

Feasibility of Seismic Alert Systems in India

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Presented in First India Disaster Management Congress, 29th November 2006

India is a country of natural Disasters.

- + Earthquakes**
- + Landslides**
- + Cyclone**
- + Floods**
- + Tsunami**





NUMBER OF CASUALTIES DURING MAJOR INDIAN EARTHQUAKES

Date	Area	Magnitude	Intensity	Deaths
16/06/1819	Gujrat (Kutch)	8.0	XI	Many thousands
12/06/1897	Assam (Shilong)	8.7	XII	1, 600
04/04/1905	Himachal Pradesh (Kangra)	8.0	XI	20, 000
15/01/1934	Bihar – Nepal	8.3	XI	14, 000
15/08/1950	Assam (NE)	8.6	XII	1, 500
21/08/1988	Bihar – Nepal	6.6	VIII	1, 003
30/09/1993	Maharashtra (Latur)	6.3	VIII	7, 928
26/01/2001	Gujarat (Bhuj)	7.6	XI	20,000

(Modified after, Arya 2000)



EARTHQUAKES OF M > 6.0 IN GARHWAL & KUMAON REGION

Sr. No.	Date	Latitude °N	Longitude °E	Depth (km)	Magnitude
1.	01/09/1803	30.3	78.8	-	8.0
2.	26/05/1816	30.9	79.0	-	6.5
3.	06/06/1902	31.0	79.0	-	6.0
4.	27/07/1926	30.4	80.4	-	6.0
5.	08/10/1927	30.5	80.5	-	6.0
6.	05/03/1935	29.7	80.2	-	6.0
7.	04/06/1945	30.0	80.0	60	6.5
8.	28/12/1958	29.5	80.0	-	6.2
9.	31/12/1958	30.1	80.7	-	6.0
10.	26/09/1964	29.6	80.9	50	6.2
11.	27/06/1966	29.6	80.9	36	6.0
12.	19/10/1991	30.75	78.86	12	6.6
13.	29/03/1999	30.01	79.42	21	6.8



ARE WE IN A POSITION TO PREDICT EARTHQUAKES ?

SEISMIC ALERT SYSTEM

CAN PROVIDE US SOME RELIEF

IN TERMS OF

- **LOSS OF HUMAN LIFE**
- **LOSS OF PROPERTY**



Seismic Alert System

Either implemented,
in Construction or Planned in

- Mexico
- California, USA
- Japan
- Taiwan
- Romania
- Greece
- Turkey
- India



UrEDAS, Japan

Urgent EQ Detection & Alarm System

- First developed for Railways in 1983
- Use of P- wave information near source
- Location of epicentre, magnitude, focal length calculated within **3 secs**
- Stops trains before S- wave arrival



Russian Nuclear Plants

- Reactor Protection System
- Max. Possible EQ 4.5 M, 10% g, 50 Km, 5-8 Km deep
- 6 Seismic stations in a ring
- Radial distance 30 Km
- Continuous monitoring
- 3 Accelerographs and 1 Seismograph
- Each instruments 500 m apart
- Trigger threshold **24.5 cm/sec²**
- Alarm to stop reactor in 2.5 secs
- Lead time available **4 secs**
- Radio telemetry network for communications
- 2 Station warning to be relied



Istanbul, Turkey

- ◆ Univ., govt, army and local municipality
Collaborative project
- ◆ 10 SMAs installed near Marmora fault
- ◆ Scenario Earthquake **7.5 M**
- ◆ SMAs on critical constructions
- ◆ Total **100 SMAs**
- ◆ Spacing **2-3 Km**
- ◆ Microwave/ Radio wave communication
- ◆ Trigger- time domain amplitude levels
- ◆ 2-3 strs trigger relied
- ◆ Automatic shutdown switches at sleeted facilities
- ◆ Secondary Recording Station (**Alternate**)
- ◆ Available alarm time **8 secs**



Taiwan

Central Weather Bureau's Seismic Network (CWBSN)

- ✔ Seismicity of Taiwan **3-5 times** of California
- ✔ **Highest density** of seismic instruments in the world
- ✔ Automatic P & S wave pickers
- ✔ Telemetered multi channel SMA network
- ✔ **M > 5** Earthquakes
- ✔ Intensity map, epicentre, magnitude
- ✔ **Within 1 minute**
- ✔ **M 6** earthquake for **Rapid Reporting**
- ✔ **M 7** earthquake for **Early Warning**
- ✔ Use of E mail for real time **Rapid Reporting**
- ✔ Users: Emergency Services, Police, NPP

