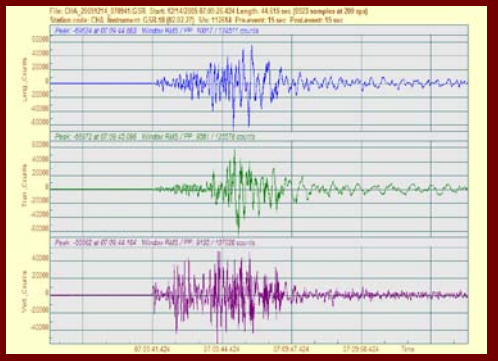
Indian Strong Motion Instrumentation Network

SMA INSTALLED IN FIELD



RECORD OF CHAMOLI EARTHQUAKE

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OBJECTIVES of NETWORK

- **Installation of 300 strong motion accelerographs in seismic zones IV and V and some thickly populated cities of zone III in North and North East part of country.**
- **Connectivity with the station through VSAT / Leased Line /modem for monitoring operating status of the instruments and quick downloading of events.**
- **Keep the strong motion network operational so that any future moderate to strong earthquake gets recorded.**
- **Data collection, processing, interpretation, dissemination and archiving.**

PRESENT STATUS OF NETWORK

- **298 instruments have been installed in the states of Uttarakhand, HP, Punjab, Delhi, Rajasthan, Haryana, Bihar, WB, Sikkim, A&N, UP, Assam, Meghalaya and Mizoram.**

- **Installations done in DM / DC / SDM office premises near or inside NIC office (in Districts).**

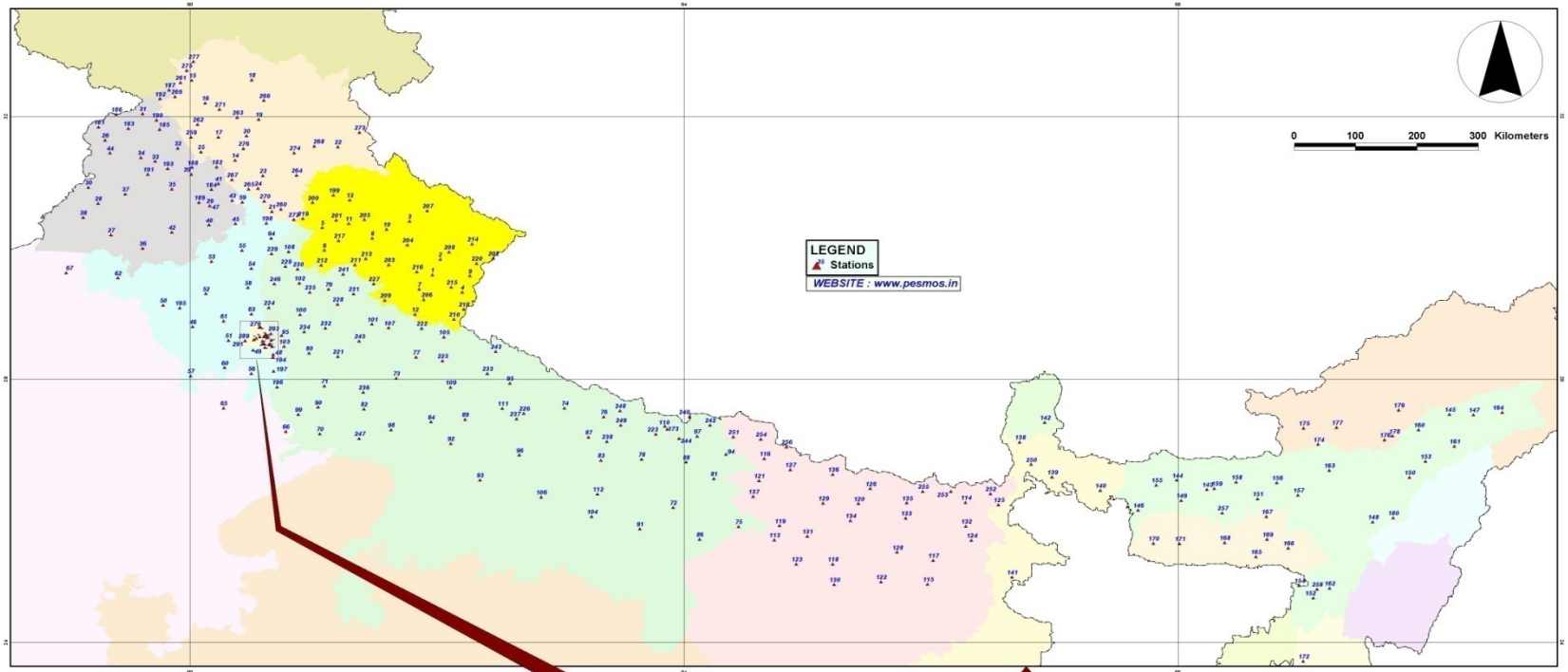
- **Connectivity through NICNET established at all district headquarters.**
- **Connectivity through SWAN in Himachal Pradesh, Uttarakhand, Punjab and U.P.**

PRESENT STATUS OF NETWORK

- Data flows field stations to NIC head quarter at Delhi through VSAT or Leased Line of NIC. From Delhi to Roorkee data flows on 2 MBPS leased line.
- All the accelerographs connected to NICNET are checked from Roorkee regularly.
- Trigger threshold set at 0.005g in general and at several station lowered to 0.001g.
- Network has recorded about 500 time histories from 198 earthquakes in a span of about five years.
- A website having address www.pesmos.in developed through which data is being disseminated to registered users of the website.
- About 150 users registered on www.pesmos.in.

