Evaluation of Earthquake Disaster Risk for Safer School Buildings Construction in Nepal

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Flagship 1: School Safety National level workshop
In collaboration with Flagship 4: Integrated Community Based Disaster Risk Reduction
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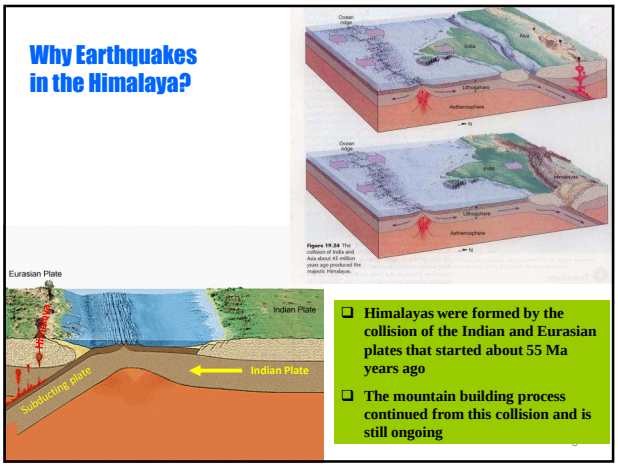
Content

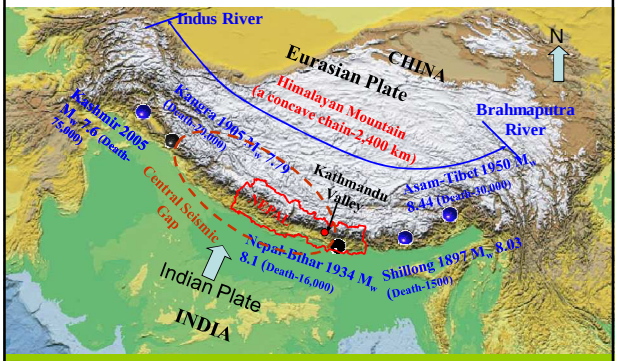
- Background information about Earthquake Disaster Risk in Nepal and in school
- Why Kathmandu Valley
- Field visit report in eastern and western part of Nepal
- Department of Education strategy
- Lesson learnt

Why Earthquakes in the Himalaya?



- Himalayas were formed by the collision of the Indian and Eurasian plates that started about 55 Ma years ago
- The mountain building process continued from this collision and is still ongoing

Major Earthquakes in the Himalayan Region and Zone of Seismic Gap



- Indian plate moving toward north at a rate of 2 to 5 cm per year and the occurrence of frequent seismic activities along the Himalaya and its surroundings
- During past 120 years, five great earthquakes occurred along the Himalayan front

History of Earthquakes in Nepal

SN	Year	M	Deaths	Damages
1	1255		One third Population of KV affected	A Lot of damage of houses and temples in KV (Ist earthquake in record)
2	1408		Many people	A Lot of damage of houses and temples
3	1681		Many people	A Lot of damage of houses and temples
4	1833	7.7	414 people	4,040 in KV & 18,000 in whole country
5	**1934**	**8.1**	**4,296 in KV & 8,519 in whole country**	**81,000(12,397 KV) destroyed in country, 200,000 damage in whole country**
6	1980	6.5	103 people	12,817 damaged, 2,500 collapsed,
7	1988	6.5	721	66,382 buildings damaged
8	2011	6.9	6 people	14,544 damaged and 6,435 completely destroyed

Sources: NSET, UNDP, NCHS 1994, Pandey & Molnar 1988, JICA 2002, [illegible]

Watch ??

Damage of Buildings in Kathmandu Valley by past Earthquakes

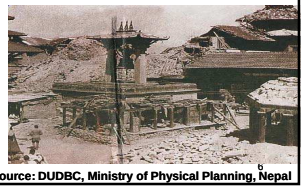
1934 Bihar-Nepal Earthquake

Total people died

- Whole country – 8,519
- Kathmandu Valley – 4,296 (50.4%)

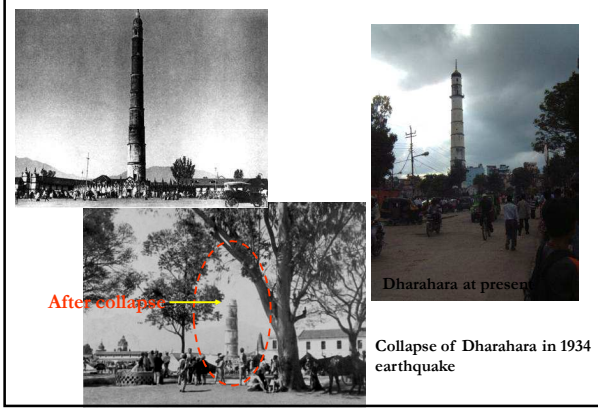
Total houses damaged

- Whole country – 207,000
- Kathmandu Valley – 56,000 (27%)



