

## Bam Citadel after the Earthquake

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**ABSTRACT:** Soon after the Bam earthquake of 26 December 2003, Iranian Cultural Heritage and Tourism Organisation (ICHTO) with the assistance of Iranian and international experts formed a workgroup for restoration and reconstruction of the Bam Citadel, and rescue activities consisting of emergency, research, and execution phases started. The actions to be undertaken in the restoration procedure are emergency measures, documentation, assessment, analysis and planning, and long-term restoration and rehabilitation of Citadel's heritage. This paper presents the rescue and research activities performed since the earthquake and outlines the objectives of the restoration and reconstruction project of the Bam Citadel in future.

### 1 INTRODUCTION

The Bam Citadel, the Arg-e Bam, is one of the most remarkable complexes of earthen architecture and construction that was ruined in the Bam earthquake of 26 December 2003. This paper overviews the safeguarding activities carried out since the earthquake and explains the proposed actions to be undertaken during the restoration of the Citadel.

These are proper and precise documentation in archaeological, architectural and structural studies, provision of modern and suitable mechanical equipment for removing debris, establishment of adobe materials laboratory for stabilization of adobe, establishment of research teams in different disciplines, holding educational workshops at Bam with the assistance of Iranian and international experts, launching research projects in different fields for investigation into the Citadel and for restoration and reconstruction, and so on. A number of scientific studies about the Citadel has been presented or published in national and international conferences and journals, and many other proposals for collaboration in the restoration project are under consideration.

### 2 THE BAM CITADEL

The Bam Citadel stands on a rocky slope at an altitude of 1065 m, latitude  $26^{\circ}5'$  North and longitude  $58^{\circ}27'$  East, with a hot-dry climate, on the North-east side of the city of Bam, South-east Iran. The Citadel, with a area of about  $200000 \text{ m}^2$ , is one of the largest mud complexes in the world, which dates back to near 2000 years ago (Fig. 1).

The Bam Citadel used to be a residential site until the middle of the nineteenth century A.D., at which time people abandoned the Citadel to build the new city of Bam. The first restoration action of the Citadel as a historical monument was taken in 1958. It was registered as a national heritage site in 1966. The comprehensive restoration of the Citadel began in 1971, which con-

tinued until the devastating earthquake on 26 December 2003 (Iranian Cultural Heritage Organisation 2004).

The Citadel, which is mainly made of adobe, is surrounded by walls of up to 18 m high and 2000 m long. The commoner's quarters and the governor's quarters are the two major sections of the Citadel, which are separated by walls and fences. The former consists of seven residential areas, and the latter consists of the military section and the governor's residence and associated buildings.



Figure 1: Bam Citadel: (a) before and, (b) after the earthquake.

### 3 THE BAM EARTHQUAKE OF 26 DECEMBER 2003

The 6.5 Richter scale earthquake which struck the city of Bam on 26 December 2003 was originated in the Bam fault at less than 10 km from the Citadel. The depth of the focus was about 8 km. The horizontal and vertical accelerations were 0.8g and 1.1g, respectively (Zare 2004). The buildings of the Citadel have been damaged to a serious degree, ranging from 80 to 100% (Fig. 1(b)).

### 4 THE ACTION PLAN

The action plan for restoration of the Bam Citadel consists of three major parts: (1) research, (2) conservation, restoration and rehabilitation, and (3) presentation and education. The action plan is not aimed to complete reconstruction of the whole complex, but to conserve, restore, revitalise, present and develop the historical areas, based on clear guidelines and a strategic, realistic action plan to be implemented in the coming months and years. Thus, restoration of the main parts of the complex and rehabilitation of some parts such as surrounding walls, passageways and squares, residential units and public buildings are in priority.

The three phases of actions to be undertaken in different stages are: phase I: emergency measures, phase II: documentation, assessment, analysis and planning, and phase III: long-term restoration, rehabilitation, presentation, and sustainable utilisation of Bam's cultural heritage (UNESCO-ICHO 2004).

#### 4.1 Phase I: emergency measures

The Bam Citadel requires urgent interventions in order to prevent further damage to the structures in case of after-shocks, and to ensure the conservation of the documentation on the site and to commence the research and analysis need to proceed with restoration plans. Phase I should be accomplished in the first half of the year 2004. Emergency measures are as follows.

