BOOK REVIEW

KUTCH (BHUJ) EARTHQUAKE OF 26th JANUARY 2001. Special Publication No.76, Geological Survey of India, Lucknow, 2003,282p. Price: Rs.460; US$23; Euro: 23

The 26th January, 2001 Bhuj earthquake is the deadliest earthquake to have struck India since the great Assam earthquake of August 15,1950. The human lives lost are estimated to be in the vicinity of about 20,000 and the estimated loss to property is around 50,000 crores. The officers of Geological Survey of India (GSI) have carried out a detailed study of this earthquake which is reported in Special Publication No. 76 of GSI. The same is being reviewed here. There are in all 13 chapters in this report. The lengthiest and the most detailed chapter is on Macroseismic Survey. It must be remembered that in the past, the officers of Geological Survey of India have done a commendable job in investigating earthquakes. The great 1897 Shillong earthquake was investigated in detail by Oldham (1899) and it has become a masterpiece of what one could infer from field observations. Even today it is referred as a standard text for students to learn what needs to be done while carrying out field investigations of earthquakes. Similarly, the Kutch earthquake was revisited by Oldham (1928) and there are interesting reports on Kangra earthquake of 1905, Bihar-Nepal earthquake of 1934 and the earlier mentioned earthquake of 1950. In the recent past, the officers of Geological Survey of India have brought out a good report on the December] 967 Koyna earthquake.

In the report under review, the 1 st chapter by Pande gives the parameters of the Kutch earthquake of 2001, an overview of the lives lost and damages in various districts and a broad map showing the distribution of intensities. The 2nd chapter on Lithotectonic Framework of Gujarat and Adjoining Regions by Pande and others provides a Geological Map of parts of western India with isoseismals of Kutch Earthquake of 26th January, 2001, a Seismotectonic map and a map showing major tectonic features in and around Gujarat. The 3rd chapter by Pande and others addresses Physiography, Stratigraphy and Seismicity of Kutch. It is basically a compilation of the available information. The 4th chapter by Pimprikar and others deals with the analysis of the main shock data. The hypo-central parameters as estimated by various agencies and waveforms of the mainshock are shown.

The 5th chapter provides the details of Macroseismic Survey carried out by Prabhas Pande and 51 other officers of Geological Survey of India. This probably is the best study of the macroseismic effects of the Bhuj earthquake of 2001 that I have seen so far. The work has been carried out very systematically. In Figure 5.1, the route map of macroseismic surveys is provided and then there is a description of individual areas in which damage to structures and the style of destruction is presented. There are a number of coloured photographs which are useful in comprehending the kind of damage inflicted in various areas. After a detailed discussion of damages, an effort has been made to examine why several multi-storied buildings, supposed to be well engineered, suffered damages and collapses at a number of cites. It has been noted that all buildings that collapsed in Ahmedabad had ground floor in the form of framework only. The space between pillars was left open to facilitate parking of the vehicles. Such buildings are called soft ground storey buildings. It is estimated that the presence of infill walls at first floor and further up above it, makes the soft storey ground floor very vulnerable. Due to presence of infill walls, the upper storeys behave stiffly and the entire drift of the building is transferred to the ground storey and the columns are unable to bear huge drift resulting mostly in distress of the whole building. It has been brought out that all buildings that suffered collapses and structural damages had ground floor in the form of soft storey.

Chapter 6 by Pande and others deals with the preparation of the Isoseismal Map and description of isoseist characteristics. Within the isoseist X, an area of 780 sq. km is enclosed. Almost everything got destroyed in this area. Although this area is only 780 sq. km, *it* accounted for 38% of the total human lives lost. There is an area of 10,455 sq. km within the isoseist IX, the major localities are Bhuj, Sukhpar, Lodai, Ratnal, Bhimasar, Anjar, Gandhidham, Kandla etc. These areas claim for 54% of total human lives lost. In Table 6.1, they have provided relevant parameters of areas with different isoseists.

