
EERI / Bret Lizundia


EERI / Courtney Welton-Mitchell


EERI / Suraj Shrestha

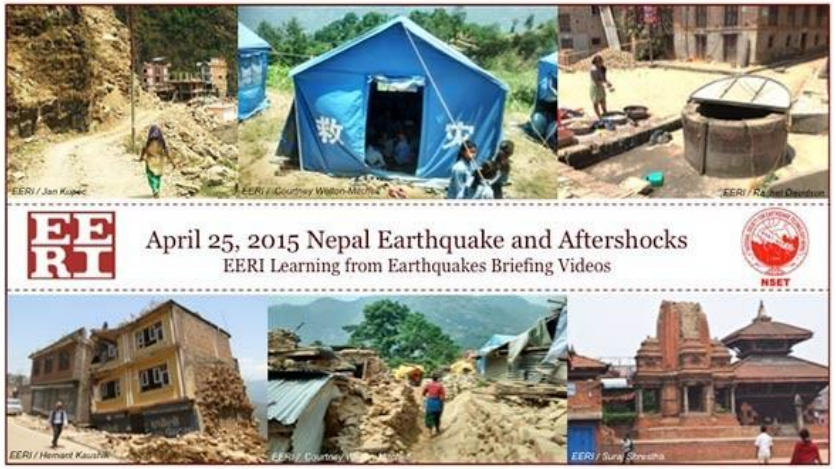
EERI Reconnaissance Overview and Findings

Bret Lizundia, S.E.
EERI and Rutherford + Chekene, San Francisco

EERI Briefing Series of Videos

http://www.eqclearinghouse.org/2015-04-25-nepal/2015/07/29/eeri-briefing-videos/

- Introduction: Objectives, methodology, unique features, team – Bret Lizundia
- Nepal Earthquake: Geography, demographics, and general damage – Surya Shrestha
- Seismology and Ground Motion – Kishor Jaiswal
- Building Performance Part I: Building type overview, RC frame with masonry infill, and woodframe – Hemant Kaushik
- Building Performance Part II: URM bearing wall, postearthquake safety evaluation, barricades/shoring, school retrofits– Bret Lizundia
- Health Facility Performance – Judy Mitrani-Reiser and Hari Kumar
- Social, Psychological and Cultural Factors – Courtney Welton-Mitchell
- Geosciences – Jan Kupec
- Emergency Response – Ganesh Kumar Jimee
- Cultural Heritage Structures – Suraj Shrestha
- Building Codes – John Bevington
- Lifelines – Rachel Davidson
- Resilience and Community Case Studies – Chris Poland
- Summary of Findings – Bret Lizundia



Unique Features of Nepal LFE Effort

- Effective partnership between EERI and National Society for Earthquake Technology - Nepal (NSET)
- Large, diverse, multi-disciplinary, international team
- Strategic objectives and task assignments for each team member
- Virtual Team Collaborators

EERI + NSET

EERI / Courtney Welton-Mitchell

EERI / Hemant Kaushik

Unique Features of Nepal LFE Effort

- Coordination with with nearly 30 reconnaissance teams
- New role of Clearinghouse Curator established to quickly share info
- Urban and rural coverage with groups of team members visiting different heavily damaged districts
- Longitudinal case study effort focused on resilience with planned follow-up reconnaissance missions


EERI / Suraj Shresha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Community Case Studies

- Selected communities with damage
- Detailed interviews with officials and residents
- Goal is to understand pre-earthquake planning, damage in earthquake, state of recovery 5-6 weeks after earthquake, and recovery progress about one year after the earthquake and after the monsoon season.
- Key focus is resilience.


