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Earthquake Seismic Distribution of Satara District (Maharashtra,India) : A Georaphical Analysis

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Abstract*: Earthquakes as we learn in school are caused mostly in and around plate boundaries. There rock masses along faults are under frictional stress, i.e. friction between the rock masses on either side of the fault inhibits slip or motion. Plate movements and pore pressures keep adding shear stresses to this rock mass to the extent that the shear stress exceeds a critical value that overcomes the frictional stress. When that happens the rock masses suddenly lurch past each other releasing energy and causing an earthquake. But southern Maharashtra is faraway from plate boundaries. What are causing these intra-plate earthquakes? Figure below (source Sheth 2006): shows zones of structural weakness in south Maharashtra. Two distinct clusters are seen in south Maharashtra, one centered along the Western Ghats in Satara and Kolhapur districts and another to the east around Latur. Both these areas have experienced devastating earthquakes in recent times. In 1967, the Koyna earthquake cause dfew hundred deaths and structural damage and then in 1993 the Killari earthquake in Latur district caused thousands of deaths and enormous structural damage. In this Peeper Earhquake Seismic Distribution and Geological Structure of Satara District The study is based on primary and secondary data.*

Key wards*: Co-efficient Index, Tahsil, District.*

I. Introduction

The fundamental zones of crustal weakness along which south Maharashtra earthquakes occur originally developed in the Precambrian and are 2-3 billion years old. These zones have been periodically re-activated first as tensional fractures and faults when India broke up from Madagascar and Seychelles and later as strike-slip and reverse faults as manifestations of the compression stresses periodically building up in the Indian peninsula. There is a very ancient geological control on the Koyna and Killari earthquakes. Finally a few thoughts on that nagging question: Did the Koyna dam cause the Koyna Earthquake in 1967? The popular notion at that time was that the impounding of water in the reservoir imposed stresses on the crust caused the earthquake. But calculations of rock mechanics show that the increase in pore pressures at depth due to loading of even a few hundred meters of water is very small, orders of magnitudes less than required to cause rock failure by itself. However, if the tectonically created stress along faults is already at a critical level, then a small increase in pore pressure due to impounding of water may act as a tipping point causing slip along the fault. This seems to be the case at Koyna. The deep crustal faults appear to be at a critical level of stress and the pattern of seismicity correlates with the loading and unloading cycles of the reservoir (Pandey and Chadha 2003). Under the right circumstances of crustal stresses, dams may induce earthquakes but are not a primary cause. This is of significance in understanding the risk imposed by the various proposed dams in the Himalayas. There faults and tectonic instability is unavoidable. Understanding the stress regime along individual faults in the vicinity of the proposed dams is of critical importance. In the present Paper Earthquake Seismic Distribution and Geological Structure **of** Satara District. The study is based on primary and secondary data.

II. Study Region

The Satara district is situated in west part in Maharashtra state. This district consist eleven tahsils covering 1739 villages. The total area extent is of 10,480 sq. km. extending from 17°05’ to 18°11’ north latitudes and 73°33’ to 74°54’ east longitudes. This district is confined by Pune district to the north, Solapur district to the east, Sangli district to south and Ratanagiri district and Raigarh districts to west (Fig.1). It has very short boundary of Raigad district to the northwest. Although the boundaries are main administrative line along with several lines this considered with physical features. Satara district has typical landscapes due to variations in relief, climate and vegetation. The variation of relief ranges from the pinnacles and high plateau of the main Sahyadrians range having heights over 1200 meters above mean sea level to the subdued basin of the Nira river with an average height of about 600 meters above mean sea level. The climate ranges from the rainiest in the Mahabaleshwar

region which has an average annual rainfall of over 6000 mm to the driest in Man, Phaltan, Khandala and Khatav tahsils where the average annual rainfall is about 500 mm. Satara is predominately a rural district of the 23 inhabited places in the district, 1739 are villages and 15 towns including the city of Satara.

III. Objectives

The present paper has main objectives are fallows.

1) To Study the Earthquake Seismic Distribution of Satara District

2) To study Geological Structure Tectonic / Geotectonic Activities in study region.

IV. Database and Methodology

The present study is based on the secondary data. The Secondary data obtained from the records of District Disaster Management Authority Satara , census of India (2011). And Socio-economic abstract of Satara District (2011). In this paper

Earthquakes :

• The district administration has ranked earthquakes at number one in terms of past occurrences and has indicated a high probability for future occurrences.

• This is mainly due to the high incidence of seismic activity in the Koyna valley which also was thee picentre of the famous 1967 Koyna earthquake - the strongest seismic event after the 1993 Killari earthquake.

• **In the 1967 earth quake, total 161 lives were lost** , damages and repairs and reconstruction cost tothe houses and the dam ran to several crores of rupees.

• Reservoir Induced Seismicity (RIS) seems to be the likely cause of the seismicity in this area.

• Earthquakes have been recorded here from 1963 and till 1997 more than 95000 tremors have been recorded.

• Even presently about 2- 3 tremors ,albeit of very small magnitude, per day is a common occurrence.

• No other part of the district has reported any seismic activity although the 1993 Killari earthquake caused some damage.

• Seismic observatories are at Koynanagar , Mahabaleshwar and Satara.

• The Koyna and dam and it's backwaters - the principal epicentral area for the seismicity- fall mainly in Patan tahsil and the southern part of Wai tahsil.

These two are comparatively backward districts with some parts of the Koyna valley in Patan tahsils till being in accessible by road.

