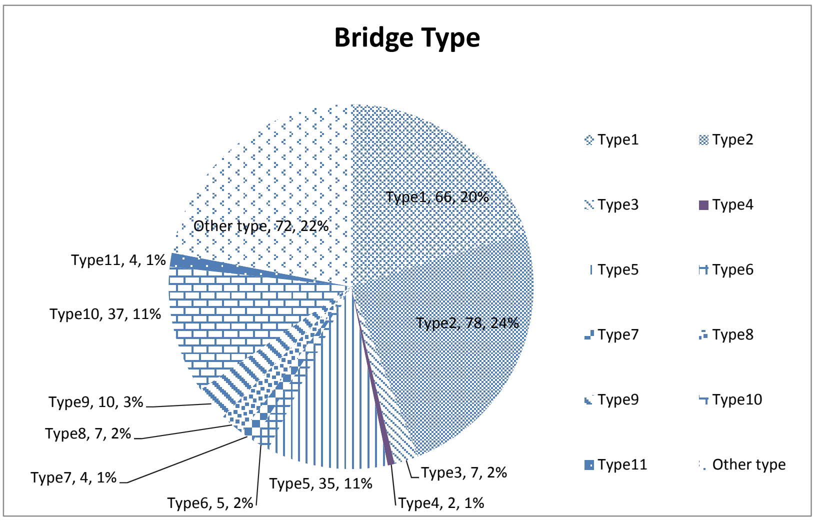


Figure 2.2.32 Percentage of bridges in Tehran by type

Table 2.2.36 Risk of collapse in each bridge type

No.	Superstructure	Substructure	Possibility of collapse	Comment
Type1	Concrete slab	Pile column bent	○	
Type2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×	
Type3	Plate girder (steel) with continuous girder	Pile column bent	△	The seismic capacity is depended on the lateral strength of pier.
Type4	Plate girder (steel) with continuous girder	Thin steel pier	×	
Type5	Concrete slab	Thin RC pier	△	The seismic capacity is depended on the lateral strength of pier.
Type6	Rigid frame (steel)	Rigid frame (steel)	○	
Type7	Rigid frame (concrete)	Rigid frame (concrete)	○	
Type8	Plate girder (Temporary bridge)	Thin steel pier (Temporary)	×	
Type9	Box beam	RC pier	△	The seismic capacity is depended on the lateral strength of pier.
Type10	1 span bridge	Abutment	○	
Type11	Concrete slab with simple girder	Pile column bent	×	

Legend
- ○ Possibility of collapse is low
- △ Possibility of collapse is middle
- × Possibility of collapse is high

As the result of the first screening, 18 bridges with the highest priority can be classified as follows.

Table 2.2.37 Highest priority bridge and possibility of collapse

Code	Bridge Name	Type	Superstructure	Substructure	Possibility of collapse
1-1	امام علی- ارتش	?			
2-8	نیایش شرق به چمران جنوب	2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×
2-9	(روی مسیل)همّت - ضلع غربی چمران	1	Concrete slab	Pile column bent	○
2-22	شیخ فضل ا...-یادگار امام	1	Concrete slab	Pile column bent	○
2-38	(گیشا)چمران - جلال	8	Plate girder (Temporary bridge)	Thin steel pier (Temporary)	×
3-18	(پلهاي فجر)همت - مدرس	1	Concrete slab	Pile column bent	○
4-26	(شهدای رسالت)شهدای شهرداری منطقه 4	7	Rigid frame (concrete)	Rigid frame (concrete)	○
5-11	اشرفي اصفهاني-همت	2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×
5-14	نیایش-شهید باکري	6	Rigid frame (steel)	Rigid frame (steel)	○
5-19	باکری - حکیم	6	Rigid frame (steel)	Rigid frame (steel)	○
6-8	(پل رسالت)مدرس-رسالت	2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×
6-13	حافظ-طالقانی	8	Plate girder (Temporary bridge)	Thin steel pier (Temporary)	×
6-14	(حافظ- انقلاب)پل کالج	8	Plate girder (Temporary bridge)	Thin steel pier (Temporary)	×
11-1	نواب- امام خمیني	11	Concrete slab with simple girder	Pile column bent	×
11-2	نواب - هلال احمر	11	Concrete slab with simple girder	Pile column bent	×
12-3	پل چوبي (سپاه - انقلاب)	8	Plate girder (Temporary bridge)	Thin steel pier (Temporary)	×
18-8	آزادگان-سعیدی	2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×
21-2	بزرگراه تهران-کرج-بلوار شیشه مینا (بلوار شرقی استادیوم)	2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×

These 18 bridges were classified according to bridge type, and a typical bridge that had high vulnerability was chosen from each bridge type to be the target bridge of the comprehensive evaluation.

Table 2.2.38 Vulnerability and typical bridge according to the bridge type

	Superstructure	Substructure	Possibility of collapse	Target bridge
Type 1	Concrete slab	Pile column bent	○	2-9, 2-22, **<u>3-18</u>**
Type 2	T-section girder (concrete) or Plate girder (steel) with simple girder	Pile column bent	×	**<u>2-8</u>**, **<u>5-11</u>**, 6-8, 18-8, 21-2 & Marzdaran
Type 6	Rigid frame (steel)	Rigid frame (steel)	○	5-14, 5-19
Type 7	Rigid frame (concrete)	Rigid frame (concrete)	○	4-26
Type 8	Plate girder (Temporary bridge)	Thin steel pier (Temporary)	×	**<u>2-38</u>**, 6-13, 6-14, 12-3
Type 11	Concrete slab with simple girder	Pile column bent	×	**<u>11-1</u>**, 11-2

*Bold type and underline: Typical Bridge

3) Comprehensive evaluation

The comprehensive evaluation was carried out based on “Ductility design” that is one of the Japanese highway bridge design methods. For carrying out the comprehensive evaluation, it was necessary to get the detailed drawings in order to determine the re-bar arrangement and materials, but the CPs had difficulty to get that information from the Technical Deputy. Therefore, JICA Expert Team with C/Ps measured the dimensions in the target bridge site and assumed that information as basic for the comprehensive evaluation. The re-bar arrangement of the internal pier was estimated from the standard drawings of a bridge in Tehran.

Japanese “Ductility design” as the comprehensive evaluation method that was explained to the C/Ps from the general theory to the real calculation procedure. The figure of real calculation flow is shown on the next page.

Start

Step	Input	Calculation	Output	Chapter of Specification of Highway Bridge
Calculation of Volume ratio of lateral confining reinforcement ρs	【Input】 Ah:Sectional area of each lateral confining reinforcement (mm2) s:Spacings of lateral confining reinforcement (mm) d:Effective length (mm)	【Calculation】 $\rho_s = \frac{4A_h}{sd} \leq 0.018$	【Output】 ρs	【Chapter of Specification of Highway Bridge】 10.4
Decision of the stress-strain curve of concrete	【Input】 ρs:Volume ratio of lateral confining reinforcement σck:Design strength of concrete (N/mm2) σsy:Yield point of lateral confining reinforcement (N/mm2) Ec:Young's modulus of concrete (N/mm2)	【Calculation】 $\sigma_c = \begin{cases} E_c\varepsilon_c\left\{1-\frac{1}{n}\left(\frac{\varepsilon_c}{\varepsilon_{cc}}\right)^{n-1}\right\} & (0 \leqq \varepsilon_c \leqq \varepsilon_{cc}) \\ \sigma_{cc} - E_{des}(\varepsilon_c - \varepsilon_{cc}) & (\varepsilon_{cc} < \varepsilon_c \leqq \varepsilon_{cu}) \end{cases}$ $n = \frac{E_c\varepsilon_{cc}}{E_c\varepsilon_{cc} - \sigma_{cc}}$ $\varepsilon_{cu} = \begin{cases} \varepsilon_{cc} & \text{(For Type I Earthguake Ground Motion)} \\ \varepsilon_{cc} + \frac{0.2\sigma_{cc}}{E_{des}} & \text{(For Type II Earthguake Ground Motion)} \end{cases}$ $\sigma_{cc} = \sigma_{ck} + 3.8\alpha\rho_s\sigma_{sy}$ $\varepsilon_{cc} = 0.002 + 0.033\beta\frac{\rho_s\sigma_{sy}}{\sigma_{ck}}$ $E_{des} = 11.2\frac{\sigma_{ck}^2}{\rho_s\sigma_{sy}}$	【Output】 σcc、εcc、σcu、εcu、f(σc)	【Chapter of Specification of Highway Bridge】 10.4
Calculation of Plastic hinge length Lp	【Input】 D:Sectional depth (mm) H:Height of superstrucutural inertial force from the bottom of column (mm) (≒Pier height)	【Calculation】 $L_p = 0.2h - 0.1D$	【Output】 Lp	【Chapter of Specification of Highway Bridge】 10.3
Calculation of Py, δy, Pu, δu by Push-Over analysis	【Input】 σcc、εcc、σcu、εcu、f(σc)、σck、h、A、W、Lp、I、Ec	【Calculation】 By Push-Over Analysis	【Output】 Pu、δu、Py、δy	【Chapter of Specification of Highway Bridge】 10.3
Calculation of Shear strength Ps	【Input】 d、b、Aw、σsy、θ、a	【Calculation】 $P_s = S_c + S_s$ …………… $S_c = c_c c_e c_{pt} \tau_c b d$ …………… $S_s = \frac{A_w \sigma_{sy} d(\sin\theta + \cos\theta)}{1.15a}$	【Output】 Ps	【Chapter of Specification of Highway Bridge】 10.5
Evaluation of Failure Mode	【Input】 Pu、Ps	【Calculation】 Pu≦Ps	【Output】 破壊形態	【Chapter of Specification of Highway Bridge】 10.2
Calculation of Ductility capacity of the reinforcement column μa	【Input】 δu、δy	【Calculation】 $\mu_a = 1 + \frac{\delta_u - \delta_y}{\alpha\delta_y}$	【Output】 μa	【Chapter of Specification of Highway Bridge】 10.2
Calculation of Force Reduction Factor cs	【Input】 μa:Allowable ductility ratio of structural system having an plastic force-displacement relation	【Calculation】 $c_S = \frac{1}{\sqrt{2\mu_a - 1}}$	【Output】 cs	【Chapter of Specification of Highway Bridge】 6.4.4
Calculation of Design Horizontal Seismic Coefficient khc	【Input】 cs、khc0、(cz)	【Calculation】 khc＝cs・cz・khc0	【Output】 khc	【Chapter of Specification of Highway Bridge】 6.4.3
Verification of the Seismic Performance of Reinforced Concrete Columns	【Input】 Pa、khc、W	【Calculation】 Pa≧khc・W	【Output】 The result of seismic capacity of pier	【Chapter of Specification of Highway Bridge】 6.4.6
Calculation of residual displacement δR	【Input】 cz、khc0、W、Pa、δy	【Calculation】 $\delta_R = c_R(\mu_r - 1)(1 - r)\delta_y$	【Output】 δR	【Chapter of Specification of Highway Bridge】 6.4.6
Verification of residual displacement	【Input】 δR、h	【Calculation】 δR≦h/100	【Output】 The result of verification of residual displacement	【Chapter of Specification of Highway Bridge】 6.4.6

End

Figure 2.2.33 Calculation flow figure of the ductility design

The Japanese “Ductility design” as the comprehensive evaluation method needed to be usable in Iran since this method was Japan’s original calculation method. Therefore, JICA Expert Team explained to the CPs how to apply this method to Code 463 in Iran.