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Nepal LFE Strategic Objectives

1. Evaluate effectiveness of past mitigation and preparedness efforts, especially in hospitals and schools, in a region with well-known, very high seismic risk
2. Investigate lessons from emergency response and building management practices
3. Investigate impacts on lifelines and communications systems, including expected and actual restoration times
4. Investigate recovery and resilience related issues
5. Improve understanding of damage to regional building types
6. Evaluate impacts on World Heritage sites
7. Investigate landslide and avalanche impacts on communities
8. Investigate casualty causes
9. Summarize key ground motion features and their significance

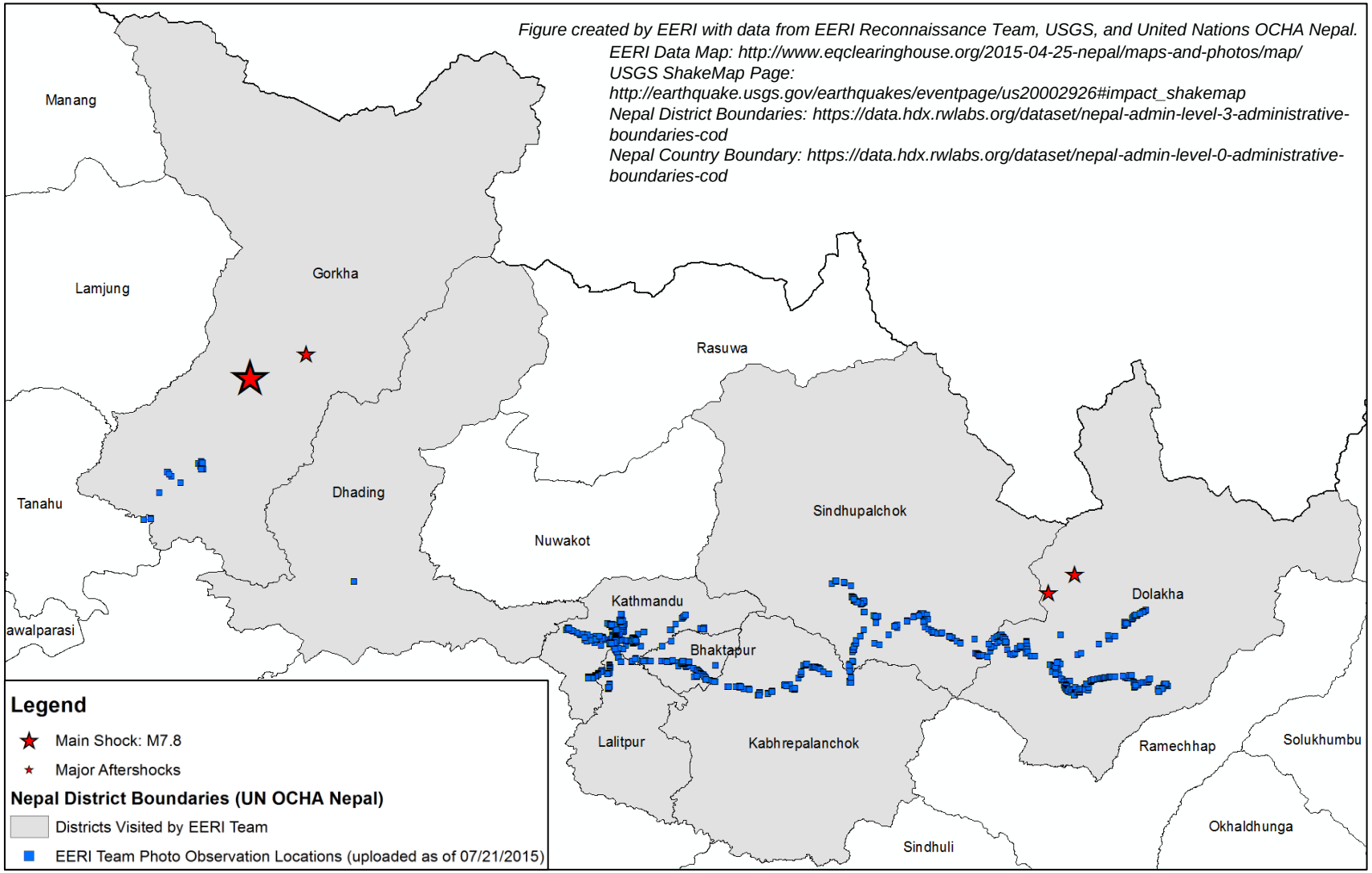
Nepal Reconnaissance Team

- **Bret Lizundia**, Rutherford + Chekene, San Francisco, USA (Co-Leader)
- **Surya Narayan Shrestha**, NSET, Kathmandu, Nepal (Co-Leader)*
- **John Bevington**, ImageCat Ltd, London, England
- **Rachel Davidson**, University of Delaware, Newark, Delaware, USA
- **Kishor Jaiswal**, USGS, Denver, Colorado, USA
- **Ganesh Kumar Jimee**, NSET, Kathmandu, Nepal*
- **Hemant Kaushik**, Indian Institute of Technology, Guwahati, India
- **Hari Kumar**, GeoHazards International, India
- **Jan Kupec**, Aurecon, Christchurch, New Zealand
- **Judy Mitrani-Reiser**, Johns Hopkins University, Maryland, USA
- **Chris Poland**, CDP Engineers, Canyon Lake, California, USA
- **Suraj Shrestha**, Dharan Sub Metropolitan City, Nepal
- **Courtney Welton-Mitchell**, Universities of Colorado & Denver, USA

** Not depicted in image above*

Special thanks to Dr. Thomas Kirsch (Johns Hopkins University)
and Rubina Awale (Transcultural Psychosocial Organization, Nepal)

Reconnaissance Effort



Overview of Nepal and Earthquake – Surya Shrestha

Human Casualties

Deaths:
8,790

Injury:
22,300

Affected Population:
8 million

Deaths in India: 78 China: 25 Bangladesh: 4

Source: NPC, 2015, *Nepal Earthquake 2015: Post Disaster Needs Assessment,* Government of Nepal, National Planning Commission, Kathmandu, 2015.

