DATA COLLECTION SURVEY REPORT
ON
EARTHQUAKE MANAGEMENT
IN
IRAN

AUGUST 2019

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

JAPAN METEOROLOGICAL BUSINESS SUPPORT CENTER AND YACHIYO ENGINEERING CO., LTD.

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Summary

1. Overview of Iran

The Islamic Republic of Iran is located in the southwest Asia and the country has a mountainous area and a desert. The land area is around 1.6 million km^2 and it is approx. 4.4 times[1] that of Japan. It is bordered by the Caspian Sea, Turkmenistan, Azerbaijan and Armenia to the north, by Afghanistan and Pakistan to the east, by Turkey and Iraq to the west, and by the Persian Gulf, Oman, UAE, Qatar, Bahrain, Kuwait and Saudi Arabia to the south.

The Zagros mountains, which run from the Iraqi border to the Persian Gulf coast, was formed as a result of a collision between the Arabian Plate and the Eurasian Plate. The Arabian Plate is still moving at a rate of around 25 mm a year, and the accumulation of seismic energy caused by its collision with the Eurasian plate produces frequent earthquakes in Iran. The capital, Tehran, experiences major earthquakes with an approximate 150-year cycle. Accordingly, there is a high interest in reducing earthquake risk.

2. Background and Outline of the Project

Accordingly, the national government has laid out policies for goals such as enhancement of measures against natural disasters and strengthened research for earthquake risk mitigation through the expansion of earthquake observation networks in its laws and development plans. Against this background, seismic activity is monitored extensively on a nationwide basis, and earthquake-related research is actively carried out.

Japan has supported on earthquake management field in Iran continuously by conducting surveys and projects such are a project on the establishment of an emergency response plan for the first 72 hours after an earthquake in the country (2007 – 2010) and a project for capacity building in earthquake risk reduction and disaster management in Tehran (2012 – 2015).

Meanwhile, because of the impact of international trade regulations, etc., it is difficult to import related equipment and equipment in the earthquake management field. As the results, delays in the updating of equipment in the field have affected research and realization of social implementation in the area of earthquake mitigation.

Against such a background, the Government of Iran asked Japan for assistance via an ODA loan toward the procurement of equipment necessary for earthquake management research. In this context, the following sub-projects (collectively referred to here as “the project”) were proposed:

1. Monitoring of Seismically Active Faults in Tehran
2. Comprehensive Seismic Hazard Assessment for Metropolitan Tehran
3. Seismic Monitoring of the Volcanic Mt. Damavand

[1] Source: Website of Ministry of Foreign Affairs of Japan

4. Evaluation of Vital Urban-artery Performance and Proposal of an Earthquake Improvement Plan
5. Development of Appropriate Moduli for Utility Risk Assessment under HAZ-IRAN
6. Establishment of Earthquake Precursor Observatories

However, in all proposed sub-projects, it is necessary to clarify the specifications of the required equipment, and the relations between research and realization of social implementation in the area of earthquake mitigation in Iran's request. Accordingly, by conducting the data collection survey on earthquake management in Iran (referred to here as "the survey"), it has been planned to examine the potential for Japanese assistance with earthquake management in Iran.

3. Outline of the Study Findings and Contents of the Project

In response to this request, JICA dispatched a study team to Iran (the 1st field survey: March 2, 2019 to March 15, 2019) to confirm the details of the request and discuss implementation details with officials of Iran. The project site survey and related materials were collected. After returning to Japan, the study team examined the necessity of the project, social and economic effects, and relevance based on the field survey materials, and compiled the draft final report based on the results. JICA dispatched a study team to Iran (the 2nd field survey: July 4, 2019-July 13, 2019) to explain and discuss the draft final report and discuss with the Iranian officials. The basic agreement was obtained.

Based on the results of the field survey, the following table shows the purpose, effect, and target "use of results" (implementation of research and society), expected results, and implementation details for each subproject.

Table Detail of the sub-projects proposed by Iran

Sub-project (executing organization)	Purpose	Description (details, outcomes, etc.)	
1. Monitoring of Seismically Active Faults in Tehran (IGUT) 2. Comprehensive Seismic Hazard Assessment for Metropolitan Tehran (IIEES)	- Monitoring of active-fault activity - Determination of active fault geometry, identification of blind faults	Impact	Mitigation of all earthquake damage risk
		Outcome	- Earthquake early warnings, rapid shaking and intensity map, accurate and rapid identification of earthquake locations - Review of existing standards for estimating earthquake risk and for earthquake-proofing
		Output	- Clarification of activity rates at active faults - Establishment of an earthquake database - Clarification of active fault geometry - Identification of hidden faults
		Activities	- Reinforcement of IRSC in metropolitan Tehran - Installation of densely portable seismometers on faults in metropolitan Teheran
3. Seismic Monitoring of the Volcanic Mt. Damavand (IGUT, IIEES)	Clarification of seismic activity and the volcano observation environment	Impact	Volcanic activity phenomena will be detected
		Outcome	Creation of a volcano-seismic event database, estimation of lava chamber locations and shapes, monitoring of volcanic activity
		Output	- Clarification of exact seismic-event locations - Identification of mechanisms behind seismic events - Establishment of a system for monitoring seismic noise around volcanoes - Determination of locations for array observation stations
		Activities	Reinforcement of the seismic network for volcano monitoring based on the installation of portable seismic sensors on the mountain itself
4. Evaluation of Vital Urban-artery Performance and Proposal of an Earthquake Improvement Plan (AUT) 5. Development of Appropriate Moduli for Utility Risk Assessment under HAZ-IRAN (IIEES)	- Collection of basic information for the formulation of an earthquake improvement plan for vital arteries in metropolitan Tehran (AUT) - Collection of basic information toward the development of appropriate moduli for utility risk assessment under HAZ-IRAN (IIEES)	Impact	Mitigation of earthquake damage risk
		Outcome	- Improvement and promotion of standards and related adaptation to the actual situation of vital arteries in Iran (AUT, IIEES) - Contribution to HAZ-IRAN (IIEES)
		Output	- Securement of feasibility regarding clarification of accuracy for numerical models in the laboratory method related to seismic design (AUT) - Improvement of seismic codes (AUT, IIEES) - Contribution to HAZ-IRAN development (IIEES)
		Activities	- Reinforcement of testing equipment related to mitigation of earthquake damage risk in the Teheran metropolis and elsewhere (e.g., hydraulic actuators, shaking tables for multi-axis simulation, test machines for seismic isolators, large material testing system machines) - Collection of basic information on seismic design
6. Establishment of Earthquake Precursor Observatories (IGUT)	Reduction of earthquake risk and mitigation of related disasters based on analysis of data from geophysical observatories as precursors and on the provision of advice to SCMO	Impact	Mitigation earthquake damage risk
		Outcome	Establishment and development of Iran earthquake precursor databases for monitoring of perturbations to support earthquake preparedness. Reduction of earthquake risk and mitigation of earthquake damage via the provision of information and advice to the State Crisis Management Organization (SCMO).
		Output	- Establishment of earthquake precursor observatories - Establishment of a system for developing Iran earthquake precursor databases - Establishment of a system for provision of information and advice to SCMO
		Activities	- Monitoring of geophysical and geochemical parameters around active faults (gravity, radon density, geophysical electromagnetism (geomagnetism, VLF/LF radio status, ionosphere status)) - Establishment of earthquake precursor observatories at RCEP - Provision of advice to SCMO based on results from analysis of data from geophysical observatories

Source: JICA Survey Team

The following shows the results of listing-up of the requested equipment and quantity for each sub-project.

Table　Equipment requested by Iran

Sub-project no.	No.	Equipment	Qty	Unit	User
1 - 3	1	Broadband seismic sensor for boreholes (BB type)	20	Set	IGUT
	2	Broadband seismic sensor for surface (BB type)	25	Set	
	3	Broadband seismic sensor for surface (SP type)	75	Set	
	4	Accelerometer sensor	120	Set	
	5	Digitizer 6 Ch	120	Set	
	6	Portable broadband sensor for surface (BB type)	35	Set	IIEES
	7	Portable broadband sensor for boreholes (BB type)	30	Set	
	8	Portable short-period sensor for surface	65	Set	IGUT/IIEES
	9	Portable short-period sensor for boreholes	30	Set	IIEES
	10	Digitizer 3 Ch	160	Set	IGUT/IIEES
	11	Server (computer)	2	Set	
	12	Radio modem	200	Set	
	13	GPRS modem	80	Unit	
	14	UPS	20	Unit	
	15	Solar panel and battery	260	Set	
4	16	Shaking table testing machine (6 DOFs)	1	Set	AUT
	17	Actuator for dynamic testing-A	1	Set	
	18	Actuator for dynamic testing-B	1	Set	
	19	Actuator for dynamic testing-C	1	Set	
	20	Actuator for dynamic testing-D	1	Set	
	21	Actuator for static testing-A	1	Set	
	22	Actuator for static testing-B	1	Set	
	23	Actuator for static testing-C	1	Set	
	24	Actuator cooling system	2	Set	
	25	Universal testing machine	2	Set	
	26	Dynamic data acquisition unit	2	Set	
	27	Static data acquisition unit	2	Set	
	28	Manual data acquisition unit	2	Set	
	29	Instrumentation	1	Lot	
	30	Axial fatigue testing machine	1	Set	
	31	Roof crane	2	Set	
5	32	Servo hydraulic actuator-A	2	Set	IIEES
	33	Servo hydraulic actuator-B	2	Set	
	34	Servo hydraulic actuator-C	4	Set	
	35	Servo hydraulic actuator-D	4	Set	
	36	Servo hydraulic actuator-E	2	Set	
	37	Servo hydraulic actuator-F	2	Set	
	38	Testing machine for seismic isolators	1	Set	
	39	Large material testing system	1	Set	
	40	Fast dynamic data logger	1	Set	
	41	3-dimensional optical data acquisition system	1	Set	
6	42	Gravity meter	15	Unit	IGUT
	43	Radon detector	20	Unit	
	44	Fluxgate magnetometer	20	Unit	
	45	Magnetotelluric sensor	20	Unit	
	46	VLF/LF Receiver	30	Unit	
	47	Advanced digital ionosonde	5	Unit	

Source: JICA Survey Team

In addition, with consideration for humanitarian assistance, the main concerns such as export restrictions and economic sanctions related to the procurement of equipment to Iran confirmed by the JICA Survey Team are shown below.

Table Equipment Procurement Issues

No.	Issues	Necessary response for the implementation
1	Issues relating to inter-bank transactions	Tokyo-Mitsubishi UFJ Bank will consider engagement in such transactions with special permission from OFAC. Thus, Iran will present the documents to JICA accordingly; then JICA will make the request OFAC to review the implementation of the issues. After getting the permission from OFAC, JICA will request to the bank on the transactions.
2	Ban on exports of US equipment	In order to cope with this, it is possible to procure equipment other than US products.
3	Self-regulatory corporate policies	In case that procurement equipment to Iran is difficult at the project implementation stage, discussions among the Iranian side, JICA, and a consultant of the project will be conducted. If it is considered that the impact on the project effect and validity without the equipment will be small, the exclusion of the equipment is examined.
4	Transport/assembly insurance	At the stage of the project implementation, the procurement company requests the insurance company to deal with the project with the special permission obtained from OFAC as mentioned in No. 1 above.

Source: JICA Survey Team

4. Evaluation of the Project

The Team believes that the project will contribute to the realization of development plans and policies in Iran’s earthquake countermeasures field, as well as cooperation related to humanitarian assistance, and the “Earthquake damage reduction” that is expected to be the effect of the project is widely Since it is beneficial to the general public, it was judged that the project is highly relevant as a project to be implemented with Japan's support (see Section 4-1-3-1 for details of the consideration).

Furthermore, regarding the implementation of the project and the operation and maintenance after the project, it is seemed that both of the organization structure and budget for the project of the Iranian side are sufficient.

5. Direction of Future Support

(1) Conditions for Project Implementation

The below shows the Iranian tasks that are needed as the conditions for project implementation, and the assumed external conditions.

1) Iranian tasks that are needed as the conditions for project implementation
   - Secure sites for installation of equipment procured under the project.
   - Management on the introduction of the equipment.
   - Japan's loan assistance or grant aid projects are exempted in principle from taxation, so if various taxes are incurred for the projects, they will be paid by Iran.
   - Continue seismic observation and research work under IGUT, IIEES and AUT.

- Secure the budgets, human resources and other items necessary for maintenance of the equipment under IGUT, IIEES and AUT .

2) Assumed External Conditions

- Policies concerning earthquake management in Iran will not be changed.
- Banking transactions will be conducted between Tokyo-Mitsubishi UFJ Bank and the central bank of Iran.
- Insurance provided by the project supplier will cover the transportation of equipment/materials and installation work under the project.
- The export control department in the country where project equipment is procured will permit export to Iran.
- There will be no large-scale natural disasters such as earthquakes or unexpected incidents such as acts of terrorism before or during the implementation of the project.

(2) Issues to be solved for direction of future support and activities needed in handling them

The results of examining the issues to be solved and the actions necessary to realize the proposed social implementation in project implementation. are outlined below.

1) Collaboration and Sharing of Data/Information among Related Organizations
2) Ensurement of Reliability in Information Announcements for Disaster Management Purposes
3) Comprehensive Handling of Improvement for Early Warning Information Announcements in Metropolitan Tehran
4) Enhancement of the Seismic Activity Monitoring System in the Damavand Volcanic Area
5) Expedited Implementation of HAZ-IRAN
6) Establishment of Earthquake Precursor Observatories for Reduction of Earthquake Risk and Mitigation of Earthquake Damage

(3) Technical guidance and assistance using soft components and similar

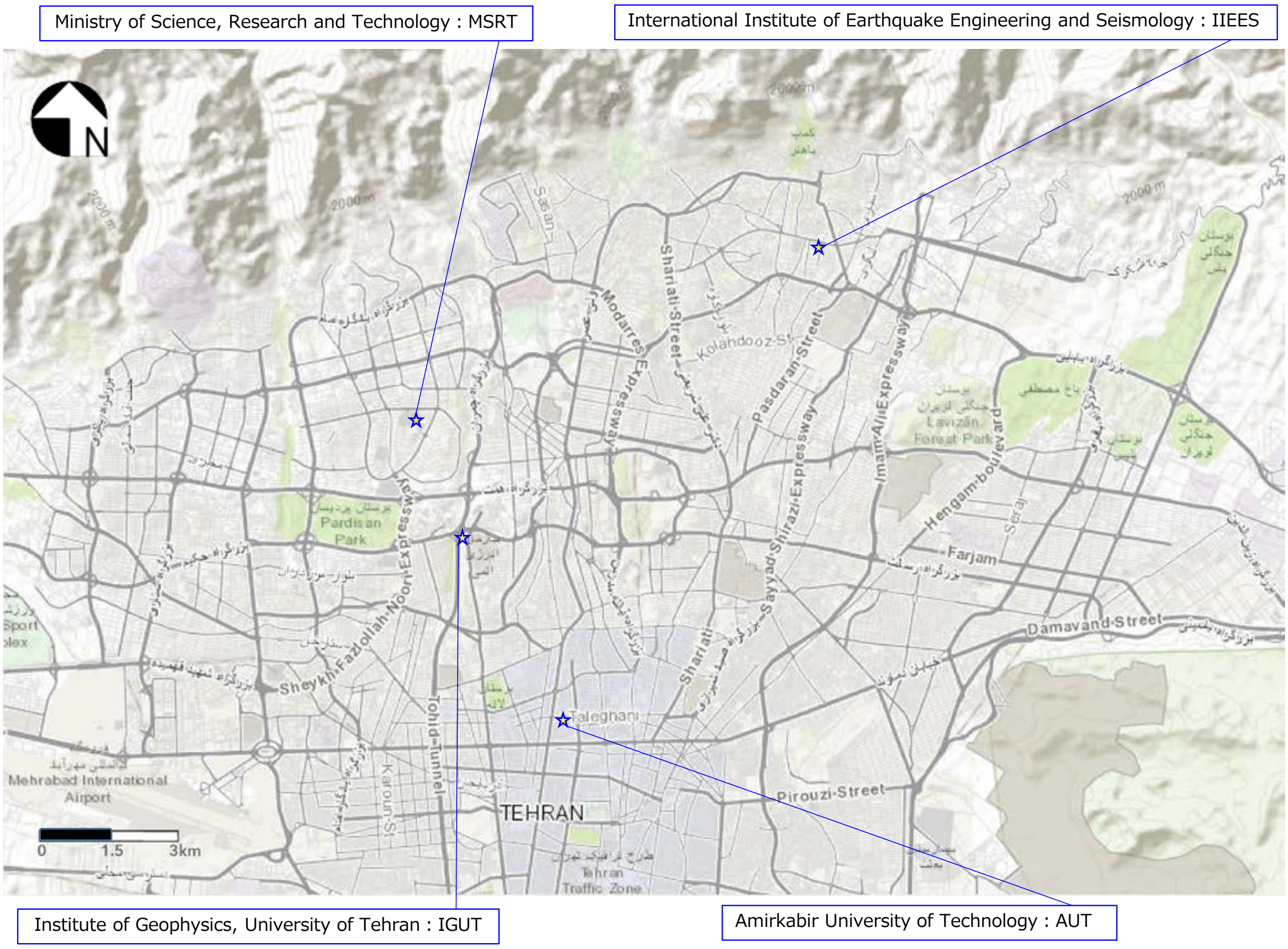
With regard to the support from Japan described in (2) above, the following forms of specific support may be considered in addition to the equipment procurement:

1. Short-term expert dispatch of Japanese experts to project-related organizations in Iran
2. Training and scholarships
3. Joint research
4. Exchange of opinions with overseas research groups through the web

Contents

Middle East/West Asia

Islamic Republic of Iran



Tehran City

Source: (c) Esri Japan | Esri, HERE, Garmin, FAO, NOAA, USGS

Pictures

Joint meeting among related organizations (2019/03/04)

At the beginning of the survey, a joint meeting was held among MSRT, BHRC, PBO, NDMO, IGUT, IIEES, AUT and JICA Survey Team. A consensus was obtained about plan, schedule and so on regarding the survey.

Meeting with NDMO and PBO (2019/03/04)

Hearing survey using questionnaires about projects requested by the Iranian side.

Seismic observation network center (2019/03/05)

Seismic observation network center operated by IGUT, which announces official epicenter, etc. of earthquakes occurred in Iran.

Seismograph of BHRC (2019/03/05)

Seismograph owned by BHRC (SSA-2 of Kinemetrics, Inc. Made in US). It is used in the seismic observation network center of BHRC. More than 20 years have passed since it was introduced.

Shaking table of BHRC (2019/03/05)

Shaking table owned by BHRC.

Meeting with AUT (2019/03/06)

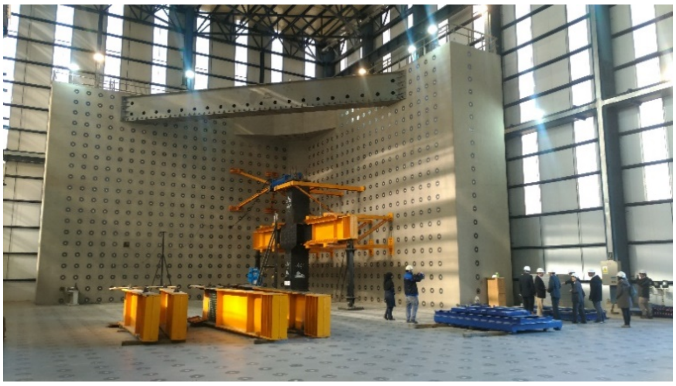
Hearing survey using questionnaires about requested projects and equipment.

Broadband Iranian National Seismic Network (BIN) of IIEES (2019/03/09)

Broadband seismic observation network operated by IIEES.

Dynamic testing at IIEES (2019/03/09)

Actuator is connected with T-shaped pipe (test body) and stress is applied to measure distortion.

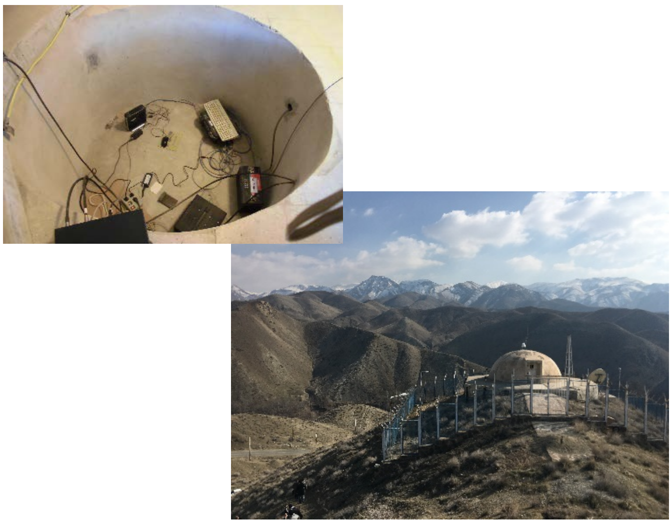


Reaction wall and reaction floor of IIEES (2019/03/10)

Reaction wall and reaction floor owned by IIEES.

Visiting IIEES (2019/03/10)

IIEES staff explained JICA Survey Team about what kind of tests are performed using reaction wall and actuator.



Damavand Station of BIN (2019/03/10)

Site surevey on the Damavand Station of BIN operated by IIEES.

Fault near Damavand Station (2019/03/10)

It is observed that fault gap is exposed on the ground.

Seismograph of IGUT (2019/03/11)

Existing seismograph owned by IGUT. (From left in the picture, Taurus of Nanometrics, CMG-T30 of GURALP, SS-1 of Kinemetrics, CMG-D24 of GURALP, Trillium 120P of Nanometrics)

Iranian Seismological Center (IRSC) (2019/03/11)

IGUTstaff explained JICA Survey Team about procedures of issuing alert.

Shaking table of AUT (2019/03/12)

Visiting AUT for inspecting the shaking table.

Visiting the proposed site for installing shaking table of AUT (2019/03/12)

A proposed site for installing shaking table in AUT premise located in Tehran city. It is adjacent with residential district and there is a concern about oscillation and noise during test.

Visiting the proposed site for installing shaking table of AUT (2019/03/12)

Another proposed site for installing shaking table in Karaj in the suburb of Tehran. It is surrounded by orchards and is far from residential district.

Joint meeting among related organizations (2019/03/13)

JICA Survey Team explained related organizations about the result of the survey.

List of Figures & Tables

Abbreviations

AEEL	Advanced Earthquake Engineering Laboratories
AG	Australia Group
AUT	Amirkabir University of Technology
B/A	Banking Arrangement
BIN	Broadband Iranian National Seismic Network
BIS	Bureau of Industry and Security
BHRC	Road, Housing & Urban Development Research Center
CCL	Commerce Control List
CISADA	Comprehensive Iran Sanctions, Accountability, and Divestment Act
EAR	Export Administration Regulations
ECCN	Export Control Classification Number
EEL	Earthquake Engineering Laboratories
EMSEV	Electromagnetic Studies of Earthquakes and Volcanoes
EU	European Union
GDP	Gross Domestic Product
GIS	Geographical information system
HS	Harmonized Commodity Description Coding System
IGUT	Institute of Geophysics, University of Tehran
IIEES	International Institute of Earthquake Engineering and Seismology
IMF	International Monetary Fund
IRSC	Iranian Seismological Center
ISMN	Iran Strong Motion Network
IT	Information Technology
IUGG	International Union of Geodesy and Geophysics
JCPOA	Joint Comprehensive Plan of Action
JICA	Japan International Cooperation Agency
LF	Low Frequency
MERC	Multilateral Export Control Regime
MSRT	Ministry of Science, Research and Technology
NDAA	National Defense Authorization Act
NDMO	Iranian National Disaster Management Organization
NSG	Nuclear Suppliers Group
OFAC	Office of Foreign Assets Control
PBO	Plan and Budget Organization

RCEP	Research Center for Earthquake Precursors
SCMO	State Crisis Management Organization
SDN	Specially Designated Nationals And Blocked Persons
SRC	Seismology Research Center
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TDMMO	Tehran Disaster Mitigation and Management Organization
VLF	Very Low Frequency
WA	Wassenaar Arrangement

CHAPTER 1 SURVEY OUTLINE

CHAPTER 1　SURVEY OUTLINE

1-1　Survey Background

The Islamic Republic of Iran is one of the world's most earthquake-prone countries, making mitigation of earthquake-related risks a major matter of concern. The capital, Tehran, is one of the largest cities in the world, and experiences major earthquakes with an approximate 150-year cycle. Accordingly, the national government has laid out policies for goals such as enhancement of measures against natural disasters and strengthened research for earthquake risk mitigation through the expansion of earthquake observation networks in its laws and development plans. Against this background, seismic activity is monitored extensively on a nationwide basis, and earthquake-related research is actively carried out.

