Neotectonic Evidences from Vellore Region, South India

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Abstract — Even though Peninsular India is considered as a stable tectonic region, numerous tremors are reported from this region. As per the literatures, most of these events are related with the reactivation of preexisting structures like active faults, shear zones etc. Present paper is an approach to understand the possible seismicity by these structures using geomorphic tools. The geomorphic anomalies observed in the morphometric data of the major rivers located in and around this structure, indicate that the river basins developed in the vicinity of NE-SW trending faults and lineaments are under structural control. It is also observed that several tremors are reported form the vicinity of this structure. These NW–SE trending faults can generate a maximum magnitude of >5.0 as per the general trend of the seismic zone of Peninsular India. So, the peak ground acceleration (PGA) calculated for a possible magnitude of 5, and the results shows that, the cities located in the vicinity of these seismically active structures may experience a ground acceleration of 0.052g in a moderate event from Main fault and Tirupathur would experience a PGA of the order of 0.123g for a similar event from the same fault. Considering the seismic potential of Peninsular India, these faults need to be focused for detailed studies by judging them as potential sources for a future moderate earthquake

Keywords — Morphometric parameters; Seismotectonics; earthquakes; Peak Ground Acceleration.

I. INTRODUCTION

Earthquake is a' sudden abrupt shaking of earth surface due to release to enormous amount of strain energy from earth's crust due to rupture of faults, which creates seismic waves and these waves travels in all directions and causes intense ground shaking. Earthquakes are caused either due to interplate or intraplate tectonic activity. An interplate earthquake is an earthquake that occurs at the boundary between two tectonic plates'. The term intraplate earthquake refers to a 'variety of earthquake that occurs' within the interior of a tectonic plate due to the presence of active faults and shear zones. Most of the earthquakes reported from South India belong to intra plate earthquakes category. As per the researchers Johnston and Kanter, 1990, South India is considered as a stable continental region. But low magnitude earthquakes are reported from various regions of South India and most of them associated with the reactivation of Pre-existing structures (Gowd, et al.,1996 and Rajendran et al. 1992). Research work carried out by Sykes (1978), Crone et al., (1997), Rajendran et al., (1996), John and Rajendran (2009) are also supporting this statement. As most of these areas where small tremors are reported, are highly populated, the causes of this earthquakes and possible peak ground acceleration due to future earthquakes in this region, need to be subjected to through study. The study area comes under these categories, where small magnitude (3.3-4.3) earthquakes were reported from a period of 1859 to 1984. As most of the areas of Peninsular India is highly modified due to anthropogenic and intense erosional activities, finding the evidences to support active tectonism become a difficult task. As per the researchers Jorgensen (1990), Holbrook and Schumm, (1999), Cox (1994), John and Rajendran (2008), Ouchi (1985), morphometric parameters can use as a best tool for the identification of active tectonic structures in stable continental region. Similarly, John and Rajendran (2008), Ramasamy et al. (2011), Subrahmanya (1996) are the researchers, they utilized the morphometric evidences to prove the neotectonic activities in South India. Therefore, in this work morphometric anomalies in the vicinity of active faults are considered as the major evidences of Active Tectonism

II. MATERIALS AND METHODOLOGY

The study area located in and around Vellore City (Fig.1), where low magnitude earthquakes are reported from the year 1859 to 1984 (Fig.2.) (Table.1). LANDSAT images, LISS IV data and CARTOSAT images are used for the interpretation of lineaments of the study area. Five major faults are observed in the study area, they are Main fault (NE-SW), Pambar River Fault (N-S), Amirdhi Fault (NE-SW), Javandi Hills Fault (NE-SW) & Palar River Fault (NE-SW) (Fig.2.) Out of five faults, four are oriented towards NE-SW direction. Even though lineaments show various orientations like NW-SE, N-S & NE-SW a major trend is observed in NE-SW direction (Fig.2.). The major rivers of the study area are Pambar river & Palar river and its tributaries. For detailed morphometric analysis, the total river system is extracted from 6 toposheets (1:50,000 scale) and assigned stream order to all the segments by Strahler's (1952) method. Morphometric analysis is done with the help of drainage system extracted from toposheets (Fig.3). The total area is then categorized into 238 basins of third order and fourth order rivers (Fig.4) & (Fig.5) to calculate morphometric parameters. Anomalies observed are correlated with the nearby lineaments and faults. The methodology involved in the analysis is shown in the flow chart (Fig.2).

