Post Earthquake Quick Damage Inspection of Buildings in Nepal

Collaborative Research and Development (R&D) Project for Disaster Mitigation in Earthquake Prone Areas in Asia (Sep 27, 2007)

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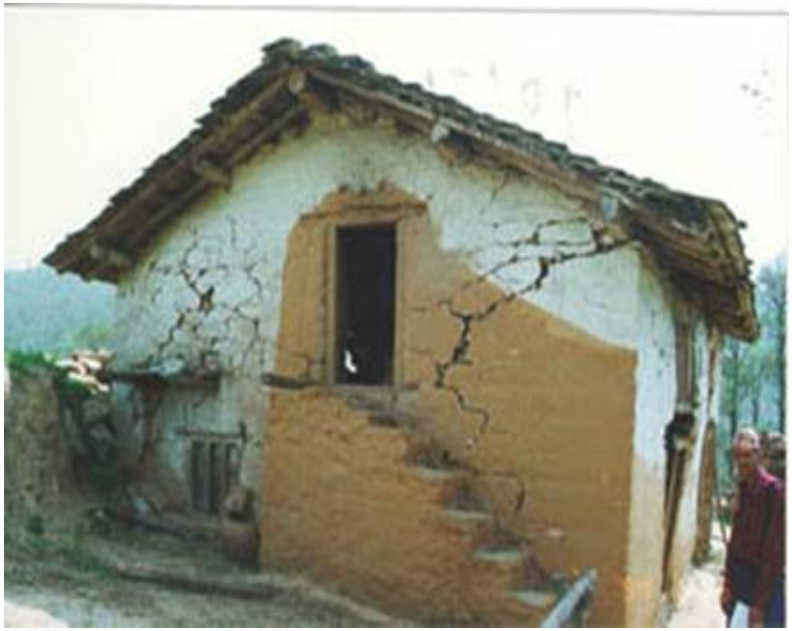
Background of study

Why Quick Damage Inspection of Buildings in Nepal ?

- Nepal is highly earthquake prone country
- A large stock of vulnerable buildings exists in the country (Non engineered masonry and light reinforced RC buildings)
- High risk of building damage even in moderate earthquake – JICA and NSET Study
- In Kathmandu valley only more than 125,000 (50%) buildings can suffer partial or heavy damage in future great earthquake
- Government have no any plan or any system in place to cope with such situations after earthquake disasters .

Background of study

Scenario after earthquake



Is my building safe for reoccupy ?

Is my building safe to enter to get my personnel belongings ?

Background of study

Quick damage inspection of buildings becomes **the first essential action** to be performed by the government to judge the safety of buildings and inform the habitants about the risk of damaged buildings.

This quick damage inspection of buildings helps

- To inform occupants about the safety of building
- To prevent secondary disasters due to aftershocks.
- To make quick action for evacuation and estimation of temporary shelters

Objective of study

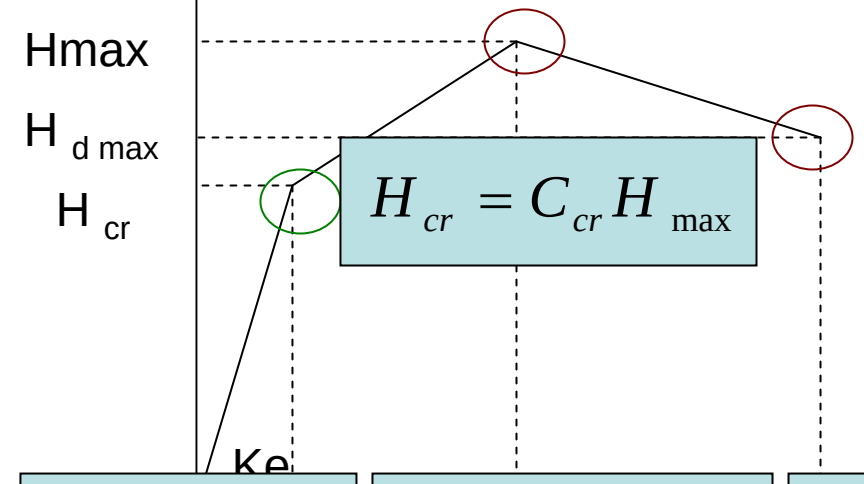
- To develop a methodology for post earthquake quick damage inspection of buildings typology of Nepal (standard inspection form, damage grade classification criteria of individual element and posting placards)