Japan's ongoing surveys and initiatives regarding earthquake management in Iran include a project on the establishment of an emergency response plan for the first 72 hours after an earthquake in the country (2007 – 2010) and a project for capacity building in earthquake risk reduction and disaster management in Tehran (2012 – 2015).

The development of Iran's social infrastructure has long been stagnant due to the effects of economic sanctions, and facilities/equipment are becoming obsolete because of restrictions on imports. Related delays in the updating of equipment in the field of earthquake management have affected research and realization of social implementation in the area of earthquake mitigation[1]. By way of example, the seismic observation network in place at the time of the November 2017 M7.3 earthquake near the Iran-Iraq border that killed over 400 people in the vicinity of Kelmanshah Province was inadequate. As a result, disaster response authorities were unable to accurately identify the area of maximum damage immediately after the quake, meaning that resources could not be optimally allocated.

Against such a background, the Government of Iran asked Japan for assistance in the development of equipment needed for research in the earthquake management field via an ODA loan (see 4-1-1). However, the specifications of the necessary equipment , as was the correlation between research and social implementation in Iran's request. Accordingly, a JICA survey team (referred to here as "the Team") was dispatched to Iran to conduct a data collection survey on earthquake management in Iran (referred to here as "the survey") to examine the potential for Japanese assistance with earthquake management in Iran.

1-2　Survey Objectives

The objectives of the survey were to promote the improvement of research in earthquake disaster prevention and the reinforcement of research and social implementation in Iran. To these ends, the Team conducted research to promote understanding of the situation of earthquake countermeasures and related issues in the country, and to clarify laws, systems and regulations of individual countries concerning the procurement of seismic observation equipment for export to Iran and associated banking transactions. The Team plans to collect and organize information required for the procurement of necessary equipment under a Japanese ODA

[1] Application and development of research results for social-problem resolution

loan.

1-3 Survey Policy

1-3-1 Survey Policy on Equipment Selection and Procurement Planning

To support earthquake disaster prevention measures in Iran, information was collected on the equipment requested by the country's government with attention to the points below and priority based on need.

- Collection and organization of information on work necessary for earthquake disaster mitigation, such as seismic observation network enhancement, consolidation and analysis of observed data, and utilization of analysis results
- Gathering and sorting of information on equipment needed for experiments on structural parts or shaking tables in the fields of seismic engineering and earthquake-resistance technology
- Consideration of export restrictions of individual countries and other factors when the procurement of the equipment listed up in the above Identification of manufacturers or countries of origin of the requested equipment, and research on relevant export controls
- Approximate cost estimation based on the information collected and organized
  - ⇒ Research on suppliers capable of providing the requested equipment, and securement of cost quotes
  - ⇒ Estimation of costs related to transportation and insurance for the requested equipment, and securement of quotes from the relevant companies

1-3-2 Survey Policy on Practical Usage of Research Results

Information necessary to consider social implementation of research in the field of earthquake disaster prevention was collected and organized. Studies in the field of earthquake disaster prevention include cooperation and collaboration based on the sharing of observation results with relevant administrative agencies, research institutes and other parties. For research in the field of earthquake engineering and resistance, reflection on Iran's structural standards, guidelines and other considerations was assumed, and a concrete method for social implementation was formulated.

1-3-3 Survey Policy on Technical Assistance Requirements

- Investigation of technical collaboration requirements related to the use of the equipment selected as detailed in 1-2-1 above
- Collection of information for consideration of financial collaboration under the conditions of trade control restrictions (Joint research using equipment from Japan and overseas to clarify needs in the area of technical collaboration such as human resource development)

1-4 Survey Location

The study targeted metropolitan Tehran and areas in which government and research institutes conduct research on earthquake countermeasures.

1-5 Survey Team and Schedule

1-5-1 Survey Team

The survey was conducted by the Team members listed in Table 1-1.

Table 1-1 Survey Team members

No.	Name	Assignment	Organization
1	Mr. Tatsuo Narafu	Leader	Japan International Cooperation Agency (JICA)
2	Ms. Sara Watanabe	Project Coordinator	Japan International Cooperation Agency (JICA)
3	Mr. Fumio Okada	Project Coordinator	Japan International Cooperation Agency (JICA)
4	Mr. Hitoshi Inoue	Seismology	Japan International Cooperation Agency (JICA)
5	Mr. Chikahiro Minowa	Seismic Engineering/ Seismic Technology	Japan International Cooperation Agency (JICA)
6	Mr. Shigeo Mori	Chief Consultant/ Disaster Prevention Planning	Japan Meteorological Business Support Center (JMBSC)
7	Mr. Yosuke Ikeda	Equipment Planning/ Cost Estimation	Yachiyo Engineering Co., Ltd. (YEC)

1-5-2 Survey Schedule

This survey was conducted on the schedule shown in Table 1-2.

Table 1-2 Survey schedule

Item		Jan 2019	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
[100] Preparations for the 1st field survey in Japan											
101	Data collection/analysis		□								
102	Formulation of basic policy for the survey/work plan		□								
103	Inception report production		□								
104	Questionnaire compilation/distribution		□								
[200] 1st field survey											
201	Inception report commentary/discussion			■							
202	Data collection from related organizations			■							
203	Analysis of issues in earthquake management and seismic engineering/technology			■							
204	Discussion regarding social implementation of research results			■							
205	Study of projects/programs by other donors			■							
[300] Preparations for the 2nd field survey in Japan											
301	Reporting on results of the 1st field survey			□							
302	Processing of equipment information and cost estimation			□	□	□	□				
303	Study on social implementation of research results			□	□	□	□				
304	Draft final report production			□	□	□	□				
[400] 2nd field survey											
401	Draft final report commentary/discussion							■			
402	Discussion regarding social implementation of research results							■			
403	Discussion regarding Japan ODA loans including technical support							■			
[500] Finalization work in Japan											
501	Reporting on results of the 2nd field survey							□			
502	Identification of high-demand equipment and cost estimation							□	□		
503	Final report production							□	□		
Report submission ① Inception report ② Draft final report ③ Final report			▲ ①				▲ ②		▲ ③		

Legend: □ Conducted in Japan ■ Conducted in Iran ▲ Submission to JICA

CHAPTER 2 GENERAL INFORMATION ON IRAN

CHAPTER 2 GENERAL INFORMATION ON IRAN

2-1 Topography

Iran is located in the Middle East, or West Asia (Fig. 2-1). To the north is the Caspian Sea – the world's largest lake – and to the south are the Persian Gulf and the Gulf of Oman. Nearby to the west are Turkey, Iraq, Kuwait, Saudi Arabia, Qatar, the United Arab Emirates and Oman, while Turkmenistan, Afghanistan and Pakistan are located to the east. The country has a land area of around 1.6 million km^2 (approx. 4.4 times[2] the size of Japan), making it the largest in the Middle East after Saudi Arabia.

Source: (c) Esri Japan | Esri, HERE, Garmin, FAO, NOAA, USGS

Figure 2-1 Location of Iran

Eastern Iran is dominated by a high plateau, with large salt flats and vast sand deserts. The plateau is surrounded by even higher mountains, including the Zagros to the west and the Elburz to the north. The Alborz Mountains in the northern part of Iran run along the southern coast of the Caspian Sea, and include Mt. Damavand (5,671 m)[3] – the highest peak in the Middle East. The Zagros mountain range in the country's western part is 1,600 km long and 240 km wide, and includes peaks of around 3,000 meters running from the Iraqi border to the coast of the Persian Gulf.

The Zagros range formed as a result of a collision between the Arabian Plate and the Eurasian Plate, and thrust faults run along the mountains as shown in Figure 2-2. The Arabian Plate is still moving at a rate of around 25 mm a year, and the accumulation of seismic energy[4] caused by its pushing against the Eurasian plate produces frequent earthquakes in Iran.

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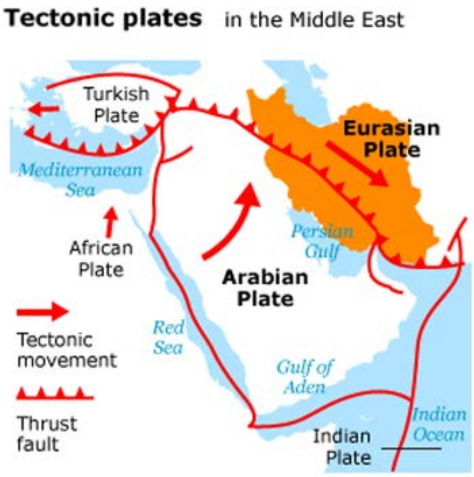
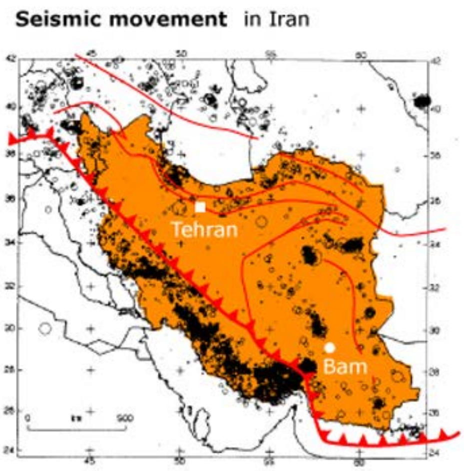
[2] Source: Japan Ministry of Foreign Affairs website
[3] Encyclopedia Britannica: https://www.britannica.com/
[4] References: Bird, 2003



Source：Fanack, Earthquake, Geography of Iran、https://fanack.com/iran/geography/



Source：Fanack, Earthquake, Geography of Iran、https://fanack.com/iran/geography/

Figure 2-2　Plate tectonics and seismicity in Iran

As shown by the red lines in Figure 2-2 (right), there are many faults in Iran other than the aforementioned thrust types. As an example, Figure 2-3 illustrates faults in metropolitan Tehran with red lines, with the North Tehran Fault extending almost the whole width of the image. Photo 2-1 shows a view from the mountainous North Tehran Fault area to the city's southern plain, illustrating the extension of the urban area along the fault (to the front of the camera location).

Figure by: Ross Stein (2017), Temblor

Source: IGUT

Figure 2-3　Metropolitan Tehran and the North Tehran Fault

Source: JICA Survey Team

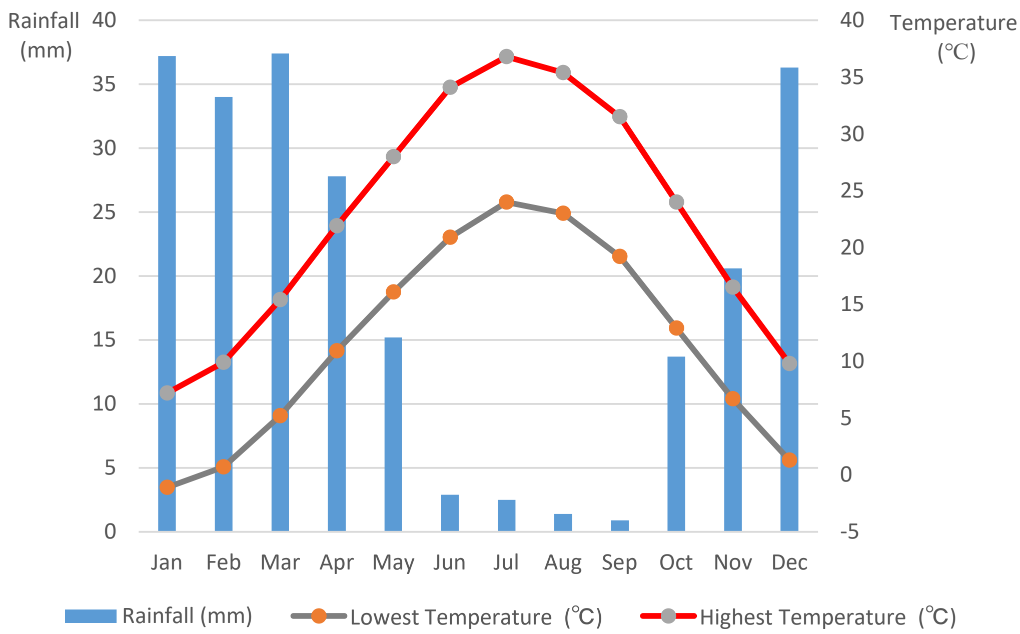
Photo 2-1　View from the North Tehran Fault

2-2　Climate

Iran is characterized by at least four different climatic zones[5]: a desert climate in the west and southwest (BWh climate), a steppe climate in the middle of the Persian Gulf and along the Turkish border (BSk climate), a Mediterranean climate in the east and north (Csa climate), and a high Mediterranean climate in the northern mountainous region (Dsa climate).

[5] Based on the Köppen-Geiger classification devised by the German climatologist Vladimir Peter Köppen with focus on vegetation distribution

The capital city, Tehran, is located at around the same latitude as Tokyo, and is characterized by long, hot, dry summers and short, cool winters (BSk climate). As shown in Figure 2-4, January is the coldest month in Iran, with near-zero temperatures sometimes accompanied by snowfall. Around 70% of annual rainfall is observed from November to April. Summers (June – September) are dry with minimal rain, and July – August is the hottest period.



Source: World Meteorological Organization

Figure 2-4 Average precipitation and temperature in Tehran (1981 – 2010)

2-3 Politics

Since the 1979 Islamic revolution, Iran's political Structure is based on the Republican System. And, the state of politics, economy, and society is stipulated in the Constitution formulated in December 1979 and the Constitution revised in 1989. According to the Iran's constitution, the country's administration and Government is run by the president who is directly elected by the people. There is also the Supreme Leader who is held by the Assembly of Experts, which consists of Islamic jurists elected by a referendum. The Supreme Leader, who is Islamic jurist, oversees judicial and security matters as well as important government affairs, including military/diplomatic decision-making.

Iran is targeted by US economic sanctions, which restrict trade (such as the movement of goods and funds) with other countries. Such sanctions were initially imposed by the US in relation to the Iran hostage crisis in 1979, with all UN member states following suit, and remained in place for more than 35 years until Iran was allowed to export crude oil and natural gas under the Iranian Nuclear Agreement (JCPOA)[6] in July 2015. However, sanctions were partially reapplied when the US left JCPOA in May 2018, meaning that non-

[6] The Comprehensive Joint Action Plan (JCPOA), originally involving Iran, the US, the UK, France, Germany, Russia and China, significantly restricts Iran's nuclear weapons development in return for the lifting of certain sanctions.

Iranian individuals and companies are now unable to trade directly with Iran without an American intermediary[7]. In May 2019, special measures exempting Iranian crude oil embargos were also abolished[8], and economic sanctions have been imposed on steel, aluminum and copper from Iran[9].

2-4 Social Situation

Basic data on Iran is shown in Table 2-1.

Table 2-1 Basic data on Iran

No.	Item	Contents
1	Area	1,648,195 square kilometers (about 4.4 times the area of Japan)
2	Population	80 million (2016 White Paper on World Population)
3	Capital	Tehran
4	Ethnicity	Persian (also Azeri Turkish, Kurdish, Arabic, others)
5	Languages	Persian, Turkish, Kurdish, others
6	Religions	Islam (mainly Shia), Christianity, Judaism, Zoroastrianism, others

Source: Ministry of Foreign Affairs of Japan website

The population of Iran was around 80 million as of 2016, with Tehran being home to around 13 million people (16.2% of the total). Persians account for the largest sector of the population, which comprises of different ethnicities such as Azeri Turks, Kurds and Arabs. The official language is Persian, and there are a large number of people speak other dialects such as Azeri, Kurdish, Arabic as well. The state religion is the Ossuri School of Shia Islam and Twelve Imams (Jafari school of law) as defined in the constitution. Around 99% of the population is Muslim, but Christian, Jewish and Zoroastrian minorities are also government-approved and enjoy certain rights.

Iran provides approximately 1 million refugees (mainly Afghan people) with basic national services such as national health insurance and work permits. Afghan refugee children may enroll in primary and secondary education institutions regardless of refugee registration status[10].

2-5 Economic Situation

As shown in Table 2-2, Iran’s nominal GDP is USD $431.9 billion (2017, IMF estimate), its GDP growth rate is 4.28% (2017, IMF estimate) and its nominal GDP per capita is USD $5,305 (2017, IMF estimate). The country has the world’s largest natural gas reserves and the fourth-largest oil reserves, cementing its reputation as a major provider to the global energy industry. The automobile industry is the largest outside the oil sector; around 1.6 million domestic cars were produced in FY 2017. Against this background, Iran is considered a leading industrialized country in the Middle East and the Western Asia[11].

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[7] US announces withdrawal from JCPOA, secondary sanctions resume: https://www.jetro.go.jp/biznews/2018/05/81f9d8c023c11e4b.html

[8] Elimination of exemption from oil embargo: https://www.jetro.go.jp/biznews/2019/04/1074b178434ed9d8.html

[9] Activating economic sanctions on steel, aluminum and copper: https://www.jetro.go.jp/biznews/2019/05/7414683cc1f4eea3.html

[10] Afghan refugee issues, entrepreneurship for self-reliance progresses in Iran: https://www.unhcr.org/jp/20918-ws-180924.html

[11] Iran Automotive and Automotive Parts Industry Market Trend Survey (Japan External Trade Organization (JETRO), Tehran Office, Business Development Division)

The country is also known for its production of dried fruit, nuts, herbs and rose water, and is a major agricultural force in the Middle East and the Western Asia. Therefore, in addition to traditional industries such as carpets, pistachios, caviar and agricultural products are also exported.

Iran’s history as a tourist destination is owed to its heritage, with attractions including historical buildings, museums and palaces, based on prosperity in East-West trade since the days when the nation was known as Persia. Around 4 million tourists visited the country in 2015. [12].

Table 2-2　Country/region information – basic economic indicators (Iran)

Item	Real GDP growth rate	Total nominal GDP	Nominal GDP per capita	Increase Rate of CPI	Unemployment rate	Export amount	(Growth rate)	Export amount to Japan	(Growth rate)	Import amount	(Growth rate)	Import amount to Japan	(Growth rate)	Current account	Policy interest rate	Exchange rate to US dollar
Unit	%	One billion dollars	Dollar	%	%	One million dollars	%	One million dollars	%	One million dollars	%	One million dollars	%	One million dollars	%	Iranian Rial
Remarks				*Note 1		Customs clearance basis	*Note 2	Customs clearance basis	*Note 2	Customs clearance basis	*Note 2	Customs clearance basis	*Note 2	Balance of Payments Base *Note 1	*Note 3	Average value during the year
Source	IMF・WEO	IMF・WEO	IMF・WEO	IMF・IFS	IMF・WEO	IMF・DOT	-	IMF・DOT	-	IMF・DOT	-	IMF・DOT	-	IMF・WEO	IMF・IFS	IMF・IFS
«Recent annual data (for 10 years)»																
2008	△ 0.08	406.2	5,621	25.55	10.40	105,164	34.58	17,213	43.01	58,729	29.11	1,322	3.03	20,265	12.00	9,429
2009	0.01	410.6	5,609	13.50	11.90	64,082	△ 39.06	8,781	△ 48.99	50,095	△ 14.70	1,399	5.77	8,775	12.00	9,864
2010	5.73	482.4	6,505	10.14	13.50	85,262	33.05	10,530	19.92	66,827	33.40	1,555	11.16	20,361	12.00	10,254
2011	3.06	577.2	7,681	20.63	12.30	111,877	31.22	12,129	15.19	68,912	3.12	1,415	△ 8.97	60,297	11.00	10,616
2012	△ 7.71	389.2	5,118	26.45	12.10	83,193	△ 25.64	7,511	△ 38.07	64,470	△ 6.45	552	△ 60.97	23,416	11.00	12,176
2013	△ 0.33	396.4	5,152	39.27	10.40	63,738	△ 23.39	6,543	△ 12.89	55,047	△ 14.62	140	△ 74.64	26,523	11.00	18,414
2014	3.22	423.4	5,396	17.24	10.60	64,043	0.48	5,836	△ 10.80	72,286	31.32	206	47.14	13,571	14.00	25,942
2015	△ 1.59	375.4	4,723	13.71	11.00	39,327	△ 38.59	3,063	△ 47.52	59,877	△ 17.17	233	12.93	1,237	14.21	29,011
2016	12.52	404.4	5,027	8.58	12.43	46,727	18.81	3,170	3.50	65,710	9.74	471	102.45	16,283	18.00	30,915
2017	4.28	431.9	5,305	10.48	11.81	63,728	36.38	3,361	6.02	72,113	9.74	707	50.12	18,395	n.a.	33,226

Note 1:　JETRO calculated the growth rate based on the Consumer Price Index (on 2010 = 100).
Note 2:　The growth rate of import and export is calculated by JETRO (dollar basis).
Note 3:　Lending rate(Annua rate)

Source: JETRO

[12] 2018 Iran Industry Guidebook (Japan External Trade Organization (JETRO), Tehran Office Overseas Research Department, Middle East/Africa Section)

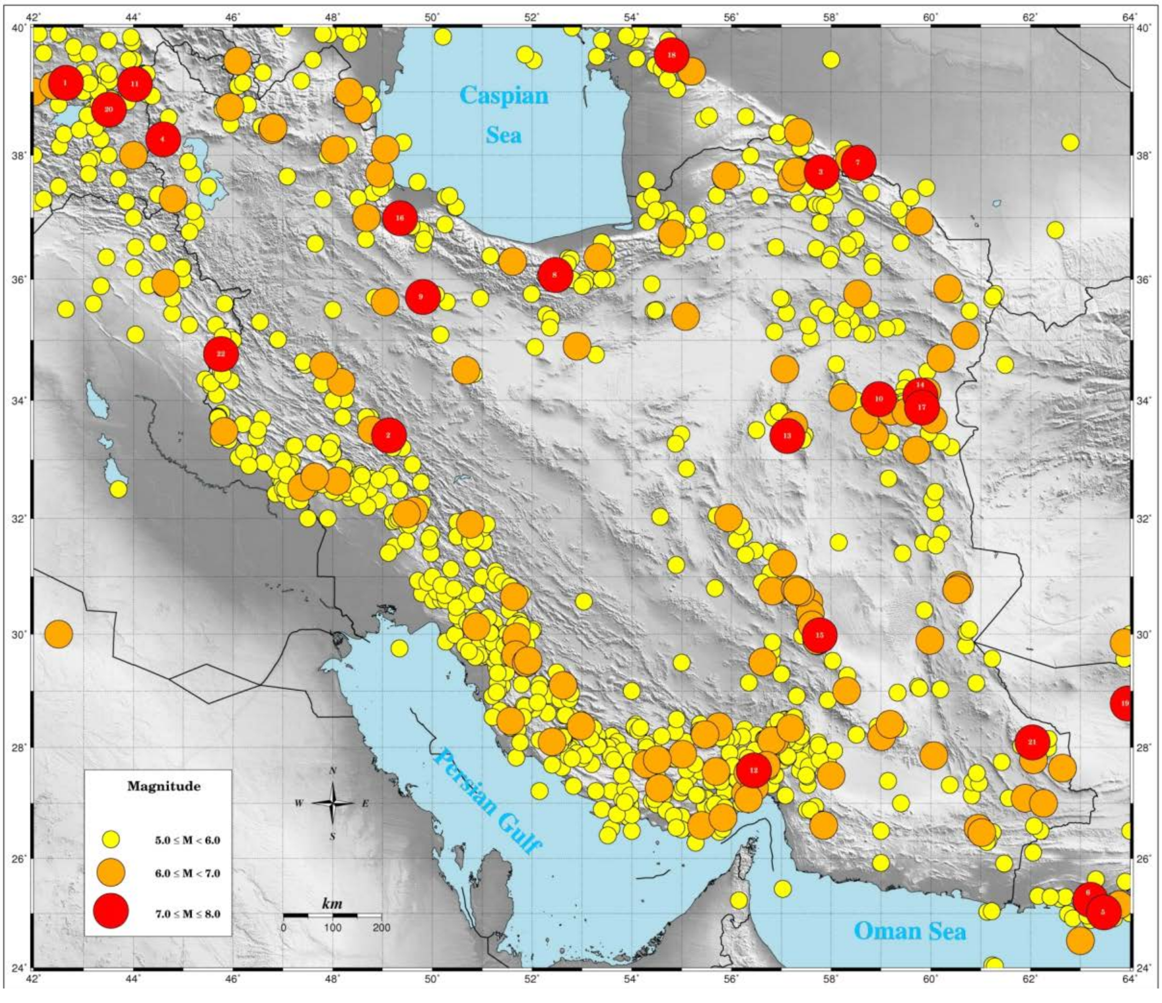
CHAPTER 3 EARTHQUAKE COUNTERMEASURE BASICS

CHAPTER 3 Earthquake Countermeasure Basics

3-1 Earthquake Countermeasures

3-1-1 History of Earthquake Damage

As detailed in Chapter 2-1, seismic activity in Iran is among the world's highest due to the country's location on the boundary of the Arabian and Eurasian tectonic plates. Figure 3-1 shows the locations of the tremors recorded on November 12 2017 that damaged the Kermanshah region along with earthquakes of magnitude 5 or more observed since 1900. Epicenters are clearly concentrated in certain locations, such as near the border with Iraq and along the Persian Gulf. Many are on the boundary of the Arabian/Eurasian tectonic plates or along active faults.



