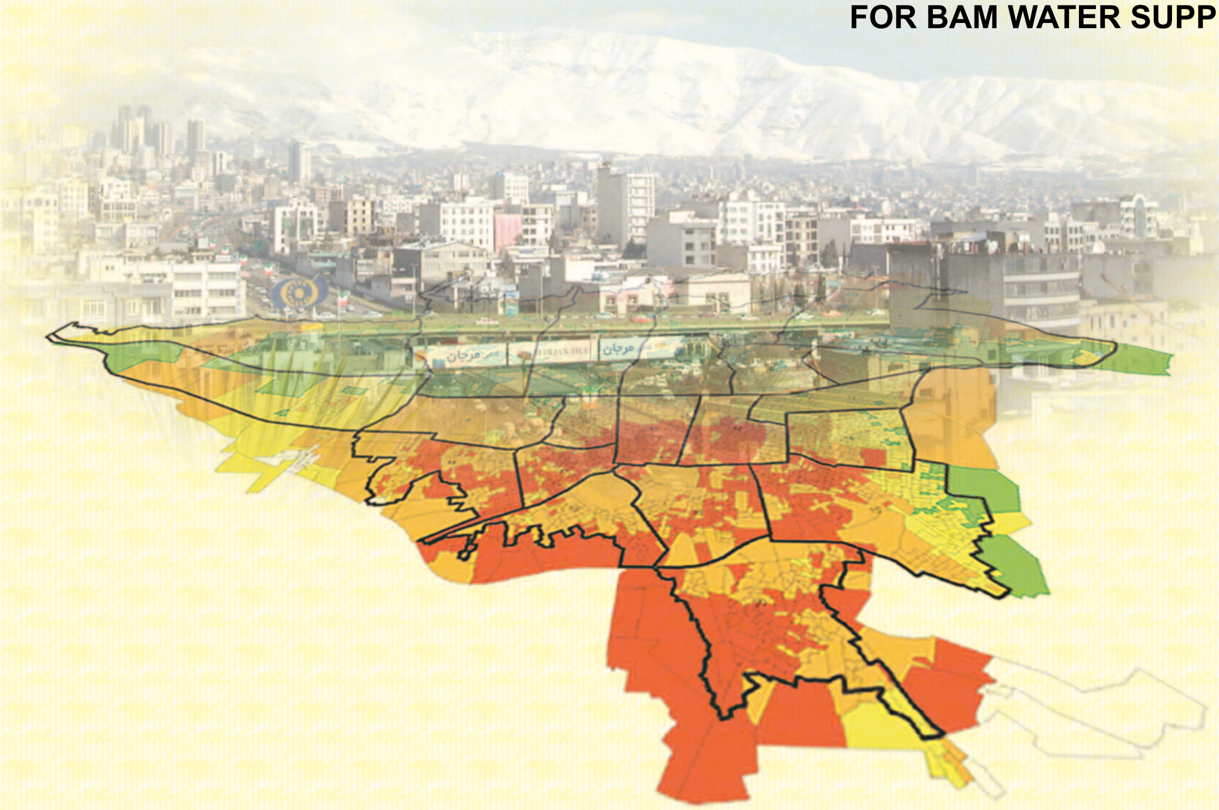
Japan International Cooperation Agency
Tehran Disaster Mitigation and Management Center

No.

The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran

Final Report
- The Study on Reconstruction Plan for Bam Water Supply System-



March 2005

Pacific Consultants International
OYO International Corporation

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

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

FINAL REPORT

- THE STUDY ON RECONSTRUCTION PLAN FOR BAM WATER SUPPLY SYSTEM -

March 2005

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The exchange rate applied in the Study is:

US $ 1.00 = Rls.8,500

(April, 2004)

PREFACE

In response to the request from the Government of the Islamic Republic of Iran, the Government of Japan decided to conduct the study entitled “The Study on Reconstruction Plan for Bam Water Supply System”. The study took the form of expanding the scope of work of “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran” to feedback the experiences of Bam earthquake to the Master Plan Study in the Greater Tehran Area.

JICA dispatched to the Islamic Republic of Iran the Study Team, headed by Mr. Ichiro Kobayashi (on behalf of Mr. Itaru Mae, Project Manager for the Master Plan Study) of Pacific Consultants International, organized shortly after the occurrence of Bam earthquake on December 26, 2003, by Pacific Consultants International and OYO International Corporation. JICA set up an Advisory Committee chaired by Dr. Kimiro Meguro of the University of Tokyo, which examined the study from the specialist and technical points of view.

The Study Team held a series of discussions with the officials concerned of the Government of the Islamic Republic of Iran and conducted the study in collaboration with the Iranian counterparts. Upon the last return to Japan, the Study Team finalized the study of the reconstruction of the water supply system damaged by Bam earthquake, the results of which were incorporated in the final report of the Master Plan Study.

I hope that this report will contribute to the promotion of Tehran seismic disaster prevention and management, and to the enhancement of friendly relationship between the two countries.

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

March 2005

Estuo KITAHARA
Vice President
Japan International Cooperation Agency

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

March 2005

Letter of Transmittal

Dear Mr. KITAHARA,

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

This report compiles the final fruits of the study that was undertaken in Bam city, the Islamic Republic of Iran, by the Study Team that was formulated shortly after the occurrence of Bam earthquake on December 26, 2003, by Pacific Consultants International and OYO International Corporation under the contract with the JICA.

The study report is prepared as the constitutive part of the final report entitled “The Comprehensive Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran”. It compiles the results of the study, including the rehabilitation plan, facility design and reconstruction of water supply system. To feedback the experiences of Bam earthquake greatly contributes to promoting the formulation of the Master Plan Study for the Greater Tehran Area, the Islamic Republic of Iran.

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

Very truly yours,

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

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

THE STUDY ON RECONSTRUCTION PLAN FOR BAM WATER SUPPLY SYSTEM

Executive Summary

1 Overview

Intoroduction

This is a report prepared by the JICA Study Team for "The Study on the Bam Earthquake and Reconstruction of Water Supply System in Bam and Baravat Areas" to transfer the findings and knowledge attained through the study and construction of water supply system in the Bam areas to the Tehran Disaster Management Organization (TDMO) in Tehran.

The Study Team was formulated shortly after the earthquake on December 26, 2003, which hit the southern Iranian city of Bam in Kerman province and left devastating physical damage and distress, not only to the people of Bam, but also to the nation.

Japan International Cooperation Agency (JICA), accordingly, appointed the study team of the "Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran" to carry out a primary survey to investigate the damage and consequence of the earthquake considering that the study team has continually worked in Tehran on earthquake disaster management, as a JICA technical cooperation assistance, since 1999.

Scope of the Study

The scope of the Study is set to formulate long-term reconstruction plan for water supply system, to implement urgent reconstruction projects and to make practical recommendations for Tehran based on lessons learned in Bam.

The long-term reconstruction plan for water supply system shall be based on the result of water resource development study conducted in the Study and accord with relating reconstruction plans of Bam. The work items cover 1) designing of seismic resistant and maintainable water supply system, 2) preparation of implementation, operation and maintenance plans, 3) preliminary designing of monitoring and control system for the operations of well pumping stations, and 4) cost estimation for reconstruction projects.

The urgent reconstruction projects implemented in the Study are 1) water distribution network facility, which is approximately 33 km of the priority route in Bam municipality, 2) distribution reservoir (V=2,000m³) with a gate house and a chlorination house, including chlorination equipment in Baravat, and 3) the building structure of pump house (No.3) in Baravat.

The ultimate objective of the rehabilitation work is to restore the damaged facilities to the pre-earthquake conditions in the course of the project.

Figure 1 shows the relationship of study organizations, and the member lists of the Study Team.

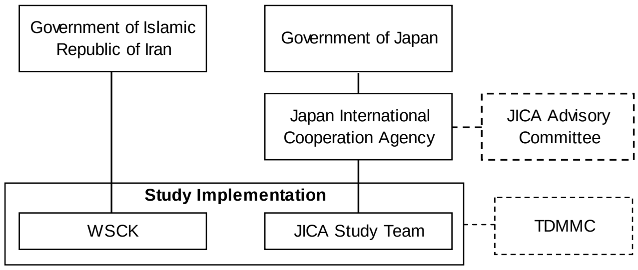


Figure 1 Study Organization

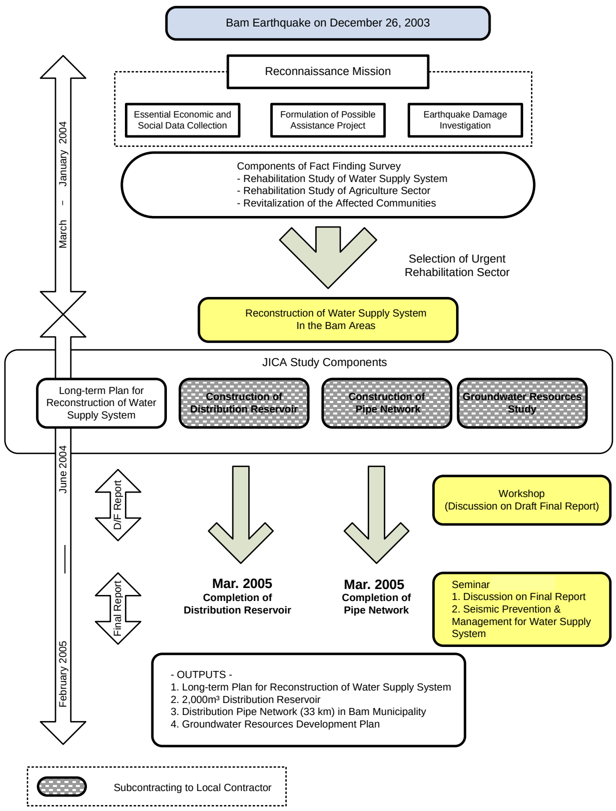


Figure 2 Schedule of the Project

2 Lesson Learned From Bam Earthquake

Scenario Earthquake

The focus in this section is to provide an answer to the following important question: did the 2003 Bam Earthquake cause a large damage simply because of the excessively strong earthquake motion or of the predominance of structurally weak buildings? This section presents substantial discussion on the relationship between the seismic resistance level of structure and its earthquake damage.

The magnitude of the 2003 Bam Earthquake was M_W 6.6, according to USGS. This figure is similar to that of scenario earthquake for the case of Tehran, which was presented in the JICA Study, "The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran". Regarding the depth of fault, the upper edge of Ray Fault Model is 5 km and the upper edge of Bam fault is assumed to be 4 km.

The Fault Parameters of these two earthquakes are summarized in Table 1. These parameters show that the focal mechanics of the 2003 Bam Earthquake is similar to the fault model of Microzoning Study.

Table 1 Fault Parameters

	Proposed Scenario Earthquake in Tehran (Ray Fault Model)	2003 Bam Earthquake (Earthquake Information Center, University of Tokyo)
Length (km)	26	20
Width (km)	16	15
Moment Magnitude (M_W)	6.7	6.5
Dip Angle (degrees)	75	85
Depth of Upper Edge (km)	5	4

Source: JICA Study Team

Earthquake Damage

In order to compare the extent of damage of the 2003 Bam Earthquake with the result of the JICA study, the difference of feature building structure between those two cases should be discreetly examined. There are many similarities in Bam and Tehran. Masonry structure is the dominant structure type in Bam and Tehran, which shares more than 60 percent of the building. Since the building construction technique is the similar in Bam and Teheran, seismic resistance level in both areas is the same. Therefore, it can be said that the estimated earthquake damage for Tehran in the Microzoning Study is validated by the 2003 Bam Earthquake.

Emergency Response

The capacity of the emergency response was relatively high at the 2003 Bam Earthquake. However, it should be bore in mind that the demand of emergency response and recovery depends on the amount of damage by the earthquake, as well as situations of damaged area, such as population size, population and building density, accessibility to the damaged area, etc.. Tehran is already urbanized to a great extent. In particular, building density is quite high in the area on the Ray fault with many masonry structures and excessively narrow streets. For example, Tehran may encounter more difficulty in finding necessary open space for the tent village and in operating emergency vehicles due to the traffic jam. Urban functions also may be seriously impaired and not be recovered as quick as in Bam.

Moreover, the mal-function of capital city may cause more serious problem in coordinate emergency response activities. The rescue and relief team from other province as well as international agency may face poor coordination of their activity and area. This is reason why the preparedness of Tehran is more critical compared to other cities.

Design of Reservoir and Distribution Pipe

Target year for long term plan for reconstruction of water supply system was set as year 2031 in accordance with that of the "Comprehensive Reconstruction Plan of Bam" prepared by Bam Reconstruction Committee.

The daily average unit water demand per capita is given below:

Table 2 Daily Average Unit Water Demand per Capita

(Unit: m³/person)

No.	Item	2003	2031
1	Domestic	151	164
2	Non-domestic	27	19
3	Losses	25	20
Total		203	203

Source: Jooyab-nou Consulting Engineers

Water Demand

Maximum water demand for designing facilities, i.e. reservoir and pipe, is estimated based on the following conditions: Daily Peak factor for determining capacity of reservoir: 1.8

Hourly peak factor for designing distribution network: 1.4 for Bam network and 1.5 for Baravat network

The planned population served, unit water demand and peak factor are authorized as applied factors for the estimation by Central Water and Sewage Company under the Ministry of Energy.

Reservoir Design Policy

It can be said that the standard design issued by the Management and Planning Organization in Iran does not have basic defects because the existing water reservoir did not suffer damage at the Bam Earthquake. Therefore, a configuration of the standard design could be adopted to this project. However, some modification on structure (i.e., dimension of column and reinforcing bar arrangement) is added reflecting analysis result, which was carried out considering seismicity of the site.

The process of consideration is as follows. The best official description on the earthquake resistant design is "Iranian Code of Practice for Seismic Resistant Design of Buildings," or Standard 2800, published by Building and Housing Research Center and Ministry of Housing and Urban Development. In this standard, intensity of earthquake motion, which is required as earthquake resistant design condition, reflecting magnitude and frequency of earthquake observed around the country by now. This concept is called hazard analysis, which is also shown in the description of "Kawasumi's Map" in the Japanese code. Bam is located in the second highest intensity zone around the country, and the required intensity of earthquake motion *A* is equivalent to 0.3G.

The basic structure of the standard reservoir is covered by the wall structure and supported by the Pier at the middle. Therefore, Upper slab and lower slab are analyzed by two-direction slab. Moment and shearing force is to be fixed at the connection point to sidewall.

In case there is no balance between left and right vertical force, a certain thickness of two-dimension frame structure is calculated in case of earthquake. (Certain thickness means effective thickness for wall structure from pier.)

The conditions mentioned above are not rules for calculation; the purpose of the analysis is rather for confirming structural viability.

The conditions mentioned above are not rule for calculation; the purpose of the analysis is rather confirming structural viability.

There are three cases for analysis:

Ordinary load case

Case 1: Both compartments are full of water

Case 2: One compartment is full of water but the other is empty.

Earthquake case

Case 3: Two compartments are full of water

It is assumed that the increase of the allowable force is stated as follows:

・Test case (one partition is full) 1.25

・Earthquake 1.50

Based on the analysis, following bar size has changed.

Top slab bar - D12→D14（Whole bar arrangement）

D10→D14（Cross-Column Line）

Regarding sidewall's D 24, it has changed to D 25 to follow.

Pier lower part- ８-D16→８-D18

Distribution Pipe

Water supply service area covers Bam city (approx. 39 km²), Baravat urbanized area (approx. 17 km²), the northern and northeastern villages of Bam such as Posht rood, Esfikan, Rahim Abad, Khagei Bala, Nartig, and Kork.

A planned service area of Baravat is approximately 17 km² and its altitude ranges from 960 to 1,010 m. The water is supplied from two reservoirs newly constructed at the middle of the service area of Bam and Baravat. The water level of these reservoirs is approximately 1,040 m above the sea level. The planned service area of Baravat is divided into two blocks, north and south.

Reconstruction

Organizations for the construction works supervision are summarized as follows:

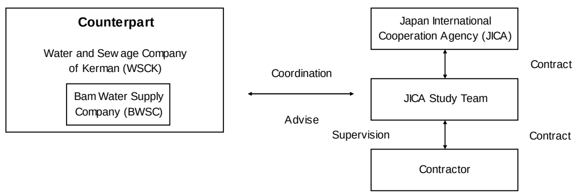


Figure 3 Organizations of Construction Works Supervision

In general, supervision of the construction works covered four items:

- Construction schedule management
- Quality control
- Cost management
- Safety control

More specifically, the construction supervision services are based on the following duties and responsibilities:

Supervision of the contractor's construction program and quality control, by such means as approval and inspection of construction materials and works.

- Inspection and approval of dimensions, and numbers of the constructed works and facilities.
- Minor alterations to the tender specifications and

drawings.

- Preparation of reports and papers as required by WSCK and JICA.

The above services were required from commencement of the construction to completion of all the construction works. Throughout the construction period, the Study Team Engineer is assigned to the Project's site to supervise and coordinate the construction works. Experts in several professional fields were dispatched to the Project site, in addition to the Study Team Engineer, as deemed necessary, for smooth implementation of the work.

Major Instruction to the Contractor

Since the reservoir was made from reinforced concrete, the equability of the concrete determined the quality of the reservoir. The JICA Study Team was very much concerned about controlling the concrete quality in terms of material used, mixing procedure, concrete casting and curing of the concrete. In order to control concrete quality, the JICA Study Team gave firm instructions on the following points:

1) Stage placing concrete wall

To prevent concrete separation, the JICA Study Team firmly instructed the Contractor to use stage placing of wall concrete. Two-stage construction was applied to cast wall concrete.

2) Treatment of careful construction joint

The JICA study Team also instructed the Contractor on treatment of the construction joint because of control of concrete quality.

Recommendation to Contract Practice in Iran

1) Improvement of technical level

The engineers at construction site lacked skill and engineering knowledge for the construction. Holding a seminar-workshop for them before construction was useful for improving their level of knowledge as construction engineer.

2) Equipment provision

In general, the construction industry is heavily depending on manpower in Iran. It was recommended that use of heavy equipment in construction was promoted at the national level. Since construction equipment was rented, it was very difficult to keep a certain schedule. The construction plan was prepared to prevent any delay of schedule.

3) Improvement of management skill

The contractor should improve management skill regarding construction schedule, construction methods and purchasing of materials. Construction plan should be formulated at the time of bidding.

Looking Beyond the Bam Earthquake

The Bam earthquake is a turning point of Iran's earthquake disaster management system for a couple of reasons, while earthquake damage has been reported in rural area in Iran. First, the earthquake happened in an urban area, though small compared to Teheran area, and second, the casualty rate is astonishingly high. The Bam earthquake showed how the urban area is vulnerable against earthquake. In fact, more than 20% of residents in Bam have lost their lives.

Lesson Learned 1: Similarity between Tehran and Bam

It is obvious that the weak buildings in Bam are the primary reason for the high human casualty and injury by earthquake. Most of the buildings in Bam are masonry structure and made from adobe (sundried brick) and brick. Masonry structures are weak against earthquake. Building type in Tehran is similar to those of Bam; most of the buildings are masonry structures made from brick. In fact, more than 60% of buildings in Tehran are masonry structure. Even in steel structure, the quality control of the building is not carried out appropriately, therefore the expected resistance capacity against earthquake is less than the design. It should be pointed out that the damage estimation done by the JICA study in 2000, the Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran, was proven to happen in Tehran area.

Moreover, it is the first time in last 20 years that urbanized area has damaged by the strong earthquake. Bam earthquake tell us that emergency response in urbanized area is different from that of rural area. There are huge amount of victims at one city. Detailed emergency response plan should be formulated before the event.

Lesson Learned 2: Importance of resident and government official's recognition of earthquake

The second lesson is the importance of the education and enlightenment of earthquake information to the residents and government officials. The people in Bam had little knowledge about earthquakes, and there was no procedure after the incident. The government sector had delayed the response to the situations.

The education and recognition of the earthquake are the most important aspects for the disaster management. The education and training should be the first priority for the residents and government officials in Tehran. The master plan study also put emphasis on the importance of community involvement and disaster training for the residents and government officials.

Lesson Learned 3: Role of government in the initial stage

It is usually pointed out that seventy-two hours after an earthquake of disastrous proportion is the critical time for rescue and relief activities. In Bam, usage of the seventy-two hours is not sufficient. Red Crescent Society has started activities just after the earthquake and lifeline companies also have started recovery work two hours after the earthquake. Red Crescent Society mainly carried out rescue and relief efforts in accordance with law. But the disaster management law in Iran is ambiguous about the role of government in disaster, especially coordination and instruction activities after the event. Therefore, the government's response to the earthquake should be reviewed and an emergency response manual towards a more organized action should be formulated.

Lesson Learned 4: Necessity of securing the government functions

The government function should be secured after the earthquake, so as to rescue the victims, keep the civil life in order and secure the economic stability. If an earthquake occurs in a city where governmental civil life in order and secure the economic stability. If an earthquake occurs in a city where governmental institutions are concentrated, the national government will malfunction and cause serious disorder in the nation.

Tehran, the capital city of Iran, is the most important city in Iran. More than 26% of economic activities and national government functions are concentrated in Tehran. Especially, national government functions should be maintained after the earthquake as well. Malfunction of the national government will cause more serious problems at the national level.

Many people from outside Bam and who were not affected by the earthquake came to the damaged area; they lined up to receive the disaster relief items and there were also reports of looting. This is why it is important for the government to maintain the security of the victims. The government should be ready to function just after the earthquake.

Lesson Learned 5: Coordination system for receiving international relief aid and NGOs

Iran accepted aid from international NGOs for the first time after the Bam earthquake. It can be expected that after a major incident, international aid and relief teams as well as international NGOs and the International Federation of Red Crescent Society will come to assist victims. Each NGO has its own interest and idea on how to operate after an incident. In Bam, the damaged area is divided into 13 areas for the deployment of international relief efforts. Therefore, Tehran also should start planning the logistics on acceptance of international assistance.

Lesson Learned 6: Preparation of temporary and permanent house constructions

In Japanese experiences, the repair and reconstruction of permanent houses is the first step towards rehabilitation. In Bam, construction of temporary housing does not work well because many people do not want to move out of their houses. It is quite understandable from the victim's point of view—they want to take care of their property.

For the case of scenario earthquake in Tehran, it is more difficult to precede temporary house construction, since the numbers of affected people in Tehran, required numbers of temporary housing and land for construction site would be considerable compared to that of bam. In addition, problem of property rights would increase the difficulty in proceeding the temporary housing transition. Preparation of evacuation site and temporary housing construction places in advance of disaster event is of great importance for transition from emergency response to rehabilitation and reconstruction as smooth as possible.

Lesson Learned 7: Preparation of earthquake damage in mega-city

A mega-city like Tehran should prepare beyond the Bam experience. The Bam earthquake provides many lessons and experiences for disaster management, yet Tehran should also learn from past experiences of other cities all over the world. In order to minimize the damage, the secondary damage should be avoided.

The followings show Japanese experience for the mega-city:

- Support for commuting residents by providing food and drinks
- Control of private car use and control of traffic in the emergency road network
- Urban planning process after the incident is established to formulate in a short period of time
- Preparation for flood-calls within and outside the city
- Establishment of foreign residents support system
- Establishing community level organization before the incident

Lesson Learned 8: Restoration of normal life

After the disaster, the victims need to buy daily necessities and earn their own livings. Restoration of normal life through revitalization of economic activity is also important for residents. Banking system should return to normal at the earliest possible time after the disaster. Working place and office should be reopened as soon as possible. Shops and commercial activity should also be started soon. The government should support those aspects as well.

The following items should also be taken into account for early restoration:

- Medical and health support for victims
- Education facility and cultural and religious facility
- Mental and child care after the incident

The government should provide job opportunity for victims. Many people will lose their jobs because of damage to production facilities. The government should support restoration of those facilities and provide job opportunity.