(5) Prepared a seismic resistant plan for the emergency road network including multiple alternative routes

1) Summary

Based on the result of the seismic vulnerability assessment of the previous paragraph (4), the seismic retrofitting plan was decided. The purpose of the seismic retrofitting plan is improvement of the seismic resistance of the emergency road network as the pivot of the disaster restoration and is to enable the disaster restoration using the emergency road network. Therefore, the priority of the emergency road network is the highest, and the priority of the seismic retrofitting is decided by evaluating the result of the comprehensive evaluation.

2) Basic policy for the development of the seismic retrofitting plan

It was decided that the priority of the seismic retrofitting should be based on its connection with the emergency road network of the bridge basically. The following table is shown the priority for seismic retrofitting (1 means the most priority for the seismic retrofitting.).

	Out of ERN	1 ERN	2 or more ERN
Low risk	4	3	2
High risk	3	2	1

The Japanese "Ductility design" is considered to be the most dependable method for evaluation of the current degree of risk with the Katayama method second most dependable and the HAZUS the least.

3) Developing the priority by comprehensive evaluation

In the Japanese “Ductility design”, it is possible to evaluate the inertial force “khcW” and the lateral strength of the pier during an earthquake. On the other hand, “khcW” is considered the inertial force acted the bearing point directly because “khcW” is considered the energy absorption by the plastic hinge at the pier. Therefore, the seismic performance of the pier and the bearing point is evaluated as follows.

a) For piers

Pier’s performance = $Pa/k_{hc}W$
1≧; The seismic performance is high, and the possibility of collapse is low.
1<; The seismic performance is low, and the possibility of collapse is high.
Where,
Pa: The lateral strength of pier (kN)
$k_{hc}W$: The inertial force acting pier (kN)

b) For bearing part

Bearing’s performance = τ_a/τ
1≧; The seismic performance is high, so the possibility of collapse is low.
1<; The seismic performance is low, so the possibility of collapse is high.

Where,
τ_a: The shear strength of the anchor bolt at bearing part (kN)
τ: The inertial force acting on the anchor bolt at the bearing part (= $k_{hc}W$) (kN)

4) Developing the seismic retrofitting plan

Based on the results of the previous section, the priority of seismic retrofitting was determined by the following procedure.

a) Sort by priority of ERN
b) Sort by Bearing's performance in the comprehensive evaluation
c) Sort by Pier's performance in the comprehensive evaluation
d) Sort by KATAYAMA Score
e) Sort by the complete HAZUS score

The emergency road is the top priority because it is necessary to improve the seismic performance of the emergency road network as soon as possible. The second priority is the seismic performance of the bearing points. This is because if the anchor-bolt of the bearing is vulnerable and the bridge seat width is narrow, it is easy for the bridge to collapse.

The flow diagram to visualize the above-mentioned procedure is shown in the following page. Based on the same procedure, the seismic retrofitting plan was established in order to decide the priority of the seismic retrofitting and the necessary seismic retrofitting measures.

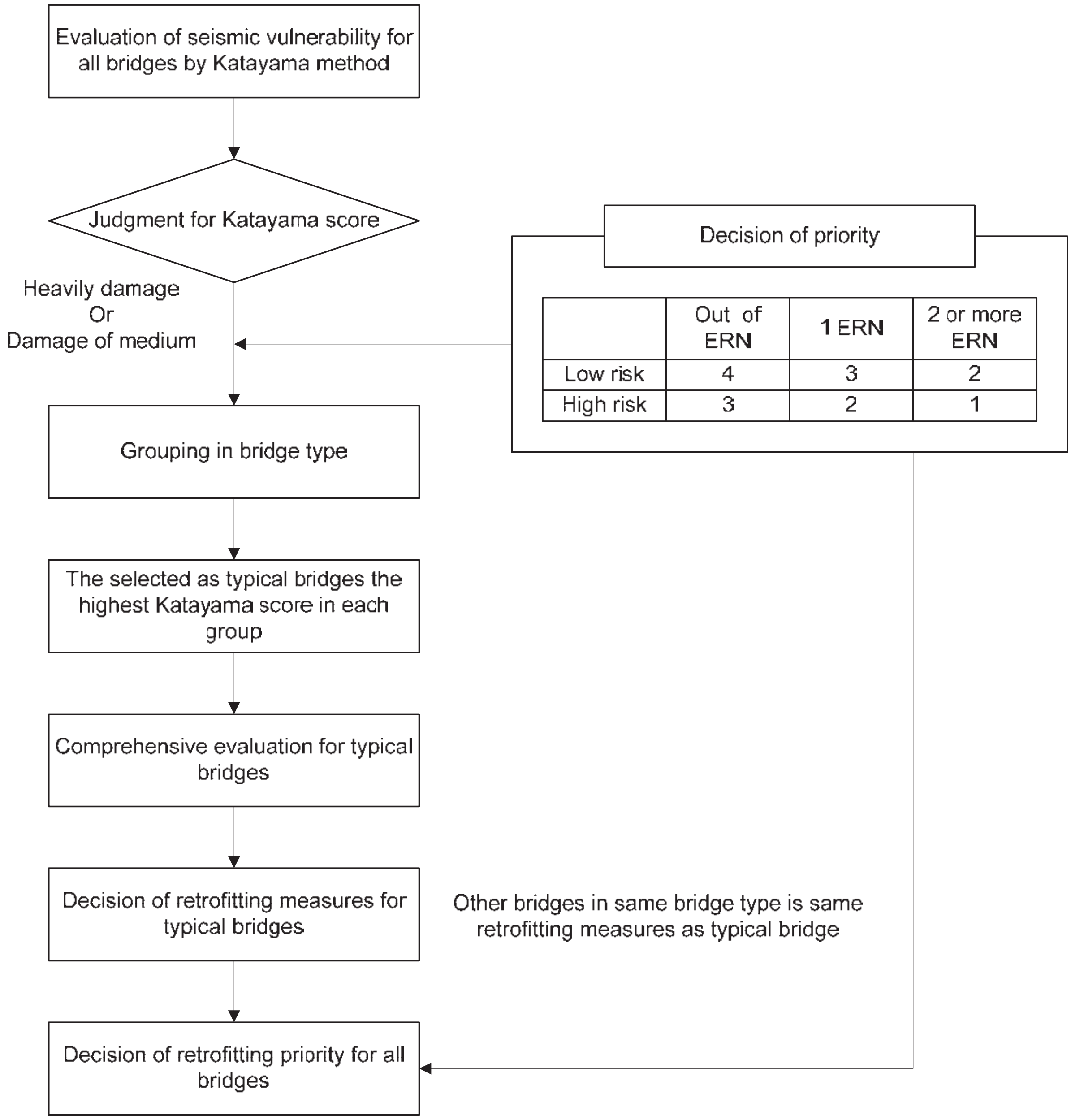


Figure 2.2.34 Development procedure for determining seismic retrofitting priorities

2.2.5 【6】To prepare an operation and maintenance plan for the emergency road networks including methodology of clearing the roads after an earthquake, and methodology of revising and expanding the emergency road networks in the future (Activity1-5)

In the activity to formulate the Operation and Maintenance Plan of the Emergency Road Networks, at the beginning of commencement of the project, as indicated in Table 2.2.39, two components are considered to be included, 1)the ”Manual for Revision of ERN” considering future expansion of road networks and additional or changes of connecting facilities, and 2) “SOP for Securing ERN” which contains procedures to secure the emergency road network by implementing road opening, traffic control, and others after occurrence of an earthquake disaster. However, due to a strong request form the Iranian side who will utilize the plan, it has been decided that in this plan only “SOP for securing ERN” would be retained. The “Manual for Revision of ERN” has been prepared by the JICA Expert Team regarding how to set up and revise the ERN and the Team has transferred the technical methods to the CPs.

Table 2.2.39 Components of the Operation and Maintenance Plan of ERN (Beginning of the Project)

Components	Contents
Manual for Revision of Emergency Road Network	In order to be able to revise ERN considering future expansion of road networks and additional or change of connecting facilities, this manual contains detailed processes and methodology including shortest path analysis between facilities utilizing GIS operations.
Standard Operation Procedures for Securing Emergency Road Network	This Standard Operation Procedures is similar to the manual to secure the Emergency Road Network, containing detailed contents and procedures regarding the roles and responsibilities of relevant organizations, road opening, traffic control, and others after occurrence of an earthquake disaster.

In the case of the activity in Output 1, the JICA Expert Team provided reference documents and information mainly from Japan and took the time to discuss the issues between the JICA Expert Team and TDMMO CPs regarding upgrading the ERN, however, in order to smoothly operate ERN under actual earthquake disaster conditions, formulation of SOP containing the clarified roles and responsibilities of relevant organizations including coordination among the Traffic Police, Directorate of Traffic and Transportation, Traffic Control Center, TDMMO, and the internal section of TDMMO, and relevant agencies of district municipalities, and many other relevant organizations are necessary.

Along with formulation of the maintenance and operation plan, a draft table of contents is proposed from both the Japanese and Iranian side, and is considered based on discussions. The plan must mainly describe the roles and responsibilities of relevant organizations and procedures, and in this point, the Japanese side gives necessary input to the Iranian side and the contents of the plan were decided.