Source: Introduction to the Iranian Seismological Center, February 2019 (IGUT)

Figure 3-1 Epicenter distribution (January 1, 1900 – December 31, 2018, M ≥ 5.0)

Since the start of observation in 1900, ten earthquakes (five occurring directly in Iran[13]) have resulted in more than 10,000 fatalities in and around the country. In the capital Tehran, which has a population of more than 8 million people, major earthquakes tend to occur every 150 years or so. Table 3-1 shows major

[13] E.g., the M 7.3 Ashgabat earthquake of October 6 1948 near the Iran-Turkmenistan border, which is thought to have claimed around 20,000 lives (source: Japan Meteorological Agency, 2017).

earthquakes occurring in Iran since 1900, including the five that killed more than 10,000 people.

Table 3-1 Major earthquakes in Iran (January 1, 1900 – December 31, 2018, M ≥ 5.0)

Date	Location	Magnitude	Fatalities
01.23. 1909	Silakhor	7.4	8,000
05.01.1929	Baghan	7.1	> 3,800
05.06.1930	Salmas	7.1	2,514
09.01.1962	Bu'in	7.0	12,200
07.02.1957	Band-e Pay	7.1	> 1,500
12.13.1957	Farsinaj	6.8	1,200
08.31.1968	Dasht-e Bayaz	7.1	10,000
09.16.1978	Tabas-e Golshan	7.3	20,000
11.27.1979	Koli	7.1	20
07.28.1981	Sirch	7.0	1,300
06.20.1990	Rudbar	7.3	13,000 – 40,000
05.10.1997	Zirkuh	7.2	1,568
12.26.2003	Bam	6.6	31,828 – 43,200
04.16.2013	Saravan	7.7	40
11.12.2017	Kermanshah province (Ezgele – Sarpo e Zahab: near the Iran-Iraq border)	7.3	620

Source: Introduction to the Iranian Seismological Center, February 2019 (IGUT)

3-1-2 Earthquake Countermeasure Laws and Regulations

Iranian ministry annual plans and budgets are formulated in accordance with the Sixth Five-Year Economic, Social and Cultural Development Plan Act (2017 – 2021), in which Article 60, Section C stipulates conduct of the following research to reduce earthquake-related risks:

1. Development of a network for observation of strong motion, seismic activity and earthquake precursors
2. Overall standardization of building materials and enhancement of construction during the implementation of the plan, thereby supporting material manufacturers/providers and the development of related methods

In a recent revision of the Disaster Countermeasures Act, monitoring of disaster-related issues was prescribed. The monitoring of disasters (earthquakes, volcanoes, tsunamis, etc.) is conducted by Iran’s Ministry of Science, Research and Technology (MSRT), and the country’s National Disaster Management Organization (NDMO) is tasked with leveraging related results.

Plans and laws related to disaster prevention in Iran are listed in the Table 3-2.

Table 3-2 Disaster prevention planning and laws

No.	Disaster prevention plans and laws	Remarks
1	Disaster Countermeasures Act	Prescription of organizations and responsibilities
2	Basic plans	-
3	Vision documents	-
4	Five-year plans	-
5	Annual plans	-
6	Integrated technical and engineering law	Prescription of seismic reinforcement

Source: JICA Team

3-1-3 Organizations in the Field of Earthquake Countermeasures

Government organizations and research institutes related to the field of earthquake countermeasures in Iran are shown in Table 3-3.

Table 3-3 Government organizations and institutes related to the field of earthquake countermeasures

No.	Body	
1	Government organizations	Ministry of Scientific Research and Technology (MSRT)
2		Tehran Disaster Mitigation and Management Organization (TDMMO)
3.		Road, Housing & Urban Development Research Center (BHRC)
4		Iranian National Disaster Management Organization (NDMO)
5	Research institutes	International Institute of Earthquake Engineering and Seismology (IIEES)
6		Institute of Geophysics, University of Tehran (IGUT)
7		Amirkabir University of Technology (AUT)

Source: JICA Team

These bodies are governed by MSRT, and are engaged in close collaboration. The National Committee of the University of Tehran (with the NDMO Director General, the MSRT Deputy Minister and the BHRC Director as members) is responsible for overseeing the activities of earthquake-related organizations, with consideration of factors that may hinder seismic observation data analysis such as a lack of modern equipment and data-related issues associated with the country’s extensive history of earthquake damage. NDMO was founded around a decade ago to oversee natural disaster countermeasures, both responding at the post-disaster stage and engaging in disaster mitigation activities. The organization also runs the National Monitoring Center for the collection of disaster prevention information[14].

The relations linking NDMO, IGUT and IIEES are prescribed by law. IGUT is uniquely responsible for earthquake announcements (e.g., epicenter, magnitude), while NDMO is responsible for coordinating emergency activities and disaster response based on information provided by IGUT and complementary information from IIEES.

The organizational statuses of MSRT, IGUT, IIEES and AUT are described below.

(1) Ministry of Scientific Research and Technology (MSRT)

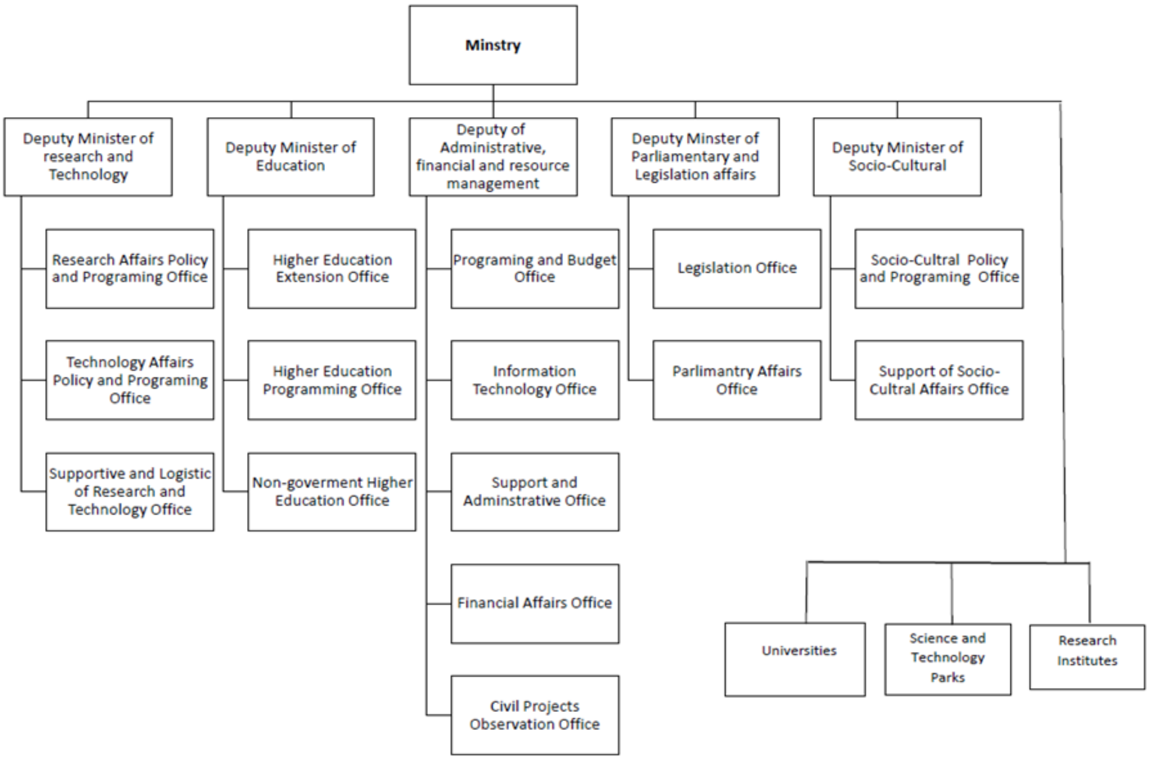
MSRT is involved in the fields of higher education, science and technology, technological innovation and intellectual property in Iran, and is required to:

- support and encourage universities and research institutes (public and private),
- promote basic and applied research,
- provide support for at least 186 incubators and 42 technology parks,
- focus on areas such as engineering, basic science, art, human science and agriculture,
- promote and support research through funding, human resource development and the provision of necessary research facilities,
- promote the creation, innovation and development of expertise in all fields of science and technology,

[14] The National Monitoring Center does not conduct observation.

- contribute to improving the quality of human life, and
- provide services to research communities, especially higher education institutions and research institutions.

Figure 3-2 shows the organization of MSRT.



Source: MSRT

Figure 3-2　MSRT organization

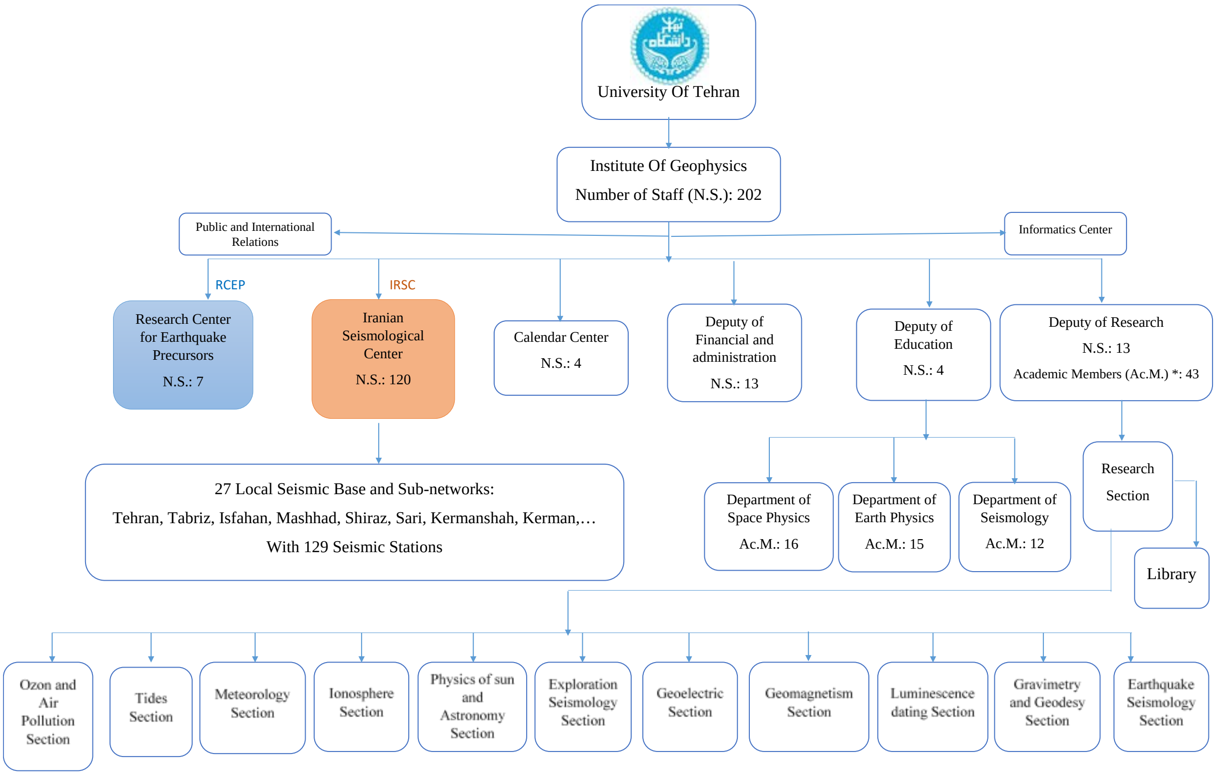
(2)　Institute of Geophysics, University of Tehran (IGUT)

IGUT is a geophysics institute operated by the University of Tehran, which by law[15] is mandated to manage information on earthquakes throughout Iran and is responsible for researching earthquake precursors and probabilities. As shown in Figure 3-3, the organization has six main divisions, among which the Research Center for Earthquake Precursors (RCEP) and the Iranian Seismological Center (IRSC) perform earthquake observation and research.

IRSC operates earthquake observation equipment and runs 21 local earthquake observation networks, 129 three-component seismometers and 6 single three-component seismic stations as seismic bases.

Established in 2005, RCEP is comprised of a council and seven scientific committees staffed by representatives from relevant organizations, and is officially responsible for monitoring and analyzing earthquake precursors in Iran.

[15] Ministers' Council Act No. 23157/33302 of 09/07/2005



Each of academic members simultaneously works as professor in one of the departments and also works as a member of scientific research sections.
Source: IGUT

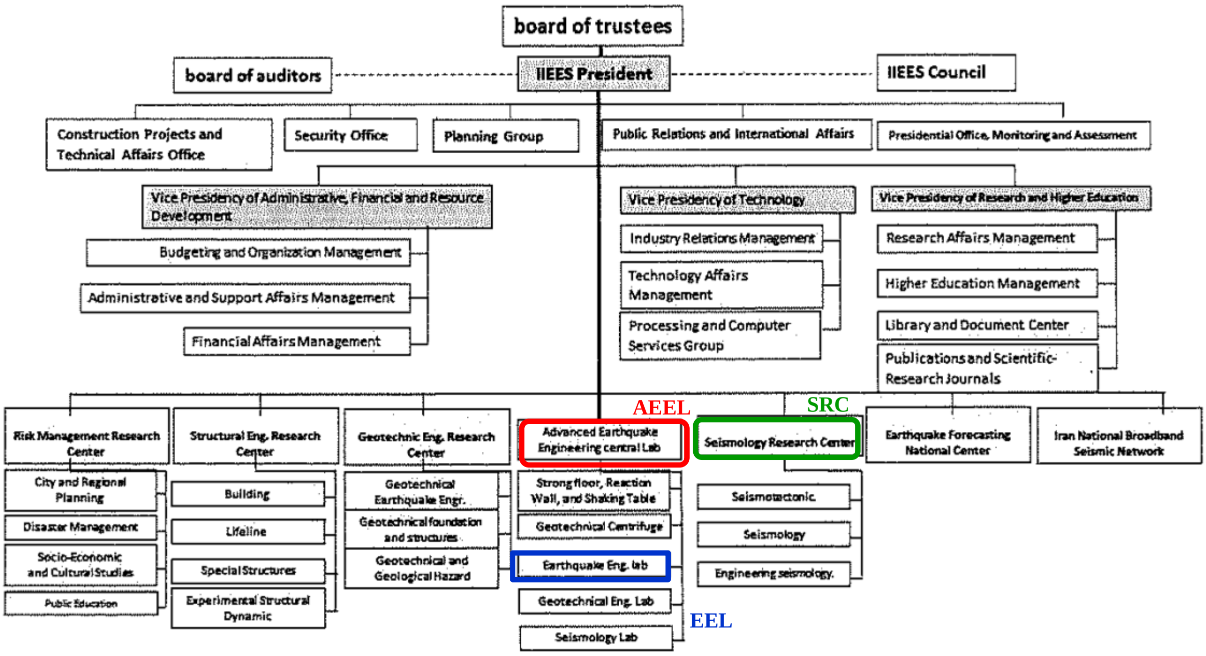
Figure 3-3 IGUT organization

(3) International Institute of Earthquake Engineering and Seismology in Iran (IIEES)

IIEES was established in November 1989 following a suggestion made at the 24th UNESCO General Conference and the approval of Iranian Government's Council of Higher Education Development based on investment from Iranian experts in earthquake engineering. Its main tasks are:

1. to engage in activities relating to investigation, technology and education in all aspects pertinent to seismology, earthquake engineering and earthquake hazards;
2. to suggest practical approaches and support related implementation to reduce earthquake risk; and
3. to develop a security culture against earthquakes in Iran and the surrounding region.

IIEES is composed of various research departments covering areas including seismology, geotechnical engineering, structural engineering, risk management, graduate studies, information technology and international relations. Figure 3-4 shows its organization.



Source: IIEES

Figure 3-4　IIEES organization

Among these divisions, the Seismology Research Center (SRC) incorporates the Seismology Department, the Seismotectonic Department, the Engineering Seismology Department, the Broadband Iranian National Seismic Network and various laboratory resources. It conducts research using seismic observation data.

The organization's Advanced Earthquake Engineering Laboratories (AEELs) test various general types of pipes, joints, bridges, special structures, buildings, equipment and other components of lifeline systems[16] to verify related performance using a large-scale experimental facility (see the pictures at the beginning of this report) run by the Earthquake Engineering Laboratories (EELs) body.

IIEES also works on the development of the HAZ-IRAN[17] system for formulating disaster prevention plans in order to analyze and evaluate earthquake risk/damage and prevent/mitigate disasters. The system enables earthquake risk evaluation based on factors such as physical, social and economic impacts, and is used in conjunction with the Geographical Information System (GIS) for estimation of related damage and loss. HAZ-IRAN is also considered applicable to the development of emergency response plans, emergency recovery measures and damage mitigation strategies.

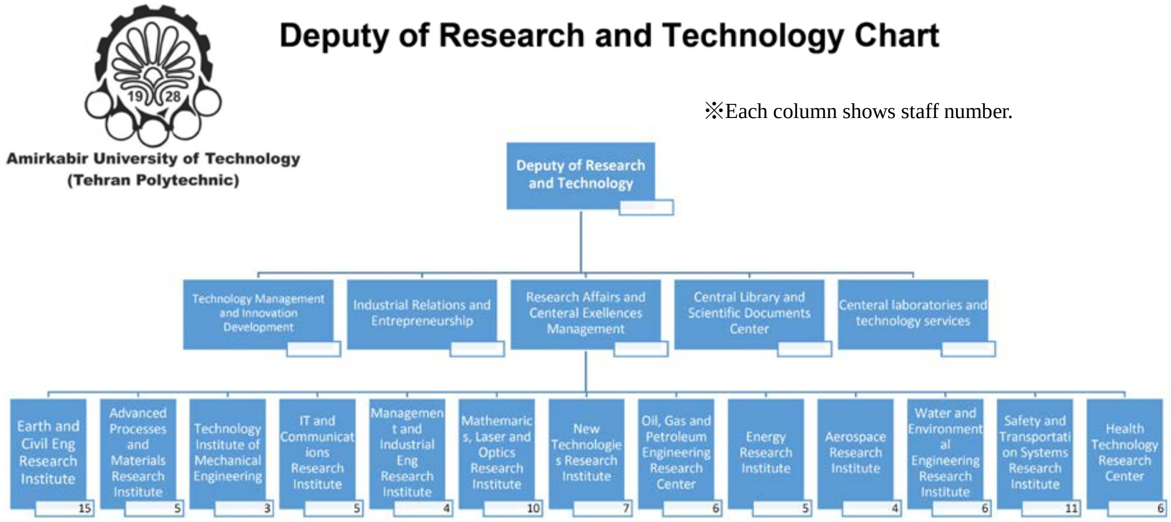
(4)　Amirkabir University of Technology (AUT)

AUT's research division conducts experiments to evaluate the strength of new materials commissioned by companies using reaction walls, reaction floors, single-axis shaking tables (see the pictures at the beginning of this report) and other resources, and issues certification when results meet the relevant standards. The university contracts for work with the municipality of Tehran and for civil engineering work on structures such as bridges and metro railways, as well as implementing projects in preparation for micro-zone mapping

[16] Electricity, water, gas, oil pipelines, etc.

[17] HAZ-IRAN is a system under development by IIEES and is a coined word combining Hazard and Iran.

of Tehran and documentation relating to evaluation procedures for structures and technical buildings. Figure 3-5 shows the organization of the university.



Source: AUT

Figure 3-5 AUT organization

3-1-4 Observation of Earthquakes and other Phenomena, and Social Implementation of Outcomes

Below are three examples of social implementation using the outcomes of research based on current observation of earthquakes and seismic precursors in Iran.

1. IGUT observes seismic activity via IRSC and provides information to disaster prevention agencies to reduce earthquake damage.
2. IIEES shares earthquake observation data and research results acquired via the Broadband Iranian National Seismic Network (BIN[18]) with IGNT. This supports the implementation and improvement of the emergency epicenter announcement service, which is the responsibility of IGUT in the event of an earthquake.
3. IIEES assesses the shape and activity of faults in the metropolitan area of Tehran using data from additional temporary observation points run by IRSC. This contributes to the improvement of seismic risk assessment in the Tehran metropolitan area.

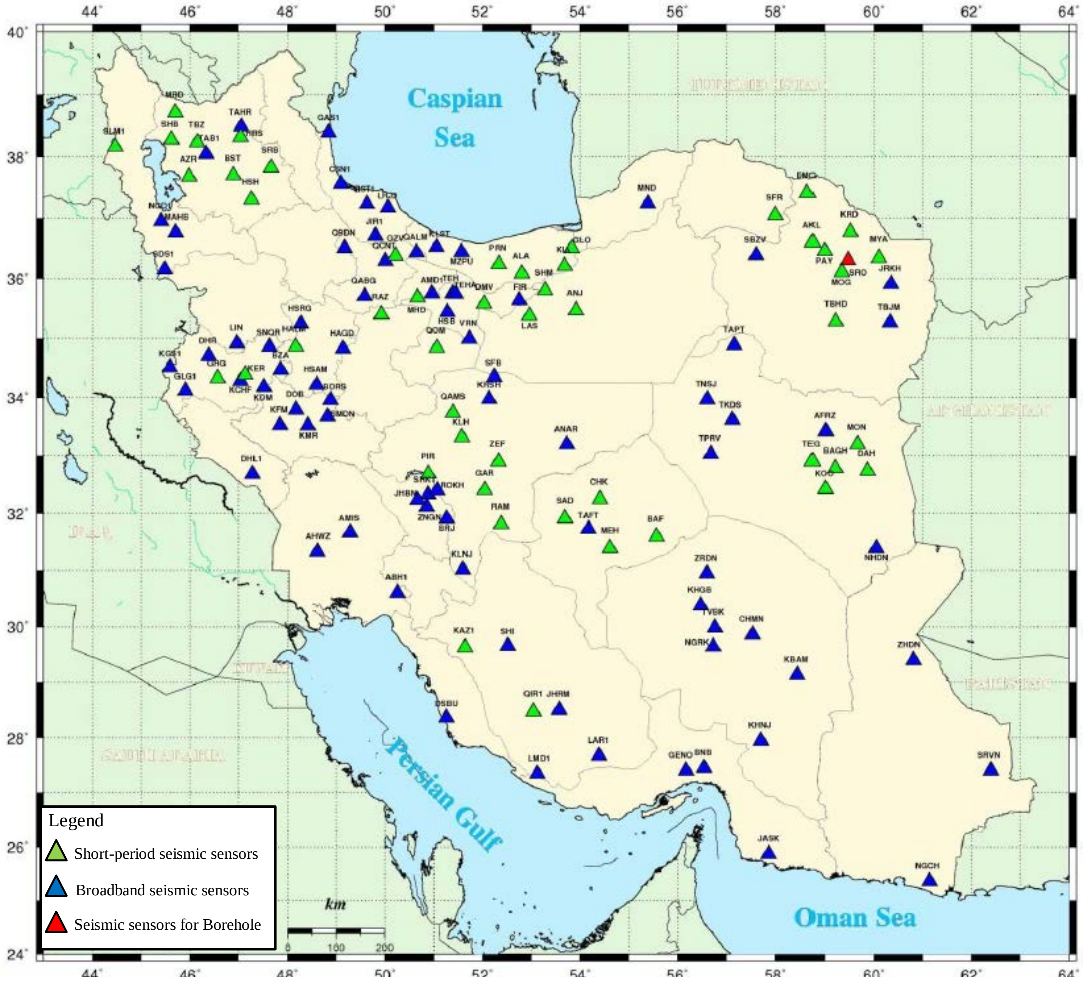
All such social implementation involves the utilization of earthquake observation outcomes, but the results of earthquake precursor research have not yet been linked to such implementation. Below is a summary of social implementation involving the results of seismic observation and monitoring of earthquake precursors.

