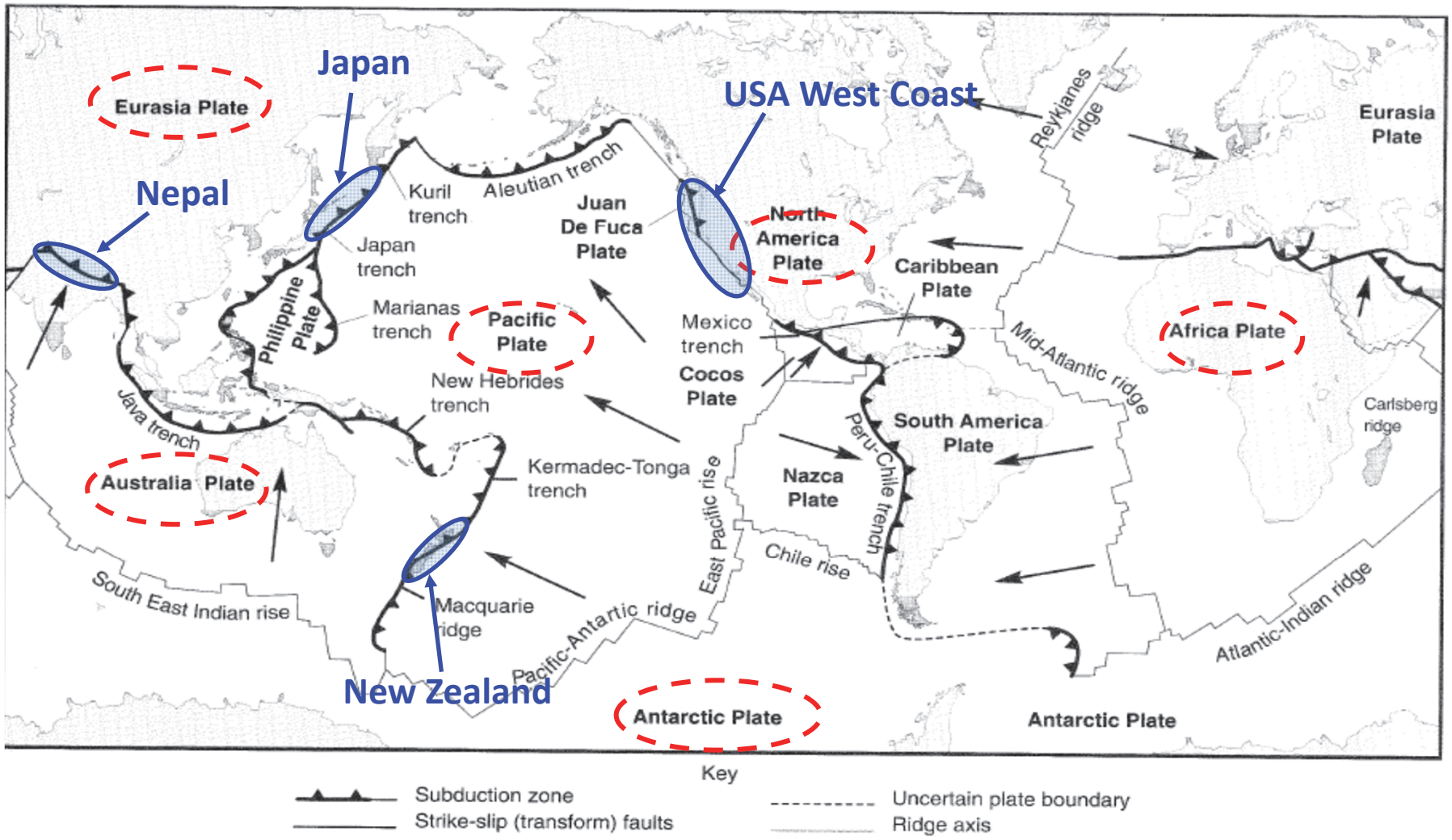
16th US-Japan-NZ Workshop on the Improvement of Structural Engineering and Resiliency
Nara, Japan, 27-29 June 2016

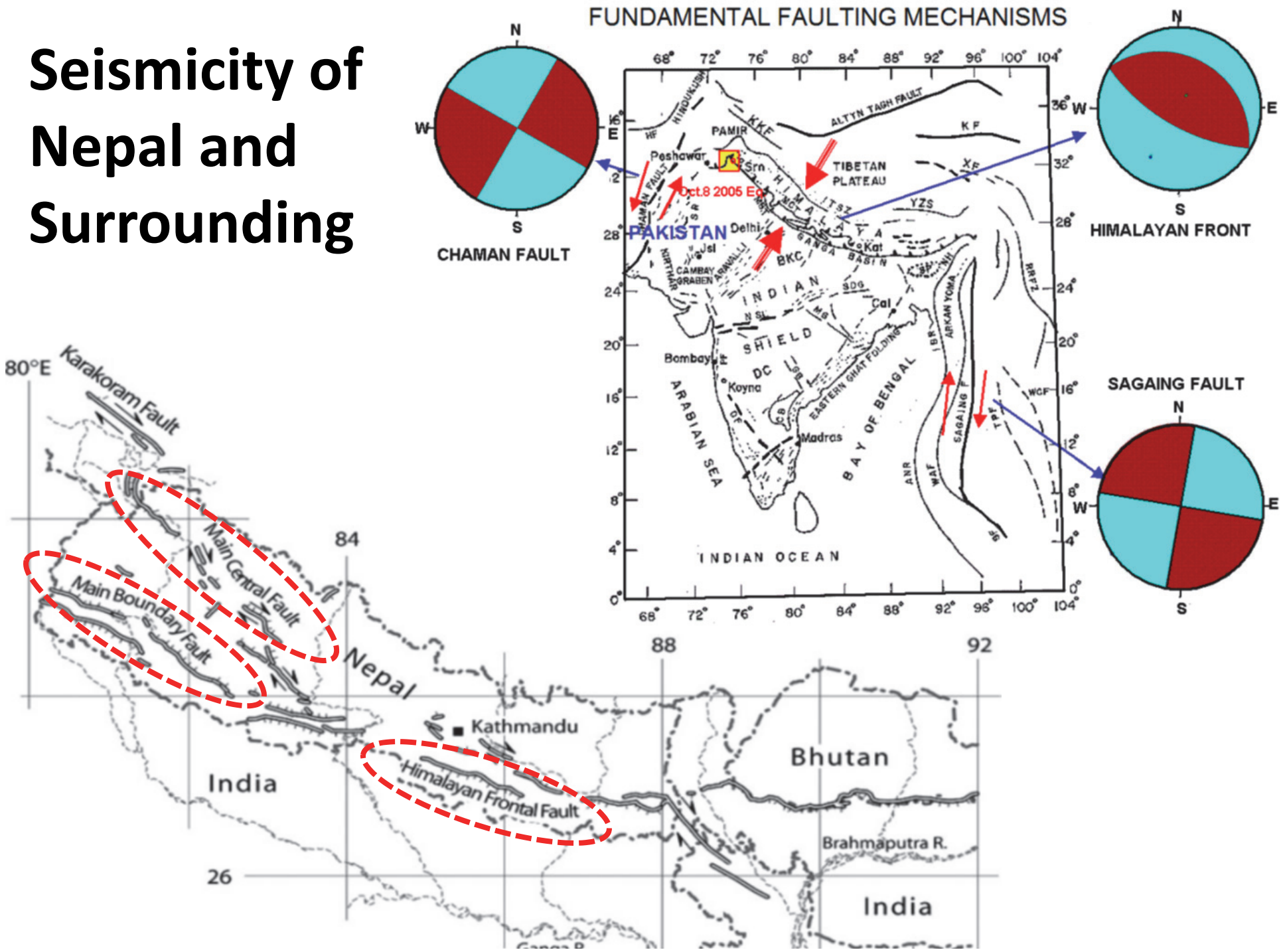
2015 Gorkha (Nepal) Earthquake: An Overview