Data: As of May 21, 2015

Impact on Infrastructure

Infrastructure	Complete damage	Partial damage
Governmental Buildings	2,649	3,617
Private Buildings	510,762	291,707
Schools	More than 7,000 school buildings damaged	
Health Institution Buildings	1,085 health facilities affected	
Archaeological sites	Affected 2,900 structures with a cultural and religious heritage value	
Hydropower Plants	About 115 MW of hydropower facilities severely damaged, 60 MW partially damaged	
Livestock	Loss of 17,000 cattle and about 40,000 smaller, domesticated animals	

Source: NPC (2015)

Impact on Infrastructure

Infrastructure	Damage
Irrigation Canals	Affected the infrastructure and functionality of about 290 small- and medium-scale farmer-managed irrigation canals within the 1,877 irrigation systems in the 31 affected districts
Industry	Larger establishments suffered less physical damages, while substantial number of household-based micro enterprises suffered major damage
Water Supply	Out of 11,288 water supply systems, 1,570 sustained major damage and 3,663 partial damage
Roads Network	Extensive road blockages were reported in the District Road Core Network (DRCN) for a number of days, while the Village Road Core Network (VRCN) roads, most of which were in a non-motorable condition even before the 25 April earthquake, suffered further blockages

Source: NPC (2015)

Building Performance Part I – Hemant Kaushik

RC Frame with Masonry Infill

Low/Medium/High-rise: All suffered damage

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Chautara: 3-story

More damage to buildings on ridge tops - likely ridge top shatter/amplification effects


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Balaju: 6-story


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Dhapasi: 17-story

Less damage to infill walls in tilted buildings - walls completely intact in many cases

Building Performance Part II – Bret Lizundia

URM Building: Dhulikhel

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Postearthquake Safety Evaluations: Chautara

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First School Retrofit in Nepal

