

LESSON LEARNED FROM RECOVERY PROJECT OF BAM'S CULTURAL HERITAGE (RPBCH)

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ABSTRACT

The destructive earthquake of 26th December 2003 caused huge damages in Bam Citadel and the Cultural Landscape of the city of Bam. Immediately after the earthquake the **Recovery Project of Bam's Cultural Heritage (RPBCH)** was established for controlling the critical period of time and tried to organize the unpredicted events after the main shock. The duty of RPBCH was divided into various fields; generally such as: crisis managements, organizing / managing the historical sites (the Citadel and other Cultural Landscapes in Bam City). But through the time and after passing the critical points the RPBCH tends to its main duty which is conservation of cultural heritage. Means providing a plan for debris removal, conservation, restoration, safe guarding, monitoring and other expected issues relevant to the great number of the monuments in Bam and its Cultural Landscapes. This paper is trying to address those activities that were organized after the earthquake and current backbone of activities / management in RPBCH, although the future plan is included the contents too.

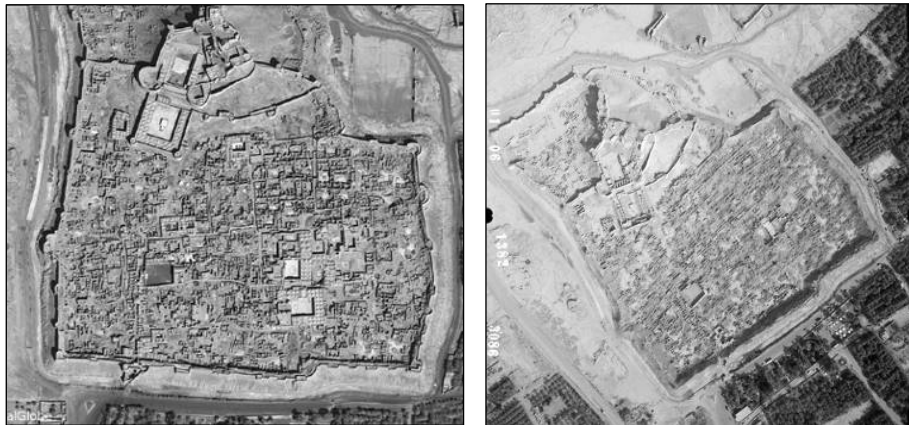


Figure 1 Bam Citadel before (left) and after (right) the earthquake of December 2003

KEYWORDS: Bam, Citadel, Arg-e-Bam, Heritage, Earthquake, Management

1-MANAGEMENT IN BAM CITADEL

During the past four years, many activities have been defined in relation to planning and management of the built and natural environments. Soon after the earthquake the **Iranian Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO)** with international supports tried to protect the remains and pass the critical time period. Since the earthquake in 2003, the RPBCH has started as a governmental body responsible for the conservation the historical buildings and organized one of the largest restoration projects in the world (Figure 2). The main measures have been done including the following parts:



Figure 2 Bam Citadel with area around 200,000 m², (Hellishot, December 2007)

1.1. Risk Management

The Minister of Housing, the General Governor for Kerman Province and the Governor of Bam are responsible for overall disaster management in the Bam's Cultural Heritage but the only institute for protection of historical properties is RPBCH. Some of the implemented projects due to crisis management done by RPBCH are as follows:

- Providing an access way for visitors in Arg-e Bam from the Main Gate up to the Second Gate (south entrance to central north of the Citadel). It made valuable opportunity for the people to pay attention to the repair and restoration process in Citadel and share them more with the recovery measures,
- Formation of a unit for safeguarding Bam Cultural Heritage which consists of 11 permanent members, deployed at a position facing the Citadel,
- Formation of the Cultural Heritage and Tourism Office of Bam. This office can take up management tasks, and play a more effective role in development of handicrafts and tourism, as well as providing better protection for the cultural heritage,
- Acquiring the lands located in the zone, with fencing, and definition of boundaries (still ongoing).

The RPBCH experienced two different post disaster mitigations and risk preparedness opportunities, firstly the measures immediately after the earthquake and secondly the preparation for the next earthquake.