Professor Rajesh Dhakal, PhD, FIPENZ
Professor of Structural and Earthquake Engineering
Department of Civil and Natural Resources Engineering
University of Canterbury
Christchurch, New Zealand

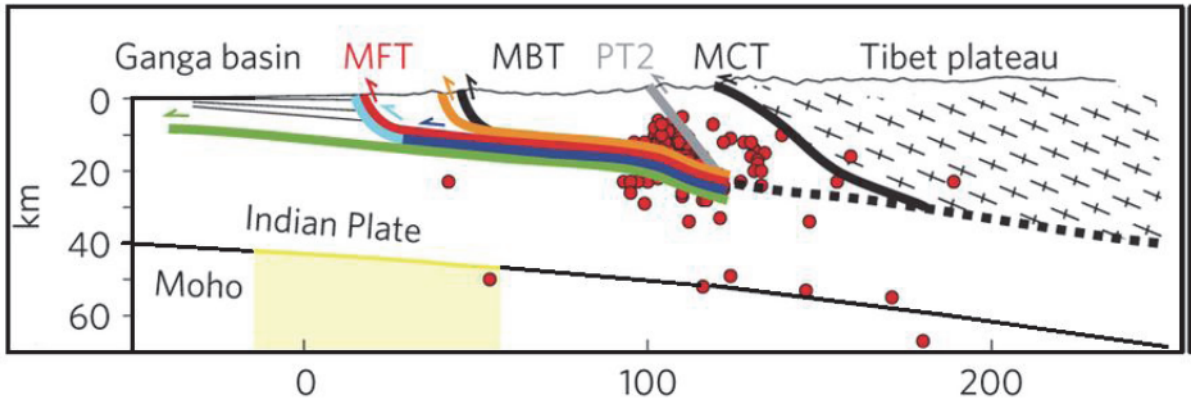
Nepal, NZ, Japan and US West Coast: Similarity in Seismic Scenario