(1) Social Implementation Involving the Results of Seismic Observation

In the event of an earthquake in Iran or the surrounding area, IGUT provides epicenter information as a public service for emergency disaster preparedness. IRSC was established within IGUT in 2004 and runs an

[18] Also known as the National Broadband Seismological Network, which involves observation using satellite communication.

earthquake observation network, with data consisting of information from the IIEES network with as many as 130 digital seismograph observation points and an availability ratio consistently above 80%. Figure 3-6 illustrates the IRSC network, with triangles in red showing borehole-type seismographs, in blue showing broadband seismographs, and in green showing short-period seismographs.

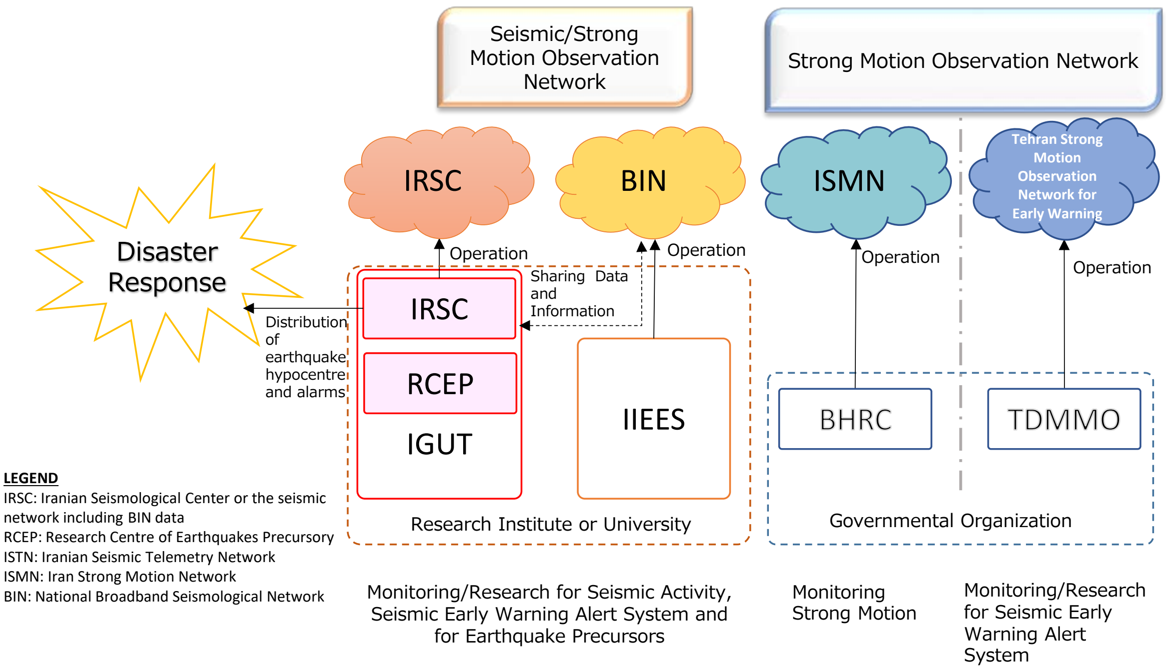


Source: IGUT

Figure 3-6 IRSC seismic observation network

IIEES also operates the BIN, which was launched in 1988 and incorporates 26 always-on observation points, sharing observation data with IGUT. Figure 3-7 shows the composition of Iran's IRSC earthquake observation network.

BHRC runs its own monitoring network of strong motion seismographs (known as the Iran Strong Motion Network, or ISMN) to monitor the situation of its buildings. TDMMO also runs a similar network (known as the Strong Motion Network for the Tehran Early Warning System) for earthquake and disaster prevention research in Tehran to support early earthquake warning announcements.



Source: JICA Team

Figure 3-7 Composition of the Iranian earthquake observation network

Disaster prevention measures in Iran are implemented via the procedure outlined below from earthquake occurrence to the provision of epicenter and magnitude information (within approximately 20 minutes).

1. An earthquake occurs.
2. IGUT (IRSC) automatically calculates the hypocenter and magnitude from seismic observation data collected across Iran.
3. IGUT provides initial information on the estimated hypocenter and magnitude for medium-to-large earthquakes to NDMO, the Iranian Red Crescent, Iranian emergency medical services, organizations, headquarters and other related parties within around three minutes of occurrence.
4. IGUT notifies the aforementioned agencies of the verified epicenter and magnitude.

Immediately after an earthquake, various domestic and international organizations provide information on the epicenter and magnitude, but the Iranian media only reports information such as the epicenter as notified by IGUT. In addition, IGUT sets a window of five minutes[19] as the target time from earthquake detection to epicenter and magnitude notification. When the main shock of the 2017 Kermanshah earthquake (M 7.3) occurred, epicenter and magnitude information were provided within five minutes via IGUT's Seiscomp3 automatic server, and information on the biggest foreshock (M 4.5), which occurred 43 minutes before the main tremors, was automatically sent within two minutes and provided to the public within ten minutes.

IIEES also automatically calculates the epicenter and magnitude immediately after an earthquake, with the results provided exclusively on its website. For the Kermanshah earthquake, this information was uploaded within five minutes.

[19] IGUT assumes that the earthquake early warning system is used, and the final target time for epicenter/magnitude notification is four seconds in the initial stage.

IGUT works closely on earthquake disaster prevention efforts with IIEES, BHRC and TDMMO, sharing earthquake data and supporting related research. The university exchanges real-time data with TDMMO and supports the development of the organization’s earthquake early warning system.

(2) Social Implementation of Earthquake Precursor Observation Results

Established within IGUT in 2005, RCEP operates magnetometers and radio disturbance observation equipment (VLF/LF receivers, radio receivers) which are available to use for earthquake precursor observation. Ionosphere disturbance observation equipment (ionosondes) and gravimeters have also been operated in the past. Such equipment has not been used for earthquake precursor observation, and the results have not yet been linked to social implementation either.

3-1-5 Social Implementation of Research Results in Earthquake and Seismic Engineering

The following points relate to the social implementation of research results in earthquake/seismic engineering currently conducted in Iran:

1. Performance evaluation for test bodies and structures, as requested by companies and other organizations, using experimental equipment of research institutes such as IIEES and AUT
2. Estimation of earthquake-related damage/loss and earthquake motion risk assessment via HAZ-IRAN, and application of the results for the formulation of disaster prevention plans and other purposes

The following is a summary of tests conducted using the experimental facilities of research institutes and social implementation of results from the HAZ-IRAN development project:

(1) Social Implementation of Results from Experiments Conducted Using Research Institute Facilities

The results of tests to verify the seismic performance of structures, system components and other elements in research using large-scale experimental equipment at IIEES are considered appropriate for social implementation. By way of example, outcomes contribute to maintenance and seismic performance improvement of the structures tested, thereby enhancing public safety and peace of mind.

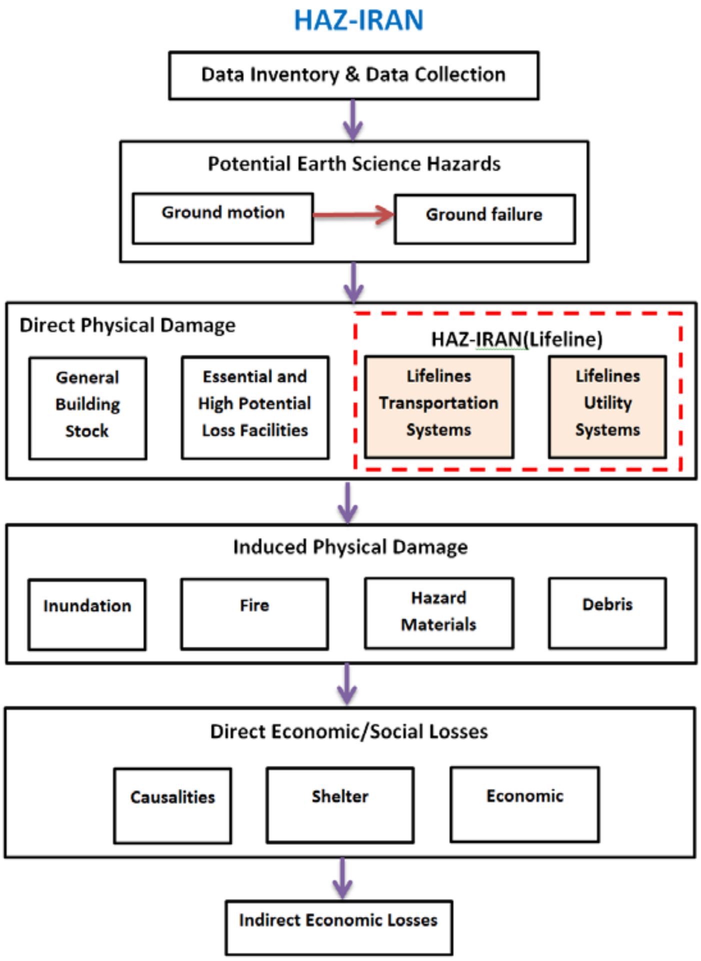
The results of experiments performed by AUT to evaluate the strength of new materials via contracts with companies and experiments on restoration of bridges and other structures in Tehran are expected to contribute to safety and public reassurance through appropriate utilization within subcontracting companies and the municipality. The outcomes are also beneficial for Tehran micro-zone mapping and documentation regarding evaluation procedures for local structures and technical buildings as well as earthquake resistance improvement.

(2) Social Implementation of HAZ-IRAN Development Project Results

Via HAZ-IRAN, IIEES will conduct estimation regarding earthquake-related damage and lifeline impairment[20], thereby contributing to public safety and peace of mind in post-earthquake environments.

Figure 3-8 shows the flow of damage/loss estimation using HAZ-IRAN. The main actions to be taken from earthquake occurrence to loss estimation and the related order are as follows:

1. Collection of strong-motion observation results
2. Estimation of seismic intensity distribution
3. Prediction of actual damage and lifeline damage using HAZ-IRAN
4. Estimation of accompanying damage (flooding, fire, structural collapse, etc.)
5. Estimation of economic and social loss (numbers of victims, shelter maintenance, economic activity)
6. Estimation of indirect economic loss



Source: IIEES

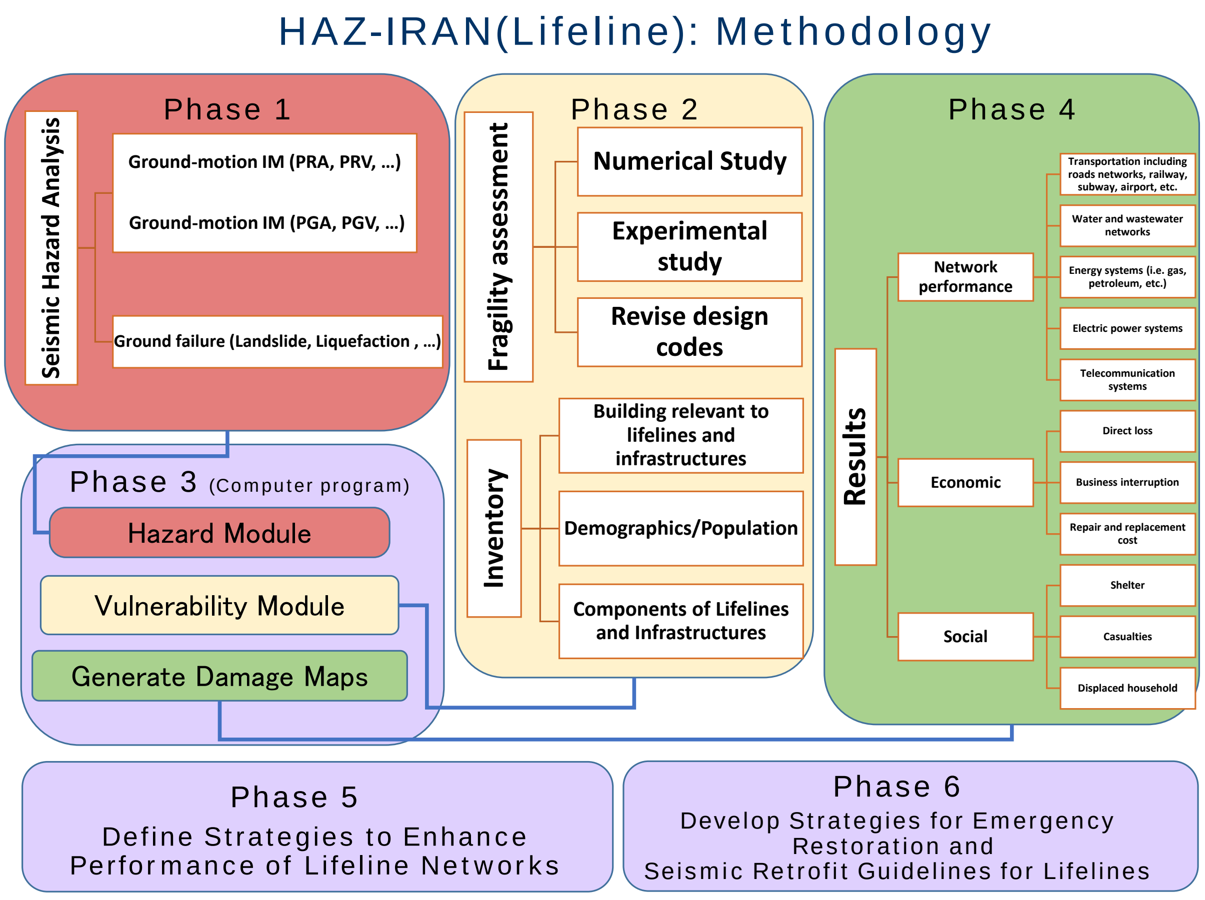
Figure 3-8 Flow of damage/lifeline loss estimation using HAZ-IRAN

The results of earthquake risk assessment using HAZ-IRAN can also be used to develop emergency response plans, emergency recovery measures and damage mitigation strategies, thereby supporting improved reliability in the formulation of disaster prevention plans. The flow of such plans as shown in Figure 3-9 is roughly as follows:

---

[20] Lifelines include electricity, water, gas and oil pipelines as mentioned above, as well as transportation networks (roads, railways, subways and airports), sewer networks and communication systems.

First stage: Earthquake motion risk assessment
Second stage: Evaluation of vulnerability and listing of structures related to lifelines
Third stage: Development of computer resources for damage calculation and prediction
Fourth stage: Summarization of calculation results
Fifth stage: Lifeline reinforcement



Source: IIEES

Figure 3-9 Flow of formulation for emergency response plans, emergency recovery measures and damage mitigation strategies

3-1-6 Assistance from Other Donors

Table 3-4 shows the results of a survey involving MSRT, IGUT, AUT and other related agencies on assistance with earthquake observation equipment by other countries and donors. Equipment was procured by IGUT and AUT with the assistance of the World Bank from the 1990s to the 2000s, but there has been no support from other donors since 2010.

Table 3-4　Assistance with earthquake countermeasures by other donors

Period	Donor/ agency	Project/activity	Amount (USD)	Grant or loan	User	Project/activity details
1994 – 1996	World Bank	Nation Seismic Network	Less than 2 million	Loan	IGUT	Seismic/geophysical equipment purchase
2009	World Bank	IRSC development	Less than 1 million	Loan	IGUT	Seismic equipment purchase
2010	World Bank	Restoration of earthquake areas	2.5 million	Grant	AUT	Seismic laboratory equipment purchase/manufacture

Source: JICA Team

3-2 Equipment Procurement

This section summarizes information collected by the Team on economic sanctions against Iran, regulations on export from individual countries and the status of interbank settlement as necessary for consideration when equipment is provided to Iran with Japanese assistance.

3-2-1 Economic Sanctions against Iran

As mentioned in Section 2-3, the United States announced its withdrawal from the Joint Comprehensive Plan of Action (JCPOA) in May 2018, and its economic sanctions against Iran have since been fully resumed. In this context, the USA's Office of Foreign Assets Control (OFAC) takes measures including trade prohibitions under the OFAC Regulations and asset freezes against designated countries/regions and specific individuals/groups in consideration of foreign policy and security. The OFAC Regulations are applied to US corporations, US citizens and financial institutions, as well to non-Americans and non-American corporations located in the US. US dollar-denominated transactions settled in the United States are generally subject to the regulations, which mainly target individuals and organizations on the Specially Designated Nationals and Blocked Persons List (referred to here simply as the SDN list)[21]. Over 550 individuals and organizations in Iran are on this list.

The OFAC Regulations also affect transactions outside the US made by non-US people and organizations, with secondary sanctions imposed on various Iranian organizations, companies and individuals. The following are also regulated for cases in which equipment is procured from Japan and other third-party countries:

- Purchase or procurement of US dollar currency by the Government of Iran
- Trading by foreign financial institutions with the Central Bank of Iran (Bank Markazi) and Iranian financial institutions stipulated in Article 1,245 of the National Defense Authorization Act (NDAA) for fiscal 2012
- Involvement in financial communications services with the Central Bank of Iran (Bank Markazi) and Iranian financial institutions specified in Article 104 (c) (2) (E) (ii) of the Comprehensive Iran Sanctions, Accountability, and Divestment Act (CISADA) of 2010

[21] A list of parties with which the involvement of US elements such as financial institutions and companies is prohibited, https://sanctionssearch.ofac.treas.gov/

- Underwriting of insurance and provision of insurance and reinsurance

Only the US withdrew from JCPOA; EU nations and many other countries continue to support the plan. However, a number of banks, insurance companies, transportation companies and equipment manufacturers do not engage with countries targeted in the OFAC Regulations.

3-2-2 Regulations on Export from Individual Countries

Japan and other major countries operate under the Multilateral Export Control Regime (MERC) – an international framework centered on developed countries. Under this arrangement, exports and similar are managed in coordination with the international community to prevent weapons, cargo and technology with potential military use from reaching nations or terrorists that threaten the security of the international community, or others considered capable of involvement in nefarious acts. Many countries in which equipment suppliers operate apply export restrictions in line with the regime in addition to their own regulations. Restrictions for export from Japan, the United States and other third-party countries are detailed below.

(1) Regulations on Export from Japan

Japan's Foreign Exchange and Foreign Control Trade Law[22] specifies restrictions on export in the categories of List Controls and Catch-all Controls as shown in Table 3-5.

Table 3-5 Regulations for export from Japan

List Controls	Catch-all Controls
Items and technologies requiring permission from Japan's Ministry of Economy, Trade and Industry for export: 1. Weapons 2. Atomic energy technology 3. Chemical and biological weapons 4. Missiles 5. Advanced materials 6. Material processing technology 7. Electronics 8. Computers 9. Telecommunication technology 10. Sensor and laser technology 11. Navigation technology 12. Ocean technology 13. Promotion technology 14. Others 15. Miscellaneous	Regulation for export/provision of items and technologies not covered under List Controls that could be used to develop weapons for mass destruction or other purposes based on usage and demand. The regulation applies to all countries except white-listed nations, such as the US, Canada and EU countries, where exports are already stringently managed. Permission for export is based on consideration of the following: **1. Usage requirement** Could the exports be abused to develop weapons for mass destruction or other purposes? **2. Demand requirement** Do the intended recipient countries/organizations develop weapons of mass destruction or have any history of doing so? Are such recipients on the End Users' List*? *A Ministry of Economy, Trade and Industry list of organizations requiring special permission for export/provision of items/technologies (except when exports will clearly not be abused toward the development of weapons for mass destruction or other purposes)

Source: J-Net21: http://j-net21.smrj.go.jp/well/qa/entry/Q0824.html (in Japanese)

Exporters must complete the following steps when exporting equipment from Japan to Iran:

[22] Foreign Exchange and Foreign Control Trade Law (Law no. 228 of 1949)

1. Check the statistical item number (HS code[23]) of the equipment in the export statistical item table.

2. Judge whether the equipment is subject to controls and draw up documentation detailing the judgement results as mentioned in the below 3rd process.

3. Judge whether the equipment is subject to List Controls (Articles 1 to 15 in Appended Table 1 of the Export Trade Control Order) using the matrix of decree for export control of goods and others.

*Equipment not judged subject to List Controls falls under the category of Catch-all Controls.

4. Verify the equipment under Catch-all Controls in terms of considerations such as destination, use and demand in accordance with the flow diagram for export license application based on complementary export control (Catch-all Controls, etc.) and judge the necessity for export permission.

5. Be aware that even equipment judged appropriate for export without license based on List Controls and Catch-all Controls is subject to export license requirement if such need is advised by the Ministry of Economy as "inform condition[24] equipment", Trade and Industry.

6. Contact the Ministry of Economy, Trade and Industry for preliminary examination and apply for an export license based on the results of 1 to 5 above.

Equipment manufacturing companies generally deal with 1 and 2 above, and the exporter or trading company handles 3 to 5. Equipment related to earthquake countermeasures may fall under any of Sections 7, 8, 9, 10, and Catch-all Controls.

In addition, for export to parties on the foreign user list, it is necessary to clarify that exported equipment will not be diverted for military development of nuclear weapons or similar. As IGUT and AUT are on the list, it is necessary to clarify how exported equipment will be used and submit basic data such as the following:

1. Destination of the equipment and user information
2. History of the researcher representing the user
3. Details of plans for work using the equipment
4. Method of funding for work using the equipment
5. Public notifications on work using the equipment
6. Laws and regulations on work using the equipment

As the Ministry of Economy, Trade and Industry needs to check intended usage and other details based on this information and decide whether to allow export, the process may take up to several months.

[23] A set of code numbers created for the purpose of unifying names and classifications of international trade products worldwide. Used for item classification in the import and export of goods.

[24] Requirements that have received notification (inform notification) from the Minister of Economy, Trade and Industry that a license application should be made. If there is a risk of the following, it may be the subject of the inform condition; 1 may be used to develop, manufacture, use or store weapons of mass destruction, etc. 2 may be used to develop, manufacture or use conventional weapons.

(2) Regulations on Export from the United States

The USA's Export Administration Regulations (EAR)[25] §746.1 (a) (2) prohibits the export of US products to Iran. However, Chapter 746.7 (b) Licensing Policy stipulates that export license applications for transactions planned for humanitarian reasons may be examined on a case-by-case basis. Accordingly, export licenses may be obtainable depending on the intended use of the items.

The EAR stipulations also apply to the re-export of US products and those primarily produced in the US from other countries. Foreign-made goods that incorporate technology originating in the US where the ratio of US-origin products does not exceed the de minimis level[26] are not subject to EAR stipulations. However, the relevant criteria depend on the destination. As Iran is in Destination Group E-1, items with a de minimis level of 10% or less are exempt from EAR for export to Iran.

High-performance computers for export to Iran and encryption technology made using US expertise as detailed in ECCN 5E002 are not subject to the de minimis regulation, but are subject to the stipulations of EAR regardless of the proportion of components originating in the US.

Items classified under EAR99, which are not subject to Commerce Control List (CCL) restrictions, are not controlled for re-export. However, earthquake countermeasure equipment is considered to fall under CCL Category 6 – Sensors and Lasers, and is therefore likely to be subject to embargo conditions.

(3) Regulations on Export from Third-party Countries

Canada, the United Kingdom and Switzerland, which are home to the head offices of major seismic observation equipment manufacturers (Nanometrics, GURALP, Streckeizen), abide by international export control regimes such as those of the Nuclear Suppliers Group (NSG), the Australia Group (AG) and the Wassenaar Arrangement (WA), and each country additionally has its own export restrictions. Accordingly, equipment exports from these nations to Iran require permission from each country's export control office. For example, the export of a Canadian seismograph to Iran requires the submission of an End User Statement issued by the intended user of the equipment to export control at the cost estimation stage, and an inspection must be carried out by export control officers.

3-2-3 International Settlement between Banks

The Society for Worldwide Interbank Financial Telecommunication (SWIFT, headquartered in Belgium)[27] has blocked several Iranian banks from using its international remittance network since November 2018 in a measure considered to relate to US economic sanctions. These banks (Table 3-6) may not transfer information

[25] §746.1 (a) (2): BIS maintains license requirements and other restrictions on exports and re-exports to Iran. A comprehensive embargo on transactions involving this country is administered by the Department of the Treasury's Office of Foreign Assets Control (OFAC).

[26] When re-exporting US original products incorporated into foreign-made goods from countries other than the United States, the integration ratio of US original products has set depends on destination country, and exports will not be possible if the ratio exceeds the setting. This regulation is called the de minimis rule, and the ratio is called the de minimis level.

[27] An international interbank approval network involving more than 11,000 financial institutions in more than 200 countries and regions

on remittances to counterparts or make international remittances.

