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EARTHQUAKE IN SOUTH INDIA ON 20th MARCH 1984

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ABSTRACT

Bangalore and its neighbourhood was rocked by an earthquake on 20th March 1984 at about 4.15 pm. On the basis of a damage survey, the epicentre has been established as between Kowthalam and Kelamangalam in Tamil Nadu. The Richter's magnitude was between 4 and 5 and the intensity in the epicentral tract as inferred from damage to buildings in the area was about VI on the M.M. scale. The depth of focus has been calculated to be about ten to eleven kilometres. As a result of this earthquake, most of the buildings in the epicentral tract developed cracks. The most probable cause of the earthquake seems to be due to slipping along the existing N 30°E fault to the west side of the Mettur reservoir.

INTRODUCTION

Bangalore (13°N, 77.6°E) and its neighbourhood experienced an earthquake on 20th March 1984 at 4.15 pm. The field study indicates that the location of epicentre is in the village Kowthalam (12.54°N. 77.8°E) in Tamil Nadu, about 60 km Southeast of Bangalore. The felt radius was 80 km. The magnitude is estimated to be between 4 and 5. The intensity at Kowthalam is estimated to be VI. A damage survey was undertaken within ten days of occurrence of the earthquake. This paper includes an account of the investigation. The places indicated in Fig. 1 and their neighbouring villages were visited.

REGIONAL SEISMIC HISTORY

In the past, during the period 1823 to 1968, about 38 earthquakes have occurred in South India. Among these shocks, 19 occurred within 30 kms of the north south trending Vettavanan-Mettur fault and six occurred close to Arachean Cretaceous boundary near the eastern coast (Grady, 1971). The frequency diagrams of earthquakes in the past around Kowthalam within 11.5° and 13.0° Latitude and 77.0° and 78.5° Longitude are shown in Figs 2 and 3. (Sharma and Varghese, 1979, Umesh Chandra, 1977).

The present area under survey is a part of Deccan Plateau and falls under seismic zone I as per I. S. Code 1893–1975. The main rock types of the area

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are hornblende granulites, quartzites, biotite gneisses and charnockites intruded by dykes of dolerite. The rocks have a general N. N. E-S. S. W strike of foliation and dip in an easterly direction.

SALIENT FEATURES OF THE EARTHQUAKE

Duration of the Shock

From the information collected, it has been estimated that the dominant phase of the earthquake lasted for about five seconds.

Sound

Local information from the epicentral region reveals that a sound resembling the operation of wet stone grinder was heard.

Epicentral tract

Based on field evidences, it has been deduced that the major affected areas lie between Kowthalam and Kelamangalam. It can therefore be concluded that the epicentral tract of this earthquake lies between these two places.

Intensity

The intensity at epicentre on the Modified Mercalli Scale has been assessed to be VI.

Magnitude

The magnitude of the earthquake estimated from the formula proposed by Gutenberg and Richter (1956)

$$M = 1 + (2/3)\ I_0 \qquad (1)$$

is 5. The magnitude of earthquake according to seismograph recordings at N. G. R. I. Hyderabad is 4.7.

Focal depth

From Murray Stuart (1919), the depth of focus d can be calculated using the relationship

$$d = 1.732x \qquad (2)$$

where x is the horizontal distance from the epicentre to a place where the intensity (equal to 3/4th of the maximum intensity) declines most rapidly from the origin. For the present shock, the intensity declines most rapidly at points situated about 6 Kms from the epicentral line. Thus the depth of focus may be approximately taken as ten to eleven kilometres. From Gutenberg and Richter 1956), focal depth d can be calculated using

$$d/h = [10^{(1/3-0.5)} - 1]^{1/2} \qquad (3)$$

where I is the epicentral intensity and h is the radius of maximum felt area. For the present shock, the maximum effect has been felt upto Bangalore, giving $h \simeq 60$ km. This equation algo gives the depth of focus to be between ten and eleven kilometres.