Table 2.2.40 Comparison of Table of Contents of Operation and Maintenance Plan

JICA Team Proposal	TDMMO Proposal
Chapter 3: Plan (Manual) for Securing Emergency Road Network 3.1 Introduction 3.1.1.Objective 3.1.2.Scope and Level Categorization of Emergency Road Network 3.1.3.Stakeholders 3.1.4.Flow of Securing Emergency Road Network 3.2 Instruction for each activities for securing ERN 3.2.1.Collection and Reporting of Information on damage or obstacle to secure ERN 3.2.2.Traffic Control 3.2.3.Dissemination of Information 3.2.4.Road Clearance 3.2.5.Emergency Recovery Work 3.2.6.Debris Removal 3.2.7.Request and Acceptance of Assistance 3.2.8.Completion of Recovery Work and Opening of Road Network 3.2.9.Utilization of other transportation mode	1. Goal 2. Overview 3. Responsibilities 4. The Implementation Method of the Operations 4-1 Collecting the passages information(condition and damages of the passages) 4-2 Emergency route finding 4-3 Clearing the road 4-4 Determining the emergency routes 4-5 Traffic Control 4-6 Resources (4-6-4 Requests of the municipalities of district) 4-7 Communications 5. Organizing 6. The emergency earthquake response by the traffic and transportation deputy of Tehran municipality 7. The emergency operations of traffic and transportation 7-1 The traffic disaster management headquarters of the district 7-3 Damage assessment helicopters 7-4 Non-military aerial patrol 8. Inspection levels 9. Logistics 10. The list of the people who participate in the emergency operations

※Red Color is almost same contents

In addition, with regard to the specific contents, so that Iranian side can formulate smooth planning, from the expert side, the information collection was carried out in Japan, the planning process was achieved by providing information to the Iranian side. The main content that was provided is as follows;

Table 2.2.41 Information Provided

Source of Information	Provided Information	Contents
West Nippon Expressway Company	Disaster Emergency Operation Plan –Earthquake and Tsunami- (Partially provided)	Plan compiling pre-disaster activities, response activities, and efforts under normal conditions based on a disaster scenario.
Tokyo Metropolitan Government	Operation Manual of Debris Removal at ERN（Partially provided）	Manual for securing ERN at Earthquake occurrence. 1) Initial Response 2) Emergency investigation, treatment and emergency road opening 3) Response Method after completion of road opening operation ４） Formulation of Plan
Other Local Governments	Manual for securing ERN, Manual for Debris Removal, etc.	Simple Manual formulated for several local governments

Hyogo Prefecture Government is one of the domestic support committees of this project. The JICA Expert Team has been asked to provide information regarding the Japanese case as needed during the project period in order to answer the queries of the Iran side. Therefore, the JICA

Expert Team visited and requested Hyogo Prefecture Government to obtain necessary information for Output 1 Activity. But because there are no appropriate materials necessary for formulation of the plan, they contacted the "West National Expressway Company" to obtain the information related to the exercise, and visited them to obtain that necessary information. In addition, the Tokyo Metropolitan Government was contacted and they provided the "Manual for emergency check of facilities during a disaster occurrence", and they gave necessary input to the Iranian side.

Based on the information collected that showed the necessary flow to secure ERN, and based on this information, a series of discussions were held. The main framework of the plan is based on this flow.

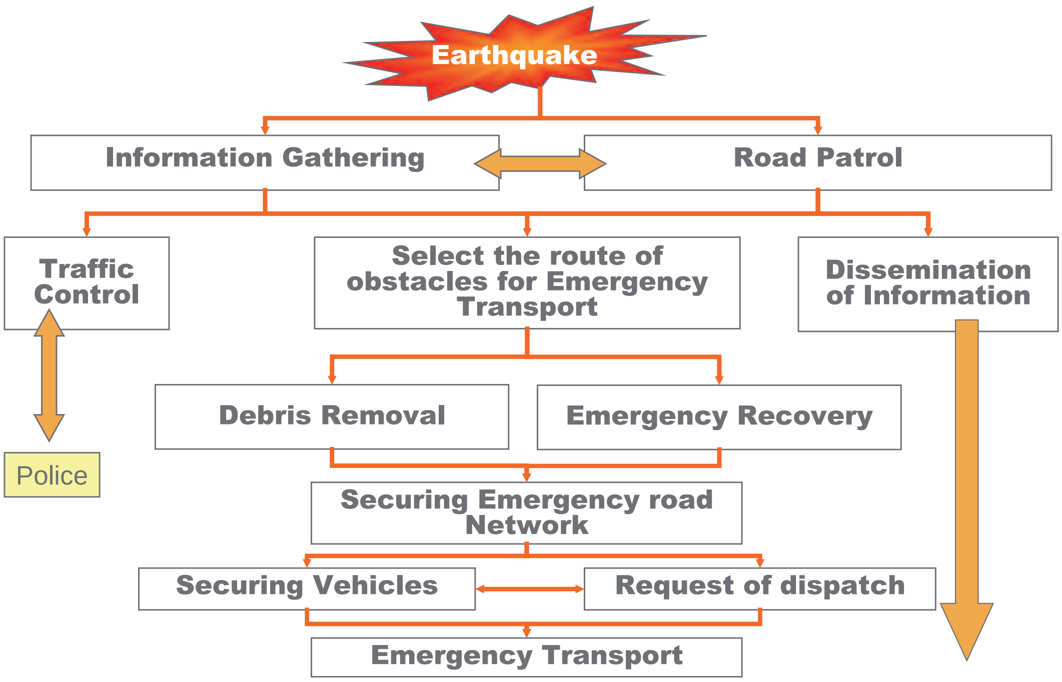


Figure 2.2.35 Flow for Securing ERN

In the planning process, the Japanese side provided information and a table of contents to the Iranians, and encouraged and supported the Iranian side to write the documents. The Japanese side then provides comments. This process repeated and gradually progressed to formulate the contents mainly by the Iranian side. As a result, the plan has been formulated with the following contents.

Table 2.2.42 Contents of SOP

Table of Contents
1. Preface
2. Goal
3. Range
4. Legal and Technical Principles
5. Time of Effect
6. Implementation of the Program
7. Assumptions
8. Organizations which are member of Transportation Working Group, their titles and Duties
9. Emergency Transportation Structure and the related Disaster Headquarter/s of Transportation
10. Role of Traffic and Transportation Staff
11. Role of Major Centers
12. Operation Instruction (main part of the plan)
13. Information Flow (circulation)
14. Resources Management
15. Implementation Manner of Emergency Operation
16. List of People participating in Emergency Operation
17. Reports and Documents
18. Education
19. Military support of Emergency Transportation

It should be noted that after formulating the draft, based on the results of the DIG (Disaster Imagination Game participatory, which is a disaster management exercise) described in item [9], participants from the exercise provided inputs to the plan and applied and revised issues raised and then finalized the plan. In the future, it is scheduled to carry out the explanation to related organizations along with supporting legislation and then it will be utilized as the official document for the city of Tehran.

2.2.6 【7】To prepare a draft instruction for design and construction of structures, lifelines and buildings adjacent to the emergency road networks, to be included in the urban development plan (Activity1-6)

Preparation of the buildings and infrastructures to protect them against an earthquake is necessary as explained in Chapter 2.2.3. The Evaluation of seismic vulnerability has to be prepared for each building in order to understand the possible degree of safety and damage. The JICA Expert Team introduced the standard of evaluation of seismic vulnerability and proposed subsidies to facilitate seismic retrofit. If the earthquake-resistance is not adequate and the effect of a road blockage by the building's collapse is significant, the building has to be rebuilt or renovated. The government of Iran ought to prepare some recommendations regarding the non-standard buildings. The JICA Expert Team supported creating the draft instruction book for it.

(1) Study of the existing urban development planning regarding the design and construction standards relating to the reinforcement of buildings and lifelines.

Guidelines for seismic design and seismic evaluation and the reinforcing of lifelines and buildings have been published. The list of guidelines on Seismic resistance is shown in Table 2.2.43.

Table 2.2.43 Guidelines for seismic resistant lifelines, buildings and bridges

No.	Notification No.	Publication	Title	Remarks
626	93/16539	2014	Guideline for Seismic Hazard Analysis	
0360_r1	92/131010	2013	Instruction for Seismic Rehabilitation of Existing Buildings (First Revision)	
605	100/65456	2012	Guideline for Seismic Design of Sewage systems	English edition
604	100/65454	2012	Guideline for Seismic Design of Water supply systems	English edition
600	100/65447	2012	Loading and Seismic Analysis Guideline of Iran's Lifelines	English edition
603	100/65453	2012	Guideline for Seismic Design of telecommunication systems	English edition
609	100/65462	2012	Guideline for seismic evaluation and rehabilitation of water supply systems	English edition
607	100/65459	2012	Guideline for seismic evaluation and rehabilitation of power supply systems	English edition
610	100/65463	2012	Guideline for seismic evaluation and rehabilitation of sewage systems	English edition
601	100/65449	2012	Guideline for Seismic Design of Natural Gas systems	English edition
608	100/65461	2012	Guideline for seismic evaluation and rehabilitation of telecommunication systems	English edition
602	100/65452	2012	Guideline for Seismic Design of Power supply systems	English edition
606	100/65457	2012	Guideline for seismic evaluation and rehabilitation of gas supply systems	English edition
511	100/25144	2011	Guide Manual for the Seismic Vulnerability Assessment and Retrofit of Bridges	
524	100/106713	2010	Guideline and Details for Seismic Rehabilitation of Existent Building No. 524	
361	3936-100	2009	Commentary of Instruction for seismic Rehabilitation of Existing Buildings	
0363_3	-	2008	Applicable Instruction for Seismic Rehabilitation of Existing Buildings, Masonry Buildings	
0363_1	-	2008	Applicable Instruction for Seismic Rehabilitation of Existing Buildings, Steel Buildings	
0363_2	-	2008	Applicable Instruction for Seismic Rehabilitation of Existing Buildings, Concrete Buildings	
364	75693-100	2008	Rapid Seismic Evaluation of Existing Buildings	
360	177721- 100	2006	Instruction for Seismic Rehabilitation of Existing Buildings	
211	54/3271-105/2400	1997	List of Geophysical Services Electrical Methods (Resistivity) Seismic Methods (Refraction)	
171	54/153_102/223	1996	Application of Geophysical Methods in Ground Water Engineering, Standards for Seismic Methods (Refraction)	

Improvement work on the lifelines has been divided into seismic design and seismic evaluation and seismic reinforcement. In addition, the guidelines for analysis of the lifelines in general have been published. The table of contents for the "Guideline for seismic evaluation and rehabilitation of gas supply systems" is shown in Table 2.2.44 as an example.