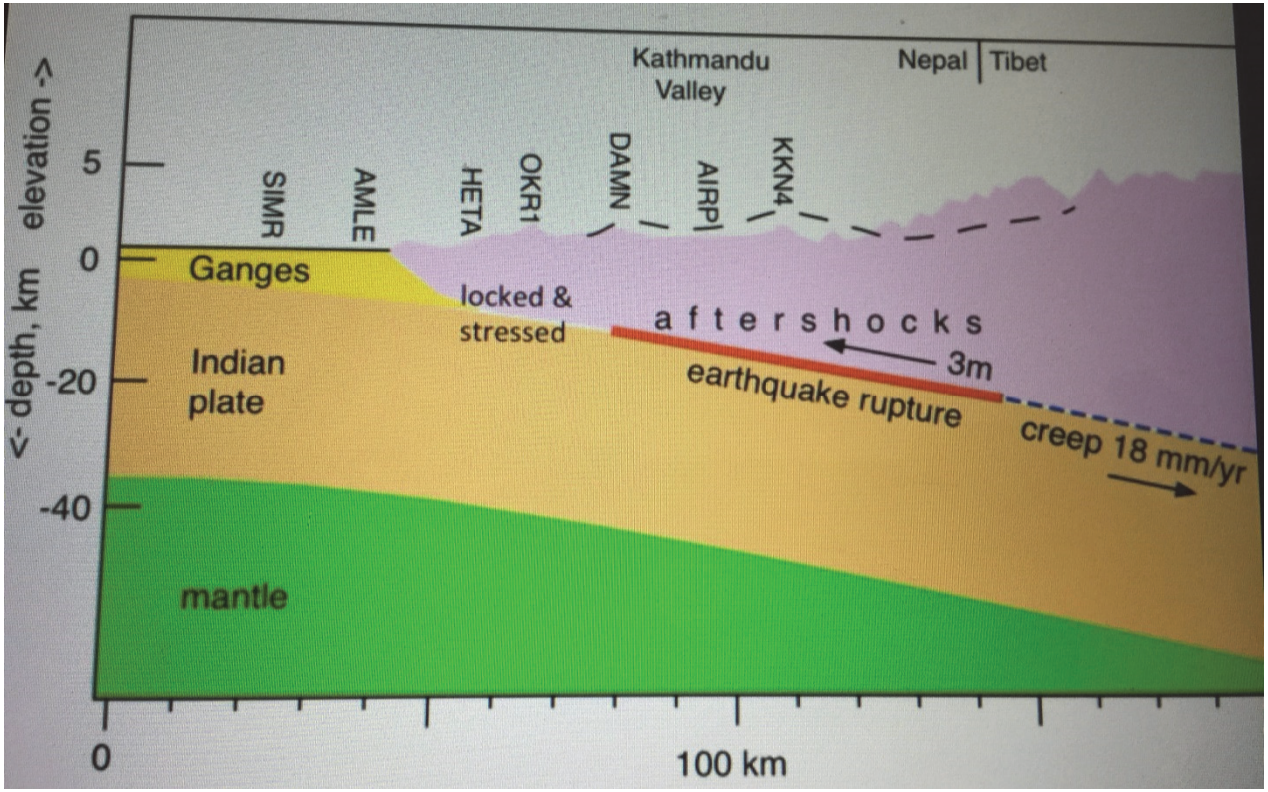


Seismicity of Nepal and Surrounding



Layout of the Fault Planes

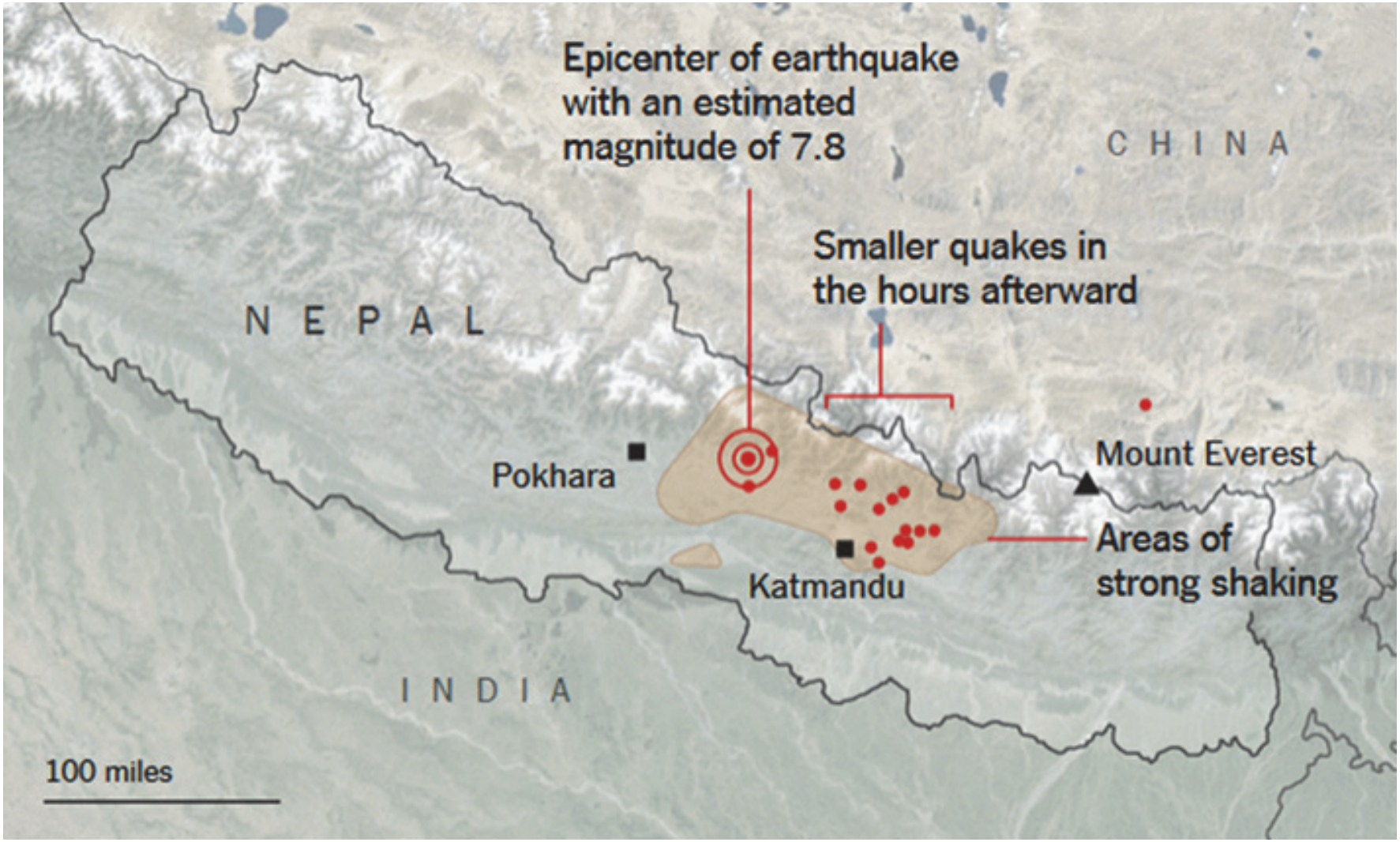




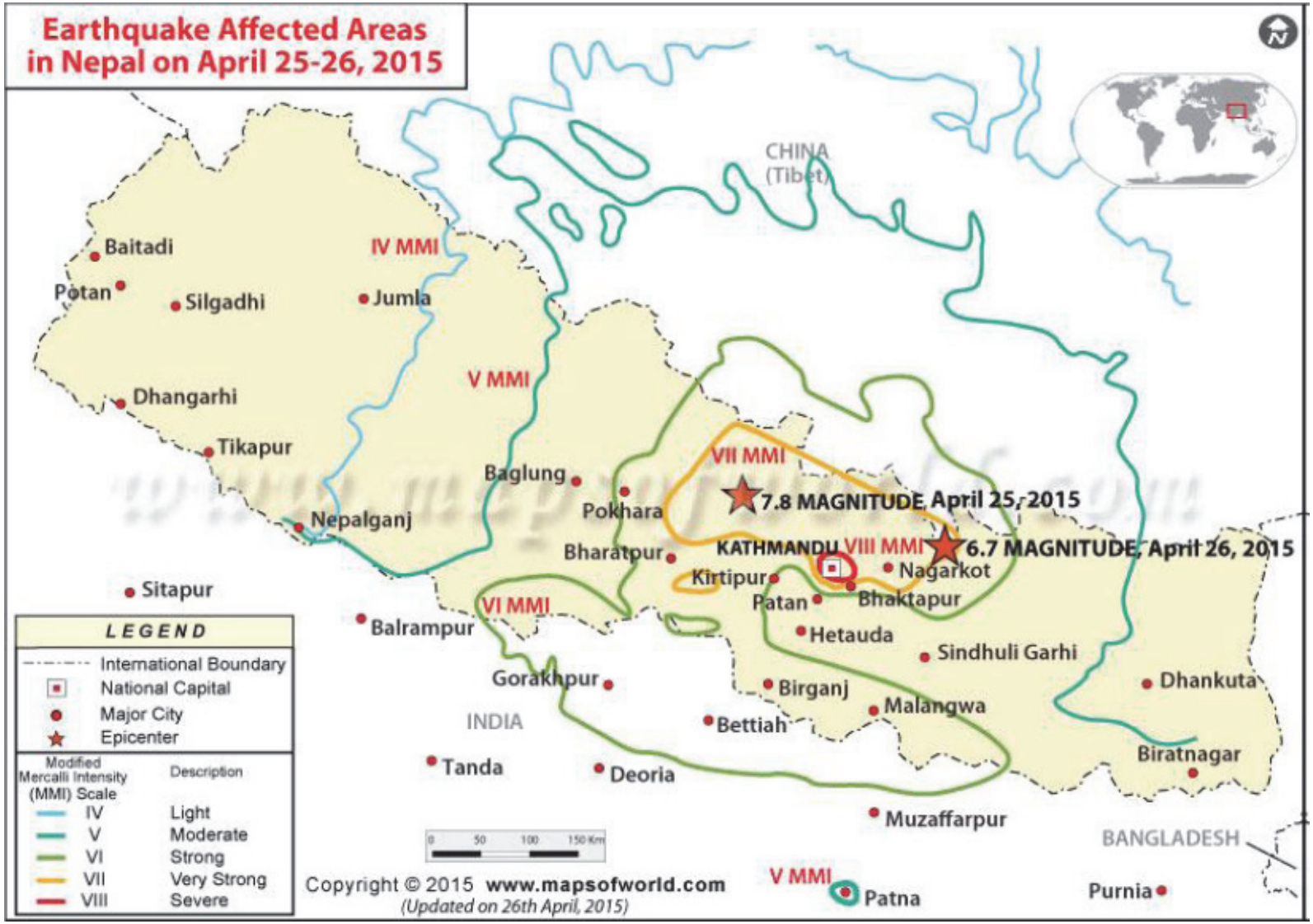
Gorkha Earthquake: Basic Facts

- When?: 25 April 2015 Saturday 11:56 am Local time
- Magnitude: 7.6-7.9
- Depth: 10-15 Km
- Epicentre: Near Barpak Village, Gorkha (78km North West from Kathmandu, similar distance to the East from Pokhara)
- Followed by hundreds of aftershocks, the most damaging one was of Magnitude 6.8 on 12 May
- Effects:
  - 8800+ deaths, about 20,000 injured
  - About 500,000 houses/buildings damaged
  - Loss: approximately 6.6 billion dollars (~33% of GDP)