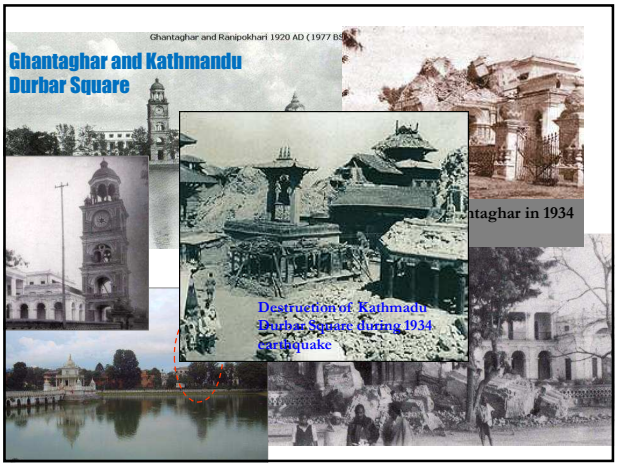
Source: DUDBC, Ministry of Physical Planning, Nepal

Fall of Dharahara in 1934 Earthquake

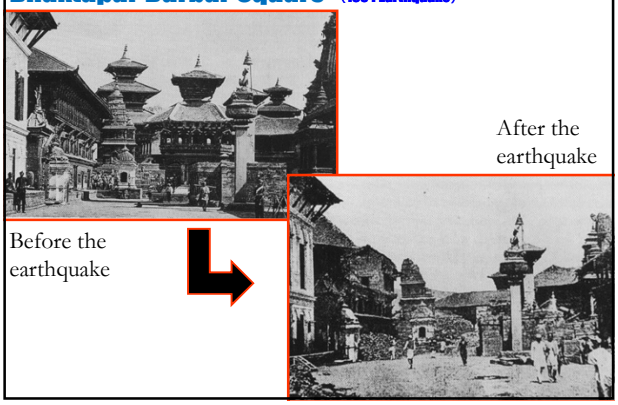


Collapse of Dharahara in 1934 earthquake

Ghantaghar and Kathmandu Durbar Square



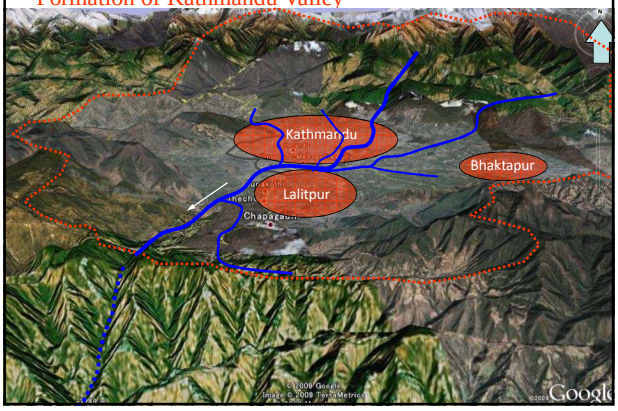
Bhaktapur Durbar Square (1934 Earthquake)



Some of Recent Research Findings about Kathmandu Valley

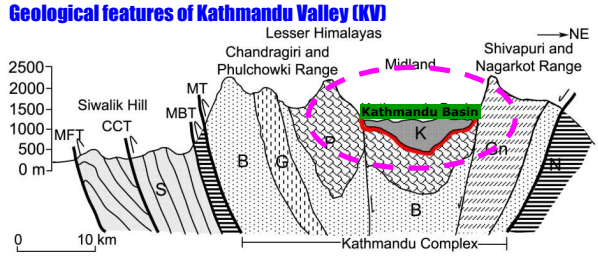
Why such heavy of damage in Kathmandu Valley?

- Formation of Kathmandu Valley



Why such heavy of damage .....?