Table 2.2.44 Example of the contents of the guidelines for the seismic assessment and seismic reinforcement of gas supply systems

Title		
Chapter 1- General		
	1-1-Generals	
	1-2-Goals	
	1-3-Scope of Work	
	1-4-Target components	
	1-5-Correlated Provisions and Standards	
	1-6-Structure of the guideline	
Chapter 2- Seismic Evaluation Procedure		
	2-1-Seismic Performance Evaluation Approaches	
	2-2-Pre Evaluation	
		2-2-1-Effective Parameters in Performance Evaluation
		2-2-2-Seismic hazard identification
		2-2-3-Seismic Vulnerability identification
		2-2-4-Seismic Performance
		2-2-6-Planning for Evaluation Study
	2-3-Seismic Evaluation Steps	
		2-3-1-Importance determination of element or System
		2-3-2-Seismic Hazard Levels
		2-3-3-Performance Level of System Elements
Chapter 3- Vulnerability Evaluation Methods		
	3-1-Target Components	
	3-2-General Approach to Determine Vulnerability	
	3-3-Seismic Evaluation Methods of Components	
		3-3-1- Seismic Evaluation of Buildings
		3-3-2-Seismic Evaluation of Non-Building Structures
		3-3-3-Equipments' Seismic Evaluation
		3-3-4-Seismic Evaluation of Non-Structural Elements
		3-3-5- Seismic Evaluation of Network and Pipelines
	3-4-Inspection and Filling Worksheets in Level One Qualitative Evaluation	
	3-5-Collection of Necessary Data for Evaluation in Level 2 and Level 3	
		3-5-1-Design and Operation Documents' Collection
		3-5-2-Visual Inspection and Extraction of Evident and Obvious Problems
		3-5-3-Conducting Soil Mechanics and Material Test and Risk Analysis
	3-6-Seismic Evaluation Using Modeling and Numerical Analysis	
		3-6-1-Equivalent Static Method
		3-6-2- Spectral Method
		3-6-3-Time History Method
	3-7-Seismic Interaction of Systems	
	3-8-Acceptance Criteria	
		3-8-1-Load Combinations
		3-8-2-Stability Controls
		3-8-3-Acceptance Criteria in Non Linear Dynamic Methods
Chapter 4- Seismic retrofitting methods and procedures		
	4-1- Prioritizing retrofitting activities	
	4-2- Seismic retrofitting procedure	
	4-3-Retrofitting selection method approach	
	4-4-Type of retrofitting method	
Chapter 5- Seismic Retrofitting Methods for Refineries		
	5-Refinery	
	5-1-Piping and pipe supporting rack	
		5-1-1-Damage modes
		5-1-2-Seismic assessment
		5-1-3-Retrofitting of pipeline and pipe supports
		5-1-4-Execution safety and cost
	5-2-Horizontal vessel	
		5-2-1-Damage modes
		5-2-2-Seismic assessment flowchart
		5-2-3-vessel retrofitting
		5-2-4-Retrofitting methods
		5-2-4-other countermeasure
	5-3-Tower and vertical tank	
		5-3-1-Damage modes
		5-3-2-Seismic assessment
		5-3-3-Tower and vertical vessel retrofitting
		5-3-4-Retrofitting methods
		5-3-5-Determine retrofitting method from safety and cost stand point of view
	5-4-Spherical tank	
		5-4-1-Damage modes
		5-4-2-seismic assessment procedure
		5-4-3-Retrofitting measures for spherical tanks
		5-4-4-List of retrofitting methods

Title			
		5-4-5-determining retrofitting method from safety, workability and cost point of view	
	5-5-Foundation		
		5-5-1-damage modes	
		5-5-2-assessment procedure	
		5-5-3- Foundation retrofitting	
		5-5-4-List of retrofitting methods	
		5-5-5-Determining retrofitting type based on safety, practicality and its cost	
Chapter 6- Tanks retrofitting methods			
	6-1-Types of tank		
	6-2-Retrofitting		
		6-3-1-Omission or replacement of shell plates	
			6-3-1-1-Minimum thickness for replacing plate of shell
			6-3-1-2-Minimum dimension of replaced shell plates
			6-3-1-3-Welding connection design
			6-3-1-4-Reinforcing shell plates
			6-3-1-5-Dimension of added plate to side wall
			6-3-1-6-Repairing the defects of shell plate material
			6-3-1-7-Replace of tank shells to change shell height
			6-3-1-8- Repair of shell inlets (manhole, nozzle, visit gate and etc.)
		6-3-2-Annular plates	
			6-3-2-1-Supporting plate
		6-3-3-Floor plate	
			6-3-3-1-Replacement of tank floor plates
			6-3-3-2-Added weld plates
		6-3-4-Foundation	
			6-3-4-1-Slabs
			6-3-4-2-Annular walls
			6-3-4-3-Piles
			6-3-4-4-Drainage of rain water beneath the foundation
			6-3-4-5-Anchoring bolts
	6-4-Attached equipments		
	6-5-Special repair methods		
	6-6-Retrofitting method from cost, applicability and safety point of view		
	6-7-Miscellaneous activities		
		6-7-1-Floors	
		6-7-2-Shells	
		6-7-3-Roofs	
Chapter 7 - Retrofitting of on ground pipelines			
	7-1-Target components		
	7-2-Damage modes due to earthquake		
	7-3-Seismic assessment procedure		
	7-4-Retrofitting		
		7-4-1-Prioritizing of retrofitting	
		7-4-2-List of possible methods	
		7-4-3-Determine retrofitting method from safety, applicability and cost point of view	
		7-4-4-Other measures	
Chapter 8- Retrofitting of buried pipeline			
	8-1-Damage modes in earthquake		
	8-2-seismic assessment procedure		
	8-3-Retrofitting		
		8-3-1-Priority in components of retrofitting works	
		8-3-2-List of Retrofitting Methods	
Chapter 9 - Retrofitting methods for internal equipments			
	9-1-Target components		
	9-2-Seismic damage modes		
	9-3-Seismic assessment		
	9-4-Selection of Retrofitting Method as for Safety, Practicability and Cost		
Chapter 10 - Retrofitting methods for other non-building structures			
	10-1-Target components		
	10-2- Culvert		
		10-2-1- Seismic damages	
		10-2-2-Assessment	
		10-2-3-Retrofitting	
			10-2-3-1-Notes
			10-2-3-2-Determining retrofitting method from safety, practicability and cost point of view
			10-2-3-3-Selection of retrofitting methods considering culvert material
			10-2-3-4-Works other than Retrofitting
	10-3-Wall and Dike		
		10-3-1-Seismic assessment and retrofitting procedure	
		10-3-2-Retrofitting method	

(2) Content to be reflected in the update of the future urban development planning for the design and construction of buildings and Lifelines with respect to the reinforcement

Based on the discussions with C/Ps, since TDMMO does not have direct authority to instruct lifeline management entities, it is recognized to inform to these entities that lifeline distribution facilities may cause malfunctions of Emergency Road Network in case of occurrence of Earthquake disaster, and needs to prioritize improvement of their seismic resistance. Following points to be reflected at the time of revision of Urban Development Plan through Draft Instruction were summarized to secure Emergency Road Network.

- Definition of Emergency Road Network
- Responsibility of Lifeline companies and the role of TDMMO
- Current seismic assessment, the concept of seismic reinforcement
- Vulnerability to earthquakes of Lifelines and buildings

(3) Draft instruction, summarizes the contents to be reflected at the time of renewal of the future of urban development planning.

1) Lifeline (water, sewage, gas, electricity, communication) facilities

The management organization for the Lifelines is an independent company and TDMMO has a responsibility to lead these companies directly. Therefore, it is expected that the earthquake resistance improvement of lifeline facilities will be planned and implemented through discussions with the TDMMO side and Lifeline companies.

In order to secure the Emergency Road Network after an earthquake, it is important to prevent damage to the lifelines the same as the prevention for damage to road structures and bridges. For this reason, it is important that the contents are reflected at the time of renewal of the future urban development plans to comply with the various guidelines that have been issued from the aforementioned Office of the Deputy for Strategic Supervision Department of Technical Affairs.

Since the lifelines are managed by public companies (under the direct control of the government), the objective of the draft instruction for lifelines is to promote the seismic resistance of the lifelines in order to secure the emergency road network based on the estimation of vulnerability of the lifelines as indicated in 2.2.3

The draft instruction was formulated separately for each lifelines, water, sewage, gas, electricity and communications, as the fundamental material to improve the securing of the emergency road network on the expectation for updating and revision in the future.

The contents of the draft instruction are shown as follows.

Table 2.2.45 Configuration example of Draft Instruction (Waterworks)

1.	Preface
1.1.	Background and the goal
1.2.	Instruction contents
1.3.	The past experiences on road blockage due to the effect of leakage of the waterworks
1.4.	Roles of TDMMO and other organizations in management of emergency transportation
1.5.	Terminology
1.5.1.	First Degree key points of the city
1.5.2.	Second Degree key points of the city
1.5.3.	Main ERN
1.5.4.	'Access' branches/roads (III)
1.5.5.	Minor/junior route network in-priority (IV)
1.5.6.	Regulations of ERN
1.6.	Generalities of response/encountering operations by companies in charge of fuel-supply
2.	ERN
2.1.	Main ERN
2.2.	Minor/junior route network in-priority
3.	Studying the effects of damaged water network on ERN
3.1.	Current condition of water network
3.2.	Assessment of water network vulnerability
3.2.1.	Vulnerability of water network of city of Tehran
3.2.2.	Calculation of vulnerability of water network in 'ERN assignment or specifying/determining ERN"' Project
3.3.	Effect of water pipeline damages on ERN
3.3.1.	Direct damage to ERN as a result of destruction of pipeline
3.3.2.	Interruption of traffic and transportation as a result of reconstruction activities
3.4.	The current existing guidelines for designing and retrofitting water pipelines and the level of their enforcement in practice
3.4.1.	604 guideline for seismic designing of water system
3.4.2.	609 guideline for seismic designing of water system
3.4.3.	Conclusion
4.	Expectations and recommendations
4.1.	Prevention:
4.2.	Choosing location of important disaster management centers
4.3.	Study of ERN
4.4.	Encountering/response plans
4.5.	Suggestions for building new pipelines
4.6.	Recommendation for retrofitting the existing pipelines
4.7.	Prioritizing actions for improving water network
5.	Conclusion
Annexes	Current state of the water pipe network
	Damage Estimation study results
	Water pipelines and Emergency Road Network (ERN), situation of crossing the fault
	The current guidelines for improvement of seismic design and seismic strengthening
	Seismic vulnerability assessment procedure

2) Drafting of Draft Instruction in designing, construction and reinforcement of buildings

In order to ensure the Emergency Road Network after an earthquake occurs, it is important to minimize the outflow of debris roadside from the collapse. However, unlike Lifelines buildings are private property and it is necessary to consider that another organization, which is separated the disaster management department, implements the approval and regulations for the buildings.

Therefore, the impact on the Emergency Road Network of a road that is blocked by debris generated from collapsed buildings can be cleared under the current laws and regulations and future prospects.