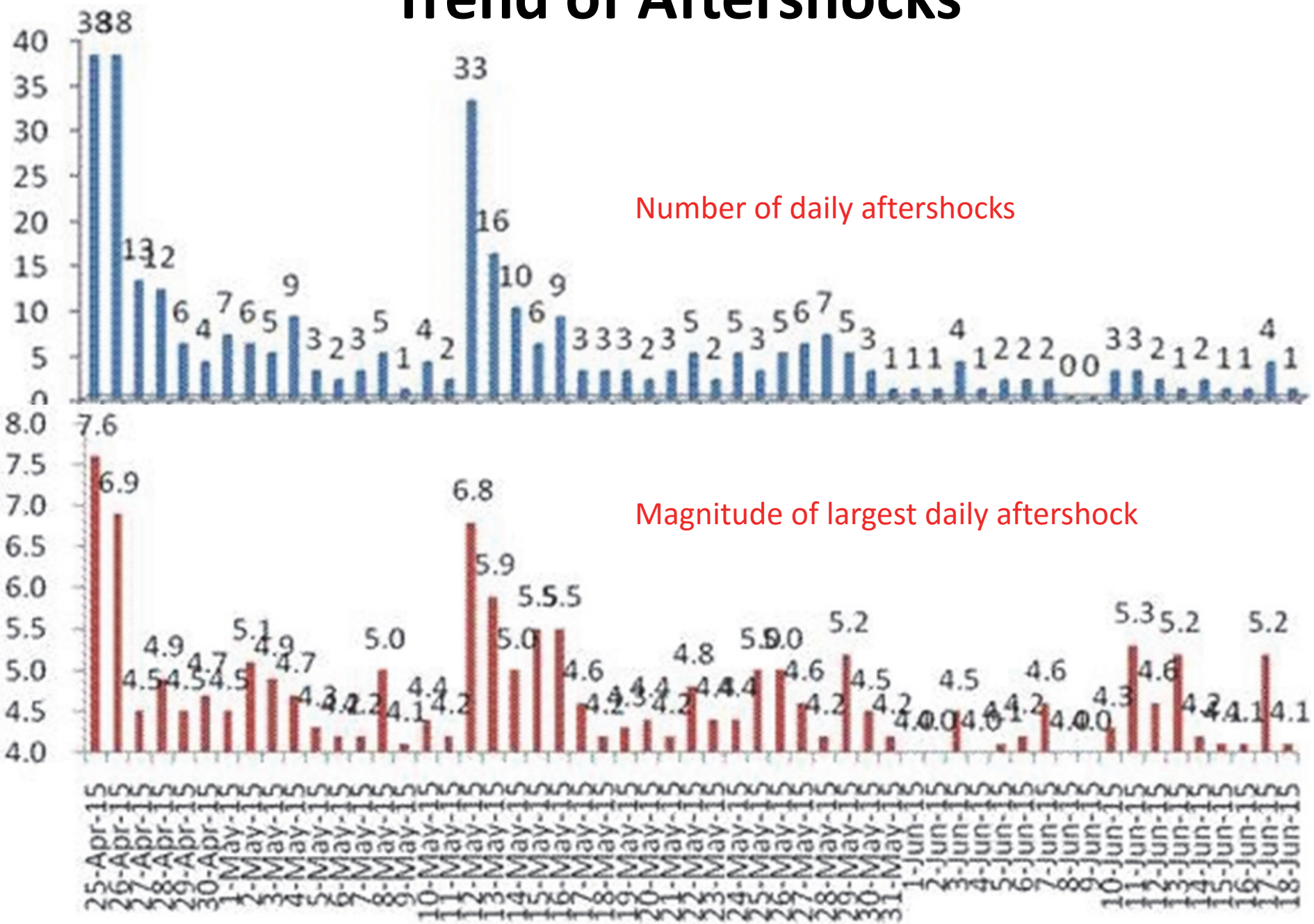
Eastward Rupture Propagation



Seismic Intensity Contours



Trend of Aftershocks



Most Non-Engineered Houses Collapsed


होटल
रसुङ्गा
अर्जुन
प्रा. लि.
19:03 16/MAY/2015

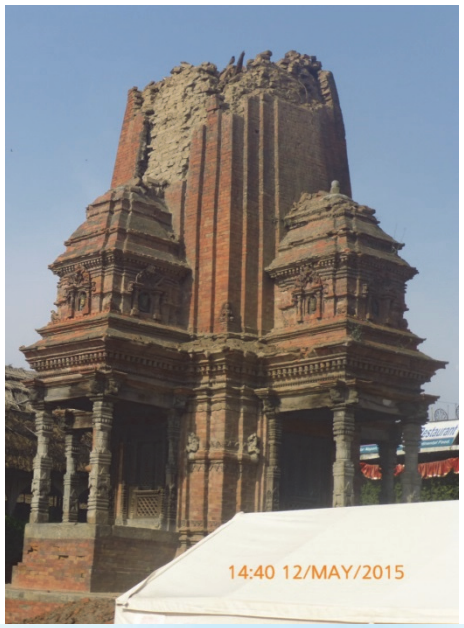

19:00 16/MAY/2015

Hilly settlements were hit harder: Ridge effect


WESTERN UNION

Severe Impact on Educational Facilities

Severe Damage to Heritage Sites



Religious Precincts also Suffered

Damage to Walls: A Common Sight in Tall Buildings

Buildings were affected also by poor performance of soil and foundation

Lokanthali (Bhaktapur)

Itahari (400 km east of Kathmandu)