Lesson Learned 9: Urgent repair of lifeline system

In Bam, lifeline damage is relatively small compared to building damage. Since many of the buildings have been damaged, water and telephone lines connections are damaged, too. In water supply, temporary repair has finished, yet most pipes have been damaged because they were made from asbestos. Therefore, the water supply authority should prepare rehabilitation of water supply system plan.

To provide lifeline services is the responsibility of each company. Services should be maintained after the disaster.

Lesson Learned 10: Technology transfer from Tehran Municipality to other cities in Iran

In Tehran, the JICA Study Team has been working for two years to formulate a comprehensive earthquake disaster management plan. Since the Microzoning Study started in 1999, Iranian side has gained more knowledge, experience and leadership as to microzonation technique, formulation of disaster management plan, promotion of community level disaster management activities, rehabilitation and reconstruction procedure and so on.

In Iran, a consciousness towards disaster preparedness of all the entities at government and community levels is widely increasing. As a leading entity of disaster management in Tehran, TDMMC should play an initiative role in disseminating those knowledge and experience to other entities in all over the country, by promoting training courses targeting on officials, organizing workshops and seminars for community level disaster management activities, developing regulations relating to disaster preparedness, emergency response and reconstruction, etc.

Urgent Action

Preparation of initial action by the government

The government's response to the Bam earthquake shows that there is some room for improvement on the organized action for emergency response period. The government sector should have a manual after the event, so that every government official could imagine what would happen next and how he/she can react during the emergency response period. The training of the government official will improve response capacity by the government. Also, it is important for the municipality government to coordinate activities and to give appropriate instructions based on the latest information.

The government should prepare the emergency response manuals for at least 72 hours after the event and emergency information system. Based on the information, the government sector should react according to the emergency situations.

Preparation of detailed rehabilitation and reconstruction procedure

The Bam earthquake has shown that reconstruction and rehabilitation takes time and causes many difficulties to the victims. As of March 2005, one year has passed since the earthquake struck in Bam, yet the actual rehabilitation of the Bam damaged area has just started. Permanent house construction has not started yet. Rehabilitation of water supply system will take one more year to install the pipes. It is a big question whether Tehran can stand still for one year for rehabilitation.

Rehabilitation and reconstruction plan should include economic and industrial sectors. The government should start thinking how to rehabilitate those sectors after the event. Private sector is the key for rehabilitation. In normal time, the disaster prevention and management should include private companies and factories.

Experience of other areas in Iran and overseas may apply to the rehabilitation and reconstruction of the damaged area, yet the characteristics of Bam and Tehran are unique. Therefore, a unified approach for reconstruction may not fit in Tehran area. Before the event, the government should prepare several options for the rehabilitation. Here are some to consider: to rehabilitate and reconstruct Tehran again or to just move to another area. It is not a technical decision but rather a political decision. In any case, to secure capital function, redundancy of the government function and information should be secured before the incident.

Community involvement for disaster management

The community activity and disaster training should be included in the disaster management in Tehran. The training and enlightenment of the earthquake disaster management is a key to success. As recommended in the master plan report, community involvement should be whole residents.

Mental health and care for victims

Mental health has become increasingly important to the recovery of victims of earthquake disaster as shown by recent experiences. As such, Bam earthquake victims also have great needs for mental care. Ministry of Health and other organizations should prepare for the care and necessary treatment after the disaster.

3. Bam Earthquake

Building Damage

More than 85% of buildings were completely destroyed and some 95% of the 2,500 years old historical archeological monument, internationally recognized Arg-e-Bam, was almost completely destroyed. Survivors had to move out of their house and live in tents or temporary housing on roadside or close to their damaged house. They were reluctant to move to emergency camps because of various reasons, such as security, inconvenience and psychological reasons

The damage observed after the earthquake is summarized by sector as shown below.

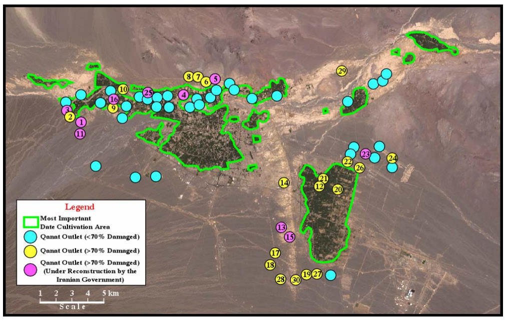
Agricultural Damage

There are qanats that were constructed 100 years ago in Bam. There are 374 qanats in the Bam, which were used for date palm farming.

According to the Agriculture Management of Bam, the most damaged date palm farms are concentrated in the Bagh-Chamak (west part), north of Bam city, Spikan (north part) and Baravat (east part).

Qanats

The earthquake damaged 64 of the 374 qanats in the region. Of the 64 damaged qanats, 30 are heavily damaged and need urgent restoration.



Source: JICA Study Team

Figure 4 Damaged Qanat Distribution Map

The most damaged qanats are pointed in yellow and pink. The outlets shown in pink are those that the Bam government is working to restore at the moment. The Baravat area is the area that has the highest concentration of qanats with high damage level.

Before the earthquake 20 to 30% of the agriculture sector utilized deep wells. Now, as an emergency situation, 40 to 45% are using this resource to irrigate the farms.

Storage Facilities

The earthquake destroyed all package industries and damaged/destroyed 88 of the 110 storage facilities. The total storage capacity was about 100,000 tons, which was reduced to 40,000 tons after the earthquake.

4. Effort toward Reconstruction of Bam

Rehabilitation and reconstruction of Bam in all its dimensions – social, economic, physical, cultural – poses a bigger challenge over the coming years. Given the magnitude of the disaster, it requires huge amounts of financial resources and work force to walk a long way to achieve total recovery, as well as to challenge to reduce the risk of future disaster by introducing innovative practices for a sustainable redevelopment of Bam.

The Iranian government has set up a multi-sectoral Task Force, in order to coordinate the reconstruction efforts and programs with sub-dividing the reconstruction by their specialties. According to the recent report from the Bam Reconstruction Committee, the government decided to rebuild the city in the existing urbanized area with some modification on the future city structural planning.

5. International Assistance in Bam

As well as the Iranian organizations, International donors such as the UN and NGOs including IFRC also undertook swift response to the disaster. Based on a rapid needs assessment, the UN and IFRC launched first-time-ever joint Flash Appeal. This asked donors for a total of US $73 million, in which $31.3 million was on behalf of the UN and $42 million on behalf of the IFRC, in order to facilitate a smooth transition from initial relief to the eventual rehabilitation and reconstruction of Bam in various sectors. Lead by UNOCHA, the UN also acted as coordination body of International aid agencies, by establishing UN camp and issuing ID card.

Japanese Assistance

JICA has Disaster Relief Program involving the dispatch of Japan Disaster Relief (JDR) teams and provision of emergency relief when major disasters occur overseas, in collaboration with Ministry of Foreign Affairs of Japan and Japan Defense Agency. The program is run on the basis of requests received from the governments of affected countries or international agencies.

Japan Disaster Relief medical team consisting of 23 people in total conducted medical relief activities, in which the first team mobilized to Iran on 28 December 2003, and a total of approximately US$ 0.32 million worth of blankets, tents, food and other emergency aid supplies were provided.[1]

As a consequence of the findings by the mission and corresponded to its urgency, the Government of Japan decided to proceed with the Bam Earthquake Study in the following three major sectors;

- Rehabilitation study of water supply system,
- Rehabilitation study of agriculture sector,

  and

- Rehabilitation of the community

In consideration of the findings in the above study and urgent need of affected people in Bam and surrounding area, the scope of the study was focused on a reconstruction of water supply system. The Study was composed of the following items.

implementation of the construction works consisting of 1) water network facility, which is approximately 33 km of the priority route in Bam municipality, 2) distribution reservoir (V=2,000m³) with a gate house and a chlorination house, including chlorination equipment in Baravat, and 3) the building structure of pump house (No.3) in Baravat.

[1] The Government of Japan also provided emergency food US$770,000on a basis of an emergency grant aid.

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Abbreviations and Acronyms

BHRC	Building and Housing Research Center
BrvtWSC	Baravat Water Supply Company
BWSC	Bam Water Supply Company
DP	Drilling Point
EMS	European Macroseismic Scale
gal	cm/s^2
GIS	Geographic Information System
GOI	Government of Iran
GOJ	Government of Japan
IIEES	International Institute of Earthquake Engineering and Seismology
JICA	Japan International Cooperation Agency
K	Coefficient of Permeability
Mb	Body wave magnitude
microS	Micro-siemens
MMI	Modified Mercali Intensity
MOE	Ministry of Energy
MPO	Management & Planning Organization, Office of the President
RCS	Red Crescent Society of Islamic Republic of Iran
Ms	Surface wave magnitude
msl	mean sea level
Mw	Moment wave magnitude
NGO	Non Government Organization
PGA	Peak Ground Acceleration
TDMMC	Tehran Disaster Mitigation and Management Center (Merged CEST and CEMS)
TDMO	Tehran Disaster Management Organization
UBC	Uniformed Design Code
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
USGS	US Geological Survey
WB	World Bank
WHO	World Health Organization
WSCK	Water and Sewage Company of Kerman

CHAPTER 1 OVERVIEW

1.1 Introduction

This is a report prepared by the JICA Study Team for “The Study on the Bam Earthquake and Reconstruction of Water Supply System in Bam and Baravat Areas” to transfer the findings and knowledge attained through the study and construction of water supply system in the Bam areas to the Tehran Disaster Management Organization (TDMO) in Tehran.

The Study Team was formulated shortly after the earthquake on December 26, 2003, which hit the southern Iranian city of Bam in Kerman province and left devastating physical damage and distress, not only to the people of Bam, but also to the nation.

Japan International Cooperation Agency (JICA), accordingly, appointed the study team of the “Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area in the Islamic Republic of Iran” to carry out a primary survey to investigate the damage and consequence of the earthquake considering that the study team has continually worked in Tehran on earthquake disaster management, as a JICA technical cooperation assistance, since 1999.

1.2 Background of the Study

The Government of Japan (GoJ), through JICA, sent a preparatory mission to the affected areas in January 2004 to investigate the extent of damage caused by the earthquake, and to formulate tangible disaster-relief measures for those who suffered, following the urgent medical assistance dispatched right after the earthquake. The first preparatory survey was conducted for two weeks from 10 January 2004, and the first report was formulated based on the observations and findings on the distressed Bam and surrounding areas.

The preparatory mission sent by the GoJ had held intensive meetings with related governmental agencies and institutions concerned, and inspected various facilities with a view on grasping tangible needs for future assistance from Japan.

Among other primary social infrastructure in the Bam areas, water supply and irrigation facilities were severely damaged by the earthquake. Residential buildings were mostly collapsed and the people were forced to live in tents or temporary housing nearby their house. In a struggle to retain the key industry of the Bam areas, it was a matter of extreme urgency to restore the functions of lifeline facilities, such as water supply, i.e. distribution reservoir, piping network and its operation systems, and quanat irrigation, so as to accelerate the reconstruction progress of the local community.

As a consequence of the findings by the mission and corresponded to its urgency, the GoJ decided to proceed with the Bam earthquake study supplemented to the "Master Plan Study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area," in collaboration with Tehran Disaster Management Organization (TDMO), covering the following three major sectors:

- Rehabilitation study of water supply system
- Rehabilitation study of agriculture sector
- Revitalization of the community

The study area was the earthquake-hit area of Bam municipality and its surrounding towns and villages, including Baravat. Counterpart agencies were set as 1) Water and Sewage Company of Kerman (WSCK) for the rehabilitation of water supply systems and 2) Management of Jihad and Agriculture in Bam Township for the rehabilitation of agriculture and community.

After the second reconnaissance mission in the Bam areas, the scope of the study was narrowed down to the rehabilitation of water supply systems as it is described in detail in the following section.

1.3 Scope of the Study

1) Study Objectives

The scope of the Study is set to formulate long-term reconstruction plan for water supply system, to implement urgent reconstruction projects and to make practical recommendations for Tehran based on lessons learned in Bam.

The long-term reconstruction plan for water supply system shall be based on the result of water resource development study conducted in the Study and accord with relating reconstruction plans of Bam. The work items cover 1) designing of seismic resistant and maintainable water supply system, 2) preparation of implementation, operation and maintenance plans, 3) preliminary designing of monitoring and control system for the operations of well pumping stations, and 4) cost estimation for reconstruction projects.

The urgent reconstruction projects implemented in the Study are 1) water network facility, which is approximately 33 km of the priority route in Bam municipality, 2) a distribution reservoir (V=2,000m^3) with a gate house and a chlorination house, including chlorination equipment in Baravat, and 3) the building structure of pump house (No.3) in Baravat.

The ultimate objective of the rehabilitation work is to restore the damaged facilities to the pre-earthquake conditions in the course of the project.

2) Study Areas

The study areas cover the earthquake-affected areas of Bam municipality and its surrounding town and villages, including the Baravat areas.

Kerman province is composed of 13 townships (shahrestan), and each township is further divided into districts (bakhsh) that include city (shahr) and village (dehestan). Bam Township has an area of 19,374 km² and a population recorded at 242,438 in year 2002. The main study area of this study is referred to as "Bam municipality," which is the urbanized area of Bam district having an area of 39 km².

Figure 1.3.1 Study Area

3) Implementation Organization

Figure 1.3.2 shows the relationship of study organizations, and the member lists of the Study Team are shown in Appendix to Chapter 1.

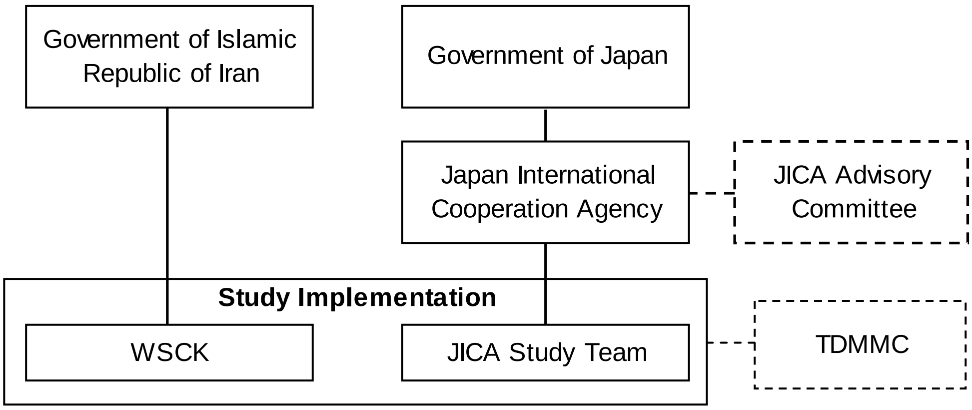


Figure 1.3.2 Study Organization

4) Schedule of the Study

Figure 1.3.3 shows the schedule of the Study from the preparatory mission sent in January 2004 to a technology transfer seminar held in February 2005.

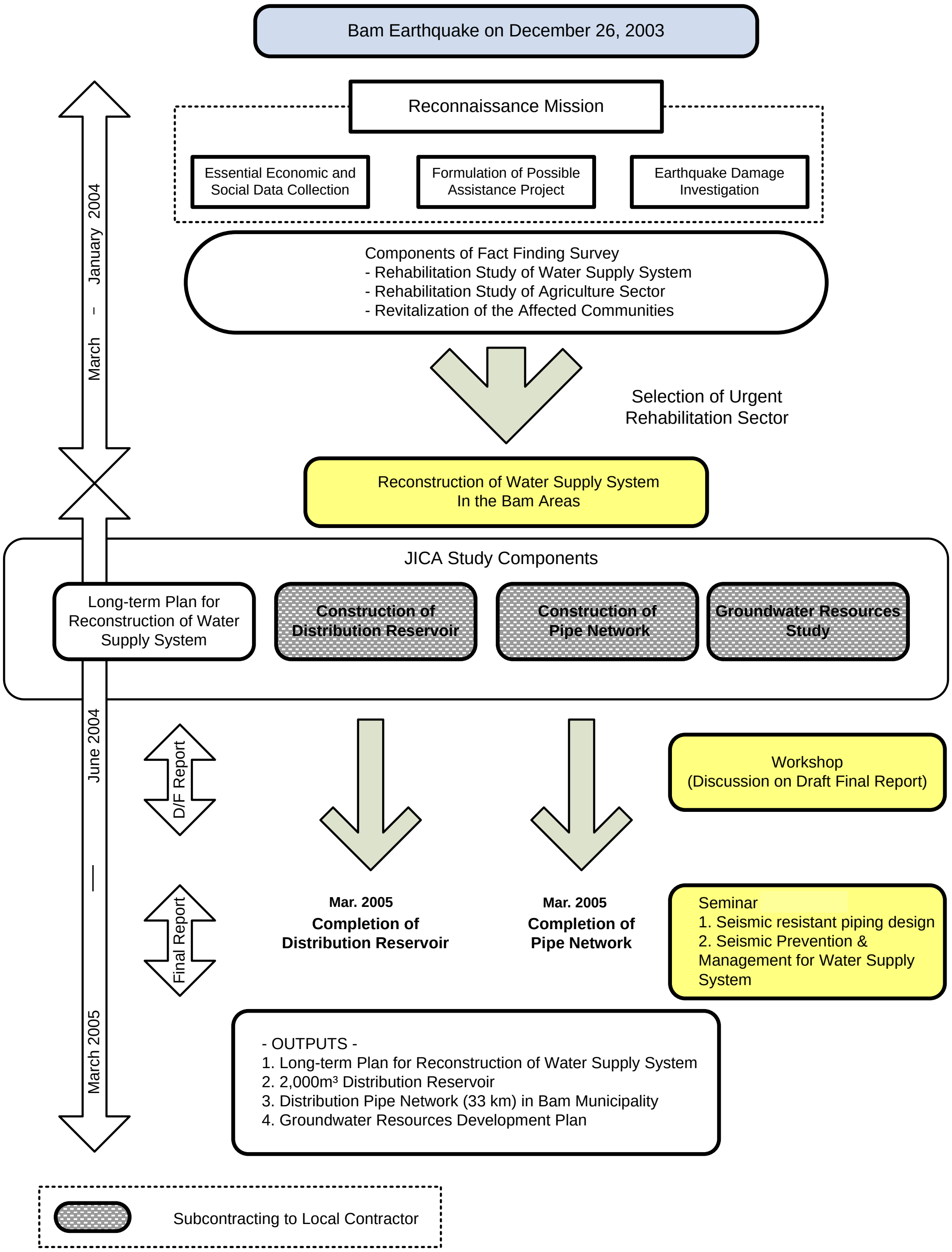


Figure 1.3.3 Schedule of the Project

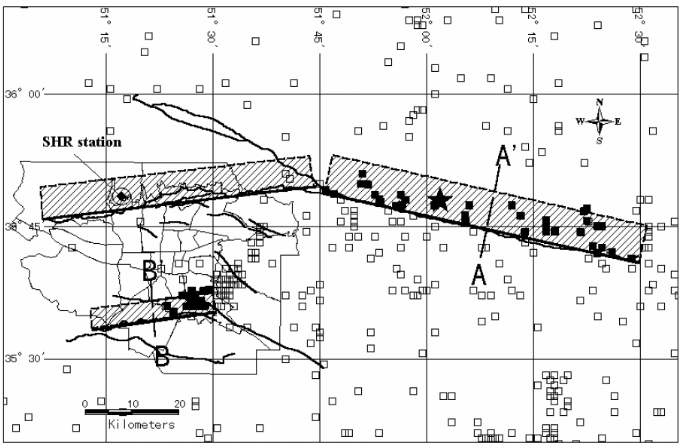
CHAPTER 2 LESSON LEARNED FROM BAM EARTHQUAKE

2.1 Tehran's Scenario Earthquake and Bam Earthquake

The focus in this section is to provide an answer to the following important question: did the 2003 Bam Earthquake cause a large damage simply because of the excessively strong earthquake motion or of the predominance of structurally weak buildings? This section presents substantial discussion on the relationship between the seismic resistance level of structure and its earthquake damage.

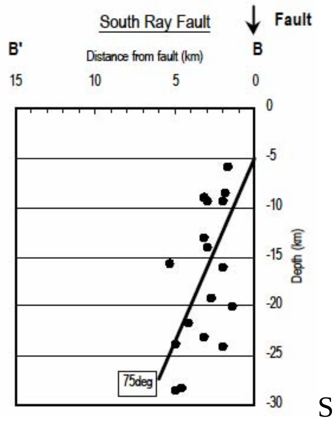
To provide some answers, let us revisit the previous JICA study titled "The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran", which assumed four types of scenario earthquake that should be set up for the disaster mitigation plan of the Greater Tehran Area. Based on the analysis of the earthquake scenarios, it was concluded that, the earthquake with the similar earthquake motion to that of the 2003 Bam Earthquake could occur in the Greater Tehran Area.

Firstly, the focal mechanics of the scenario earthquakes in the previous study are compared with that of the 2003 Bam Earthquake as shown below. Four types of fault models are proposed in the previous study (i.e., Ray Fault Model, North Tehran Fault Model, Mosha Fault Model, and Floating Model). The model that causes the largest damage to the Greater Tehran Area is the "Ray Fault Model". The magnitude of this focal mechanics is M_W 6.7. This model is shown in the lower-left of Figure 2.1.1. Section B-B is shown in Figure 2.1.2.



Source: JICA Study Team

Figure 2.1.1 Distribution of Fault Model (Proposed Scenario Earthquake in Tehran)

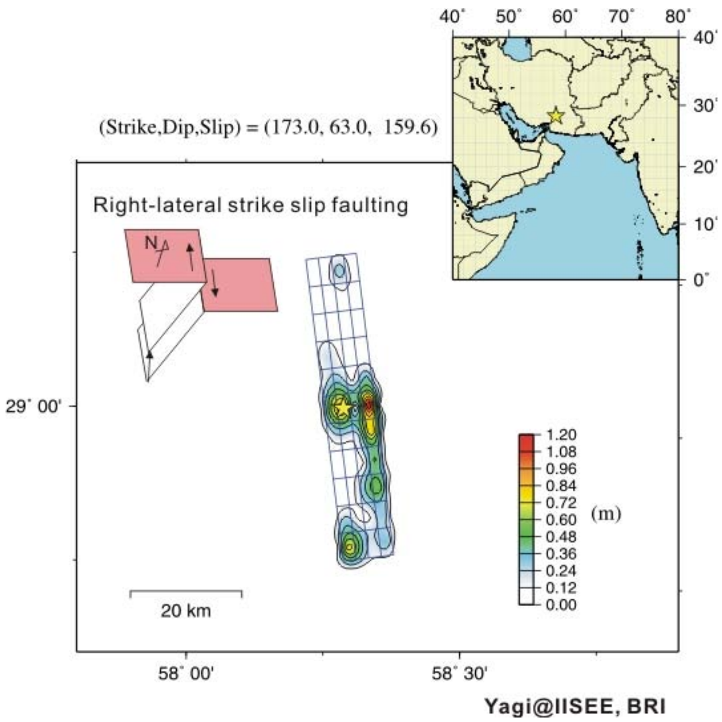


Section B-B of Figure 2.1.1

Source: JICA Study Team

Figure 2.1.2 Estimated Dip Angle of South Ray Fault (Proposed Scenario Earthquake in Tehran)

The focal mechanics of the 2003 Bam Earthquake and distribution of fault-slip, which was analyzed by Dr. Y. Yagi of the International Institute of Seismology and Earthquake Engineering, are shown in Figure 2.1.3.



