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A Report on Mw 6.7 Manipur Earthquake of January 4, 2016

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Abstract

An earthquake of Mw 6.7 occurred in Manipur on January 4, 2016 at 4:35 am early morning (January 3 at 23:05:21UT). Epicenter is about 35 km west of Imphal in Tamenglong district near village Noney. Location is 24.8^{0}N 93.5^{0}E at focal depth of 38km. The earthquake is of moderate MM intensity VII. As the epicentral zone is in forest area damage is less. Some 8 deaths are reported in India and some in Bangladesh. Some 165 houses collapsed in Imphal and a few partially collapsed at Guwahati and Silchar. Amplification is noticed in soft sedimentary basins of Imphal, Silchar, Guwahati and Bangladesh. Damage in Imphal is more as it is on a soft sedimentary basin and is close to the epicenter.

Keywords: Seismicity of Northeast India, Manipur, isoseismals, earthquake damage

1. Introduction

A preliminary report on Mw6.7 Manipur earthquake of January 4, 2016 is presented. Epicenter is in Seismic Zone V which covers the entire NE India (Figs. 1 and 2). The region has many large and active faults. Earthquakes of magnitude 8 or more can strike anywhere, anytime. The Manipur earthquake is within a major Naga Thrust Zone. However, the present earthquake is along a small fault, named Irang River Fault which is a NNW-SSE trending strike-slip fault near Noney village in Tamenglong district of Manipur (Arun Kumar, Manipur Univ., Imphal).

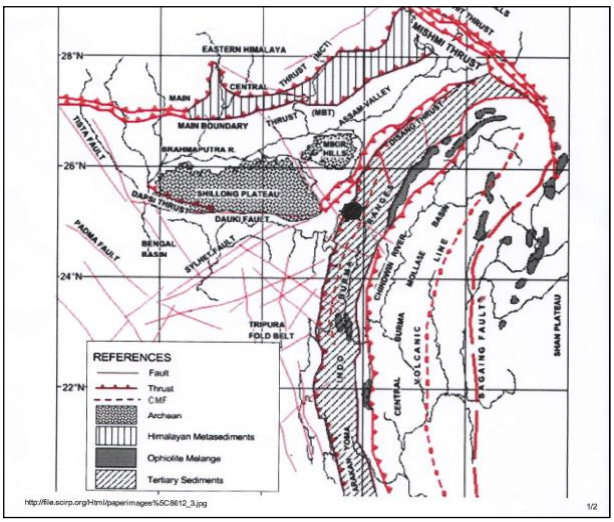

Fig. 1: Seismotectonics and Geology of NE India. Epicenter of the Manipur earthquake of Jan 4, 2016 is shown by big circle

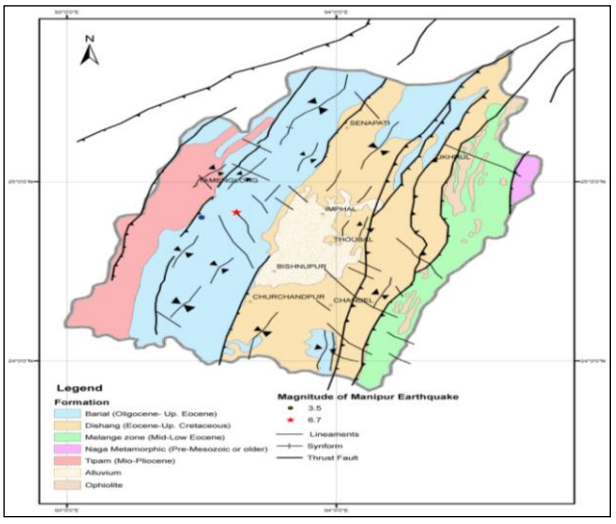

Fig. 2: Epicenter of the Manipur earthquake of Jan 4, 2016 on Geological map of Manipur. Note that Imphal city is in soft sedimentary basin. Epicenter is along NNW-SSE trending strike-slip Irang River Fault.

