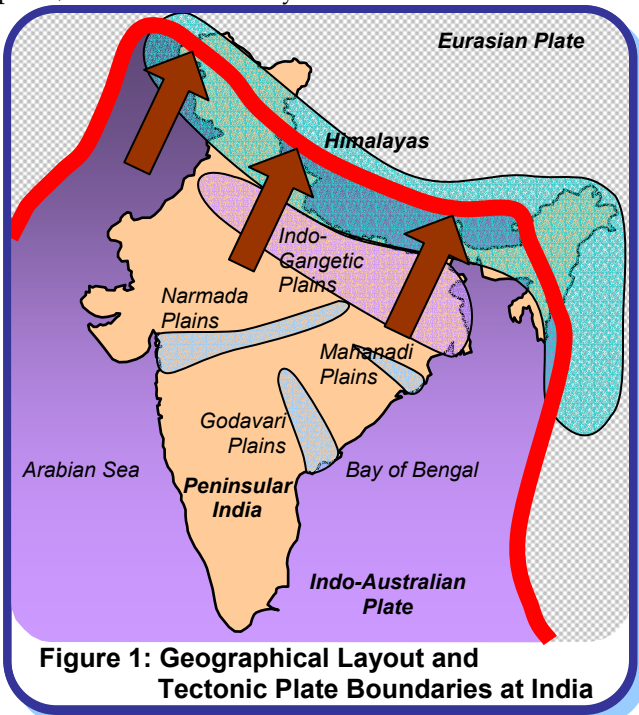


Where are the Seismic Zones in India?

Basic Geography and Tectonic Features

India lies at the northwestern end of the *Indo-Australian Plate*, which encompasses India, Australia, a major portion of the Indian Ocean and other smaller countries. This plate is colliding against the huge *Eurasian Plate* (Figure 1) and going under the Eurasian Plate; this process of one tectonic plate getting under another is called *subduction*. A sea, *Tethys*, separated these plates before they collided. Part of the lithosphere, the Earth's Crust, is covered by oceans and the rest by the continents. The former can undergo subduction at great depths when it converges against another plate, but the latter is buoyant and so tends to remain close to the surface. When continents converge, large amounts of shortening and thickening takes place, like at the Himalayas and the Tibet.

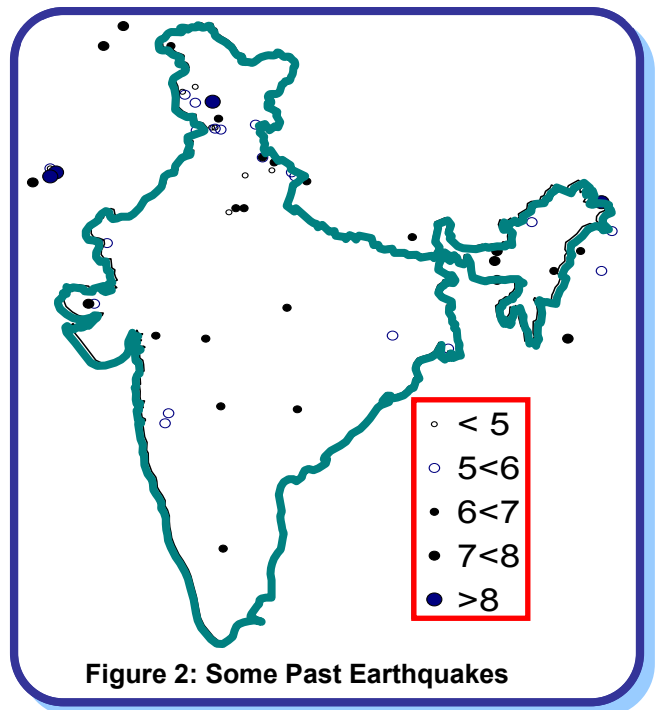


Three chief tectonic sub-regions of India are the mighty *Himalayas* along the north, the plains of the Ganges and other rivers, and the peninsula. The Himalayas consist primarily of sediments accumulated over long geological time in the Tethys. The Indo-Gangetic basin with deep alluvium is a great depression caused by the load of the Himalayas on the continent. The peninsular part of the country consists of ancient rocks deformed in the past Himalayan-like collisions. Erosion has exposed the roots of the old mountains and removed most of the topography. The rocks are very hard, but are softened by weathering near the surface. Before the Himalayan collision, several tens of millions of years ago, lava flowed

across the central part of peninsular India leaving layers of basalt rock. Coastal areas like Kachchh show marine deposits testifying to submergence under the sea millions of years ago.

