Science & Technology Conference 2011

Vienna, June 8-10, 2011

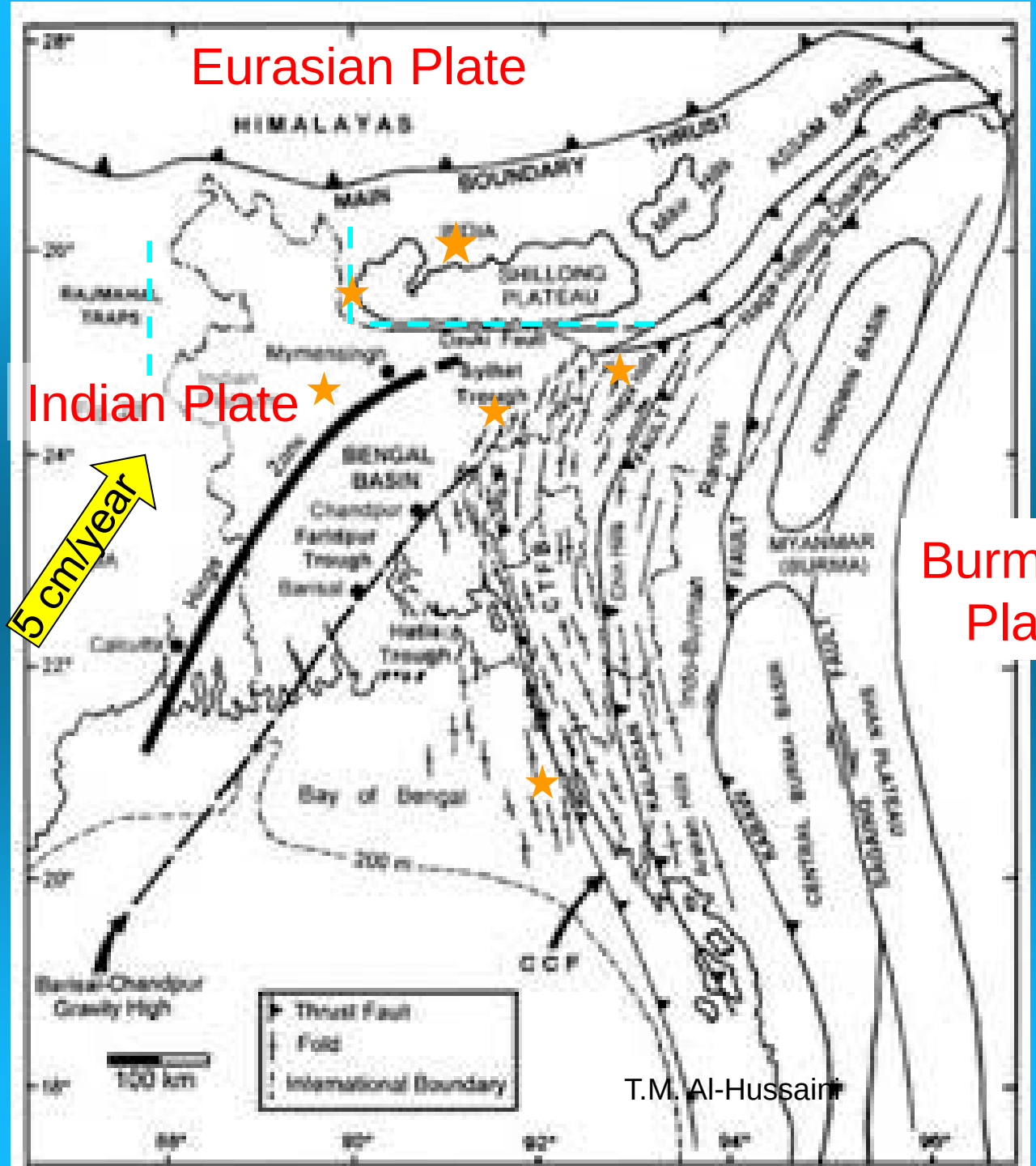
Ground Motion Studies for Critical Sites in North-West Bangladesh

Dr. Tahmeed M. Al Hussaini
Professor of Civil Engineering,
Bangladesh University of Engineering & Technology
&
Vice-President, Bangladesh Earthquake Society