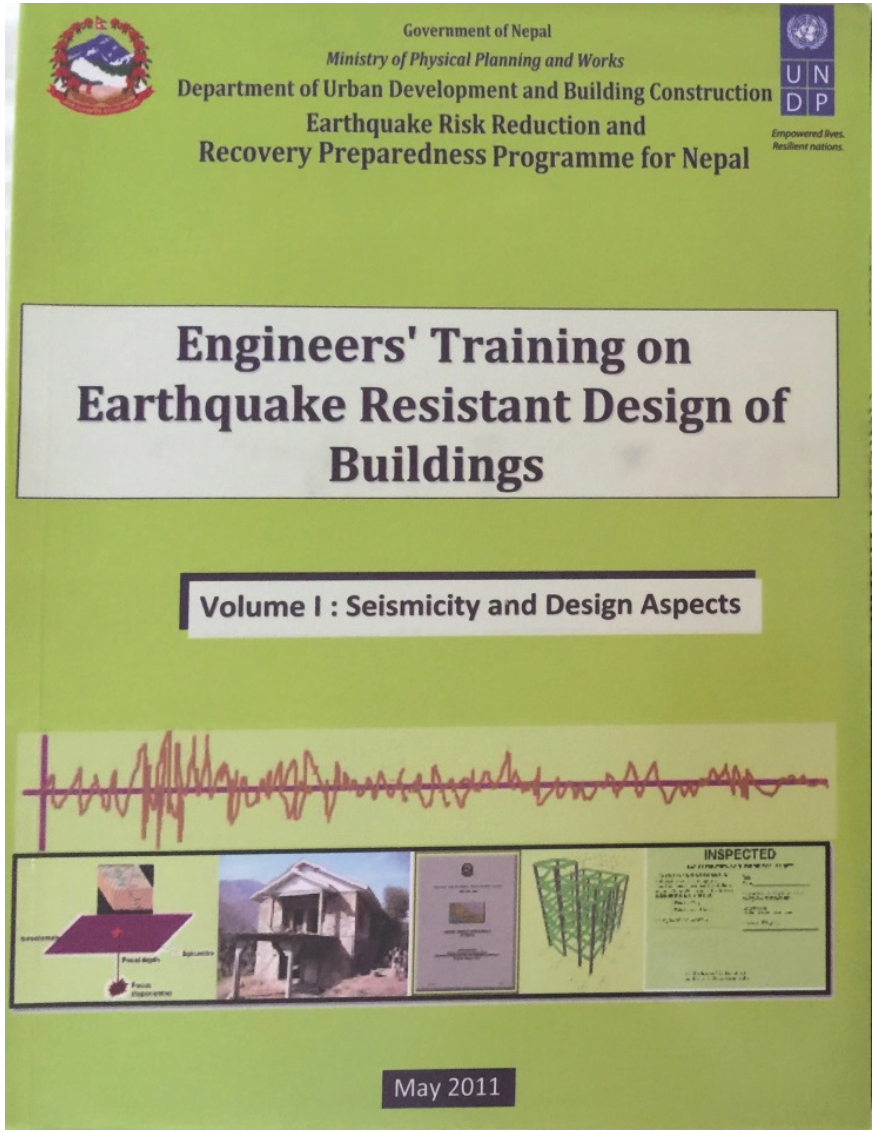
For Many, the Cause was Obvious

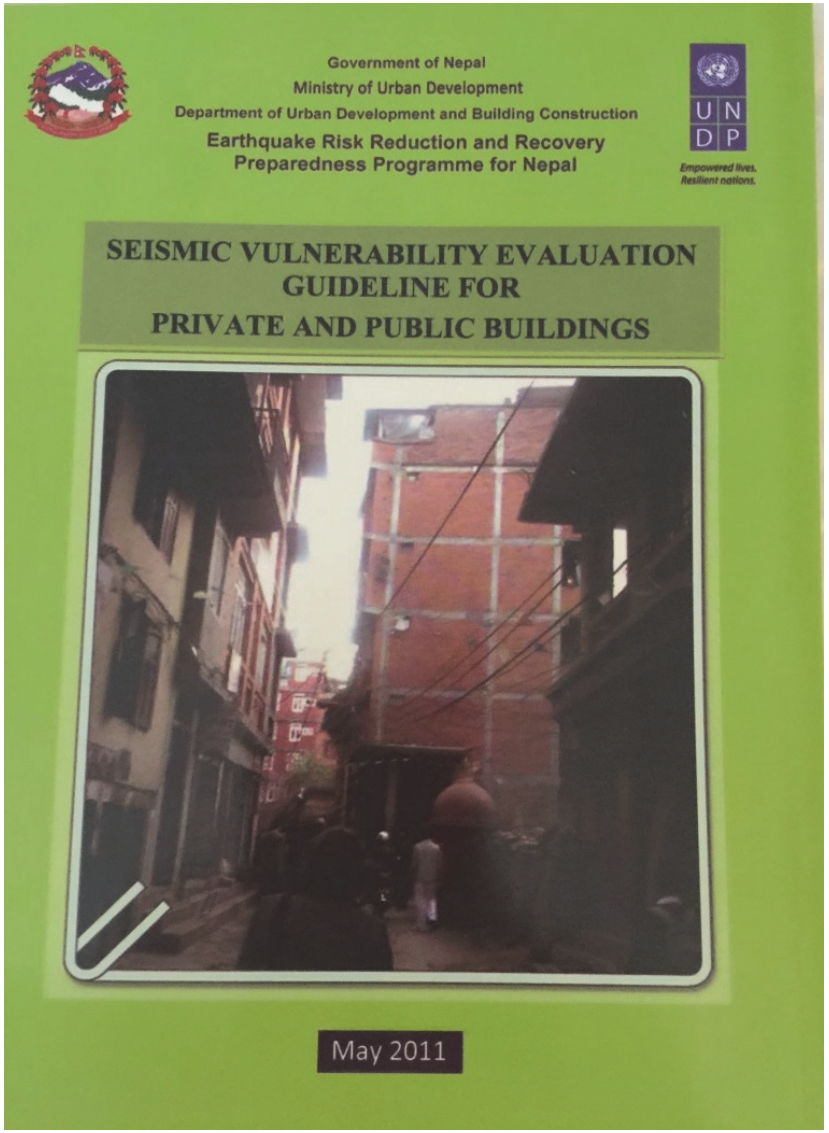
- No anti-seismic features in design/construction
- Fundamental technical faults in buildings
  - Slender columns
  - Insufficient reinforcement
  - Inadequate splice/anchorage
  - Inadequate confinement
  - Poor detailing
  - Unnecessarily thick plaster

- Poor material quality
- Amplification of ground shaking due to local geological features
- Foundation depth/type not adequate for the local soil condition