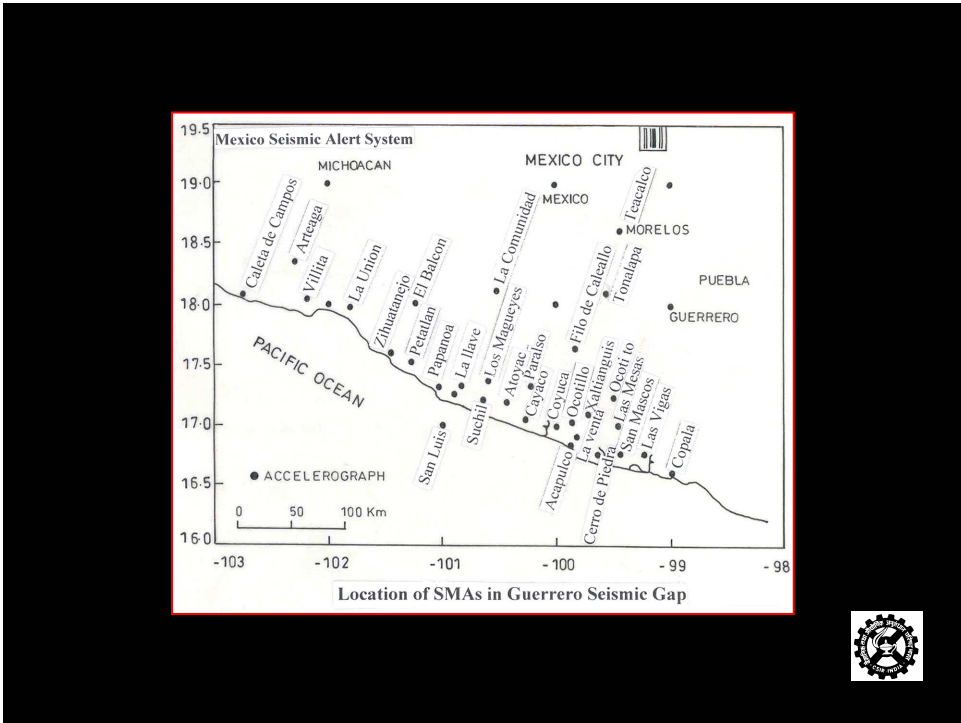


MEXICO CITY SEISMIC ALERT SYSTEM

- Sept. 1985, Michoacan Earthquake caused > 10,000 casualty
- Operational since August 1991
- Public Announcement May 1993
- Focussed on Guerrero Gap, between Acapulco and Zihuatanejo ports
- Initially 12 SMAs were deployed
- Present strength 30 SMAs all along the Sea Coast
- > 60 seconds time advantage
- AM / FM radio transmission used
- 98 Radio stations involved
- Public Schools widely involved
- 1.4 million people covered during rush hours
- General Alert > M = 6.0
- Restricted Alert < M = 6.0
- Cost \$ 1.2 million (development & installation)
- Cost \$ 0.2 million / year (operationa & maintenance)

(1996)





MEXICO SEISMIC ALERT SYSTEM

FOUR COMPONENTS

- **Seismic Detection System**
- **Dual Telecommunication System**
- **Central Control System**
- **Radio Warning System**



SUCCESSFUL PERFORMANCE

NO CASUALTY IN MEXICO CITY

Upto November 2003

> 1500 earthquakes detected (Max. Mag. M = 7.4)

M 6.7, October 24, 1993

M 7.4, September 14, 1995

M 6.5, July 15, 1996

M 7.1, January 11, 1997

M 7.4, January 22, 2003



IN CONTEXT OF OUR COUNTRY

SEISMIC ALERT SYSTEM IS THE NEED OF TODAY

**DELHI
LUCKNOW
PATNA
KOLKATA**



RISK AT DELHI

Khatti (1999)

Central Gap between 1905 & 1934 EQs. may produce two great earthquakes.

Bilham (2001)

Out of ten regions in Himalaya, six may produce at least one 1934 EQ. (exposing 50 million people at risk).

Singh (2002)

M 8.0 may produce 96 – 140 cm / sec*sec PGA

M 8.5 may produce 174 – 218 cm / sec*sec PGA

Amplifications may go upto 20 times at certain pockets.