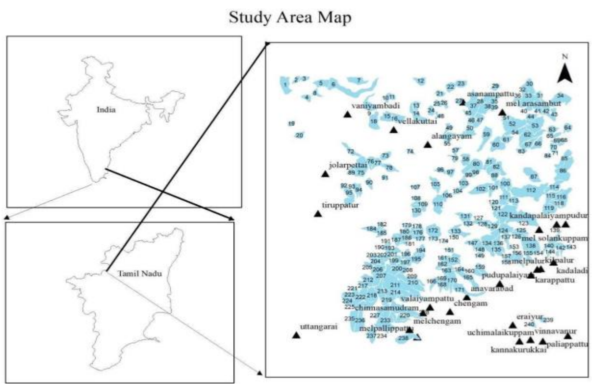

Fig.1. Study area map

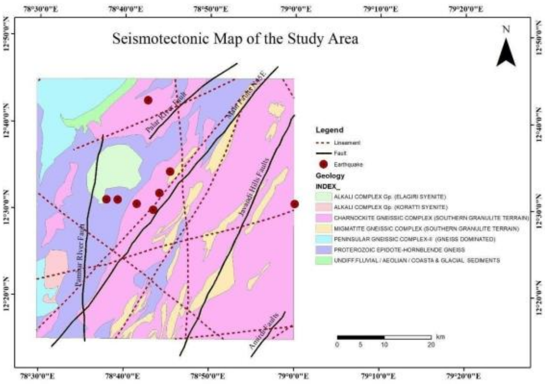

Fig.2 Map shows lineaments, Geology & Earthquake data, of the study area

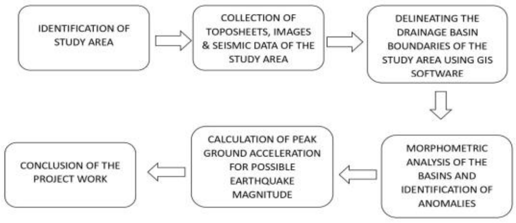

Fig.3. Structural outline of the methodology involved in the analysis of study.

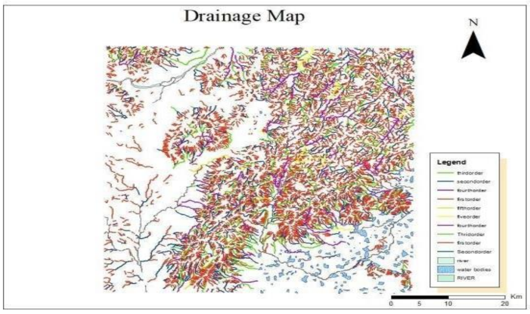

Fig.4. Drainages of map of the study area.

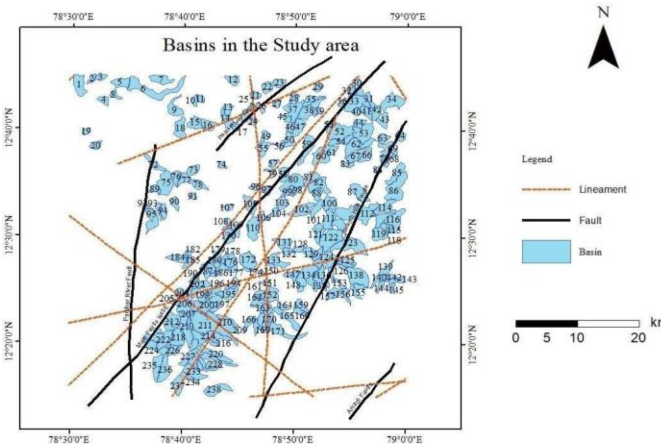

Fig.5 Drainage basin map of the study area

III. RESULT AND DISCUSSION

a. Morphometric data

i. Bifurcation ratio

According to Strahler (1951,1957) bifurcation ratio (Rb) values ranges between 3 and 5 in an area, where the drainage basins developed without any influence of geologic structures and it show high disparity only in those regions which is under high structural control. Supporting evidences are reported from a research work carried out in a basin near Cuddappah (Sreedevi et al., 2005) (Rb value is 3.61). As per the researches carried out by (Horton, 1945) it can be considered as an index for the representation of relief and dissections of an area. Bifurcation ratio of 2nd and 3rd order drainages of the study area is ranging between 1 and 12(Fig.6). Out of 238 basins, 15 basins show values higher than 4. Basins of high Rb value (>5) are observed as clusters in the study area, near lineaments & faults. Basin 200 with a Rb value of 12 is located along the Major fault in the study area. These anomalies in bifurcation ratio near the faults indicate the structural control of the faults over the drainages.

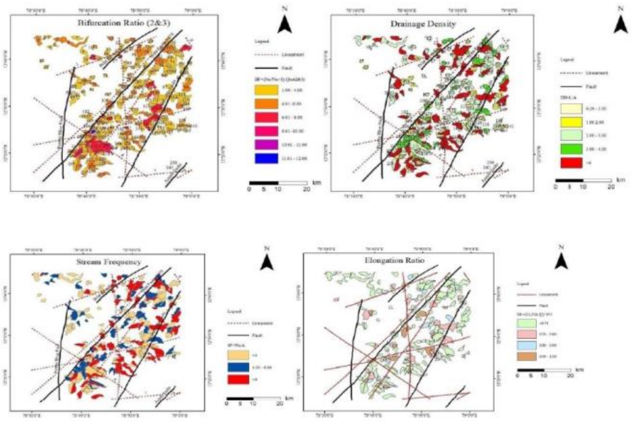

Fig.6. Figure shows the bifurcation Ratio, Drainage density, Stream frequency & Elongation ratio of the study area