Technically, Nepal was in a state of

Reasonable Knowledge, Limited Preparedness, Mixed practice





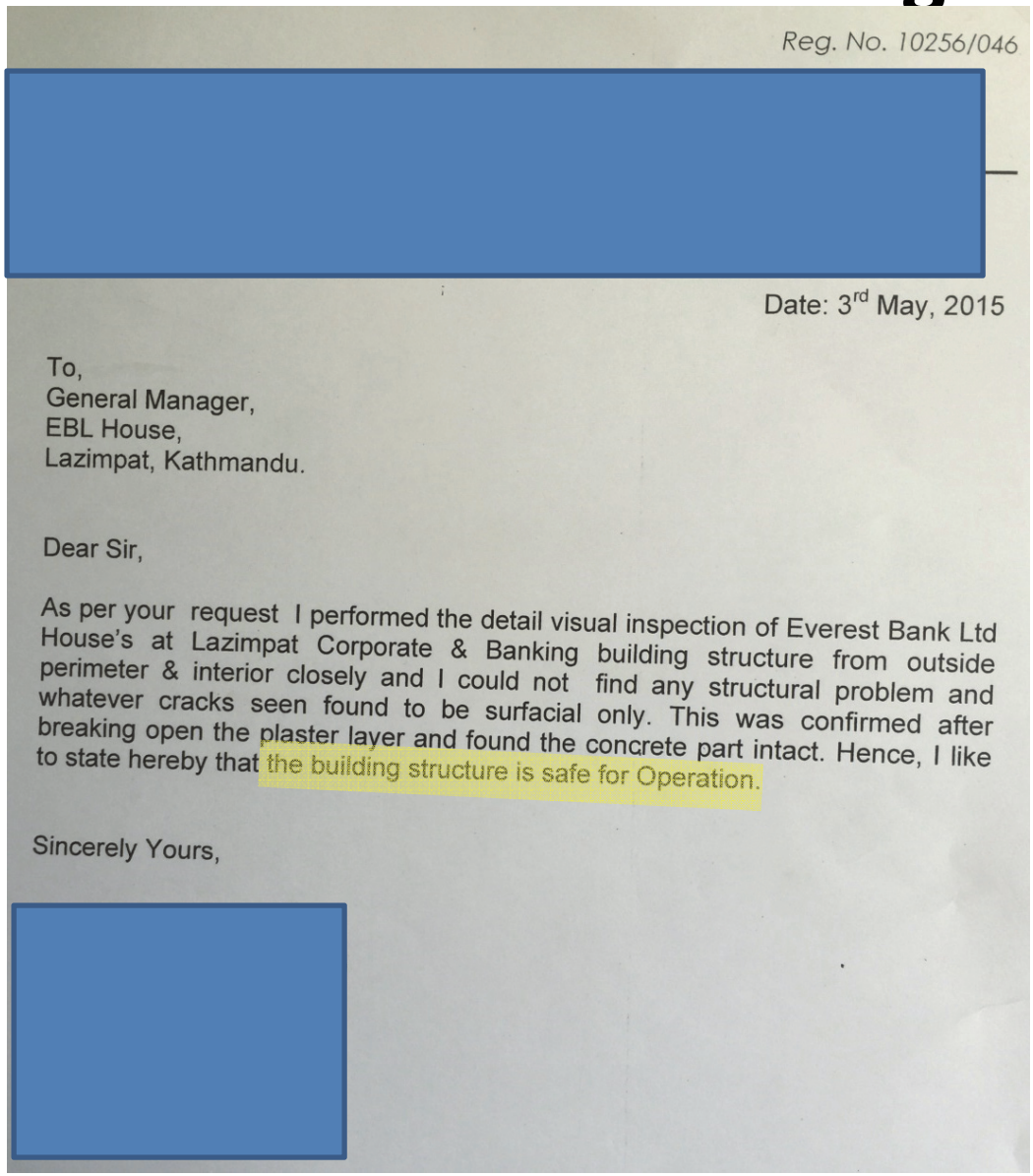
New Buildings: Some Good Examples

Buildings under construction: Bad Examples

Incorrect strength hierarchy

Gongabu

Engineering Advice: At least being Sought for Commercial Buildings



Reg. No. 10256/046

[redacted]

Date: 3rd May, 2015

To,
General Manager,
EBL House,
Lazimpat, Kathmandu.

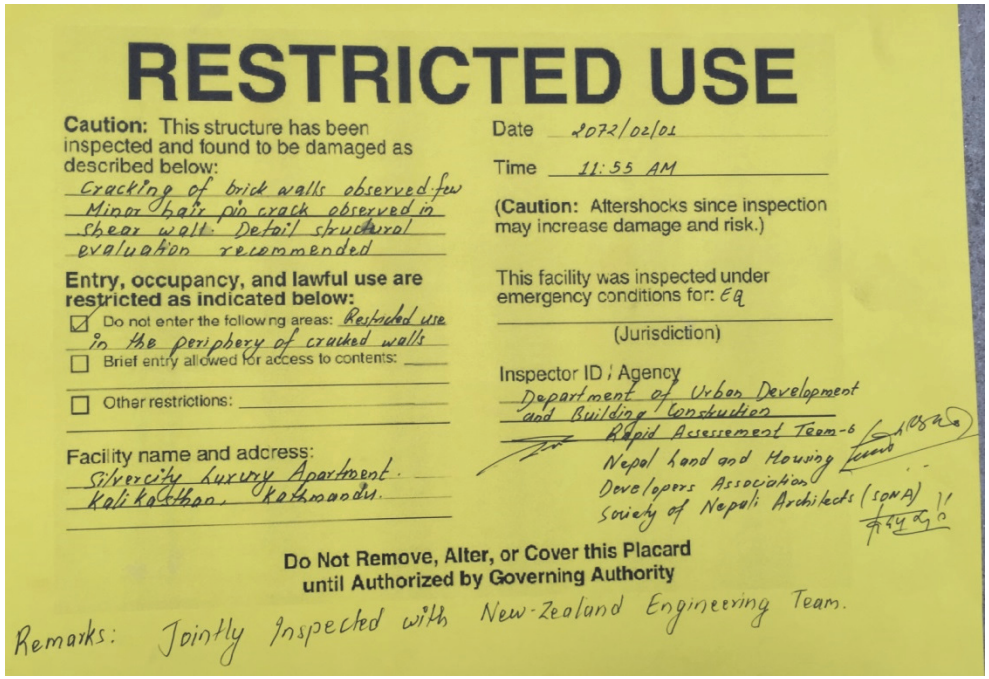
Dear Sir,

As per your request I performed the detail visual inspection of Everest Bank Ltd House's at Lazimpat Corporate & Banking building structure from outside perimeter & interior closely and I could not find any structural problem and whatever cracks seen found to be surfacial only. This was confirmed after breaking open the plaster layer and found the concrete part intact. Hence, I like to state hereby that the building structure is safe for Operation.

Sincerely Yours,

[redacted]

Building Tagging



RESTRICTED USE

Caution: This structure has been inspected and found to be damaged as described below:
Cracking of brick walls observed few Minor hair pin crack observed in shear wall. Detail structural evaluation recommended

Entry, occupancy, and lawful use are restricted as indicated below:
☑ Do not enter the following areas: Restricted use in the periphery of cracked walls
☐ Brief entry allowed for access to contents: ____
☐ Other restrictions: ____

Facility name and address:
Silvercity Luxury Apartment. Kalikasthan, Kathmandu.

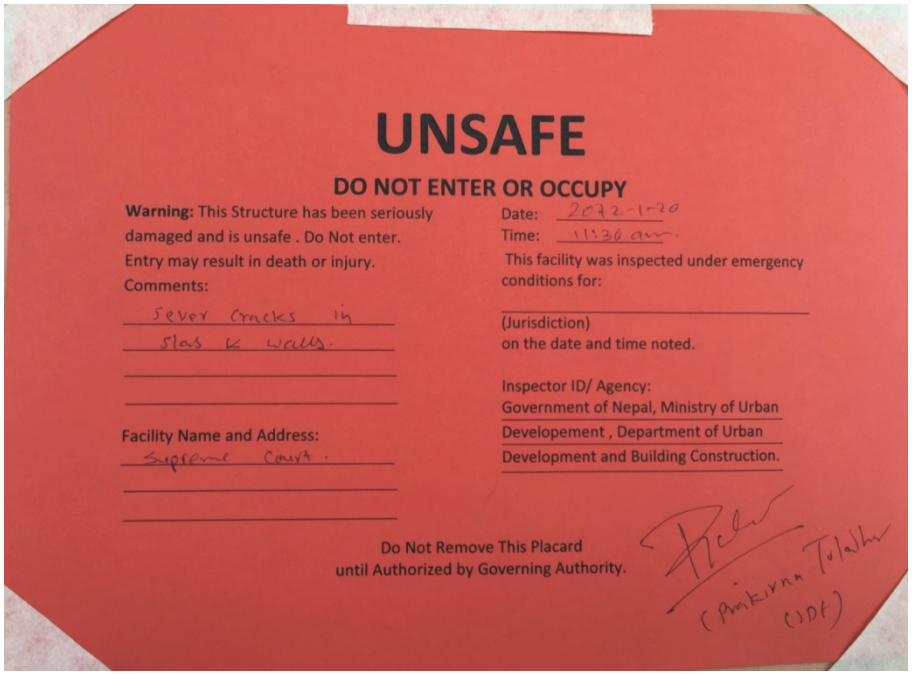
Date 2072/02/01
Time 11:55 AM
(**Caution:** Aftershocks since inspection may increase damage and risk.)

This facility was inspected under emergency conditions for: EQ
(Jurisdiction)

Inspector ID / Agency
Department of Urban Development and Building Constuction
Rapid Assessement Team-6
Nepal Land and Housing Developers Association
Society of Nepali Architects (SONA)

Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

Remarks: Jointly Inspected with New-Zealand Engineering Team.