Table 2.2.46 Configuration example of Draft Instruction (buildings)

1.	Introduction
1.1.	Background and the goal
1.2.	Instruction contents
1.3.	Experiences regarding the related issues of the buildings adjacent to the Emergency Routes
1.3.1.	Past Experiences of route blockage due to the damage of the buildings due to the earthquakes
1.4.	Role of TDMMO regarding the buildings adjacent to the emergency routes
1.4.1.	The emergency response program of Tehran city
1.4.2.	The transportation appendix of the emergency response program of Tehran city
2.	Terminology and introduction of the ERN
2.1.	Introducing the ERN
2.1.1.	The access routes (III)
2.1.2.	The prioritized branch route network
2.2.	The primary key places of the city
2.3.	The secondary key places of the city
2.4.	Regulations of the emergency routes
2.5.	Specifications of the main ERN of Tehran
3.	Studying the effects of a damaged gas network on ERN
3.1.	Types of Building damage and their effects on ERN
3.1.1.	Blockage of the route due to the collapse of buildings and falling debris
3.2.	Blockage of the route during the debris removal and rescue and relief activities around the buildings adjacent to the emergency routes:
3.3.	Temporary blockage of the route due to existence of weakened buildings that may collapse at any time
4.	The expectations and recommendations
5.	Recommendations and expectations
5.1.	Recommendations and expectations about new buildings adjacent to ERN
5.2.	Expectations and recommendations on existing buildings adjacent to ERN
5.2.1.	General visit and risk assessment
5.2.2.	Prioritizing the risks of vulnerable buildings under study for ERN
5.2.3.	Assessment and seismic improving of vulnerable buildings adjacent to ERN
6.	Annex
6.1.	general items for quick assessment according to 364 regulations

3) Future tasks

In order to secure the Emergency Road Network after an earthquake, damage estimation of Lifelines is important to identify the location of high vulnerability. Through the energetic efforts of the counterparts in this project, the vulnerability of Lifeline in each district was examined.

Draft Instruction for Lifelines was shown the necessity for improvement of seismic resistance to the management organization of Lifelines through showing the result of damage estimation and the objective of Emergency Road Network.

For future tasks, it is required that discussion and mutual understanding are worked at the working level between the management organization of Lifelines and management organization of Emergency Road Network. In particular, for the emergency recovery of lifelines, it is expected that the seismic resistance of lifelines is improved with promotion of comprehensive capacity development of disaster management. Lifelines are expected to recover promptly after disaster occurrence, therefore not only considering effects to Emergency Road Network, but also improvement of seismic resistance of entire system is expected. Therefore, in addition to improve seismic resistance of entire system, it is expected to put priority to implement measures to reduce disturbance for emergency operations by lifeline facility damages, and as TDMMO is authority to guide to relevant organizations on Disaster Management, it is also expected to promote measures contribute towards improvement of seismic resistance by establishment of relevant regulations, and etc. at the earliest possible.

Draft instruction which was formulated in this project, which is utilized for promotion activities, is not the final version and the tool to promote the discussion and mutual understanding among related organizations, therefore, it is necessary to be upgraded.

Many of the middle-to-high rise buildings are constructed with steel structures, and the steel is covered by RC or stone. Therefore, it would be necessary to break away those materials to assess the strength of the structure. Also, few buildings have their construction plans available. From the above, it seems to be difficult to evaluate seismic capacity, and this issue will be a future task. Improvement of seismic performance of buildings will directly contribute to mitigate risks against Earthquake Disaster, and TDMMO is expected to promote concrete efforts such as promotion of diagnosis of buildings, establishment of subsidy system, promotion of retrofitting and reconstruction of vulnerable buildings, restriction of building permission process, and etc.

2.2.7 【8】To hold seminars and workshops on the plans related to the emergency road network (Activity1-7)

Although in the work plan which was formulated at the beginning of project, three seminars are planned, four seminars were actually held due to the request from TDMMO. Originally TDMMO requested 5 seminars, but since the contents of the fifth seminar would have overlapped the other seminars, the fifth seminar was cancelled based on the discussions with TDMMO. Seminars were held to invite not only TDMMO staffs but also a wide range of parties concerned with the emergency road network including: relevant sections in the Tehran Municipality; members of the Technical Committees; and university staffs. Both the progress of the project and lessons learned from the earthquake in Japan were presented in the seminars. Outlines of the seminars are shown on Table 2.2.47.

Table 2.2.47 Outline of seminar about emergency road network

	First Seminar	Second Seminar	Third Seminar	Forth Seminar (UNDP-JICA Joint seminar)
Time	2 June 2012	22 April 2013	22 October 2013	26 January 2014
Participants	Parties concerned with Output 1	Parties concerned with Output 1	Parties concerned with Output 1	Parties concerned with Output 1
Subject/Theme	・Outline and Schedule of output1 ・Lessons learned from the Great East Japan Earthquake ・Vulnerability of bridges in Teheran city and countermeasures for quake-resistance for bridges in Japan ・Vulnerability and improvement of lifelines to protect against earthquake ・Current emergency road network in Teheran city	・Outline and progress of output1 ・Lessons learned from the Great East Japan Earthquake ・Principles to improve emergency road network in Teheran city	・Outline and progress of output1 ・Situation underground after earthquake happens ・Effect of earthquake on the lifelines and transportation ・Experience in Japan regarding transportation after an earthquake ・Earthquake-resistant design, its evaluation, examination, and maintenance	・History of support to Teheran city regarding disaster mitigation ・Experience in Japan regarding transportation after earthquake

1st Seminar（2 June 2012）

2nd Seminar（22 April 2013）

Third Seminar(22 October 2013)

Fourth Seminar（26 January 2014）

Figure 2.2.36 Seminar of Output1

2.2.8 【9】To hold Simulations (Drills) utilizing disaster scenarios based on the result of damage estimation and in consideration of the emergency road networks (Activity1-8)

In PDM and the work plan the drill was to be undertaken using a DIG (Disaster Imagination Game) in order to check the feasibility of the plans prepared through the project. However, TDMMO asked the JICA Expert Team to carry out a more practical drill which can make the participants experience the simulated situation after a disaster. Therefore, the drill was divided into three steps. The beginning step was DIG（DIW(Disaster Imagination Workshop)）, the intermediate step was TTX (Table Top Exercise) and the advanced step was CPX(Command Post Exercise). Technical transfer was also considered by lecturing the C/Ps about the purpose, contents, preparation, and scenario of each course, so that C/Ps can prepare the exercise by themselves in the future. An outline of each project and the relationship between the exercise and the O&M plan is shown on Table 2.2.48 and Figure 2.2.37.

Table 2.2.48 Outline of training for Output1

Type of training	Date	Outline	Application of result
DIW	24 April 2013	Discussion about method and things to do for emergency assembling	Utilization of preconditions, methodology of collecting data and information, creating imagination, and collecting data for creating maintenance plan Implementation of DIW to administrative officer of each district
TTX	3 February 2014	Exercise about summarizing the initial response and the method to secure the emergency road network, roles and responsibilities	Consideration of roles and responsibilities, contents of activities to formulate the operation and maintenance plan
CPX	27 September 2014	Simulated exercise of emergency response after the earthquake	Reflection to operation and maintenance plan such as re-consideration of roles and responsibilities, flow of information ,etc.

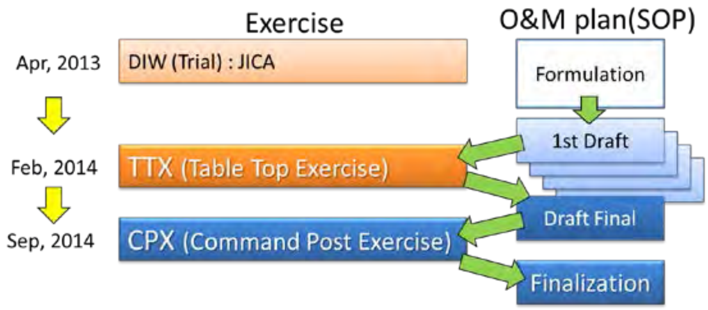


Figure 2.2.37 Relationship between exercise and O&M plan

(1) To hold DIW (Disaster Imagination Workshop)

The JICA Expert Team and TDMMO agreed to call DIG (Disaster Imagination Game) DIW (Disaster Imagination "Workshop") because of a suggestion from TDMMO. The first DIW was held in April 2013 due to the request from C/Ps, although it was originally planned to be held in October 2013. An outline of the DIW is shown on Table 2.2.49. Staffs of TDMMO and 9th district officials participated in the DIW. They imagined the earthquake happened on a weekend, and discussed the methodology and things to do for emergency assembling.

Table 2.2.49 Outline of DIW

Objective	It is aimed at confirming the methodology and things to do for emergency assembling by imagining the damage after an earthquake. The methodology of proceeding DIW is also mastered.
Implementation Method	Exercise on disaster mapping using DIG
Date	23 April 2013
Participants	TDMMO The person in charge of disaster management in 9 districts
Scope	The time frame is approximately 72 hours after the occurrence of an earthquake. This means from when the earthquake happens to when emergency assemble has finished.

The method of carrying out the DIW is also shared with C/Ps so that they can hold DIW for staffs of each district.