Table 3-6 SWIFT constraints on major Iranian financial institutions

No.	Financial institution	Connection with SWIFT
1	Bank Markazi	Prohibited
2	Karafarin Bank	Allowed
3	Bank Keshavarzi	Allowed
4	Bank Maskan	Allowed
5	Bank Melli	Prohibited
6	Parsian Bank	Prohibited
7	Bank Pasargad	Allowed
8	Saman Bank Corporation	Allowed
9	Bank Sepah	Prohibited
10	Bank Tejarat	Prohibited

Source: Mizuho Country Focus
https://www.mizuhobank.co.jp/corporate/world/info/country_focus/pdf/18_22_mcf.pdf
(in Japanese)

CHAPTER 4 EARTHQUAKE MANAGEMENT PROPOSALS

CHAPTER 4 Earthquake Management Proposals

4-1 Support Requirements and Related Issues

4-1-1 Project Requests from Iran

As described in Chapters 2 and 3, despite being one of the world's most earthquake-prone countries, Iran struggles to import earthquake management equipment due to international trade restrictions, etc.. The consequent delays in the updating of aging equipment and facilities has had a serious impact[28] on research and social implementation in the field.

Against such a background, the Government of Iran asked Japan for assistance via an ODA loan toward the procurement of equipment necessary for earthquake management research in 2018. In this context, the following sub-projects (collectively referred to here as "the project") were proposed:

1. Monitoring of Seismically Active Faults in Tehran[29]
2. Comprehensive Seismic Hazard Assessment for Metropolitan Tehran
3. Seismic Monitoring of the Volcanic Mt. Damavand[30]
4. Evaluation of Vital Urban-artery Performance and Proposal of an Earthquake Improvement Plan
5. Development of Appropriate Moduli for Utility Risk Assessment under HAZ-IRAN
6. Establishment of Earthquake Precursor Observatories

In the 1st field survey of March 2019, the JICA Survey Team (referred to here as "the Team") conducted interviews with government organizations and research institutes related to the above sub-projects regarding the details of the proposals. The particulars of the equipment requested by Iran (referred to here simply as "the equipment") and the relationship between research and social implementation were checked for each relevant organization as listed in Tables 4-1 and 4-2.

[28] The seismic observation network in place at the time of the November 2017 M 7.3 earthquake near the Iran-Iraq border that killed over 400 people in the vicinity of Kermanshah was inadequate. As disaster response authorities were therefore unable to accurately identify main areas of damage in the immediate aftermath of the quake, resources were not optimally allocated.

[29] Active-fault commentary brochure (Japan Meteorological Agency): https://www.jma.go.jp/jma/kishou/books/katsudansou/

[30] Located 50 km east-northeast of urban Tehran, Mt. Damavand has 15 million people living within a 100-km radius (IIEES, IGUT).

Table 4-1 Detail of the sub-projects proposed by Iran

Sub-project (executing organization)	Purpose	Description (details, outcomes, etc.)	
1. Monitoring of Seismically Active Faults in Tehran (IGUT) 2. Comprehensive Seismic Hazard Assessment for Metropolitan Tehran (IIEES)	- Monitoring of active-fault activity - Determination of active fault geometry, identification of blind faults	Impact	Mitigation of all earthquake damage risk
		Outcome	- Earthquake early warnings, rapid shaking and intensity map, accurate and rapid identification of earthquake locations - Review of existing standards for estimating earthquake risk and for earthquake-proofing
		Output	- Clarification of activity rates at active faults - Establishment of an earthquake database - Clarification of active fault geometry - Identification of hidden faults
		Activities	- Reinforcement of IRSC in metropolitan Tehran - Installation of densely portable seismometers on faults in metropolitan Teheran
3. Seismic Monitoring of the Volcanic Mt. Damavand (IGUT, IIEES)	Clarification of seismic activity and the volcano observation environment	Impact	Volcanic activity phenomena will be detected
		Outcome	Creation of a volcano-seismic event database, estimation of lava chamber locations and shapes, monitoring of volcanic activity
		Output	- Clarification of exact seismic-event locations - Identification of mechanisms behind seismic events - Establishment of a system for monitoring seismic noise around volcanoes - Determination of locations for array observation stations
		Activities	Reinforcement of the seismic network for volcano monitoring based on the installation of portable seismic sensors on the mountain itself
4. Evaluation of Vital Urban-artery Performance and Proposal of an Earthquake Improvement Plan (AUT) 5. Development of Appropriate Moduli for Utility Risk Assessment under HAZ-IRAN (IIEES)	- Collection of basic information for the formulation of an earthquake improvement plan for vital arteries in metropolitan Tehran (AUT) - Collection of basic information toward the development of appropriate moduli for utility risk assessment under HAZ-IRAN (IIEES)	Impact	Mitigation of earthquake damage risk
		Outcome	- Improvement and promotion of standards and related adaptation to the actual situation of vital arteries in Iran (AUT, IIEES) - Contribution to HAZ-IRAN (IIEES)
		Output	- Securement of feasibility regarding clarification of accuracy for numerical models in the laboratory method related to seismic design (AUT) - Improvement of seismic codes (AUT, IIEES) - Contribution to HAZ-IRAN development (IIEES)
		Activities	- Reinforcement of testing equipment related to mitigation of earthquake damage risk in the Teheran metropolis and elsewhere (e.g., hydraulic actuators, shaking tables for multi-axis simulation, test machines for seismic isolators, large material testing system machines) - Collection of basic information on seismic design
6. Establishment of Earthquake Precursor Observatories (IGUT)	Reduction of earthquake risk and mitigation of related disasters based on analysis of data from geophysical observatories as precursors and on the provision of advice to SCMO	Impact	Mitigation earthquake damage risk
		Outcome	Establishment and development of Iran earthquake precursor databases for monitoring of perturbations to support earthquake preparedness. Reduction of earthquake risk and mitigation of earthquake damage via the provision of information and advice to the State Crisis Management Organization (SCMO).
		Output	- Establishment of earthquake precursor observatories - Establishment of a system for developing Iran earthquake precursor databases - Establishment of a system for provision of information and advice to SCMO
		Activities	- Monitoring of geophysical and geochemical parameters around active faults (gravity, radon density, geophysical electromagnetism (geomagnetism, VLF/LF radio status, ionosphere status)) - Establishment of earthquake precursor observatories at RCEP - Provision of advice to SCMO based on results from analysis of data from geophysical observatories

Source: JICA Survey Team

Table 4-2 Equipment requested by Iran

Sub-project no.	No.	Equipment	Qty	Unit	User
1 - 3	1	Broadband seismic sensor for boreholes (BB type)	20	Set	IGUT
	2	Broadband seismic sensor for surface (BB type)	25	Set	
	3	Broadband seismic sensor for surface (SP type)	75	Set	
	4	Accelerometer sensor	120	Set	
	5	Digitizer 6 Ch	120	Set	
	6	Portable broadband sensor for surface (BB type)	35	Set	IIEES
	7	Portable broadband sensor for boreholes (BB type)	30	Set	
	8	Portable short-period sensor for surface	65	Set	IGUT/IIEES
	9	Portable short-period sensor for boreholes	30	Set	IIEES
	10	Digitizer 3 Ch	160	Set	IGUT/IIEES
	11	Server (computer)	2	Set	
	12	Radio modem	200	Set	
	13	GPRS modem	80	Unit	
	14	UPS	20	Unit	
	15	Solar panel and battery	260	Set	
4	16	Shaking table testing machine (6 DOFs)	1	Set	AUT
	17	Actuator for dynamic testing-A	1	Set	
	18	Actuator for dynamic testing-B	1	Set	
	19	Actuator for dynamic testing-C	1	Set	
	20	Actuator for dynamic testing-D	1	Set	
	21	Actuator for static testing-A	1	Set	
	22	Actuator for static testing-B	1	Set	
	23	Actuator for static testing-C	1	Set	
	24	Actuator cooling system	2	Set	
	25	Universal testing machine	2	Set	
	26	Dynamic data acquisition unit	2	Set	
	27	Static data acquisition unit	2	Set	
	28	Manual data acquisition unit	2	Set	
	29	Instrumentation	1	Lot	
	30	Axial fatigue testing machine	1	Set	
	31	Roof crane	2	Set	
5	32	Servo hydraulic actuator-A	2	Set	IIEES
	33	Servo hydraulic actuator-B	2	Set	
	34	Servo hydraulic actuator-C	4	Set	
	35	Servo hydraulic actuator-D	4	Set	
	36	Servo hydraulic actuator-E	2	Set	
	37	Servo hydraulic actuator-F	2	Set	
	38	Testing machine for seismic isolators	1	Set	
	39	Large material testing system	1	Set	
	40	Fast dynamic data logger	1	Set	
	41	3-dimensional optical data acquisition system	1	Set	
6	42	Gravity meter	15	Unit	IGUT
	43	Radon detector	20	Unit	
	44	Fluxgate magnetometer	20	Unit	
	45	Magnetotelluric sensor	20	Unit	
	46	VLF/LF Receiver	30	Unit	
	47	Advanced digital ionosonde	5	Unit	

Source: JICA Survey Team

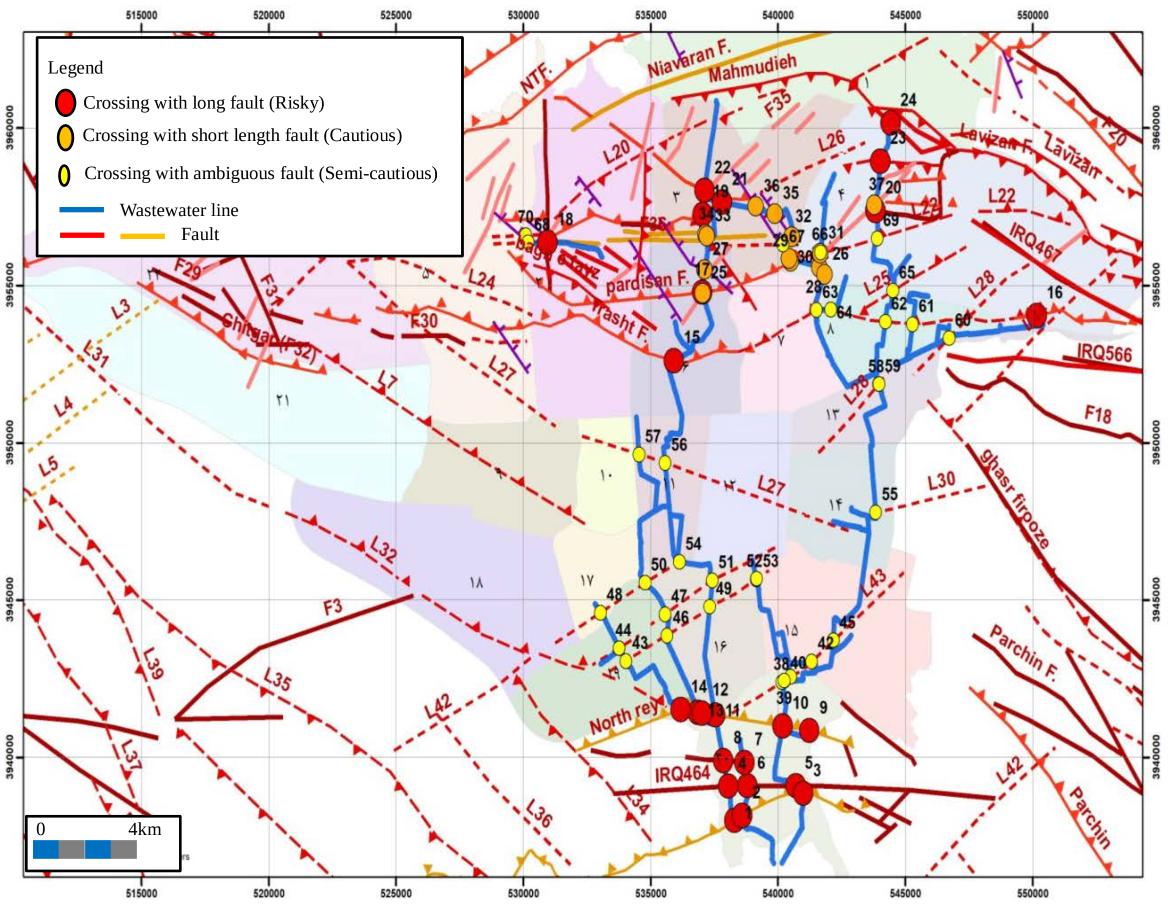
4-1-2 Challenges and Support Required in Earthquake Disaster Management

The Team investigated Iran’s request for assistance as described in Section 4-1-1, and summarized the main challenges and the current need for assistance.

(1) Increasing Earthquake Vulnerability in Metropolitan Tehran

Infrastructure facilities (gas, water, electricity, oil pipelines, etc.) related to daily life have been developed, diversified and enlarged in line with the growth of metropolitan Tehran, but earthquake resistance efforts have lagged behind due to the sheer number of structures involved. As a result, the earthquake vulnerability of the metropolis is increasing.

Figure 4-1 shows the local water supply system and the faults on which it sits. Any significant earthquake in this area can be expected to cause significant displacement that may cause water pipe rupture. If such pipes do not satisfy earthquake resistance standards, damage may be even greater than expected.



Source: IIEES

Figure 4-1 Faults across the main lines of wastewater for metropolitan Tehran

Against such a background, there is a need for early earthquake resistance evaluation regarding infrastructure equipment by IIEES and AUT, which are responsible for such work. However, such evaluation is challenging with the current quantity and functionality of seismic assessment equipment owned by these organizations.

In addition, any major earthquake directly under the Teheran metropolis is expected to damage infrastructure facilities and significantly impair daily living. The number of earthquake-related fatalities may also depend on the extent of such damage.

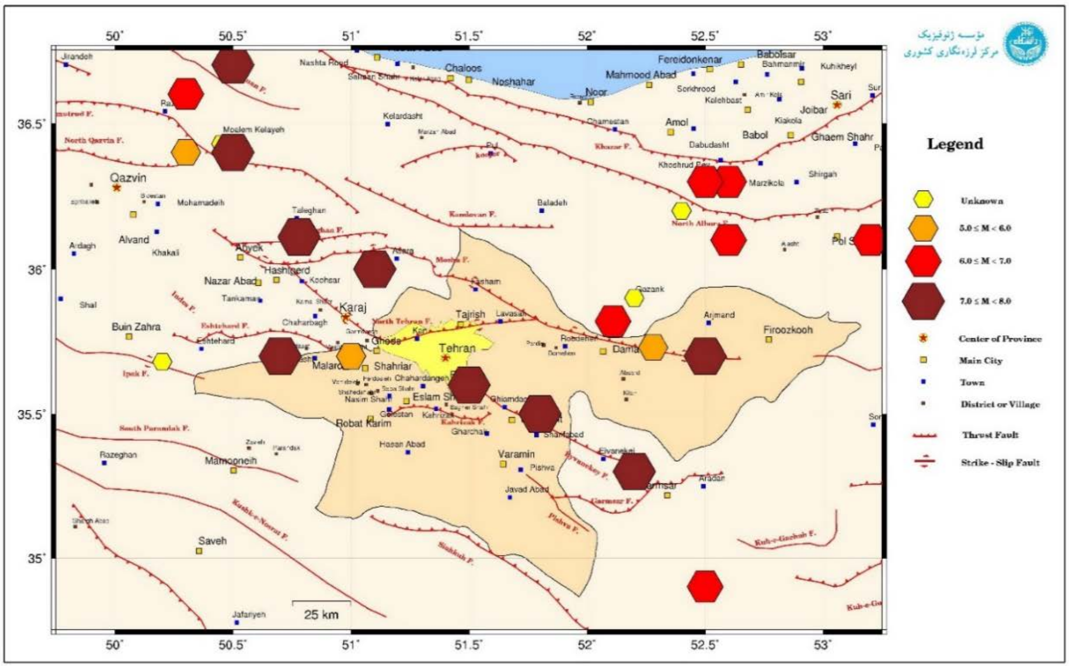
Accordingly, the following support needs should be considered in response to requests from Iran:

- Promotion and acceleration of experimental research and model development for earthquake resistance evaluation regarding infrastructure equipment
- Development of an earthquake-damage-area early detection system

These needs should be given particularly high priority, and early action is considered necessary due to high earthquake risk in the Teheran metropolis as detailed below.

(2) High earthquake risk and concerns over Mt. Damavand volcanic activity in the Teheran metropolis

Earthquake energy is known to have accumulated in the crust under the Teheran metropolis due to the situation of Iranian seismic tectonics (see Sections 2-1 and 3-1-1). There are also numerous active faults[31] along which shallow crustal earthquakes have historically occurred over the topography shown in Figure 4-2.



Source: IGUT and IIEES

Figure 4-2 Distribution of active and other surface faults in the Teheran metropolis (plus pre-1900 earthquakes)

Meanwhile, the potential presence of active sediment-covered faults not visible on the ground surface has

[31] Active fault investigation: Aerial photographs are referenced to identify terrain with potential active faults, and the geology of the surrounding area is clarified via field surveys, excavation, strata analysis and other techniques. Surveys may be conducted based on the nature of seismic waves reflected and refracted by strata and faults, with the results helping researchers to narrow down fault locations. A trench is sometimes dug across a suspected location for direct checking. Historical earthquakes are also examined using archives. Source: Japan Meteorological Agency brochure at https://www.jma.go.jp/jma/kishou/books/katsudansou/katsudansou_tohoku.pdf

also been considered based on actual examples[32] and the results of active fault studies conducted worldwide. Observation of the seismic characteristics of micro earthquakes (seismicity) along active faults during periods of lesser earthquake activity have been conducted to clarify the distribution of activity and changes in activity levels, and to seismologically determine whether faults may be active. Seismological surveys to check such areas as well as their extent and shape[33] are in progress in Iran[34].

Thus, considering additionally that the Teheran metropolis is an area of potentially high earthquake risk, along with its increased vulnerability (as described in Section 4-1-2 (1)), the following forms of support should be examined:

- Promotion of fault investigation
- Enhancement of a seismic activity[35] monitoring system for active faults

Additionally, recent years advances in information technology (IT) have also facilitated the distribution of panic-inducing hearsay and speculation concerning the occurrence of disastrous earthquakes. Recently media speculation related to Mt. Damavand[36] has included headlines such as "Damavand Governor: Possible volcanic activity at Mt. Damavand; a consideration for crisis headquarters." Against these hearsay and speculation, there is a steadily increasing need to promote detecting of phenomena related to geophysical factors other than seismicity and geochemical quantification, which may be affected by gradual changes in crustal characteristics; and to inform the detected data to the public.

(3) Aging of Equipment in the Field of Earthquake Disaster Management

The service life of earthquake management equipment such as broadband seismometers and strong-motion seismometers is generally 20 to 30 years, and such units require regular maintenance for stable operation. As major manufacturers of observation equipment are located in specific countries such as the United States, Canada and Japan, it is currently difficult for Iran to procure new units in light of the economic sanctions imposed by the United States and to obtain replacement parts/consumables for existing equipment. As a result, related facilities and equipment are aging, and support for replacement/repair has been stagnant.

4-1-3 Validity of Iran's Project Requests, Challenges Associated with Related Output, and Remaining Issues to be Addressed

With regard to Iran's requests (see Table 4-1), the validity of yen loan project development was considered

[32] The Iwate-Miyagi Nairiku Earthquake (June 14 2008, M 7.2) occurred in the southern inland part of Iwate Prefecture, with a maximum Japanese seismic intensity of 6-upper observed in Oshu City, Iwate Prefecture, and Kurihara City, Miyagi Prefecture. The quake is considered to have been related to a hidden active fault.

[33] Micro-earthquakes generally occur regularly along active fault planes between large earthquakes, and may be attributable to aftershock activity. The distribution of related hypocenters may enable estimation of the hypocenter area of past large earthquakes (i.e., the shape and spread of the active fault).

[34] Response from IIEES to a questionnaire from the Team (received in March 2019)

[35] Research results indicate that reduced micro-seismic activity may be observed before the onset of a large earthquake.

[36] Example of information of Damavand volcano,
https://www.farsnews.com/news/13970611001262/%D9%81%D8%B9%D8%A7%D9%84-%D8%B4%D8%AF%D9%86-%D8%A2%D8%AA%D8%B4%D9%81%D8%B4%D8%A7%D9%86-%D9%82%D9%84%D9%87-%D8%AF%D9%85%D8%A7%D9%88%D9%86%D8%AF-%D8%B4%D8%A7%DB%8C%D8%B9%D9%87%E2%80%8C-%D8%A7%D8%B3%D8%AA-%D9%85%D9%88%D8%B6%D9%88%D8%B9%DB%8C-%D8%AF%D8%B1-%D8%B3%D8%AA%D8%A7%D8%AF-%D8%A8%D8%AD%D8%B1%D8%A7%D9%86-%D9%85%D8%B7%D8%B1%D8%AD

in relation to equipment and other considerations. The results of examination regarding the issues in question are listed below.

4-1-3-1 Checking of Request Validity

From a scientific point of view regarding the validity of implementing the six requested sub-projects under a Japanese ODA loan project, the following points were compared with those in Japan and examined:

- Achievement of expected outputs
- Appropriacy of equipment specifications and quantities

The results indicated that each sub-project was appropriate. The details of the examination are outlined below for each of the above points.

(1) Sub-projects 1 and 2

These sub-projects involve monitoring of seismically active faults in Tehran Province and comprehensive seismic hazard assessment for metropolitan Tehran. The results of project validity consideration are outlined below.

a) Achievement of Expected Outputs

The expected outputs from the sub-projects are listed below.

- Clarification of activity rates at active faults
- Establishment of an earthquake database
- Clarification of active-fault geometry
- Identification of hidden faults

These outputs may be achieved by appropriately arranging equipment and constructing the necessary seismic observation network. Such action requires proper administrative systems and budgetary measures for the usage and operation of equipment. The presence of such systems and measures was checked via institutional visits and a questionnaire survey.
Achievement of the expected outputs may be achieved by this approach.

b) Appropriacy of Equipment Specifications and Quantities

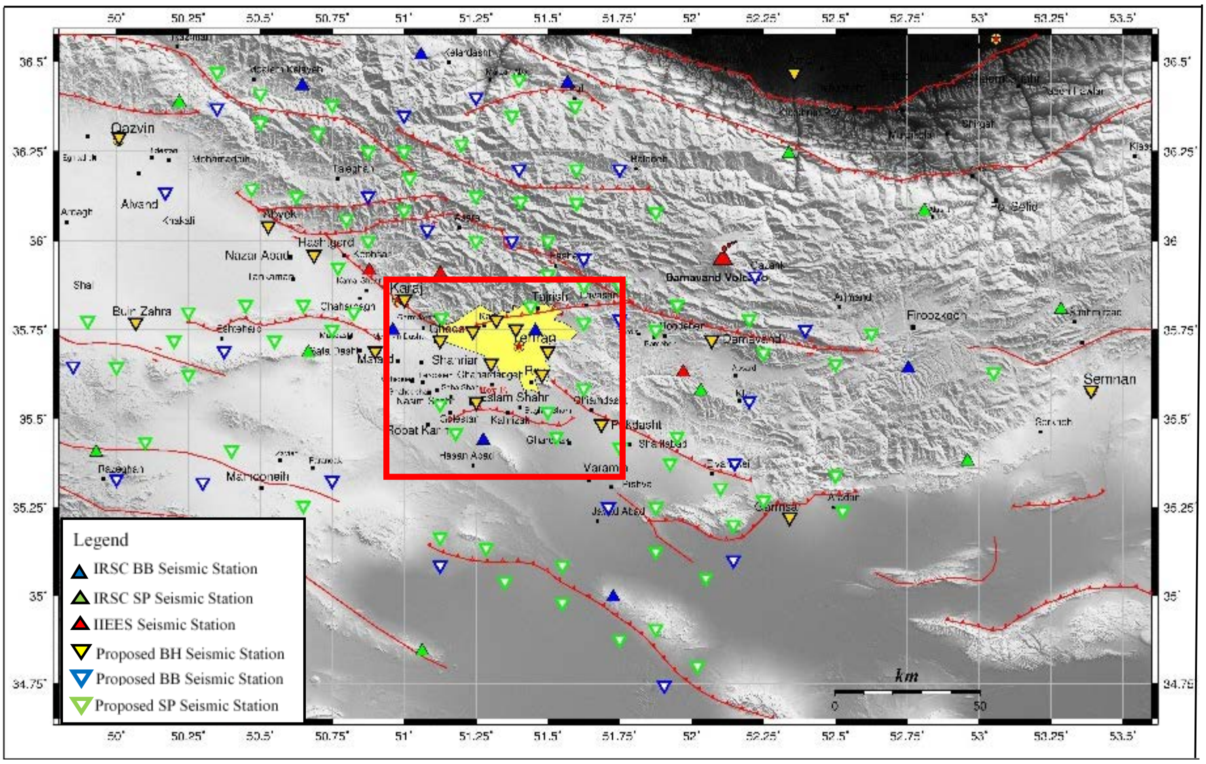
Equipment can be categorized as permanent or portable based on sub-project details relating to IRSC implementation and installation of densely portable seismometers on faults. Further classification is based on installation site characteristics and observation purposes. In this context, an interview survey was conducted with IGUT and IIEES, and sensors identified for use in sub-projects 1 and 2 based on the results are indicated in Table 4-3. The table does not list other equipment to be used in the project, such as digitizers, servers, modems, UPS, solar panels and batteries, as their quantity and specifications would generally be fixed to match sensor values.