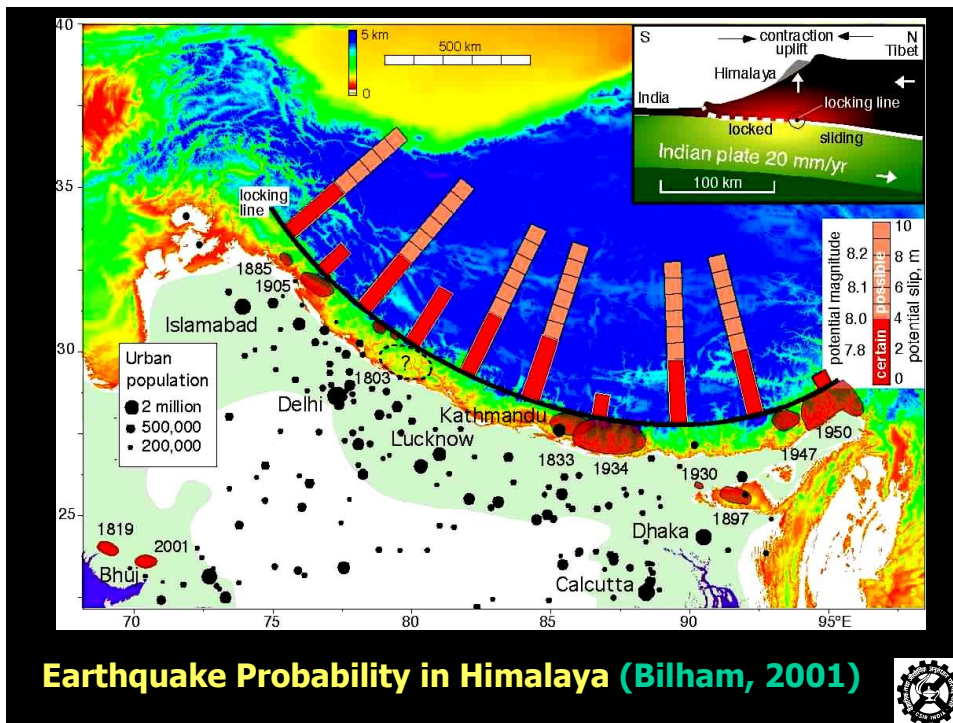
❖ **Large scale liquefaction predicted**

❖ **Most vulnerable area – EAST OF YAMUNA**



Seismozenic Source Zone Max. Mag. Experienced

Himalayan Seismozenic zone	: 7.0 (19th Oct. 1991)
Delhi-Haridwar Ridge zone	: 6.5 (15th July 1720)
Moradabad Fault zone	: 6.0 (10th Dec. 1956)
Rajasthan Great Boundary Fault zone	: 7.0 (31st Aug. 1803)
Mathura Fault zone	: 7.0 (31st Aug. 1803)
Sohna Fault zone	: 6.5 (15th July 1720)

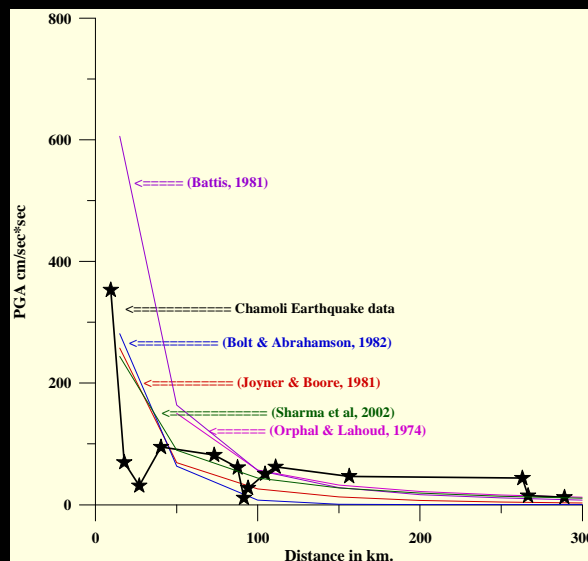


DELHI SEISMIC ALERT SYSTEM (DSAS)

HIMALAYAN SEISMIC ZONE : 300Km.