- To propose the formal mechanism for inspection system and a long term plan for capacity building to effectively implement the quick inspection system in Nepal

Resistance envelope of Plain and confined masonry wall

$$H_{s,w} = A_w \frac{f_t}{b}\sqrt{\frac{\sigma_0}{f_t}+1}$$

$$H_{\max} = \frac{f_t A_w}{C_I b}\left[1+\sqrt{\left[1+C_I^2\left(1+\frac{N_w}{A_w f_t}\right)\right]}+n*0.806 d_{rv}^2\sqrt{f_c f_y}\right]$$



$$H_{cr} = C_{cr} H_{\max}$$

$$H_{d_{\max}} = C_{sd} H_{\max}$$

$$d_{cr} = \frac{H_{cr}}{k_e}$$

$$d_{H\max} = \frac{H_{\max}}{0.51Ke}$$

$$d_{\max} = \frac{H_{d\max}}{0.16Ke}$$

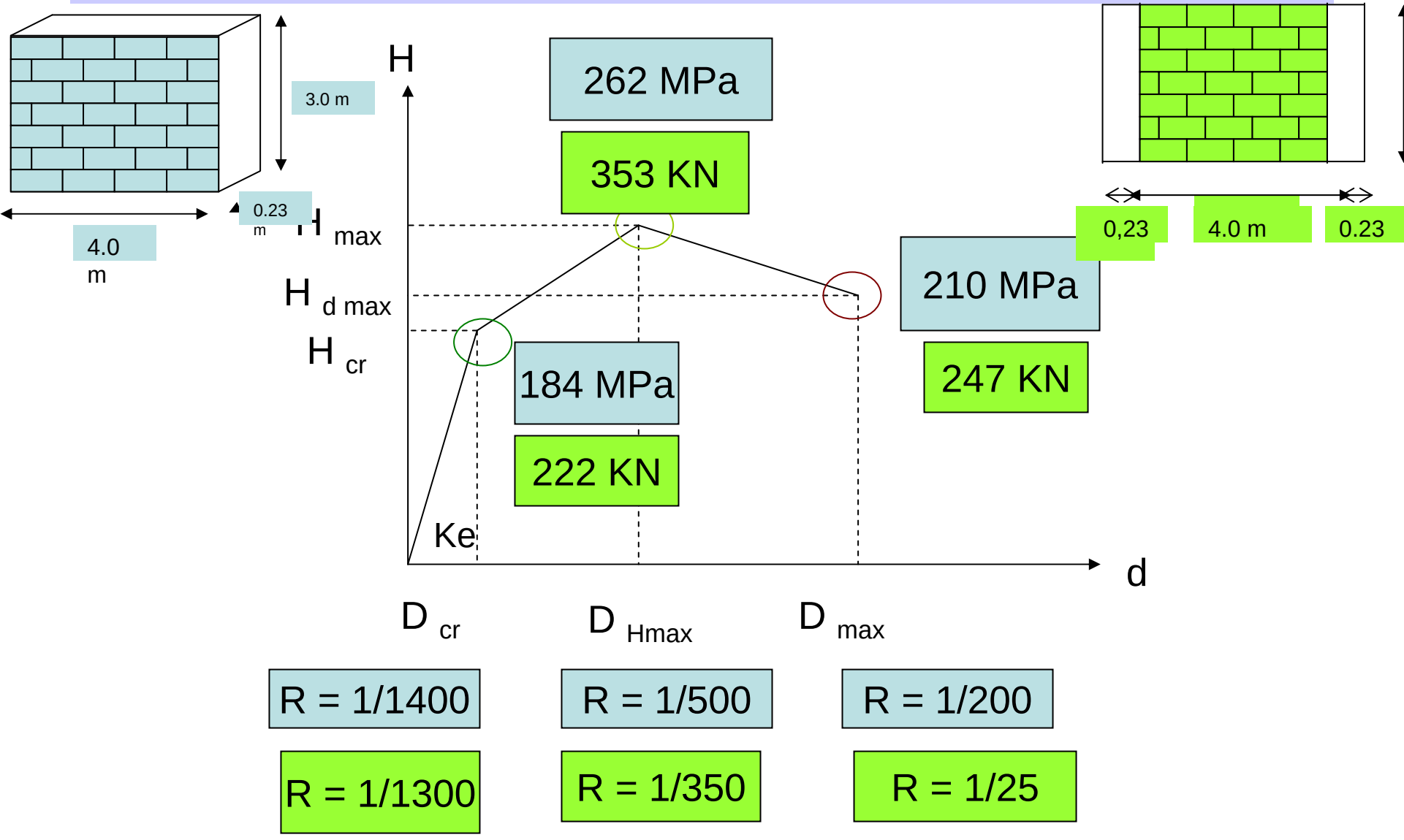
$$d_{cr} = \frac{H_{cr}}{k_e}$$

$$d_{H\max} = \frac{H_{\max}}{0.43Ke}$$

$$d_{\max} = \frac{H_{d\max}}{0.02Ke}$$

Theoretical fundamentals of building damage inspection

Resistance envelop of Typical Plain and confined masonry wall



R = 1/1400 | R = 1/500 | R = 1/200

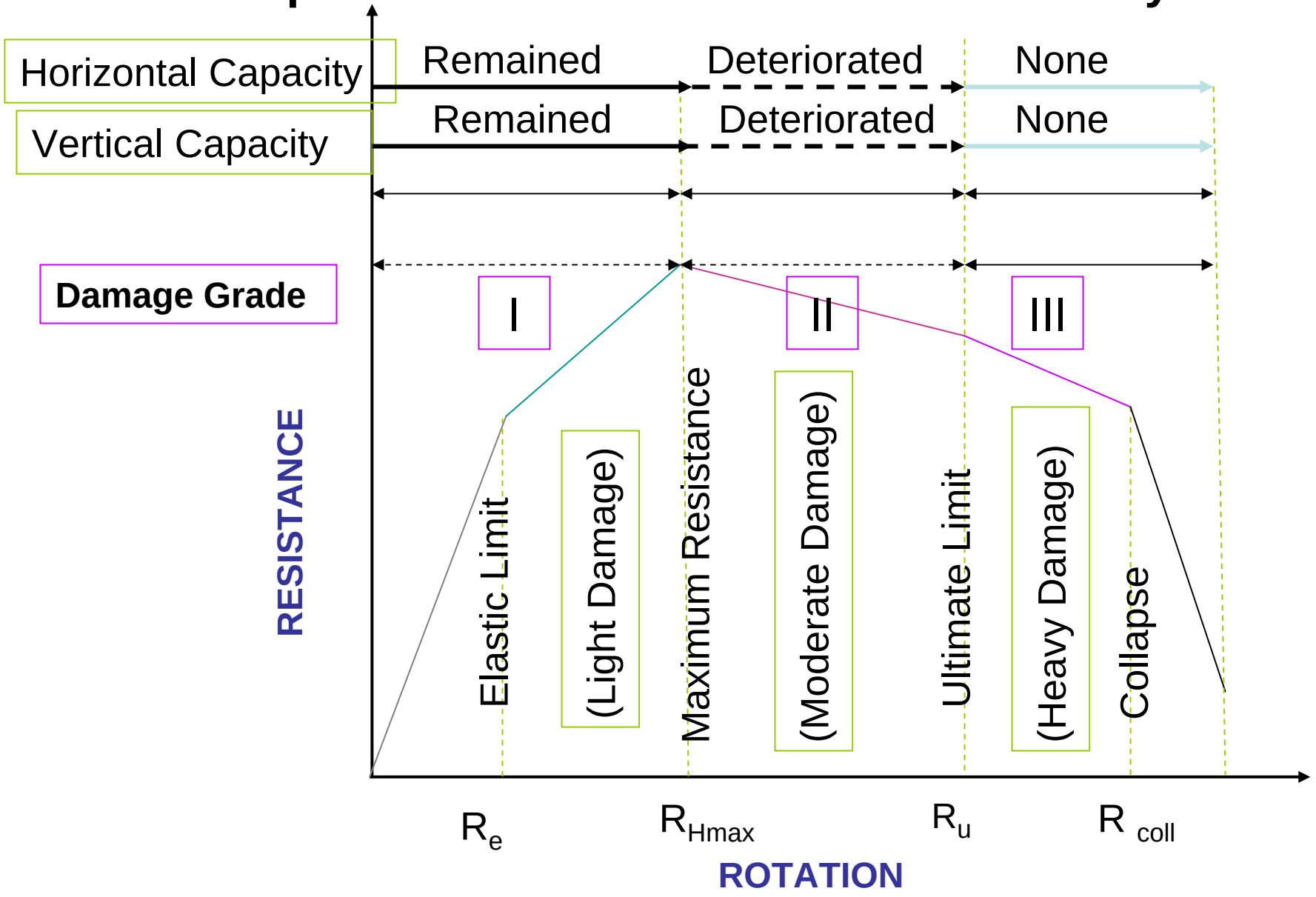
R = 1/1300 | R = 1/350 | R = 1/25

Theoretical fundamentals of building damage inspection

On the basis of above calculation and some experimental results already proposed in M. Tomazevic & I. Kelmenc Paper and Peru papers the following value of angle of rotation (R) for plain and confined masonry wall of Nepal has been proposed in this study

	For plain masonry		For confined masonry	
	Values of R	Proposed value	Values of R	Proposed value
Elastic limit	0.07% to 0.09%	**0.08%**	0.07% to 0.12%	**0.09%**
Max. Resistance	0.20% to 0.26%	**0.25%**	0.30% to 0.83%	**0.50%**