Geological features of Kathmandu Valley (KV)

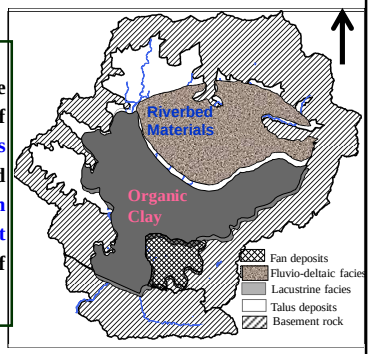


A schematic geologic cross-section in the Central Nepal Himalyas, Modified from Stocklin and Bhattari (1981)

- The Kathmandu Basin is an intramontane (alleviated area lying within the confines of mountains) basin.
- This nearly round valley (Bowl shape) has a diameter of about 30 km E-W and 25 km N-S

Geological features of Kathmandu Valley (KV)

- Northern part of the basin consists of riverbed materials (Sand, Clay and Gravels) and southern part and central part mostly consist of organic clay

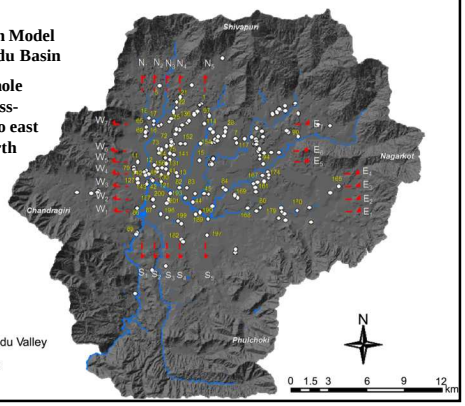


Kathmandu Valley Basin

Source: Dept. of Mines and Geology, Nepal

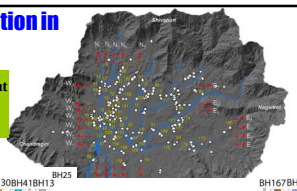
Borehole and sediment distribution in the Kathmandu Valley

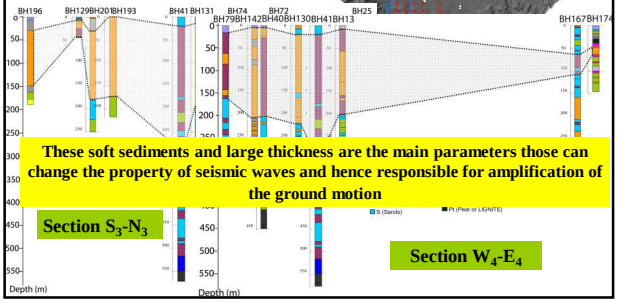
- Digital Elevation Model of the Kathmandu Basin
- Shows the borehole location and cross-section in west to east and south to north
- 340 borehole points in KV. Depth ranging from few meters to 550 m at central part of KV



Borehole and sediment distribution in the Kathmandu Valley

Variation of thickness of sediments in different location of valley (area enclosed by black dotted line represents the soft soil layer)





These soft sediments and large thickness are the main parameters those can change the property of seismic waves and hence responsible for amplification of the ground motion

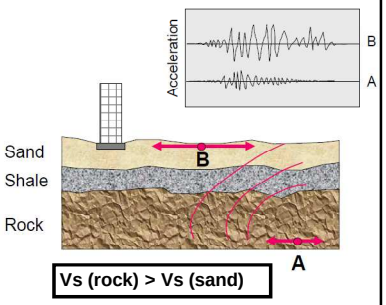
Section S_3-N_3

Section W_4-E_4

Soft ground effect

Soil profile acts as filter

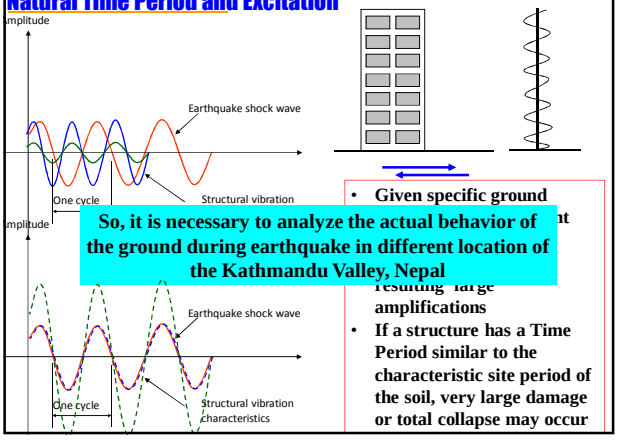
- Change in frequency content of motion
- Amplification or de-amplification of ground motions can occur
- Duration of motion is increased



Vs (rock) > Vs (sand)

The soil profile acts as filter modifying the amplitude and nature of the motions.