Chapter 7 by Joshi and others deals with Damage to Engineered Structures. The authors have addressed the damage to buildings, projects, bridges and water resource projects. The authors bring out that while in high intensity areas, buildings suffered nearly total damage, houses with traditional designs were not so badly damaged and therefore, saved many lives. Bridges, including culverts, got severely damaged in high intensity zone which demonstrated the

inadequacy of seismic designing The most common forms of damage to the bridges involved crushing of the bearings, tilting of piers and development of low amplitude wavy manifestations on the deck portion As far as the water resource projects are concerned, there are 20 medium and 165 minor irrigation schemes in Kutch district and in the coastal parts of northern Saurashtra region

Chapter 8 by Pande and others deals with Coseismic Structural Ground Deformation The deformations are in the form of lateral displacements, linear subsidence, upheaval, pronounced liquefaction etc Interesting findings include co-seismic deformation of ground near Bodhormora Village in intensity X zone, an E-W trending bump extending to 350 m in length with a maximum height of 80 cm Several ground fractures were observed with lengths upto 8 -10 km and having openings of upto 10 cm

In Chapter 9 Secondary Effects of the Earthquake are dealt by Prabhas Pande and others The authors note that 26th January, 2001 earthquake caused large scale liquefaction which was seen in an area of about 50,000 sq km The extensive plains of Rann of Kutch, the marshy tracts of Little Rann and the shallow groundwater zones of Banni Land provide a very conducive environment for development of liquefaction Most of the liquefaction was observed within intensity X and IX, widespread in intensity VIII and at a few places in area covered by intensity VII and VI At several places, lurching of ground due to lateral spreading was observed A very interesting observation was made of a circular subsidence zone of about 5 m diameter which became better defined after a month of the occurrence of the earthquake Mud craters were also seen at various areas In Table 9 1, the authors have described liquefaction and landslides as observed in areas covered by intensity V to intensity X

Kayal and others have investigated aftershocks of Bhuj earthquake in Chapter 10 Soon after the earthquake, a seismograph station was established at the Geological Survey of India office complex in Gandhinagar on January 28,2001 and a three station network was set up in the epicentral area by midnight of 29th January, 2001 Within a few days time, this was increased to a network of 12 stations including several digital data acquisition devices The authors have made use of the large amount of aftershock data to estimate hypocentral parameters and present diagrams showing their distribution for various magnitude ranges at various depths A look at the depth distribution shows that maximum number of aftershocks were estimated in the depth range of 15-20 km and very few occurred at depths deeper than 40 km The focal mechanism of the aftershock were also determined and a schematic model of the mainshock, occurring at a depth of 25 km, by reverse faulting, has been developed

Chapter 11 deals with the post earthquake geophysical studies by Mukherjee, Lai and Singh The investigations included gravity and magnetic profiling, levelling and Induced Polarization (IP)/Resistivity surveys Interesting structural features have been delineated through these studies

Chapter 12 by Prabhas Pande addresses Seismotectomc Framework of the Region and source Mechanism of Bhuj earthquake A model of the Kutch Rift Basin has been developed The causative fault along with the rupture was initiated at a depth of 20 km, is inferred to be a Precambi lan structural discontinuity following theDelhi-Aravalli trend

In the last chapter, Prabhas Pande and Jaya Singh addresses the Societal Issues and Couise foi Future Studies Many of the conclusions are interesting and important Thei e is a combined bibliography for all the 13 chapters Annexure I gives Newspaper Reports, Annexure II is a Locality Index, Annexure III is a description of Medvedev-Sponheuer Karnik (MSK) Intensity Scale while Annexure IV is a list of Aftershock and their Hyopcentral Parameters

I find the Special Publication No 76 of the Geological Survey of India very informative The section on macroseismic investigations is indeed vety compiehensive A 4-5 page summary integrating the entire work in a nutshell would have been useful The officers of Geological Survey of India need to be complimented for putting together a good report within a short span of time after the Bhuj earthquake This report would be of interest to researchers, students, and other responsible for earthquake disaster management

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