Prominent Past Earthquakes in India

A number of significant earthquakes occurred in and around India over the past century (Figure 2). Some of these occurred in populated and urbanized areas and hence caused great damage. Many went unnoticed, as they occurred deep under the Earth's surface or in relatively un-inhabited places. Some of the damaging and recent earthquakes are listed in Table 1. Most earthquakes occur along the Himalayan plate boundary (these are *inter-plate* earthquakes), but a number of earthquakes have also occurred in the peninsular region (these are *intra-plate* earthquakes).



Four Great earthquakes ($M > 8$) occurred in a span of 53 years from 1897 to 1950; the January 2001 Bhuj earthquake ($M 7.7$) is almost as large. Each of these caused disasters, but also allowed us to learn about earthquakes and to advance earthquake engineering. For instance, 1819 Cutch Earthquake produced an unprecedented $\sim 3m$ high uplift of the ground over $100km$ (called *Allah Bund*). The 1897 Assam Earthquake caused severe damage up to $500km$ radial distances; the type of damage sustained led to improvements in the intensity scale from I-X to I-XII. Extensive liquefaction of the ground took place over a length of $300km$ (called the *Slump Belt*) during 1934 Bihar-Nepal earthquake in which many structures went afloat.

Table 1: Some Past Earthquakes in India

Date	Event	Time	Magnitude	Max. Intensity	Deaths
16 June 1819	Cutch	11:00	8.3	VIII	1,500
12 June 1897	Assam	17:11	8.7	XII	1,500
8 Feb. 1900	Coimbatore	03:11	6.0	X	Nil
4 Apr. 1905	Kangra	06:20	8.6	X	19,000
15 Jan. 1934	Bihar-Nepal	14:13	8.4	X	11,000
31 May 1935	Quetta	03:03	7.6	X	30,000
15 Aug. 1950	Assam	19:31	8.5	X	1,530
21 Jul. 1956	Anjar	21:02	7.0	IX	115
10 Dec. 1967	Koyna	04:30	6.5	VIII	200
23 Mar. 1970	Bharuch	20:56	5.4	VII	30
21 Aug. 1988	Bihar-Nepal	04:39	6.6	IX	1,004
20 Oct. 1991	Uttarkashi	02:53	6.6	IX	768
30 Sep. 1993	Killari (Latur)	03:53	6.4	IX	7,928
22 May 1997	Jabalpur	04:22	6.0	VIII	38
29 Mar. 1999	Chamoli	12:35	6.6	VIII	63
26 Jan. 2001	Bhuj	08:46	7.7	X	13,805

The timing of the earthquake during the day and during the year critically determines the number of casualties. Casualties are expected to be high for earthquakes that strike during cold winter nights, when most of the population is indoors.

Seismic Zones of India

The varying geology at different locations in the country implies that the likelihood of damaging earthquakes taking place at different locations is different. Thus, a seismic zone map is required to identify these regions. Based on the levels of intensities sustained during damaging past earthquakes, the 1970 version of the zone map subdivided India into five zones - I, II, III, IV and V (Figure 3). The maximum Modified Mercalli (MM) intensity of seismic shaking expected in these zones were V or less, VI, VII, VIII, and IX and higher, respectively. Parts of Himalayan boundary in the north and northeast, and the Kachchh area in the west were classified as zone V.