2. Earthquake Parameters

Manipur earthquake of Mw 6.7 on January 4, 2016 occurred at 4:35 am early morning. Epicenter is about 35 km west of Imphal in Tamenglong district near village Noney. Energy released in seismic waves due to this earthquake is equivalent to 11 Hiroshima. The unit Hiroshima is equivalent to M5.5. Location of the Manipur Earthquake of January 4, 2016 determined by various agencies is given in Table 1. Seismic moment Mo (which depends upon rupture area and slip) is determined has been determined by GeoForshung Zentrum, Potsdam and Harvard Univ. (Fig. 3)

```
Agency: GFZ
Content-Length: 1182
GFZ Event gfz2016afks
16/01/03 23:05:21.10
Myanmar-India Border Region
Epicenter: 24.77 93.59
MW 6.7
GFZ MOMENT TENSOR SOLUTION
Depth  48        No. of sta: 174
Moment Tensor;   Scale 10**19 Nm
  Mrr= 0.29       Mtt=-0.60
  Mpp= 0.31       Mrt= 0.82
  Mrp= 0.08       Mtp= 0.77
Principal axes:
  T  Val=  1.13  Plg=37  Azm=313
  N        0.22      44       89
  P       -1.34      24      204

Best Double Couple: Mo=1.2*10**19
 NP1:Strike=343 Dip=45 Slip= 169
 NP2:        81     82        46

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Agency: HARVARD
January 3, 2016, MYANMAR-INDIA
BORDER REGION, MW=6.7
Goran Ekstrom
CENTROID-MOMENT-TENSOR  SOLUTION
GCMT EVENT:     C201601032305A
DATA: II G  LD DK IU CU MN IC GE
 KP
L.P.BODY WAVES:165S, 418C, T= 50
MANTLE WAVES:  151S, 306C, T=125
SURFACE WAVES: 165S, 424C, T= 50
TIMESTAMP:      Q-20160103230934
CENTROID LOCATION:
ORIGIN TIME:      23:05:29.0 0.1
LAT:24.70N 0.00;LON: 93.46E 0.00
DEP: 54.1  0.4;TRIANG HDUR:  5.5
MOMENT TENSOR: SCALE 10**26 D-CM
RR= 0.317 0.006; TT=-0.809 0.005
PP= 0.491 0.006; RT= 0.827 0.008
RP= 0.335 0.007; TP= 0.941 0.005
PRINCIPAL AXES:
1.(T) VAL=  1.445;PLG=34;AZM=306
2.(N)       0.060;    50;     88
3.(P)      -1.506;    19;    202
BEST DBLE.COUPLE:M0= 1.48*10**26
NP1: STRIKE=339;DIP=51;SLIP= 168
NP2: STRIKE= 77;DIP=81;SLIP=  39

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Fig. 3: Full tensors solutions indicate strike slip+ reverse faulting along a NNW trending fault. Results exactly match from GFZ and Harvard

The moment magnitude Mw is determined from Mo using the relation:

$M_w = 2/3 \log Mo - 6.06$

where Mo is in N-m. If the Mo is given in dyne-cm it can be converted to N-m as 1N-m = 10^7 dyne-cm. Hence, Mo 1.2×10^{19} N-m given by GFZ or 1.48×10^{19} N-m given by Harvard yield M_w 6.7**Table 1**: Parameters of the Manipur Earthquake of January 4, 2016

Agencies	**Lat ^{0}N, Long ^{0}E**	**Depth(km)**	**Area**
EMSC	24.75 93.45	40	37 km west of Imphal
USGS	24.834 93.635	55	29 km west of Imphal
Ind. Nat. Center Seism.	24.8 93.5	38	35 km west of Imphal
GFZ	24.78 93.58	37	30 km west of Imphal

3. Earthquake Mechanism:

