Preliminary Report on the Bhuj Earthquake, January 26 2001, in India

by

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ABSTRACT

The Bhuj earthquake occurred in the western part of India on January 26, 2001. People, buildings and infrastructures suffered great damage in Kachchh County and Ahmedabad City of Gujarat State. In Kachchh County, many buildings, not only traditional masonry housings but also reinforced concrete buildings, were collapsed due to the earthquake. In Ahmedabad City, in spite of about 300 km east from the epicenter, some of higher apartment buildings, about 10 story buildings with soft first story, were collapsed totally. This report presents results of a quick observation carried out at the beginning of March.

KEY WORDS:

India, Bhuj Earthquake, Building, Damage,

1. INTRODUCTION

The Bhuj earthquake occured in Kachchh County, Gujarat State, the western part of India, at 8:46 AM (local time) on January 26, 2001, with moment magnitude 7.5 (United State Geological Survey), magnitude 6.9 (Indian Meteorological Department). This earthquake caused about 20,000 fatalities, 166,000 injured people, 37,000 totally collapsed buildings by March 20, reported by the Indian Government. The heavy damaged areas are Bhuj, Anjar, Bachau, Rapar in Kachchh County, and Ahmedabad City. The location of damaged areas is shown in Fig.1 and Fig.2.

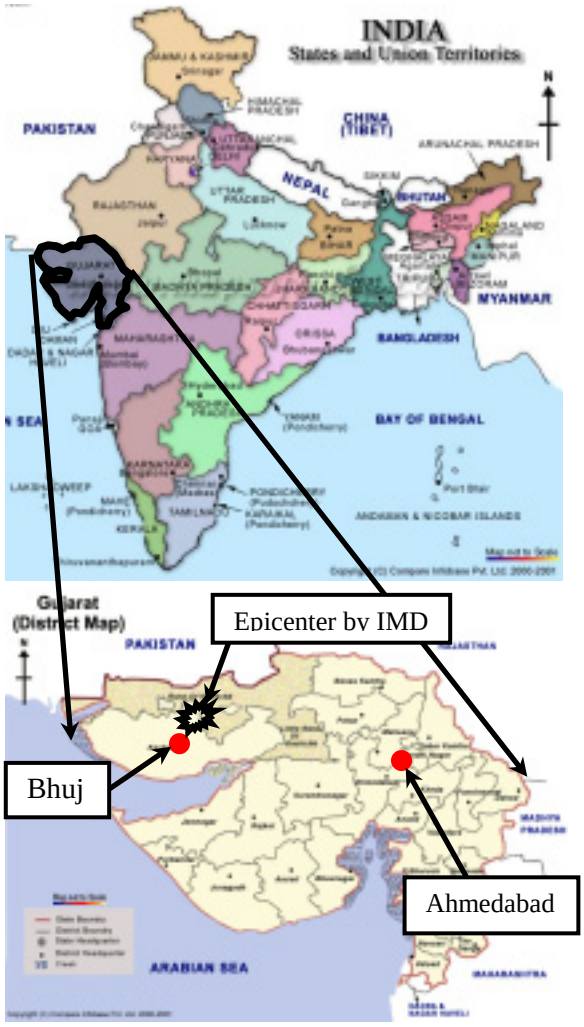

Fig.1 Map of India and Gujarat State
(http://www.mapsofindia.com)