1.2. Preparing Management Plans

According the definition criteria and procedures for intervention and managing the debris and remains in Bam's Cultural Landscape five plans have been applied; **I**-the "***Comprehensive Master Plan***" for Bam's Cultural Heritage by ICHHTO and UNESCO Cluster Office in Tehran, **II**- the "***First Draft for Conservation Program in Bam Citadel***" has being providing by ICHHTO, **III**-the "***Preparation of the draft of Comprehensive Archeological Plan of Bam and its Cultural Landscape***" by ICHHTO, **IV**- the "***Plans for the Introducing of Bam Citadel and its Cultural Landscape***" by ICHHTO, and **V**- the "***Draft of Studies Associated with Development of Tourism Improvement in Bam***" by ICHHTO.

1.3. Plans and Timetables

After establishing the professional committees was further explosions and clearly defining the priority of the actions as following steps:

- 2003, “***Emergency Conservation***”, for document, identify and analyze initial risks and implement emergency stabilization treatments especially for the weak and unstable parts,
- 2004-2005, “***Short-Term Action***”, criteria for site management, collaboration of ICHHTO & the national / international parties and the preliminaries for a Comprehensive Management Plan.
- 2004-20010, “***Mid-Term Action***”, development / implement the Comprehensive Management Plan of Bam’s Cultural Heritage Site.
- 2004-2015, “***Long-Term Action***”, assess the objectives of the management plan of Bam Citadel, the policies effectiveness within the management plan and the compatibility with the outcomes from the General Master Plan.

1.4. International Collaboration

Conservation of Bam Citadel was pursued vigorously by a team of national and international experts experienced master masons and skilled labors. Co-operation among governmental and non governmental institutions and associations at the national and international levels were essential, for instance UNESCO, ICOMOS, Iranian and foreign universities and institutes are working with RPBCH beyond ICHHTO.

1.5. Training

Trainings have been provided with the purpose of improving the technical skill and productivity of all those involved in preservation, restoration, and recognition of the Citadel. Training could include different levels of team in RPBCH, such training craftsmen, site staff, local workers and training the archeology students of Azad University of Bam.

2. REQUIREMENTS FOR PREPARING RESTORATION PLAN

A glance at the history of construction of buildings in the Citadel shows that there has been an unceasing trend to utilize and adapt new technological developments in order to screen new disaster preparedness techniques. Doubtlessly, the new technology is part of the culture. Considering authenticity matters, It needs to adopt its capabilities with the restoration plans. For example using laser-scanner or other new techniques are valuable tools for enhancing and developing the restoration plan of any monument in Citadel. The backbone of any restoration plan in Citadel is based on two issues; first: use of new techniques for improve the surveying, pathology, monitoring, etc and second: use of such materials for overcoming the weakness of the adobe

structures against the further disaster (for example the use of fiber glass in Sistani's House Pilot Project). In this respect, it could be pointed to the following process within the projects:

2.1. Study on Monuments

The first step for recognition is to determine the buffer zone for the historical, cultural and natural significance within Bam Citadel as well as making the list for the cultural properties in Bam Citadel. According to the archaeological point of view, Bam Citadel has been divided into many zones which present the layers belong to historical and pre-historical periods. In these zones, each structure has to be surveyed and provided a pathology plan by the architects. Urgent site-structural-solutions, required to stabilize the structure as well as removing the debris. Archeological documentation of debris and remains have been commenced as well as debris removal and recorded as a document. The next step is to make the reliable mapping documentation which was applied by the different methods, for example: the 3D model of the Citadel (NII Institute and Tehran University), the 3D cartographic maps of the Citadel before earthquake (scaled 1:500), current status of the District of Governor, Carvansaray Stable and Surrounding Walls (photogrammetry techniques).

2.2. Pathology

Structural Damages for historical buildings in Citadel could be divided into five parts:

- Damages are caused by dynamic load of earthquake (around 0.8g in 3D) and the relevant response of the monument based on the dynamic specification of the structure. (Figure 3).



Figure 3 The bed rock in District of Governor caused different dynamic response in comparison with other parts

- Lack of any earthquake base design in previous interventions and measures for example disconnection between the walls and buttresses in the west part of Caravansaray (Figure 4).