Mechanism for this earthquake determined from seismological data worldwide with moment tensor analysis is strike-slip in right-lateral sense along NNW-SSE trending fault (Fig. 3, GFZ, Potsdam and Harvard). The mechanism matches with the Irang River Fault which is also a NNW-SSE trending strike-slip fault.

4. Damage

The earthquake was moderate with maximum Modified Mercalli intensity VII (Fig. 4). Due to slightly deeper depth (40-50km), the energy is less intense near the epicenter and spreads out to more distance. Moreover, the epicenter is in forest area with fewer villages and no big towns. For M6.7 earthquake collapse of structures was confined to about 50 km radius. Within this distance (35km east) is Imphal which is situated in a soft sedimentary basin. Hence damage is maximum at Imphal. There may be pockets of amplification in soft sedimentary basins like Silchar, Guwahati or Bangladesh where partial collapse may be at distances of greater than 50 km. Cracks in buildings are expected up to 250 km distance.

In the villages near the epicenter widening of cracks was noticed on day 2 after the earthquake. Villagers were scared due to apprehension of a larger earthquake.

Total no. of deaths reported in India is 8. In Manipur 6 deaths, 100 injured and 165 houses collapsed. There were 3 deaths in Imphal west, 2 in Imphal east and 1 in Senapati (22 km north of Imphal). Shaking felt for 1 minute. Shaking was intense in Manipur, biggest after 1950.

At Imphal, Hotel Nirmala tilted and sunk probably due to liquefaction. Minithong bridge cracked. Buildings in main market cracked. Partial collapses in all women market, named Ima Keithal, Ima, meaning mother and Keithal meaning market. Many pillars failed and walls collapsed. Church collapsed in Ukhrul. Total 165 houses collapsed (Fig. 5).

In 3 parts of a village near Imphal total 37 houses, made of mud & boulders collapsed. In one part of the village, some 16 out of 22 houses collapsed. Down the hill in Chingmong

village a man and his granddaughter got killed in a collapsed RCC house. A 3-storey house, of P.W.D, Ex. Engg., collapsed.

Large cracks developed during the quake at Noney (Longmai) Part-1. It ejected vapour-smoke on 7th January, 2016 morning. On the other hand, quantity of water flowing down from the hill streams has increased after the tremor. Several houses developed cracks in Silchar (80km) and Dimapur (100 km) where MMI is assigned VI.
Some 15 persons injured in Guwahati (230km NW) while running out of their houses. At least 20 buildings developed cracks. Two persons died in densely populated Maligaon area of Guwahati. Scores injured in Barak valley, Kamrup and Karbi-along districts of Assam adjoining Manipur.

Five persons are reported to have died in Bangladesh; 1 each died in Dhaka, N-W Rajshahi, Lalmonirhal, N. Jamalpur and N-W Panchgarh. Several buildings in old part of Dhaka developed cracks. A 6 storey building tilted.

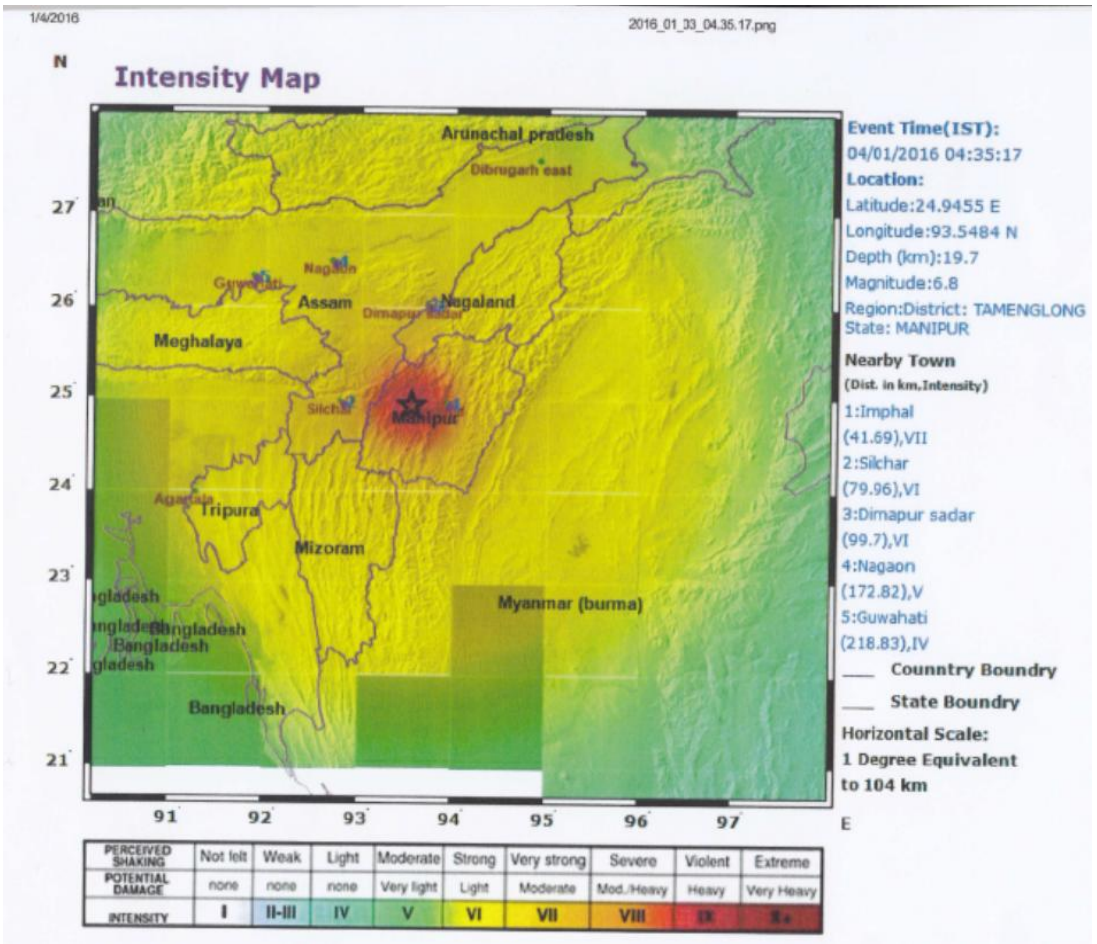