Note: Hypocenter of the main-shock was determined by USGS. Blue lines represent the extent of the fault plane used in Yagi's inversion analysis

Source: JICA Study Team

Figure 2.1.3 Distribution of Fault-slip (by Yagi) (2003 Bam Earthquake)

The magnitude of the 2003 Bam Earthquake was MW 6.6, according to USGS. This figure is similar to that of scenario earthquake for the case of Tehran, which was presented in the JICA Study, "The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran". Regarding the depth of fault, the upper edge of Ray Fault Model is 5 km and the upper edge of Bam fault is assumed to be 4 km.

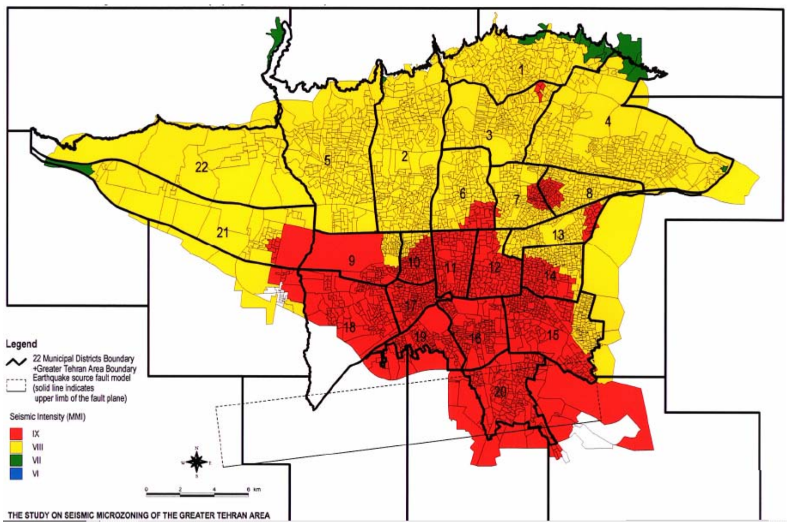
The Fault Parameters of these two earthquakes are summarized in Table 2.1.1. These parameters show that the focal mechanics of the 2003 Bam Earthquake is similar to the fault model of Microzoning Study.

Table 2.1.1 Fault Parameters

	Proposed Scenario Earthquake in Tehran Ray Fault Model	2003 Bam Earthquake (Earthquake Information Center, University of Tokyo)
Length (km)	26	20
Width (km)	16	15
Moment Magnitude (M_W)	6.7	6.5
Dip Angle (degrees)	75	85
Depth of Upper Edge (km)	5	4

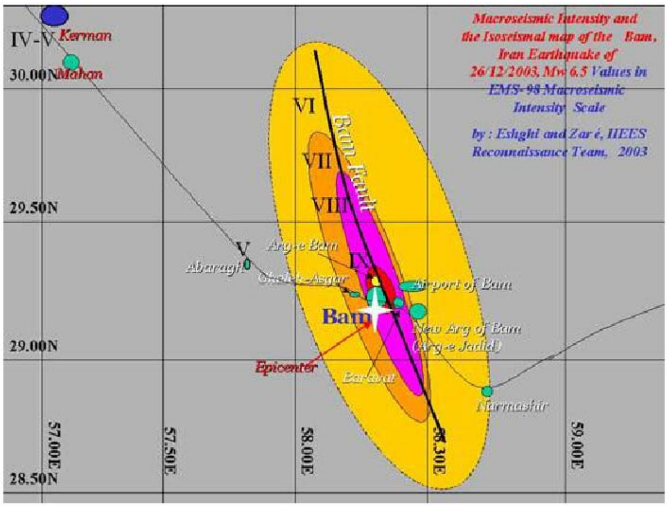
Source: JICA Study Team

As the next issue of this comparison, the motions of the ground surface caused by these two earthquakes are shown in Figure 2.1.4 and Figure 2.1.5, respectively. The maximum value of the ground surface motion is evaluated as MMI IX for each earthquake. Considering that MMI scale arranges from I to XII, MMI IX does not necessarily indicate that the earthquake motion is especially large. Therefore, it can be concluded that the building structure should overcome this extent of earthquake by its strengthening.



Source: JICA Study Team

Figure 2.1.4 Seismic Intensity Distribution (Proposed Scenario Earthquake in Tehran)



Source:IIEES

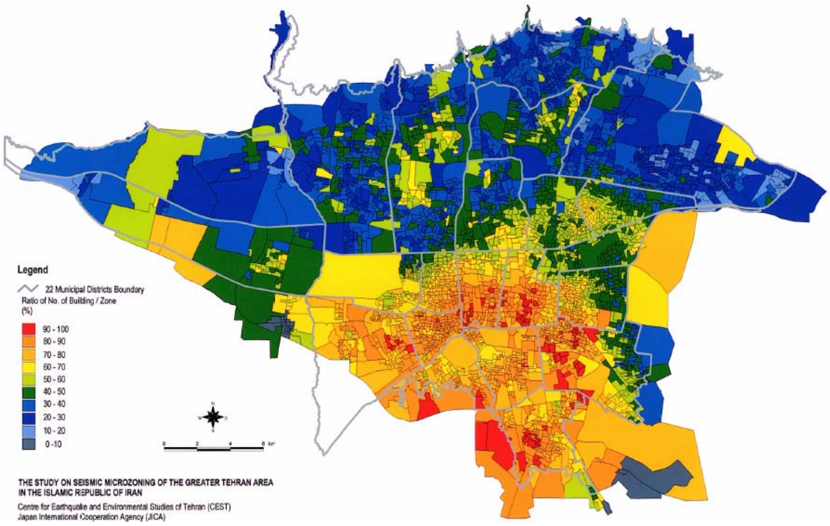
Figure 2.1.5 Seismic Intensity Distribution (2003 Bam Earthquake)

Taking into account the above comparison, it can be concluded that the earthquake motion estimated in the JICA study and the earthquake motion caused by the 2003 Bam Earthquake have lots of common features so that the experience of the 2003 Bam Earthquake can give us effective suggestions. That is, if the Ray Fault is set up as the target of the disaster mitigation plan in the Greater Tehran Area, since the earthquake motion estimated in the JICA study was validated by the 2003 Bam Earthquake.

2.2 Earthquake Damage

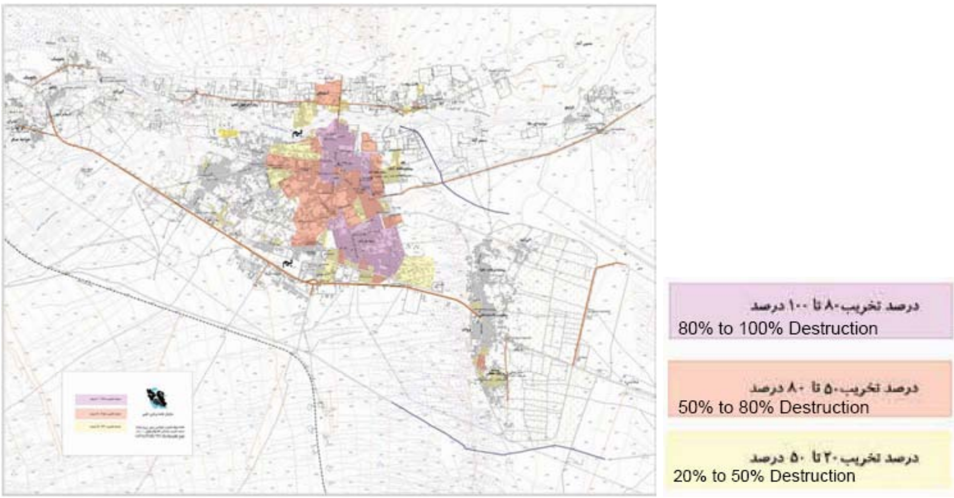
In order to compare the extent of damage of the 2003 Bam Earthquake with the result of the JICA study, the difference of feature building structure between those two cases should be discreetly examined. There are many similarities in Bam and Tehran. Masonry structure is the dominant structure type in Bam and Tehran, which shares more than 60 percent of the building. Since the building construction technique is the similar in Bam and Teheran, seismic resistance level in both areas is the same. Therefore, it can be said that the estimated earthquake damage for Tehran in the Microzoning Study is validated by the 2003 Bam Earthquake.

First of all, the damage ratio of the buildings is the most reliable factor to indicate the scale of disaster. The damage ratio of the buildings estimated by the JICA study is shown in Figure 2.2.1 and that in Bam is shown in Figure 2.2.2.



Source: JICA Study Team

Figure 2.2.1 Heavily Damaged or Collapsed Building Ratio shown in the JICA Study



Source: National Geoscience Database of Iran Website

Figure 2.2.2 Destroyed Building Ratio in Bam

There is a critical point required to note the difference between these two graphic displays. Figure 2.2.1 shows the building damage corresponding to the threshold more than “Grade 4 Very heavy damage” in EMS-98, but Figure 2.2.2 shows the building damage corresponding to “Grade 5 Destruction” in EMS-98. Taking the difference of definition between these two graphic displays into consideration, it is recognized that the damage in Bam city is larger than that of Tehran city. This aspect can be explained by the difference in predominant building type of these two cities. The building type in severely damaged area of Bam is adobe, but there is hardly that kind of building type in Tehran. And yet, the damage ratio of Bam reached 80% and the predicted damage ratio of Tehran also reaches 80%. It can be said that there is considerably proper proportion between the damage ratio of Bam and that of Tehran even though the difference of the building type exists.

The next aspect is the earthquake resistance of each different building type. There can be a misconception that modern buildings, constructed by construction methods other than adobe, can resist against this scale of earthquake. It is because some examples can be found, in which some buildings made by RC or “confined masonry” in the west part of Bam and Argejadit were not so heavily damaged. However, the buildings in the central part of Bam made by RC or “confined masonry” received catastrophic damage. Especially, steel frame buildings received damage of total collapse (see Figure 2.2.3).

Source: JICA Study Team

Figure 2.2.3 Example of a Totally Collapsed Building of Steel Frame

Even in the public buildings, which may have been constructed with considerable inspection, brick infill walls blew off into the out of plane direction. It is thought that human lives may be lost if the disaster occurred in noontime (see Figure 2.2.4)

Source: JICA Study Team

Figure 2.2.4 Destroyed Public Buildings, which may have been Constructed with Considerable Inspection

Steel frame building is increasing in Tehran. But the idea that the main cause of the Bam disaster was the use of adobe for building construction is a misconception. Moreover, the idea that the Bam disaster may be minimized if adobe is not the predominant building type in Bam is also not true. Even the buildings made by the building type other than adobe cannot prevent collapse if those are constructed without sufficient consideration based on engineering. On the other hand, there were some buildings that did not totally collapse even though they were made by adobe. A typical example can be seen in Figure 2.2.5.

Material of this building is sun-burned brick

Source: JICA Study Team

Figure 2.2.5 Typical Example of Adobe Building that did not Totally Collapse

The damage of this building made of sun-burned brick was confined in the end wall even though the arch remained regardless of its long span. The reason why the damage of this building is limited to that small extent is the existence of the steel tie located at the base of arch.

Another aspect of Bam disaster is damage of qanat. Diameter of qanat in Bam is smaller than that of Tehran. Depth of qanat in Bam is shallower than that of Tehran. However, it must be noted that there are many instances of qanat collapse in Tehran even though they were not caused by earthquake. If these are taken seriously, it can be concluded that there may be some qanat collapse and ground settlement in Tehran in the event of earthquake. There can be some building collapse caused by the ground settlement. A sewage well, which is set up below the ground, also may cause the ground settlement and the building collapse when the severe earthquake motion hit it. This is not a negligible aspect for thinking about the safety of buildings in Tehran although it was not taken into account in "The Study on Seismic Microzoning of the Greater Tehran Area in the Islamic Republic of Iran". Many defects, which are caused by overconfidence in the ground stability, can be seen in Tehran. The qanat under unstable situation, the basement of the building built at high-pitched slope and the sewage well casted-off may become causes for building collapse and the destruction of Tehran city.

2.3 Emergency Response and Recovery

The capacity of the emergency response was relatively high at the 2003 Bam Earthquake. It was reported that the emergency headquarters was set up in Kerman within one hour and search and rescue team of the Red Crescent Society arrived at the disaster-affected area after about five hours of the earthquake. A task force was assigned to each of the 13 administrative districts in Bam city 3 days after the earthquake. Each task force consisted of the relief team dispatched by other provinces in Iran and overseas relief team.

The situation of lifeline facility immediately after the earthquake (i.e., water supply, electric power supply, gas supply and telecommunication) was as follows.

The recovery of electric power supply was very fast; almost 30% of demand was satisfied within the same day of the earthquake occurrence. There is a disaster evaluation system in which the loss of streetlight is monitored, but this system was not effective for the evaluation of Bam because of the fast pace of the recovery process. The reason why this fast pace of recovery was possible is the simple layout of electric power supply system in Bam. Checking and recovery work was relatively easy because most of the facilities were located on the surface of the earth. The part where there was trouble was limited in the ceramic insulators on transformer and utility pole collapse.

The pace of recovery progress of water supply was not so good; 20% of demand was satisfied by the next day of the earthquake, but it is not yet recovered completely even now in February 2005. One of the reasons why the pace of recovery progress is discouraging is the difficulty of checking because the leaking parts are under the ground. Another reason is the large number of leaking points because most pipes are made of very weak material, asbestos.

Regarding the telecommunication, there were so many troubles while the emergency intermediary station of mobile phones was set up in the afternoon of the same day.

The demand of emergency response and recovery depends on the scale and density of the disaster area. Tehran city is considerably larger than Bam city. Therefore, the whole city of Tehran does not necessarily suffer from the damage as heavily as Bam city suffered at the 2003 Bam Earthquake, even if the same feature of earthquake hits Tehran city. Some places far from the epicenter may not be damaged so heavily. However, Tehran city is already urbanized to a great extent. Especially the area near the Ray fault is occupied by houses that are located so closely, and most of the streets are excessively narrow. Therefore, the citizens of Tehran may encounter more difficulty to find necessary open space for the tent village than those of Bam did. Emergency vehicles may not be able to go to the disaster site because of traffic jam. Tehran may suffer from more catastrophic damage just after earthquake than Bam did. The facilities in highly urbanized area are highly complicated. Therefore, urban functions also may be seriously impaired and not be recovered as quick as in Bam. It takes long to recover civilian life and industry, a place of work for each citizen, even if some public facilities are recovered. And though one year has already passed since the earthquake struck Bam there remain a lot of things yet to be done.

Moreover, the mal-function of capital city may cause more serious problem in coordinate emergency response activities. The rescue and relief team from other province as well as international agency may face poor coordination of their activity and area. This is reason why the preparedness of Tehran is more critical compared to other cities.

2.4 Design of the Reservoir and Distribution Pipe

2.4.1 Planning Condition

1) Target Year

Target year for long term plan for reconstruction of water supply system was set as year 2031 in accordance with that of the "Comprehensive Reconstruction Plan of Bam" prepared by Bam Reconstruction Committee.

2) Planned Population Served

Bam city and its surrounding area are divided into 14 zones as shown in Table 2.4.1. These zones are established by Task Force for handling of reconstruction activities sponsored by Provincial Housing Foundation. The future service population projected by zone is indicated below.

Table 2.4.1 Future Service Projected Population by Zone

Zone	Category	Population After Disaster	Population Served In 2031
1	Bam Rural	2,284	6,106
2	Bam Urban	4,333	11,583
3	Bam Urban	4,176	11,166
4	Bam Urban	9,459	25,290
5	Bam Urban	16,091	43,022
6	Bam Urban	10,992	29,390
7	Bam Urban	6,046	16,164
8	Bam Urban	3,396	9,081
9	Bam Urban	2,395	6,403
10	Bam Urban	4,517	12,077
11	Bam Urban	3,482	9,310
12	Bam Rural	*	*
14	Bam Rural	2,023	5,408
Total (Bam Urban)		64,887	173,486
Total (Bam Rural)		4,307	11,514
13	Baravat	15,875	43,905
Grand Total		85,069	228,905

Note: * means outside of service area
Source: Jooyab-nou Consulting Engineers

3) Water Demand

(1) Unit Water Demand

The daily average unit water demand per capita is given below:

Table 2.4.2 Daily Average Unit Water Demand per Capita

(Unit: m³/person)

No.	Item	2003	2031
1	Domestic	151	164
2	Non-domestic	27	19
3	Losses	25	20
Total		203	203

Source: Jooyab-nou Consulting Engineers

(2) Water Demand

Maximum water demand for designing facilities, i.e. reservoir and pipe, is estimated based on the following conditions:

- Daily Peak factor for determining capacity of reservoir: 1.8
- Hourly peak factor for designing distribution network: 1.4 for Bam network
  1.5 for Baravat network

Table 2.4.3 Future Water Demand in 2031

Area	Population	Daily Ave.		Daily Max.		Peak Hourly	
		Unit Water Demand (lpcd)	Water Demand (m³/day)	Unit Water Demand (lpcd)	Water Demand (m³/day)	Unit Water Demand (lpcd)	Water Demand (l/s)
Bam	185,000	203	37,555	365	67,525	512	1,096
Baravat	43,905	203	8,913	365	16,025	548	279
Total	228,905	-	46,468	-	83,550	-	1,375

Source: Joyaab-nou Consulting Engineers

Table 2.4.4 Future Water Demand in 2023

Area	Population	Daily Ave.		Daily Max.		Peak Hourly	
		Unit Water Demand (lpcd)	Water Demand (m³/day)	Unit Water Demand (lpcd)	Water Demand (m³/day)	Unit Water Demand (lpcd)	Water Demand (m³/hour)
Bam	145,590	203	29,555	365	53,140	512	863
Baravat	31,660	203	6,427	365	11,556	548	201
Total	177,250	-	35,982	-	64,696	-	1,064

Source: JICA Study Team

The planned population served, unit water demand and peak factor are authorized as applied factors for the estimation by Central Water and Sewage Company under the Ministry of Energy.

2.4.2 Characteristics of Water Supply Structural in Bam

There are four types of water supply facility in Bam:

- Reservoir
- Elevated water tank
- Pump house and other buildings for machinery

- Pipes

There is no water treatment facility in Bam because water resource depends on the underground resources. The facilities damaged by the Bam earthquake are pipe and building for machinery. In general, the pipe damages by earthquake are ground deformation owing to the strong seismicity, ground settlement before the earthquake, weak joint or lack of material strength and insufficient construction. In case of Bam, most of the damage was caused by lack of material strengthen and weak joint. The building damages are caused by the weak building structure.

Despite partial damage such as cracks on the concrete surface, elevated water tanks have not been collapsed and malfunctioned. In general, the civil structure often referred to international design codes and manuals, and so damage to civil facility is less than that of building.

Reservoir in Bam has not incurred major damage by the earthquake. Its structure is made of reinforced concrete and is semi-underground. Semi-underground facility is often used in Japan as well because of balance between water pressure and soil pressure. The Bam earthquake proved this type of structure can withstand strong earthquake motion (MMI IX).

2.4.3 Seismic Resistance Design in Iran

The "Iranian Code of Practice for Seismic Design of Buildings," or Standard 2800, regulates seismic resistance design in Iran not only for buildings but also for civil structures. In Japan, building and civil structures have different standards or manuals. The main concepts of the Standard 2800 are based on the Uniform Building Code (UBC) and Japanese seismic resistance code. Although the latest version of the seismic resistance design code was revised based on the experience of the Great Hanshin Awaji Earthquake in Japan and Northridge, U.S.A., Iranian standard has not been revised to include the latest design concepts.

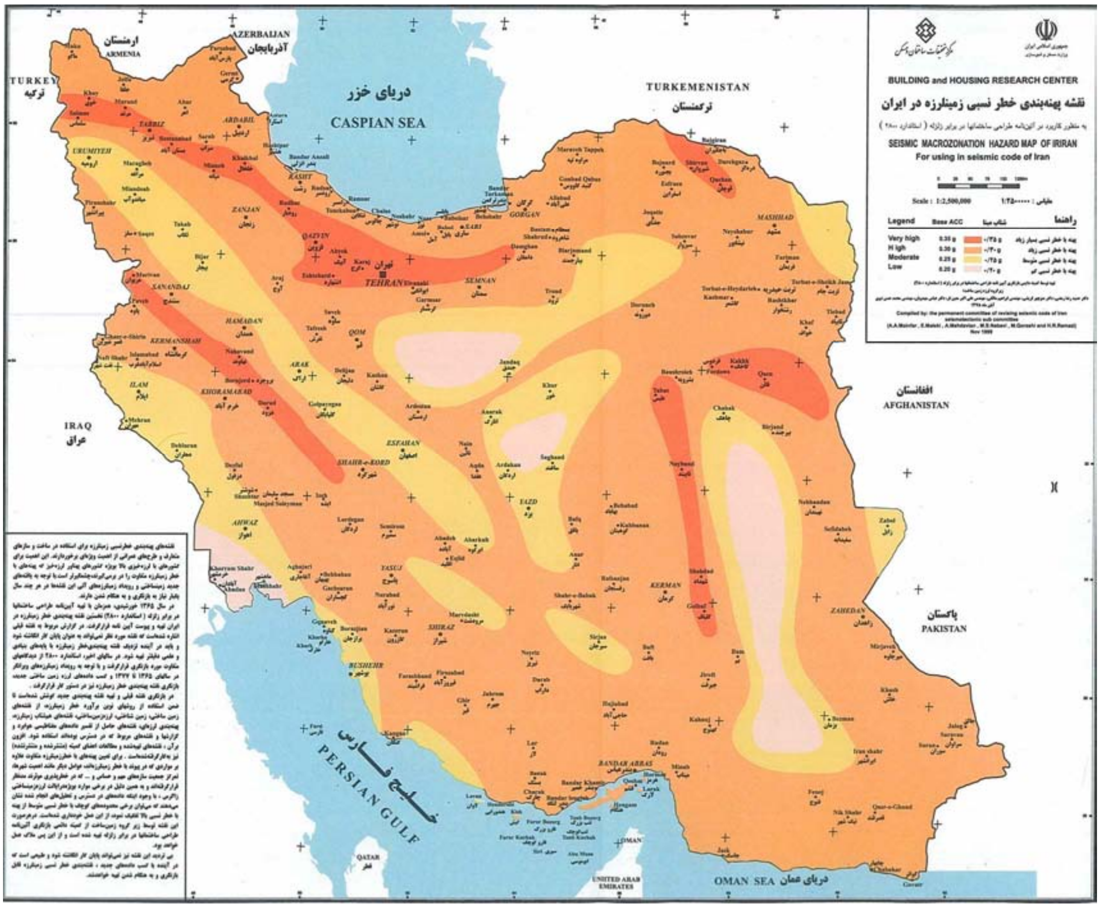
The most problematic section of Standard 2800 is the Building Behavior Factor R from design spectrum, which allowed decreasing design seismic intensity excessively. There is no explanation of the maximum seismic intensity of designed facility, and design spectrum has applied without reasonable explanation. The design seismic intensity based on the Iranian standard is not effective not only for the Bam earthquake but also for the strong seismic intensity such as Northridge and Great Hanshin earthquake. To design reservoirs, there is no effective method to prevent water leakage caused by the earthquake. Therefore, it allows water leakage from the reservoir in case of strong earthquake. In case of leakage, the emergency response will take care of the problem.

2.4.4 Design Policy of Reservoir

It can be said that the standard design issued by the Management and Planning Organization in Iran does not have basic defects because the existing water reservoir did not suffer damage at the

Bam Earthquake. Therefore, a configuration of the standard design could be adopted to this project. However, some modification on structure (i.e., dimension of column and reinforcing bar arrangement) is added reflecting analysis result, which was carried out considering seismicity of the site.

