

Bam Earthquake: From Emergency Response to Reconstruction

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ABSTRACT: *This paper gives a brief explanation of the earthquake in Bam, casualties, as well as a report on rescue and relief operations, emergency shelters, temporary housing, and the country's plan for the reconstruction of the city, which includes, debris removal, rebuilding rural and urban residential and commercial units, reconstructing state and public buildings and facilities, schools, rural and urban water aqueducts and grid, establishing sewerage system, power network, and telecommunication system, supplying orchards and farmlands with water, renovating industries, reviving cultural heritage particularly the historical Bam citadel and the like.*

Keywords: Bam; Rescue and relief; Emergency shelters; Temporary housing; Reconstruction strategy; Construction Bazar; Local participation; Reconstruction funding

1. Introduction

The city of Bam is located at a vast plain in the southeast of Kerman province, 190km from Kerman toward the south. The city's plain has a slope from south west toward northeast with a gradient of about 1.2 percent. Bam has an area of 19,374 square kilometers and is 1,076 meters above the sea level. Avardi river flows in north of the city. Except the citadel, which is located at a 60m height, no natural structure can be found in Bam. Winds often blow from the northwest to the southeast. The city experiences 298 days of dry weather in average, while the rainy days stand at eight in average and at least three. The maximum temperature is 44 degrees centigrade in June, the minimum is -2 degrees centigrade, and the average annual temperature is 23 degrees centigrade. The annual rainfall is 62.5mm. The southern part of Bam is the room of rich underground waterbeds of which 51.5% is used in the city's aqueducts.

People financial resources have been mainly through farming and gardening as the city has big orchards of citrus fruits and palm groves. Bam's date is well known worldwide. According to the statistics,

Bam had a population of 70,000 people in 1996 and its population in the rural and urban areas reached 142,376 people in January 2004 as shown in Table (1), according to Iran Census Center.

A destructive earthquake with a central depth of 10km and a magnitude of M_s 6.5 leveled the historical city of Bam and Barvat in the wee hours of September 26, 2003 at 05:26:56 local hours (01:56:56 GMT). The earthquake epicenter was located at 29.21N, 58.40E (IGTU). 80% of building has been completely destroyed while approximately 17% of buildings' structures have been totally damaged and cannot be used any longer and structures of about 2.8% of buildings have remained undamaged and 0.2% have experienced minor damages. Table (2) shows the buildings damage situation. Apart from residential and commercial units, most of the public and state buildings, urban facilities including water, sewerage, power, and telecommunication systems as well as irrigation and agricultural systems, gardens, streets and roads have been badly damaged and should be rebuilt. Also the historical citadel of Bam (Arge-Bam) was totally devastated.

Table 1. Population of Bam and Baravat.

No. of Outlined and Approved Plans	Mapping with Pair	Laying Foundations	Laying Mortar and Concrete	Raising Foundations with Concrete	Reconstructing Skeleton	Finishing with Walls	Carving
25	19784	13279	8061	2908	1057	358	12

Table 2. Distribution of damaged buildings.

Total	59366	
Urban Residential	To be Reconstructed	26561
Commercial Units	To be Repaired	777
Rural Residential	To be Reconstructed	21711
Units	To be Repaired	7375

2. Rescue and Relief Operations

As the news broke, the responsible organizations such as Iran Red Crescent society, law enforcement forces, Basij, and volunteers from inside and outside the country rushed to the area and made every effort to rescue the people, transfer and treat the injured and help the quake-stricken people. The wounded people were transferred to Kerman and Tehran hospitals by planes and helicopters. The noble nation of Iran played its role again and did a praiseworthy task by offering relief. Relief workers removed the victims and wounded people from the debris with the help of machinery and people. The injured were transferred to the field hospitals of the above-mentioned hospitals. The dead were buried during traditional religious ceremonies at the newly-established Behesht-e-Zahra (SA) cemetery. As an emergency service, the Red Crescent Society distributed tents to house the survivors. Figures (1) show some scenes of the relief operation.