Natural Time Period and Excitation

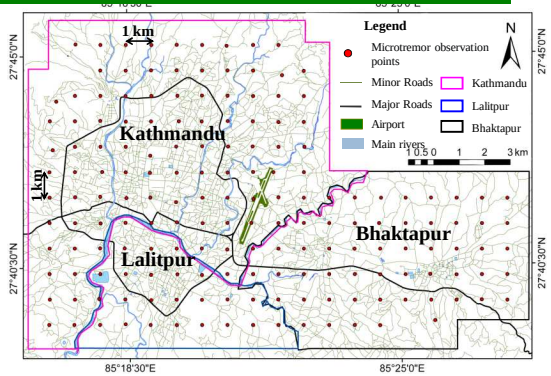


So, it is necessary to analyze the actual behavior of the ground during earthquake in different location of the Kathmandu Valley, Nepal

- Given specific ground [illegible]nt resulting large amplifications
- If a structure has a Time Period similar to the characteristic site period of the soil, very large damage or total collapse may occur

Materials and method

Ground motion (microtremor) observation sites in the Kathmandu Valley



- Actual microtremor observation points in the study area = 172

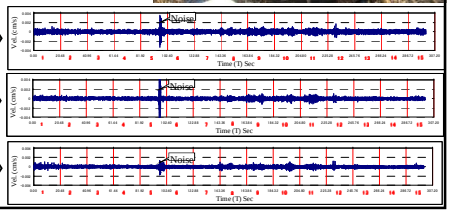
Instrument used in microtremor survey

Three components (EW, NS and UP) of ground motion (velocity) measured at single station

North- South (NS) component data

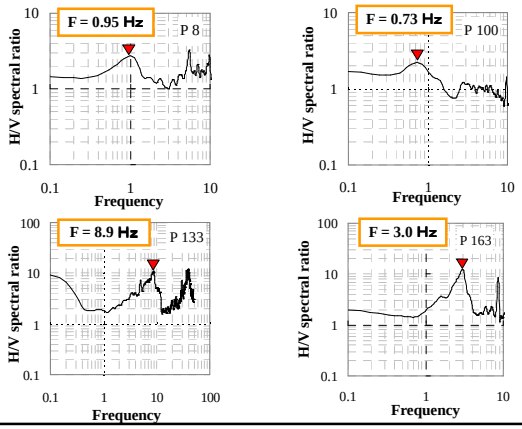
East- West (EW) component data

Vertical (UP) component data



Analysis and result

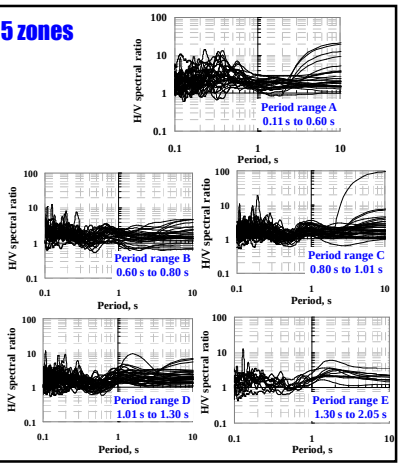
(F – Predominant frequency of the sites)



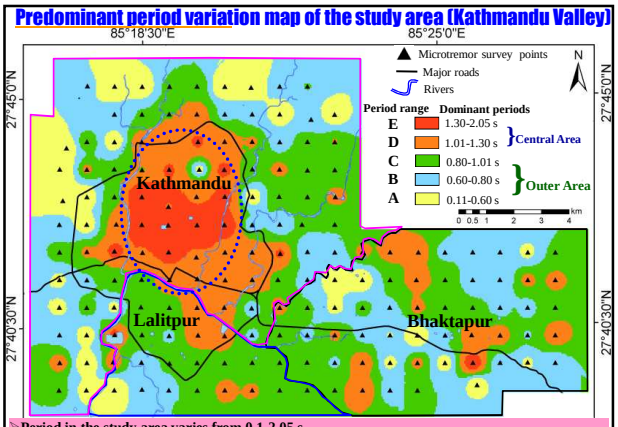
H/V spectral ratio of 5 zones

- Study area is divided into five different range of predominant period using natural break technique which regroups similar values together and represents the distribution properly

Predominant period range	Description of zone
A	0.11 s to 0.60 s
B	0.60 s to 0.80 s
C	0.80 s to 1.01 s
D	1.01 s to 1.30 s
E	1.30 s to 2.05 s