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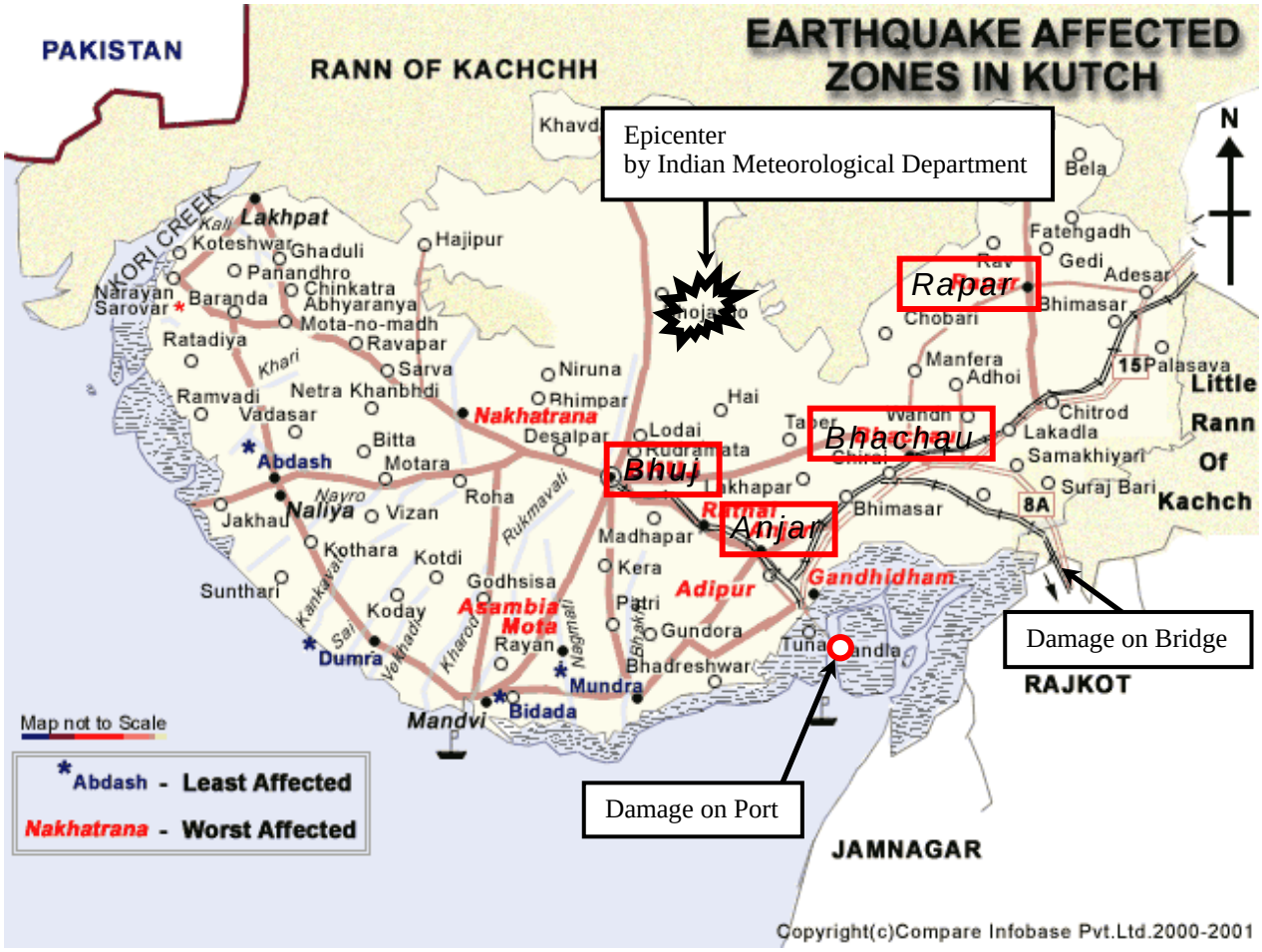

Fig.2 Map of Kachchh County (Bhuj, Anjar, Bhachau, Rapar, Kandla-Port)
(http://www.mapsofindia.com)

A mission was dispatched by the Japanese Government to discuss with related officials for father assistance to India. During the stay, a quick observation of the damage due to the earthquake was made from February 28 to March 2. This report is described based on this quick observation.