3. Emergency Shelters and Temporary Housing

Tents were distributed between the homeless people since the early other the event to provide them with the emergency shelters. Figure (2) shows some of these emergency shelters.

Interior Ministry and Kerman Governor General office were ordered to provide prefabricated buildings with an area of 18-20 square meters, equipped with water heater, air conditioning, sink, and sanitary ware to be erected in the area and camps for housing the survivors. Almost all the survivors were housed by June 12, 2004. Figure (3) show the construction of temporary housing units. Almost all of the homeless people were habituated in the temporary houses, either prefabricated or built-insitu till end of April 2004.

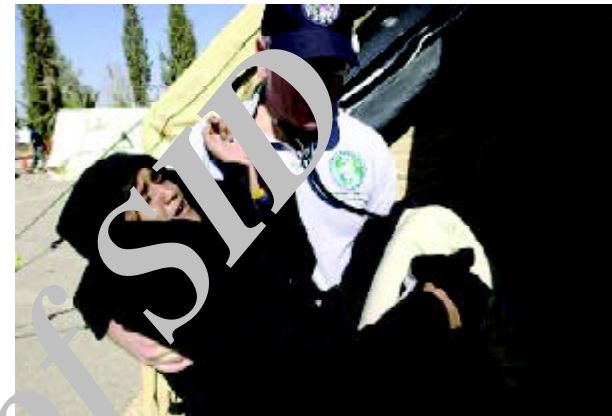


Figure 1. Relief workers removed the victims.

4. Bam Reconstruction

Following the proposal of the cabinet and order of President Seyed Mohammad Khatami, a headquarters for adopting policies and steering reconstruction of Bam was run and headed by Minister of Housing and Urban Development. Iran Housing Foundation (IHF) was appointed as the main executive organization for the reconstruction.

4.1. The Reconstruction Strategy

The headquarters decided on planning, providing financial sources, policymaking, executive operations, and supervision, which were briefed in the following topics:



a) On the pedestrian area



b) In a camp

Figure 2. Emergency shelter.



Figure 3. A sample of insitu-built temporary housing.

1. Removing the debris in the city and suburban villages by the *IHF*
2. Reconstructing the city of Bam in its current location, observing local architecture
3. Reconstructing damaged residential and commercial units in the city and villages through:

- ♦ Encouraging the owners of the units
 - ♦ Providing people with the necessary facilities to have information about construction technology
 - ♦ Promoting regional construction quality
 - ♦ Inviting university professors, consulting engineers, and contractors to render technical services including design and implementation
 - ♦ Inviting suppliers of sand, and gravel, and concrete makers to set up plants in the region to meet the regional needs and supervise the supply
 - ♦ Establishing a workshop and exhibition area for offering technical and engineering services to people, as well as consulting centers to offer technical information, map, stores, and construction materials centers to build residential buildings for people to choose and buy, and to run workshop for rendering technical services related to construction operations. This is called the construction Bazar and its details are shown in Figure (4).
 - ♦ Preparing the ground for mass-constructors to build residential complexes in the areas where residential units cannot be constructed due to technical reasons
 - ♦ Hiring local people for reconstruction with the aim of creating job opportunities and promoting their technical know-how
 - ♦ Setting up Bam Architecture Council to issue orders on architectural designs and urban development in conformity with Islamic cultural, social, and regional values of Bam
 - ♦ Running laboratories to control the quality of construction materials
4. Inviting all state-run organizations to offer their proposals on reconstruction of devastated units with the aim of regional development
 5. Feasibility study on plans and projects in Projects and Allocations Committee and making final decision in the headquarters
 6. Using international help (foreign loans) for implementing development plans on water and sewage, power, irrigation, health, streets and roads, railroad, and schools
 7. Managing reconstruction operations whose financial needs are met by foreign banks' loans
 8. Authorizing Public and State Buildings and Facilities Executive Organization to do related task
 9. Authorizing Ministry of Agricultural Jihad to manage reconstruction of the agriculture sector's infrastructures