ultimate State	0.46% to 0.66%	**0.50%**	1.61% to 4.17%	**1.5%**

Relationship between lateral resistance and storey rotation



Damage grade classification of individual members (In-plane failure)

Hairlines cracks in the splendor portion of wall - Damage grade I

Diagonal oriented cracks up to the upper portion of solid wall - Damage grade II

Damage grade classification of individual members (in-plane failure)

Heavy diagonal cracks, width > 6 mm passing through masonry units of pier - Damage grade III

Severe cracks in upper wall and significant movement along plane – damage grade III

Damage grade classification of individual members (Out of plane failure)

Moderate vertical crack throughout the height of the wall - Damage grade II

Widened vertical crack throughout the wall and significant splitting of mortar - Damage grade III

Steps of Quick inspection procedure

- ***Step 0 : Description of Inspected Building***
- ***Step 1 : General Inspection of Entire Building***
- ***Step 2 : Structural Safety***
- ***Step 3 : Nonstructural Safety***
- ***Step 4 : Sub-summary***
- ***Step 5 : Summary***

Quick inspection procedure

Step 0 : General Information about inspection and inspected buildings

ID Code : _____Serial No. Number of Inspections : _____
Time and Date of Inspection : __ : __ , Year___ / Mon.__ / Day __
Name of Inspector(s) (Affiliation / ID Number)
_____ (_____ / _____)
_____ (_____ / _____)

Description of Inspected Building

1. Address : _____
2. Contact Person : _____ Tel : _____
3. Building Use :
1. Individual House, 2. Residence with Commercial Use