2. AHMEDABAD

About 760 fatalities, about 60 medium-rise (around 4 story) and 4 higher-rise (around 10 story) buildings were suffered in Ahmedabad City. This city develops on the thick alluvial deposits along the Sabarmati River. Because of soft deposits and the long distance form the epicenter, it is considered that long period vibration was dominant at urban area of Ahmedabad City. The typical buildings damaged due to the earthquake consist of reinforced concrete resisting frame, open frame at the first story for open areas, and non-reinforced masonry infill panels on upper stories for residence. Most of damage concentrated to the soft first story, and some of buildings collapsed totally.

Damages of Manasi Tower, 11 story apartment building with the soft first story, are shown in Photo 1 to 3.

Photo 1 Manasi Tower apartment building
There was a part of building on this side that has the same structural system as the back side of the remaining building. The part of building was totally collapsed.

Photo 3 Damaged column
Manasi Tower apartment building
This column has small thickness. If the column suffers damage in thickness direction, the column will lose the weight support capacity easily. (AIJ report "Kentiku-zassi", Yoshiaki HISADA, Kogakuin University)

Photo 2 Manasi Tower apartment building
This building has a soft first story.
At first, damage concentrated to columns at the first soft story, the columns lost weight support capacity, and finally the building collapsed totally.

Another apartment building damaged heavily is shown in Photo 4 to 9. This building consisted of reinforced concrete moment resisting frame with non-reinforced masonry infill panels from the second story and above. A part of the building totally collapsed. The damage of this building is identical type of damage of the Manasi Tower apartment building (Photo 1).

After the earthquake, temporary wooden supports were installed, and also columns at the first story were retrofitted by jacketing technique to prevent the total collapse of the remaining building.

Photo 4 Apartment building
This building has a soft first story.
A part of building on this side collapsed totally.

Photo 5 Apartment building
This building has a soft first story.
At first, damage concentrated to columns at the first soft story, the columns lost weight support capacity, and finally the building collapsed totally.

Photo 6 Retrofitted columns
These columns were temporarily retrofitted using angle and flat steel plates.

Photo 7 Temporally wooden support

3. KACHCHH

3.1 Bhachau

Almost of housings constructed by traditional masonry structure were destroyed.

Photo 6 Damage at Bhachau
Most of masonry housings were destroyed.

Photo 7 Damage of masonry housing
This building has no reinforcement in walls. Walls fell in out-of-plane direction.

3.2 Bhuj

Bhuj is located on hill and the ground is hard and good condition. But the epicenter is near form Bhuj, therefore various type of buildings, low-rise masonry housings, reinforced concrete buildings, apartment housings, schools and hospitals suffered heavy damage due to the earthquake. Low-rise buildings in old city area are constructed by mainly traditional masonry structure, and almost all were destroyed.

Photo 8 Damage in old city area at Bhuj
Most of traditional masonry housings were destroyed.

Photo 9 Debris in old city area at Bhuj

Photo 10 Collapse of soft first story of building
This 6 story building in old city area of Bhuj was collapsed at the soft first story.

Photo 11 Damage on hospital building
All masonry walls were damaged heavily.

Photo 12 Damage on column
Masonry wall and Short reinforced masonry column were failed in shear.

4. TEMPORARY BUILDING

Temporary buildings and housings were constructed around the damaged areas of Bhachau, Bhuj and Anjar. Temporary building of the central hospital of Bhuj is relatively good condition, but temporary shelters for housings and schools are poor tents, blue sheets and wooden frames with steel panel.

July is a monsoon season in India. it is important to provide shelters enough quality against heavy rain and wind.

Photo 13 Shelters at Bhachau
Tents or blue sheets were used for shelters for refugees.

Photo 14 Temporary Buildings for hospital at Bhuj
The structure consists of steel frame and pre-cast concrete panels.

Photo 15 Shelter for school at Anjar
The shelter is built using wooden frame and steel panel.

Photo 16 Shelter for classroom at Anjar

5. BULIDING CODE

The earthquake resistant design of buildings was introduced in India in1962. The standard had been revised four times, and that is the Indian Standard (IS) 1893-1984. Indian seismic zoning map is shown in Fig.3. According to the IS1893-1984, Ahmedabad is in Zone III, and Buji is in Zone V.