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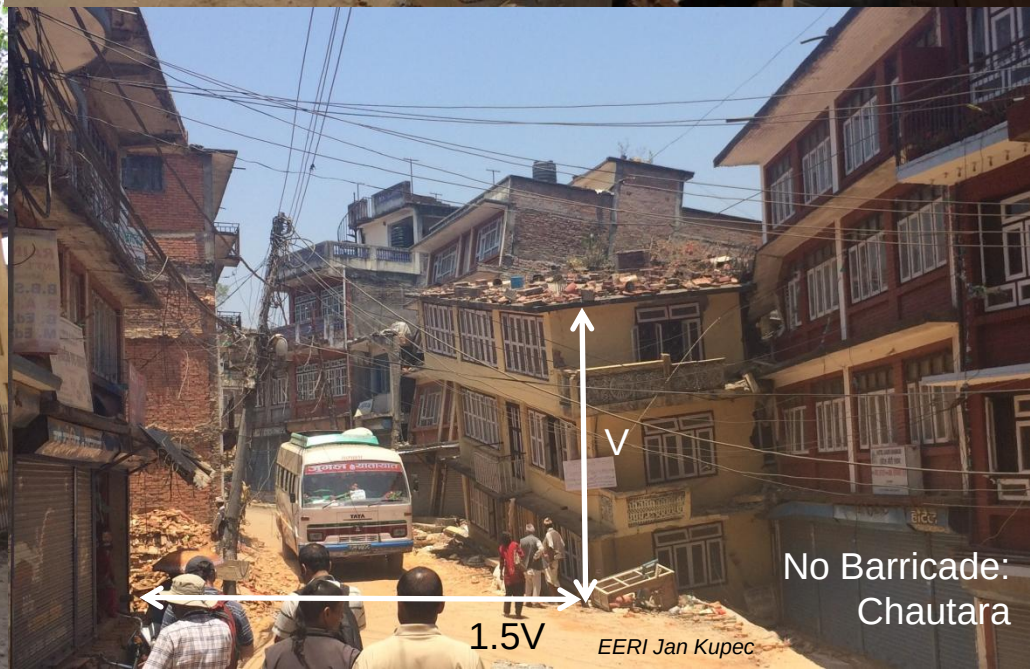


No Barricade: Chautara

EERI Jan Kupec

Building Performance Findings

- Reinforced Concrete with Masonry Infill Buildings
  - Poor performance of non-engineered buildings
  - Foundations on slopes performed extremely poorly.
  - Severe geometric irregularities in buildings make them seismically vulnerable.
  - Poor material and poor quality control resulted in more damage.
  - Seismic codes not followed
  - Non-ductile detailing observed in most buildings.
  - Unplanned development resulted in haphazard construction, which is more vulnerable to pounding.
  - Mandatory Rules of Thumb (NBC 201 and NBC 205) are not followed → poor detailing of members

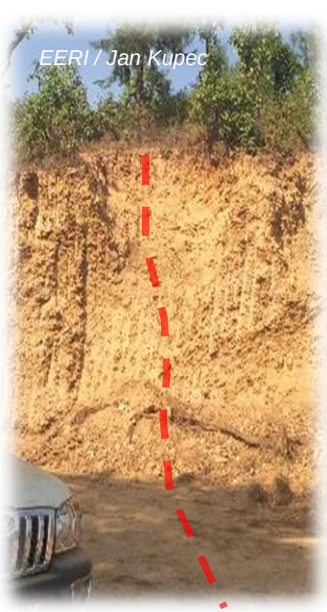
- Wood Frame Buildings
  - Damage mostly due to slope failure and large ground movements, and cracking and collapse of the brick veneer on the building exterior