The process of consideration is as follows. The best official description on the earthquake resistant design is "Iranian Code of Practice for Seismic Resistant Design of Buildings," or Standard 2800, published by Building and Housing Research Center and Ministry of Housing and Urban Development. In this standard, intensity of earthquake motion, which is required as earthquake resistant design condition, is displayed in Figure 2.4.1 reflecting magnitude and frequency of earthquake observed around the country by now. This concept is called hazard analysis, which is also shown in the description of "Kawasumi's Map" in the Japanese code. Bam is located in the second highest intensity zone around the country, and the required intensity of earthquake motion *A* is equivalent to 0.3G.



Source: JICA Study Team

Figure 2.4.1 Distribution of Design base acceleration A (Iranian Code of Practice for Seismic Resistant Design of Buildings (Standard 2800))

Required earthquake resistant design condition is given by equation (1). This coefficient is usually called seismic coefficient or base shear coefficient.

$$C = \frac{ABI}{R} \qquad (1)$$

where,

C：Seismic coefficient

A：Design base acceleration

B：Building response factor

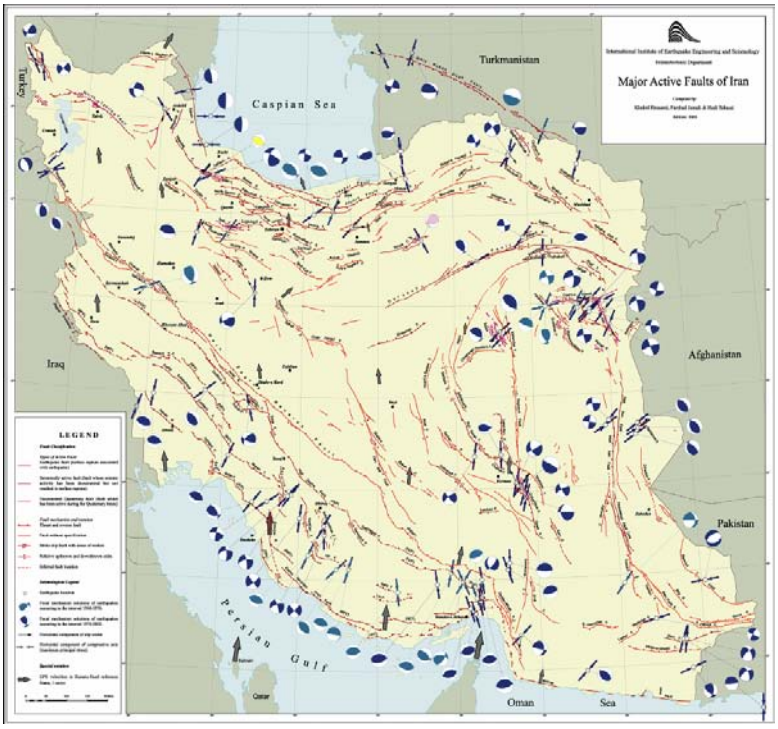
I：Building importance factor

R：Building behavior factor

Seismic coefficient C is equivalent to 0.225 when the following combination of values is given, i.e., A=0.3， Building response factor B=2.5, Building importance factor I=1.2, Building behaviour factor R=4. Basically, the building response factor B is a characteristic vale for free oscillation system, so the value of B is given as a function of natural period. The value of B was decided reflecting the constant value, which corresponds under 0.4 sec, because semi-subterranean structure was not oscillated so freely. Building behavior factor R is applied as a modification factor, which represents effect of ductility and redundancy of the structure. The value for wall structure was taken for R. Even among Japanese engineers setting the value for semi-subterranean structure is a critical point. In this section, the seismic coefficient C was discussed and the value 0.3 was taken as a safe setup when the design base acceleration was applied directly. If some modification is added considering characteristics of structure, the seismic coefficient is changed to 0.225.

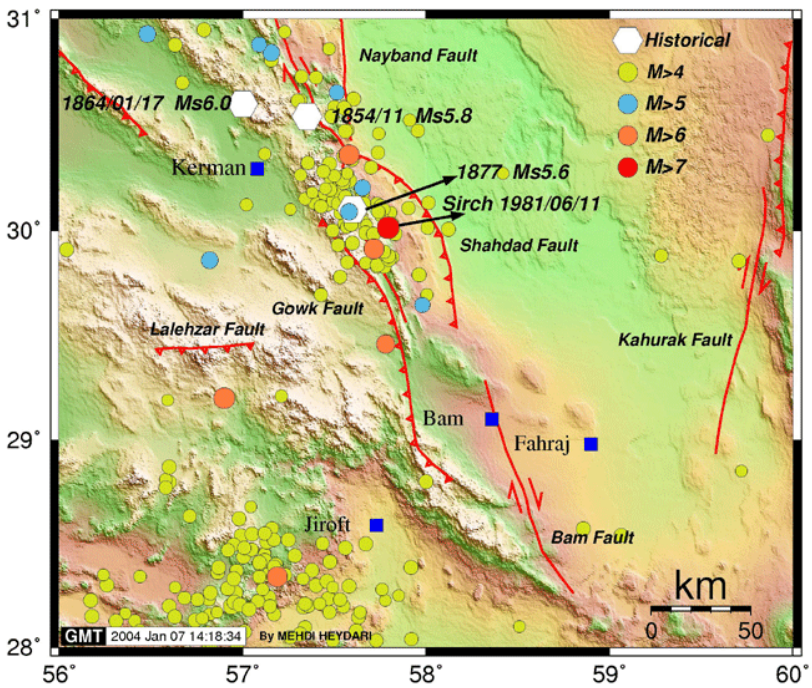
Let us now focus on past events that could have significantly affected Bam.

Figure 2.4.2 gives the location of the active faults around the country. And the detailed active faults location and epicenter of past earthquakes around Bam are shown in Figure2.4.3.



Source: IIEES

Figure 2.4.2 Major Active fault in Iran



Source: IIEES

Figure2.4.3 Seismicity near Bam

From Figure2.4.3, one that could have significantly affected Bam in recent past is the 1981 Sirch Earthquake. Magnitude of this earthquake was reported at more than 7 but distance from epicenter to Bam is more than 100 km. Therefore, it is thought that the 1981 Sirch Earthquake did not give a larger effect than that of Bam Earthquake.

In terms of “historical” earthquakes, they also did not give a larger effect compared to the earthquake in Bam in 2003. Past earthquakes have resulted in some part of Bam to experience earthquake motion corresponding to MMI 9 but the existing water reservoir did not suffer damage.

From this information, it can be said that the standard design of water reservoir, which was prepared by MPO, can offer basic earthquake resistance. Therefore, the new reservoir can have more perfect earthquake resistance if it is designed reflecting the result of analysis in this project.

2.4.5 Analytical Methods

The basic structure of the standard reservoir is covered by the wall structure and supported by the Pier at the middle.

Therefore,

- Upper slab and lower slab are analyzed by two-direction slab.

  Moment and shearing force is to be fixed at the connection point to sidewall.

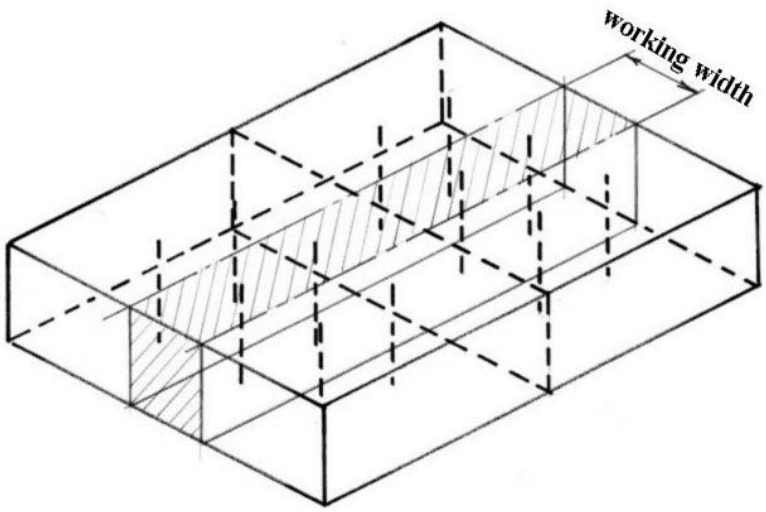
  The pier area supports pier point.

- In case there is no balance between left and right vertical force, a certain thickness of two-dimension frame structure is calculated in case of earthquake. (Certain thickness means effective thickness for wall structure from pier.)

The conditions mentioned above are not rules for calculation; the purpose of the analysis is rather for confirming structural viability.

There are three cases for analysis:

Certain thickness means effective thickness for wall structure from pier.



Source: JICA Study Team

Figure 2.4.4 Working Width

The conditions mentioned above are not rule for calculation; the purpose of the analysis is rather confirming structural viability.

There are three cases for analysis:

- Ordinary load case

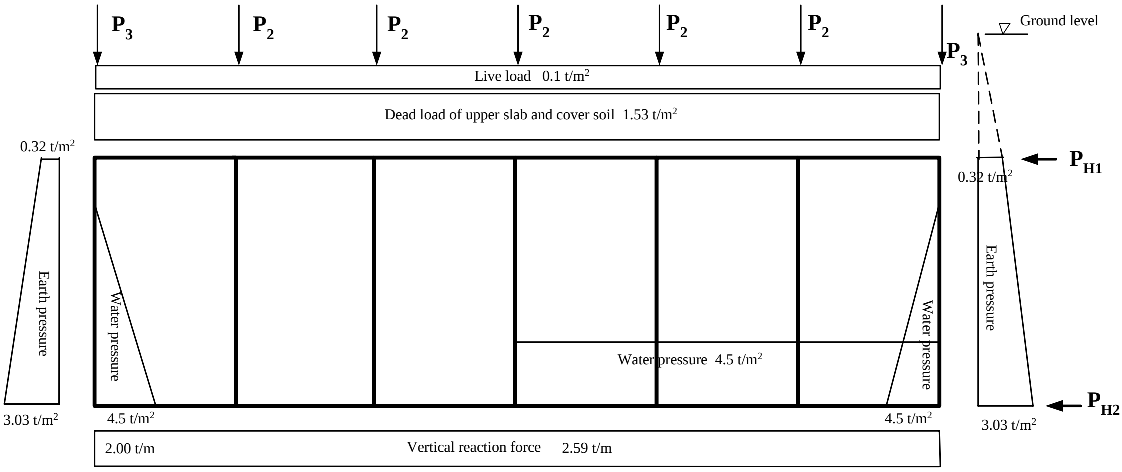
Case 1: Both compartment are full of water

Case 2: One compartment is full of water but the other is empty.

- Earthquake case

Case 3: Two compartments are full of water

(1) Case 1：Ordinary condition



Source: JICA Study Team

Figure 2.4.5 Load Condition-Case 1 (Service Loading)

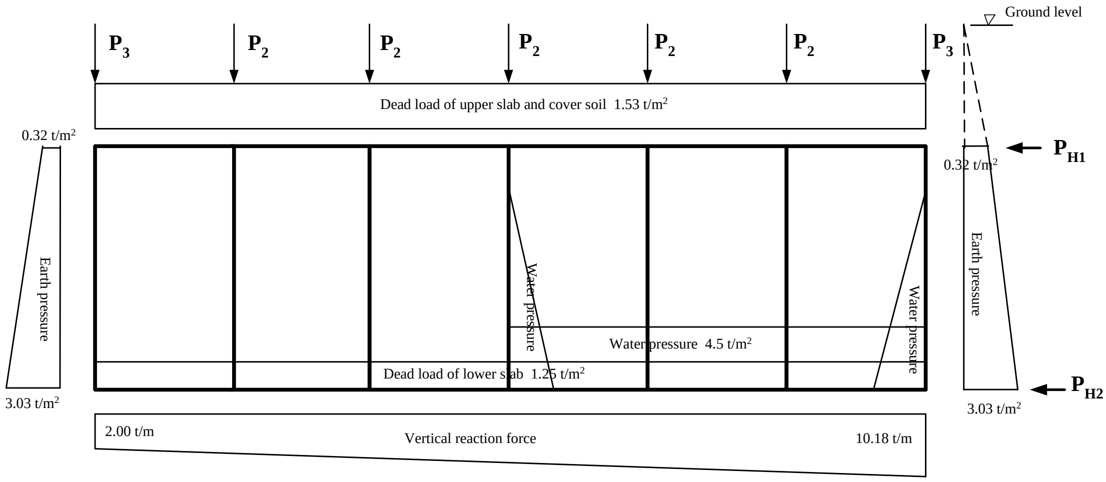
P1: Dead load for partition 7.99t

P2: Dead load for pier 2.13t

P3: Dead load for sidewall 5.99t

- Lower slab’s resistance force is not shown because dead load for lower slab of 1.25 ton/m and water 4.5 ton/m are balanced

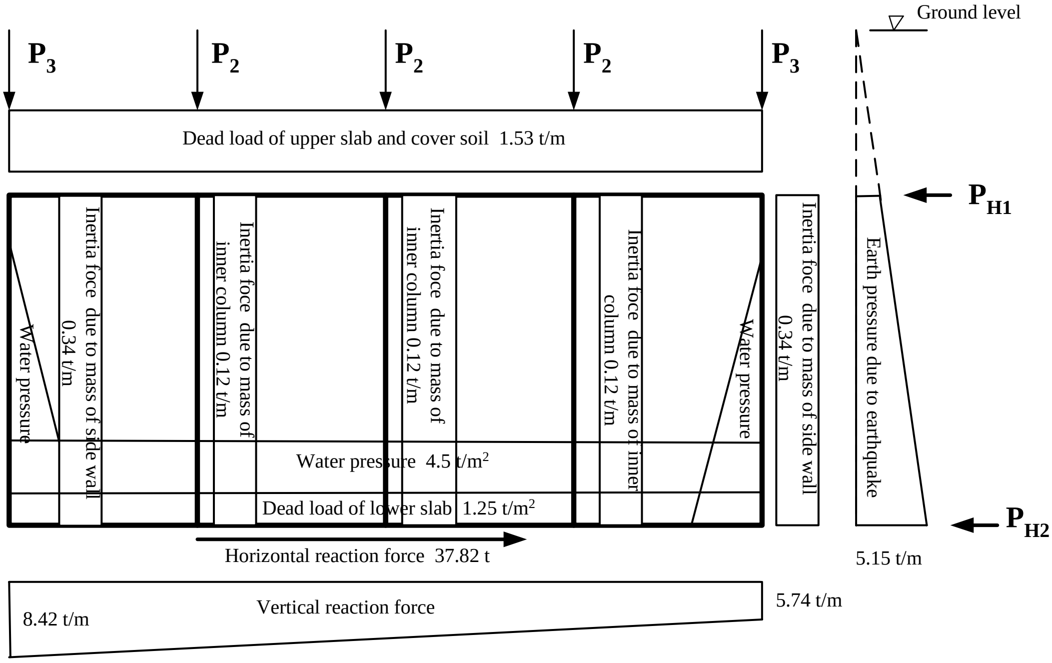
(2) Case 2：One compartment is full of water



Source: JICA Study Team

Figure 2.4.6 Load Condition-Case 2 (Unneutral Water Loading)

(3) Case 3：Earthquake



Source: JICA Study Team

Figure 2.4.7 Load Condition-Case 3 (Service loading + Seismic inertia force)

PH_1: Vertical force of slab's dead load 3.43t

PH_2: Vertical force of bottom slab dead load 6.98t

Pew: Water pressure increase under earthquake 3.50t

P_2': Pier's load for earthquake 2.45t

P_3': Sidewall load for earthquake 6.92t

Water pressure:

Water pressure was modified reflecting rise or fall due to earthquake inertia. (rise for left hand side, fall for right hand side)

Assumption for soil pressure and ground level:

The purpose of the analysis is to analyze the worst scenario for right side pressure, i.e. soil pressure from the right side is given maximum case under no restitution from left side.

2.4.6 Results and Revision

Based on the above mentioned analysis, stress intensity of reinforcement bar and concrete was checked as the following table. Appendix to Chapter 2 shows the calculation results.

Table 2.4.5 Stress Intensity of Reinforcement Bar and Concrete

		Lower End of Side Wall	Upper End of Side Wall	Upper Slab		Lower Slab		Lower End of Column
				At Column Line	Cross-Column Line	At Column Line	Cross-Column Line	
Critical Load Case		Case 1	Case 3	Case 1	Case 1	Case 2	Case 2	Case 3
Bending Moment (tm)		7.50	2.99	2.67	2.41	5.43	4.04	3.33
Axial force (t)		12.5	—	—	—	—	—	46.5
Width (cm)		100	100	100	100	100	100	40
Height (cm)		60	30	25	25	40	40	40
Cross Sectional Area of Reinforcing Bar (cm^2)		D25 @ 20 24.55	D16 @ 20 10.05	D14 @ 7.5 20.53	D14 @ 15 10.27	D18 @ 7.5 29.99	D12 @ 15 7.53	D18 × @ 8 7.65
Cover (cm)		5	5	5	5	5	5	5
Concrete	Sstress Intensity (kg/cm^2)	15	39	32	40	21	29	86
	Allowable Sstress Intensity (kg/cm^2)	80	120	80	80	105	105	120
Reinforcing Bar	Sstress Intensity (kg/cm^2)	613	1,865	780	1,330	598	1,731	380
	Allowable Sstress Intensity (kg/cm^2)	1,600	2,400	1,600	1,600	2,000	2,000	2,400

Source: JICA Study Team

It is assumed that the increase of the allowable force is stated as follows:

・Test case (one partition is full) 1.25

・Earthquake 1.50

Based on the analysis, following bar size has changed.

Top slab bar - D12→D14（Whole bar arrangement）

D10→D14（Cross-Column Line）

Regarding sidewall’s D 24, it has changed to D 25 to follow

Pier lower part ８-D16→８-D18

2.4.7 Distribution Pipe

1) Planned Service Area

Water supply service area covers Bam city (approx. 39 km²), Baravat urbanized area (approx. 17 km²), the northern and northeastern villages of Bam such as Posht rood, Esfikan, Rahim Abad, Khagei Bala, Nartig, and Kork.

2) Distribution Block

Bam service area has a slope evenly tilting toward the east. The altitude ranges from 1,130 m at the westernmost point to 1,020 m at the easternmost point of the service area. Existing distribution reservoirs are located in the southwest of the city to distribute water by gravity. The service area of Bam is divided into two blocks; West Block and East Block. The No. 1 reservoir (R1), located near the intersection of Amir Kabir Street and the main road (Kerman to Bam), distributes water to East Block. The No. 2 reservoir (R2), located 1.7 km away from the main road, distributes water to West Block. The water level of this reservoir is approximately 1,160 m above the sea level.

The altitude of east block ranges from 1,080 to 1,020 m, so that excessive water pressure may be seen through the distribution network in eastern part of the block during the night. Due to the excessive water pressure during the night, the east block shall be divided into two areas, connected with two pipelines. The water to the east area is supplied through western pipe network and two pressure-reducing valves.

A planned service area of Baravat is approximately 17 km² and its altitude ranges from 960 to 1,010 m. The water is supplied from two reservoirs newly constructed at the middle of the service area of Bam and Baravat. The water level of these reservoirs is approximately 1,040 m above the sea level. The planned service area of Baravat is divided into two blocks, north and south.

3) Hydraulic Calculation

Hydraulic calculations to determine pipe diameter were made based on the following conditions:

- Computer software for analysis: EPANET 2.0
- Head loss formula: Hazen-Williams
- Roughness Coefficient
- Diameter of 110 mm or less: 130
- Diameter of 150 mm and over: 110
- Minimum water head at junction: 20 m

4) Planned Distribution Pipe Network

Preliminary design with target year 2031 was carried out by Jooyab-nou Consulting Engineers based on the aforementioned conditions.

Table 2.4.6 Length of Distribution Pipe by Diameter

(Unit: m)

Dia.(mm)	Bam East	Bam West	Baravat North	Baravat South	Total
110	64,950	43,220	20,140	30,420	158,730
150	35,490	7,430	8,810	15,310	67,040
200	23,660	2,330	1,250	8,660	35,900
250	4,840	2,210	360	2,570	9,980
300	3,150	1,560	-	840	5,550
350	-	3,320	-	-	3,320
400	8,670	-	-	160	8,830
500	390	-	-	-	390
Total	141,150	60,070	30,560	57,960	289,740

Source: Jooyab-nou Consulting Engineers

Note: The table does not include the length of existing pipes, which will be used in the future.

2.5 Reconstruction

2.5.1 Introduction

JICA decided to construct a water reservoir including installation of distribution pipe as a pilot project for the rehabilitation and reconstruction in Bam, because water supply system has suffered earthquake damage, and it is very difficult to distribute water by temporary pipe and water tanker. Moreover, water is the basic need for the victims. General information on the construction works is given below.

1) Water reservoirs

Capacity: 2,000 m^2

Structure: Reinforced Concrete

Construction period: 5 months

Contractor: Mahan Sazeh Gostar (Kerman Province)

Others: Pump house and gatehouse

2) Pipe installation

Construction area: 33 km in zone 1, 2 and 3

Installed pipe: High-density polyethylene pipe for 110 mm diameter pipe

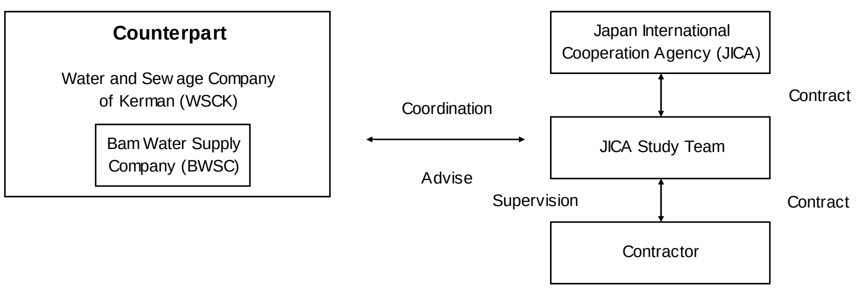
Ductile iron pipe for 150 mm diameter pipe and over

Construction period: 5 months

Contractor: Atie Kavir (Kerman Province)

2.5.2 Organization

Organizations for the construction works supervision are summarized as follows:



Source: JICA Study Team

Figure 2.5.1 Organizations of Construction Works Supervision

In order to carry out the construction, the Study Team has discussed closely with WSCK, which is the responsible agency for water supply in Kerman province. Apart from those shown in the organizational chart, WSCK hired local consultants, Jooyab-Nou Consulting Engineers, to design and supervise the Bam rehabilitation. The JICA Study Team has been working with the local consultants for future development policy and design conditions. The supervising organizations also worked with the local consultants to coordinate to other facilities.

2.5.3 Methods of Supervision

In general, supervision of the construction works covered four items:

- Construction schedule management
- Quality control
- Cost management
- Safety control

More specifically, the construction supervision services are based on the following duties and responsibilities:

- Supervision of the contractor's construction program and quality control, by such means as approval and inspection of construction materials and works.
- Inspection and approval of dimensions, and numbers of the constructed works and facilities.
- Minor alterations to the tender specifications and drawings.
- Preparation of reports and papers as required by WSCK and JICA.

The above services were required from commencement of the construction to completion of all the construction works. Throughout the construction period, the Study Team Engineer is assigned to the Project's site to supervise and coordinate the construction works. Experts in several professional fields were dispatched to the Project site, in addition to the Study Team Engineer, as deemed necessary, for smooth implementation of the work.

2.5.4 Project Management

1) Subject of the Study Team's Management

It was clearly pointed out what the Study Team checked, controlled and managed in this Project. The Study Team's management activities consisted of the following four subjects:

(1) Document Checkup

The Consultant checked, controlled and managed the materials as well as methods which the Contractor employed, and the results which the Contractor thereby created, by the documents that the Contractor sent to the Consultant for approval, in light with the specifications stipulated in the tender documents.