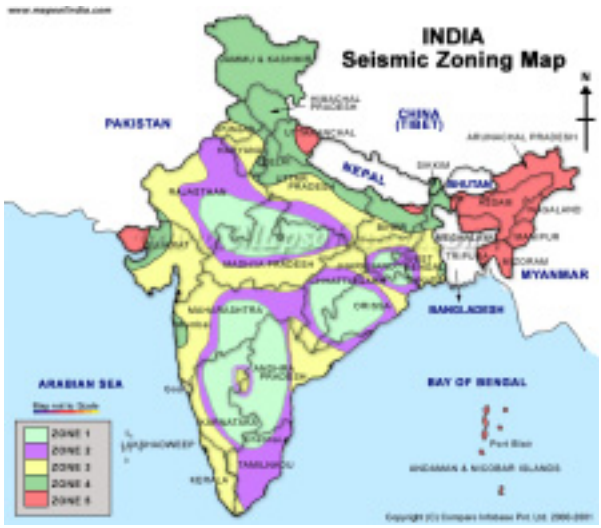

Fig.3 Seismic zoning map (IS1893-1984)
(www.mapsofindia.com)

Medium rise buildings constructed in Bhuj, Zone V, with reinforced concrete moment resisting frame structure and masonry infill walls, were recommended to use the following base shear Vb, and also recommended to conform to Indian standard "Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces" (IS13920-1993).

$$Vb=K\ C\ \alpha h\ W=K\ C\ \beta\ I\ \alpha o\ W=0.128W \quad (1)$$

K: performance factor (1.6)

C: coefficient for fundamental time period (1.0)

β: coefficient for soil-foundation system (1.0)

I: Importance factor (1.0)

αo: Basic horizontal seismic coefficient (0.08)

Indian standard "Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces" (IS13920-1993) shows many details of structural members.

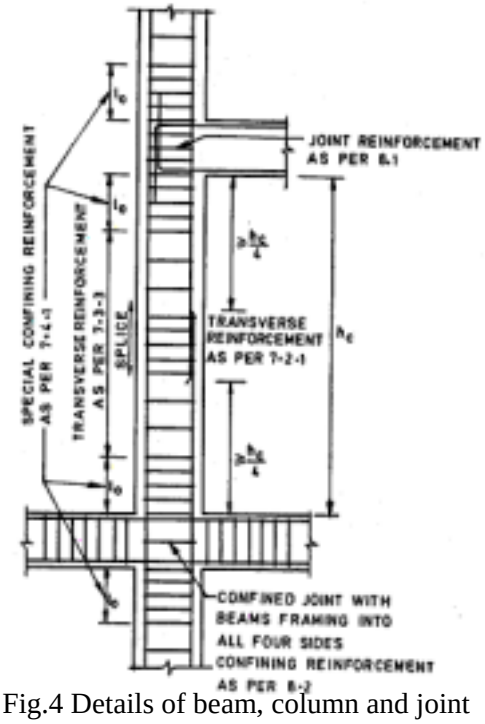

Fig.4 Details of beam, column and joint
(IS13920-1993)

India has already Indian Standards for earthquake resistant buildings, but those are only recommendations and are not enforced by the low.

Following Photo 17 to 22 show details and configuration of reinforced concrete buildings those are under construction at Bhuj.

6. CONCLUSION

It is very important to construct good engineered buildings using knowledge of earthquake, earthquake resistant design, structural details, material and construction quality control prescribed in standards in order to decrease earthquake disasters.

Photo 17 Column and beam
Beams are eccentrically connected to columns.

Photo 20 Column, beam and joint details
Anchorage of beam reinforcements is not enough as described in Indian Standard.

Photo 18 Column, beam and slab

Photo 21 Two story reinforced concrete building

Photo 19 Column, beam and joint details
Anchorage of beam reinforcements is not enough as described in Indian Standard.

Photo 22 Short column at basement