3. Govermental building ,4. Office, 5.Hospital, 6. Hotel
7. Others (_____)
4. Type of Structure :
[ ] Bricks wall [ ] Hollow concrete blocks [ ] Stone walls
[ ] Others (_____)
5. Number of Stories :
1. One storied 2. Two storied 3. Others ( )
6. Size of building Dimensions of the first floor .....m X....._m

Quick inspection procedure

Step 1 : General inspection of entire building

Inspection 1 : The degree of danger judged from general inspection of the entire Building

If a building is obviously unsafe due to following damage, mark the corresponding reasons, identify the building "Unsafe". Stop the inspection & skip the inspection 2& 3.

[ ] Total or Partial Collapse and fallen floors of the building

[ ] Significant Damage to Superstructure /Remarkable Offset of Superstructure from Foundation

[ ] Significant Inclination of Entire Building or Individual Storey

[ ] Others _____

Quick inspection procedure

Step 2 : Structural Safety

Inspection 2. ***The degree of danger judged from the hazard from adjacent buildings, surrounding ground and structural elements***

	Rank A	Rank B	Rank C
1. Presence of danger caused by damage from adjacent buildings or surrounding ground Failure	[ ] No	[ ]Uncertain	[ ] Yes
2. Settlement of building due to gr. failure	[ ] < 0.2 m	[ ] 0.2-1.0m	[ ] > 1.0m
3a. Inclination of building due to differential settlement (For plain masonry building)	[ ] < 1/400	[ ] 1/400-1/200	[ ] > 1/200
3b. Inclination of building due to differential settlement (For confined masonry building)	[ ] < 1/200	[ ] 1/200-1/65	[ ] > 1/65