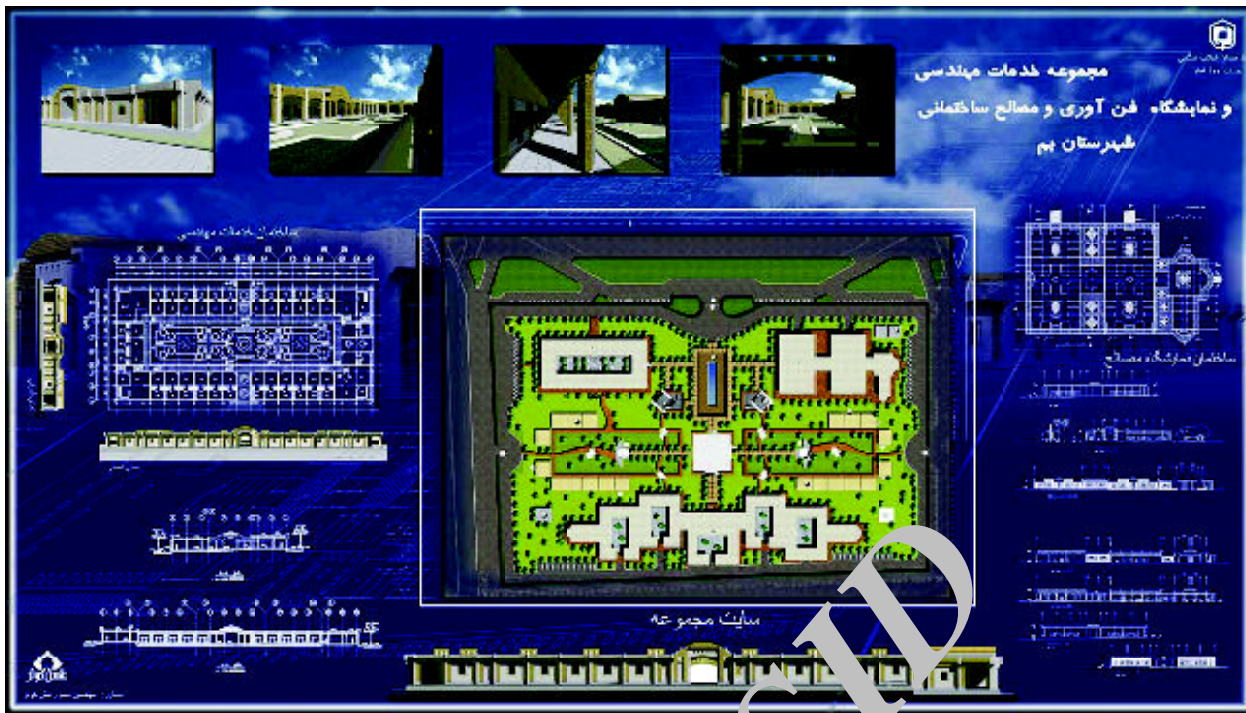


Figure 4. Construction Bazar (Market) for the reconstruction of Bam.

10. Authorizing Ministry of Energy to manage reconstruction of water, sewerage, and power systems' infrastructures
11. Authorizing Ministry of Industries and Mines to manage reconstruction of industries
12. Authorizing Organization for Equipment Developing, and Rebuilding Schools to manage reconstruction of schools
13. Authorizing the technical and engineering departments of the Islamic Revolution Guards Corps, Basij, and law enforcement forces to manage reconstruction of military centers and police stations
14. Planning for running websites to give necessary information
15. Ratifying the ex-gratia aid and banking facilities for residential and commercial units in the city and villages and for private units used by the public
16. Attracting financial aid of benevolent people to allocate for building schools and medical centers
17. Introducing qualified people to banks by the *IHF* for receiving banking facilities

The *IHF* also reserves the right to supervise reconstruction of buildings whose expenses are paid by non-governmental organizations, endowment institutes, and benevolent people. The executive organizations are obliged to offer their schedule and

report their projects' physical progress to the *IHF*. The *IHF* is obliged to set up a secretariat to institutionalize reconstruction affairs. The secretariat is duty-bound to document all stages of reconstruction of Bam as the operations are progressed.