Acceleration

From the relationship connecting the MMI and the maximum ground acceleration (Gutenberg and Richter 1956),

$$\log a_m = 0.333I - 0.5 \quad (4)$$

it follows that $a_m = 0.032g$ or 31.5 cm/sec^2.

From another relationship suggested by Esteva (Newmark and Rosenblueth 1971) between a_m, M and the focal distance R

$$a_m = 1230\, e^{0.8M}\, (R + 25)^{-2} \quad (5)$$

For the present shock taking $R = 20$ km and $M = 5$ one gets $a_m = 0.033g$. Yet another estimate for the least possible a_m can be obtained from observation of overturned objects. The only reliable observation the authors could make was of a wooden post, 3.5m tall and 10cm in diameter, in a hut in the epicentral village Kowthalam. This had tilted by about 3° to the vertical. The minimum acceleration needed for initiating the rocking motion for this object is

$$a = (10/350)g \quad (6)$$
$$= 0.028g$$

From the above three estimates it may be safely concluded that the maximum ground acceleration at the epicentre has been about 0.03g.

DAMAGE SURVEY

A description of the seismic disturbance in various places enclosed by isoseismals IV, V and VI is given below. The classification of buildings as type A, B, C follows the IS Code 1893–1975. The isoseismal map is presented in Fig. 1.

BANGALORE (13°N, 77.6°E), MMI = IV

The tremor was felt by all. Cracks developed in old buildings. There were instances of falling down of plaster from partition walls and ceilings. Stacked furniture in one of the rooms in the state legislature building Vidhana Soudha tumbled down. People rushed out of theatres and offices. Swaying of trees was observed. At a few places window planels broke. Heavy furniture in top floors moved.

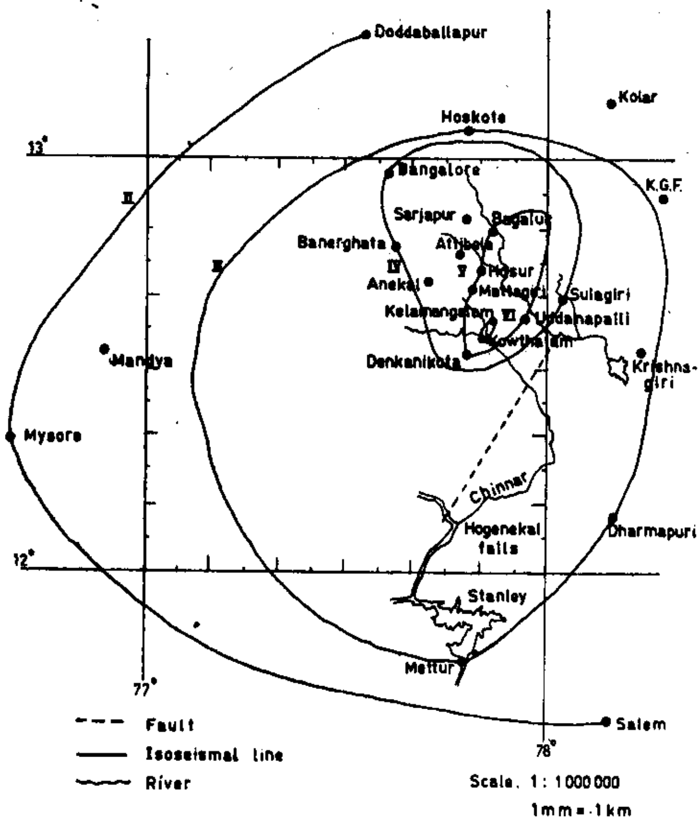


Fig. 1. Isoseismal map of the South Indian earthquake of 20–3–1984.