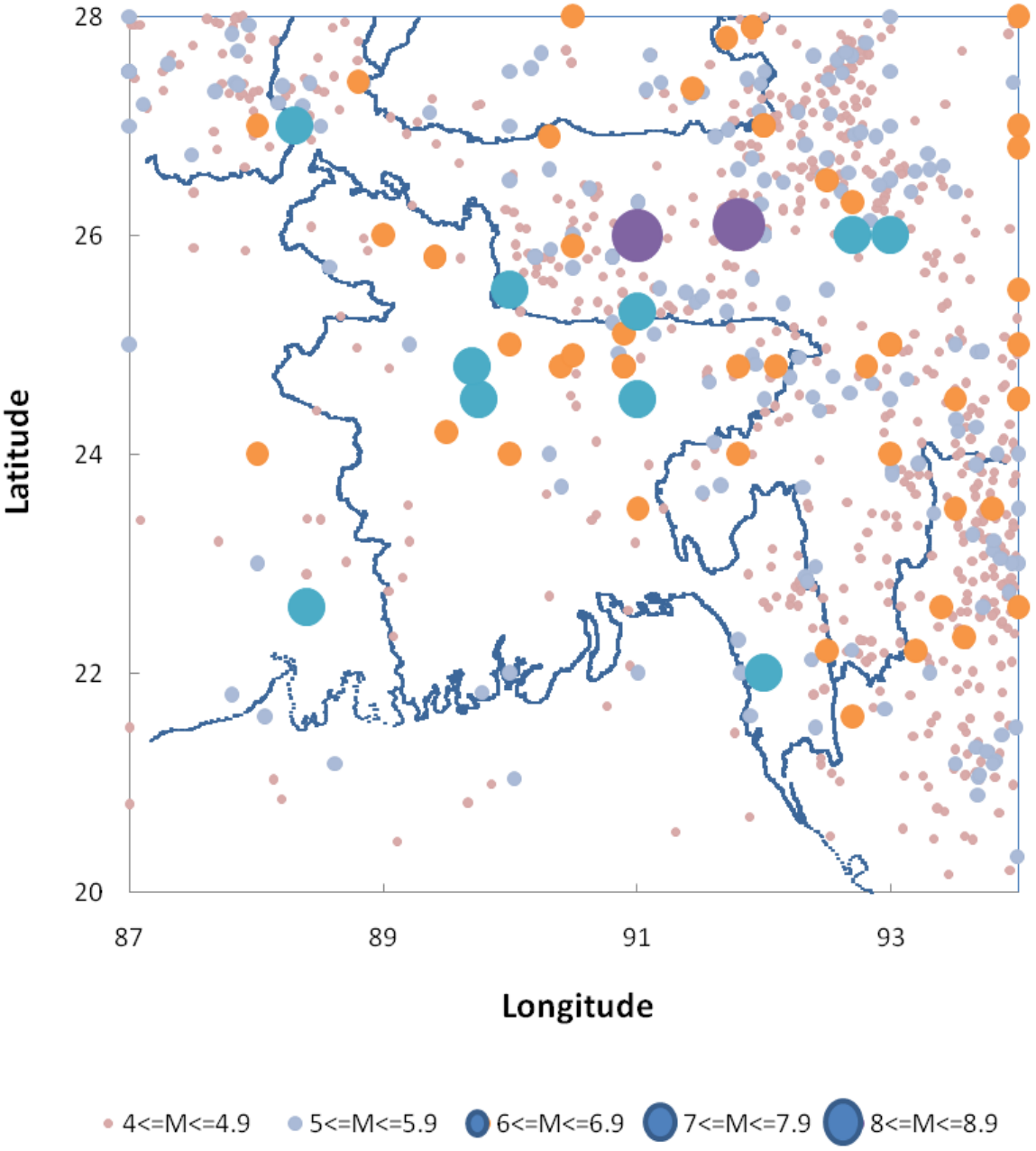
CONTENTS:

- Earthquake Occurrence
- Development of Attenuation Law
- Seismic Source Zone
- Probabilistic Seismic Hazard Assessment
- Concluding Remarks

Earthquake Occurrence in Bangladesh
&
Two Critically Important Sites in North-Eastern Bangladesh



Tectonic Map of Bengal Basin



EARTHQUAKES IN AND AROUND BANGLADESH

New Earthquake Catalogue formed covering 825-2010

Data Sources:

- ISC (1964-2008)
- IRIS (2008-2010)
- NDMA, India (2010) for historical & paleo-seismological period