#### *4.1.1 Establishment of an ICHTO camp in Bam*

The urgent establishment of a camp should be accomplished to allow ICHTO staff to undertake all the necessary emergency measures.

#### *4.1.2 Minimum protection of the heritage assets*

Establishment of fences along the perimeters of the heritage areas is necessary for minimum protection of the heritage assets.

#### *4.1.3 Compilation of information*

Systematic compilation of documents, existing maps, drawings, plans, aerial photos, photographs, slides, and so on should be combined with all other information on the Bam Citadel including structural information such as building material characteristics, strength, stabilization processes and performances, conservation history, and so on.

#### *4.1.4 On-site inspection*

A preliminary diagnosis of the following situations should be undertaken.

- structural damages, typology, materials
- geology, including structural failures and patterns
- geotechnical conditions of the area
- archaeology
- safety of structures, including mapping of all potential risks to heritage assets, identifying priority security areas

#### *4.1.5 Provisional conservation interventions for safety and stability*

The provisional conservation interventions should focus on the followings.

- areas where immediate intervention on the structures are demanded, such as where stabilization and consolidation of damaged structures is impossible
- management and organisation of the debris of the historical areas
- security of the structures as well as all personnel working within the heritage areas and future visitors to the property

#### *4.1.6 Access of visitors to the Bam Citadel*

Urgent measures should be made to make the Bam Citadel accessible and visible to visitors. Hence, provisional pathways for limited and controlled access within the Bam Citadel should be designed and built.

#### *4.1.7 Organisation of joint UNESCO-ICHTO high-level technical and scientific steering committee*

A joint UNESCO-ICHTO High-Level Technical and Scientific Steering Committee should be established to discuss, elaborate and adopt principles and guidelines for the immediate, mid to long-term conservation, preservation and development plans for the heritage assets of the Bam Citadel.

#### *4.1.8 Proposal of inscription on the World Heritage list on an emergency procedure*

The inscription of the Bam Citadel should be proposed on the World Heritage List.

#### *4.1.9 Recording of all actions taken*

All the actions taken within Phase I should be recorded.

### *4.2 Phase II: documentation, assessment, analysis and planning*

Phase II, which should be undertaken in 2004 and 2005, comprises comprehensive analysis and research aimed at improving the knowledge of the structural, geological and geotechnical condi-

tions of the site, extending the knowledge of the archaeological strata, and improving the performance of the materials and of the construction of all future reconstruction or restoration activities.

#### 4.2.1 *Archeology*

Due to heavily damaging earthquake important heritage assets have been revealed from underneath the damaged layers. A full archaeological survey of the Bam Citadel is required to plan and implement a conservation, preservation and development plan.

#### 4.2.2 *Conservation and structural stability*

The followings should be taken into consideration for conservation and structural stability.

- in-depth examination and analysis of the history of conservation for Bam's heritage
- possible methods of improving the quality and strength of earthen architectural material (adobe materials)
- studies on structures, dynamic conditions, analysis of construction history of each type of structure
- cost analysis for the conservation and structural stabilization interventions
- survey of traditional architecture in the Bam Citadel focusing on damage caused by the earthquake
- identification of the quarries for the construction materials used for the earthen architectural heritage assets of the Bam Citadel
- examination of the state of the art conservation techniques, with particular focus on earthquake resistance
- research on typology of historical buildings in the Bam Citadel
- collection of all data to undertake a feasibility study (technical and economical) for the re-establishment of an earth construction branch for large-scale production of earthen building materials
- definition of a research and experimentation programme on the earthen architectural construction material
- elaboration of a capacity building programme for seismic resistant earthen architecture

#### 4.2.3 *Geological and geotechnical studies*

Geological and geotechnical studies should be accomplished on the following subjects.

- collection of all geological seismological data within the area and execution of experiments to understand the functioning of brick structures
- compilation of the earthquake history of the area
- undertaking shaking table tests to understand the functioning of brick structures
- investigation underground geological structures (stratigraphy, etc) of the Bam Citadel, if necessary, making bore holes and so on

#### 4.2.4 *Information management*

The following actions should be taken.