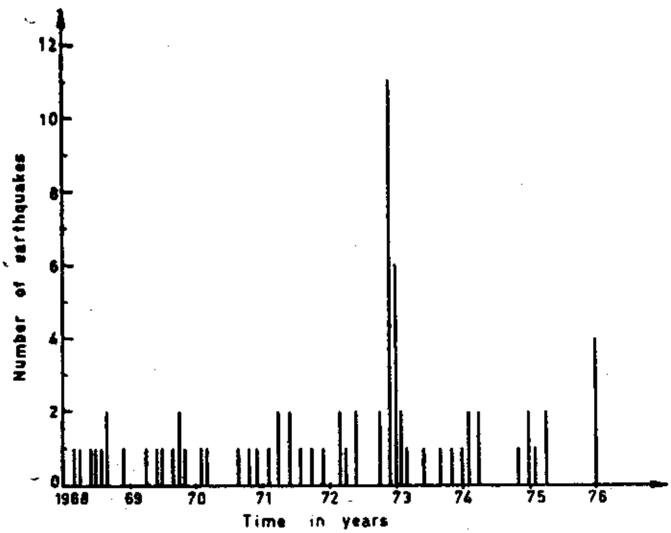


Fig. 2. Monthly occurrence of earthquakes including micro earthquake activity around Kowthalam as recorded by Gauribidanur Seismic array.

SARJAPUR (12.9°N, 77.8°E), MMI = IV

The earthquake was widely felt. Cracks developed in a bank building (structure of type B) and a temple.

ANEKAL (12.7°N, 77.7°E), MMI = IV

The earthquake was felt by all. There were plaster cracks in buildings of type A.

BANNERGHATTA (12.8°N, 77.6°E), MMI = IV

A recently constructed multistoreyed building has shown up a few cracks in the walls and in the water tank.

HOSUR (12.75°N, 77.8°E), MMI = V

The earthquake was felt by all. Through cracks in old buildings and cinema theatres (buildings of type B) have developed. It was reported that projectors in cinema theatres, fire extinguishers and furniture vibrated severely. In a new electronics factory building (structure of type C), through cracks got developed in many places. Most of these are in partition walls. However a few horizontal cracks have developed at beam wall junctions also. No damage to tall structures like water tanks has been observed. At a few places, window penels broke. The cracks have a general pattern of being vertical and in the northeast southwest direction.

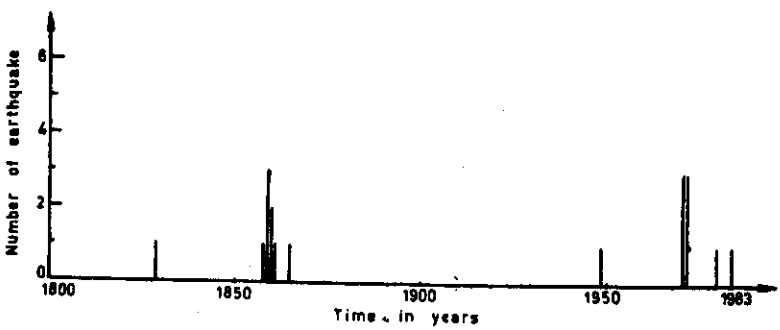


Fig. 3. Frequency of occurrence of earthquakes of intensity greater than IV around Kowthalam (within 11.5°—13.0°N and 77.0°—78.5°E).

UDDANAPALLI (12.6°N, 77.9°E), MMI = V

The earthquake was felt by all. It was reported that utensils and roof tiles shook heavily.

KUNDUMARANAPPLI, MMI = V

The earthquake was felt by all. Tiles from roofs fell down. Sliding of furniture, overturning of utensils was observed.

M. BARANDUR AND D. BARANDUR (MMI = V)

The earthquake was widely felt. There was no damage to buildings.

MALLASANDRA, MMI = V

The earthquake was widely felt. There were vertical cracks in walls of a school building.