Recent Earthquake Damage in SE Bangladesh

1997: RC Frame Building, Chittagong

2003: Brick Masonry Building, Kolabunia

2003: Long crack along River, Kolabunia

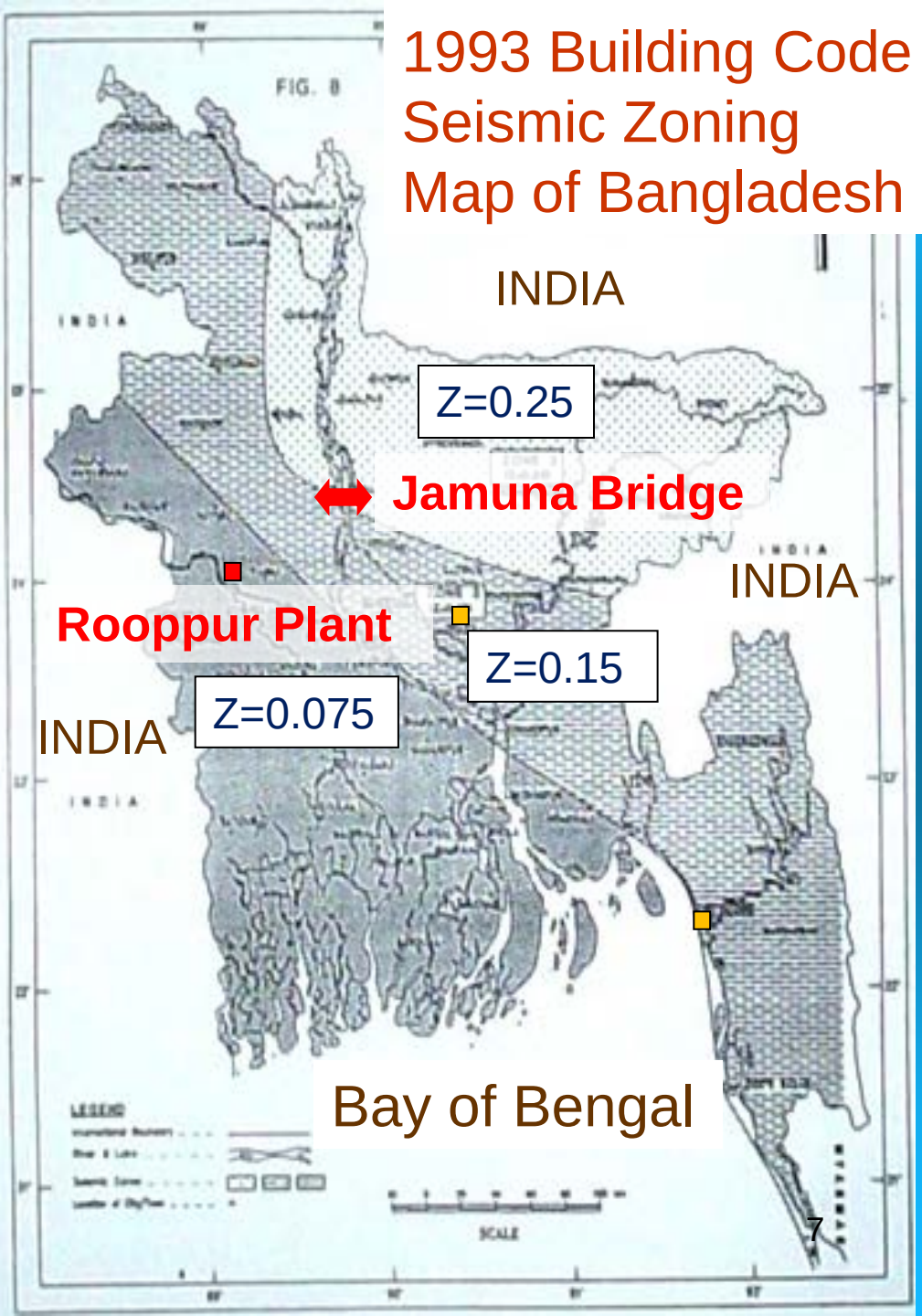
2003: Mud-walled House, Kolabunia

Location of two critical sites in North-West Bangladesh

1. **4.8 km long Bangabandhu Bridge over river Jamuna**
2. **Planned Nuclear Power Plant at Rooppur**

Seismic Zoning Map
Z value represents design basis ground motion (g) on rock/very stiff soil.