Table 4-3 Requested sensors (sub-projects 1 and 2)

Sub-project no.	No.	Equipment	Qty	Unit	User
1 - 2	1	Broadband seismic sensor for boreholes (BB type)	20	Set	IGUT
	2	Broadband seismic sensor for surface (BB type)	25	Set	
	3	Broadband seismic sensor for surface (SP type)	75	Set	
	4	Accelerometer sensor	120	Set	
	6	Portable broadband sensor for surface (BB type)	30	Set	IIEES
	7	Portable broadband sensor for boreholes (BB type)	30	Set	
	8	Portable short-period sensor for surface	30	Set	IGUT/IIEES
	9	Portable short-period sensor for boreholes	30	Set	IIEES

Source: JICA Survey Team

Sub-project 1 (Monitoring of Active Faults) involves related monitoring with the assumption that fault shape, approximate location and other characteristics have already been clarified by the below-mentioned surveying, and focuses also on overt and hidden faults expected to affect urban areas. A plan of observation point distribution is shown in Figure 4-3.



*BB: Broadband Seismic Sensor for surface,SP: Short Period Seismic Sensor for surface,BH; Broadband Seismic Sensor for borehole

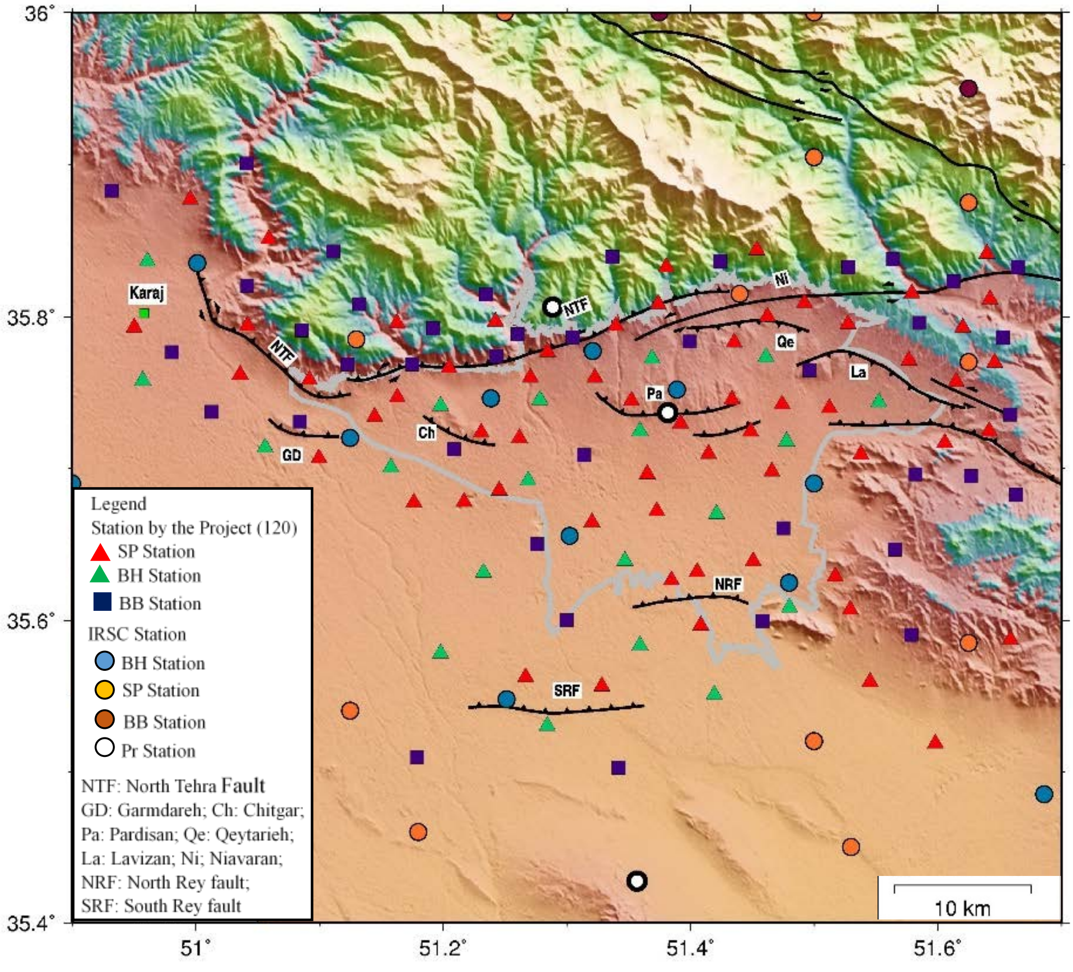
Source: IGUT

Figure 4-3 Distribution of requested sensors and existing IRSC stations

The red frame in the figure indicates the range shown in Figure 4-4. It is understood that, by comparison between permanent (Red frame of Figure 4-3) and temporary observation (Figure 4-4), permanent observation is planned to be sparser than temporary one, and that the permanent observation point arrangement shows that the distance between such points near target fault areas is set as an average of around 20 km. Further, IGUT has proposed that the permanent station should adopt sets with one broadband seismic sensor and one accelerometer sensor to widen the observable amplitude range.

Thus, the total of 120 permanent station sets can be considered to strengthen real-time monitoring. The breakdown is 25 broadband seismic sensors for surface (BB type), 20 for borehole (BB type), 75 for surface (SP type), and 120 accelerometer sensors.

Meanwhile, sub-project 2 (Comprehensive Seismic Hazard Assessment for Metropolitan Tehran) is a survey of the shapes of faults in urban areas that may cause significant disasters locally. The survey requires high depth determination accuracy in hypocenter calculation (within 1 km) around faults close to the ground surface (5 – 20 km in depth) and a sufficiently narrow initial distribution direction interval in motion data (approx. 10 degrees). This requirement may be met by installing observation stations at an average interval of around 5 km on targeted faults. The observation point arrangement shown in Figure 4-4 was planned in this way with temporary and permanent IRSC stations (● in three colors and ○, respectively). This shows that the above mentioned requirement should be satisfied by using existing permanent stations, and newly installing portable broadband sensors and portable short-period sensors all together.



Source: IIEES

Figure 4-4 Distribution of portable sensors and IRSC stations

The total of 120 temporary portable sensors for investigation breaks down as 60 portable short-period sensors (red▲ : 30 for surface, 30 for boreholes) and 60 portable broadband sensors (violet ■: 30 for surface (BB type) ; green ▲:30 for borehole (BB type)).

It is desirable to essentially use short-period sensors (rather than broadband sensors) in many places due to their capacity to get accurate clarification of very-short-period initial motion. However, international trade restrictions hinder the procurement of such sensors, and available equipment is extremely expensive. Due to these limitations, IGUT tends to use broadband seismic sensors that at least cover some of the functionality required for short-period activity. Further, if evaluation of crustal (underground) structures is required in future work, the waveform analysis function will be essential and analysis will require data over periods longer than the 1-sec window of standard short-period sensors (i.e., broadband sensor functionality).

Based on the above, the specifications and quantity of the relevant equipment can be considered appropriate.

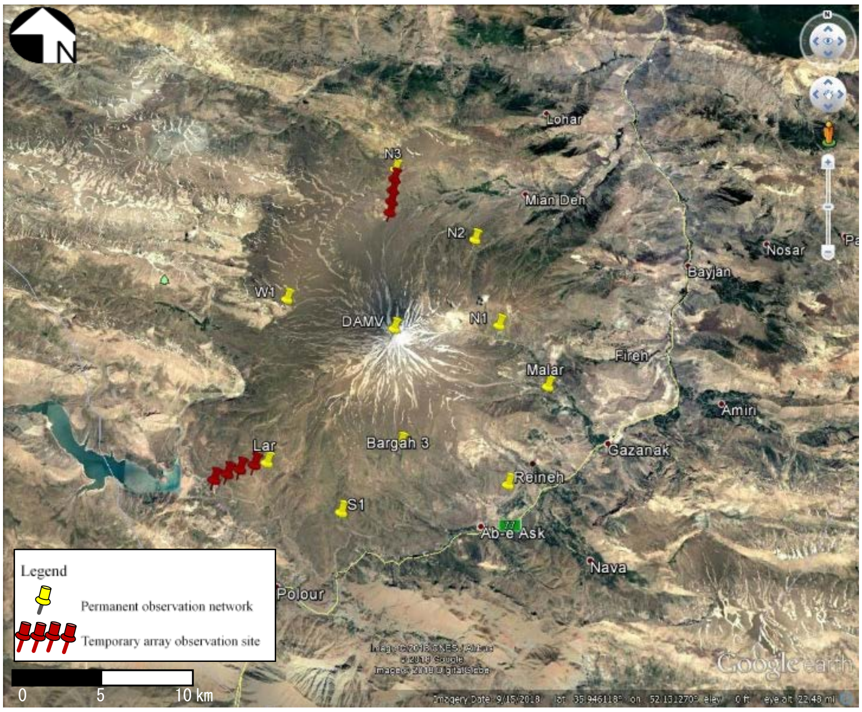
(2) Sub-project 3

This sub-project involves seismic monitoring of Mt. Damavand. Below are the considerations examined in determining the validity of project implementation.

a) Achievement of Expected Outputs

For the expected outputs “Accurate determination of seismic event locations”, “Clarification of mechanisms behind seismic events”, and “Establishment of a system for monitoring seismic noise around volcanoes”, it is necessary to be able to observe both short-period seismic and long-period volcanic phenomena.

Figure 4-5 obtained from IGUT shows the planned installation sites for the permanent observation network (10 yellow pins) and temporary array observation sites (two systems. Each with 4 red pins representing 15 sensors) at Mt. Damavand. The yellow pins in the figure surround the summit, thereby enabling observation of target phenomena such as seismic events and seismic noise.



Source: IGUT

Figure 4-5 Permanent observation network and temporary array station setting site for Mt. Damavand

For the expected output “Determination of locations for array observation stations”, this is for the lava chamber survey. The recent study results indicate the presence of lava chambers in the depth range of approximately 3 – 4.5 km[37]. The planed two arrays (the red pins in Figure 4-5) orthogonally arranged toward the summit. The outcomes indicated that the required results for the lava chamber survey may be obtained.

In addition, these actions require the essential administrative systems and budgetary measures for equipment usage and operation. The presence of such systems and measures has been verified via institutional visits and questionnaire surveys.

In this way, achievement of the expected outputs may be achieved.

b) Appropriacy of Equipment Specifications and Quantities

The Team interviewed IGUT and IIEES, sorted the seismic sensors used in subproject ③, and organized them in Table 4-4. In this table, equipment other than sensors procured in the same subproject for the same reason as Table 4-3 is not included.

Table 4-4 Requested sensors (sub-project 3)

Sub-project no.	No.	Equipment	Qty	Unit	User
3	6	Portable broadband sensor for surface (BB type)	5	Set	IIEES
	8	Portable short-period sensor for surface	35	Set	IGUT/IIEES

Source: JICA Survey Team

Starting with seismic observation is the right approach for the first stage of comprehensive volcano observation, but IGUT and IIEES have proposed the first observation network to be installed on volcanoes that have not been seismically observed in the past. It seems that observation points of 5 broadband sensors (BB / surface type) and 35 short-period sensors (surface type) are too much. Generally, about 3-5 short-period sensors are installed at first and it has been observed for several years, and then the presence and outline of the seismic activity are grasped. After that it is considered efficient to follow the procedure of observing multiple points such as 40 sensors as Iran’s proposal.

However, this subproject is not a steady-state observation but a temporary observation for research purposes. There are several other volcanoes in Iran. Considering that the institutions have sufficient experience and knowledge about earthquake observation, it is reasonable to introduce the observation equipment of the proposed scale for volcano observation.

The following is a summary of the results of survey on the appropriacy of equipment specifications and quantities.

(a) Seismometer for observing seismic activity caused by the volcanic activity of Mount Damavand

The analysis items that are indispensable for the observation are the determination of the epicenter and “estimation of the focal mechanism of the occurrence of the earthquake due to the force from which direction”.

[37] Reference: Z. Hossein Shomali and Taghi Shirzad 2014: Crustal structure of Damavand volcano, Iran, ambient noise and earthquake tomography, Journal of Seismology

It is essential to capture the arrival time and the direction of the initial movement. On the other hand, since volcanic activity also causes long-period vibrations, it is necessary to secure a wide frequency band. From the above, IIEES has proposed five short-period seismometers and five broadband seismometers that also supplement long-period waves for this purpose, and this configuration is considered appropriate.

Seismic activity resulting from volcanic activity is characterized by repeated activity and fluctuations on a yearly basis, and this observation requires response to the state of volcanic activity, so it will be necessary to move to other volcanoes in the future. It is also assumed that all the seismometers for observation are considered to be "portable", which is also considered appropriate.

(b) Seismometer for detecting magma chambers

IGUT has proposed 30 short-period sensors (15 per array × 2 sets) as sensors for array observation. In order to identify the location of the magma chamber and to grasp its extent in detail, it is necessary to capture short-period seismic waves that are easily affected by the attenuation by the magma chamber. IGUT has proposed 30 short-period sensors as the seismometers used for this purpose, which is considered appropriate.

The proposed array observation is performed in advance to determine the location of the final array observation point, and all 30 sensors for the observation have been proposed as "portable". The idea is considered reasonable.

(3) Sub-projects 4 and 5

These sub-projects involve "evaluation of vital urban-artery performance and proposal of an earthquake improvement plan", and "development of appropriate moduli for utility risk assessment under HAZ-IRAN". Below are the considerations examined in determining the validity of project implementation.

a) Achievement of Expected Outputs

Regarding the expected outcomes of "Determination of feasibility regarding clarification of numerical model accuracy in the laboratory method related to seismic design" and "Improvement of seismic codes", their purpose is to respond the fact that seismic tests on infrastructure facilities as shown in the current problems are social needs. Japan and the world's seismic standards have been created taking into account the strong ground motions observed during recent major earthquakes, and it is necessary to formulate standards in Iran as well. As a result of surveying the specifications of the requested the Shaking table testing machine (6 DOFs), the Actuators, and the Servo hydraulic actuators, it was confirmed that, by using the equipment, the maximum "displacement and deformation velocity" experiment was feasible and that the maximum acceleration indicated in the strong motion record of the Bam earthquake (see Table 3-1) that occurred in Iran in December 2003 could be tested. For this reason, it is considered that expected results can be obtained by conducting seismic tests using the requested equipment.

Among the expected outcomes, "Contribution to HAZ-IRAN development" is a lifeline risk that is difficult to handle with existing equipment alone in promoting the development of the system based on socially required circumstances. The purpose is to respond to risk assessments. As a result of interviews at the site, it was confirmed that the requested equipment can be used for the system, such as lifeline risk assessment, so that expected results can be obtained.

In addition, it was confirmed that the required equipment and the necessary measures for its use and operation, as well as budget measures, were secured based on the operation status of the existing observation equipment that was obtained through the questionnaire.

From the above, it is considered that the expected outcome can be obtained with certainty.

b) Appropriacy of Equipment Specifications and Quantities

The requested equipment is seismic equipment (Shaking table testing machine (6 DOFs), Servo hydraulic actuator, etc.) for the purpose of strengthening earthquake resistance in the Tehran metropolitan area. Table 4-5 shows the equipment used in subprojects 4 and 5.

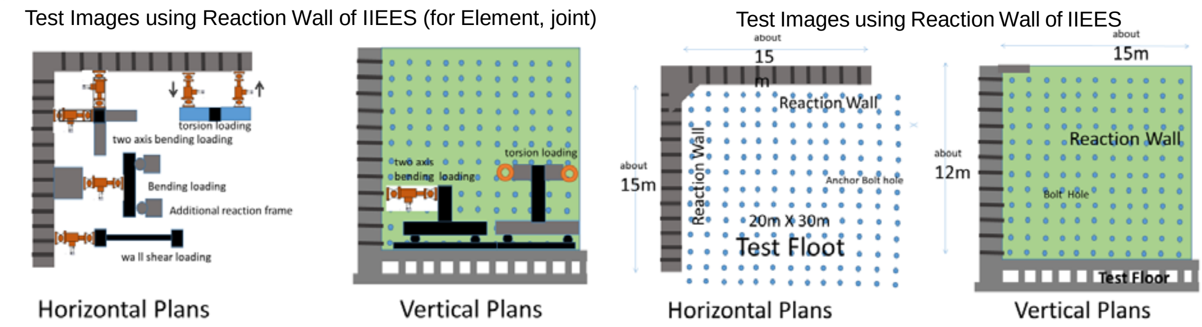
Table 4-5 Requested equipment (sub-projects 4 and 5)

Sub-project no.	No.	Equipment	Qty	Unit	User
4	16	Shaking table testing machine (6 DOFs)	1	Set	AUT
	17	Actuator for dynamic testing-A	1	Set	
	18	Actuator for dynamic testing-B	1	Set	
	19	Actuator for dynamic testing-C	1	Set	
	20	Actuator for dynamic testing-D	1	Set	
	21	Actuator for static testing-A	1	Set	
	22	Actuator for static testing-B	1	Set	
	23	Actuator for static testing-C	1	Set	
	24	Actuator cooling system	2	Set	
	25	Universal testing machine	2	Set	
	26	Dynamic data acquisition unit	2	Set	
	27	Static data acquisition unit	2	Set	
	28	Manual data acquisition unit	2	Set	
	29	Instrumentation	1	Lot	
	30	Axial fatigue testing machine	1	Set	
	31	Roof crane	2	Set	
5	32	Servo hydraulic actuator-A	2	Set	IIEES
	33	Servo hydraulic actuator-B	2	Set	
	34	Servo hydraulic actuator-C	4	Set	
	35	Servo hydraulic actuator-D	4	Set	
	36	Servo hydraulic actuator-E	2	Set	
	37	Servo hydraulic actuator-F	2	Set	
	38	Testing machine for seismic isolators	1	Set	
	39	Large material testing system	1	Set	
	40	Fast dynamic data logger	1	Set	
	41	3-dimensional optical data acquisition system	1	Set	

Source: JICA Survey Team

There were initial concerns that experimental operation of shaking table test machines would be restricted due to the influence of vibration on urban surroundings. However, this potential issue was avoided by the availability of the AUT Science Park in suburban Tehran as the installation site.

The Team has also examined the issue of equipment quantities via virtual experiments. At IIEES, numerous experiments for corporate clients can be conducted at the same time. In this regard, Figure 4-6 shows an assumed situation in which multiple experiments are run simultaneously using the existing reaction wall and reaction floor of IIEES and the servo hydraulic actuators specified among the requested equipment. Based on this, the equipment quantity can be deemed appropriate.

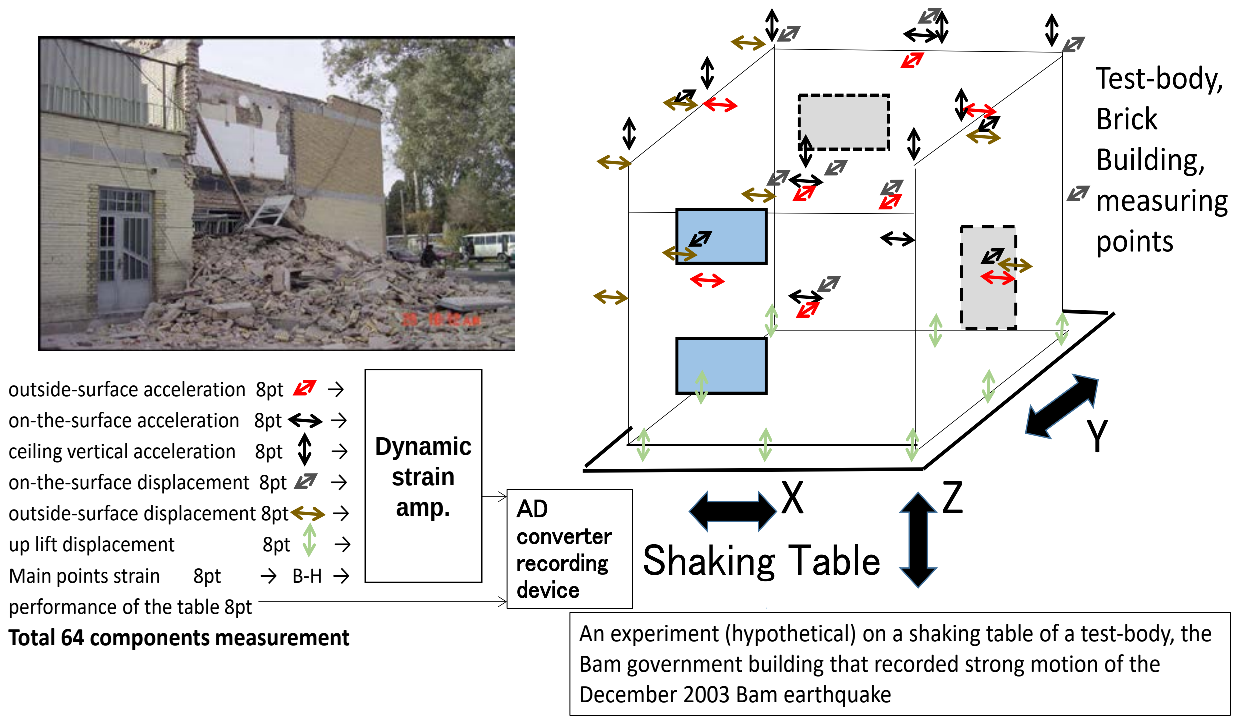


Source: JICA Survey Team

Figure 4-6 Assumed layout of equipment in multiple experiments using the IIEES reaction wall

Figure 4-7 shows a hypothetical shaking table testing machine examination with the conditions of the strong motion caused by the Bam earthquake. It was assumed that multiple sensors from among the equipment would be placed on the brick test body for monitoring of 64 components. As the experiment is fully feasible, the number and types of sensors to be used can be considered appropriate.

The above outcomes indicate that the equipment specifications and quantity are appropriate.



Source: JICA Survey Team

Figure 4-7 Sensor arrangement in the shaking table test with the conditions of strong motion caused by the Bam earthquake

(4) Sub-project 6

This sub-project focuses on "the establishment of earthquake precursor observatories" and "Provision and advice of analysis results of observation data to SCMO". Below are the considerations examined in determining the validity of project implementation.

a) Achievement of Expected Outputs

The expected result, "Establishment of earthquake precursor observatories" can be obtained by procuring the requested equipment and putting it into operation. The "Establishment of a system for developing Iran earthquake precursor databases" may be obtained by continuing the operation of equipment for a certain period, but the time length required for it is unknown.

Among the expected outcomes, it is difficult to instruct evacuation behavior based on the analysis results in "Establishment of a system for the provision of information and advice to SCMO". This is because no method has been established for predicting the hypocenter, magnitude, and time of an "earthquake that will occur" with certain certainty based on the analysis results. Meanwhile, it is possible to pre-determine the social response system that does not disrupt society. For example, the system will not direct the actions of the people, but will instead publicize the phenomenon that occurred and scientific interpretation, etc. And from this point of view, this outcome is achievable[38].

In addition, it was confirmed that the required equipment and the necessary measures for its use and operation, as well as budget measures, were secured based on the operation status of the existing observation equipment that was obtained through the questionnaire.

From the above, it is considered that the expected outcome can be obtained with certainty.

b) Appropriacy of Equipment Specifications and Quantities

The equipment discussed here is used to detect geophysical changes in the crust and to observe gravity, global electromagnetic phenomena (radio disturbances, geomagnetism, ionospheric disturbances) and radon concentration ratios. Observation data are used for earthquake precursor studies. As research on short-term earthquake precursors to date has been limited, focus is placed on the appropriacy of equipment specifications and quantities. The equipment to be used in sub-project 6 is shown in Table 4-6.