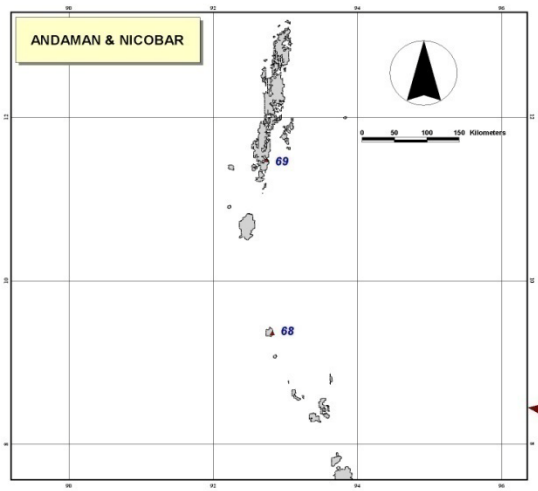
INDIAN NATIONAL STRONG MOTION INSTRUMENTATION NETWORK

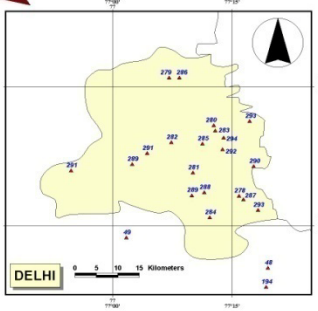
SPONSORED BY : MINISTRY OF EARTH SCIENCES

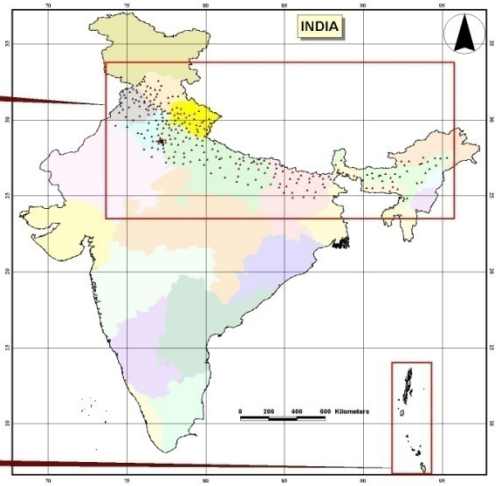


LIST OF STATIONS

SNO	STATION NAME	SNO	STATION NAME
1	Almora	151	Guwhati
2	Bageshwar	152	Hailakandi
3	Chamoli	153	Jorhat
4	Champawat	154	Karimganj
5	Dehradun	155	Khokrajhar
6	Haridwar	156	Mangaldai
7	Nainital	157	Morigaon
8	Pauri	158	Nalbari
9	Pithoragarh	159	Nazgaon
10	Rudraprayag	160	North Lakhimpur
11	Tehri	161	Silsagar
12	Udham Singh Nagar	162	Silchar
13	Uttarkashi	163	Tegpur
14	Bilaspur	164	Tinsukia
15	Chamba	165	Cherapunji
16	Dharamshala	166	Jowai
17	Hamirpur	167	Nongpow
18	Keylong	168	Nongstain
19	Kullu	169	Shilong
20	Mandi	170	Tura
21	Nahan	171	William nagar
22	RekongPeo	172	Aizwal
23	Shimla	173	Kolasib
24	Solan	174	Bhalukpong
25	Una	175	Bomdila
26	Amritsar	176	Itanagar
27	Bhatinda	177	Seppa
28	Faridkot	178	Yupia
29	Fathehgarh Saheb	179	Zero
30	Firozpur	180	Dimapur
31	Gurdaspur	181	Ajnala
32	Hoshiarpur	182	Anandpur Saheb
33	Jallandhar	183	Batala
34	Kapurthala	184	Chamkaur saheb
35	Ludhiana	185	Dasua
36	Mansa	186	Dera Baba Nanak
37	Moga	187	Dhar Kalan
38	Muktsar	188	Garhshankar
39	Nawanshahar	189	Khanna
40	Patiala	190	Mukerian
41	Rupnagar	191	Nakodar
42	Sangrur	192	Pathankot
43	Mohali	193	Phagwara
44	Tran Taran	194	Rattabhgarh
45	Ambala	195	Hansi
46	Bhiwani	196	Hodal
47	Fatehabad	197	Palwal
48	Faridabad	198	Sadhura
49	Gurgaon	199	Basket
50	Hisar	200	Chakrata
51	Jhajjar	201	Dhanaulti
52	Jind	202	Dharchula
53	Kaithal	203	Dhunakot
54	Karnal	204	Garsain
55	Kurukshetra	205	Ghansali
56	Mewat	206	Haldwani
57	Narnaul	207	Joshimath
58	Panipat	208	Kapkot
59	Panchkula	209	Kashipur
60	Rewari	210	Khatima
61	Rohtak	211	Ketdwar
62	Sirsa	212	Laksar
63	Sonipat	213	Lansdown
64	Yamunanagar	214	Munsyari
65	Alwar	215	Patli
66	Bharatpur	216	Rankhet
67	Hanumangarh	217	Rishikesh
68	Car Nicobar	218	Tanakpur
69	Port Blair	219	Vikasnagar
70	Agra	220	Didihat
71	Aligarh	221	Anoop Sahar
72	Azamgarh	222	Baheri
73	Badaun	223	Bansi
74	Bahraich	224	Baraut
75	Balia	225	Bisalpur
76	Balrampur	226	Biswan
77	Bareilly	227	Chandausi
78	Basti	228	Chandpur
79	Bijnor	229	Chhata(Kosi)
80	BulandShahar	230	Deoband
81	Deoria	231	Dhampur
82	Eta	232	Garh Mukteshwar
83	Fatzabad	233	Gola Gokarnath
84	Farrukhabad	234	Hapur
85	Gaziabad	235	Jansath(Khatauli)
86	Gazipur	236	Kashganj
87	Gonda	237	Laharpur(Tambaur)
88	Gorakhpur	238	Mankapur
89	Hardoi	239	Nakur (Gangoh)
90	Hathras	240	Nautanwa
91	Jaunpur	241	Nazibabad
92	Kannauj	242	Nichlaul (Siswa)
93	Kanpur	243	Pilia
94	KushuNagar	244	Pharenda
95	Lakhimpur	245	Sambhal
96	Lucknow	246	Shamli
97	Maharaj Ganj	247	Shikohabad
98	Mainpuri	248	Tutstpur (Jarwa)
99	Mathura	249	Ultrala
100	Meerut	250	Siliguri
101	Moradabad	251	Bagha
102	MuzaffarNagar	252	Bahadurganj
103	Naida	253	Ferbesganj
104	Pratap Garh	254	NarkatiaGanj
105	Pilibhit	255	Raghopur
106	Rai Bareilly	256	Raxaul
107	Rampur	257	Beka
108	Saharanpur	258	KataKhal
109	Shahjahanpur	259	Amb
110	Sidharth Nagar	260	Dadahu
111	Sitapur	261	Dalhousie
112	SultanPur	262	Dehra
113	Ara	263	Jogindernagar
114	Araria	264	Jubbal
115	Banka	265	Kasauli
116	Bettiah	266	Manali
117	Bhagalpur	267	Nalagarh
118	Bihar Shariff	268	Nathhpa
119	Chapra	269	Nurpur
120	Darbhanga	270	Pachchhad
121	Gopalganj	271	Palampur
122	Jamui	272	Paonta Sahib
123	Jehanabad	273	Puh
124	Katihar	274	Rampur
125	Kishanganj	275	Saluni
126	Madhubani	276	Sundernagar
127	Motihari	277	Tisa
128	Munger	278	Kalka Ji
129	Muzzafarpur	279	Delhi College of Engineering (DCE)
130	Navada	280	Delhi University
131	Patna	281	Dhaula Kuan
132	Purnia	282	Raja Garden
133	Saharsa	283	Inderprastha University
134	Samastipur	284	IGNOU
135	Saupaul	285	Delhi Jal Board,
136	Sitamari	286	Swami Shradhanand College,
137	Siwan	287	Jamia Millia
138	Darjeeling	288	IIT Delhi
139	Jalpiguri	289	Jawahar Lal Nehru University,
140	Keech Vihar	290	NSIT Dwarika
141	Malda	290	Mayur Vihar
142	Gangtok	291	IGIPE Vikaspuri
143	Barpeta	291	Jaffarpur
144	Bongaigaon	292	Zakir Hussain College,
145	Dhemaji	293	NPTI Badarpur
146	Dhubri	293	Yamuna Vihar
147	Dibrugarh	294	Ridge Observatory, IMD
148	Diphu		
149	Goalpara		
150	Golaghat		