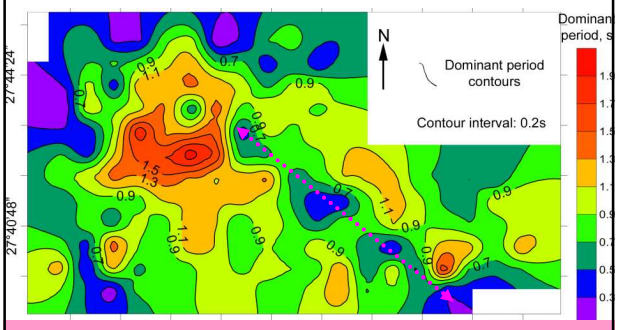


Predominant period variation map of the study area (Kathmandu Valley)



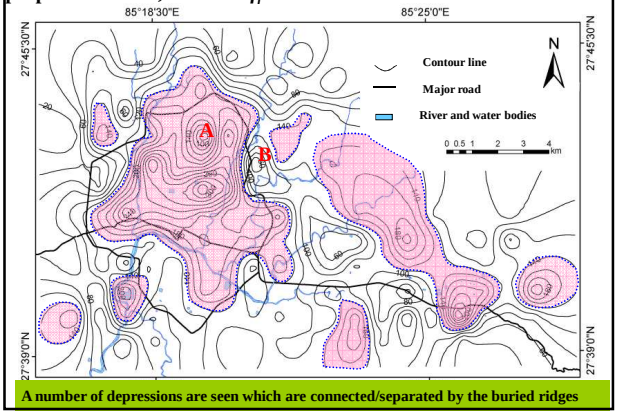
- Period in the study area varies from 0.1-2.05 s
- Period in central part varies from 1-2 s, which covers about 30% of the urban area of the valley

Predominant period contours for the Kathmandu Valley



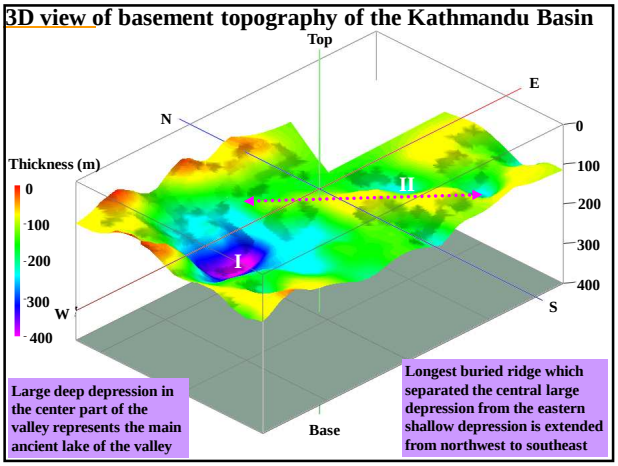
- Higher period range in the eastern and western part of the valley is separated by the long low period line extended from north-west to south-east in the valley
- This also proved the assumption made by the geologist who were working in KV

Basement Contour map for the Kathmandu Basin based on the proposed relation, $D=146.01f_r^{-1.2079}$



A number of depressions are seen which are connected/separated by the buried ridges

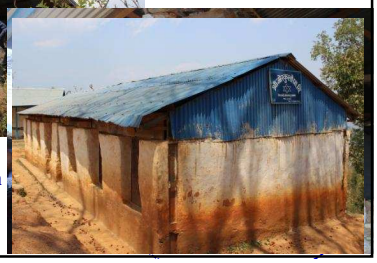
3D view of basement topography of the Kathmandu Basin



Some observation of recent visit in Eastern and Western part of Nepal

Some observation of recent visit in Eastern part of Nepal

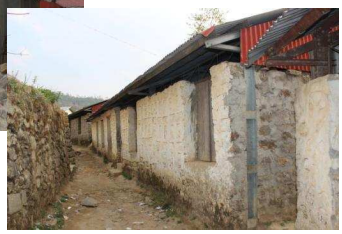
❖ No major problem in design



❖ Problem in construction quality

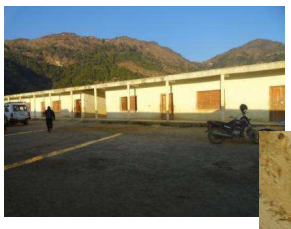
Some observation of recent visit in Eastern part of Nepal