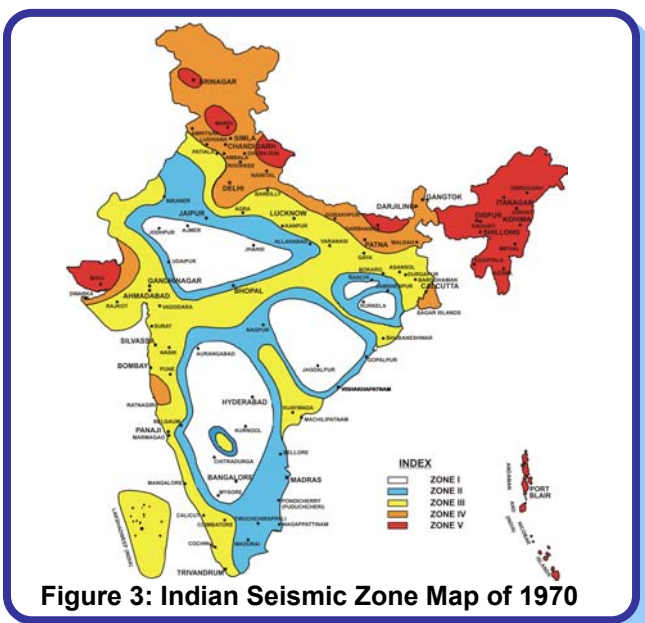


Figure 3: Indian Seismic Zone Map of 1970

The seismic zone maps are revised from time to time as more understanding is gained on the geology, the seismotectonics and the seismic activity in the country. The Indian Standards provided the first seismic zone map in 1962, which was later revised in

1967 and again in 1970. The map has been revised again in 2002 (Figure 4), and it now has only four seismic zones - II, III, IV and V. The areas falling in seismic zone I in the 1970 version of the map are merged with those of seismic zone II. Also, the seismic zone map in the peninsular region has been modified. Madras now comes in seismic zone III as against in zone II in the 1970 version of the map. This 2002 seismic zone map is not the final word on the seismic hazard of the country, and hence there can be no sense of complacency in this regard.

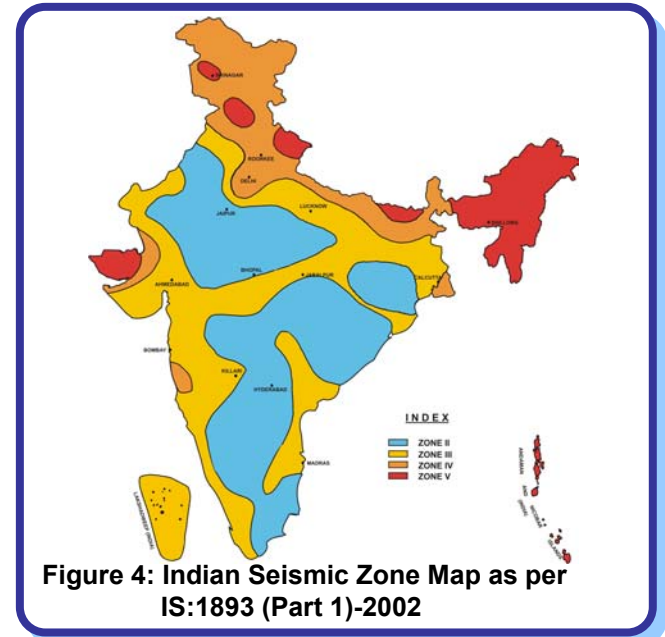


Figure 4: Indian Seismic Zone Map as per IS:1893 (Part 1)-2002

The national Seismic Zone Map presents a large-scale view of the seismic zones in the country. Local variations in soil type and geology cannot be represented at that scale. Therefore, for important projects, such as a major dam or a nuclear power plant, the seismic hazard is evaluated specifically for that site. Also, for the purposes of urban planning, metropolitan areas are microzoned. Seismic microzonation accounts for local variations in geology, local soil profile, etc.,

Resource Material

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- Dasgupta,S., et al, (2000), *Seismotectonic Atlas of Indian and its Environs*, Geological Survey of India.
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