DENKANIKOTA (12.5°N, 77.79°E), MMI = V

The earthquake was felt by all. About 2 km from Denkanikota, tiles stacked in a tile factory rattled and a few fell down also. Existing cracks widened as a result of the earthquake. A structure of type B in the premises of the factory developed cracks. New Horizontal and Vertical cracks developed in a brick chimney 3 × 3 m at base and 25 m in height. (Fig. 4). However in a nearby factory no cracks were observed on a recently constructed similar chimney. Logs stacked in the forest range office got dislodged.

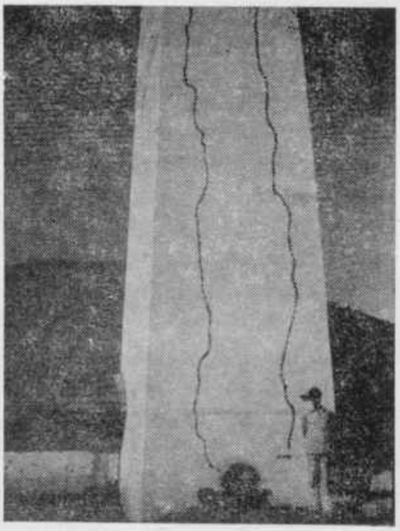


Fig. 4. Damage to brick chimney of a tile factory in Denkanikota.

KELAMANGALAM (12.6°N, 77.88°E) MMI = VI

The earthquake was felt by all. People in cinema halls panicked and ran out. People interviewed by authors reported to have heard a sound resembling the operation of a wet stone grinder. Through running cracks in walls of buildings of type B, have occurred. Existing cracks have widened after the earthquake in type A and type B structures (Fig. 5).

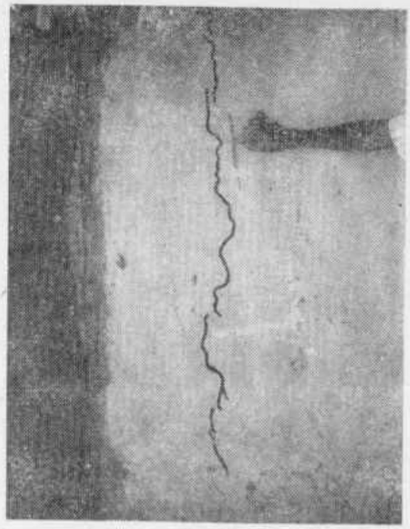


Fig. 5. Cracks in a mud house in Kelamangalam

In the office of the Assistant Commissioner (structure of type B), already existing cracks widened (Fig. 6). In a building under construction adjacent

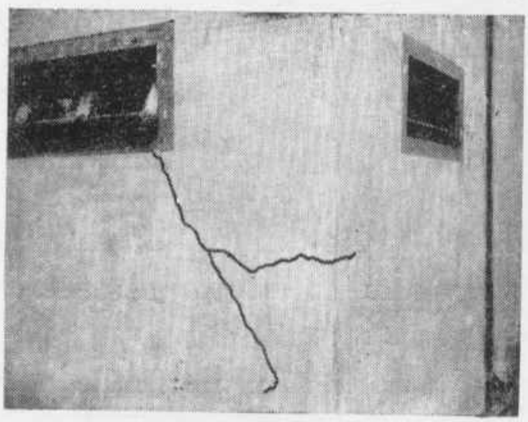


Fig. 6. Cracks developed in the Assistant Commissioner's Office, Kelamangalam.

to the Assistant Commissioner's Office, vertical cracks have developed at all brick column-wall junctions (Fig. 7) in the north south direction. The opening seen at the bottom is made after the shock for inserting bond stones.