❖ No major problem in design



❖ Problem in construction quality

Some observation of recent visit in Western part of Nepal



❖ Problem in design

❖ Problem in construction quality

Some observation of recent visit in Western part of Nepal

❖ Filling area

❖ Minor in design

❖ Problem in construction

Visit in Sindhupalchkowk District

- Problem in Design
- Problem in construction quality
- Problem in maintenance

DOE Strategy for Improvement of School Physical Facilities in Nepal

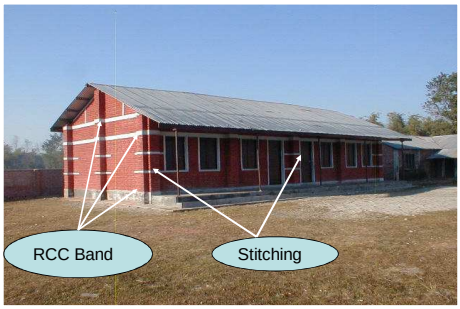
- Decentralization
  - Need identification through community (Bottom up approach)
  - Program implementation through Community
  - Ensures ownership & thereby Ensures sustainability of the created facilities
- Collaboration with I/NGOs
  - Harmonization
  - Quality Supervision
  - Involvement of social mobilizers
  - Better Transparency (Public Audit)
  - Effective in awareness Raising

DOE Strategy on Design & Construction of School Buildings

Basic Principal for Design/Drawing

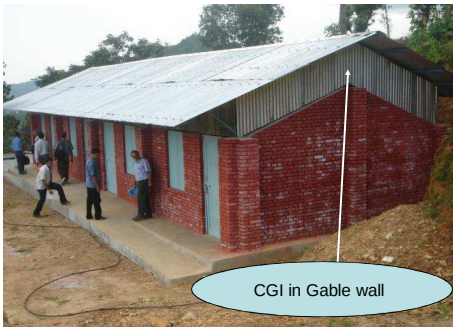
1. Structural Safety of Buildings (Design as per Building Code).
2. Child-friendly and disable friendly design and construction.
3. Environment-friendly design & construction
4. Easy to understand, simple to construction and less maintenance

Example: Type Design Prepared by Department of Education



Load Bearing Wall and Steel Truss

Example: Type Design Prepared by Department of Education



Tubular Steel Frame Structure

Example: Type Design Prepared by Department of Education

Galvanized Lipped Channel Frame Structure

DOE New Strategy

School Earthquake Safety Program (SESP)

- Retrofitting of existing vulnerable school buildings
  - There are large number of school buildings (Approx. 50,000 (?)) need retrofitting program however it require huge resources (Financial and Manpower)

School Earthquake Safety Program (SESP)

NEED for Kathmandu Valley

- Approximately 980 (?) school buildings out of about 1400 buildings of the valley are vulnerable to earthquake
- Approximately 700 buildings need retrofitting and about 280 buildings need dismantling and reconstruction

School Earthquake Safety Program (SESP)

Some of the issues in the current program

Department of Education has started the school retrofitting program since 2010, however there are some issues in the current program

- Risk assessment of the Valley considering the ground response during earthquake
- Need identification (Need to be identified exact school buildings for retrofitting)
- Priority for retrofitting program (Priority identification)
- Cost estimation (norms, code, guidelines etc.)
- Implementation modality
  - Can we maintain quality through cost sharing modality?
  - Do we need to redefine the community participation?

School Earthquake Safety Program (SESP)

Some lessons Learned

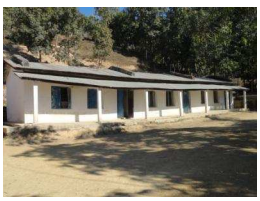
- Present provision of Contribution from School and community (currently 15%) is too high and it should be reduced
- Community awareness is a much needed program to create the demand of retrofitting as well
- Technical capacity of DEOs should be increased by increasing the number of adequately trained qualified professionals
- Supervision technicians shall be trained and existing number shall be increased
- Mason training should make as one of the priority program of the Government
- Multi stakeholder partnership is necessary for successful implementation of the program

THANK YOU

Vulnerability of School Buildings in Nepal

Critical Analysis

- Location problem
  - Donated land
  - Near jungle
  - Near landslide area
  - Top of the hill
  - Near the river and streams
  - Steep slope area
  - Filling area
- Planning & Design
  - Haphazard, without master plan
  - Occupancy change
- Budget
  - Design as per the available budget
  - Lack of priority from government (quantity only)



Vulnerability of School Buildings in Nepal

Critical Analysis

- **Construction quality problem**
  - Without minimum standard/norms
  - Addition as per need
  - Mix construction (behave differently with each other)
  - Mason problem
- **Supervision problem**
  - Supervision from technical manpower
- **Monitoring problem**
  - District level
  - Central level