A Slide Show of the Aftermath of Bam Earthquake

Barzin Mobasher

Dept. of Civil and Environmental Engineering, Arizona State University, AZ

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Presentation Outline

- Overview of the history of the region
- The Citadel (Arge Bam)
- Societal Norms and style of construction,
- The Earthquake of December, 2003
- Steel buildings,
- Concrete buildings
- Masonry buildings
- Materials quality, practices and quality of construction
- Old vs. new construction
- Disaster management system
- Public buildings, banks, fire departments, airport, and hospitals
- Lessons learned
Arriving in Kerman International Airport
Shah Nematollah Vali Mosque
Kerman-Bam Road
The Citadel- Arge Bam
DIAGRAM OF A TYPICAL QANAT

Mother-Well
Channel
Water Table
SANDS
ALLUVIUM
BEDROCK

CROSS SECTION

ALLUVAL FAN

AERIAL VIEW

Cross sections a-b, c-d
Hoop (nay)

MOUNTAIN

5-30 Miles

Village
Some 3,000 years ago the Persians learned how to dig underground aqueducts that would bring mountain ground water to the plains. Today, the system provides 75 percent of the water used in Iran. (H. E. Wulff, Scientific American, April 1968, p.94 – 105)
Inside of a Quanat
At the time of the earthquake the Citadel was under a major restoration project.
BABYLONIAN LAW
The Code of Hammurabi (1780 B.C.)

- [229] If a builder build a house for some one, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.
- [230] If it kill the son of the owner the son of that builder shall be put to death.
- [231] If it kill a slave of the owner, then he shall pay slave for slave to the owner of the house.
Active Faults and Recent Earthquakes in the Region
Accelerograms recorded maximum accelerations of 0.988g and 0.798g on vertical and horizontal components of main shock. Eshghi and Zare, 2003
The Fault crossing the Bam-Baravat highway
Direction of ground motion
Destruction in the Arge-Bam
Destruction in the City

- The major cause of failure of many buildings may be attributed to lack of proper design, analysis by standard accepted engineering methods. Inadequate supervision, and inspection procedures.
- Lack of design considerations for lateral loads.
- Failure of soft storey systems is a predominant mode of failure.
A typical “Soft Storey System” characterized by a lower floor that has long unsupported length columns, making the structure considerably weak. This is predominantly a standard (but faulty) practice, Babol, Iran.
Causes of Failure in Steel Buildings

- Major sources of failure include:
  - Inadequate strength in lateral direction
  - Buckling of columns due to lateral translation
  - Soft storey collapse mechanism
  - Failure of the welded connections
  - Inadequate design of connections
  - Inadequate lateral bracing
  - Lack of adherence to analysis/design/inspection based on sound engineering guidelines and construction processes.
Twisting of the columns leads to failure of the connection by snapping out.
Failure of Structural Bracing
Sway Buckling
Failure of Structural Facades
Inadequate Connection design and field work. Effective weld length is about 1 cm
Failure of internal non-load bearing wall systems which were inadequately tied into the structure resulted in many deaths.
Causes of Failure in Reinforced Concrete Buildings

- Inadequate strength in lateral direction
- Inadequate design/Failure of the connections
- Lack of quality control in materials used
- Soft storey collapse mechanism
- Lack of shear design for columns
- Lack of adherence to analysis/design/inspection based on sound engineering guidelines and construction processes.
Inadequate design and construction of the beam-column connections
Masonry Buildings

- Traditional design procedures lack the ability to handle lateral loads.
- New methodologies in strengthening masonry building are available, but never applied.
- The traditional parts of the town where mud bricks were the primary construction material were destroyed by 80-90%.
- Interestingly domed masonry structures fared much better than one would expect, perhaps due to the arching action.
Transportation Infrastructure
Emergency Management System
The exemplary devotion and commitment of various officials we met working under extreme conditions with limited resources was inspirational.
Domed Structures
New Airport Building Under Construction
Buildings which Survived with Minimal Damage
Lessons Learned

• Money, sympathy, prayers, loans, grants, orphanages, and rebuilding and will not solve the root problems.

• We Need:
  – Universal Adherence to the International building codes which address the seismic nature of the region. (Iran, Turkey, Armenia)
  – Urgent need to require construction according the commonly accepted building codes in existence.
  – Development of proper oversight mechanisms for qualification and supervision of those in construction industry.
  – Knowledge based rehabilitation and reconstruction as opposed to traditional approaches.
  – Adequate Emergency Management Systems
Dedication

- This presentation is dedicated to the memory of the thousands of casualties of this devastating earthquake. So many lives, hopes, dreams, and futures were cut short due to technological failures of construction systems following a mere twelve second natural event. It is hoped that this tragedy will inspire all of us to work toward preparation for the next cycle of expected but unknown natural events. Our ability to develop viable and safe construction systems, to institute and execute long term goal oriented regional plans which value peaceful development of resources will be tested by the next earthquake, flood, etc. This can only be achieved by proper application of scientific knowledge and valuing long term safety over short term economics while minimizing the risk of human loss.
US Gov. Approved Humanitarian relief and reconstruction NGOs working in Bam

- [http://www.american-iranian.org/beta/](http://www.american-iranian.org/beta/)
- Air Serv International
- American Red Cross
- American Refugee Committee International
- Catholic Relief Services
- Counterpart International
- Doctors Without Borders
- House of Iran
- International Medical Corps
- Iranian Medical Relief Foundation
- Mercy Corps
- Operation USA
- Relief International
- Samaritan’s Purse
- Save the Children
- World Relief World Vision
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