Building Performance Findings

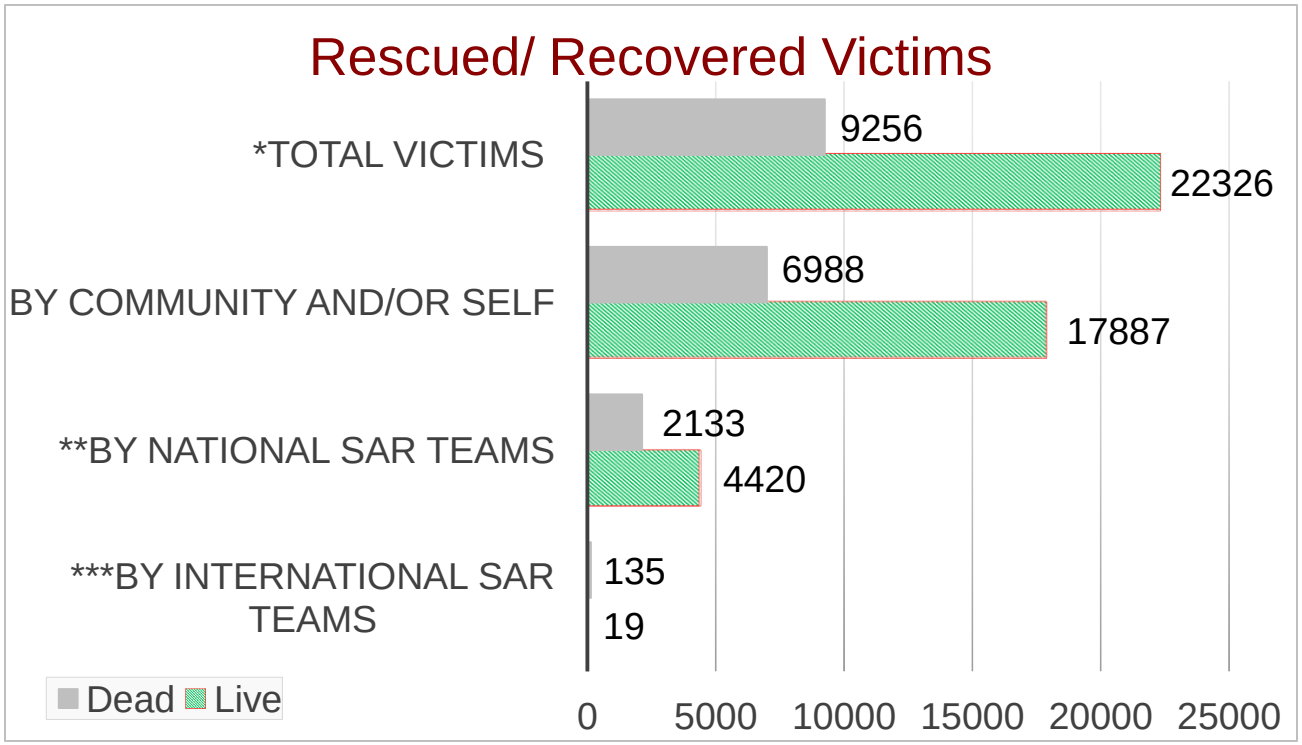
- URM Bearing Wall Buildings
  - URM buildings performed worse than RC frame with masonry infill.
  - Poor quality construction and mud mortar performed noticeably worse.
  - Typical damage includes wythe delamination, out-of-plane/in-plane/corner wall damage, roof/attic damage, and partial/total collapse.
  - Significant rebuilding of housing and repair/strengthening standards needed.
- Postearthquake Safety Evaluations
  - Coordination between different organizations and quality assurance will be challenging.
  - Is the understanding of red and yellow tags clear to evaluators and public?
  - Increase specificity and range of examples in guidelines.
- Barricades/Shoring: Realistic guidelines and effective implementation needed.
- School Retrofits
  - The program should grow. There are many schools left to retrofit.
  - EERI would like more information to understand technical basis of approach.
  - Publish the design guidelines.

Geosciences–Jan Kupec

- Nepal has extensive landslides due to steep terrain.
- This cliff collapse buried a village.
- Village was relocated to a ridge spur.
- Cracking in recent road cut at top along ridge 15-25m back from cliff edge observed—potential future cliff collapse.
- EERI seeks to develop improved advice for postearthquake safety evaluation from landslide threats.



Emergency Response – Ganesh Jimee



*Source: *Nepal Police, 2 July 2015, **Reports by Nepalese Army, Nepal Police and Armed Police Force June 2015 *** report by Nepalese Army, June 16, 2015*

Community responders

National responders

International responders

Emergency Response Findings

- Develop at least one community search and rescue (SAR) squad in each village/community; and pre-position minimum equipment in strategic locations.
- Develop at least one well-equipped professional SAR team for each district (in case of urban, based on population)
- Develop/improve coordination/response mechanism from top to bottom and among the communities.
- Common understanding and implementation of plan and policies from different level of government authorities
- Assist/guide international SAR teams properly in local context
- Disaster Preparedness and Response Plan exists in each districts - develop mechanism to test and update the plans
- Review and standardize awareness materials and insure proper dissemination
- Further research:
    - Safe behavior and identifying safe/unsafe areas in the context of local physical, socio-cultural environment and building types
    - Temporal variation of extricating live victims by SAR teams
    - Comparative study of cost and saving lives by SAR teams
    - Induced landslides and potential risk

Cultural Heritage – Suraj Shrestha

- Performance of monuments varies

Patan DS-Before and After Earthquake

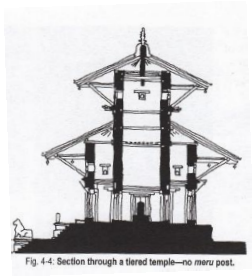
Chyasilin Mandap in Bhaktapur DS- seismically strengthened and undamaged