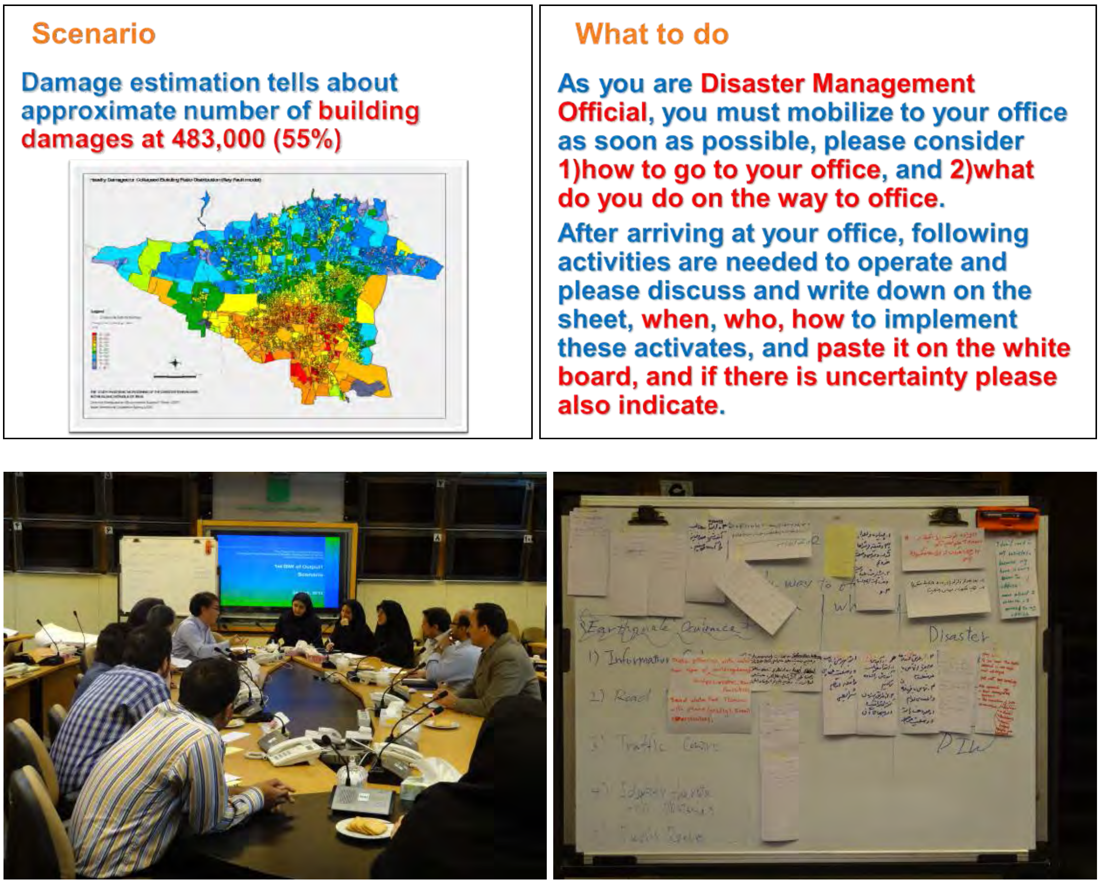


Figure 2.2.38 Situation of DIW (upper: Scenario, lower: photo)

(2) To hold TTX (Table Top Exercise)

The purpose of TTX is to confirm the validity of the roles and responsibilities and contents of activities for the operation and maintenance plans being formulated. It was held in February 2014. Approx. 40 people from TDMMO and other concerned organizations participated. More than 2 people participated from each organization, and the participants were divided into 2 groups. Each group was given 2 scenarios and 3 tasks through the discussion. All participants discussed actively. The JICA Expert Team and C/Ps did a rehearsal before TTX, and confirmed the method of proceeding. The outline of TTX is as shown in the following Table.

Table 2.2.50 Outline of TTX

Objective	It is aimed at confirming the methodology of initial response, securing the emergency road network and the roles and responsibilities of each organization, and to foster cooperation. The methodology of proceeding TTX is also mastered.
Implementation Method	Exercise on table top with discussion
Date	3 February 2014
Participants	Player ・ TDMMO ・ Traffic Police ・ Police ・ Deputy for Technical & Civil Construction ・ Deputy for Traffic & Transportation ・ Deputy for Public Works ・ District 1 : Disaster Management Coordinator ・ District 1 : Technical & Civil Construction ・ District 1 : Public Works ・ District 1 : Traffic & Transportation ・ District 1 : Traffic Police ・ Metro company ・ Bus company Observer ・ NDMO ・ Tehran Municipality ・ Committee of debris removal and re-opening of the passages ・ Research company for comprehensive studies of traffic and transportation (TCTTS)
Scope and task	task 1 ,2: To divide the 72 hours just after an earthquake t into 3 phases. To summarize the disaster and damage situation at each phase. To confirm the process of activities of each organization Task3 : To consider the methodology to secure the emergency road network if it has blocked by collapsed buildings or something similar.

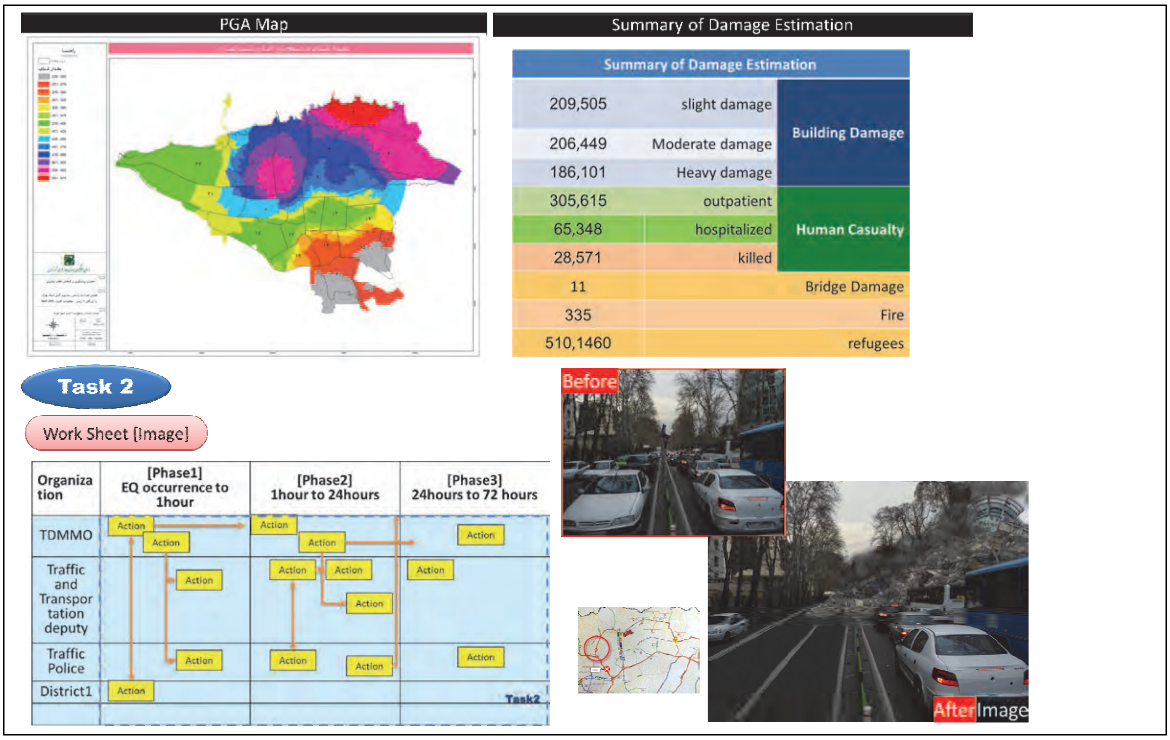


Figure 2.2.39 Explanatory material for TTX

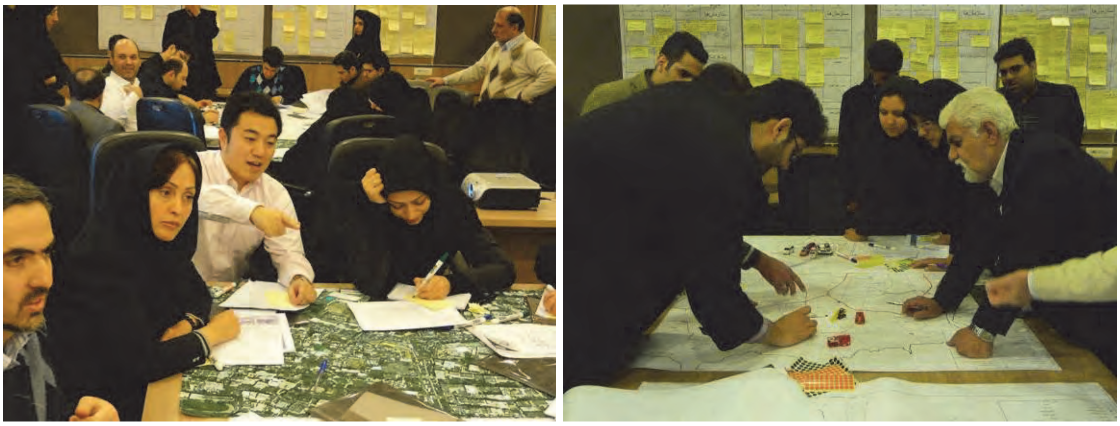


Figure 2.2.40 Situation of TTX

Moreover, C/Ps implemented TTX by themselves on 21 May 2014 with the same materials as in 3 February. The JICA Expert Team participated in it as observers. The participants were from districts 2, 3 and 6, and they made 2 groups.

Figure 2.2.41 Situation of TIX organized by TDMMO

(3) To hold CPX (Command Post Exercise)

CPX was prepared, implemented, and produced feedback in accordance with the following flow.