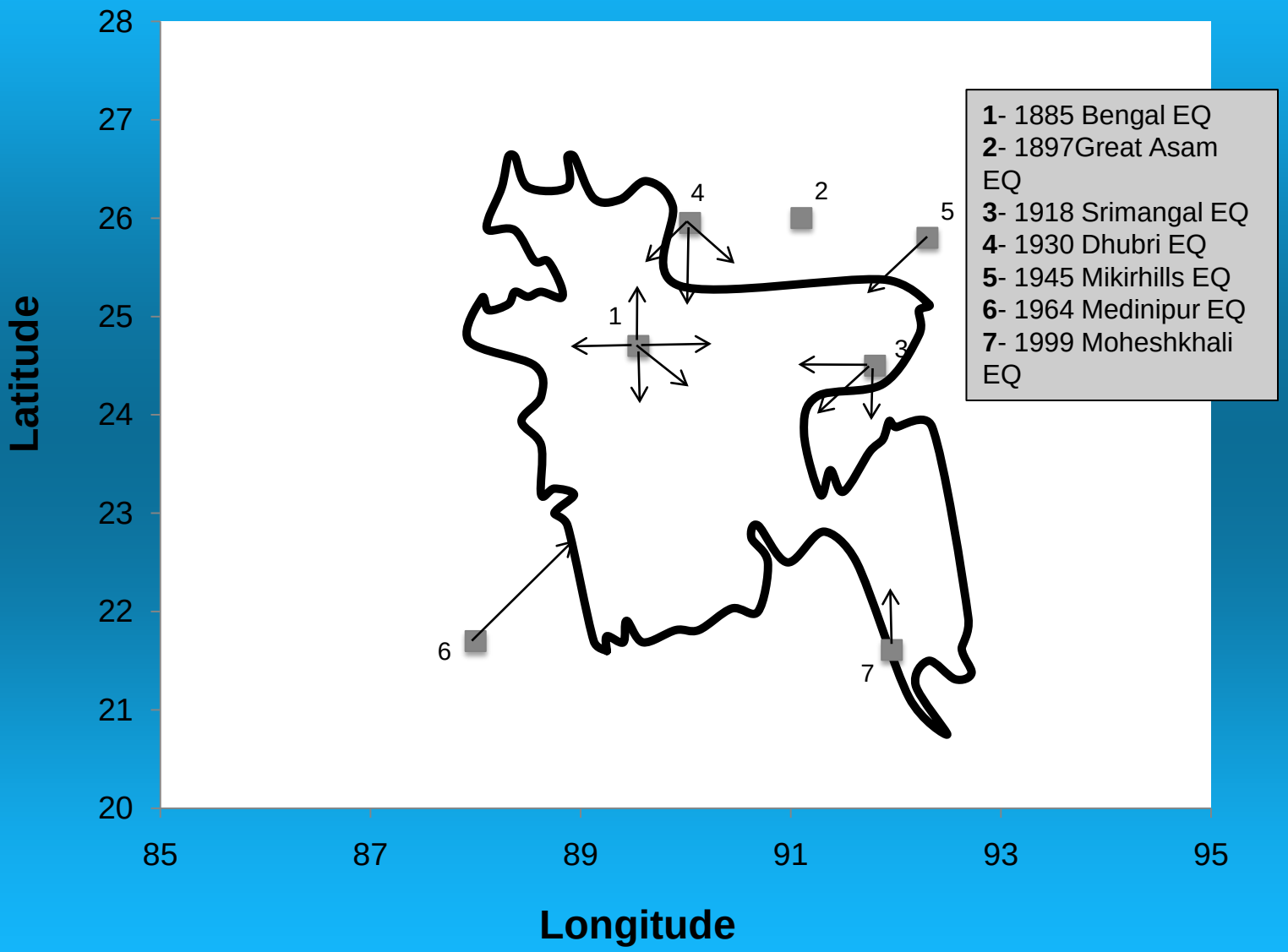
This zoning map is currently being changed.



Development of Attenuation Law for Bangladesh

(from intensity isoseismals of historical and recent earthquakes, M=5.1-8.1)