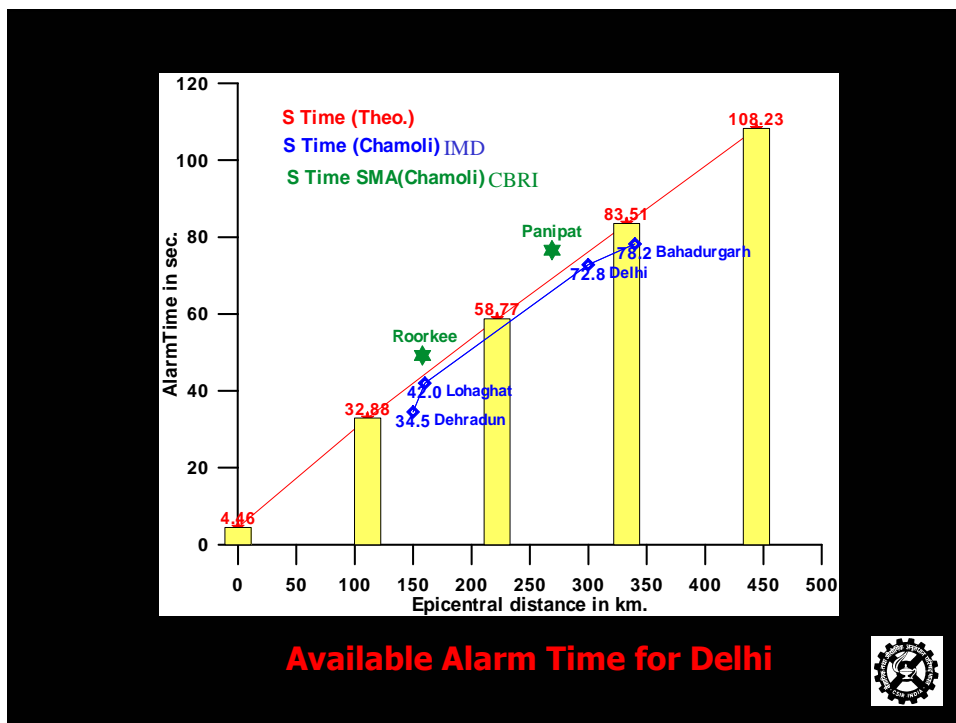
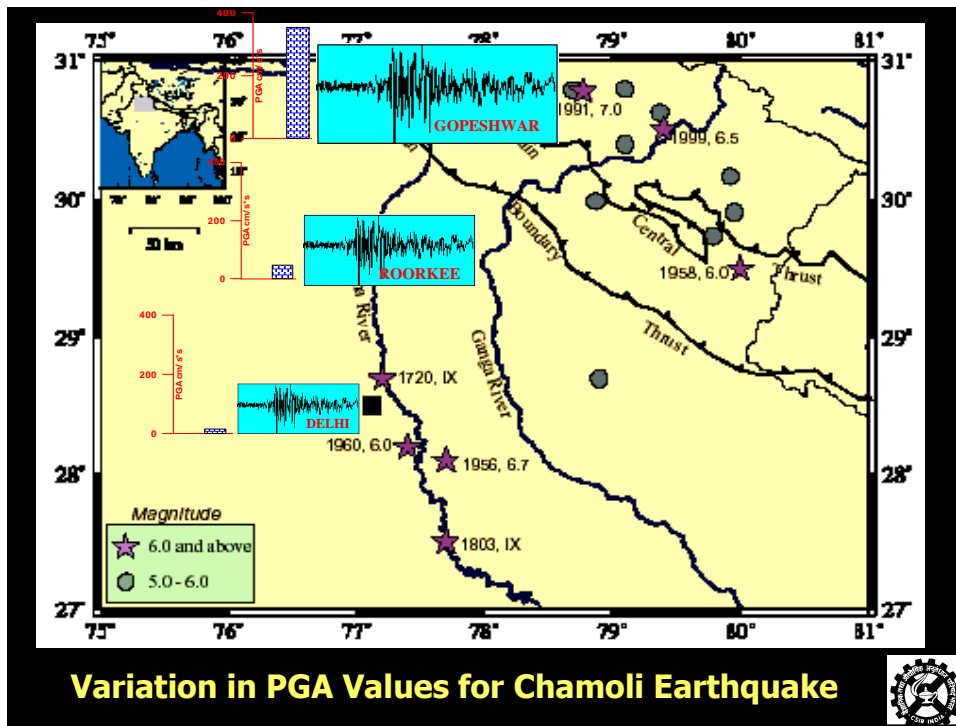
- **Sensors in HIMALAYA**
- **Central Recording Station in DELHI (CRS)**
- **Real Time DATA Transfer Through VSAT**
- **Alarm Algorithm for SENSORS & CRS**