Quick inspection procedure

Step 2 : Structural Safety (Continued)

	Rank A	Rank B	Rank C
4.. Damage to load bearing wall *1. Inspect the most seriously damaged storey, sketch building and measure the length of damaged walls of grade III and II and fill up the following 4-a and 4-b*			
4-a. Ratio of damage III [(length of wall of damage grade III / Inspected length)X100] __%	*[ ] < 1 %*	*[ ] 1%-10%*	*[ ] > 10%*
4-b. Ratio of damage II [(length of wall of damage grade II / Inspected length)X100] ___%	*[ ] < 10 %*	*[ ] 10%-20%*	*[ ] > 20%*

Structural safety judgment from 1 to 4	*[ ] Inspected (When all items are given rank A)*	*[ ] Limited entry (When Rank B >= 1 but C = 0)*	*[ ] Unsafe (When Rank C >= 1 or Rank B >= 2)*

Quick inspection procedure

Step 3 : Nonstructural Safety

Inspection 3 : The degree of danger caused by falling and/or overturning of objects

	Rank A	Rank B	Rank C
1. Frame and glass of the window wall	[ ] No damage	[ ] Visible Deformation and/or cracks	[ ] Danger of falling
2. Stairways [ ] Interior [ ] Exterior	[ ] No damage	[ ] Slight damage	[ ] Significant damage
3. Elevated water tank, chimney, signboard, machinery etc.	[ ] No inclination	[ ] Slight inclination	[ ] Danger of falling down
4. Others Hazard( )	[ ] No damage	[ ] Special attention reqd.	[ ] Life threatening

Judgment of the degree of danger of Nonstructural element from 1 to 4.	[ ] INSPECTED (only A and / or B)	[ ] LIMITED ENTRY (C >= 1)

Quick inspection procedure

Step 4 : Sub-summary

1. Check one in inspection 2 and 3, and then choose the highest rating among them as the OVERALL RATING.

	INSPECTED	LIMITED ENTRY	UNSAFE
Inspection 2 (Structural safety)	[ ]	[ ]	[ ]
Inspection 3 (Non structural safety)	[ ]	[ ]	_____
OVERALL RATING. Check the highest rating among Inspections above.	[ ]	[ ]	[ ]

Step 5 : Summary

Overall Rating

INSPECTED *LIMITED ENTRY* *UNSAFE*

Quick inspection procedure

On the basis of above result buildings are posted with one of the following placards

t Tofins Ifit lgl/Ifof kl/0ffd

;/llft

INSPECTED

t Tofins Ifit lgl/Ifof kl/0ffd

l;ldt kj}z

LIMITED ENTRY

t Tofins Ifit lgl/Ifof kl/0ffd

c;/llft

UNSAFE

- ej g leq kj}z ug{c;/llft 5 .
- ej g leq kj}z ug{kj'{ljz]f1sf]; Nnfx j dfl]hd cfjZos dd{ clgjfo{5 .

ej gsf]gfd M-

Vofg lbg'kg]{s/fx? M-

lgl/Ifof g=M-

lgl/Ifof u/]sf]ldlt /;do M-

lgl/Ifssf]; xLM-

lgl/Ifof ug]{lgsfo M-

Red placard posted after Nigaata earthquake (16,July 2007)