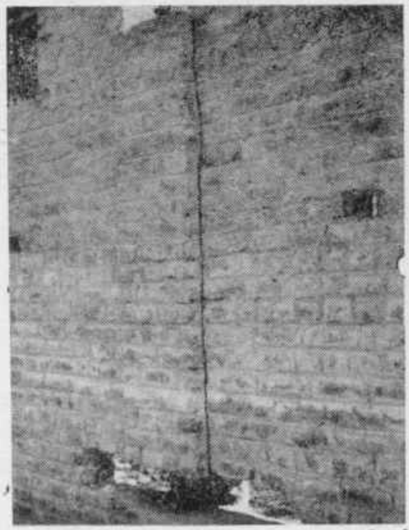


Fig. 7. Crack in column-wall junction of a building under construction.

In a doctor's residence, (structure of type B) cracks run continuously through the wall and floor (Fig. 8). The roof has developed plaster cracks.

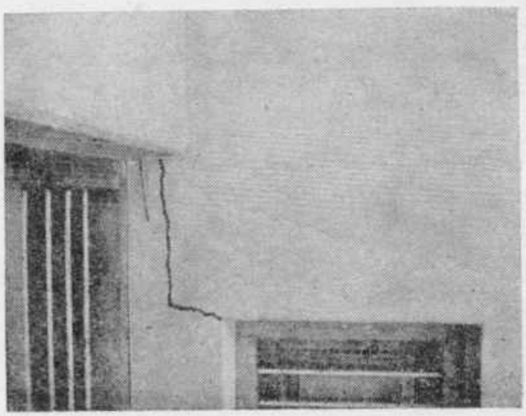


Fig. 8. Residential building with fresh cracks.

The cracks in the roof and floor run roughly in the north-south direction. Cracks were also observed in the Primary health centre hospital.

In buildings of type A, existing cracks have got widened (Fig. 9).

Local people reported of cracks and damage to the road bridge across the river Sanat Kumar. The bridge is of three spans with a steel girder deck. The piers and abutments are of stone masonry. Vertical cracks in the piers were observed by the authors during the investigation. However, it was not possible to conclude whether they were new or already existing cracks (Fig. 10).

Fig. 9. Widening of cracks in a stone masonry wall.

Fig. 10. Crack in the abutment of a road bridge.

KOWTHALAM (12.58°N, 77.8°E), MMI = VI

The earthquake was intensely felt by all. The people reported a general feeling of swinging action. Everyone panicked and ran out of their homes. All structures of type A and B have cracked (Fig. 11).

In the old school building (structure of type B) freshly developed vertical cracks are visible in parallel walls (Fig. 12). In the new school building under construction, vertical cracks have developed in parallel walls below window sill level. The cracks are very severe and do not lie along bonds. Bricks in all the courses including the stone masonry in the plinth courses have broken (Fig. 13). In a flour mill, vertical cracks have developed in parallel walls (Fig. 14). It may be mentioned here that this village has

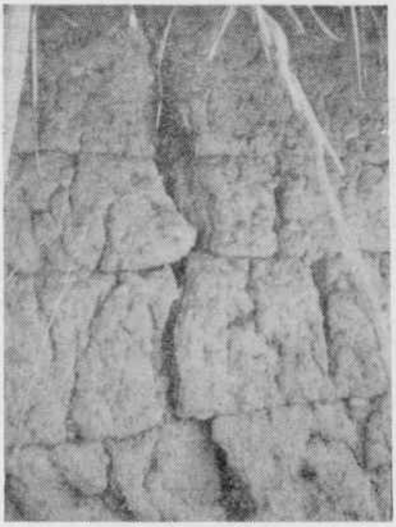


Fig. 11. Typical cracks in mud houses in Kowthalam.