UNSAFE

DO NOT ENTER OR OCCUPY

Warning: This Structure has been seriously damaged and is unsafe . Do Not enter. Entry may result in death or injury.
Comments:
Sever Cracks in Slab & walls.

Facility Name and Address:
Supreme Court.

Date: 2072-1-20
Time: 11:30 am.
This facility was inspected under emergency conditions for:
(Jurisdiction)
on the date and time noted.

Inspector ID/ Agency:
Government of Nepal, Ministry of Urban Developement , Department of Urban Development and Building Construction.

Do Not Remove This Placard until Authorized by Governing Authority.

(Ankirma Tulachan (UDF)

In general, the practice was of international standard

Shoring/Protection of Damaged Structures

This is how buildings are shored in NZ

Problems/Challenges Immediately after the Earthquakes

- Misinterpretation of colour tags
- Crack-phobia among public
- Shortage of engineers with earthquake engineering expertise
- Professionals speaking outside area of competence
- Scarcity of demolition skill and equipment
- Debris clearance
- Confused authorities/people

My Past Involvement (May 15-Jan 16)

Assessing Hospitals and Advising Medics

Building Inspection and Counselling

Advising Government Officials

Educating Good Practice to Masons





Raising Public Awareness on Seismic Risk

Educating Junior/Fresh Engineers & Students

Shortage of engineers with knowledge/expertise in earthquake engineering

Interaction with Senior Engineers

Professionals speaking/advising outside their area of competence was common

My ongoing/future involvements in Nepal's long-term recovery to seismic resiliency

- Development of earthquake engineering qualifications in Universities
- National Building Code Revision
- National Earthquake Engineering Centre of Excellence
- Facilitating the transfer of low-cost and safe construction techniques developed overseas (Earthbag Technology)

Earthbag Technology

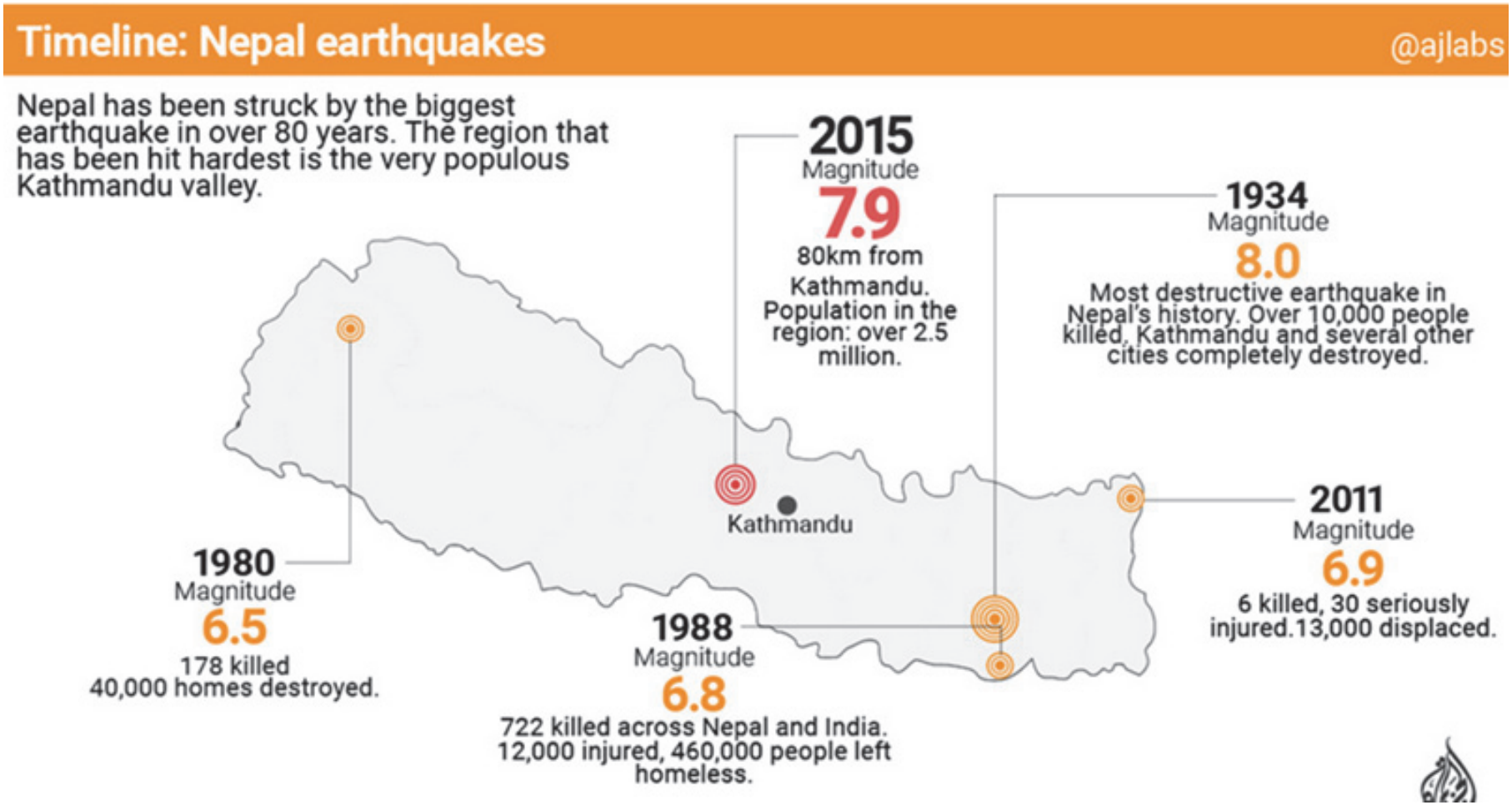
Where to from hereon?

Big earthquakes cause unbearable pain, but also provide a golden opportunity to develop a more resilient community that is better equipped to combat similar disasters in future