(2) Job-Site Checkup

When construction work was ordinarily going on, the Consultant attended to the Contractor's work practices and inspection activities at construction site, as the need arose. It should be noted, however, that the Consultant was not an inspector who works jointly with or on behalf of the Contractor, but a checker looking over whether the Contractor's work practices and inspection activities were appropriately carried out in accordance with the specifications in the tender-documents.

(3) Completion Checkup

When a given part or entire part of the Project's work was completed, in accordance with the Contractor's written request, the Consultant inspected the completed work to determine whether the work was completed according to the specifications.

(4) Report

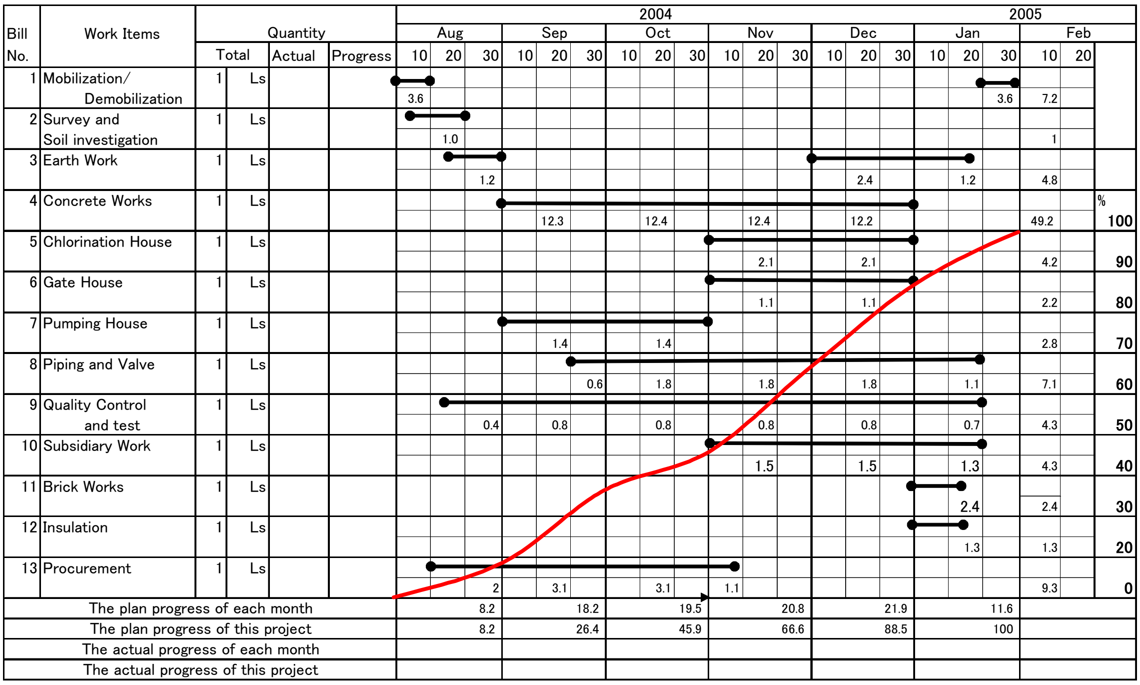
The Study Team gave a progress of the project as Monthly Report to WSCK and JICA.

2) Progress Control

The Study Team carried out a progress control of this project as scheduled and completed within contract period.

(1) Construction Schedule Chart

Construction schedule was shown below as an example. The actual progress was different from the figure.



Source: JICA Study Team

Figure 2.5.2 Construction schedule

(2) Progress Report

The Study Team checks the progress report submitted by the contractor every month and reports to the JICA and WSCK as monthly report. Monthly reports contained the progress, results of quality test, data of construction materials, instruction letter, schedule of next month and any events.

3) Quality control

(1) Quality Control Process

Quality Control (QC) should be carried out in conformity with the designs and specifications in the Tender Documents and should be based on the internationally authorized standards stipulated in the Tender Specification.

In this Project, a process of QC was summarized in the following table.

Table 2.5.1 Quality Control Set-up Before the Work

QC Process Flow			
What should be inspected as QC?	What document should be produced as QC?	Who should produce such document as QC?	Who should check and approve such document as QC?
1.Construction Method	Shop Drawing Approval Docs. Work Execution Plan	The Contractor	The Study Team
2.Installation Method	Shop Drawing Approval Docs. Work Execution Plan	The Contractor	The Study Team
3.Materials			
(1) Construction Materials (ex. cement, aggregate, re-bar, pipe, valve, fitting, etc.)	Shop Drawing Approval Docs. Work Execution Plan	The Contractor	The Study Team
(2) Operation Equipment (ex. chemical dosing system, flow meter, etc.)	Shop Drawing Approval Docs. Work Execution Plan	The Contractor	The Study Team

Source: JICA Study Team

(2) Analysis and Tests for Quality Control

Testing and analysis of the following items for quality control were done by the Contractor.

Table 2.5.2 Items for Test and Analysis

Test Item	Standard	Remarks
Water Content	ASTM-D2216	soil condition at site
Grain Size Analysis	ASTM-D421	ditto
Permeability Test	ASTM-D24-34	ditto
Compaction Test	ASTM-D1557	ditto
Specific Gravity	ASTM-D853	ditto
Direct Shear	ASTM-D3080	ditto
Atterberg Limited	ASTM-D423-425	ditto
Consolidation Test	ASTM-D243	ditto
Triaxial Compression Test(CD)	ASTM-D4768-88	ditto
Unconfined Compression Test	ASTM-D2166-66	ditto
Density Test(field)	ASTM-D1556	ditto
C.B.R	ASTM-D1883	ditto
Compressive Strength Test	ASTM-C39-83b	for Concrete
Slump Test	ASTM-C505-509	ditto
Hydrostatic Test		Pressure and leakage for pipes installation

Source: JICA Study Team

Regarding material and workmanship, the JICA Study Team prepared the inspection sheet and control the quality on the following items.

Table 2.5.3 Quality Control Items

Quality Item		Test/Inspection/Check/Measurement
Material	Concrete	Design mix, Compression Test、Temperature of concrete and air, slump test、Inspection of concrete factory, Check of method statement,
	Re-bar	Mill sheet
	Cement	
	Brick	Sample check
	Tile	
	Drain material	
	Backfill material	
	Water stop	
	Pipe	Pressure test
Workmanship	Fabrication of re-bar	Measurement of dimension
	Formwork for concrete	Observation

Source: JICA Study Team

(3) Controlling Form of the Work Done

The plan of the controlling form of the work done was shown in the table below; photos were taken of all works.

2.5.5 Safety Control

1) Emergency Contact Members and Organizations

The emergency contact numbers and organizations in case of accident and emergency were shown in the figure below.

2) Safety Control Check Points

To ensure a safe and clean work environment, the following items were checked. The Study Team requested the Contractor to submit the safety control activities report every month.

(1) General

- Advance confirmation of working method, procedures and staff in charge for each work
- Port of helmet and safety shoes
- Work stoppage due to bad weather condition with strong wind and/or heavy rain

(2) Mobilization, setting-up and demobilization

- Prohibition of over-loading and pre-studying of the access condition
- Prohibition of entering within the working radius of a crane
- Ensuring safety and working passes
- Placing fire extinguishers at appropriate locations
- Keeping the site clean and putting machinery, equipment and hand tools in order after the work

(3) Earth work, Concrete work, Housing Work, etc.

- Inspection of machinery, equipment (checking oil level, wire slings, etc.) and hand tools prior to the commencement of work
- Paying attention to safety around workers and ensuring a signal between operator and assistants during the operation of construction equipment.

2.5.6 Major Instruction to the Contractor

Since the reservoir was made from reinforced concrete, the equability of the concrete determined the quality of the reservoir. The JICA Study Team was very much concerned about controlling the concrete quality in terms of material used, mixing procedure, concrete casting and curing of the concrete. In order to control concrete quality, the JICA Study Team gave firm instructions on the following points:

1) Stage placing concrete wall

To prevent concrete separation, the JICA Study Team firmly instructed the Contractor to use stage placing of wall concrete. Two-stage construction was applied to cast wall concrete.

2) Treatment of careful construction joint

The JICA study Team also instructed the Contractor on treatment of the construction joint because of control of concrete quality.

2.5.7 Recommendation to Contract Practice in Iran

1) Improvement of technical level

The engineers at construction site lacked skill and engineering knowledge for the construction. Holding a seminar-workshop for them before construction was useful for improving their level of knowledge as construction engineer.

2) Equipment provision

In general, the construction industry is heavily depending on manpower in Iran. It was recommended that use of heavy equipment in construction was promoted at the national level. Since construction equipment was rented, it was very difficult to keep a certain schedule. The construction plan was prepared to prevent any delay of schedule.

3) Improvement of management skill

The contractor should improve management skill regarding construction schedule, construction methods and purchasing of materials. Construction plan should be formulated at the time of bidding.

2.6 Looking Beyond the Bam Earthquake

The Bam earthquake is a turning point of Iran's earthquake disaster management system for a couple of reasons, while earthquake damage has been reported in rural area in Iran. First, the earthquake happened in an urban area, though small compared to Teheran area, and second, the casualty rate is astonishingly high. The Bam earthquake showed how the urban area is vulnerable against earthquake. In fact, more than 20% of residents in Bam have lost their lives.

Just after the earthquake, JICA dispatched a fact-finding team followed by an emergency relief team. Since then, the JICA Study Team has been stationed in Bam. Members of the Study Team are eyewitness to what happened in Bam and how the reconstruction work has been progressed in Bam. Therefore, it is important to relay feedback of the experience of Bam earthquake to Tehran and other cities in Iran. It is imperative to improve disaster management system in Tehran and other cities in Iran based on the Bam experience. The following shows the Study Team's view on "Lesson Learned" from Bam Earthquake for Tehran disaster management.

1) Lesson Learned 1: Similarity between Tehran and Bam

It is obvious that the weak buildings in Bam are the primary reason for the high human casualty and injury by earthquake. Most of the buildings in Bam are masonry structure and made from adobe (sundried brick) and brick. Masonry structures are weak against earthquake. Building type in Tehran is similar to those of Bam; most of the buildings are masonry structures made from brick. In fact, more than 60% of buildings in Tehran are masonry structure. Even in steel structure, the quality control of the building is not carried out appropriately, therefore the expected resistance capacity against earthquake is less than the design.

As the other similarities between Bam and Tehran, which prove the devastating damage estimation in the Microzoning Study, the similarity of earthquake magnitude of Bam and that of scenario earthquake in Tehran, and extent of damage in densely populated area in Bam and Tehran are also the key factors to be noted in this comparison.

Given the considerations above, it should be pointed out that the damage estimation by the Microzoning Study was proven to be realistic.

The most effective way to reduce the human casualty before the incident is the investment in building by reinforcing the structure and building more earthquake-resistant buildings. The Comprehensive Master Plan for Earthquake Disaster Management Plan for Tehran Area also pointed out the building strengthening is the first priority.

2) Lesson Learned 2: Importance of resident and government official's recognition of earthquake

The second lesson is the importance of the education and enlightenment of earthquake information to the residents and government officials. The people in Bam had little knowledge about earthquakes, and there was no procedure after the incident. The government sector had delayed the response to the situations.

The education and recognition of the earthquake are the most important aspects for the disaster management. The education and training should be the first priority for the residents and government officials in Tehran. The master plan study also put emphasis on the importance of community involvement and disaster training for the residents and government officials.

3) Lesson Learned 3: Role of government in the initial stage

It is usually pointed out that seventy-two hours after an earthquake of disastrous proportion is the critical time for rescue and relief activities. In Bam, usage of the seventy-two hours is not sufficient. Red Crescent Society has started activities just after the earthquake and lifeline companies also have started recovery work two hours after the earthquake. Red Crescent Society mainly carried out rescue and relief efforts in accordance with law. But the disaster management law in Iran is ambiguous about the role of government in disaster, especially coordination and instruction activities after the event. Therefore, the government’s response to the earthquake should be reviewed and an emergency response manual towards a more organized action should be formulated.

4) Lesson Learned 4: Necessity of securing the government functions

The government function should be secured after the earthquake, so as to rescue the victims, keep the civil life in order and secure the economic stability. If an earthquake occurs in a city where governmental institutions are concentrated, the national government will malfunction and cause serious disorder in the nation.

Tehran, the capital city of Iran, is the most important city in Iran. More than 26% of economic activities and national government functions are concentrated in Tehran. Especially, national government functions should be maintained after the earthquake as well. Malfunction of the national government will cause more serious problems at the national level.

Many people from outside Bam and who were not affected by the earthquake came to the damaged area; they lined up to receive the disaster relief items and there were also reports of looting. This is why it is important for the government to maintain the security of the victims. The government should be ready to function just after the earthquake.

5) Lesson Learned 5: Coordination system for receiving international relief aid and NGOs

Iran accepted aid from international NGOs for the first time after the Bam earthquake. It can be expected that after a major incident, international aid and relief teams as well as international NGOs and the International Federation of Red Crescent Society will come to assist victims. Each NGO has its own interest and idea on how to operate after an incident. In Bam, the damaged area is divided into 13 areas for the deployment of international relief efforts. Therefore, Tehran also should start planning the logistics on acceptance of international assistance.

6) Lesson Learned 6: Preparation of temporary and permanent house constructions

In Japanese experiences, the repair and reconstruction of permanent houses is the first step towards rehabilitation. In Bam, construction of temporary housing does not work well because many people do not want to move out of their houses. It is quite understandable from the victim's point of view—they want to take care of their property.

For the case of scenario earthquake in Tehran, it is more difficult to precede temporary house construction, since the numbers of affected people in Tehran, required numbers of temporary housing and land for construction site would be considerable compared to that of bam. In addition, problem of property rights would increase the difficulty in proceeding the temporary housing transition. Preparation of evacuation site and temporary housing construction places in advance of disaster event is of great importance for transition from emergency response to rehabilitation and reconstruction as smooth as possible.

7) Lesson Learned 7: Preparation of earthquake damage in mega-city

A mega-city like Tehran should prepare beyond the Bam experience. The Bam earthquake provides many lessons and experiences for disaster management, yet Tehran should also learn from past experiences of other cities all over the world. In order to minimize the damage, the secondary damage should be avoided.

The following show Japanese experience for the mega-city:

1. Support for commuting residents by providing food and drinks.
2. Control of private car use and control of traffic in the emergency road network.
3. Urban planning process after the incident is established to formulate in a short period of time.
4. Preparation for flood-calls within and outside the city.
5. Establishment of foreign residents support system.
6. Establishing community level organization before the incident.

8) Lesson Learned 8: Restoration of normal life

After the disaster, the victims need to buy daily necessities and earn their own livings. Restoration of normal life through revitalization of economic activity is also important for residents. Banking system should return to normal at the earliest possible time after the disaster. Working place and office should be reopened as soon as possible. Shops and commercial activity should also be started soon. The government should support those aspects as well.

The following items should also be taken into account for early restoration:

1. Medical and health support for victims.
2. Education facility and cultural and religious facility.
3. Mental and child care after the incident.

The government should provide job opportunity for victims. Many people will lose their jobs because of damage to production facilities. The government should support restoration of those facilities and provide job opportunity.

9) Lesson Learned 9: Urgent repair of lifeline system

In Bam, lifeline damage is relatively small compared to building damage. Since many of the buildings have been damaged, water and telephone lines connections are damaged, too. In water supply, temporary repair has finished, yet most pipes have been damaged because they were made from asbestos. Therefore, the water supply authority should prepare rehabilitation of water supply system plan.

To provide lifeline services is the responsibility of each company. Services should be maintained after the disaster.

10) Lesson Learned 10: Technology transfer from Tehran Municipality to other cities in Iran

In Tehran, the JICA Study Team has been working for two years to formulate a comprehensive earthquake disaster management plan. Since the Microzoning Study started in 1999, Iranian side has gained more knowledge, experience and leadership as to microzonation technique, formulation of disaster management plan, promotion of community level disaster management activities, rehabilitation and reconstruction procedure and so on.

In Iran, a consciousness towards disaster preparedness of all the entities at government and community levels is widely increasing. As a leading entity of disaster management in Tehran, TDMMC should play an initiative role in disseminating those knowledge and experience to other entities in all over the country, by promoting training courses targeting on officials, organizing workshops and seminars for community level disaster management activities, developing regulations relating to disaster preparedness, emergency response and reconstruction, etc.

2.7 Urgent Action

The master plan study in Tehran shows the 15 priority projects as urgent action plan for the earthquake disaster management. The master plan shows the complete mitigation and preparedness action plan. Experience of Bam earthquake helps determine the damage level for the preparation before a major incident. Huge damage makes emergency response more difficult, and more coordination problems may happen. Again the importance of the mitigation and preparedness before the event cannot be emphasized enough. Urgent action plans are already shown in the report. In this section, focus is on the more specific topics of the earthquake disaster management in Tehran.

1) Preparation of initial action by the government

The government's response to the Bam earthquake shows that there is some room for improvement on the organized action for emergency response period. The government sector should have a manual after the event, so that every government official could imagine what would happen next and how he/she can react in the emergency response period. The training of the government official will improve response capacity by the government. Also, it is important for the municipality government to coordinate activities and to give appropriate instructions based on the latest information.

The government should prepare the emergency response manuals for at least 72 hours after the event and emergency information system. Based on the information, the government sector should react according to the emergency situations.

2) Preparation of detailed rehabilitation and reconstruction procedure

The Bam earthquake has shown that reconstruction and rehabilitation takes time and causes many difficulties to the victims. As of March 2005, one year has passed since the earthquake struck in Bam, yet the actual rehabilitation of the Bam damaged area has just started. Permanent house construction has not started yet. Rehabilitation of water supply system will take one more year to install the pipes. It is a big question whether Tehran can stand still for one year for rehabilitation.

Rehabilitation and reconstruction plan should include economic and industrial sectors. The government should start thinking how to rehabilitate those sectors after the event. Private sector is the key for rehabilitation. In normal time, the disaster prevention and management should include private companies and factories.

Experience of other areas in Iran and overseas may apply to the rehabilitation and reconstruction of the damaged area, yet the characteristics of Bam and Tehran are unique. Therefore, a unified approach for reconstruction may not fit in Tehran area. Before the event, the government should prepare several options for the rehabilitation. Here are some to consider: to rehabilitate and reconstruct Tehran again or to just move to another area. It is not a technical decision but rather a political decision. In any case, to secure capital function, redundancy of the government function and information should be secured before the incident.

3) Community involvement for disaster management

The community activity and disaster training should be included in the disaster management in Tehran. The training and enlightenment of the earthquake disaster management is a key to success. As recommended in the master plan report, community involvement should be whole residents.

4) Mental health and care for victims

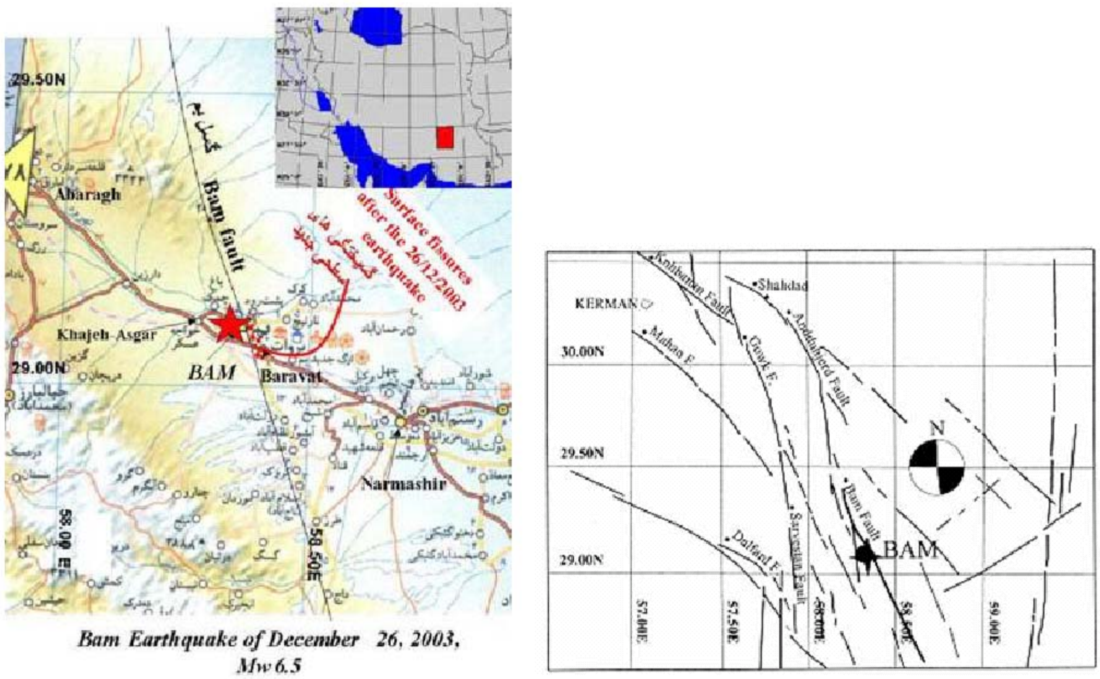
Mental health has become increasingly important to the recovery of victims of earthquake disaster as shown by recent experiences. As such, Bam earthquake victims also have great needs for mental care. Ministry of Health and other organizations should prepare for the care and necessary treatment after the disaster.

CHAPTER 3 BAM EARTHQUAKE

3.1 Intensity and Characteristics of the Bam Earthquake

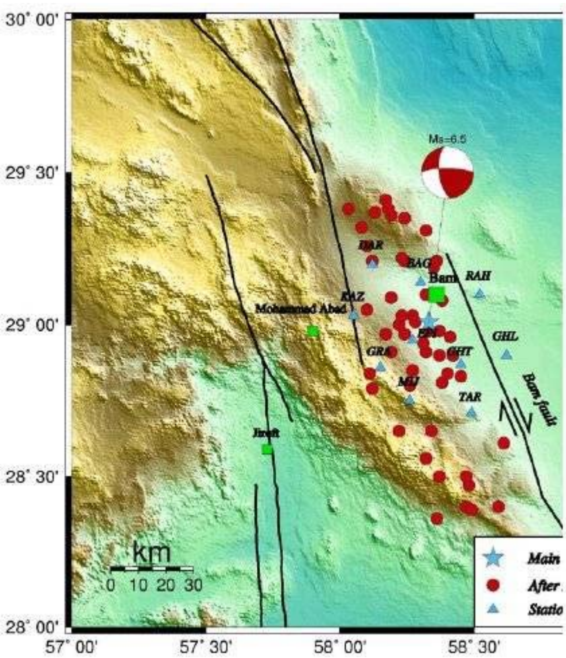
The earthquake hit Bam and the surrounding areas at 5:26 in the morning on December 26, 2003, measuring 6.5 on the Richter scale. According to seismologists, the earthquake was one of the shallowest recorded with a focal depth of only 10-12 km, and the epicenter was directly underneath Bam city where a main earthquake fault line can be found. The earthquake was the worst one to hit the country in more than a decade. USGS reported Ms=6.8, Mb=6.0 and Mw=6.5 as the extent of the earthquake in the Bam areas, and Harvard university reported Mw=6.6, Tokyo university at Mw=6.7 and Building Research Institute in Japan at Mw=6.5.[1]

The report of IIEES is shown in Figure 3.1.1 regarding the epicenter and focal mechanism of the earthquake, and that of USGS is shown in Figure 3.1.2. Figure 3.1.3 shows the distribution of fault-slip estimated using the inversion analysis by Yuji Yagi. The analysis of stress change on the fault plane due to fault-slip done by Yagi is also shown in Figure 3.1.4.