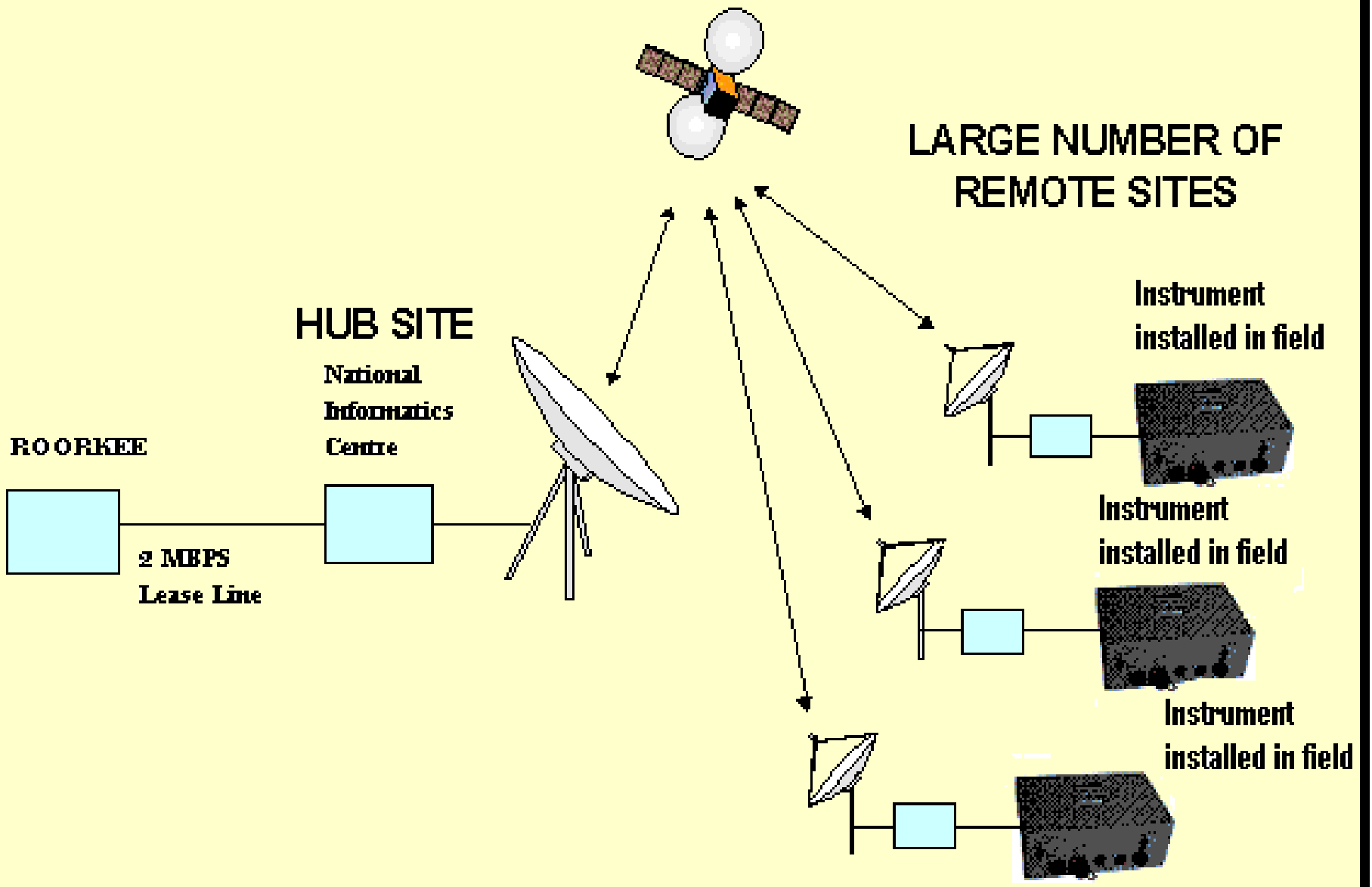




Installed Stations

A Typical Field Installation of Instrumentation

A Typical Installation of Solar Panel and GPS



A Schematic Diagram of Data Flow Using NICNET

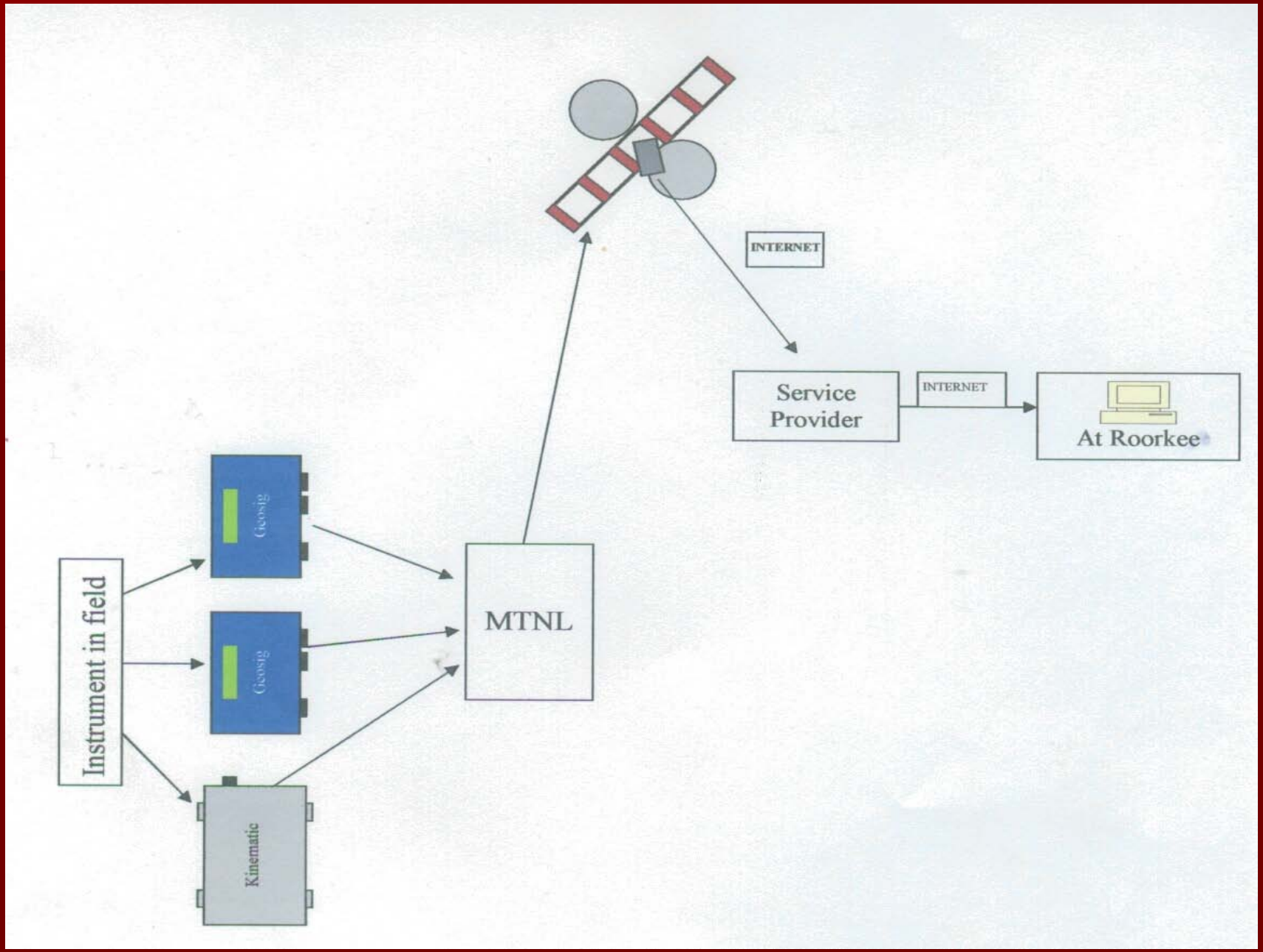
Delhi Instrumentation

- 20 instruments have been installed at different locations in Delhi.
- Out of these 20 instruments, 12 instruments are K2 of Kinemetrics while 8 are GSR 18 of GeoSig of Mission Mode Project.
- All installations in Delhi made in free field.
- At all 20 locations, we have established connectivity through MTNL broadband.

Number in figure	Location of Station
1	Indira Gandhi Institute of Physical Education, Vikaspuri
2	Indian Institute of Technology
3	Maharaja Agarsen College, Mayur Vihar
4	Swami Sharadhanand College, Alipur
5	Netaji Subhash Intitute of Technology, Dwarka
6	National Power Training Institure, Badarpur
7	Venkteshwar College, Dhaula Kuan
8	Bhim Rao Ambedkar College, Yamuna Vihar
9	Zakir Hussain College, JLN Road
10	Govt. Engineering College, Jaffarpur
11	Delhi College of Engineering, Bawana Road
12	Indira Gandhi National Open University, MaidanGarhi
13	Guru Gobind Singh Inderprastha University, Kashmiri Gate
14	Shivaji College, Raja Garden
15	Jawahar Lala Nehru University, New Mahrauli Road
16	Delhi University (Pedestal ready, installation not yet done)
17	Acharya Narender Dev College, Govindpuri