- establishing a sustainable information management system (IMS) based upon long-term heritage conservation, management and presentation needs, and organisation and undertaking database creation and inputting which fits within such IMS
- undertaking and elaborating 3D mapping and virtual reconstruction based on aerial photos taken by the National Cartographic Centre of Iran, photos, drawings, plans, maps, 3D scanning, and any other relevant information, to research, to examine and consider for conservation purposes, and to present the evolution of the cultural heritage of the Bam Citadel over the past half century and post-earthquake
- making a model of the Bam Citadel for improved interpretation of the area's cultural values

#### 4.2.5 *Harmonisation of conservation and redevelopment efforts of Bam*

- integration of heritage protection and conservation within the overall redevelopment Master Plan of Bam City
- taking each step on the understanding that the process will be an important demonstrative case study for the future of all Iranian historical cities concerning planning and protection of monuments against seismic risks

#### 4.2.6 *Presentation, awareness raising and tourism redevelopment*

The revitalisation of the cultural heritage of Bam, including the Bam Citadel, is essential in the recovery process of Bam post-earthquake. A plan of action, which integrates living cultural heritage continuation, local community participation and awareness raising activities, should be elaborated and implemented.

#### 4.3 *Phase III: long-term conservation, restoration, rehabilitation, presentation, and sustainable utilisation of Bam's cultural heritage*

These activities must be linked to the overall reconstruction and recovery plan of Bam City and represent an opportunity to improve the local and national capacities to build and restore structures in a seismic-safe manner, while representing the authentic designs and materials of the heritage assets. This action will be implemented in the coming decade (2005-2015) and beyond.

### 5 ACTIONS TAKEN AFTER THE EARTHQUAKE

The main rescue actions taken since the earthquake until November 2004 are as follows.

#### 5.1 *Equipment*

##### 5.1.1 *Establishment of residing campus*

- removing the ruins and grading the ground around the Citadel
- erection of eight temporary compartments with a capacity of 30 persons for accommodating working expert groups
- equipping the campus with drinking water, electricity and sewage
- fencing the campus frontage
- equipping with air-conditioners

##### 5.1.2 *Establishment of the office for facilities planning and construction*

- grading the ground opposite the Citadel for establishment of the office
- restoration of the previous restaurant to use as an exhibition hall
- erection of four temporary compartments
- equipping with air-conditioners
- equipping with a number of computers, printers, scanners, digital cameras and photocopiers
- equipping with furniture

##### 5.1.3 *Establishment of cabins for guards*

- grading the ground opposite the Citadel for cabins
- erection of three temporary compartments
- equipping with air-conditioners, drinking water and sewage

##### 5.1.4 *Equipping with guarding equipment*

- equipping with wireless
- erection of aerials

#### 5.1.5 *Workshop equipment*

Equipping the workshop with:

- two canteens as warehouse
- scaffolding
- plywood
- safety shoes and helmets
- mobile tanks
- wheelbarrows, shovels, and picks

#### 5.1.6 *Establishment of kitchen*

- construction of a permanent kitchen at the garden opposite the Citadel servicing 40 persons daily
- equipping with refrigerator, freezer and cooking equipment

#### 5.1.7 *Transportation equipment*

- repair of two old transportation equipment
- equipping with two new transportation equipment
- renting transportation equipment for restoration activities
- providing flight fare for experts visiting the Citadel

#### 5.1.8 *Removing the ruins*

Removing the ruins of the following parts:

- Passageways of the Citadel
- Surrounding Walls of the Citadel
- Main Entrance of the Citadel
- Old Bazaar in the City of Bam
- Historical House of Ameris in the City of Bam
- Historical Mosque of Vakil in the City of Bam
- Historical Icehouse near the Citadel
- Mirza Ebrahim Shrine in the City of Bam
- House of Sanati and House of Hafiz Abadi near the Citadel
- Henna Making Factory in the City of Bam

#### 5.2 *Safety measures*

Safety measures consist of scaffolding and shoring the following parts of the Citadel:

- main entrance
- tower No.1
- some parts of surrounding walls (Fig. 2)
- Mirza Naeim complex
- second entrance
- a number of workshops inside the Citadel