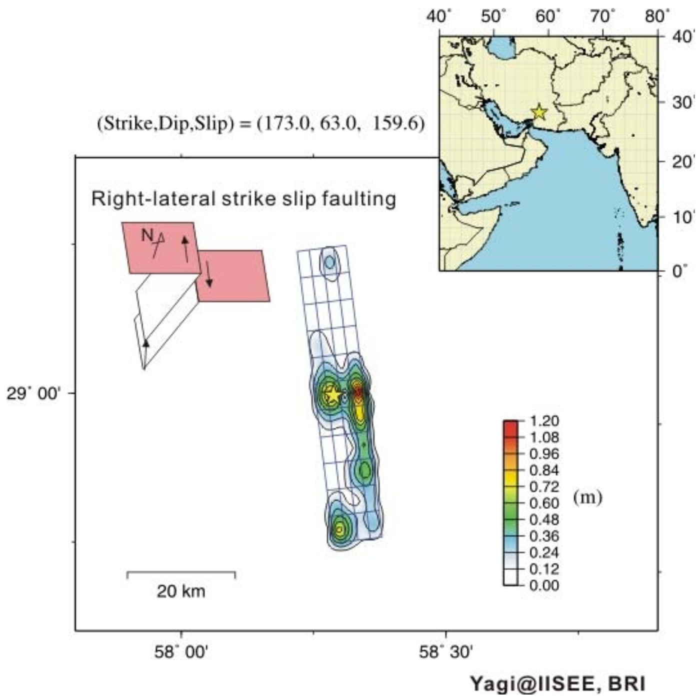
Source: International Institute of Seismology and Earthquake Engineering (IIEES)

Figure 3.1.1 Location Map of Bam Earthquake



Source: IIEES

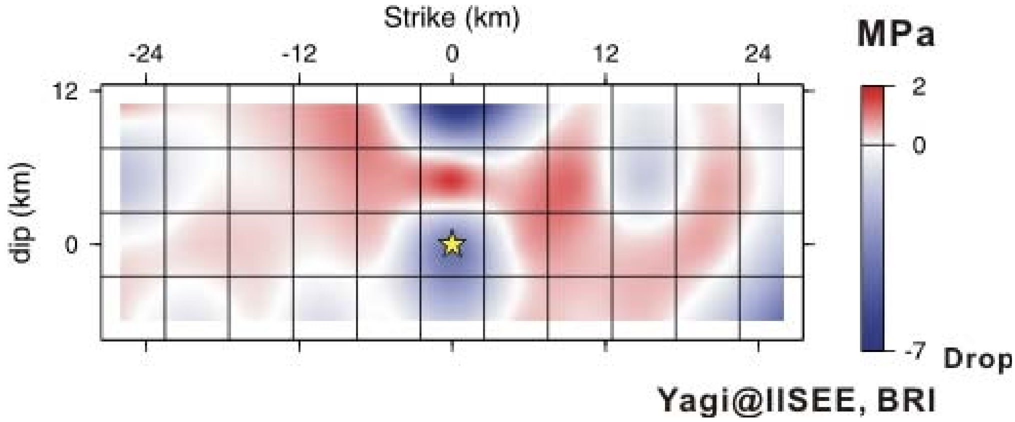
Figure 3.1.2 Bam Fault and Epicenter



Source: IIEES

Figure 3.1.3 Distribution of Fault-Slip (by Yagi)

[1] Mw is the unit used to express the magnitude of damage based on the physical condition of fault.



Source: IIEES

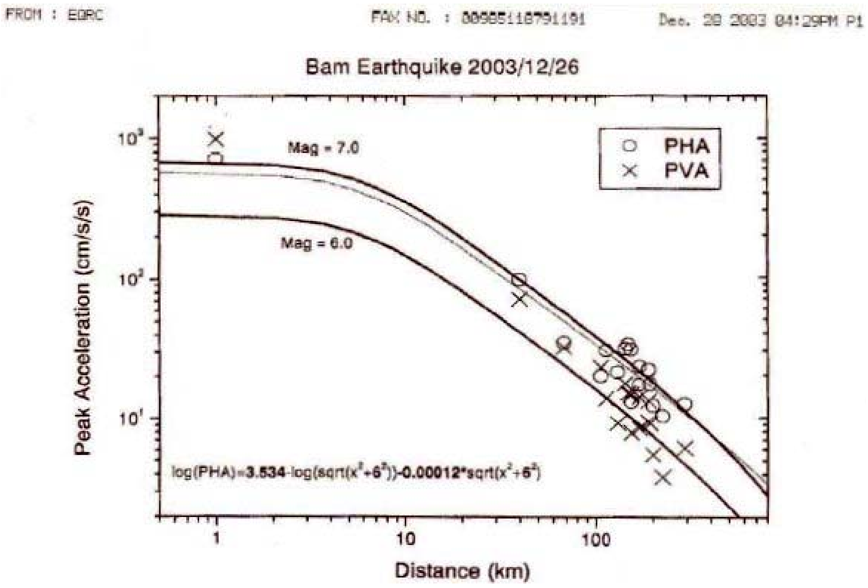
Figure 3.1.4 Stress Change on the Fault Location due to Fault-Slip (by Yagi)

Table 3.1.1 Specification of the Accelerograms of Main Shock recorded by Accelerographs

Site Name	Record No.	Geographic Coordinates		Marcoscismic Center		Distance (km)	Reporter	Uncorrected PGA cm/s/s			Height from sca	Installation angle	
		E	N	E	N			L	V	T		L	T
Bam	3168/02	58.35	29.09	58.40	29.21	14	IGTU	799.06	988.50	636.37	1094	278	8
Mohamad abad Maskoon	3162/01	57.89	28.90	58.40	29.21	60	IGTU	123.52	70.74	71.40	1961	350	80
Jiroft	3170/02	57.74	28.67	58.40	29.21	88	IGTU	40.33	31.81	28.30	725	240	330
Jushan	3156	57.60	30.12	58.40	29.21	127	IGTU	24.99	17.52	36.64	1650	142	232
Anduhjerd	3164	57.75	30.23	58.40	29.21	130	IGTU	32.05	14.91	34.38	851	200	290
Sirj	3161	57.55	30.20	58.40	29.21	137	IGTU	31.13	14.64	29.71	1685	30	120
Golbaf	3155/02	57.72	29.88	58.40	29.21	99	IGTU	30.78	13.70	29.46	1698	150	240
Kerman	3157	57.04	30.29	58.40	29.21	178	IGTU	18.75	9.40	25.03	1767	175	265
Ghalchganj	3163	57.87	27.52	58.40	29.21	195	IGTU	21.04	13.99	24.99	439	210	300
Nosratabed	3160	59.97	29.85	58.40	29.21	168	IGTU	19.79	13.16	23.92	1115	284	14
Kahnuj	3166	57.70	27.94	58.40	29.21	157	IGTU	23.53	9.24	18.55	556	20	110
Cheshmesabz	3169	56.42	29.46	58.40	29.21	194	IGTU	23.39	9.15	11.09	2581	65	195
Rein	3167/02	57.44	29.59	58.40	29.21	102	IGTU	21.49	22.95	18.08	2195	334	64
Shahdad	3165	57.69	30.41	58.40	29.21	150	IGTU	20.50	8.49	13.55	515	78	168
Bardseer	3172	56.57	29.92	58.40	29.21	194	IGTU	13.97	5.50	10.43	2113	75	165
Mahan	3159	57.29	30.06	58.40	29.21	143	IGTU	12.70	7.88	13.26	1864	150	240
Ravar	3173	56.79	31.26	58.40	29.21	275	IGTU	12.47	6.15	12.62	1244	320	50
Bolvard	3154	56.05	29.42	58.40	29.21	229	IGTU	10.11	3.83	10.45	2088	145	235

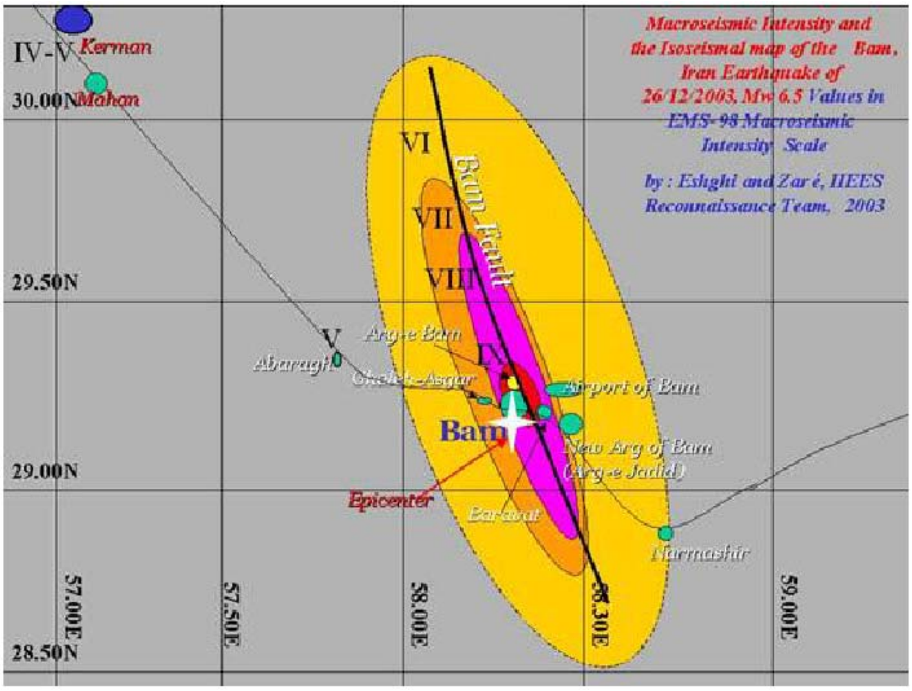
Source: BHRC

The largest value for horizontal peak ground acceleration is recorded at No.1 site, which is shown in Table 3.1.1. No.1 site is located 14 km from the epicenter and it recorded 799.06gal. Attenuation curve is summarized in Figure 3.1.5. Figure 3.1.6 shows the distribution of the macro seismic intensity of the earthquake analyzed by IIEES.



Source: Ministry of Housing and Urban Development, Building and Housing Research Center.

Figure 3.1.5 Attenuation Curve



Source: IIEES

Figure 3.1.6 Distribution of the Macro Seismic Intensity of the Earthquake

As Figure 3.1.6 shows, macro seismic intensity of the earthquake for almost all of Bam urban area is lo=IX in the European Macroseismic scale.

If the PGA value for No.1 site, 799.06 gal, is applied to the equation below (by Trifunac and Brady, 1975), the figure of "modified Mercalli intensity scale" is corresponded to 9.6.

$$\log(a) = 0.014 + 0.3 \times I$$

The findings indicate that the intensity of the earthquake in almost all urban area of Bam shows same magnitude, yet Figure 3.1.3, Distribution of Fault-slip (by Yagi), implies that it could be some larger intensity area in the southern side of the epicenter, while the northern area of epicenter, where the center of Bam is located, shows the only slip. Thus, it can be said that the seismic intensity was probably high in the southern area of the epicenter, yet it is, at the same time, difficult to accurately identify the seismic intensity because no building structure can be found on these areas.

The findings, therefore, imply that the intensity of the earthquake motion in the central area of Bam city corresponds to MMI 9, and the intensity of the earthquake motion of the Baravat area, the Bam airport and the Arg-e-Jadid area corresponds to MMI 8 or less than that.

3.2 Damage Assessment

1) Building Damage

More than 85% of buildings were completely destroyed and some 95% of the 2,500 years old historical archeological monument, internationally recognized Arg-e-Bam, was almost completely destroyed. Survivors had to move out from their house and live in tents or temporary housing on roadside or close to their damaged house. They were reluctant to move to emergency camps because of various reasons, such as security, inconvenience and psychological reasons.

The extent and distribution of damage can be illustrated as follows:

- Damage level in Bam and Baravat shows some difference, even though those two areas are not far from each other and from the fault line and epicenter.
- Many pancake-crushed buildings are found in the Bam areas.
- A significant correlation between the damage of buildings and intensity of earthquake motions was not found because the intensity of earthquake motions was very strong compared to the seismic resistance capacity of buildings.
- Earthquake resistance capacity of buildings is one of the dominant reasons for causing damages on building structures. Arg-e-Jadid area, especially, is different from the Bam and Baravat areas because the former have been developed recently targeting high-income residents, which implies higher quality building structures and with better earthquake resistance.

(1) Damage on Building Structures

Building structures in Bam municipality are classified into three categories according to their construction year: 1) Arg-e-Bam, built about 2,500 years ago, 2) the buildings in old core city, built about 150 years ago, and 3) the buildings built in the vicinity of revolution era.

Old buildings were mostly built with masonry, some of which are called “adobe,” which is made of sun-dried brick or burned brick. On the other hand, the buildings recently built have steel frame.

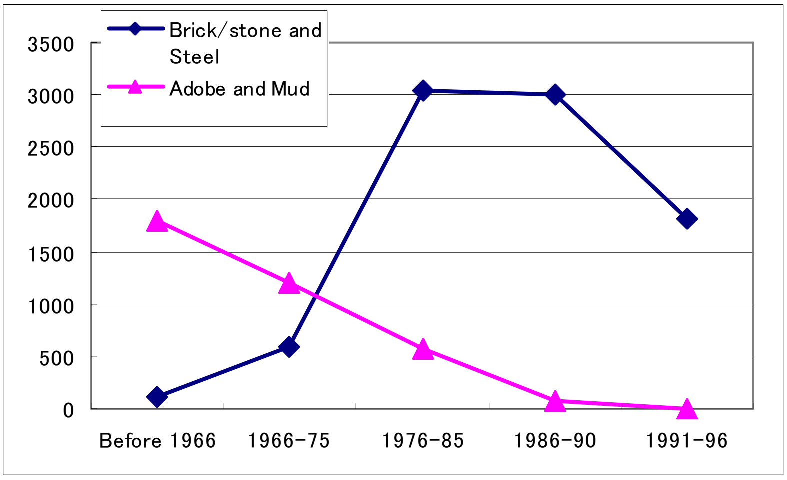
Table 3.2.1 shows the type of residential housing categorized by structure and material, built before 1996 in the Bam areas. As it shows, “steel frame” and “RC frame” are only at 0.3% to the total, and the majority of buildings is built with “brick/stone and steel” and “adobe and mud” at 68.2% and 29.1%, respectively.

Table 3.2.1 Type of Residential Housing by Structure and Material

Structure & Material	Numbers	Ratio (%)
Steel frame	20	0.2
RC frame	9	0.1
Brick/stone and steel	8,602	68.2
Brick or stone-brick	91	0.7
Adobe and mud	3,666	29.1
Others	43	0.3
Not specified	176	1.4
Total	12,607	100.0

Source: Statistical Data 1996. Central Statistical Survey of Iran

Figure 3.2.1 shows the trend of typical structure and material of residential buildings over the last decades. As it shows, the combination of adobe and mud used for residential buildings has decreased significantly over the years, and since 1986 it has not been used as much as before. Brick/stone and steel has taken the place of adobe and mud significantly since 1986 and has become the core structural material for building residential houses.



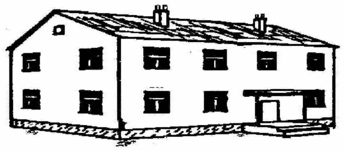
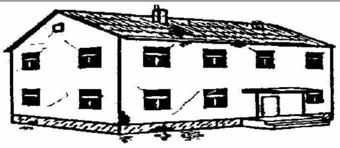
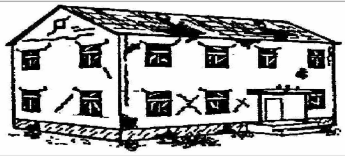
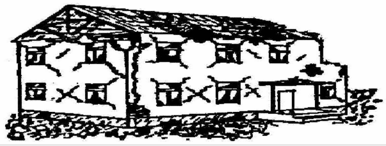
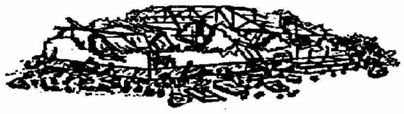
Source: Statistical Data 1996. Central Statistical Survey of Iran

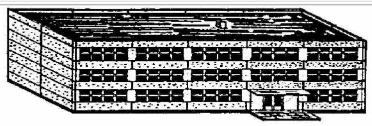
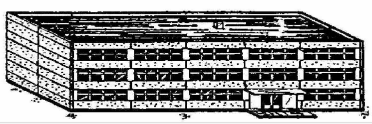
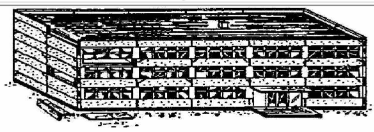
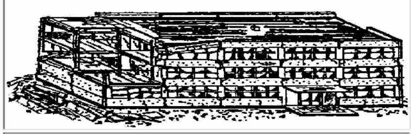
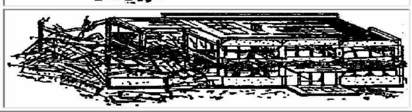
Figure 3.2.1 Residential Buildings Categorized by Year Built and Structure Type

Findings from the reconnaissance right after the earthquake and primary observation are as follows:

- The damage of most buildings in Bam is seen as Grade 5 in EMS-98 scale.
- Satellite image shows that there is some disparity in the extent of damage between the eastern side, where commercial complexes are located, and the western side where land is mostly agricultural. However, the Study Team found little difference on the damage level between these two areas after field surveys.
- The extent of damage on adobe (sun-dried brick) structures is rated Grade 5.
- The damage of steel frame buildings in the center of Bam city is mostly rated Grade 4.
- The damage of masonry and steel frame structures in western side of Bam city is mostly rated Grade 4, heavily damaged, and some of them are rated Grade 3.
- The damage of adobe structures in Baravat is rated Grade 5.
- Building structures in Arg-e-Jadid, mainly built with masonry, steel frame and RC, are less damaged than those in Baravat and Bam city.
- The damage observed at most buildings in Arg-e-Jadid is rated Grade 3, if they are inspected from outside, but the inside damage can be downgraded to Grade 4.

Table 3.2.2 Damage State in EMS-98

Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage** **(no structural damage, slight non-structural damage)** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
	**Grade 2: Moderate damage** **(slight structural damage, moderate non-structural damage)** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage, heavy non-structural damage)** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
	**Grade 4: Very heavy damage** **(heavy structural damage, very heavy non-structural damage)** Serious failure of walls; partial structural failure of roofs and floors.
	**Grade 5: Destruction** **(very heavy structural damage)** Total or near total collapse.

Classification of damage to buildings of reinforced concrete	
	**Grade 1: Negligible to slight damage** **(no structural damage, slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
	**Grade 2: Moderate damage** **(slight structural damage, moderate non-structural damage)** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage, heavy non-structural damage)** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
	**Grade 4: Very heavy damage** **(heavy structural damage, very heavy non-structural damage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
	**Grade 5: Destruction** **(very heavy structural damage)** Collapse of ground floor or parts (e. g. wings) of buildings.

Source: IIEES

Adobe

The majority of old buildings in the Bam areas are built with "adobe," or sun-dried brick. A typical shape of house is one-story, rectangle-shape with dome or cylindrical roof. Adobe is recognized as one of traditional forms of masonry in Iran, although the structure is significantly different from normal structure of masonry commonly known. Adobe is made with sun-dried brick and grouting materials, such as lime and clay mixture. A room of this type of building does not have a bind-up effect as a diaphragm; as a result, sidewalls easily fall down at the corner of building.

A foundation is not formed using this type of building material, but a mixture of lime and clay, or lime and sand is spread and compressed on the ground as flooring. Usually adobe is used to build very thick walls and they have caused large numbers of human casualties, once natural disasters such as an earthquake hit the areas.

Masonry

Masonry building is relatively new in the areas and masonry is made of burned brick, but sun-dried brick is used in some cases for inside core, i.e. burned brick is used only for surface layer of walls. It was found that almost all masonry buildings have flat roof supported by steel beams; yet, some of steel beams are not connected to brick walls. In some cases, steel column is used instead of internal brick walls, and this type of building looks like a steel-frame structure, but beam-column connections do not have sufficient strength and bracing is not installed in many cases; thus, steel frames do not have enough resistance against horizontal inertia force.

Masonry with Tie

The structural type of "masonry with tie" has horizontal tie on brick walls. Bricks are firstly piled and concrete tie is cast in those bricks, so there is no void between bricks and tie, and surrounding tie confines the brick walls. The brick walls are relatively resistant against vertical force. The role of tie is to bind up the walls, especially, binding effects of walls in different directions are effective for resistance against horizontal force.

Steel Frame

The concept of steel frame in Iran is somehow different than Japan's. A steel frame in Japan requires sufficient strength to every beam-column connection against base material; therefore, the connections form moment resisting frame, and ductility is gained to earthquake resisting motion. Nevertheless, most buildings in Iran do not reach this level of technology, although this concept is introduced in some standard and instruction manual.

Beam-column connection, in most cases, does not have sufficient strength compared to the base material because it is welded at site by filet welding. As a result, it does not form moment resisting frame. Some bracings are set to share resistance against horizontal force, but welding in gusset plate is also defective.

A space between frames is filled with infill wall, which is made of hollow brick or porous brick. The infill wall does not support vertical dead load because a slight void exists between frame and infill wall, so it does not provide sufficient resistance against horizontal inertia force due to insufficient shearing capacity of bricks. A brick wall is very heavy compared to recently developed materials, and it is one of the main reasons that most buildings in Iran do not have enough strength against an earthquake.

Reinforced Concrete

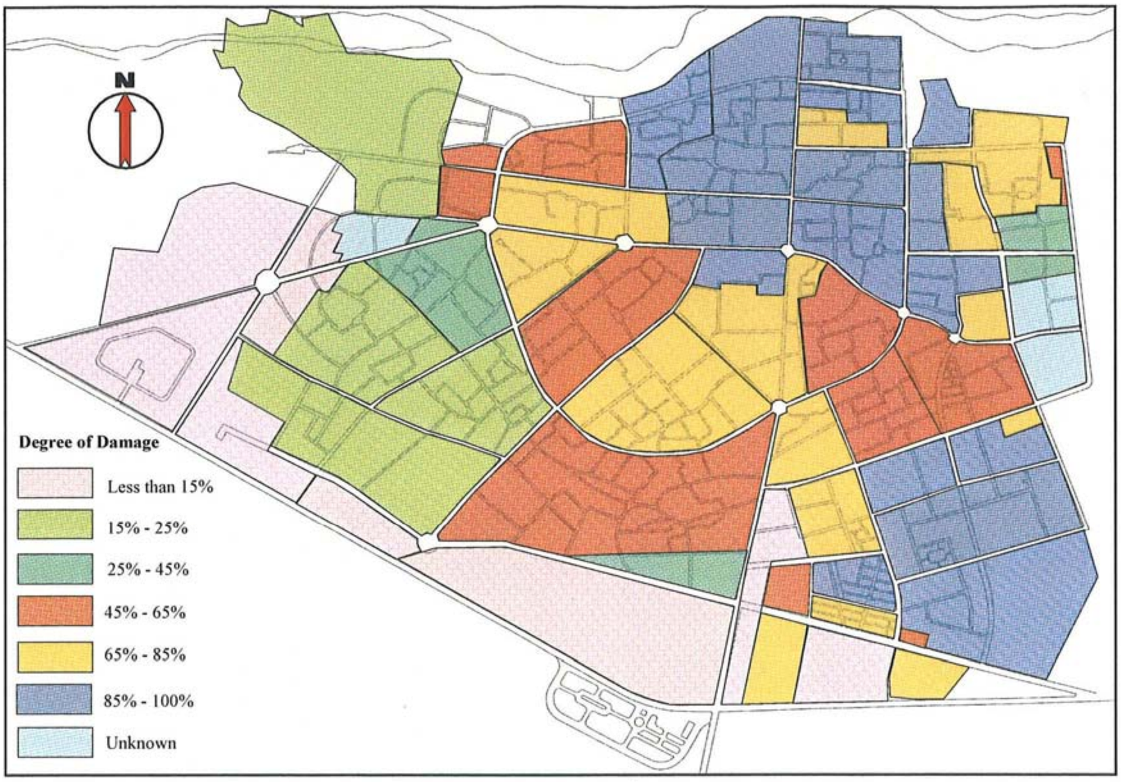
Only a small number of buildings are built as reinforced concrete structure in the Bam areas, and most of walls in the areas are made from hollow brick or porous brick. Since some void can be found between brick wall and reinforced concrete frame, the brick wall does not share a vertical dead load and there is no resistance on horizontal load when an earthquake hits. A floor in reinforced concrete structure is "joist and brick." This type of floor is very heavy compared to materials developed recently, and consequently it ruins the seismic resistance capacity of buildings.