Figure 4 Incorrect interventions, the butters behind the west wall of the Caravansary

- Regarding to the long return period of earthquakes in Iran, mostly the earthquake load was not considered as a design load for the buildings in Citadel. For example the disconnection between the load-bearing parts and dome (Figure 5-left).



Figure 5 Disconnection between dome and walls in Stable (left) - although the First-Wall acted as a shear wall but finally the tower crashed with 45° pattern (right)

- Adobe masonry is inherently weak material and has low resistance against the lateral loads.
- Lack of appropriate foundation, form and the shape, the main direction of the earthquake definitely could affect the seismic response of the structures (Figure 6-right).
- Natural factors, such as wind (sometimes around 130^{km/hr}), termite, etc.



Figure 6 Termite effect on the palm tree in the wall of Ice House, Bam Citadel

2.3. Restoration Executive Plans

According to the national and international achievements of the professional teams in Bam Citadel, the following approaches for restoration of the adobe structures in Bam Citadel are developed:

- Strengthening & injection for the cracks with the 2^{cm} width (Sistani House and Stable),
- Strengthening with replacing the tensile elements, with or without the ending plates (Sistani House and Stable),
- Setting vertical elements under the walls (Sistani House), the vertical elements replaced 1.5 m inside the ground level to omit the uplift effects,
- Integration of the outer surfaces like the arches and the domes with Geo-Grids (Stable),
- Strengthening with replacement of the deteriorated adobe bricks (Payambar Mosque),
- Strengthen with simple measures such as lightening the weight of the structures or increasing the thickness of the walls (Barracks / Payambar Mosque),
- Sub-soil stabilization to avoid resonance effect in next earthquakes (District of the Governor),
- Increasing ductility with reinforced adobes by palm fiber (Sistani House),
- Increasing the box effect in top of the walls with the use of ring beams (Sistani House),
- Natural fibers such as Guni to improve the resistance of adobe building, as prototype pilot project in laboratory in Bam Citadel (under construction).

3. CONSERVATION AND RESTORATION PROJECTS

The pilot projects have been undertaken to property owners illustrating possible solutions and to know the reinforcement of traditional structures in earthen architecture to resist seismic hazards and to improve the quality of traditional settlements. These specific projects have followed the studies, detail design, costing, frame works and time tables.

3.1. Executed Projects

The most important activities in Bam Citadel as well as debris removal and cleaning the pathways are the implementation of the pilot projects. There are executed by national and international teams and supports to reinforce and improve the traditional adobe structures through a research plan.

In this regard some pilot projects have been executed some of which are as follows:

- Barrack by ICHHTO (Figure 7),



Figure 7 Restoration of Barrack, Bam Citadel

- Restoration of the Stable by Soil Engineering Services(Iran) (Figure),



Figure 8 Strengthening of the Stable, by SES Consulting Engineers, Iran

- Restoration of Sistani House by Dresden University of Technology-Germany (Figure 9),
- Restoration of Baazar by Mie University(Japan),



Figure 9 Strengthening of the Sistani House, by Dresden University of Technology-Germany

- Restoration of Second Gate by CRA Terre Institute of France,

- Restoration of Tower 1 by Italian Ministry of Culture,
- Restoration of Mirza Naim's School by University of Padova-Italy,
- Improving the resistance of adobe walls by using Guni by Kassel University-Germany,
- Restoration of Tower 32 by Isfahan University-Iran.

3.2. Basis Diagnosis for Restoration Plan

The basic measures for retrofitting the mechanical specification of adobes consist of the following items:

- Finding a suitable source to provide appropriate soil quality,
- To earn proper percentage for producing the retrofitting adobe bricks,
- To search for the natural additives to improve the mechanical quality of adobes(for example the palm fibers (Figure 10),



Figure 10 Process of producing the reinforced adobes with the palm fibers

3.3. Maintenance in Bam's Cultural Heritage

Actually the buildings which were maintained correctly faced less damage through the earthquake. The aforementioned buildings in the seismic area have more chance to resist under a maintenance program. One of the most important experiences in Bam is the possible measures for regularly and pre-estimated inspection after restoration. It is necessary to undertake the after earthquake cares and observations to monitor the natural and manmade damages in the remains, gardens and equipment.

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