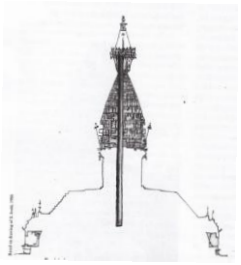
Kathmandu DS-Before and After Earthquake

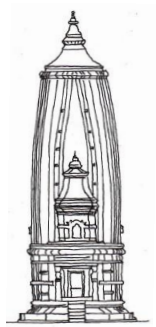
Similar Temples- Anantapur Temple (Superstructure collapsed) and Pratappur Temple (Plinth damage) of Swayambhu

Cultural Heritage Findings

Source: Tiwari, S.R., 1989, *Temples of the Nepal Valley*, Himal Books, Kathmandu.







- Key question: Rebuild with traditional techniques and materials or include some form of enhancement?
- Positive side
  - Plenty of available artists/ masons
  - Guthi: Community based management
- DOA staff size to manage the scale is small
- Lack of proper documentation and record of art and artifacts
- Lack of drawings (both architectural and structural) of monuments
- Reaching consensus on plans on how to rebuild
- Funding issues
- Technological issues

- Pilot study vs. large program
- Repair guidelines (Norms/ Standards) needed
- Material testing warranted
- Strong motion instruments would help improve understanding of behavior
- Analytical modeling recommended
- Shake table testing of repair, retrofit solutions
- Quality assurance and peer review
- Research studies on underlying reasons of good and bad performance needed to verify effectiveness of local traditional technology and materials

Building Codes – John Bevington

Development of a complex of five 17-story apartment buildings

Permit issued for 12 stories

Inappropriate detailing of concrete reinforcement

Nonductile concrete with 90 degree hooks, wide tie spacing and no cross-ties on middle vertical longitudinal bar

Building Code Findings

- Building codes exist, yet adequacy, adoption and compliance are key issues.
- There are a number of potential areas for improvement and an update to the code is planned
- Evidence of code compliance is very low throughout country, especially outside of Kathmandu.
- There is heightened awareness since the earthquakes of the need to adopt the Nepal National Building Code.
  - Need to act quickly to capitalize on this.
- Awareness was increasing, even before the earthquakes, thanks to activities by organizations such as NSET.
  - Public policy needs to increase in tandem.
- Several international initiatives have been established to increase adoption and monitor compliance of codes.
  - Many initiatives are ongoing – a positive sign.
- Lessons learned from LFE reconnaissance mission have enhanced the ongoing EERI Housner Fellows Program investigation into code compliance issues in Nepal.

Lifelines – Rachel Davidson

- In city, immediate effect on consumers smaller because of limited normal service
- Severe delay in on-going development
- Effects worse in rural areas
- Limited interdependencies
- Little preparation before Now plan to build back better
- Landslide risk pervasive
- Monsoons will exacerbate damage, delay restoration

http://www.ekantipur.com/2015/05/19/national/worst-quake-hit-sindhu-in-shambles/405401.html

Infrastructure Sector	Total Loss US$ Million
Electricity	186
Communication	49
Community Infrastructure	45
Transport	282
Water and Sanitation	181
Total for Infrastructure Sectors	743
Total for All Sectors (~1/3 GDP)	6,695