Table 3.2.3 shows the estimated monetary damage caused by the earthquake. The estimate was done by a consultant hired by the Housing Foundation of Kerman. Figure 3.2.2 illustrates the damage of building structure due to the earthquake in Bam municipality.

Table 3.2.3 Estimated Monetary Damage caused by the Earthquake

Type of Facility	Number of Facility	Land Measure (m^2)	Damage Ratio (Max: 100%)	Amount (per m^2)	Total Damag in Monetary Value '000 (Rial)	Total Damage in Monetary Value Eqv. To '000US$
Education	83	544,208.42	60%	2,000,000	653,050,100	74,640
Medical facility	21	190,626.63	70%	4,000,000	533,754,580	61,010
Public & Municipality Bldg.	41	270,720.90	60%	2,500,000	406,081,350	46,410
Military	1	237,303.89	60%	2,500,000	355,955,840	40,690
Police	11	81,974.11	50%	2,500,000	102,467,630	11,720
Religious facility	54	77,867.76	60%	1,300,000	60,736,850	6,950
City services/Infrastructure	18	571,514.61	60%	3,500,000	1,200,180,680	137,170
Residential Bldg.	-	2,380,000.00	80%	150,000	285,600,000	32,640
Industrial Estate	50	135,190.84	60%	3,500,000	283,900,770	32,450
Roads	-	7,477,815.18	50%	200,000	747,781,520	85,470
Others	-	26,439,572.78	40%	700,000	7,403,080,380	846,070
Total		38,406,795.12				1,375,220

Source: Bam Reconstruction Master Plan. Bam Reconstruction Committee



Source: Bam Reconstruction Master Plan. Bam Reconstruction Committee

Figure 3.2.2 Building Structure Damage Map

2) Infrastructure

The damage observed after the earthquake is summarized by sector as shown below.

- Electricity Sector
  - 300 poles of medium-voltage power cables out of 5,200 poles were damaged.
  - 30,000 households received a half level of electric power, 14 MW, after the earthquake.
  - Insulators broke.
  - Electric cables got damaged due to the damaged electric poles.
  - A part of power transmission facilities was damaged
- Water Supply Sector
  - The system has a total of 9.3 km of conveyance pipe between wells and reservoirs and a total of 420 km of distribution pipe network. The network was heavily damaged.
  - 22,000 house connections were almost all destroyed and malfunctioned due mainly to the collapse of residential building.
  - Distribution reservoirs in Bam (R1 and R2) had little damage. On the other hand, the reservoir (1,600 m³) in Baravat was seriously damaged
  - The pump houses around R1 and R2 are made of brick and

	suffered quite big damage, especially, the pump houses of No.1 and No.2 wells, totally collapsed. The drawn quantity of two wells of No.13 and No.14 decreased to some extent
- Telecommunication Sector	• There is no major damage of telecommunication building facilities. • 18,000 telephone cables were unworkable. • Public telephones were also broken. • Mobile phone was temporarily malfunctioned right after the earthquake, but it functioned again within two hours.
- Road	• There was no major damage.
- Bridge	• There was no major damage.
- Agriculture	• Qanats received significant damages and major plants accordingly were adversely affected. • 1,500 livestock farmhouses were collapsed. • Market garden, 8,000 ha, somehow needs restoration.

3) Agricultural Damage

The study area has an average annual rainfall of only 60 mm; thus, the agriculture is highly dependent on irrigation. The total agriculture land is 8,000 ha and about 70% of the inhabitants depend directly or indirectly on agricultural activities.

The most important crop is the date palm. The dates produced in Kerman are said to be the best in quality in Iran and they command high prices. Iran is the biggest date producer in the world, producing about 980,000 tons per year. The average total production in Kerman is 250,000 tons, where 120,000 tons are produced in Bam.

Citrus are also important in the area and they are cultivated mixed with the date palm. Total citrus cultivation area is 10,000 ha, with an annual production of 80,000 to 90,000 tons. All of citrus production is for the domestic market.

Other crops such as pistachio (2,000 ha with 3,200 tons/year), vegetable, rape, barley, wheat, watermelon, Garmak (kind of melon), Henna (for cosmetic and medicinal purposes) and Vasmeh (black color for cosmetics) are also cultivated in the area. But they are not significant compared with the date and citrus. Vegetables consumed in Bam, for example, are produced mainly in Giroft. The alp alpha (14,000 ha) is also produced for livestock feed.

The irrigation in the area is highly dependent on a traditional water source system called qanat. There are qanats that were constructed 100 years ago in Bam. There are 374 qanats in the Bam, which were used for date palm farming.

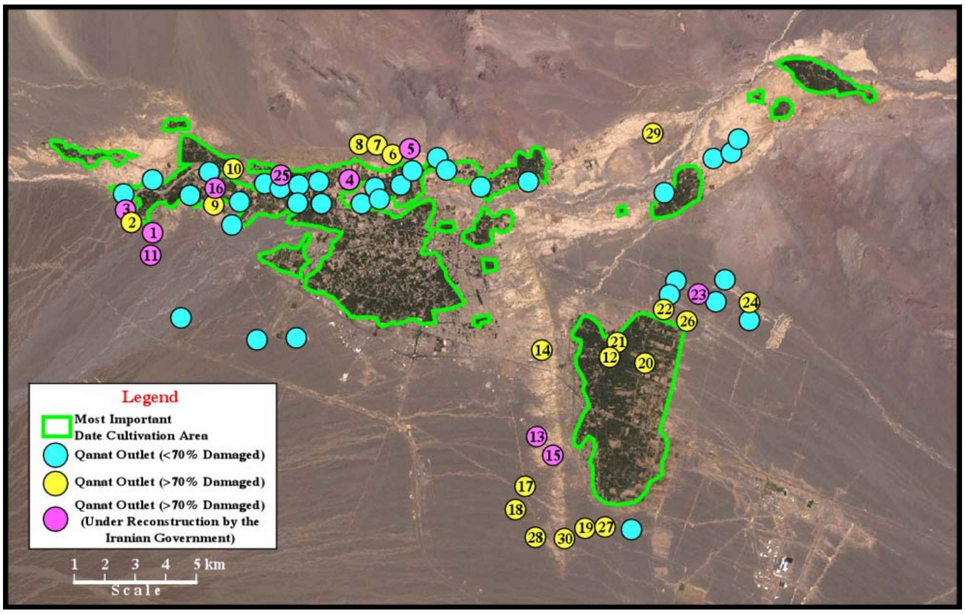
According to the Agriculture Management of Bam, the most damaged date palm farms are concentrated in the Bagh-Chamak (west part), north of Bam city, Spikan (north part) and Baravat (east part).

The Agriculture Management of Bam also says that the qanats are damaged and need urgent restoration.

Qanats

The earthquake damaged 64 of the 374 qanats in the region. Of the 64 damaged qanats, 30 are heavily damaged and need urgent restoration.

The damaged qanats' outlet distribution is shown in Figure 3.2.3.



Source: JICA Study Team

Figure 3.2.3 Damaged Qanat Distribution Map

As Figure 3.2.3 shows, the most damaged qanats are pointed in yellow and pink. The outlets shown in pink are those that the Bam government is working to restore at the moment. The Baravat area is the area that has the highest concentration of qanats with high damage level.

Before the earthquake 20 to 30% of the agriculture sector utilized deep wells. Now, as an emergency situation, 40 to 45% are using this resource to irrigate the farms.

Storage Facilities

The earthquake destroyed all package industries and damaged/destroyed 88 of the 110 storage facilities. The total storage capacity was about 100,000 tons, which was reduced to 40,000 tons after the earthquake.

CHAPTER 4 EFFORTS TOWARD RECONSTRUCTION OF BAM

4.1 Tasks Ahead

Rehabilitation and reconstruction of Bam in all its dimensions – social, economic, physical, cultural – poses a bigger challenge over the coming years. Given the magnitude of the disaster, it requires huge amounts of financial resources and work force to walk a long way to achieve total recovery, as well as to challenge to reduce the risk of future disaster by introducing innovative practices for a sustainable redevelopment of Bam.

The Iranian government has set up a multi-sectoral Task Force, in order to coordinate the reconstruction efforts and programs with sub-dividing the reconstruction by their specialties. According to the recent report from the Bam Reconstruction Committee, the government decided to rebuild the city in the existing urbanized area with some modification on the future city structural planning.

Under a supervision of Iranian Government, Iranian local consultant company has prepared the master plan for reconstruction of Bam municipality and neighboring areas. Yet its subsequent Action Plan will be ready sometime in year 2005. It would cover sector-base programs and projects for the reconstruction of the Bam areas with schedule and arrangement for required capital finds, financial resources and investment plans.

4.2 Reconstruction Requisites

4.2.1 General Urban Texture

1) Administrative Features

Kerman province is composed of thirteen townships (shahrestan), and each township is further divided into districts (bakhsh) that include city (shahr) and village (dehestan). Bam Township, locating in the eastern part of Kerman province, has an area of 19,374 km² and 242,438 populations in year 2002. Bam Township is composed of five regions, five cities and thirteen rural districts. As one of the five cities in the Township, Bam municipality is composed of two districts, seven sub-districts and twenty neighborhoods, with an area of 39 km².

2) Geographical and Climatic Conditions

Kerman Province is in southeastern edge of Iranian highland, and Bam is located on a flat land created by the dry river of Posht-rood. The altitude is around 1,000 m in height and the terrain is slightly tilting toward east. On its west and south, there is the mountain range of Jebal Barez.

The mountains have a peak of as high as 3,700 m and serve as the catchment to water resources for the Bam areas.

The temperature of the Bam areas is relatively low with an average temperature throughout the year of around 24.3ºC and an average lowest temperature in the winter of 6.4ºC given its high altitude.

3) Population

According to the Statistical Centre of Iran (SCI), the population of Bam Township before the earthquake in 2003 was estimated at about 223,415, which is almost 10% that of Kerman province. The Township's most populated area is Bam municipality. The population of Bam municipality in 2003 was 87,661 with population growth rates at 3.29% in urban area and 1.34% in rural area, and the average population density was 30 persons per hectare. The Baravat town had 16,888 populations in 2003.

Table 4.2.1 shows the population of Bam Township in 1996 and the estimated population based on the analyzed growth rate from 1991 to 1996.

Table 4.2.1 Population in Bam Areas before Earthquake

Area/Administrative Boundary	National Census (1996)	Estimated Population	
		2002	2003
Bam Township	198,435	219,790	223,415
Urban areas	91,538	111,255	114,774
Rural areas	106,897	108,535	108,641
Bam municipality	70,079	85,016	87,661
Baravat town	13,857	16,439	16,888
Total	**83,936**	**101,455**	**104,549**

Note: After the latest national census in 1996, population of Bam Township was adjusted to correspond to the new administrative boundary.

Source: Statistical Centre of Iran

After the earthquake, several institutions released data on before and after earthquake populations and their projections on population growth, yet their figures widely differed, as shown in Table 4.2.2. Considering continuous inflow of legal and illegal migrants and/or seasonal labors, which are unregistered from surrounding provinces and even from neighboring countries, it is presumed that capturing the exact number of residents in the affected areas is rather complicated.

Table 4.2.2 Comparison of Population Before and After the Earthquake

		UNOCHA	Statistical Centre of Iran (SCI) *	Bam Reconstruction Committee
Before Earthquake	Bam	120,760	89,145	n.a.
	Baravat	20,800	15,324	n.a.
	Total	**141,560**	**104,469**	**92,361**
After Earthquake	Bam	67,595	55,167	n.a.
	Baravat	15,875	13,532	n.a.
	Total	**83,470**	**68,699**	**60,000**

Note: Latest projection of SCI was applied. (June 2004).

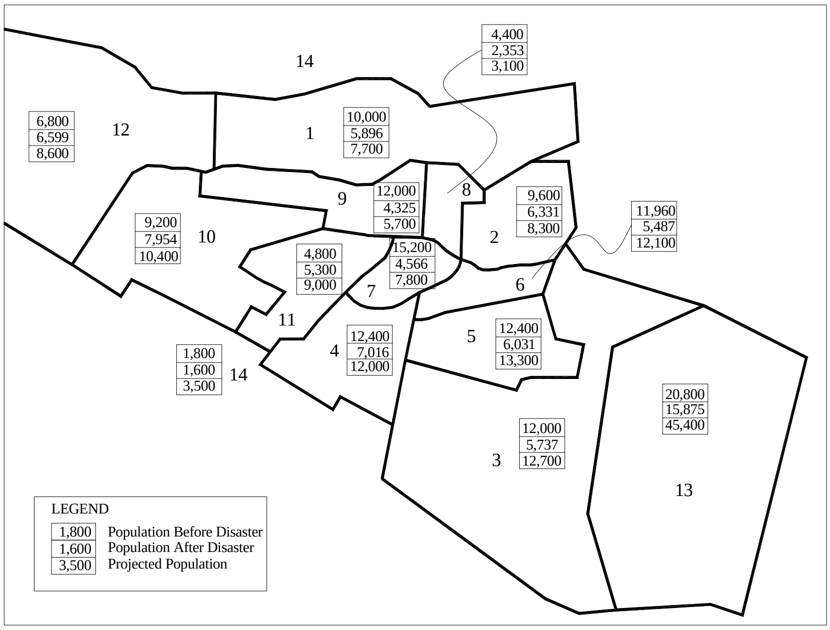
Source: UNOCHA, SCI and Bam Reconstruction Committee

Though each figures on the table above differs, three institutions estimated the population in year 2015 around 120 thousand to 160 thousand, and around 150 thousand to 220 thousand in year 2025. The Study Team has decided to adopt the projection by UNOCHA as the base to estimate water demand in the Bam areas and design mid- and long-term water supply master plan, as shown in Table 4.2.3 and Figure 4.2.1. The population projection seems to be between moderate to conservatively high growth rate.

Table 4.2.3 Population Projection by UNOCHA

	Zone	Before & After Disaster		Projected Population		
		Before	After	2004	2015	2023
Bam	1	10,000	5,896	2,603	3,920	7,700
	2	9,600	6,331	5,375	8,100	8,300
	3	12,000	5,737	26,424	39,820	12,700
	4	12,400	7,016	11,701	17,640	12,000
	5	12,400	6,031	11,255	16,960	13,300
	6	11,960	5,487	4,225	6,370	12,100
	7	15,200	4,566	2,937	4,430	7,800
	8	4,400	2,353	1,389	2,090	3,100
	9	12,000	4,325	2,680	4,040	5,700
	10	9,200	7,954	3,512	5,290	10,400
	11	4,800	5,300	2,340	3,530	9,000
	12	6,800	6,599	2,914	4,390	8,600
	14	1,800	1,600	706	1,060	3,500
Sub-total (Bam)		122,560	69,195	78,061	117,640	114,200
Baravat	13	20,800	15,875	7,009	10,570	45,400
Grand Total		143,360	85,070	85,070	128,210	159,600

Source: UNOCHA



Source: UNOCHA

Figure 4.2.1 Population Projection by Zone by UNOCHA

4.2.2 Reconstruction Context in Major Sectors

1) Agriculture

The economy of Bam district was essentially agriculture-based. The agriculture sector provided direct employment for over 25% of the population. Date palm plantation comprised 70% of the total area of Bam city, and further 4,000 hectares in Baravat, 10 km southeast from Bam. Most of date farmers were small holders and approximately 80% of irrigation to the agriculture is supplied by qanat system. The qanat, supplemented by deep wells and irrigation water canals supplied water to the agriculture fields, thus making the district one of the richest qanat-irrigated regions in Iran. Therefore, rehabilitation of qanat was the highest priority in this sector. Livestock farming was also an important part of the agricultural sector.

2) Tourism

The city of Bam is famous for its 2,500-year-old ancient architecture. The largest adobe (mud-brick) fortress in the world and tentative listed as world heritage site, the Arg-e-Bam, was almost completely destroyed. Owing to the monument, tourism sector drew in about 15,000 foreign tourists and 45,000 domestic tourists in 2003. Tourism used to be the second highest earning industry after agriculture. Its rehabilitation is a vital factor of economic revitalization of Bam.

3) Water Supply

The earthquake also damaged the water supply network and facilities in Bam and surrounding villages, resulting in disruption of water supply to most of the city. After the earthquake, water consumption amount has increased. The reasons are as follows:

- While the water from the water supply system is consumed only for domestic use before the earthquake, the water is also used for irrigation at present due to the damage of qanats irrigation system.
- The leaking water quantity from distribution pipes and service pipes is added to the increase of water consumption.
- The water from public tap seems to be used improperly even after the earthquake, although there is now some awareness of the need to conserve water.

Since water demand has increased in Bam and Baravat, WSCK expanded its water supply by renting one well in Bam from RWRCK and resuming the usage of one well in Baravat, which was not used then. Before the earthquake, 15 wells in Bam and 2 wells in Baravat were under operation. As two wells were newly developed after the earthquake due to the increased water demand, the total number of wells in the Bam and Baravat areas became 19. It is estimated that each well produces approximately 30 l/sec of raw water. One newly developed well in Bam directly provides water to the Bam area, and the other one in Baravat, located at No. 3 pump house, directly provides water to the Baravat area. After one compartment of Baravat reservoir was damaged, only No.2 well supplies raw water to the reservoir, and discharge pipes of No. 1 and No. 3 wells are connected to Bam distribution network.

Two reservoirs in Bam are still working under their original conditions; while the capacity of Baravat reservoir decreased from 1,600 m^3 to 600 m^3 due to earthquake damage in masonry reservoir.

As reconstruction efforts, WSCK commenced the three year project to rebuild 3,000 m^3 capacity reservoir and install 420 km of distribution pipe, based on the long-term water supply plan. JICA has granted a fund to construct 2,000 m^3 distribution reservoir in Baravat and to install about 33 km of distribution pipe in Bam area. The construction of 2,000 m^3 distribution reservoir and relating facilities, and distribution pipe installation by JICA completed in March 2005. Although there is a long way left to rehabilitate the whole water supply system in Bam and Baravat area.

4) Community: Health and Mental Care

The entire health infrastructure of the affected area has sustained heavy damage. No health facility including three hospitals was functional due to extensive damage and unavailability of local health workers just after the event. Primary healthcare services including disease surveillance, treatment of traumatized patients, maternal and antenatal care, and child immunization, as well as management of Tuberculosis and Malaria have been disrupted. Establishment of temporary public health facilities and rehabilitate medical care system was an urgent need.

According to reports from the State Welfare Organization, 1,800 children have lost both parents. At least another 5,000 children have lost a parent. Other children were severely traumatized, having lost other family members, homes, and properties.

Conditions and traditions often put women and girls in the most vulnerable position in the aftermath of these crises. Underlying geographic and socio-economic conditions in the region of Bam expose local women and girls to an even greater degree of physical and psychological harm. The rehabilitation of these women and girls therefore necessitate special measures. This is important in view of the fact that a large proportion of the population would have income generation methods.

4.3 Aid Activities in Bam

4.3.1 Characteristics in General

Numbers of Iranian national and international organizations and aid agencies has put efforts after the event. Although, despite those dedications, the amount of debris, rubble and remained crashed buildings in Bam city area after one year of the event implies the difficulty of revival from disaster. The earthquake damage in Bam were so devastated that those aid activities seems to come short. However, it is a worthy lesson for other cities or towns in the country against the next post-disaster activities in the future, from the viewpoint of efficient and coordinated aid provisions.

In general, aid activities after disaster event are categorized into three phases, 1. emergency response, 2. recovery, and 3. rehabilitation and reconstruction. Aid activities, particularly provisions for basic human needs of disaster-affected people such as foods, blanket, medical product, tent and so on, tend to be concentrated in emergency response phase by virtue. As public attention gradually fades away and the amount of emergency aid provisions is lessened, aid activities transit into rehabilitation and reconstruction phase, as is the case in Bam.

4.3.2 Emergency Response Phase

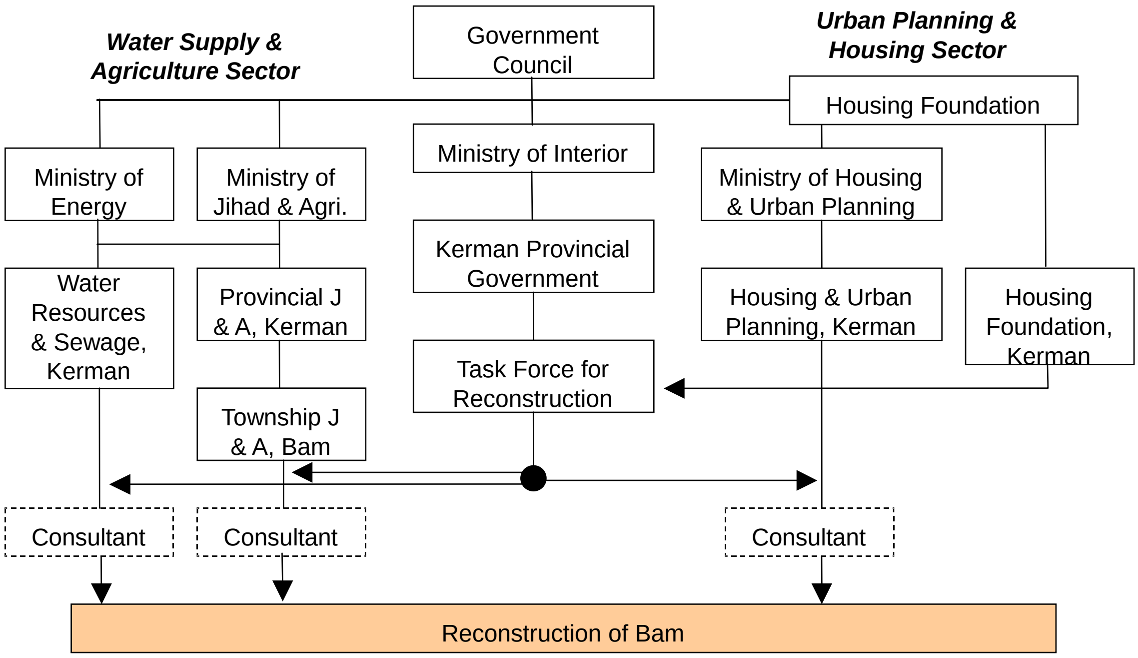
1) Duration

For the case of Bam Earthquake, it can be said that the duration of emergency response phase was approximately 3 or 4 months, from the occurrence of the event to around April, when Bam

Task Force, a coordination authority given general power of attorney by the Iranian government, declared that the emergency response phase was over.

2) Coordination and Logistics

In accordance with the Rescue & Relief Comprehensive Plan enforced since April 2003 in the country, the first major action was a set up of the High Level Task Force by the Iranian government on the day of the earthquake, playing a role of requesting international assistance. In addition, Bam Task Force was also established, taking a responsibility to coordinate all the aid activities. Figure 4.3.1 shows organization structure for Bam reconstruction.



Source: Bam Task Force

Figure 4.3.1 Organization Structure for Bam Reconstruction

Bam Task Force, in collaboration with the Iranian Red Crescent Society (IRCS), divided damaged Bam township area into 13 zones and nominated responsible province from all over the country for each zone to provide emergency activities and provisions.