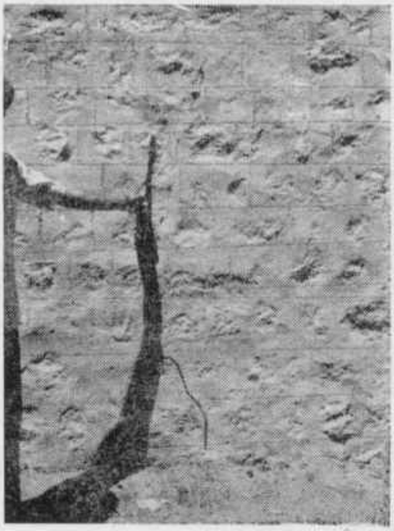


Fig. 12. Crack in the old school building in Kowthalam.

suffered the maximum damage. The cracks have a general pattern of being vertical and in the north south direction. Light objects like utensils in most of the houses overturned. A steel trunk ($70 \times 27 \times 38$ cms) kept on a masonry platform at a height of 75 cms above the floor level fell down. A 2 m tall papaya tree with a circular base of about 30 cms diameter got uprooted. In one of the houses, portions of a mud wall collapsed. In another house a bamboo rafter was dislodged. Two supporting posts (3.5 m high, 10 cms dia) of the roof, one embedded in the ground and another embedded in a platform rocked and tilted by 3° to the vertical. Another interesting observation is that a spliced bamboo rafter got dislocated. In the same place

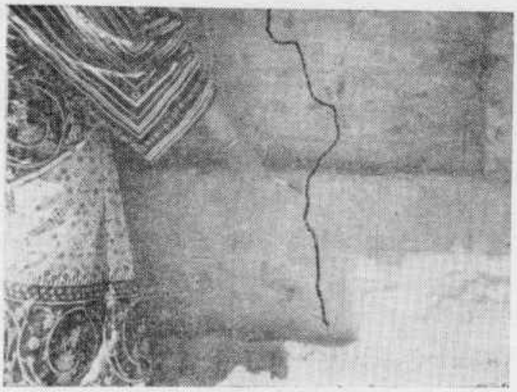


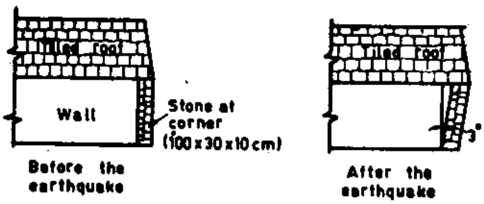
Fig. 13. Rupturing of stones in the foundation of a new school building under construction in Kowthalam.

Fig. 14. Cracks in the wall of a flour mill in Kowthalam.

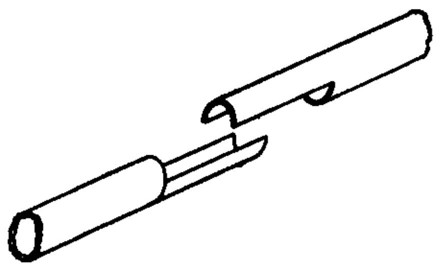
a stone slab (Fig. 15) used as a supporting column at the corner tilted by about 3°. The only special structure near this village is the old earthen bund with a small reservoir. This has withstood the earthquake very well without any visible serious damage.

DISCUSSION AND CONCLUSIONS

Contrary to popular belief, earthquakes do occur in South India, although these are not very frequent. As reported by Grady (1971), there are several active deep seated faults in the region of interest. The slippage of these might have triggered the present shock. Damage survey indicates that the epicentre is in the village of Kowthalam in Tamil Nadu. The fault nearest to this point is marked on Fig. 1. As per the I S Code 1893-1975



Tilting of corner stone in a mud house.



Spliced joint in rafter after earthquake.

Fig. 15

the epicentre is in Zone I with a seismic coefficient of 0.01. Since the present shock shows an acceleration of about 0.03g there is a need to revise the Codal provisions suitably. The following conclusions emerge from the present study.

1. The epicentre of the earthquake felt widely in South India on 20 March 1984 was in Kowthalam, Tamil Nadu (12.58°N, 77.8°E).

2. The MM intensity of the shock at the epicentre was VI.

3. The shock is attributed to the known existing N 30°E fault about 17 km south-east of the epicentre.

4. There is a need to reconsider the provisions made in the present IS Code for the epicentral region under consideration.

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