18	Jamia Milia University
19	Delhi Jal Board, Karol Bagh
20	Indian Meteorological Department Ridge

Table 1: Delhi Strong Motion instruments location

A trypical Installation of SMA in field in Delhi



A Diagram showing connectivity of accelerographs in Delhi

Some Works

- Development of strong ground motion parameters, validation of existing attenuation relationship and making attenuation relationship and / or neural network model most suitable for our country.
- To understand propagation and site response characteristics of the sediments that underlie and are thought to produce large site amplification and seismic hazard. .
- Classification of all field station .
- Validation of theoretical simulation of strong ground motion using recorded strong motion data.
- Preparation of almost real time shake maps immediately after major events.
- Develop algorithms for earthquake early warning system.

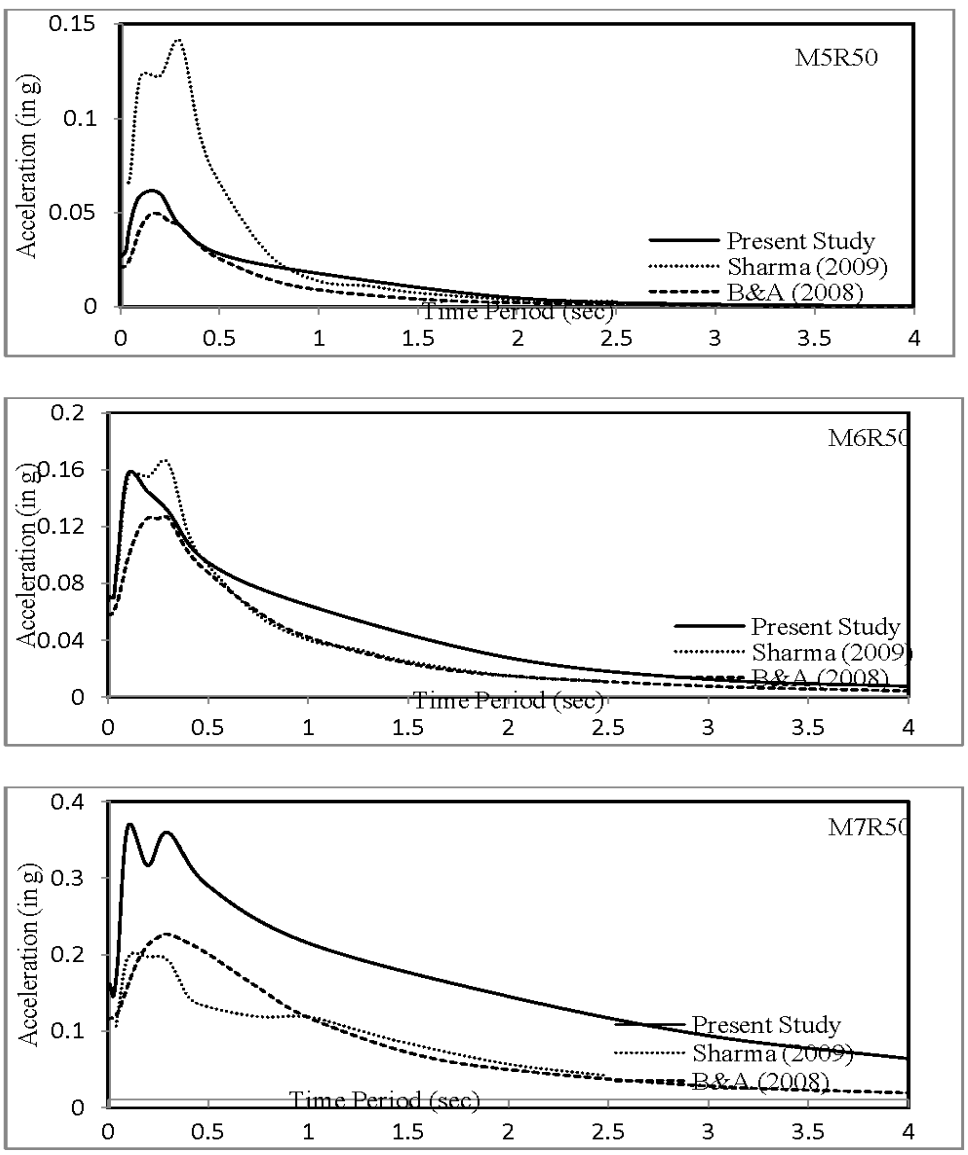
Attenuation Relationship

- **An attenuation relationship for peak horizontal ground accelerations for North-East region in India has been developed. The data base consists of 214 peak ground horizontal accelerations from 25 earthquakes recorded by strong-motion stations and arrays in India. The database consists of earthquake from 1986 to 2010, with magnitude ranging from 4 to 6.8. The attenuation relationship proposed is**