#### 5.3 *Fencing and stabilizing the buffer zone*

Fencing and stabilizing of the following parts:

- the buffer zone of residing campus
- the buffer zone of the southern part of the Citadel

#### 5.4 *Organising the surroundings of the Citadel*

- removing the recently built street on the western side

- removing the unnecessary urban signboards and equipment opposite the Citadel
- grading the site opposite the Citadel including the demolition of the concrete square and the semi-ruined building of Tourism Organisation
- fencing the entrances of the Citadel on the southern and eastern sides
- irrigation of gardens opposite the Citadel
- providing a car parking opposite the Citadel



Figure 2 : Scaffolding and shoring the surrounding walls.

### 5.5 *Establishment of adobe laboratory*

- equipping with chemical tests equipment
- equipping with mechanical properties tests equipment
- start of studies on adobe materials
- start of collaboration with universities and research institutions for studies on adobe materials

### 5.6 *Research activities*

#### 5.6.1 *Contracts*

Contracts have been made for the following research projects:

- geological studies of the Citadel
- structural studies and retrofitting plan for the Governor's district
- surveying the passageways of the Citadel
- GIS plan for the Bam Citadel
- restoration plan for the Sistani house
- restoration plan for the Stable
- restoration plan for the Icehouse
- studies on the qanats of the Citadel
- identification of the castles around the city of Bam
- surveying the old bazaar of the city of Bam
- reconstruction plan for the old bazaar of the city of Bam
- landscape pathology studies
- identification of historical heritage of the city of Bam
- preparing the 1:500 map of the Citadel before and after the earthquake

#### 5.6.2 *Activities of the office for facilities planning and construction*

#### 5.6.3 *Documentation*

The documentation of the following parts is carried out:

- restoration activities in the Bam Citadel before the earthquake
- archeological documentation of removing the ruins from the passageways of the Citadel

- tower No. 1
- daily restoration activities in the Citadel
- collection and classification of photographs of the Citadel before and after the earthquake

#### 5.6.3.1 Archeological activities

- establishment and equipping the archeological division of the Rescue Project of the Bam Citadel
- study and documentation of 5000 discovered pieces of earthenware and terra-cotta out of the ruins in the Citadel
- daily report of archeological activities in the Citadel

#### 5.6.3.2 Preparing the buffer zone plan

- preparing the buffer zone plan of the Citadel
- preparing and notification of Cultural Heritage Regulations of the city of Bam to the consulting engineers of the master plan of the city of Bam

### 5.7 Presenting activities

- making an English language movie to introduce the Citadel before and after the earthquake
- holding an exhibition to introduce the Citadel before and after the earthquake
- holding an international workshop, attending more than 30 international experts in April 2004, to adopt the Bam Declaration
- erecting a wooden pathway inside the Citadel to facilitate the visit of people and experts
- preparing the facilities for holding the exhibition on the anniversary of the earthquake for introducing the rescue activities after the earthquake
- publishing two English books and some flyers for introducing the Bam Citadel
- translating and publishing the book "Between the Two Earthquakes" (UNESCO publication)

### 5.8 Management activities for preserving the Bam Citadel and cultural heritage of the city of Bam

facilitating the visit of international experts and diplomats from Bam in order to accelerate international collaboration for the rescue of the Citadel

- establishment of the national scientific committee for restoration and preservation activities of the Bam Citadel consisting of ten distinguished Iranian experts
- establishment of the international committee for restoration and preservation activities of the Bam Citadel consisting of four experts from UNESCO and five Iranian experts
- holding the international workshop for preparing the guidelines for restoration and preservation activities of the Bam Citadel
- participating in the 28th Conference of the World Heritage Committee for including the Bam Citadel into the World Heritage List
- making a contract with the Japanese government for granting one million dollars for mechanical equipment
- activities for holding the Bam assistant countries conference in Italy in February 2005
- participating in international conferences to present the rescue activities carried out in the Bam Citadel after the earthquake

## 6 CONCLUSIONS

This paper outlined the actions to be undertaken in the different stages of restoration project of the Bam Citadel and presented the rescue and research activities carried out since the earthquake.

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