Fig. 4: The shake map prepared by Ind. Nat. Center of Seism. Maximum Modified Mercally intensity (MMI) assigned is VII. Numbers within brackets are distances from epicenter.

Damages in Imphal

Fig. 5a: Clockwise from top (a) Damaged Imphal church (b) Collapsed house in Imphal (c) Collapsed new buildings in Imphal market (d) Collapsed walls and failed pillars in All Women Market

Fig. 5b: Government Polytechnic Takyelpat, Imphal West

Fig. 5c: Building Collapse, Imphal

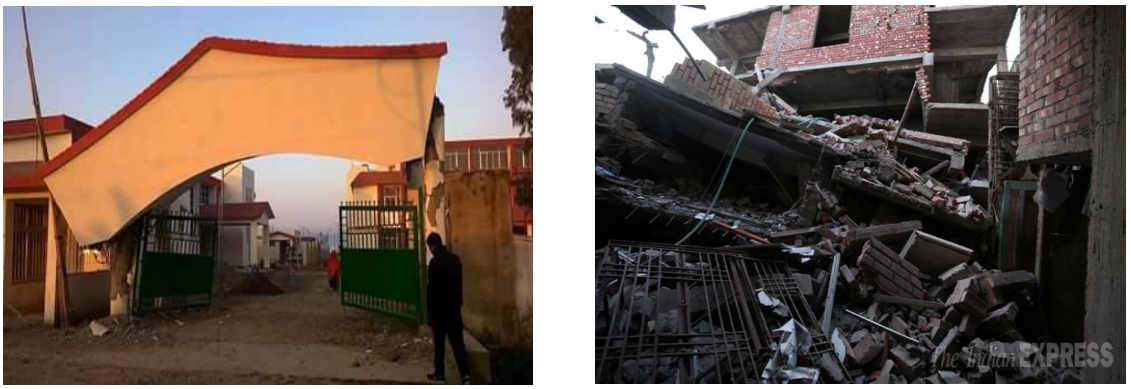

Fig. 5d: Damaged buildings in Imphal.

Fig. 5e: Ima Keithal, Imphal

Fig. 5f: Cracks developed at Noney

Fig. 5g: Damaged road and power line, Imphal

Fig. 1h: Damages in Dewlahand, Wangkhei Angom leikai,Tabungkhok and Lamshang localities of ImphaL

5. Rescue

One NDRF team of 65 reached same day. Another reached next day. 83 rescuers airlifted from Guwahati. Another team of 35 NDRF rescuers was deployed in Silchar. A 3-member team of Power Grid Corporation for restoration of power started working on second day. A team of doctors reached second day.

6. Some Salient Features:

i. Mechanism for this earthquake determined from seismological data worldwide is strike-slip in right-lateral sense along a NNW-SSE trending fault (Fig. 3, GFZ, Potsdam and Harvard).
ii. Due to slightly deeper depth (40-50km), the energy is less intense near the epicenter and spreads out to more distance.
iii. Energy = 11 Hiroshima.
iv. Villagers were scared due to widening of cracks on day 2 after the earthquake

7. Recommendations

The most crucial aspect to study is detailed structure through local and regional tomography in different sectors of Himalaya. This will help in refining the tectonic model of Himalaya.

The existing data sets of earthquakes need to be seen in totality for the entire Himalaya in near real-time. It is proposed to synthesize the earthquake data from different organizations through MoES, in order to (i) prepare Atlas of different types of data bases and earthquake catalog (ii) study the space time pattern of Himalayan seismicity in detail in order to identify the active faults along with the earthquake mechanics derived from Moment tensor inversion. Also the gaps in the data may be identified from the point of view of seismotectonics and earthquake prediction research.

Geotechnical studies need to be done and depth of different soft sedimentary basins present in Himalaya needs to be estimated. This is required for assessing amplifications at different frequencies.

Greater no. of GPS may be installed along MBT and MFT zones. Deformation through GPS needs to be monitored in near-real time. Changes in water level as well as Radon and Helium in the boreholes in Lesser as well as Frontal Himalaya need to be monitored at numerous locations.

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