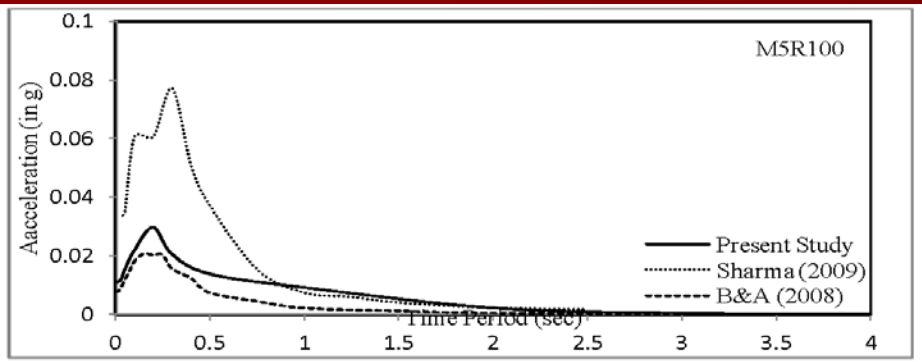
$$\log (A) = -1.2151 + 0.5161M - 1.5299 \log (R + e^{0.5873M})$$

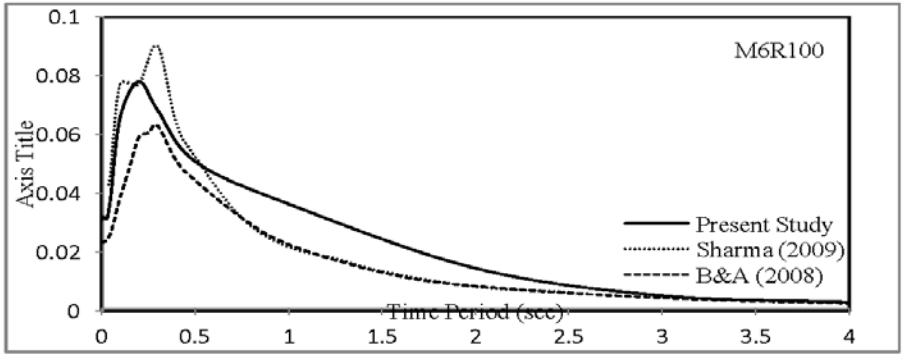
where A is the peak ground acceleration (g), M is the magnitude, and R is the hypocentral distance from the source. The residual sum of squares is 0.2855.

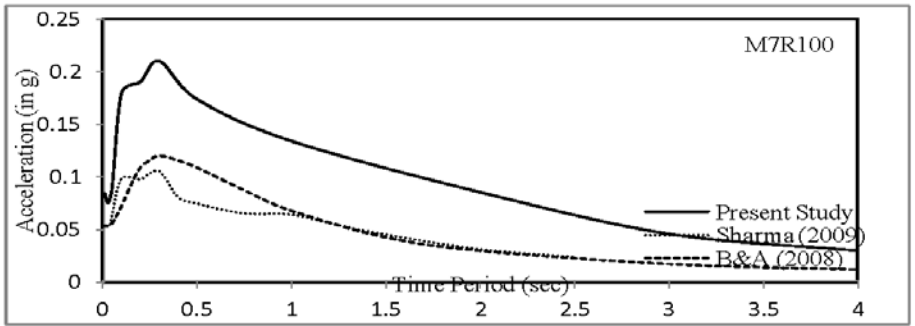
Comparison with Sharma(2009) & Boore and Atkinson(2008)



Comparison with Sharma(2009) & Boore and Atkinson(2008)





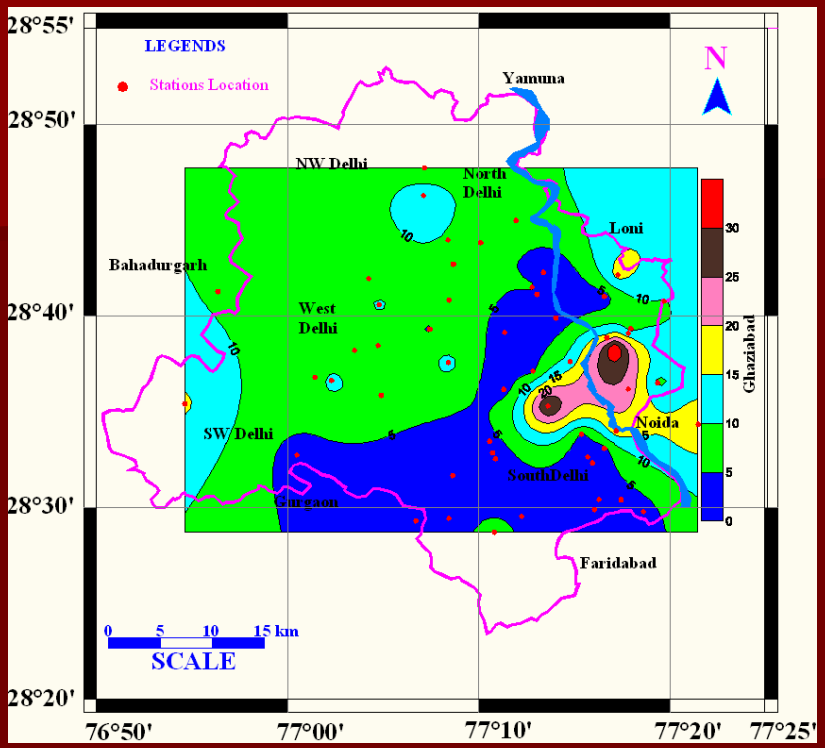


It can be seen that new model behaves similarly with the previous relationship like Sharma (2009) and Boore and Atkinson (2008) at all distances with magnitude of 6, behaves very well with magnitude of 5 but gives high acceleration at magnitude of 7 and vice versa for Sharma (2009).

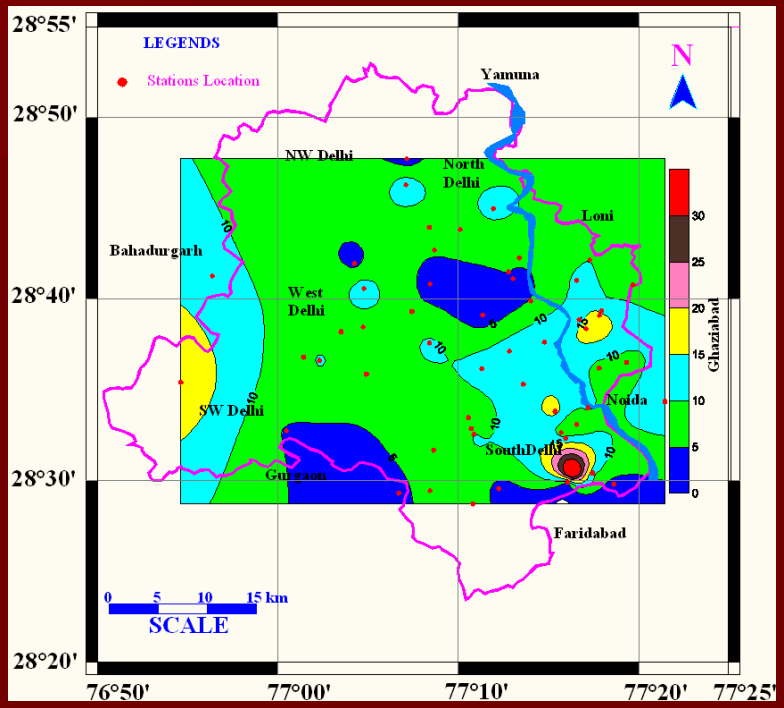
Site Effects in Delhi

- **Site effects estimated at 55 places in Delhi using Standard Spectral ratio.**
- **Amplification higher at sites near Yamuna river. Amplification at these sites ranges from 10 to 30.**
- **At sites falling on quartzite formations, amplification is 2-5.**