ii. .Drainage density

Similarly, the density of stream channels can understand using a parameter called Drainage density (Dd). Low Dd is the characteristic of ahighly permeable subsoil with high resistance (Strahler, 1964). Relief characteristics of a terrain and its development can clearly understand by the analysis of this morphometric parameter. High drainage density value of a basin specifies that major portion of the precipitation flow over the ground without infiltration. The drainage density of the area varies between 0.3 and 11(Fig.6). Highest Dd value (Dd -11) is observed for the basin no 137 located along Javandi Hills Fault. Similar to bifurcation ratio basins with high Dd values are mainly concentrated in clusters near NE-SW orientated faults. High Dd values observed in the basins close to the Faults & lineaments may be due to the movement along the faults (Vittala, et al. 2004)

iii. Stream Frequency

As per Horton (1945), this parameter represents the number of streams developed per unit area. If stream frequency value is greater for a basin, that indicate the ground surface is steeper with high surface runoff (Vittala et.al 2004). It is observed that the basins with high stream frequency values (>6) in the study area are mainly concentrated near faults and lineaments in cluster forms (Fig.6). At the same time, basins located at the

North - East part of the study area away from lineaments shows, comparatively lower stream frequency values.

iv. **Elongation ratio**

In the study area, the values range between 0.42 and 0.98 (Fig.6). Regions of very low relief showing values near to 1.0 and values between 0.6 and 0.8 are associated with steep ground slope and high relief (Strahler, 1964). Elongated basins are observed in clusters in and around the lineaments and faults. Highly elongated NE-SW basins observed in clusters surrounding NE-SW structures may indicate their control over these basins.

b. Seismic analysis based on morphometric data

Reactivation possibility of the faults in the study area are supporting by morphometric data. In addition to this numerous low-magnitude earthquakes also reported from here. Four events are reported in the year 1984, within a span of one week (Fig.2.). The highest observed magnitude in these tremors is 4.3, on December 3rd 1984. Another event reported the same day with a magnitude of 3.5 after 2 hours. Six events out of 8 reported from the study area are located between the two major faults, the Main fault & Pambar river Fault. Even though location accuracy is not enough to connect these tremors with any lineaments, the frequent earthquake may due to the reactivation of the structures. As these faults are oriented favorable to the current NW-SE stress regime (Gowd et al. 1992) the reactivation possibilities are more for these NW-SE trending faults. Similar events favorable to the current stress regime also reported from Central Kerala (Rastogi et al. 1995; Bhattacharya and Dattatrayam 2002; Saikia et al. 2014). In view of this situation, the peak ground acceleration (PGA) for a possible magnitude in the level of bed rock, at various nearby cities are calculated. The mostly accepted Iyenger and Raghukanth (2004) attenuation relation for Peninsular India is used for this calculation is as follows

$\ln y = c1 + c2\,(M-6) + c3\,(M-6)^2 - \ln R - c4R + \ln €$…………………….(1)

where y refers to peak ground acceleration in g, M refers to magnitude of earthquake, and R refers to hypocentral distance. Since PGA is known to be attributed nearly as a lognormal random variable, ln y would normally distribute with the average of (ln €) being almost zero and the constants for the South Indian Province are c1=1.7816, c2=0.9205, c3=0.0673 and c4=0.0035; (ln €) = 0.3136 (taken as zero). As the focal depth of the moderate events in Peninsular India is in between 7 to 10 km. Based on this the PGA at rock level that would experience to the nearby cities, in the event of moderate earthquake (M=4.5) from these two potential sources, has been calculated. Vellore is the city located only 35.45 km from the Main fault and Tirupathur located nearest (13.6 km) from the same fault. It found that the city of Vellore would experience a PGA of 0.052g in a moderate event from Main fault and Tirupathur would experience a PGA of the order of 0.123g for similar event from same fault.

IV. CONCLUSION

Earlier studies identified the indications of fault systems in the hill ranges, but no studies were carried out to identify its morphologic evidences in this area. Present study mainly concentrated to delineate the faults and lineaments of the study area and to find its control over the drainages. The control of fault & lineaments over the area and its drainages are clearly perceptible in the morphometric results. The anomalies observed in the drainage density, elongation ratio, stream frequency etc. are mainly concentrated in and around the vicinity of faults & lineaments. Considering the general trend of the seismic source zone reported in the peninsular India, the study area faults can generate a Magnitude M >4.5. Peak ground acceleration calculated for a magnitude of M=5.0, as the maximum credible earthquake that can generate by these two faults. The peak ground acceleration that Tirupathur, the nearest city, would experience from Main fault is 0.123g. The spatial association of seismic activities with these lineaments is indicating that these structures are responding to the present regional stress regime of peninsular India. Considering the seismic potential of Peninsular India, these faults need to be focused for detailed studies by judging them as potential sources for a future moderate earthquake.

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