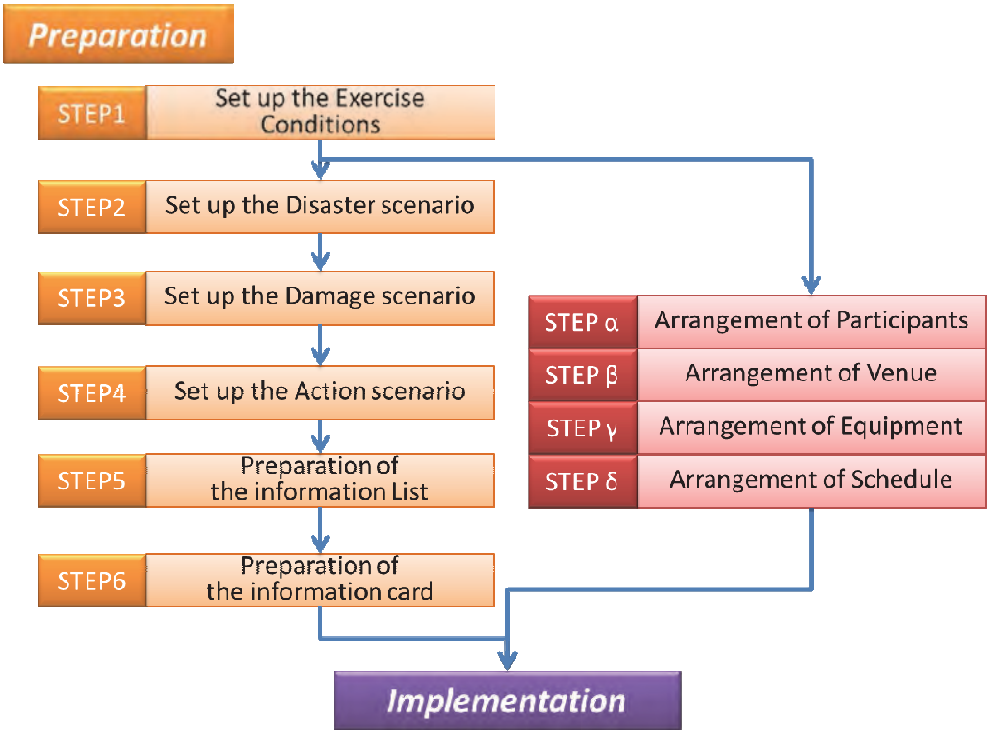


Figure 2.2.42 Flow of preparation for CPX

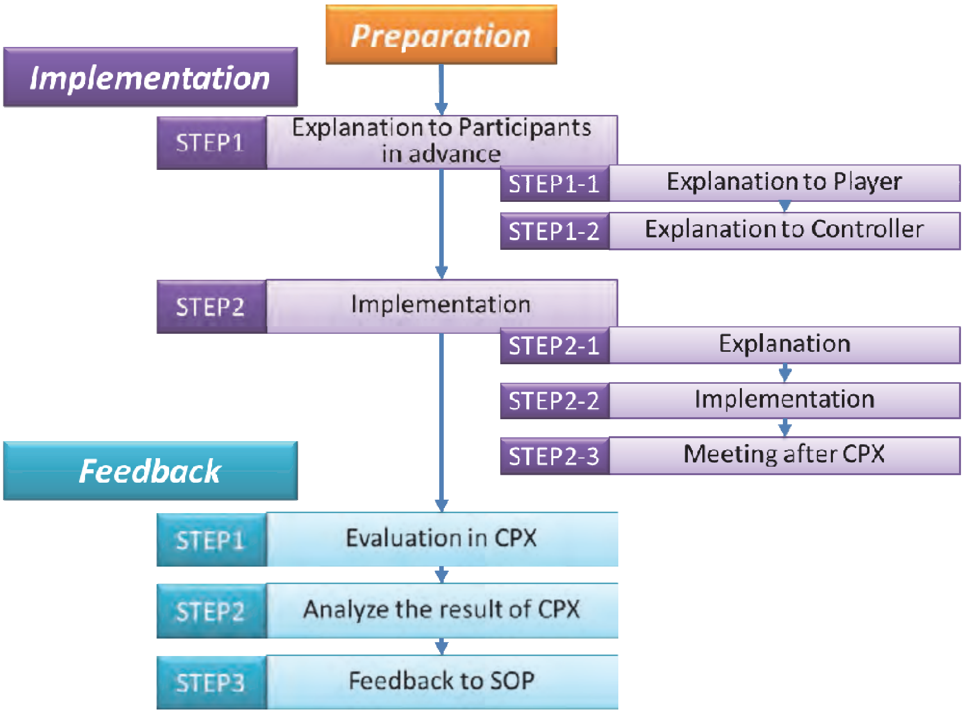


Figure 2.2.43 Flow of implementation and feedback for CPX

1) Preparation for CPX

The preconditions and scenario were prepared through discussions with C/Ps. The details are as follows.

a. To set preconditions

Preconditions of CPX were discussed based on the purpose and scope of training, and were set as shown in Table 2.2.51. Participants were chosen as shown in Table 2.2.52 and Table 2.2.53. The flow of information was considered to choose the participants.

Table 2.2.51 Outline of CPX

Objective	It is aimed at confirming the process of the O&M plan, deciding the issues and strengthening the capacity for emergency response. The methodology of proceeding the CPX is also mastered.
Implementation method	Command Post Exercise using a role-playing method
Date	27 September 2014
Participants	Table 2.2.52 and Table 2.2.53
Scope	Scope area : Activities with regard to the emergency road network Scope Time : 2 to 5 hours after earthquake happens

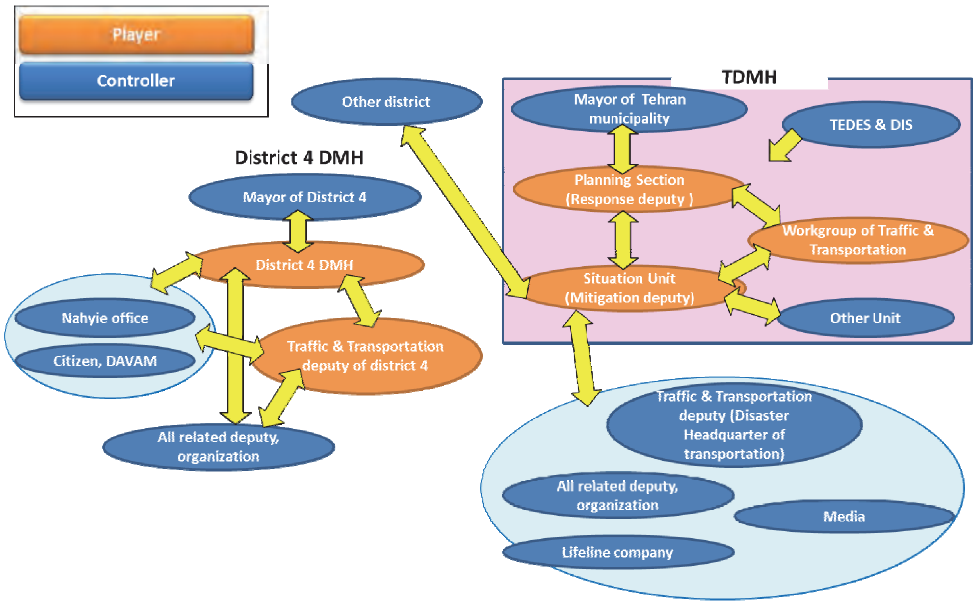


Figure 2.2.44 Organization chart of CPX

Table 2.2.52 Participants as players

Player

Role		Organization	Number	
TDMH	Planning Section	TDMMO	10	21
	Situation Unit	TDMMO		
	Workgroup of Traffic & Transportation	Traffic & Transportation deputy	1	
District4	District 4 disaster management headquarters	TDMMO District 4	5	
	Traffic & Transportation deputy	Traffic & Transportation deputy District 4	5	

Table 2.2.53 Participants as controllers

Controller

Role		Organization	Number	
Control Team		TDMMO	4	
		JICA Expert Team		
Information Team	Traffic & Transportation deputy ((Disaster Headquarters of transportation)	Traffic & Transportation deputy of Tehran municipality	2	16
	Traffic Control center	Traffic Control center	1	
	Technical & Civil construction deputy (municipal level and district4)	Technical & Civil construction deputy of Tehran municipality	1	
	Traffic Police (municipal level and district4)	Traffic Police of District 4	1	
	Urban Service deputy (municipal level and district4)	Urban Service deputy of Tehran municipality	1	
	Water company	Water company	1	
	Gas company	Gas company	1	
	Electricity company	Electricity company	1	
	Mayor of Tehran municipality	TDMMO	1	
	Mayor of District 4			
	TEDES & DIS	TDMMO	1	
	Other Units in TDMH			
	Other districts	TDMMO	1	
	Nahyie office of District4	TDMMO	1	
	Other deputy (municipal level and district4)	TDMMO	1	
	Citizen, DAVAM	District 4	1	
	Others	TDMMO	1	
Evaluation Team		TDMMO	3	

<u>b. To set the scenario</u>

The scenario of CPX requires three types of scenarios, which are the disaster scenario, damage scenario and action scenario. Various elements of the earthquake are set as shown in Table 2.2.54. According to the various elements, each scenario was created in the order of the disaster scenario, damage scenario and activity scenario. Figure 2.2.45 shows the scenarios that were created.

Table 2.2.54 Various elements for CPX

Situation of Main Earthquake		
EQ	Date & Time of occurrence	8:00, 27th September(Saturday), 2014
	Fault	North Tehran Fault (NTF)
	Magnitude (Mw)	7.2
	Depth	10 km
	MMI Scale (Maximum)	9

c. To create information plans and information cards

"Information plans" were created based on each scenario. Complex situations were avoided because almost none of the participants had ever experienced CPX. The main situation was like regular reporting. The "information cards "and map attached to the cards was also created by discussions with C/Ps based on the information plan. Figure 2.2.46 shows the "Information plans" that were created

d. Preparation of venue and equipment

CPX was held at the conference room of TDMH (Tehran Disaster Management Headquarters) in TDMMO, because of the availability of a player room and controller room. Telephone number list, Name tags, maps and so on were prepared for CPX.