4.2. Debris Removal

After the rescue operations and housing the survivors ended, 17 provincial affiliates of the Housing Foundation and other executive organizations in the region were assigned (according to the agreed contracts) to remove debris and to prepare the land for reconstruction of residential and commercial units. Figure (5) shows the scene and Table (3) shows the statistics of the removed debris. The operation of removing debris in each case was started after the confirmation of the unit's ownership. To separate usable materials or goods from the debris, the owner was encouraged by some allocation to restore brick, iron profiles, etc.

Table 3. Progress of operations for removing debris.

Debris Removal in City and Villages	
No. of City's Bldg. (Commercial and Residential)	26501
No. of City's Bldg. Cleared of Debris	21634
No. of Rural Bldg. Cleared of Debris	4447
No. of Motor Vehicles Used Daily	Truck: 351; D. Bulldozer: 96



Figure 5. Debris removal.

4.3. Urban Reconstruction

Reconstruction operations of residential and commercial units have not started yet since the studies related to the comprehensive plan of Bam are not complete. The owners will be introduced to Bam and Baravat municipalities to receive permits for rebuilding their units when the first phase of Bam comprehensive plan is completed. The expenses of issuance of the permits will be borne and deposited in favor of Bam and Baravat municipalities by the *IHF*.

Each residential unit has an area of at least 80 square meters. The state allocations for residential and

commercial units are shown in Table (4). The total low-interest loan and Grants for each house holes are 60 and 35 Million Rls., respectively.

Table 4. Budget allocation of low interest loan and grant (in 1000 Rials) for reconstruction and repair of residential and commercial buildings Bam and Baravat and rural area. (8500 Rials =1US\$)

	Bam and Baravat: Reconstruction		Rural Area: Reconstruction and Repair
	Residential	Commercial	
Low-Interest Loan	60,000	1,300.in ²	45,000 (Resoush) 13,000 (Repair)
Grant	35,000	10,000	15,000 (Reconstr) 1,000 (Repair)

The maximum amount of loan allocated to construction of houses for each unit is 20,000,000 Rials. In case an owner demands for more built-up area, the executive organization introduces him to bank to receive more facilities. The *IHF* distributes building materials and prefabricated metal skeleton from grant found and the owners. As the permits are issued, the owners will be introduced to receive banking loan whose amount is decided by the *IHF* due to progress of construction in different stages.

4.3. Reconstruction of Rural Residential Units

Although banking facilities have not been offered so far, the reconstruction operations of 60-square-meter residential units in villages have started in accordance with the approved policies. Ex gratia aid and sources of the *IHF* have been used for the operations, and their progress are shown if Table (5).

Table 5. The progress of ex gratia and sources of *IHF* in reconstruction of rural units.

No. of Outlined and Approved Plans	Mapping with Plan	Laying Foundations	Laying Mortar and Concrete	Reinforcing Foundations with Concrete	Erecting Skeleton	Finishing with wall	Carling
95	10764	10279	8161	2908	1057	358	13

4.4. The Technical and Human Resources for Reconstruction

For operation of reconstruction, several subsidiary headquarters and workshops have been equipped as shown in Table (6). A great volume of workforce was also assigned to the job as shown in Table (7).

Structural Drawing and details for 60 square-meter residential units that their construction will be supported by the government are shown in Appendix I.

Table 6. The equipped headquarters and workshops for reconstruction operation.

No. of Subsidiary HQ	No. of Material Labs	No. of Sand, Gravel, Concrete, Skeleton Producing Workshop
17	7	17

Table 7. The assigned workforce in region.

Engineer	Technician	Office Worker	Others
104	95	99	1000

5. Conclusion

The construction bazar (exhibition and market), proposed by the Iran Housing Foundation, is an innovating way for employing the maximum contribution of local people, the present and future residents of the city, to the reconstruction process. However, for reconstruction of the rural area the proposed architectural plans should be informed to the people before any action take place in construction, so that they can observe if these plans are satisfactory to them.