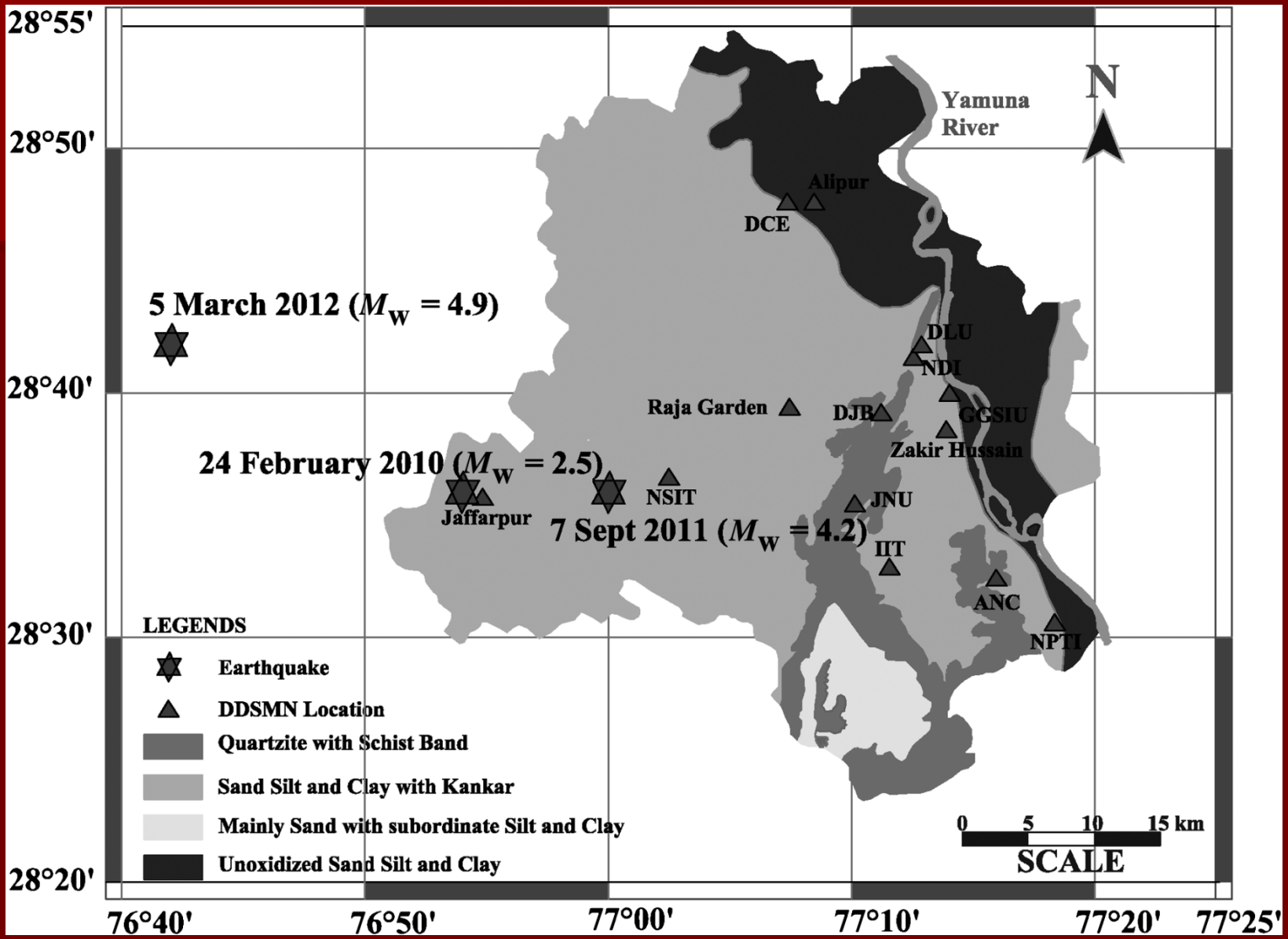
Amplification Map

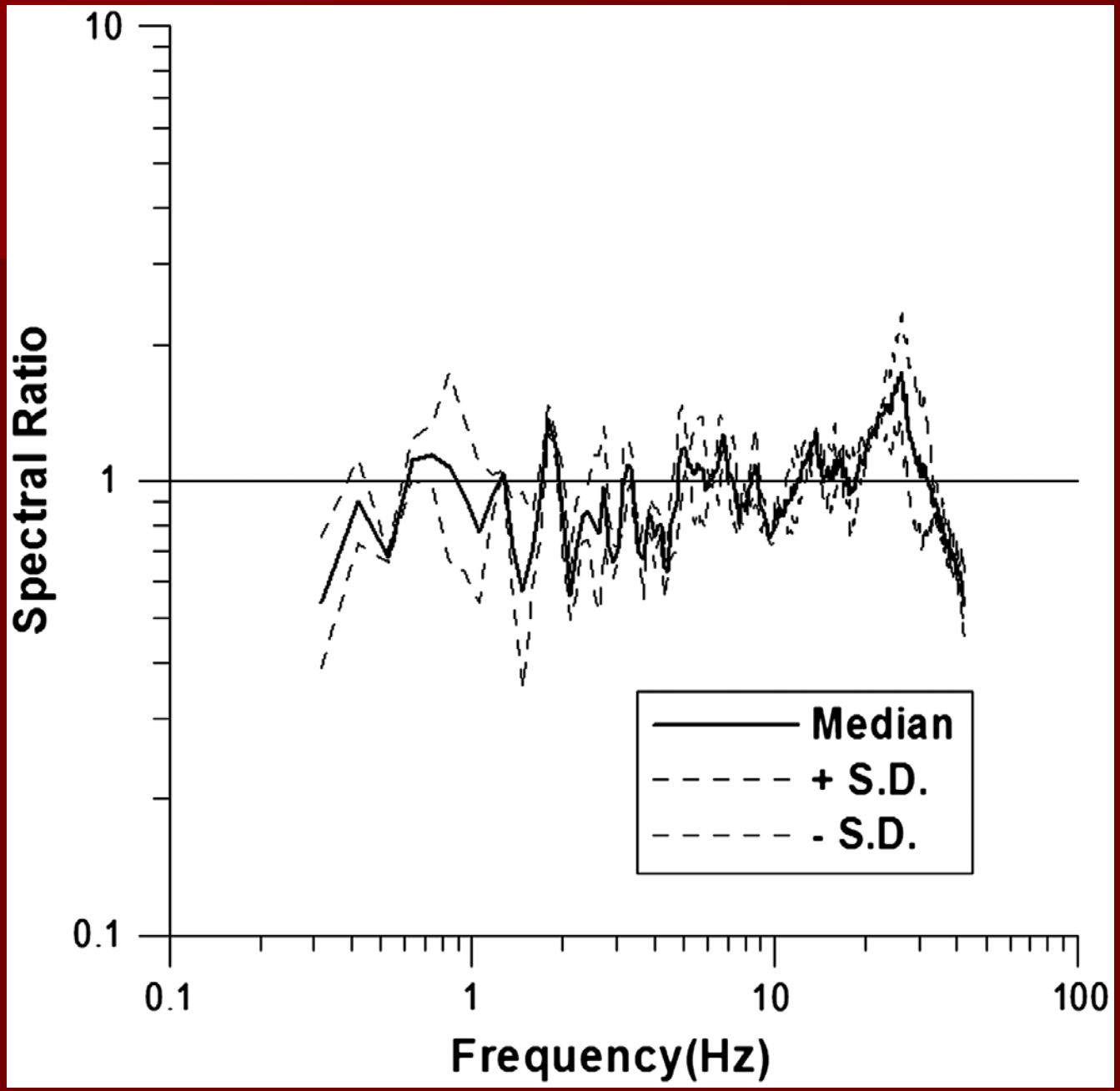


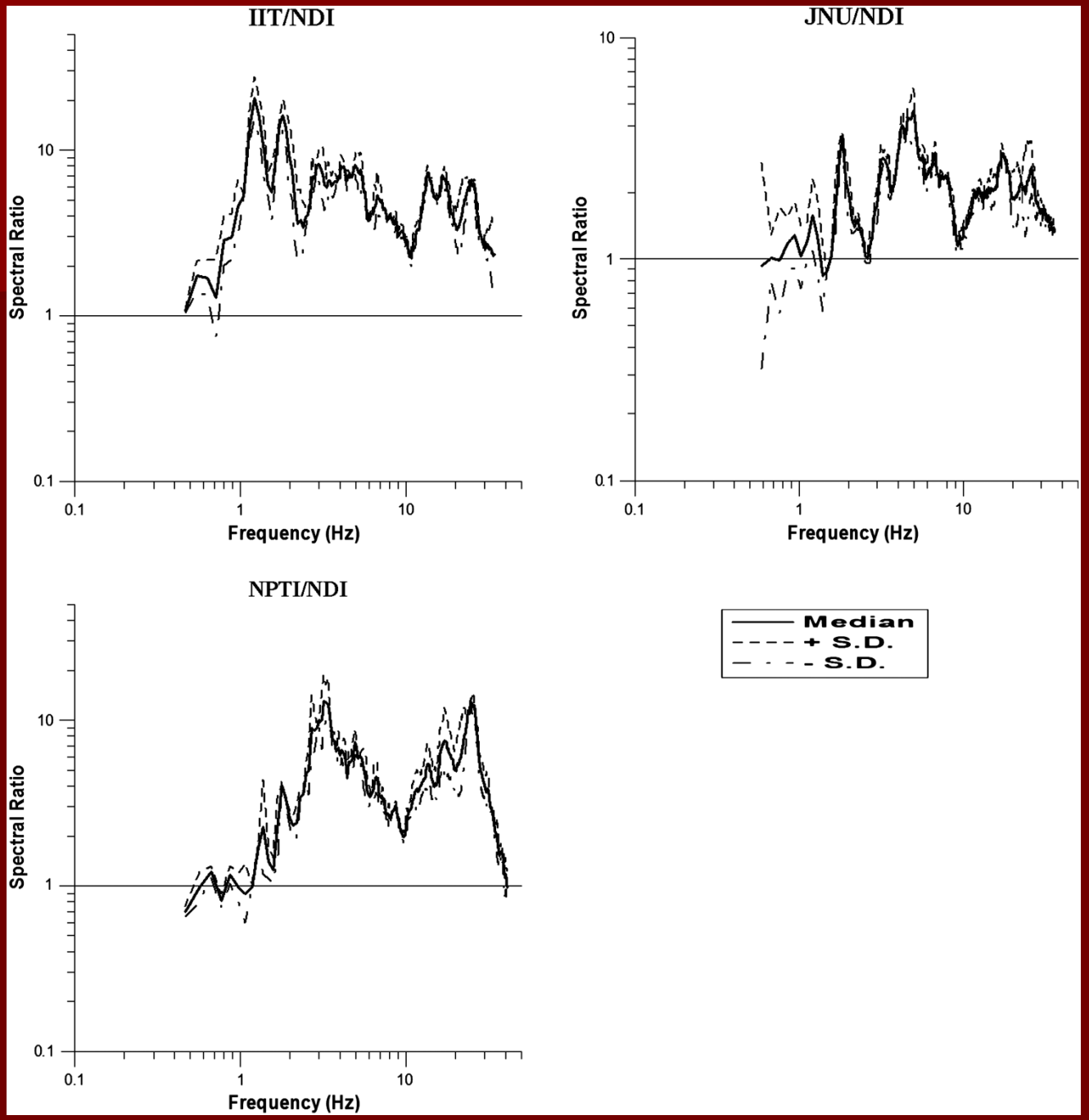
Amplification at various sites between 0.5 -1 Hz



Amplification at various sites between 2.0 -5.0 Hz


28°55'
28°50'
28°40'
28°30'
28°20'
76°40'
76°50'
77°00'
77°10'
77°20'
77°25'
N
Yamuna River
Alipur
DCE
5 March 2012 (M_W = 4.9)
DLU
NDI
GGSIU
Zakir Hussain
Raja Garden
DJB
24 February 2010 (M_W = 2.5)
NSIT
JNU
Jaffarpur
7 Sept 2011 (M_W = 4.2)
IIT
ANC
NPTI
LEGENDS
Earthquake
DDSMN Location
Quartzite with Schist Band
Sand Silt and Clay with Kankar
Mainly Sand with subordinate Silt and Clay
Unoxidized Sand Silt and Clay
0 5 10 15 km
SCALE


10
1
0.1
Spectral Ratio
0.1
1
10
100
Frequency(Hz)
Median
+ S.D.
- S.D.


IIT/NDI
JNU/NDI
NPTI/NDI
Spectral Ratio
Frequency (Hz)
0.1
1
10
Median
+ S.D.
- S.D.

Stations of DDSMN

Stations of DDSMN categorized in three different types:

- Stations having high amplification and fundamental frequency below 2 Hz, such as Alipur, IIT, NSIT, GGSIU, DCE, and DLU, may be categorized as high amplification site.
- The sites such as Raja Garden, NPTI, and Jakir Hussain with moderate amplification and fundamental frequency between 2 and 4.5 Hz may be categorized as moderate amplification sites.
- NDI, DJB, JNU, and ANC, falling on quartzite formation, having less amplification and fundamental frequency above 4.5 Hz, may be categorized as less amplification sites.