Directions affecting Bangladesh

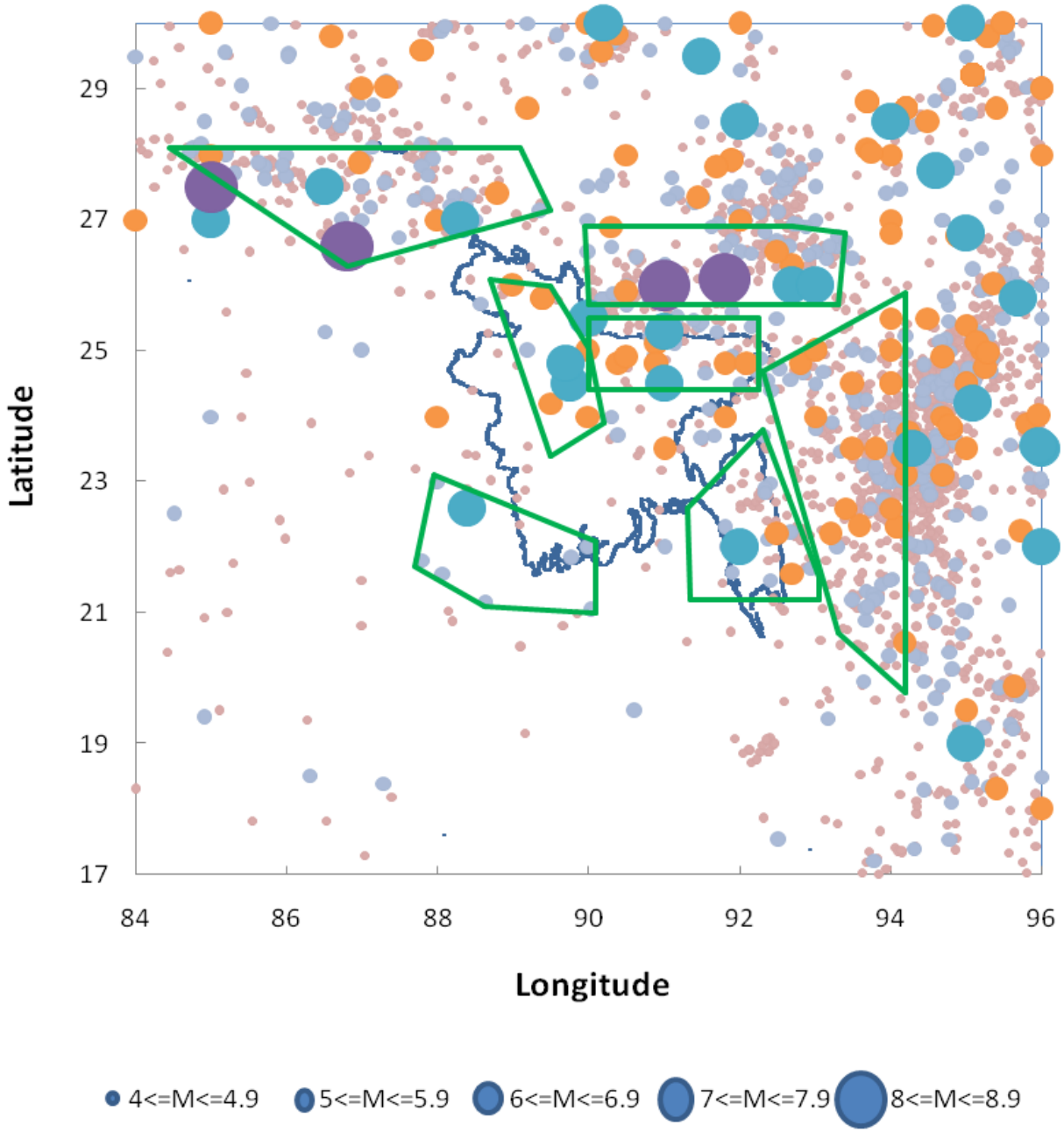


Attenuation Law for Bangladesh
Islam et al. (2010)

- Attenuation of earthquake intensity appears to have directional dependence. Directions affecting Bangladesh appear to show greater attenuation.
- Developed equations for intensity attenuation agree quite well with field data for the different earthquakes except for Srimangal earthquake which was a very shallow earthquake with relatively faster attenuation.
- Attenuation equations for PGA have been developed based on standard intensity-PGA relationship.