Acknowledgment

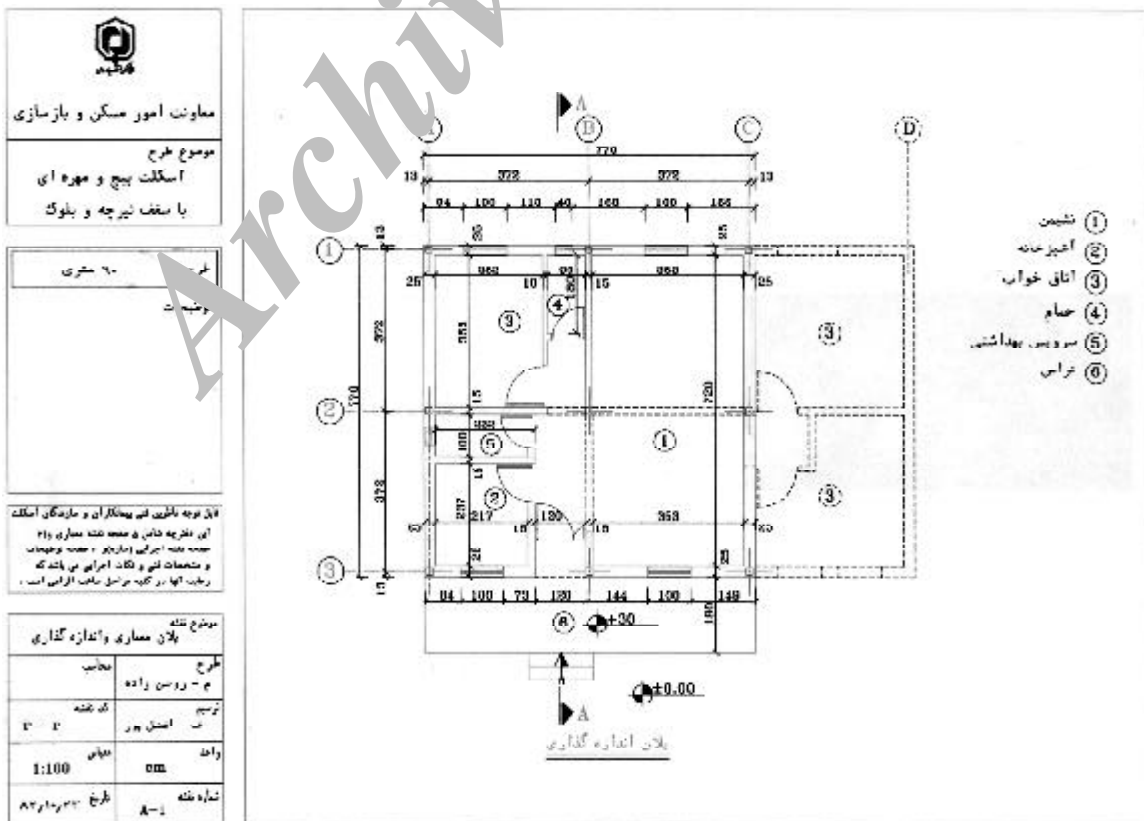
The authors wish to express their highest thanks to Mr. Saïidi-Kia, the president of Housing Foundation for

his valuable efforts for the reconstruction of Bam, who has almost an authorship role in this paper. The authors are also grateful to professor M. Ghafory-Ashtiany, the president of the *IIEES* for his valuable comments.

References

1. ISC (2004). "The Results of the Places and Families Listing of Bam Earthquake Regions", The Iran Statistics Center (ISC).
2. The preliminary report of Bam city, Deputy of the Engineering Statute and Building Executing (2004). Ministry of Housing and Rural development.
3. The Maps of Type 60-Square-Meter Fastening Skeleton with Tile and Block- Iran Housing Foundation (2004).
4. Eshghi, S. and Zare, M. (2004). "Reconnaissance Report on 26 December 2003, Bam Earthquake", *International Institute of Earthquake Engineering and Seismology (IIEES)*, Tehran, Iran.
5. The Acts Collection of Bam Reconstruction Guidance and Policy Task Force.
6. The Collection of Work Progress Reports of the Iran Housing Foundation.