Table 4-6 Requested equipment (sub-project 6)

Sub-project no.	No.	Equipment	Qty	Unit	User
6	42	Gravity meter	15	Unit	IGUT
	43	Radon detector	20	Unit	
	44	Fluxgate magnetometer	20	Unit	
	45	Magnetotelluric sensor	20	Unit	
	46	VLF/LF Receiver	30	Unit	
	47	Advanced digital ionosonde	5	Unit	

Source: JICA Survey Team

[38] See "Nankai Trough Earthquake Information in Japan: Recent Crustal Activity around the Nankai Trough" in Japan.

All equipment here (except gravity meters) has reportedly been used to identify internationally recognized short-term phenomena ahead of earthquake occurrence, and may therefore be expected to catch such precursors if introduced in operational observation.

Although previous researchers have reported on long-term precursors in gravity observation[39], there have been no reports on internationally recognized short-term precursors in gravity meter observation. Accordingly, there is a need to collect further observation examples from other countries and to re-examine validity in relation to actual procurement for short-term precursor observation. It is also important to understand that gravity data can be used for a wide range of purposes other than short-term precursor observation, including:

1. Long-term precursor study
2. Identification of faults
3. IGUT tidal research
4. Seismic observation with ultra-long-period seismographs

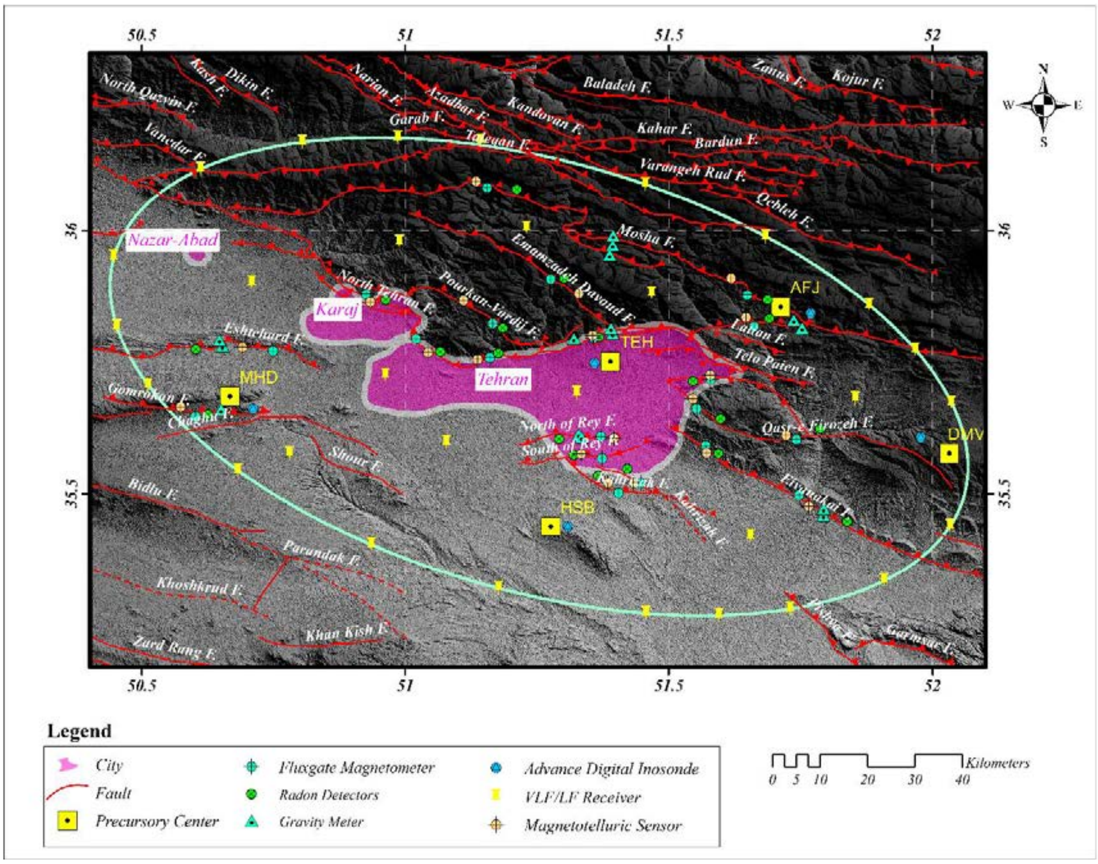
The quantity validity study involved examination of the distribution arrangement shown in Figure 4-8 (with data management centered on the yellow square) and Table 4-7. The results indicate that distribution covers fault areas where residents may be concerned about earthquakes. Accordingly, a system for the provision of information and advice to SCMO may be established based on the implementation of observation in such areas.

Table 4-7 Equipment for monitoring by the five precursory centers

No.	Center location	Gravity meters	Radon detectors	Fluxgate magnetometers	Magnetotelluric sensors	VLF/LF receivers	Advanced digital ionosondes
1	MHD (western Tehran)	3	3	3	3	6	1
2	AFJ (northern Tehran)	2	4	3	3	6	1
3	THE (central Tehran)	7	6	4	4	6	1
4	HSB (southern Tehran)	1	4	6	6	6	1
5	DMV (eastern Tehran)	2	3	4	4	6	1
Total		20	20	20	20	30	5

Source: IGUT

[39] Example: A previous report indicated a gravity field increase before the 25 April 2015 Nepal earthquake (Mw: 7.8) in the Himalayan front fault zone. Chen, S., Liu, P., Guo, Y., Liu, L., and Ma, J., (2015). An experiment on temperature variations in sandstone during biaxial loading, Phys. Chem. Earth, 85 – 86, 3 – 8 (source: IGUT).



Source: IGUT

Figure 4-8 Distribution of observation equipment for the earthquake precursor observation network

The above observations indicate that the equipment specifications and quantity are appropriate, including those of gravity meter instrumentation for long-term precursor study and other purposes than short-term precursor study. But, it should be noted that there is a need to investigate and re-examine examples of short-term observation and research for the procurement of gravity meters.

4-1-3-2 Challenges and Issues Concerning the Outcomes of Iran Project Requests

(1) Challenges Related to Clarification for the Use of Results in Future Commercial Application

1) Sub-projects 1 and 2

These sub-projects involve active fault monitoring and earthquake disaster assessment strengthening for the Tehran metropolis, with plans stipulating the following for future application of project results:

(a) Issuance of earthquake early warnings, formulation of maps showing areas of strong shaking and related intensity, and accurate/rapid identification of earthquake locations

(b) Reviewing of existing standards for earthquake risk estimation and earthquake-proofing

For (a), as the sub-projects are expected to strengthen the observation network, results will be applied both in the implementation of early warnings and in the improvement of related information. It is important for early warning information users such as residents and disaster management organizations to understand the progress of the sub-projects in order to allow appropriate usage of the information based on advance awareness of expected improvements and by making preparations for related systems and responses. Accordingly, implementation of the following needs to be clarified:

- Usage of results for the improvement of early warning information
- Sharing of information on the progress of the sub-projects with related organizations

2) Sub-project 3

This sub-project involves monitoring of Mt. Damavand seismic activity, with a plan stipulating the following for future application of project results:

(a) Creation of a volcano-seismic event database
(b) Estimation relating to volcano lava chambers
(c) Monitoring of volcanic activity

For (a), it should be understood that even active-volcanoes generally only become actually active at certain intervals, such as a decade. Mt. Damavand is currently inactive, and is considered to have an activity periodicity of a century or more. As long-term observation is essential against such a background, an equipment maintenance management system needs to be established.

For (b), the optimal position of the array observation point for estimation is determined and set from temporary observation. As researchers needing to collaborate with other research groups usually include staff from the executing organizations (IIEES, IGUT) and researchers from related institutes/universities for such observation and subsequent estimation research, sharing of information on sub-project progress with relevant organizations is considered essential.

For (c), the direct link between volcanic activity and disasters necessitates advance discussions with disaster management organizations such as NDMO on how to handle observation data collected in continuous monitoring and information obtained from related analysis. For this reason, it is essential to establish a system for monitoring, analysis and coordination with NDMO.

From the above, implementation of the following needs to be clarified:

- Establishment of a maintenance system for observation equipment based on the concept of long-term observation toward the relevant target
- Sharing of information on research progress with relevant organizations
- Establishment of a system for monitoring, analysis and coordination with NDMO based on the concept of a direct link between monitoring and disasters

3) Sub-projects 4 and 5

These sub-projects involve the following points with assumed results based on checking of earthquake resistance in major urban facilities and earthquake resistance plans, and on development of a risk assessment component for utilities based on HAZ-IRAN:

(a) Improvement and promotion of standards related to seismic design
(b) Improvement of seismic codes and related application
(c) Contribution to HAZ-IRAN

For (b), the many seismic standards in place require the establishment of an equipment maintenance system in consideration of utility providers (Gas company, Water department and others) and utility users (public institutions) and efficient operation of equipment. For (c), the HAZ-IRAN system's six work phases and many elements (see Section 3-1-5) necessitate the setting of a schedule for appropriate processing.

From the above, implementation of the following needs to be clarified:

- Sharing of information on research progress and results with beneficiaries
- Clarification of beneficiary needs
- Establishment of an equipment maintenance management system
- Establishment of a system for shaking table testing machine handling
- Formulation of a schedule to expedite the start of HAZ-IRAN operation

4) Sub-project 6

This sub-project involves the establishment of earthquake precursor observatories with the following stipulated as outcomes:

(a) Reduction of earthquake risk and mitigation of earthquake damage via SCMO work and related advice
(b) Establishment and development of an Iran earthquake precursor database for peturbation monitoring toward earthquake preparedness

The progress of earthquake precursor studies remains limited, and prediction of timing for outcome achievement is largely impractical. For this reason, it is important to maintain the operation system appropriately and to collaborate with the precursor observation research community. Careful operation is required in any SCMO usage of data and analysis results from precursor observation to combat panic-inducing hearsay.

From the above, implementation of the following needs to be clarified:

- Establishment of an observation operation system
- Sharing of data, research results and information on research progress with individuals and institutes conducting earthquake precursor observation research and with international research organizations such as the International Union of Geodesy and Geophysics (IUGG[40])
- Establishment of a system to promote collection and analysis of results from other research organizations in Iran and elsewhere
- Establishment of a system to examine the use of observation results against panic-inducing hearsay together with SCMO

[40] Explanation of IUGG http://www.iugg.org/about/

(2) Sharing of Data and Information Obtained from Research Results toward Efficient Disaster Management

The six sub-projects in Table 4-1 are research-related, but associated outputs are directly linked to earthquake disaster management as described in Section 4-1-3 (1). In addition, as described in Section 4-1-2 (addressing current support needs), there is a need for expedited implementation of these initiatives.

In light of the characteristics and purposes of these sub-projects, collaboration with result users and other researchers/institutions is essential toward steady and efficient promotion of related activities. Specific collaboration measures are listed in Table 4-8.

Table 4-8 Specific measures for collaboration among organizations related to sub-project output and outcomes

Sub-project (executing organization)	Output	Specific measures for collaboration	Purpose of collaboration
1. Monitoring of seismically active faults in Tehran (IGUT) 2. Comprehensive seismic hazard assessment for metropolitan Tehran (IIEES)	- Clarification of activity ratios at active faults - Establishment of an appropriate earthquake database	Provision of a database incorporating updated information to NDMO, seismic code development-related institutions and associated research institutions	Promotion of related earthquake research and provision of basic information on disaster management measures toward appropriate implementation of early warning information issuance
		Ongoing provision of information and commentary on activity ratios at active faults to NDMO	Provision of basic information on disaster management measures toward appropriate implementation of early warning information issuance
	- Clarification of active fault geometry - Identification of blind faults	Ongoing provision of checked and specified research results to NDMO and related research institutes	Promotion of related information on earthquake research and provision of basic information on disaster management measures
3. Seismic monitoring of the volcanic Mt. Damavand (IGUT, IIEES)	- Clarification of seismic event locations - Elucidation of seismic event mechanisms - Establishment of a system for monitoring seismic noise around volcanoes - Determination of locations for array observation stations	Ongoing provision of information and commentary on the mechanisms of seismic events to NDMO and research institutes related to volcanic activity	Promotion of related volcanic activity research and provision of basic information on disaster management measures
		Ongoing provision of information and commentary on seismic noise around volcanoes to NDMO and research institutes related to volcanic activity	
4. Evaluation of vital urban-artery performance and proposal of an earthquake improvement plan (AUT) 5. Development of appropriate moduli for utility risk assessment under HAZ-IRAN (IIEES)	Determination of feasibility for clarification of the accuracy of numerical models in the laboratory method related to seismic design	Ongoing provision of information on the accuracy of numerical models in the laboratory method to organizations related to seismic codes and associated research institutes	Acceleration of seismic code improvement and setting work
	Improvement of seismic codes	Ongoing provision of basic information on seismic code improvement to related organizations and associated research institutes	

Sub-project (executing organization)	Output	Specific measures for collaboration	Purpose of collaboration
	Contribution to HAZ-IRAN development	Ongoing provision of information on the progress of development to NDMO	Acceleration toward the establishment of a system for HAZ-IRAN usage
6. Establishment of earthquake precursor observatories (IGUT)	- Establishment of earthquake precursor observatories - Establishment of a system for the development of an Iran earthquake precursor database - Establishment of a system for provision of information and advice to SCMO	Ongoing provision of observation results to NDMO and related research institutes	Promotion toward the establishment of a system for preparation against disastrous earthquakes

Source: JICA Survey Team

(3) Reliability in Issuance of Disaster Management Information Obtained from Research Results

Utilization of results from the sub-projects in Table 4-1 is characterized by a direct connection to earthquake disaster management, as mentioned above. Accordingly, in disaster management usage, products from output require stable provision with the relevant systems and equipment as necessary.

One issue related to system development involves the development of a legal system for the provision of reliable information in the event of an emergency. In particular, any unreliable announcements of seismic information for emergency response immediately after an earthquake will cause delays in action by NDMO and emergency response organizations, which may in turn lead to life-threatening situations. Reliable provision must be ensured for disaster management and to ensure that project results are fully connected to social implementation.

As discussed in Section 3-2, the difficulty of import means that the time required for procurement of equipment and replacement parts is expected to vary significantly. Accordingly, the following should be considered in terms of ingenuity for appropriate implementation as shown in the Table 4-9, which shows examples of the ingenuity as well.

Table 4-9 Ingenuity for appropriate implementation

No.	Ingenuity for appropriate implementation	Example of ingenuity
1	Use of existing equipment in line with the purposes of equipment introduction	One of the equipment proposed by AUT is “Roof Crane”. In the case of the delay of the procurement of this item, the experiment plan that should use this item could be developed using the substitute-equipment that covers the function of “Roof Crane” to some extent.
2	Incorporation of equipment obtained in the later phase of the project into the established system	One of the equipment proposed by IGUT is "Magnetotelluric Sensor", but when it is procured late with other equipment, the activity for the output, "Establishment of a system for provision of information and advice to SCMO", could be proceeded under the assumption that the data from "Magnetotelluric Sensor" would be provided accordingly.
3	Establishment of a maintenance system for equipment introduced into the system on an ongoing basis	One of the equipment proposed by IIEES and IGUT is "Radio Modem", but it is assumed that the planned 200 sets cannot be procured at once. The equipment is planned to be used in combination with the seismograph. However, when the equipment is procured late, when only the seismograph is used, there is a situation where the seismic observation data cannot be transmitted remotely. As a result, it

No.	Ingenuity for appropriate implementation	Example of ingenuity
		means that the operation status of the observation point cannot be grasped in real time. In such a case, the maintenance system for the network could introduce the site-visit in it to examine and maintain the sites with no "Radio Modem".

Source: JICA Survey Team

(4) Equipment Procurement Issues

The Team listed specific models and manufacturers for the equipment listed in Table 4-2, contacted the manufacturers regarding the feasibility of procuring the items for export to Iran, and requested quotes from insurance and transport providers in parallel (see Appendix 4 for details). Information was also collected on potential equipment procurement based on assistance from Japan, and the following points were considered:

- Issues relating to inter-bank transactions

  Loan assistance and grant aid from Japan involves the Banking Arrangements (B/A) between the central bank of the target country and Tokyo-Mitsubishi UFJ Bank, which does not handle transactions related to Iran in principle due to OFAC regulations[41]. However, the bank will consider engagement in such transactions with special permission from OFAC. When implementing the project, the Iranian side will submit necessary documents for the permission to JICA in accordance with his request. Then JICA will make an inquiry to OFAC and request a transaction with the bank after obtaining permission.

- Ban on exports of US equipment

  Many of the items listed in Table 4-2 (such as accelerometer sensors, broadband seismic sensors and radon detectors) are categorized as US products. As detailed in 3-2-5, the export of US products and items containing US-made components are restricted due to the EAR regulations. Therefore, in case same situation is occurred when implementing the project, it is necessary considered that to procure equipment other than US products.

- Self-regulatory corporate policies

  Certain major manufacturers (such as Nanometrics (Canada, broadband seismic sensors), Streckeizen (Switzerland, broadband seismic sensors), Saginomiya Seisakusho (Japan, shaking table testing machine) and Hitachi Industrial Products (Japan, shaking table testing machine)) contacted by the Team for equipment estimates stated that they do not deal with shipments to Iran. This is considered attributable to the following:

  - The manufacturer wishes to maintain good relations with the US.
  - Operations of manufacturer affiliates involve the use of US capital.
  - The manufacturer wishes to avoid the complex procedures that accompany export.

  In case that procurement equipment to Iran is difficult at the project implementation stage, discussions among the Iranian side, JICA, and a consultant of the project will be conducted. If it is considered that the impact on the project effect and validity without the equipment will be

[41] Tokyo-Mitsubishi UFJ Bank website: https://www.bk.mufg.jp/tsukau/kaigai/soukin/OFAC_ryui.html

small, the exclusion of the equipment is examined.

- Limited numbers of freight carriers

  Freight carriers contacted by the Team for estimates of transportation cost replied that shipping operators willing to handle cargo bound for Iran are scarce, which places limitations on options for shipping ports, transportation routes and the like. For this reason, depending on the time of transportation, the transportation cost may be higher than usual.

- Transport/assembly insurance

  Insurers contacted by the Team for estimates on marine and land transport/assembly insurance (Tokyo Marine & Nichido Fire Insurance, Mitsui Sumitomo Insurance Company and Sompo Japan Nipponkoa Insurance) stated that they were unable to provide services on exports to Iran. The US imposes sanctions on the provision of underwriting, insurance or reinsurance services to state-owned Iranian oil companies and those on the SDN list, which clearly impacts the stance of such providers. For this reason, as in the case of dealing with the above-mentioned bank, at the stage of the project implementation, the procurement company requests the insurance company to deal with the project with the special permission obtained from OFAC.

4-2 Proposal for Social Implementation of Research Results

Based on the purposes of the six sub-projects, the details provided in Table 4-1 and the current challenges described in Section 4-1-2, the Team proposes social implementation of research results as detailed here.

(1) Proposal for Sub-projects 1 and 2

The following should be considered in regard to the usage of results for the improvement of early warning information:

- Improvement of information reliability an expedited announcement
- Efforts to promote understanding of the information and optimal response
- Efforts to leverage the information for improvement of disaster management measures and implementation of disaster management drills based on the provision of announcements

The following should be considered in regard to sharing of information on the progress of sub-project implementation with related organizations:

- Utilization of results obtained in the course of research
- Promotion for the establishment of methods, procedures and systems for response to expected final results

(2) Proposal for Sub-project 3

As the social implementation scenario of the project, we propose IGUT/IIEES the following points while addressing the current issues.

- Establishment of a system for announcing monitoring results, and provision of announcements in line with regular monitoring results to promote the use of such information on volcanic activity in disaster management activities

- Using the developed seismo-volcanic activity database and the estimated position and shape of the magma chamber, the development of abnormal activity standards and detection methods, and the promotion of understanding of their contents; through conducting these activities, their linkage to establishment of how to announce the content to the public and to setting of the ideal way of disaster prevention according to the announcement.

- Establishment of a plan for research on
  1. Overall observation for volcanoes in Iran,
  2. Comprehensive (seismological, geophysical, geological and geochemical) observation of Mt. Damavand, and
  3. Demarcation between IGUT and IIEES regarding areas of research purpose

(3) Proposal for Sub-projects 4 and 5

Leveraging of results for seismic code improvement and expedited implementation of HAZ-IRAN.

(4) Proposal for Sub-project 6

Leveraging of results for the reduction of earthquake risk and earthquake damage based on the provision of observation results and related advice to SCMO.

4-3 Direction of Future Support

Based on current issues, the proposals for social implementation of research results and export controls, the following considerations are addressed here.

- Conditions for project implementation
- Issues to be solved for future support and activities needed in handling them
- Technical guidance and assistance using soft components and similar

(1) Conditions for Project Implementation

The below shows the work demarcation by the Iranian side for the project and the assumed external conditions, that are needed as the conditions for project implementation.

1) Work demarcation by Iran that are needed for project implementation

- Secure sites for installation of equipment procured under the project.
- Installation works of the equipment procured by the project.
- Taxes regarding the project by Japan’s loan assistance or grant aid projects are exempted in principle, so if various taxes are imposed for the projects, they will be covered by Iran.
- Continue seismic observation and research work under IGUT, IIEES and AUT.

- · Secure the budgets, human resources and other items necessary for maintenance of the equipment under IGUT, IIEES and AUT.

2) Assumed External Conditions

- · Policies concerning earthquake management in Iran will not be changed.
- · Banking transactions will be conducted between Tokyo-Mitsubishi UFJ Bank and the central bank of Iran or other bank related to the project.
- · Insurance provided by the project supplier will cover the transportation of equipment/materials and installation work under the project.
- · The export control department in the country where project equipment is procured will permit export to Iran.
- · There will be no large-scale natural disasters such as earthquakes or unexpected incidents such as acts of terrorism before or during the implementation of the project.

(2) Issues to be solved and activities to be needed for future support

The results of examining the issues to be solved and the actions necessary to realize the proposed social implementation in project implementation are outlined below.

1) Collaboration and Sharing of Data/Information among Related Organizations

For sub-projects 1, 2 and 3, MSRT, IGUT and IIEES should hold joint meetings at least once every six months to report on research progress. To support Iran, Japan should collect and publish the details of such reporting.

2) Ensurement of Reliability in Information Announcements for Disaster Management Purposes

Iran should continuously consider ingenuity for appropriate implementation regarding introduction of the equipment detailed in Section 4-1-3 (3). To support Iran, Japan should provide assistance in the form of technical collaboration and information related to the handling of challenges in consideration of restrictions on functionality and the operation system in Iran related to the equipment.

3) Comprehensive Handling of Improvement for Early Warning Information Announcements in Metropolitan Tehran

Iran should play a proactive role in this improvement, and Japan should provide support based on the experience of the Japan Meteorological Agency (JMA) as appropriate, including:

- Experience in improving the reliability of announcements and related timing
- Experience in facilitating comprehension of information and optimizing related response
- Experience with concrete approaches for the improvement of disaster management measures, implementation procedures and implementation plans for disaster management training

4) Enhancement of the Seismic Activity Monitoring System in the Damavand Volcanic Area

Iran should consider announcement criteria and the particulars of abnormal activity detection in advance, and Japan should provide support based on JMA's experience.

5) Expedited Implementation of HAZ-IRAN

Iran should advance experimental research toward expedited implementation. Japan should provide support based on JMA's experience, specifically in regard to the latest 1) JMA seismic intensity information, 2) JMA Earthquake Early Warnings[42], and 3) response to earthquakes in Japan.

6) Establishment of Earthquake Precursor Observatories for Reduction of Earthquake Risk and Mitigation of Earthquake Damage

Iran should advance the establishment of observatories toward expedited implementation in collaboration with related organizations via regular meetings. Japan should provide support, especially when related research is immature, based on the experience of JMA as appropriate.

(3) Technical guidance and assistance using soft components and similar

With regard to the support from Japan described in Section (2) above, the Team examined specific forms of technical support regarding soft components and similar. In regard to a current request from Iran for technical assistance involving personnel exchanges, the following forms of specific support may be considered for realization in spite of international regulations and other limitations:

1. Short-term expert dispatch of Japanese experts to project-related organizations in Iran

2. Training and scholarships
   - Short-term training for Iranian experts at Japanese laboratories
   - Training programs of six months to a year in Japan for research staff from Iranian universities and research institutes
   - Overseas study programs of six months to a year for doctoral students in Iran
   - Promotion of PhD securement for Iranian students

3. Joint research
   - Usage of equipment from Japan and other countries
   - Collaboration with Japanese researchers related to the use of equipment to be procured under the project

4. Exchange of opinions with overseas research groups through the web

Interaction with International Union of Geodesy and Geophysics (IUGG) one of international academic institutions, and Electromagnetic Studies of Earthquakes and Volcanoes (EMSEV) group[43] via mailing lists[44] and similar

[42] Under JMA's Earthquake Early Warning system, prompt alerts are publicly issued as soon as an earthquake occurs, providing valuable seconds for people to protect themselves before strong shaking (seismic motion) starts. The service was launched on 1st October 2007.