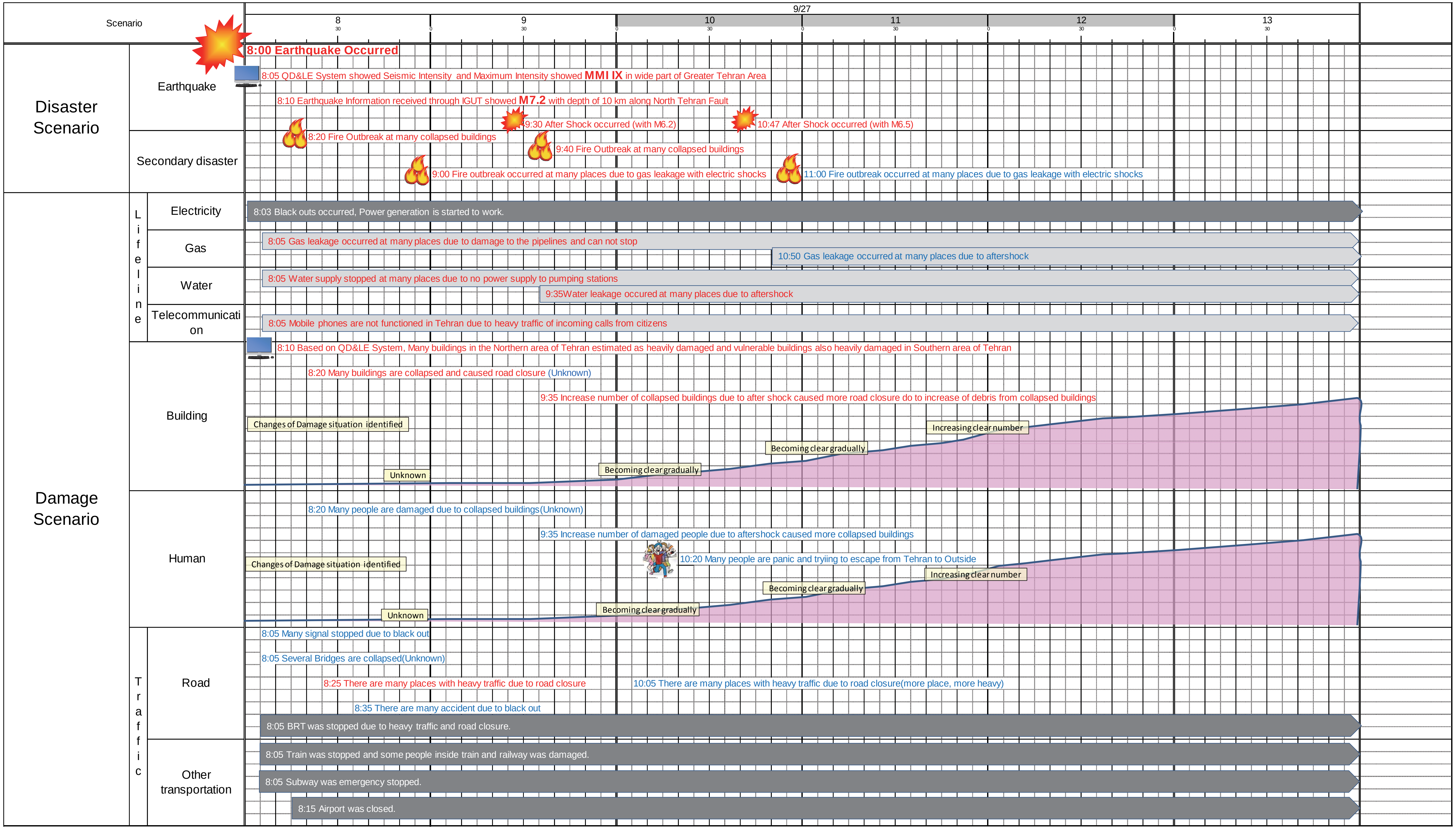


Figure 2.2.45 Disaster and damage scenarios for CPX

Role			Destination	Information Sheet: 10	11	12
Mayor(1)	Mayor of Tehran Municipality		TDMH Planning section	10:00: Order (Information gathering, indentify the route damaged of ERN)	11:10 Confirmation of request to province, country, etc.	12:00: Order (Make a material of current condition for information dissemination)
Mayor(1)	Mayor of District4		D4 DMH	10:05: Order (Information gathering, Emergency recovery of ERN)	11:50: Order (Make a material of current condition for information dissemination)	
TDMH TEDES & DIS Other Unit in TDMH (1)			TDMH Situation Unit	10:55: Showed Seismic Intensity and damage estimation 10:15 Damage Information from DIS	11:15 Damage Information from DIS	
TDMH TEDES & DIS Other Unit in TDMH (1)			D4 DMH	10:55: Showed Seismic Intensity and damage estimation 10:15 Damage Information from DIS	11:15 Damage Information from DIS	
Traffice and Transport deputy (Disaster Headquater of transportation) (2)			TDMH Situation Unit	10:00 Report to Road blockage to TDMH 10:30 Confimation of ERN and priority 10:10: Report traffic condition (from Camera) 10:20: Report condition of transportation company 10:40: Report traffic and people condition	11:00 Report to Road blockage to TDMH 11:10: Report traffic condition (from Camera) 11:20: Report condition of transportation company 11:40: Report traffic and people condition	12:00 Report to Road blockage to TDMH 12:10: Report traffic condition (from Camera) 12:20: Report condition of transportation company 12:40: Report traffic and people condition
Traffice and Transport deputy (Disaster Headquater of transportation) (2)			D4 Traffic deputy	10:05 Order to report to District traffic deputy		
Traffic control center (1)			D4 Traffic deputy	10:00: Report current condition to traffic deputy	11:00: Report current condition to traffic deputy	12:00: Report current condition to traffic deputy
Traffic Police (1)	District 4		D4 Traffic deputy	10:30: Report current condition to traffic deputy	11:30: Report current condition to traffic deputy	12:30: Report current condition to traffic deputy
Technical and Civil construction deputy (1)	Municipal level		TDMH Situation Unit	10:05 Report Bridge, etc condition, Confirmation of recovery priority	11:05 Report Bridge, etc condition	12:05 Report Bridge, etc condition
Technical and Civil construction deputy (1)	District 4		D4 DMH	10:00 Report Bridge, etc condition, Confirmation of recovery priority	11:00 Report Bridge, etc condition	12:00 Report Bridge, etc condition
Urban service deputy (1)	Municipal level		TDMH Situation Unit	10:30 Report Tree condition 10:15 Confirmation of debris removal priority	11:30 Report Tree condition 11:15 Report debris removal condition	12:15 Report debris removal condition
Urban service deputy (1)	District 4		D4 DMH	10:20 Report Tree condition 10:05 Confirmation of debris removal priority	11:20 Report Tree condition 11:05 Report debris removal condition	12:05 Report debris removal condition
Other deputy, organization in Tehran municipality (1)	Planning & Architecture deputy	Municipal level	TDMH Situation Unit	10:25 Report Building condition	11:25 Report Building condition	12:25 Report Building condition
Other deputy, organization in Tehran municipality (1)	Planning & Architecture deputy	District 4	D4 DMH	10:15 Report Building condition	11:15 Report Building condition	12:15 Report Building condition
Other deputy, organization in Tehran municipality (1)	Firefighting service		TDMH Situation Unit		11:05 Confirmation of Gas exposure	
Water Company (1)			TDMH Situation Unit	10:45 Report Water condition	11:45 Report Water condition	12:45 Report Water condition
Gas Company (1)			TDMH Situation Unit	10:35 Report Gas condition	11:35 Report Gas condition 11:00 Report Gas explosure	12:35 Report Gas condition
Electricity Company (1)			TDMH Situation Unit	10:50 Report Electricity condition	11:50 Report Electricity condition	12:50 Report Electricity condition
District 4 Nahyie office (1)			D4 Traffic deputy	10:50 Report to Road blockage to District4	11:50 Report to Road blockage to District4	
Citizen, Davam group (1)			D4 DMH	10:40 Confirmation of ERN	11:40 Confirmation of Evacuation	
Other district (1)			-			
Others (1)	Media		TDMH Situation Unit	10:10 Request information of ERN	11:50 Request current traffic condition	

Figure 2.2.46 Information plan for CPX

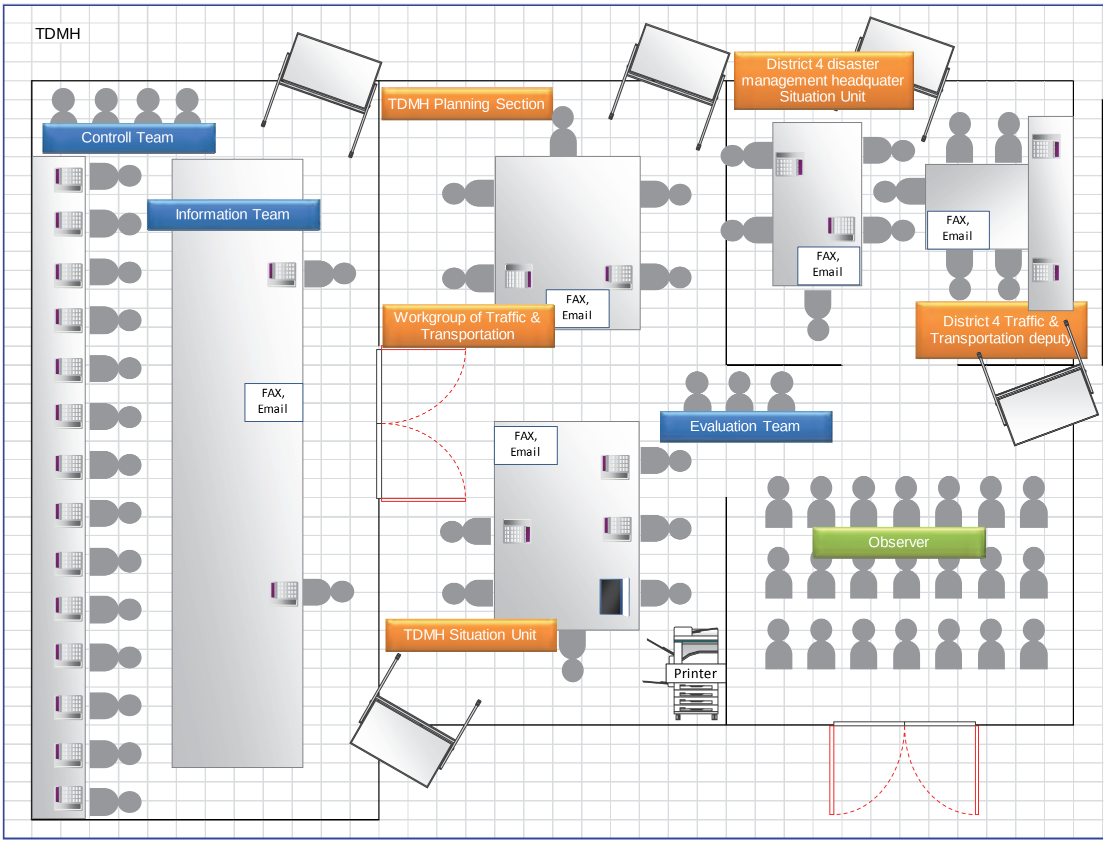


Figure 2.2.47 Arrangement Plan of CPX venue

Figure 2.2.48 Situation of preparing CPX

2) To hold CPX

<u>a. To hold an information session for CPX</u>

Before holding CPX, the JICA Expert Team held explanation sessions for both the controllers and players on 21 September 2014, and explained the method and purpose of CPX. At the explanation session for the controllers, all supposed scenarios from starting the exercise to after the end of the exercise were explained. For the players, only the scenario before starting the exercise was explained.

<u>b.To hold CPX</u>

CPX was held on 27 September 2014. The schedule was as follows. CPX was implemented to synchronize the exercise time and real time.

Table 2.2.55 Schedule of CPX

No.	Time	Agenda	
1	08:30 —09:00	Registration	
2	09:00—09:05	Opening Ceremony	Organizer
3	09.05 – 09.10	Opening Speech	TDMMO
4	09:10— 09:30	Explanation of CPX	JICA Expert Team
5	09:30— 09:45	Tea Break	All
6	09:45— 10:00	Preparation Time	All
7	**10:00— 13.00**	**CPX (3 hours)**	All
8	13.00 – 14.00	Lunch	
9	14.00— 15:30	Evaluation - Review by Evaluation Team - Presentation by Players - Comments from Participants	All
10	15.30 – 15.40	Closing Remarks	TDMMO

Though there was some delay in the process because it was the first experience for almost all participants, gradually they became positive. For instance, some participants collected the information of their own accord. They seemed to experience the situation of the emergency through CPX

Figure 2.2.49 Situation of CPX

3) Feedback from CPX

After CPX, an evaluation meeting was held. Some participants gave comments that they were able to learn a lot through confirming the information exchange in case of emergency, etc. Also, many participants said that it was a great opportunity to exchange information, understand each other's organization, and construct a cooperative system. Based on CPX, activities, roles and responsibilities of each organization have been defined more clearly, issues have been summarized, and the operation and maintenance plan was revised. In detail, some issues have been found such that the role and responsibilities for information collection were not classified and there is possibility not to be seen the live camera by power failure after an earthquake. For the information collection, it is clearly indicated in SOP and, for the live camera, in order to check damage status alternatively, it is considered the organization of damage investigation team in SOP.