In the Koyna valley, agricultural activities are rare, and most of it is forest land. and industrialization is negligible Hence the regular tremors of magnitude 2 to 3 are not strongly felt outside the district ; slightly larger tremors do cause some minor damage to houses in parts of the valley. A comprehensive study aimed at assessing the risk of major seismicity is necessary especially since this area is very close to the Western Ghats Fault(?) scarp.

A major earthquake here of magnitude more than 6 could cause substantial damage not only in Satara district but also in the neighboring more industrialized districts of Pune and Kolhapur.

V. Geology and Structure

The Koyna River basin consists of basaltic lava flows of the late Cretaceous to lower Eocene age. Each flow consists of two main units: (i) a lower massive unit and (ii) an upper vesicular unit. The massive unit constitutes

the main trap. It occasionally exhibits columnar and spherical structures and often shows well-developed joints. The vesicular unit forms the upper horizon of each basaltic flow. Generally, the consecutive lava flows are separated by a red layer, varying in thickness from 0.20 to1.30 m termed as 'red bole'. Some of the basaltic flows are lateralized. Later ties of ten form flat plateaus and tablelands at elevations ranging from 975-1400 m above m.s.l.

The major structural features found in the Koyna River basin are joints and faults. Sub vertical to vertical joints are common. Sheet joints are found towards the top of the individual flows. Several lineaments were demarcated on the basis of aerial photographs and satellite imageries. The drainage network is mostly controlled by these lineaments (Fig 1). The Koyna River flows along a N-S trending lineament in the upper reaches and along other lineaments in its lower and middle reaches. The rose diagram, based on 162 measurements, indicates their prominent trends as NESW,N-S and NW-SE. Kaila et al (1981) have proved the presence of a N-S trending fault in the basement rocks just below the Koyna dam.

VI. Tectonic / Neotectonic Activities

Seismic activities with varying degree of intensities have been continuing forthe past four decades in the Koyna River basin, especially after impoundment of waterin the Koyna reservoir. Until 1992, about 60 earthquakes of greater than 4 magnitude were recorded along with more than 100 accelerogrammes including that of the Koyna earthquake of December 11, 1967 (Patil et al., 1992) Continued seismicity following impoundment is a unique seismo-tectonic feature not usually found elsewhere in the world.

Deep-seated Tectonics

The existence of three major structural features in the form of Son-Narmada belt (West, 1962), Konkan offshore faulted belt (Krishna, 1953) and Cambay Greenbelt, have rendered instability to the Deccan plateau. Plots of the epicenters in the peninsular shield by Guha and padale (1981) have indicated that the instability is localized in the marginal areas and mostly to those areas within which rifts and faults are

Earthquake SeismicZone of Satara District (I - Low, VI – High)

Sr.no.	Taluka	Earthquake Seismic Zone
1	Satara	IV
2	Jaoli	IV
3	Koregaon	IV
4	Karad	IV
5	Patan	IV
6	Wai	IV
7	Mahableshawr	IV
8	Khandala	III
9	Phaltan	III
10	Man	III
11	Khatav	III

Source: District Disaster Management Authority Satara

The seismic data of the Koyna region since 1963 is given in the following table :

Sr.no.	Years	No of Shock as per Magnitude				Total No Of Shock	NO Felt shock
		3	< 4	< 5	5		
1.	1963	9	9	0	0	00	0
2.	1964	46	6	0	0	262	0
3.	1965	53	6	0	0	169	0
4.	1966	37	5	0	0	152	0
5.	1967	800	28	8	3	5049	
6.	1968	396	51	0	1	8558	00
7.	1969	252	8	4	0	3314	00
8.	1970	472	1	4	0	2507	00
9.	1971	713	6	4	0	1833	105
10.	1972	659	6	0	0	1705	80
11.	1973	151	0	0	1	2182	101
12.	1974	719	2	2	0	2773	43
13.	1975	476	5	1	0	1522	44
14.	1976	206	8	1	0	245	48
15.	1977	606	4	1	0	631	30
16.	1978	587	4	1	0	612	29
17.	1979	230	5	0	0	255	24
18.	1980	933	33	5	0	071	124
19.	1981	434	3	0	0	477	43

20.	1982	289	9	2	0	310	29
21.	1983	211	7	2	0	250	35
22.	1984	219	2	2	0	233	18
23.	1985	356	1	0	0	387	14
24.	1986	529	1	0	0	540	26
25.	1987	739	2	0	0	751	21
26.	1988	491	5	1	0	507	27
27.	1989	984	0	1	0	995	17
28.	1990	219	1	0	0	2130	14
29.	1991	179	4	2	0	195	27
30.	1992	764	0	0	0	774	15
31.	1993	005	9	5	1	050	38
32.	1994	771	8	0	1	820	64
33.	1995	053	9	2	0	084	37
34.	1996	364	9	1	0	394	29
35.	1997	85	8	0	0	393	05
36.	Total	3697	370	9	7	95413	1094

Source: District Disaster Management Authority Satara

VII. Conclusions

• The district administration has ranked earthquakes at number one in terms of past occurrences and has indicated a high probability for future occurrences.
• This is mainly due to the high incidence of seismic activity in the Koyna valley which also was thee picentre of the famous 1967 Koyna earthquake - the strongest seismic event after the 1993 Killari earthquake.
• **In the 1967 earth quake, total 161 lives were lost,** damages and repairs and reconstruction cost to the houses and the dam ran to several cores of rupees.
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• Earthquakes have been recorded here from 1963 and till 1997 more than 95000 tremors have been recorded.
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