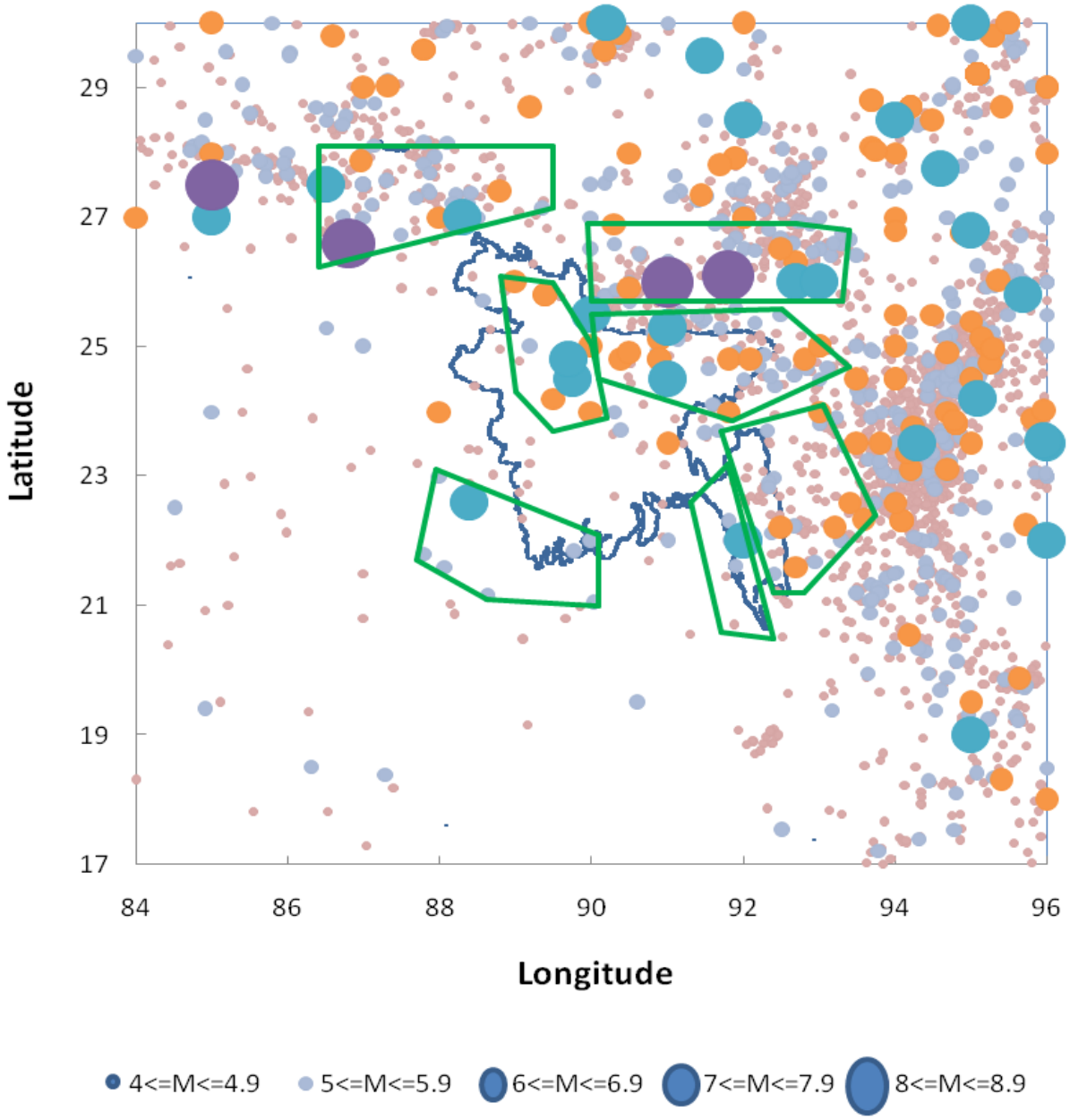
Seismic Source Zoning
&
Probabilistic Seismic Hazard Assessments for Two Sites

SOURCE ZONE MODEL - 1



Zone	M_{max}	a	b
Zone 1	8.3	3.87	0.77
Zone 2	8.1	3.58	0.73
Zone 3	7.8	3.43	0.81
Zone 4	7.6	3.12	0.69
Zone 5	7.2	2.82	0.81
Zone 6	7.5	3.04	0.71
Zone 7	6.8	5.66	1.06

SOURCE ZONE MODEL - 2



Zone	M_{max}	a	b
Zone 1	8.3	3.49	0.72
Zone 2	8.1	3.58	0.73
Zone 3	7.8	3.43	0.81
Zone 4	7.6	3.68	0.76
Zone 5	7.2	2.82	0.81
Zone 6	7.5	1.53	0.54
Zone 7	6.5	4.64	0.97

Probabilistic Seismic Hazard Assessment:

- PSHA involves estimation of ground motion at a site for a specified probability of being exceeded in a given time period.
- The computational scheme involves: delineation of seismic source zones, characterization of the source zones, selection of appropriate attenuation laws with source-site distance, and a predictive model of seismic hazard.
- All possible and relevant earthquake scenarios (magnitude and location combinations) are considered as well as all possible ground motion probability levels.
- The program CRISIS (UNAM, 1999) has been used for PSHA study.

Attenuation Law:

Different attenuation laws developed for different regions of the world have been used, including one developed recently for Bangladesh

- Abrahamson & Silva (1997) : Western USA
- Zare & Bard (1999) : Iran
- Iyengar & Ragukanth (2004) : India
- Islam et al. (2010) : Bangladesh

The following two attenuation laws have also been tried, but ignored as they appear to have too high or too low attenuation

- Ambrasseys et al.(1996) : Europe
- Atkinson & Boore (1995) : Eastern USA

Proposed Nuclear Power Plant at Rooppur

Probabilistic Peak Ground Acceleration for Return Period = 2475 YEARS (Critical Facility)

Attenuation Law	PGA (g)	
	Model-1	Model -2
Abrahamson & Silva (1997)	0.22	0.20
Iyengar & Ragukanth (2004)	0.23	0.21
Islam et al (2010)	**0.20**	**0.18**
Zare & Bard (1999)	0.24	0.22

Jamuna Bridge

4.8 km long Bangabandhu Bridge over Jamuna river completed in 1998 is **base-isolated.**

It is designed for **PGA=0.2 g** from a M=7.0 magnitude earthquake in Bogra fault zone at a distance of 25 to 50 km (Bolt, 1987).

