NOTES

TARGETING EAST-WEST NORMAL FAULTS IN PENINSULAR INDIA
FOR SEISMIC HAZARD STUDIES

During the last ten years or so, India has witnessed a
number of damaging earthquakes that occurred both in the
Himalayan belt and the Peninsular Indian shield. Within the
Himalayan belt, large earthquakes struck in 1988 (north
Bihar-Nepal), 1991 (Uttarkashi) and 1999 (Chamoli),
whereas Peninsular India experienced devastation due to
Latur (September, 1993), Jabalpur (May 1997) and the
recent Kutch (January 2001) earthquakes.

At least on two counts, the Peninsular Indian earthquakes
are intriguing; firstly, all the three earthquakes are associated
with roughly E-W trending rift system of Proterozoic age.
They have a history of rejuvenation during the Palaeozoic
and/or Mesozoic when they were reactivated as reverse
faults during the contemporary north-south compressive
stress regime to generate these earthquakes. Secondly, the
gap between the three successive events is 3 years 8 months
(3.66 years). While the second observation could just be a
coincidence (till we encounter another earthquake at a
comparable gap), the first point gives us a certain food
for thought. Site-specific, causative fault system for each
of the three Peninsular Indian earthquakes is as follows:

- The Latur earthquake of 1993 was caused due to
  thrusting along an E-W fault that is located below the
  Deccan trap cover. The fault is likely to be a part of the
  Proterozoic concealed rift basin.

- After 3.66 years, further north, occurred the Jabalpur
  earthquake of 1997 that ruptured (with reverse slip) the
  E-W segment of the Narmada fault, more precisely the
  Narmada South Fault, a member of the Son-Narmada-
  Tapti (SONATA) Proterozoic rift system (with
  Proterozoic-Mesozoic reactivation) traversing across
  the Indian Peninsula.

- With the lapse of another 3.66 years came the
This earthquake occurred due to activity along the
E-W Kutch Mainland Fault, a member of the roughly
east-west trending family of faults that constitute the
Mesozoic Kutch rift basin between the Nagar-Parkar
Ridge in the north and the Kathiawar Uplift in the
south. Reactivation with reverse slip along the
Mesozoic normal fault is considered to be the immediate
cause of this earthquake.

Occurrence of these three damaging earthquakes, all
with magnitude ≥6.0, indicates that the E-W trending, steeply
dipping, major normal faults belonging to Proterozoic-
Mesozoic rift system with protracted history of reactivation
could be the potential source of earthquakes in Peninsular
India. These faults appear to be ideally oriented to
reactivate as reverse faults in the contemporary north-
south compressive stress regime and generate earth-
quakes.

Following the foregoing arguments, the faults/regions
discussed below are to be studied carefully to document
strain build-up if any, for possible future earthquakes:

1. The SONATA fault system is more than 1500 km
   long dividing India into northern and southern segments.
   The Jabalpur earthquake is located almost in the mid-
   segment of this fault zone. Western extremity of this
   fault zone has already been ruptured to generate the
   Broach earthquake of 1970. The 700-800 km segment
   east of Jabalpur defines the Gondwana basin of Son
   and Damodar valleys. The Palaeozoic normal fault
   system in this part, though has not produced any
   major earthquake in the historical past, remains a
   potential source of earthquake hazard in the
   contemporary stress field. The area west of Rihand is
   particularly interesting as a few low magnitude
   earthquake clusters occur in the region.

2. In the southern part of the SONATA fault zone, swarm
   type activity is known for quite sometime and deserves
   attention.

3. Though not associated with Palaeozoic-Mesozoic
   rifts, the east-west faults/shears traversing Karnataka-
   Tamil Nadu cannot be overlooked.

4. But the most potential E-W trending, sub-vertical
   normal fault occurs further northeast, i.e., the Dauki
   fault between the Shillong plateau and the Sylhet
   plains. Geological records indicate the fault to be
   active during the Mesozoic with effusion of Sylhet
   Traps and the fault was rejuvenated during the Tertiary.
   In the contemporary stress regime, this fault will behave
   in a fashion similar to the Narmada South and the
   Kutch Mainland faults to generate earthquakes with
   reverse slip. The region around the Dauki fault is
   seismically active and more active than the other faults.
INDO-ITALIAN WORKSHOP ON SEISMIC RISK EVALUATION

Seismic risk evaluation is being considered as one of the fields of collaborative research programmes under the Protocol of Cooperation between the Governments of India and Italy. As a first step, an Indo-Italian Workshop on Seismic Risk Evaluation was organized from March 3 to 9, 2001. The workshop was sponsored by the Department of Science and Technology (DST) of Government of India, and the Ministry of Foreign Affairs of Government of Italy. This workshop was planned as a forum for deliberations amongst a close group of scientists directly involved in this field, with a test area for microzonation and seismic risk evaluation as the core topic of discussion. The Committee for the Indo-Italian Workshop on Seismic Risk Evaluation, set up by the Department of Science and Technology of Government of India, selected Jabalpur as the test area and formed a working group for carrying out the test exercise. Intensive preparatory work was carried out by Geological Survey of India (GSI) and National Geophysical Research Institute (NGRI), Hyderabad in the Jabalpur area. A reference document detailing the geological, geotechnical and geophysical information was prepared for presentation and discussions during the technical sessions. The workshop had two components (1) A field visit to Jabalpur from March 3 to 5, 2001 and (2) Technical sessions at NGRI, Hyderabad from March 6 to 9, 2001. The field visit to Jabalpur during March 3-5, 2001 was organized by GSI. The visiting group comprised 8 members of the Italian delegation, members of NGRI, and the working group and scientists of GSI and Jabalpur Engineering College. The field programme included visits to a number of type areas to give exposure to regional geological and tectonic settings, as well as visits to specific geotectonic and lithological type areas in the Jabalpur city and its close vicinity, which had experienced different scales of damage during the 1997 earthquake of Mw 5.8.

The technical sessions at NGRI were attended by about 45 participants comprising 8 members of Italian delegation and representatives of DST, Italian Embassy in India, NGRI, GSI, IMD, IITs, WHG, CBRI, CMMACS, Kurukshetra University, Jabalpur Engineering College and others. The deliberations essentially included about 20 oral presentations on the approaches for seismic hazard assessment and risk evaluation as well as presentation of case studies from Italy and India. The presentations broadly covered the three important themes which are the essential components of seismic risk evaluation viz. seismic hazard assessment, microzonation and vulnerability studies. The Indian and the Italian scientists also reviewed the status of the seismological networks, the geological, geophysical and tectonic data for hazard analysis and microzonation. It was opined that although the seismological network in India now enables detection of earthquakes of Magnitude 4 and above, it is important to fill the gaps with installation of new observatories so that the detection level may be brought down to Magnitude 3. Also, the need for a network of strong motion accelerographs was emphasized, to enable realistic estimates of seismic hazard.

It was felt that the approaches for detailed microzonation of urban areas must be based on a deterministic approach. In these, theoretical computations of synthetic seismograms can be used to estimate the expected ground motion for a set of possible scenario of earthquakes, using different fault geometries, source complexities like rupture dynamics, propagation characteristics of media and site effects. Such numerical modelling of ground motion, coupled with the geotechnical data generated from soil penetration techniques (for N values) and directional dependence of attenuation would thus lead to a pre-disaster microzonation. In cases where strong motion records are available, the synthetic ground motion can be compared to the observed ones, to include more complex source models and 2D site amplification effects. Concern was raised about appropriate