[43] EMSEV of IUGG, http://www.emsev-iugg.org/emsev/index.html

[44] EMSEV mailing list, http://www.emsev-iugg.org/emsev/emsevml.html

Appendices

Appendix 1 List of Parties Concerned in the Recipient Country

1. List of Parties Concerned in the Recipient Country

Name and Affiliation	Position
Ministry of Science, Research and Technology (MSRT)	
Dr. Masoud Boroomand	Vice-Minister of Research and Technology
Dr. Amir Saeed Karami	Deputy Director of International Scientific Cooperation Center
Dr. Abdolsadeh Neisy	Director General of Logistics and Supportive
Dr. SM Hossein Adeli	Advisor of the Yen-Loan Project/ Ex-Ambassador
Dr. Nikhbakht	Advisor to the Vice-minister
Me. Maryam Eftekharian	Expert in Research and Technology Department
Plan and Budget Organization (PBO)	
Mr. Sa'adati	Expert – Higher Education Bureau
Mr. Bakhtiari	Expert – Higher Education Bureau
Ministry of Foreign Affair (MOFA)	
Mr. Javaherian	Expert
Organization for Investment Economic & Technical Assistance of Iran (OIETAI), Ministry of Economic Affairs & Finance	
Mr. Mohammad Reza Salimian	Expert, Foreign Economic Relations Office
Road, Housing & Urban Development Research Center (BHRC)	
Dr. Shekarchizadeh	President
Mr. Omid Motalebi	Expert- International Affairs Bureau
Dr. Beitullabi	Director of Seismic Engineering
Dr. Shahwar	ISMN Expert
Dr. Farzanegan	Director of ISMN
Dr. Eshaghi	Faculty Member of ISMN
Mr. Hamid Alavi	Director General of Public Relations and International Affairs Bureau
National Disaster Management Office (NDMO)	
Mr. Latifi	Vice-president ; Reconstruction and Rehabilitation Department
Mr. Hossein Shahin	Expert- International Affairs Bureau
International Institute of Earthquake Engineering and Seismology (IIEES)	
Dr. M. K. Jafari	President

Dr. Mohammad Tatar	Associate Professor of Seismology, Vice-President for Research and Postgraduate Education
Dr. M. Bastami	Director of Advanced Labs, Associate Professor, Structural Engineering Research Center, Construction Manager of Earthquake Engineering Labs
Mr. Kambod Amini Hosseini	Associate Professor, Director of Risk Management Research Center
Dr. Mansour Ziyaeifar	Director of Structure Lab.
Dr. Mohammad Davoodi	Vice President of Technology

Institute of Geophysics, University of Tehran (IGUT)

Mr. Majid Nabi-Bidhendi	Director, Professor of Geophysics, Director of Institute of Geophysics
Dr. Ali Moradi	Director, Assistant Professor of Seismology
Dr. Mehdi Rezapour	Associate Professor of Seismology Department of Earth Physics Institute of Geophysics
Dr. Habib Rahimi	Director of RCEP

Amirkabir University of Technology (AUT)

Dr. Touray Taghikhany	Associate Professor, Head of Department of Civil and Environmental Engineering
Dr. Farzad Hatami	Assistant Professor, Structure & Earthquake Research Center (SERC)
Dr. Mohammad Z. Kabir	Professor, Structural Division School of Civil & Environmental Engineering
Dr. Hossein Hosseini-Toudeshky	Research and Technology Vice Chancellor

Embassy of Japan in Iran (EOJ)

Mr. Kazuki Hoshi	Primary Secretary
Mr. Akihiro Konno	Second Secretary

JICA Iran Office

Mr. Yukiharu Kobayashi	Chief Representative
Ms. Mina Eto	Representative
Ms. Yoshie Kobayashi	Project Formulation Adviser
Ms. Atefeh Asadi	Program Officer

Appendix 2 List of Collected Materials

2. List of Collected Materials

No.	Name of Materials	Type	Issued or Presented by	Year
1	EARTHQUAKE ENGINEERING LABORATORIES	Power Point	IIEES	2019
2	Developing Appropriate Modulus for Lifeline Risk Assessment in HAZ-IRAN	Power Point	IIEES	2019
3	APPLICATION FORM FOR JAPAN'S "GRANT AID" for Developing appropriate modulus for Lifeline Risk Assessment in HAZ-IRAN	Word	IIEES	2018
4	Comprehensive Seismic Hazard Assessment of the Tehran mega city	PDF	IIEES	2019
5	Rapid Assessment of Iran Seismic Events (RAISE)	PDF	IIEES	2019
6	Explanation Documents for Sub Project 1 and 3	PDF	IIEES	2019
7	INTRODUCTION TO THE IRANIAN SEISMOLOGICAL CENTER	Power Point	IGUT	2019
8	IRSC Station List	Excel	IGUT	2019
9	Monitoring of Tehran Province seismically active faults	Word	IGUT	2019
10	Establishing earthquake precursor observatories with "Tehran" and "Tehran topo" that have the distribution of the locations of the equipment.	Word and PNG	IGUT	2019
11	The Necessity of Seismic Monitoring of Damavand in English and in Persian	Power Point	IGUT, IIEES	2019
12	Bidding Documents of Shaking Table System	PDF	AUT	2019
13	Answer for Questionnaire	Word、PDF	MSRT	2019
14	Organization Chart	PDF	MSRT	2019
15	Answer for Questionnaire	Word、PDF	PBO	2019
16	Answer for Questionnaire	Word	NDMO	2019
17	Answer for Questionnaire	Word	BHRC	2019
18	Answer for Questionnaire	Word、PDF	IIEES	2019
19	Answer for Questionnaire	Word	IGUT	2019
20	Answer for Questionnaire	Word、PDF	AUT	2019
21	Seismicity Maps of The Province of Iran 1900-2015	PDF (original: Hardcopy)	IGUT	2015
22	Institute of geophysics seismological stations and equipment	PDF	IGUT	2019
23	gravity as precursor having 7 documents on the Gravity monitoring issue)	PDF	IGUT	2019
24	Appendix Damavand	Word	IGUT	2019
25	Decrees for IGUT	Word	IGUT	2019
26	Damavand ISI Paper	PDF	IGUT	2014

Appendix 3　Equipment Procurement Considerations

3. Equipment Procurement Considerations

Table 3A-1 shows the results of considerations regarding candidate equipment in each sub-project.

Table 3A-1 Equipment procurement considerations

Sub Project No.	No.	Equipment	Manufacturer	Candidate Model	Country of Origin	Availability of Procurement	Remark	Qty	Unit	Total Amount (Yen)	User
①～③	1	Broadband seismic sensor for boreholes (BB type)	GURALP	3TB-120, Single Jaw Hole Lock, etc.	UK	OK	-	20	set	This section is closed due to confidentiality.	IGUT
	2	Broadband seismic sensor for surface (BB type)	GURALP	3T-120, 20m Sensor Cable	UK	OK	-	25	set		
	3	Broadband seismic sensor for surface (SP type)	GURALP	40T Seismometer	UK	OK	-	75	set		
	4	Accelerometer sensor	GURALP	Fortis, 5m Sensor Cable, etc.	UK	OK	-	120	set		
	5	Digitizer 6 Ch	GURALP	Affinity 8Ch	UK	OK	-	120	set		
	6	Portable broadband sensor for surface (BB type)	GURALP	3T-120, 20m Sensor Cable	UK	OK	-	35	set		IIEES
	7	Portable broadband sensor for boreholes (BB type)	GURALP	3TB-120, Single Jaw Hole Lock, etc.	UK	OK	-	30	set		
	8	Portable short-period sensor for surface	GURALP	40T Seismometer	UK	OK	＊	65	set		IGUT/IIEES
	9	Portable short-period sensor for boreholes	GURALP	40T Seismometer (Posthole type)	UK	OK	＊	30	set		IIEES
	10	Digitizer 3 Ch	GURALP	Minimus, Minimus Accessary Pack	UK	OK	-	160	set		IGUT/IIEES
	11	Server (computer)	GURALP	NAM, Software, etc.	UK	OK	-	2	set		
	12	Radio modem	ICOM	IC-F4400DT	Japan	OK	-	200	pair		
	13	GPRS modem	MOXA	OnCell G2111	Taiwan	OK	-	80	unit		
	14	UPS	PCM	VGD-3000 3KVA	Taiwan	OK	-	20	unit		
	15	Solar panel and battery	Kyocera	Custom Made	Japan	OK	-	260	set		
④	16	Shaking table testing machine (6 DOFs)	Netplus	Custom Made	Japan	OK	-	1	set		AUT
	17	Actuator for dynamic testing-A	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	18	Actuator for dynamic testing-B	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	19	Actuator for dynamic testing-C	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	20	Actuator for dynamic testing-D	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	21	Actuator for static testing-A	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	22	Actuator for static testing-B	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	23	Actuator for static testing-C	SHIMADZU	Custom Made	Japan	OK	-	1	set		
	24	Actuator cooling system	SHIMADZU	Custom Made	Japan	OK	-	2	set		
	25	Universal testing machine	SHIMADZU	Custom Made	Japan	OK	-	2	set		
	26	Dynamic data acquisition unit	Tokyo Sokki Kenkyujo	TMR-311, 321, 322, 381	Japan	OK	-	2	set		
	27	Static data acquisition unit	Tokyo Sokki Kenkyujo	TDS-540, ISW-50G	Japan	OK	-	2	set		
	28	Manual data acquisition unit	Tokyo Sokki Kenkyujo	TC-32K	Japan	OK	-	2	set		
	29	Instrumentation	Tokyo Sokki Kenkyujo	ARF-50A, etc.	Japan	OK	-	1	lot		
	30	Axial fatigue testing machine	Tokyo Sokki Kenkyujo	DP-1000F	Japan	OK	-	1	set		
	31	Roof crane	Hitachi Plant Mechanics	Custom Made	Japan	OK	-	2	set		
⑤	32	Servo hydraulic actuator-A	SHIMADZU	Custom Made	Japan	OK	-	2	set		IIEES
	33	Servo hydraulic actuator-B	SHIMADZU	Custom Made	Japan	OK	-	2	set		
	34	Servo hydraulic actuator-C	SHIMADZU	Custom Made	Japan	OK	-	4	set		
	35	Servo hydraulic actuator-D	SHIMADZU	Custom Made	Japan	OK	-	4	set		
	36	Servo hydraulic actuator-E	SHIMADZU	Custom Made	Japan	OK	-	2	set		
	37	Servo hydraulic actuator-F	SHIMADZU	Custom Made	Japan	OK	-	2	set		
	38	Testing machine for seismic isolators	Tomoe Giken	Custom Made	Japan	OK	-	1	set		
	39	Large material testing system	Tomoe Giken	Custom Made	Japan	OK	-	1	set		
	40	Fast dynamic data logger	Tokyo Sokki Kenkyujo	TMR-311, 321, 322, 381	Japan	OK	-	1	set		
	41	3-dimensional optical data acquisition system	ForA	FT-ONE-SS4K	Japan	OK	-	1	set		
⑥	42	Gravity meter	SCINTREX	CG-6 Autograv gravity meter	Canada	OK	-	15	unit		IGUT
	43	Radon detector	Durridge	RAD7	USA	To be considered	＊	20	unit		
	44	Fluxgate magnetometer	SHIMADZU	MB162	Japan	OK	-	20	unit		
	45	Magnetotelluric sensor	SCINTREX	Cs-3	Canada	To be considered	＊	20	unit		
	46	VLF/LF Receiver	Radiosurplus Elettronica	TRACOR 599K	Italy	OK	-	30	unit		
	47	Advanced digital iono-sonde	SIL	CADI Basic VI Ionosonde	Canada	OK	-	5	unit		

Source: JICA Survey Team

Requested equipment that may be difficult to procure or export to Iran (such as items marked "To be considered" in the Availability of Procurement[1] column) is detailed in the special remarks below (1). Other particular issues concerning equipment procurement are summarized in (2), and equipment specifications are presented in (3).

(1) Special Remarks on Equipment Associated with Procurement Challenges

1) Portable Short-period Sensors (No. 8 and No. 9)

Geo Space (US) and Sercel (France) manufacture reliable equipment meeting the required specifications (1 Hz natural frequency). However, due to the challenges associated with the procurement of such equipment, Guralp 40T sensors were selected in consideration of related application and the required specifications.

2) Radon Detectors (No. 43)

The Team has studied a reliable model of the equipment in the research of atmospheric radon fluctuation measurement, and has contacted manufacturers regarding the possibility procurement for Iran as shown in Table 3A-2 below.

Table 3A-2 Radon detector procurement survey

No.	Manufacturer	Country of origin	Model	Response to quote request
1	Hitachi	Japan	DGM-1101	No option for overseas shipping
2	Pylon Electronics	Canada	PMT-TEL with AB-5	No option for shipping to Iran
3	Durridge	US	RAD7	No option for shipping of US-made products to Iran
4	Bertin Instruments	France	Alpha GUARD	Pending

The Team arranged the examinations in the case where it is difficult to procure the equipment as follows.

If the equipment cannot be procured, radon concentration cannot be observed. However, it is possible to achieve the three (3) expected outputs of sub-project 6 listed in Table 4-1 using other procured equipment. As the impact on sub-project 6 as a whole appears minimal, exclusion of radon detectors from the equipment of the sub-project can be considered as an option if the same situation remains at the project implementation stage.

3) Magnetotelluric Sensors (No. 45)

The Cs-3 unit from Scintrex is seen as a candidate model for the equipment. However, the manufacturer advises that export authorities in Canada regard the equipment as dual-use (normal weapons and related general-purpose goods), meaning that the potential for export may be low.

The equipment is used to measure changes in magnetic field strength, but as with radon detectors in 2) above, the impact on sub-project 6 as a whole is considered to be small. Accordingly, exclusion of magnetotelluric sensors may be considered if procurement appears impractical.

1 This item indicates the possibility of equipment shipping by the manufacturer, and does not guarantee export to Iran. Examination by export authorities in each country may result in exports not being possible.

(2) Other Special Remarks Regarding Equipment to be Procured

1) Candidate Equipment Related to Seismic Observation (No. 1 to No. 10)

Based on the 1st field survey by the Team, IGUT proposed products from Nanometrics (Canada), such as Trillium Compact, Titan and Centaur, as components of the seismic observation network. However, the Team's inquiry with the sales agency of the company regarding procurement for export to Iran was met with a negative response. Accordingly, the Team contacted the manufacturers listed in Table 3A-3 regarding the procurement of reliable equipment for export to Iran.

Table 3A-3 Survey on seismic observation equipment procurement

No.	Manufacturer	Country of origin	Model	Response to quote request
1	Nanometrics	Canada	Trillium Compact, etc.	No option for shipping to Iran
2	Kinemetrics	US	MBB, etc.	No option for shipping of US-made products to Iran
3	Streckeizen	Switzerland	STS2, etc.	No option for shipping to Iran
4	Guralp	UK	3TB, etc.	Shipping to Iran possible

Guralp is the only manufacturer capable of handling product procurement for Iran. Table 3A-4 compares the equipment proposals of Iran and the Team.

Table 3A-4 Comparison of candidate equipment proposed by Iran and the Team

No.	Equipment	Iran proposal	Team proposal
1	Broadband seismic sensor for boreholes (LP Type)	Trillium Compact/Nanometrics	3TB/Guralp
2	Broadband seismic sensor for surface (LP Type)	Trillium Compact/Nanometrics	3T-120/Guralp
3	Broadband seismic sensor for surface (SP Type)	Trillium Compact/Nanometrics	40T/Guralp
4	Accelerometer sensor	Titan/Nanometrics	Fortis/Guralp
5	Digitizer 6 Ch	Centaur/Nanometrics	Affinity 8Ch/Guralp
10	Digitizer 3 Ch	Centaur/Nanometrics	Minumus/Guralp

The Team has also considered Guralp products as the server (PC) for equipment no. 11, but it is highly unlikely that re-export will be possible under the de minimis rule of EAR. Accordingly, checking with manufacturers is being conducted to identify products with 10% or less of US-made content.

2) Consideration of Estimated Amounts for Each Sub-project

Table 3A-5 compares project costs estimated by Iran and the Team.

Table 3A-5 Estimated project costs[2]

Currency: JPY

Sub-project	Iran estimate at project request stage	Iran estimate at 1st field survey stage	Team estimate after 1st field survey stage
1 – 3	This section is closed due to confidentiality.		
4			
5			
6			
Total			

[2] Calculated as 1 US dollar = 110 JPY and 1 Euro = 112 JPY.

(3) Required Specifications for Equipment

The specifications of the equipment to be procured under the project are shown in Table 3A-6.

Table 3A-6 Equipment specifications

Sub Project No.	No.	Equipment	Qty	Unit	Specification	User
①～③	1	Broadband seismic sensor for boreholes (BB type)	20	set	For fault area, Bandwidth: 120 sec	IGUT
	2	Broadband seismic sensor for surface (BB type)	25	set	For fault area, Bandwidth: 120 sec	
	3	Broadband seismic sensor for surface (SP type)	75	set	For fault area, Bandwidth: 30 sec	
	4	Accelerometer sensor	120	set	Range: +/-3000 gal or wider, Response: 100 Hz or equivalent	
	5	Digitizer 6 Ch	120	set	6 Ch, 24 bit	
	6	Portable broadband sensor for surface (BB type)	35	set	30 for fault area, 5 for volcano, Bandwidth: 120 sec	IIEES
	7	Portable broadband sensor for boreholes (BB type)	30	set	For fault area, Bandwidth: 120 sec	
	8	Portable short-period sensor for surface	65	set	35 for IIEES (30 for fault area, 5 for volcano), 30 for IGUT (for volcano), Bandwidth: 30 sec	IGUT/IIEES
	9	Portable short-period sensor for boreholes	30	set	For fault area, Bandwidth: 30 sec	IIEES
	10	Digitizer 3 Ch	160	set	3 Ch, 24 bit, for the Portable Sensors	IGUT/IIEES
	11	Server (computer)	2	set	1 for IGUT, 1 for IIEES; to be used at the data center of IGUT and IIEES	
	12	Radio modem	200	pair	Radio with Portable Cabinet, Antenna, Antenna Pole, Antenna Base (1 Pair)	
	13	GPRS modem	80	unit	To be used in the urban area, namely in the locations of borehole-stations	
	14	UPS	20	unit	Capacity: 3000 VA	
	15	Solar panel and battery	260	set	Solar Panel: 270 W, Storage, Battery: 12 V 100 A x 3, Solar stand, Charge Controller , etc.	
④	16	Shaking table testing machine (6 DOFs)	1	set	Size: 5 m x 5 m, Max Velocity: 1.5 m/s, Max. Stroke: +/- 0.5 m	AUT
	17	Actuator for dynamic testing-A	1	set	Max. Work Load: 30 t, Max Velocity 30 cm/s, Max. Stroke: +/- 5 cm	
	18	Actuator for dynamic testing-B	1	set	Max. Work Load: 50 t, Max Velocity 30 cm/s, Max. Stroke: +/- 5 cm	
	19	Actuator for dynamic testing-C	1	set	Max. Work Load: 100 t, Max Velocity 30 cm/s, Max. Stroke: +/- 5 cm	
	20	Actuator for dynamic testing-D	1	set	Max. Work Load: 200 t, Max Velocity 30 cm/s, Max. Stroke: +/- 5 cm	
	21	Actuator for static testing-A	1	set	Max. Work Load: 50 t, Max Velocity 3 cm/s, Max. Stroke: +/- 30 cm	
	22	Actuator for static testing-B	1	set	Max. Work Load: 100 t, Max Velocity 3 cm/s, Max. Stroke: +/- 30 cm	
	23	Actuator for static testing-C	1	set	Max. Work Load: 200 t, Max Velocity 3 cm/s, Max. Stroke: +/- 30 cm	
	24	Actuator cooling system	2	set	10 kW (Cooling Tower) for Actuator for Dynamic Testing and Actuator Static Testing	
	25	Universal testing machine	2	set	Max. Work Load: 100 t	
	26	Dynamic data acquisition unit	2	set	Channel: 128 Ch or more, For the Shaking Table Control Unit Display Unit Input Unit for Strain Gauge Type Transducer Strain 1G/2G/4G Unit	
	27	Static data acquisition unit	2	set	Static Strain Gauge, Switch Box, for the Shaking Table	
	28	Manual data acquisition unit	2	set	Handheld Data Logger, for the Shaking Table	
	29	Instrumentation	1	lot	1. Displacement Sensors - String Potentiometers: Maximum displacement: +/- 2 to +/-25 inch, total 20 units - Linear Potentiometers: Maximum displacement: +/- 0.25 to +/-20 inch, total 35 units	

Sub Project No.	No.	Equipment	Qty	Unit	Specification	User
④					- Linear Variable Differential Transformers (LVDTs): Maximum displacement: +/- 0.25 to +/-20 inch, total 35 units	AUT
					2. Accelerometers Range: +/-10 peak g, Sensitivity: 2.4 to 5.0 mV/g, Usable Frequency: 0 to 400 Hz, Mounted Resonant Frequency: 1,000 Hz, total 10 units	
					3. Loading Sensors for Shaking Table Floor Testing - Load Cell (axial-shear-moment): Axial: 10 t to 50 t, Shear: 2 t to 10 t, Moment: 1 ton.m to 10 ton.m, total 12 units - Load Cell (axial-Comp/Ten): Axial 200 t, total 4 units	
					4. Loading Sensors for Actuator - Load Cell (axial-Comp/Ten): Axial: 50 t to 200 t, total 12 units	
					5. Image Processing Devices - 3D Dimensional Optical Data Acquisition, total 2 sets - High Performance Dynamic Mobile Coordinate Measurement Machine, total 2 sets	
	30	Axial fatigue testing machine	1	set	Channel: 8 Ch or more, Max. Work Load: 30 t, for the Shaking Table	
	31	Roof crane	2	set	Max. Work Load: 20 t, for the Shaking Table	
⑤	32	Servo hydraulic actuator-A	2	set	Max. Work Load: 200 t, Frequency: 0 to 10 Hz, Max. Stroke: +/-25 cm	IIEES
	33	Servo hydraulic actuator-B	2	set	Max. Work Load: 200 t, 0 to 10 Hz, Max. Stroke: +/-50 cm	
	34	Servo hydraulic actuator-C	4	set	Max. Work Load: 100 t, Frequency: 0 to 10 Hz, Max. Stroke: +/-25 cm	
	35	Servo hydraulic actuator-D	4	set	Max. Work Load: 100 t, Frequency: 0 to 10 Hz, Max. Stroke: +/-50 cm	
	36	Servo hydraulic actuator-E	2	set	Max. Work Load: 50 t, Frequency: 0 to 10 Hz, Max. Stroke: +/-25 cm	
	37	Servo hydraulic actuator-F	2	set	Max. Work Load: 50 t, Frequency: 0 to 10 Hz, Max. Stroke: +/-50 cm	
	38	Testing machine for seismic isolators	1	set	Max. Work Load: 2,000 t vertical force, 100 t horizontal force, Max. Stroke: +/-50 cm	
	39	Large material testing system	1	set	Max. Work Load: 500 t or more, Testing specimens length: 5 m or more	
	40	Fast dynamic data logger	1	set	Channel: 128 Ch or more, For the Shaking Table Control Unit Display Unit Input Unit for Strain Gauge Type Transducer Strain 1G/2G/4G Unit	
	41	3-dimensional optical data acquisition system	1	set	4K Slow Motion Digital Camera, Frame Rate: 240 fps Remote Control Panel 7 inch View Finder Eye-cup View Finder Zoom Lens UV Filter, etc.	
⑥	42	Gravity meter	15	unit	Reading Resolution: 0.1 micro Gal or equivalent, Standard Deviation: < 5 microGal or equivalent	IGUT
	43	Radon detector	20	unit	Minimum Detectable Concentration: 0.025 pCi/l (0.93 Bq/m3) or equivalent	
	44	Fluxgate magnetometer	20	unit	Range: 0 - +/- 50 uT or equivalent	
	45	Magnetotelluric sensor	20	unit	Frequency Range: 0.0001 - 1,000 Hz or equivalent	
	46	VLF/LF Receiver	30	unit	Sample signal receiver from 0.1 kHz to 99.90 kHz or equivalent	
	47	Advanced digital iono-sonde	5	unit	Sensitivity: 23 cpm (37 Bq/m³) or equivalent	

Source: JICA Survey Team