Bam Task Force has requested international aid agencies a close coordination and collaboration with relevant Iranian authorities. A renewal and approval of any visa for a continued activities of NGOs depended on a detailed plan of action and weekly reports submitted to the government. At the peak of emergency response operation, 87 international aid agencies and a total of 1,854 expatriates conducted aid activities in Bam, according to the report of International Red Cross and Red Crescent Society (IFRC). The Iranian authority waived visas for international relief teams by easing customs procedures for relief goods and adopting 'open sky' policy for emergency flights, so as to allow swift delivery of aid.

Emergency response was a race against time. Particularly in the case of Bam earthquake, earliest possible improvement of living condition of affected people in a breezing weather is a serious concern. In order to meet the immediate needs, International community raised the quick response to support emergency assistance and reconstruction activities in the form of Flash Appeal. Table 4.3.1 shows the sectors and requirements amounts of the UN, and Table 4.3.2 shows that of IFRC, which is a revised version of IFRC's preliminary Appeal launched on 26 December 2003. IFRC's appeal amounted approximately US$ 42 million. The UN and IFRC Joint Appeal amounted US$ 73 million in total.

Table 4.3.1 The UN Flash Appeal as of 8 January 2004

Sector	Requirements (US$)
Food and Logistics	2,577,237
Water and Sanitation	5,760,000
Health and Nutrition	6,395,000
Protection	3,700,560
Education,	3,950,000
Cultural Heritage	200,000
Economic Recovery, Infrastructure Rehabilitation and Reconstruction	5,882,500
Shelter	2,580,000
Coordination and Security	261,610
Awaiting allocation to specific projects	0
Total	**31,316,907**

Source: UNOCHA

Table 4.3.2 The IFRC Flash Appeal as of 8 January 2004

Sector	Requirements (CHF)
RELIEF NEEDS	
Shelter & constructions	12,304,000
Clothing & textiles	3,300,000
Food & seeds	4,375,000
Water and sanitation	5,184,000
Medical & first aid	5,256,000
Teaching materials	298,000
Utensils & tools	4,380,000
Other relief supplies	658,000
Sub Total (Relief Needs)	**35,755,000**
OPERATIONAL NEEDS	
CAPITAL EQUIPMENT	
Vehicles	329,000
Computers & telecom. equipment	388,000
Medical equipment	2,900,000
Office & household	40,000
Other equipment	65,000
PROGRAMME SUPPORT	
Programme support	3,374,000
TRANSPORT STORAGE & VEHICLE COSTS	
Transport and storage	1,395,000
Vehicle costs	100,000
PERSONNEL	
Expatriate staff	3,963,000
National staff	2,021,000
Training & workshops	152,000
ADMINISTRATIVE & GENERAL SERVICES	
Travel & related expenses	307,000
Information expenses	150,000
Administrative & general expenses	974,000
Sub Total (Operational Needs)	**16,158,000**
TOTAL APPEAL CASH, KIND, SERVICES	**51,913,000**

Source: IFRC

It is noted that overall coordination mechanism for aid delivery among the Iranian authorities, UN agencies and NGOs were initially perceived as chaotic, since there was no proper mechanism of information sharing and demarcation guidance for international aid activities. A tendency of demanding commands by the Iranian authorities such as Bam Task Force and the command structure itself was unclear among government ministries and local authorities.

3) Emergency Supply Provision

It was IRCS who were in charge of distributing emergency provisions to the affected population. For each of divided 13 zones in Bam township and 1 surrounding area, provincial IRCS coordinated registration of beneficiaries and food distribution of food. Each district has 1 to 3 of emergency provision distribution points. Given the extent of devastating area and vast numbers of affected people, those points were, unfortunately, not enough to reach all registered beneficiaries. In particular, female-headed households, orphans, and people living suburbs had difficulties in reaching distribution points.

It is also noted that, in collaboration with IRCS and an advisory and technical support of the International Federation of Red Cross and Red Crescent Societies (IFRC), WFP (World Food Program) started to distribute food on the third week of February.

4.3.3 Recovery Phase

1) Duration

The primal concern in the recovery phase is to put damaged infrastructure such as water, electricity, gas, etc back in use tentatively and provide temporary housing for the affected people. In this regard, it can be said that the duration of recovery phase began from approximately one week after the event and lasted until around July 2004.

By April, shops were reopening and the local food supply was slowly beginning to improve in Bam city area. The Bam Task Force declared the transition from emergency and relief phase to medium and longer-term rehabilitation phase. It was also in this phase that the Iranian authority asked all the international NGOs to submit summary reports of their activities and preparation of long-term plan. The agencies were forced to leave Bam if the Iranian authorities would not accept their reports on future plan. By the end of June, a numbers of international organizations in Bam dropped to 37[1].

2) Recovery Works

For each lifelines such as water, gas, electricity, telecommunication, qanats, etc, each responsible Iranian authorities conducted a quick damage assessment within a week after the event, and consequently a tentative recovery work began.

3) Temporary Housing Construction

Both the Iranian government and some international aid agencies, in parallel with recovery works, began to construct temporary housing. Bam Task Force informed that the immediate need for temporary housing was 25,000 for Bam city and 5,000 for surrounding villages directly affected. At the beginning, the Iranian authorities asked International NGOs to submit their detailed plans for any involvement in provision of temporary or permanent housings. It was a sign that temporary housing construction was under the control of the Iranian government. Eventually, it was at full blast after a few months from the event. The transfer of the tented population to temporary and semi-permanent prefabricated “container” housing had

[1] The Foreign NGO’s Progress Reports of SIX Months Work in Bam

gradually been undertaken since March 2004. By up to two months from the event, Bam city accommodated 16,200 prefabricated temporary housings procured by the Iranian authorities, 1,000 container houses by Turkey and 800 used prefabs by Tehran City, mainly located along the east-west highway at south suburban area of the city.

Temporary housing unit has designated floor area of $16m^2$ to $36m^2$ per household and will be used for 2-year duration. After the end of duration, the temporary housing complexes will be reused for students training camp or tourism center, if Bam Task Force would not decide to demolish.

4.3.4 Rehabilitation and Reconstruction Phase

1) Reconstruction Plan of Bam

Bam Reconstruction Committee, headed by the Minister of Housing and Urban Planning has principally taken the responsibilities for the reconstruction process in the Bam areas. The committee consists of nine ministers from the central government, one secretary general and the governor of Kerman province. The Iranian government gave Ministry of Housing and Urban Planning an approval of preparation of reconstruction plan of Bam on 19 January, 2004. Through discussion whether to reconstruct Bam city in the same location or to relocate, the Bam Reconstruction Committee decided to reconstruct the Bam city in former urbanized area, for a better urban living condition. Bam Task Force hired local consultants from Tehran to prepare reconstruction plan of Bam including urban planning, traffic network as well as utility services for lifelines. After several months of preparation, the plan was finally accepted on 20 September, 2004.

Major topics of urban planning issues in the Reconstruction of Bam are as follows.

- To analyze former land use, land ownership/cadastre, geographical conditions, traffic network, damage situation as well as historical background of the community to respect identity of the area
- To preserve existed green area with, mostly, date plantation in order to maintain urban environment and atmosphere of the city

In spite of the fact that the individual efforts to construct small-scale buildings were abundant, none of major reconstruction works could not been seen in Bam until around September 2004 apart from the construction of temporary and semi-permanent housings. People had long waited for the issue of reconstruction plan of Bam to ensure authorization for major reconstruction works.

2) Reconstruction Works

In addition to the delay of issuing reconstruction plan of bam, the enormous amount of debris in the city area caused a slow pace of reconstruction movement. Adobe structure generates more debris than frame structure when collapsed. The Iranian official estimated the total amount of debris to be removed about 12 million tons. An administrative constraint also put the breaks on the reconstruction movement. The Iranian authorities had to get permission from property owners before starting a clear-up of remains, which was quite difficult in case that property owner already became a casualty of the earthquake or left home to go to another town.

For a sustainable reconstruction effort lead by Iranian authorities in the coming years, financial arrangement is critical. The below summarize the reconstruction efforts made so far, but not exclusive.

- Allocation of 60 million Iranian Rials to lend with 5% interest over 15 years to every household in the city, and 45 million Iranian Rials to lend with 5% interest over 15 years to every household in the surrounding villages.
- Grant of 35 million Iranian Rials to rebuild houses in the city and 15 million Iranian Rials for the surrounding villages.
- 20 million Iranian Rials to build walls around properties.
- 1.3 million Iranian Rials per sq.m. by loan and 10 million Iranian Rials by grant for each commercial building.

Despite of the amount of governmental financial support for physical reconstruction, the lack of the sense of coordinated reconstruction activity and the delay of reconstruction plan of Bam prevented form accelerating housing reconstruction. About 5 percent of the houses have been rebuilt in a year after the event, according to official figures.

CHAPTER 5 INTERNATIONAL ASSISTANCE IN BAM

5.1 Assistance by International Community

As well as the Iranian organizations, International donors such as the UN and NGOs including IFRC also undertook swift response to the disaster. Based on a rapid needs assessment, the UN and IFRC launched first-time-ever joint Flash Appeal. This asked donors for a total of US $73 million, in which $31.3 million was on behalf of the UN and $42 million on behalf of the IFRC, in order to facilitate a smooth transition from initial relief to the eventual rehabilitation and reconstruction of Bam in various sectors. Lead by UNOCHA, the UN also acted as coordination body of International aid agencies, by establishing UN camp and issuing ID card.

Table 5.1.1 shows the coverage of the UN Flash Appeal as of 6 February 2004, and Table 5.1.2 shows activities by international aid agencies after six months of the event.

Table 5.1.1 Coverage of the UN Flash Appeal

Sector	Requirements (US$)	Contributions and Pledges (US$)	Coverage (%)
Food and Logistics	2,577,237	1,433,772	55.6
Water and Sanitation	5,760,000	100,000	1.7
Health and Nutrition	6,395,000	2,162,531	33.8
Protection	3,700,560	1,811,483	49.0
Education,	3,950,000	0	0
Cultural Heritage	200,000	200,000	100
Economic Recovery, Infrastructure Rehabilitation and Reconstruction	5,882,500	494,050	8.4
Shelter	2,580,000	447,761	17.4
Coordination and Security	261,610	50,000	19.1
Awaiting allocation to specific projects	0	7,672,319	0
Total	**31,316,907**	**14,371,916**	**45.9**

Source: UNOCHA as of 6 February, 2004

Table 5.1.2 Activities by International Aid Agencies 6 Months after the Event

Organization	Activities
United Nations	
UNOCHA	Launching UN Flash Appeal Organizing the UN aid activities Coordinating with the Iranian government and NGOs
UNDP	Restoration of water supply infrastructure for dates plantations Conducting of sustainable Housing Reconstruction Programme in Bam through community mobilization and participation
UNICEF	Procurement of water supply system equipments Conducting health care, nutrition and protection programs for children and pregnant women Provision of educational program
UNESCO	Implementation of Arg-e-Bam reconstruction projects Supporting of training session for trainers and managers for tentative schools
WFP	Procurement, distribution and storage of emergency food
UNHCR	Assistance for Afgan refugees
WHO	Investigation of communicable disease
UNHAS	Operating passenger air service
NGOs	
IFRC	Launching Flash Appeal Conduction of primal rescue and relief activities Provision of medical and health care services, emergency aid supplies and food
IRCS	Conduction of primal rescue and relief activities Provision of medical and health care services, emergency aid supplies and food
ISC (International Blue Crescent Relief and Development Foundation)	Provision of Emergency supplies and distribution of kits, food and hygiene items Support of installment of Turkish container Supply of Bam Health Center
MEDICOS DEL MUNDO	Operation of medical emergency response Reinforcement of temporary health structure in District 2 and 6
MEDAIR	Assistance in emergency sanitation, educational support and non-food distribution Reconstruction of 35 seismic resistant houses
MERCY CORPS	Provision of kerosene, Latrines, showers and agricultural toolkits Psychosocial support Construction of health houses, hospital infrastructure and 20 prefabricated shelter
MERLIN	Rehabilitation of 14 health houses Health service reconstruction with re-equipping of furnishing, medical equipment and medicines, and refresher training of health workers
OPERATION MERCY	Provision of showers Equipment of supplies for hospital
PIN (People in Need)	Rebuilding of health and education facilities Children protection and education
SAVE THE CHILDREN	Health sector rehabilitation Child protection and education
WORLD RELIEF	Temporary housing provision Provision of water and sanitation equipments
ACH (Action against Hunger)	Water and sanitation project Food security project Nutritional project
ADF (Anatorian Development Foundation)	Provision of latrine and shower

Continue

Organization	Activities
ADRA (Adventist Development and Relief Agency	Reconstruction of health centers
ASB (Arbeiter Samariter Bund)	Search and rescue with trained dog Construction of 2 school buildings and rehabilitation center
CARITAS INTERNATIONALIS	Construction of 733 houses, permanent toilet, and schools Clearing of an irrigation canal
HANDICAP INTERNATIONAL	Provision of hospital and rehabilitation cares

Source: "The Foreign NGO's Progress Reports of SIX Months Work in Bam" and JICA Study Team

Table 5.1.3 shows the various assistance provided by domestic and mostly international NGOs. The list does not necessarily show all activities operated in the Bam areas since the earthquake hit the areas; yet it could be said that the list comprises activities that the Bam municipality has been trying to render.

The tangible information on bilateral financial assistance has been sought at local governments, the Bam reconstruction committee and other sources, but it seems such information is unavailable at least at the local government level. Due to such conditions, it is challenging for the local governments to make comprehensive recovery plans to rebuild the affected areas and provide necessary social support in sustainable manner. It was often indicated that the central government must have such information, but somehow the information has not been disclosed to the public. Thus, it is difficult to estimate the total amount of financial assistance, yet, it has been widely acknowledged that not all financial assistance pledged right after the disaster has been in fact delivered or in some cases such commitments were withdrawn.

Table 5.1.3 Activities by Domestic and International Donors 10 Months after the Event

Project Components	Name of NGO	Country	Fund Amount	Progress of the Project
3 schools & 20 temporary housing	Malteser	Germany	€60,000	Completed
4 Workshops	Malteser	Germany	€20,000	50%
Procurement of 3 air conditioners for schools	Malteser	Germany	€6,000	Completed
3 school buildings	Malteser	Germany	€42,000	20%
Micro-scale projects	Malteser	Germany	€70,000	20%
Rebuilding of medical facilities (clinic, laboratory)	Malteser	Germany	€250,000	10%
6 classrooms in Baravat	Malteser	Germany	€150,000	10%
Procurement of 650 refrigerators & 650 potable water tanks	Agiran Al Kuwait	Kuwait	€78,000	Completed
Construction of 200 houses (framework only)	Act of Netherlands	Netherlands	€800,000	10%
Construction of orphanage	SVA	Japan	US$68,000	10%
2 container-houses for special medical treatment	Private donation	Iran	Rls.100 mil.	Completed
Construction of educational facilities	Peace of Spain	Spain	€20,000 2 yrs expense	60%
3 workshops	Save the Children	UK	US$30,000	50%
Transportation fee of containers "German helps"	Daimler-Chrysler	Germany	€150,000	Completed
Construction of medical center for special medical needs	Special Disease Organization	Iran	Rls.3,500 mil.	10%
Construction of school buildings (temporary buildings)	Daimler-Chrysler	Germany	€110,000	Completed
Construction of educational centers for mitigation management	Kobe municipality	Japan	Not fixed	-
Construction of clinic for the poor	Iranian in USA	USA	US$820,000	Completed
Donation and donation in-kind	Iranian in USA	USA	US$23,000	
Construction of kindergarten	Message from Kobe	Japan	US$12,000	Completed
Construction of orphanage	UAE	UAE	Rls.3,500 mil.	0%
Job placement services (Loan)	Iranian in USA	USA	US$200,000	0%
Total Amount			Approx. US$4 million	

Note: As of October 2004

Source: Bam Municipality

5.2 Assistance by Japan's ODA

5.2.1 JICA Disaster Relief Program

JICA has Disaster Relief Program involving the dispatch of Japan Disaster Relief (JDR) teams and provision of emergency relief when major disasters occur overseas, in collaboration with Ministry of Foreign Affairs of Japan and Japan Defense Agency. The program is run on the basis of requests received from the governments of affected countries or international agencies.

Having received a request from the Iranian government, the Government of Japan decided to send a JDR team to Bam with emergency relief supplies. Japan Disaster Relief medical team consisting of 23 people in total conducted medical relief activities, in which the first team mobilized to Iran on 28 December 2003, and a total of approximately US$ 0.32 million worth of blankets, tents, food and other emergency aid supplies were provided.[1]

5.2.2 JICA Study Team

As described in Chapter 1, JICA has assisted the urgent rehabilitation and reconstruction of disaster affected city of Bam by its Technical Cooperation scheme, as a part of JICA Development Study, Comprehensive Master Plan Study on Urban Seismic Prevention and Management for the Grater Tehran Area, in collaboration with Tehran Disaster Mitigation and Management Center.

Receiving a request from the Government of Iran, The Government of Japan sent a preparatory mission for two weeks from 10 January 2004. The mission held meetings with related government agencies and other organizations concerned, and inspected various facilities, with a view to grasping concrete needs for Japanese future assistance. As a consequence of the findings by the mission and corresponded to its urgency, the Government of Japan decided to proceed with the Bam Earthquake Study in the following three major sectors;

- Rehabilitation study of water supply system,
- Rehabilitation study of agriculture sector, and
- Rehabilitation of the community

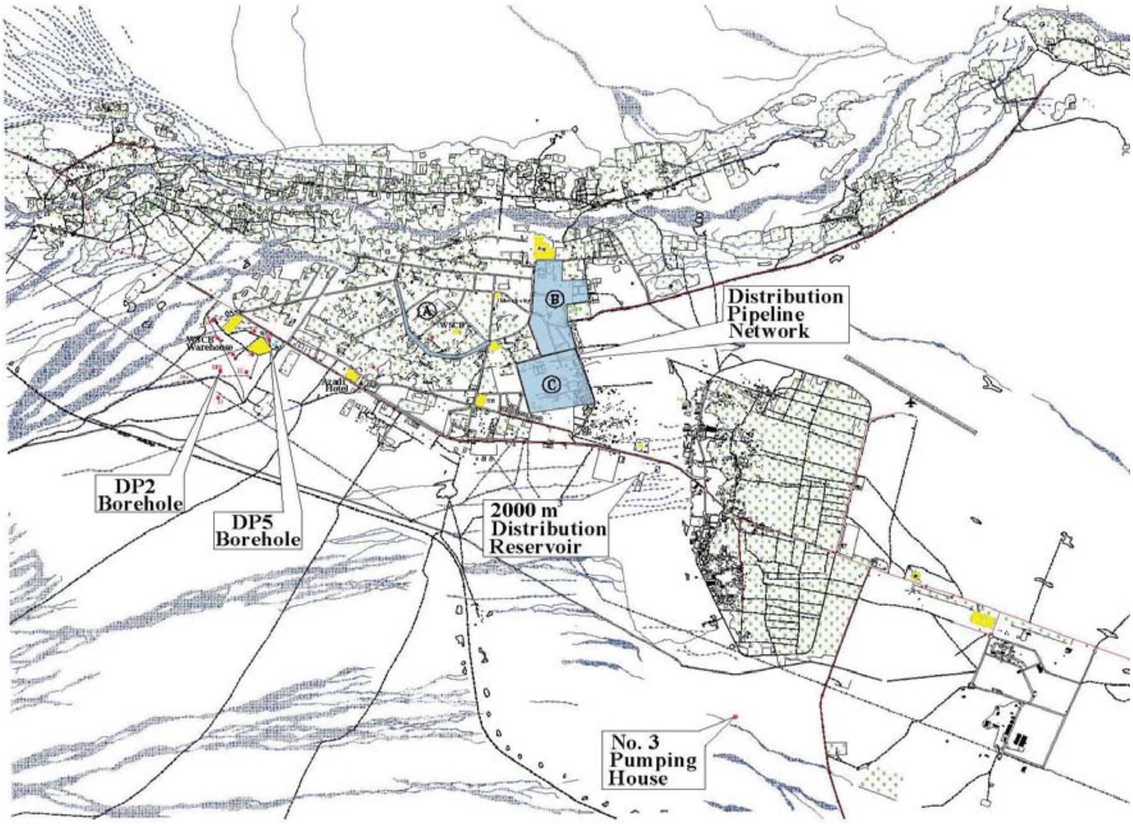
In consideration of the findings in the above study and urgent need of affected people in Bam and surrounding area, the scope of the study was focused on a reconstruction of water supply system. The Study was composed of the following items.

1) formulation of the long-term water supply system reconstruction plan

[1] The Government of Japan also provided emergency food US$770,000on a basis of an emergency grant aid.

2) implementation of the construction works consisting of 1) water network facility, which is approximately 33 km of the priority route in Bam municipality, 2) distribution reservoir (V=2,000m³) with a gate house and a chlorination house, including chlorination equipment in Baravat, and 3) the building structure of pump house (No.3) in Baravat

The construction work of water network facility commenced on the early November 2004. UNICEF procured water distribution material and Iranian construction company conducted the construction work under the supervision of WSCK and JICA. Due to the difficulty in material procurement and coordination with other reconstruction works lead by Bam Task Force, the scope and designing of network facilities changed several times in the course of construction work. The construction work finished in 4 month with a total length of approximately 33km of water distribution pipe, and the facilities were handed over to WSCK.



Source: JICA Study Team

Figure 5.2.1 Project Location Map

On the other hand, the construction work of distribution reservoir (V=2,000m³) with a gate house and a chlorination house, and chlorination equipment in Baravat commenced on August

2004. Actual construction work was also conducted by Iranian construction company, under the supervision of WSCK and JICA. The reservoir construction was completed by the end of December 2004, and both Iranian and Japanese sides hold the hand-over ceremony on the one year anniversary day of the event with a presence of numbers of high officials, including Kerman Provincial Governor and Minister from Japanese Embassy.

5.2.3 Other Assistance by Government of Japan

1) Temporary Housing

On 19 March 2004, the Government of Japan decided to extend emergency assistance of approximately US$ 13 million for a provision of temporary housing on a basis of Emergency Grant Assistance for the Earthquake Disaster.

2) Arg-e-Bam

On 13 January 2004, in response to the Flash Appeal announced by the UN, the Government of Japan has decided to extend contribution of US$ 0.5 million through the United Nations Educational, Scientific and Cultural Organizations (UNESCO)/Japan Trust Fund for the Preservation of the World Cultural Heritage to protect the cultural heritage of Bam.

This aid was to support UNESCO's efforts to preserve cultural property in Bam, and to implement projects for the protection and restoration of the Arg-e-Bam, including dispatch of Japanese experts.

3) NGO’s Activities through Japan Platform

As shown in Table 5.2.1, eight organizations under the Japan Platform, an organization for emergency humanitarian assistance established through the cooperation of the Government of Japan, the economic community and NGOs, have provided assistance activities from rescue to reconstruction through utilization of government and private funds together amounting to approximately US$ 2 million.

Table 5.2.1 Activities of Japanese NGOs

NGOs	Activities
Peace Winds Japan	Establishment of a tent village Construction of temporary school buildings Implementation of dissemination activities on seismic resistant strengthening method of masonry
Nippon International Cooperation for Community Development (NICCO)	Establishment of shower rooms and bathrooms Distribution of blankets, clothing and commodities for living
World Vision Japan	Distribution of shoes and underclothing
BHN Association	Establishing FM radio station
JEN	Establishment of portable bathrooms and shower rooms Distribution of sanitary kits
Save the Children Japan	Implementation of health education Restoration of medical care facilities
Shanti Volunteer Association (SVA)	Assistance for orphanages by distributing daily commodities and restoration of facilities
Japan Rescue Association	Conducting rescue with search dogs

Source: Japan Platform Website