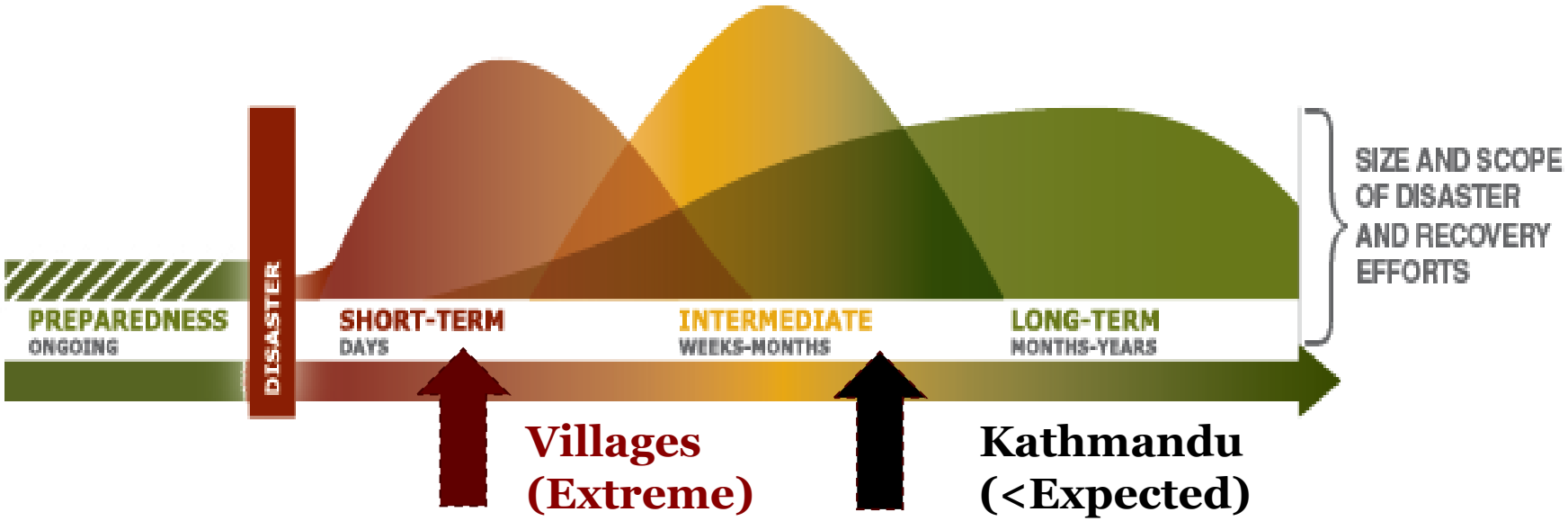
Source: NPC (2015)

Resilience – Chris Poland

Preparedness, Response and Recovery

Routine – Expected – Extreme Events

Source: National Disaster Recovery Framework



Critical Facilities, Emergency Housing and Lifelines

Housing, Neighborhoods, Business

Community Economic Recovery

Resilience Findings

Housing
- Upgrade code to shelter in place
- Re-plan before the next event for reconstruction: Access, open space, egress

Construction Process
- Owners need to embrace the value of building to code.
- Contractors should be trained and licensed.
- All construction should undergo plan review and inspections.

Roads
- Provide wider and redundant routes to villages and lifeline systems.

Airport
- Update plans to increase capacity.
- Upgrade runway; provide additional emergency parking.
- Incorporate domestic airports to expand capacity.

Communications
- Retrofit vulnerable towers.
- Add redundancy.

Electricity
- Design for robustness.
- Add redundancy to transmission and distribution systems

Critical Facilities
- Determine vulnerabilities.
- Plan for temporary operations.
- Retrofit/replace as possible

Water
- Design for robustness.
- Recharge groundwater.

Wastewater
- New network of treatment plants should remain operational.
- Design for robustness.

Observations Related to Community Resilience in the United States

1. Resilience should begin with saving lives.
2. Emergency access needed to people and critical facilities.
3. Adopt and enforce proper performance-based building codes and inspect for compliance.
4. Distributed lifeline systems are naturally more resilient.
5. Understand community-wide recovery vulnerabilities, conceptualize work-arounds, and plan for mitigation when possible.

Acknowledgements

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  - EERI's Learning from Earthquakes Program for travel and logistic support
  - NSET for coordination, logistics, and linkages to local individuals and organizations in Nepal
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- This presentation deliberately copies or utilizes information directly from briefing presentations by other members of the EERI Reconnaissance Team. Their contributions are essential and appreciated. Please see individual presentations for details and additional acknowledgements of assistance.

More Information: Reports, Data & Photos

http://www.eqclearinghouse.org/2015-04-25-nepal/

- Visit EERI's Virtual Clearinghouse Website for:
  - Geolocated Data Map
  - Photo Gallery
  - Team Report *(available in late summer 2015)*
  - Reports from other teams & organizations
  - Curated Topic Posts
- Thanks to all Virtual Team Collaborators, who helped process and upload team photos to the EERI map.