Seismic Sensors have been installed on this bridge.

Bangabandhu Bridge over Jamuna River

Probabilistic Peak Ground Acceleration for Return Period = 475 YEARS (Bridge Facility)

Attenuation Law	PGA (g)	
	Model-1	Model -2
Abrahamson & Silva (1997)	0.20	0.17
Iyengar & Ragukanth (2004)	0.22	0.18
Islam et al (2010)	**0.17**	**0.15**
Zare & Bard (1999)	0.18	0.18

Site Response Analysis using SHAKE

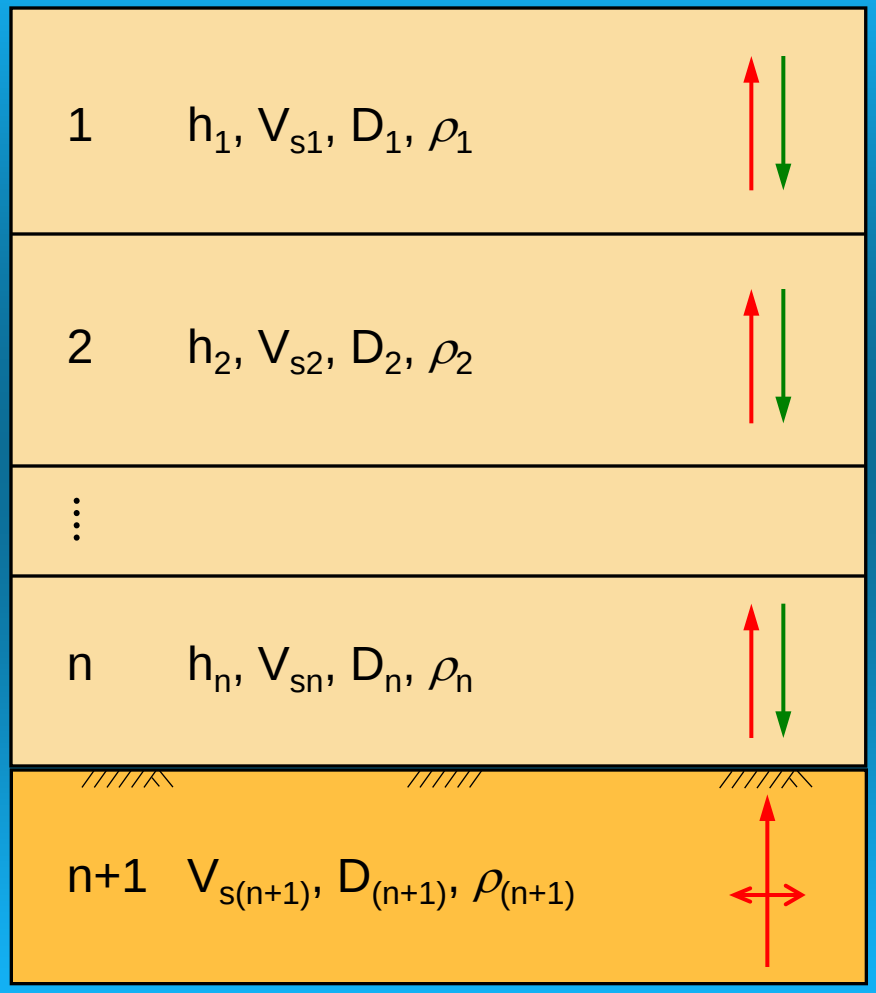
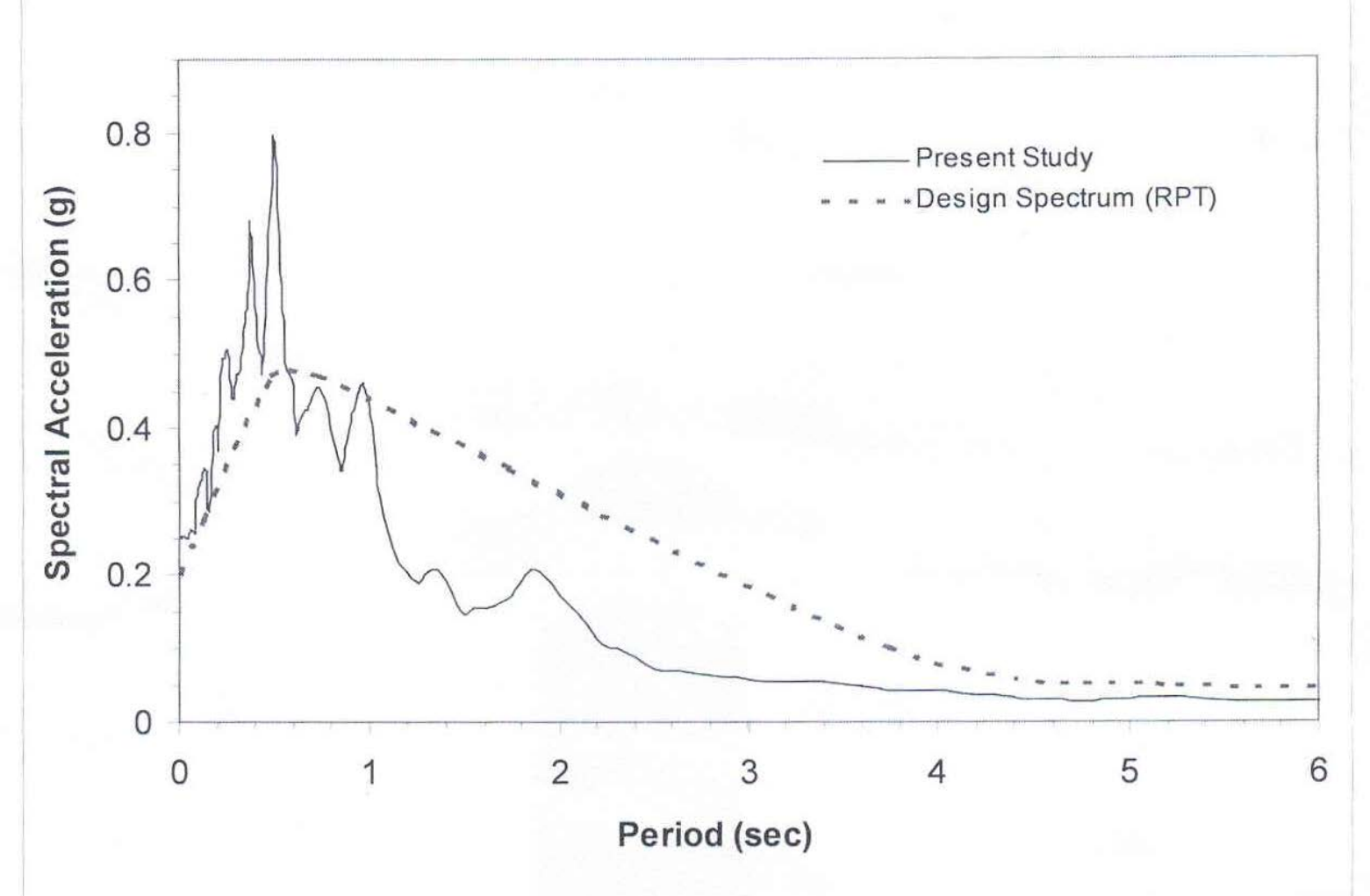


Figure adapted from Rix, G. J., (2001)

- One-dimensional wave propagation analysis is conducted using program SHAKE.
- Measured Shear wave velocity V_{smax} and density profile was used.
- Considering close earthquake 25 to 40 km from Bridge, the Taft EW earthquake record was used as Input time-history, as suggested by Bolt (1987).
- PGA of 0.18g was used in input as judged from PSHA results (475 years return period).
- Site response spectrum obtained using SHAKE is compared with Design response spectrum used in bridge design. There is some site amplification effect on the PGA.

Response Spectrum for Jamuna Bridge



Concluding Remarks:

- New earthquake catalogue has been developed for seismic hazard assessment studies for Bangladesh for the period 825-2010.
- New attenuation law for Bangladesh has been developed and used in PSHA studies.
- PSHA studies for proposed nuclear power plant at Rooppur show PGA values (very stiff soil) of around 0.18 to 0.24g, considering a return period of 2475 years. Site amplification effect has to be added.
- PSHA studies for Jamuna Bridge show PGA value (very stiff soil) of around 0.15 to 0.22g for a return period of 475 years. Response spectrum estimated by site response analysis is in reasonable agreement with that used for bridge design.

Thank you all !