Implementation plan for the quick inspections system in Nepal

Plan of inspection practice

1. Decision of quick damage inspection practice

2. Declaration of quick damage inspection practice
Set up quick damage inspection emergency office

District administration office

Chief District Officer

District Natural Disaster Relief Committee

Chief of district natural disaster relief committee

Decision for quick damage inspection practice

Set up

Disaster information

Chief of Municipality/ VDC concerned

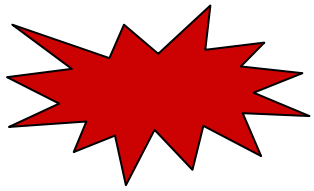
Collect information on disaster

Quick damage inspection emergency office

Nomination of

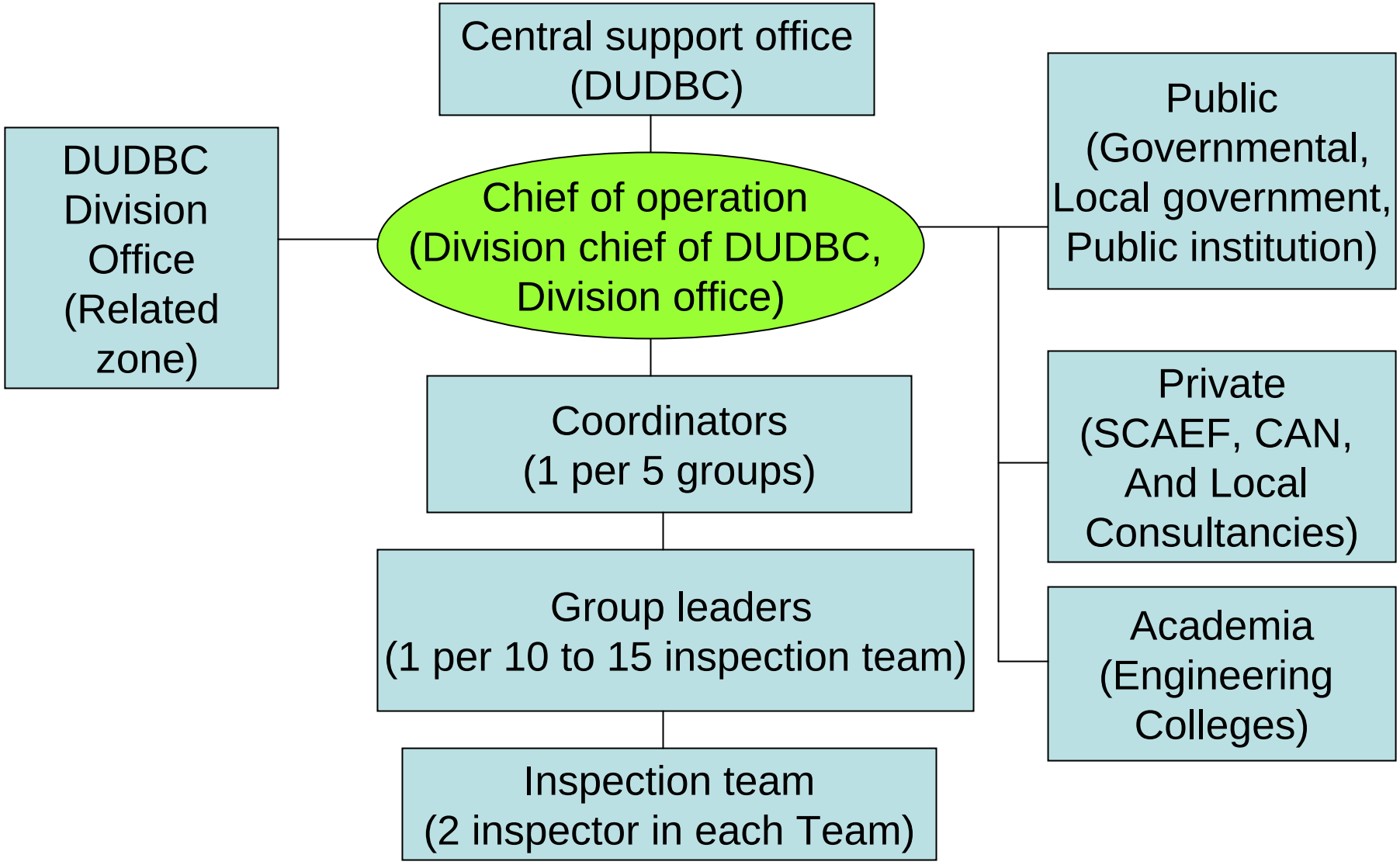
Chief of quick damage inspection emergency office
(Division chief of DUDBC, Division office)

Local governments



Implementation plan for the quick inspections system in Nepal

Organization structure



Conclusions and future research

- The proposed inspection sheet and damage grade classification criteria for damage assessment of buildings will provide uniformity in inspection procedure in Nepal
- The proposed operation plan and organization structure will help to execute the operation quickly in post earthquake phase and to organize in pre earthquake period.
- This study will help as basic tool to develop detail manual.
- The study will be a meaningful step for post earthquake emergency risk mitigation in Nepal
- Damage grades classification criteria and value of R proposed in this study are based on theoretical analysis and judgment, hence it requires further study and research based on field for more accurate value.

Thank You for Your Attention