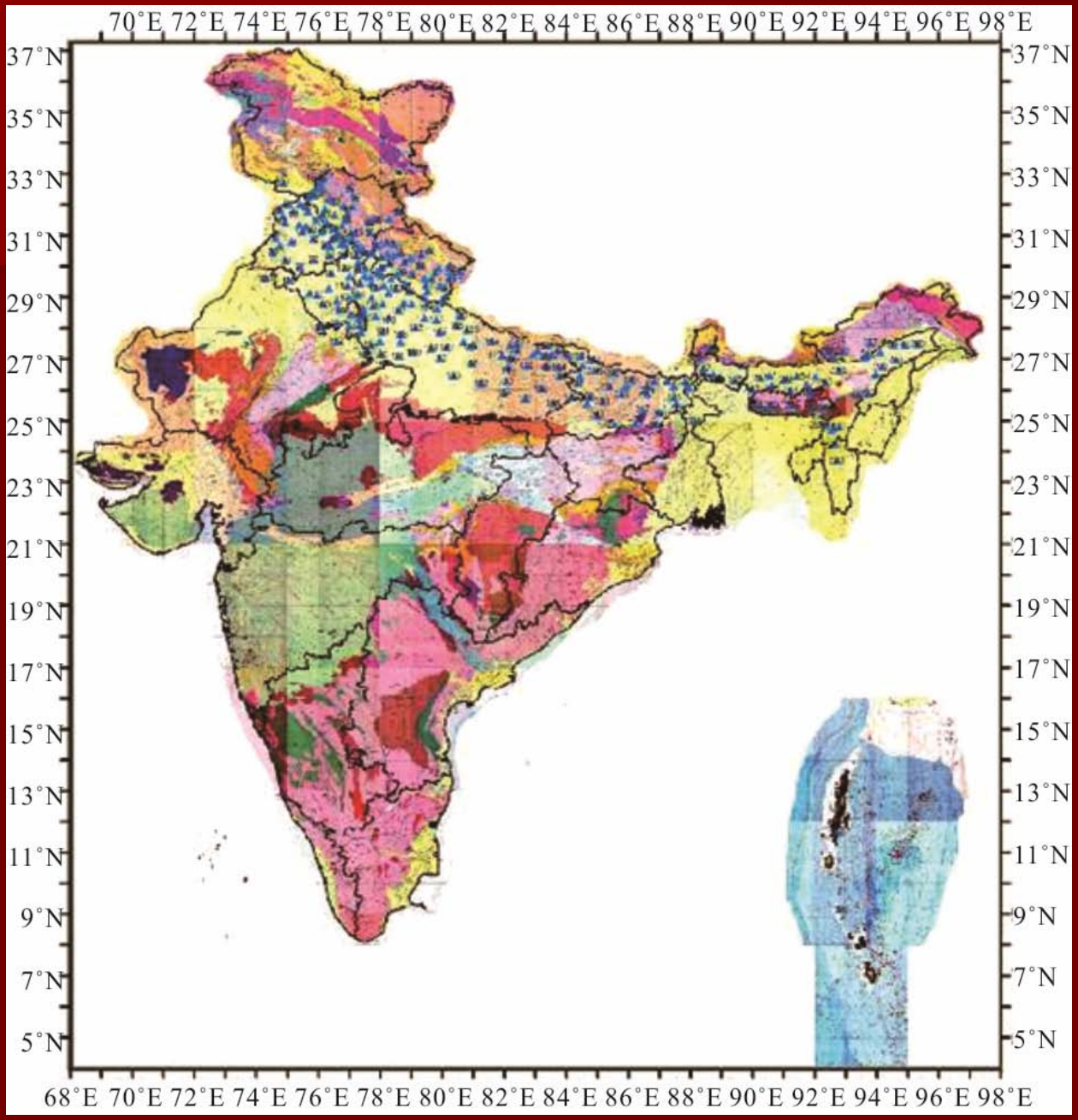
Classification

- Based on modifying Borcherdt (1976) classification
- Based on physical descriptions of the near surface materials
- Rock/soil types.
- Information about the site geology have been gathered from maps viz., Seismotectonic Atlas of India and its Environs, Geological Maps of India and books.

Classification

- Information on rock types obtained based on color coding of the Seismotectonic Atlas of India representing particular rock type.
- The stations falling under pink color represent firm and hard quartzite and dolomite rocks and hence classed as A.
- The dark yellow represents sandstone, slates, limestone and dolomites and classed as B.
- The strong motion stations falling in the region of light yellow color are represented by soil and classed as C.

Site class for strong motion accelerographs (SMA) station by modifying Borcherdt(1976).	General description	Shear wave velocity
A	Firm/hard rocks (Fresh and compact metamorphic e.g. gneiss, schist, migmatites, phyllites, quartzites, dolomites and igneous rocks e.g. granites, granodiorites, granitoids, basic volcanics).	700 m/sec - 1620 m/sec
B	Soft to firm rocks (Sedimentary rocks e.g., sandstone, sltstone, shale, limestone)	375 m/sec - 700 m/sec
C	SOILS (Alluvium, slope wash material, Aeolian).	200 m/sec - 375 m/sec


70°E 72°E 74°E 76°E 78°E 80°E 82°E 84°E 86°E 88°E 90°E 92°E 94°E 96°E 98°E
37°N
35°N
33°N
31°N
29°N
27°N
25°N
23°N
21°N
19°N
17°N
15°N
13°N
11°N
9°N
7°N
5°N
68°E 70°E 72°E 74°E 76°E 78°E 80°E 82°E 84°E 86°E 88°E 90°E 92°E 94°E 96°E 98°E

Some Publications

- H Mittal, A Kumar, A Kumar(2013). Site Effects Estimation in Delhi from the Indian Strong Motion Instrumentation Network. Seismological Research Letters 84 (1), 33-41.
- H Mittal, A Kumar, R Ramhmachhuani (2012). Indian National Strong Motion Instrumentation Network and Site Characterization of Its Stations. International Journal of Geosciences 3 (6), 1151-1167.
- A Kumar, H Mittal, R Sachdeva, A Kumar (2012). Indian Strong Motion Instrumentation Network. Seismological Research Letters 83 (1), 59-66.
- H Mittal, A Kumar, Kamal (2012). Ground motion estimation in Delhi from postulated regional and local earthquakes. Journal of Seismology, 1-13.

Preparedness for Earthquake Early Warning (EEW)

- **Feasibility studies are being done for EEW system for Delhi centric northern India.**
- **MBT about 200 Kms and MCT is about 300 Kms from Delhi.**
- **Dense Instrumentation required along these features to capture ground motion from epi-central region.**
- **Installations necessarily required at to be done even at village level with VSAT connectivity.**
- **Present installations need up-gradation of acquisition software for real time streaming .**

Conclusions

- Indian National Strong Motion Instrumentation Network has started yielding good SM data set for India.
- Availability of Indian SM data has started substantial research on ground motion studies in India.
- India is preparing for its first EEW system for Delhi.
- EEW work in India is still at infant stage.
- EEW has lot of scope for Indo-Taiwan collaborative work

THANK YOU