Appendix 1. Structural Drawing and details for 60 square-meter residential units that will be supported by the government.




معاونت امور مسکن و بازسازی

موضوع طرح
اسکلت بتنی و مهره ای
با سقف تیرچه و بلوک

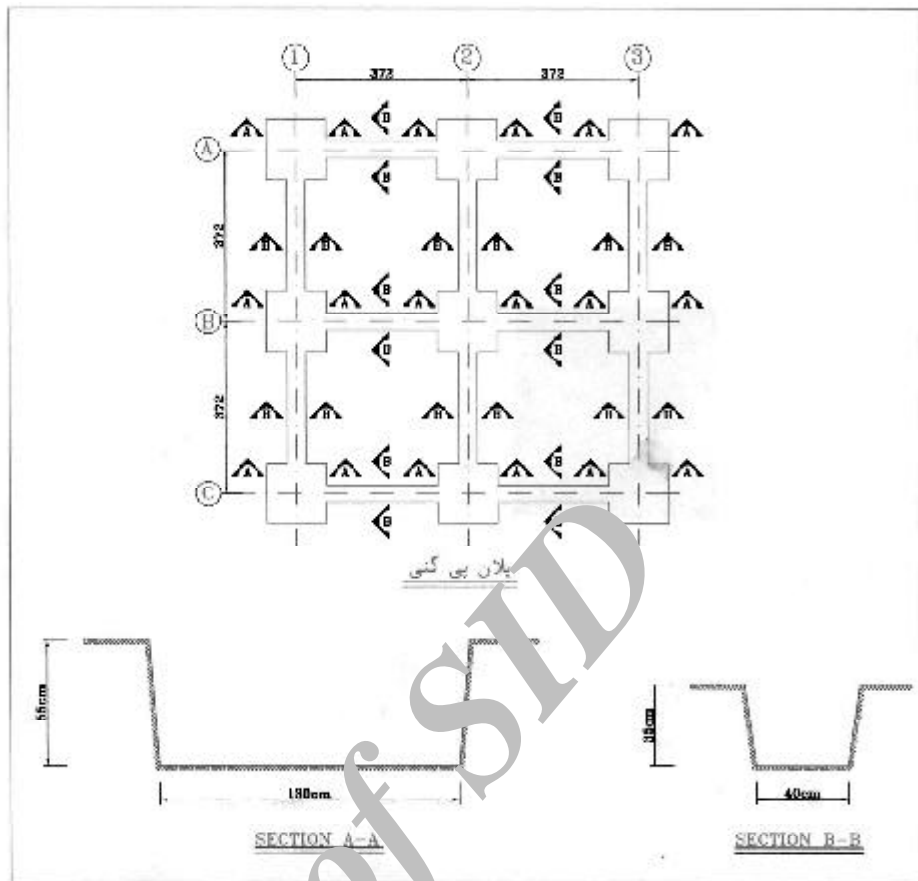
طرح تپ ۶۰
متری

توضیحات

این پروژه مطابق با مقررات و استانداردهای اجرائی و ملی ایران و همچنین نقشه شهرداری و سند تفصیلات و مشخصات اجرایی و سایر اسناد است. و رعایت آنها در کلیه مراحل ساخت الزامی است.

موضوع نقشه
پلان و برش یو گئی

طرح	محاسب
ترسیم	تصویب
م - برسانی	P-2145-P
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S-1	۸۷.۱۰.۲۰




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موضوع نقشه
جزئیات دیوارهای ستونها

طرح	محاسب
ترسیم	گردته
م - برسانی	P-2145-P
واحد	مقیاس
mm	1:20
شماره نقشه	تاریخ
S-12	۸۷.۱۰.۲۰