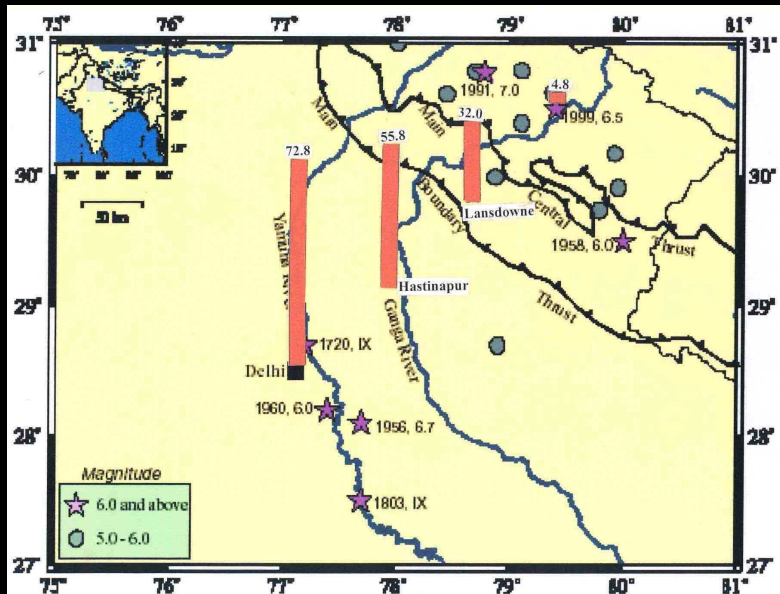
Alarm to be given few seconds after the event
Alarm time will more than a MINUTE



ATTENUATION CURVE FOR CHAMOLI EARTHQUAKE







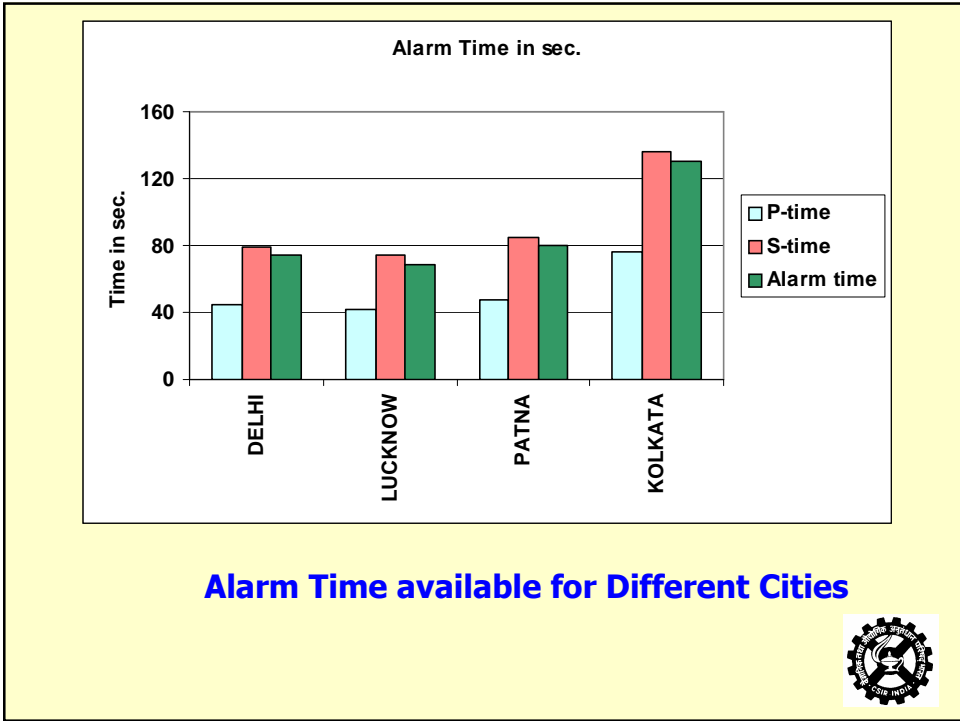
AVAILABLE ALARM TIME IN DELHI



AVAILABLE ALARM TIME FOR DIFFERENT CITIES

CITY	DISTANCE (in km)	P – TIME (in sec)	S – TIME (in sec)	ALARM TIME (in sec)
DELHI	300	44.65	79.05	74.0
LUCKNOW	325	41.90	74.1	69.0
PATNA	280	47.95	84.98	80.0
KOLKATA	550	76.27	135.9	130.9





Thanks