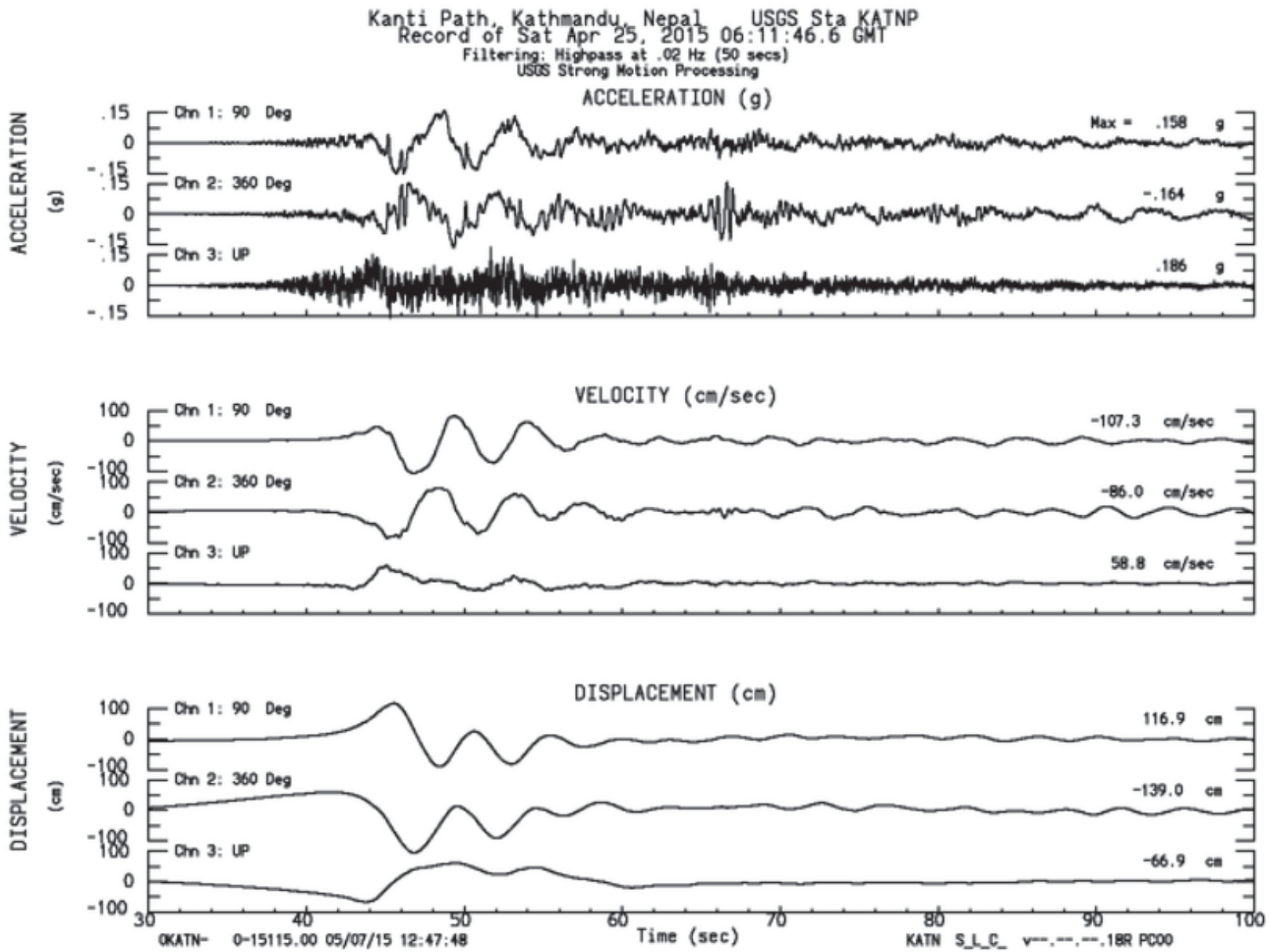
- Develop/improve the building codes
- Establish robust construction quality control mechanisms
- Establish mechanisms to ensure the codes/rules are strictly followed
- Urban development strategy based on a sound land use planning
- Develop comprehensive soil mapping and reconstruct to suit the local soil condition
- Start state-of-the-art earthquake engineering education and training for capacity enhancement

THANK YOU!

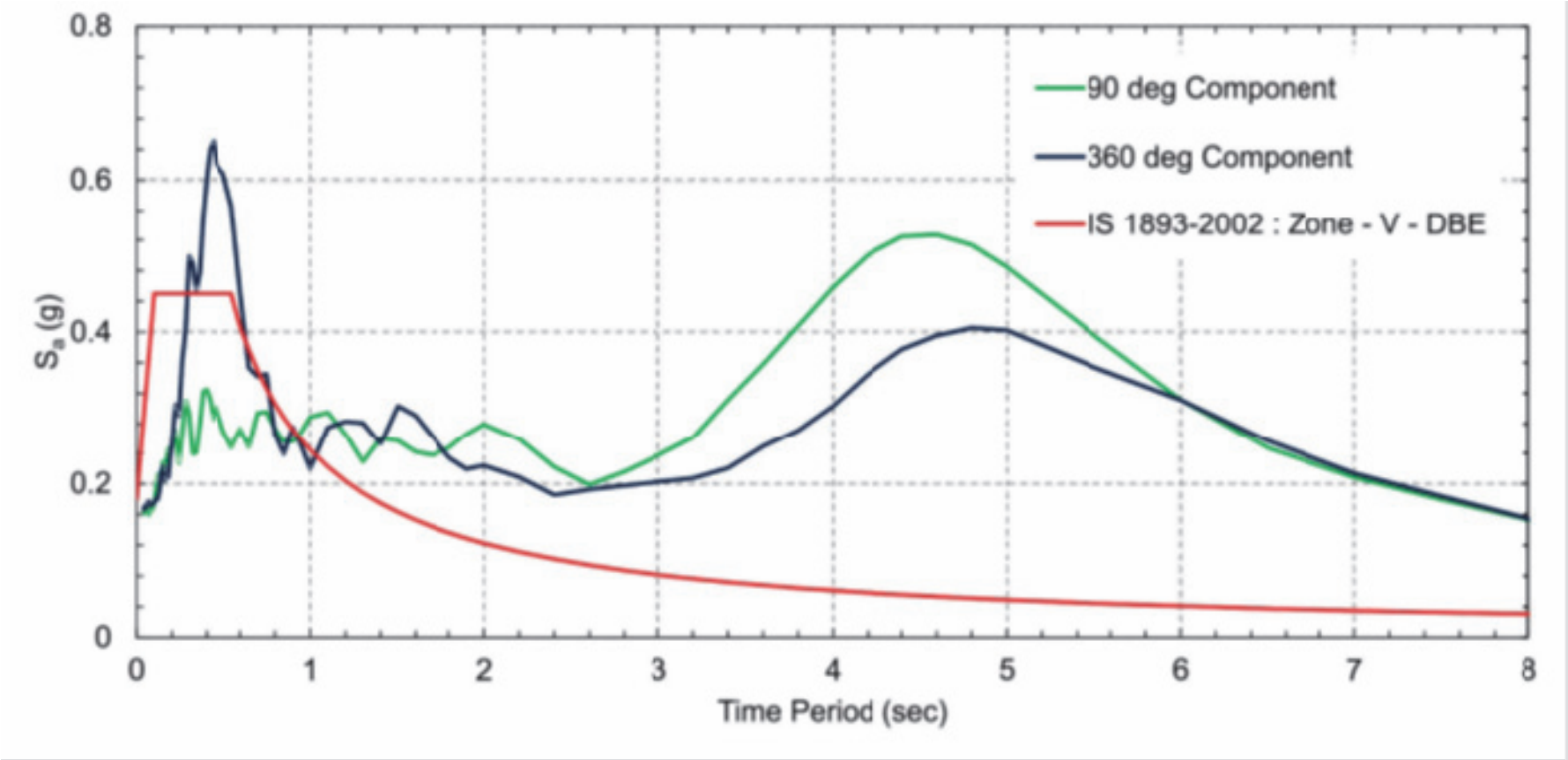
Historic Major Earthquakes in Nepal



Ground Motion Record



Response Spectra



The shakings were larger than the design level for all structures except very stiff (T<0.3s) structures; i.e. 1-2 storey stiff load bearing houses, Rana era palaces with thick stiff walls

NS shaking: gentle to stiff structures, but very harsh on tall/flexible (T>3s) structures

EW shaking: High demand on structures around 0.5s period as well.

But, the shaking intensity was still less than what is normally expected of a 7.9 magnitude earthquake at 75km away.

Kathmandu basin's clay deposits appear to have suppressed low frequency (characterised by high acceleration but small displacement) motions and transferred with amplification the low frequency (large displacement but small acceleration) motions.

This logic is in line with people's recollection of the shaking and the only record available.