Appendix 1 Review of Related Policies, Plans, Laws and Organizations

1.1 Review of Related Policies, Plans, Laws and Organizations

1.1.1 Review of Policies and Plans for Urban Development and Disaster Management

(1) National Plan and Policy

Table 1.1.1 summarizes the National plans and policy with its organization. The details are explained below.

Table 1.1.1 Summery of National Plans and Policies

No	National Policy/Plan	Main Organization	Related Organization	Year
1	The Constitution of Nepal	Government of Nepal	All federal level, state level and local level government agencies	2015
2	Thirteenth Three-Year Plan(2013/14-2015/16)	GoN,NPC	Public, Private and Cooperative Sectorial Organizations	2013
3	National Urban Policy (2064)	MoUD, DUDBC	MoFALD, MoPIT, MoLRM, KVDA and otherrelated organizations	2007
4	National Land Use Policy 2069 (revised 2072)	MoLRM	National Land Use Project, MoFSC, MoPIT, MoA, CBS, DoS, MoIr, MoEnv, MoI, MoFALD, MoD	2012 (revision 2015)
5	National Urban Development Strategy	MoUD	NPC, MoF, MoFALD, MoCTCA, MoI, MoLRM, MoPIT, MoSTE, MoFSC, MoEn, MoIC, DUDBC, DWSS and other Urban Development related organizations	2015
6	Post-Earthquake Recovery and Reconstruction Policy	NPC/NRA	Gov't agencies, Donors, NGOs, Cooperatives, Social Organizations & Volunteer groups	2015

*The data needs to be updated.
Source: JICA Project Team

1) The Constitution of Nepal

The constitution of Nepal was passed and promulgated through the Constituent Assembly on 20 September 2015 in order to fulfill the aspirations for sustainable peace, good governance, development and prosperity through a federal, democratic, republican system of governance. The Constitution of Nepal is the fundamental law of Nepal to which any law inconsistent is void to the extent of such inconsistency. Along with the Fundamental Rights and duties, in the constitution of Nepal, directive principles, policies and obligation of the State is clearly mentioned. The following policies have been clearly mentioned which Nepal shall pursue

- **a)** Policies relating to national unity and national security
- **b)** Policies relating to political and governance system of state
- **c)** Policies relating to social and cultural transformation
- **d)** Policies relating to economy, industry and commerce
- **e)** Policies relating to agriculture and land reforms
- **f)** Policies relating to development
- **g)** Policies relating to the protection, promotion and use of natural resources
- **h)** Policies relating to the basic needs of the citizens
- **i)** Policies relating to labor and employment
- **j)** Policies relating to social justice and inclusion
- **k)** Policies relating to the justice and penal system
- **l)** Policies relating to tourism
- **m)** Policies relating to international relations

In order to achieve the goal of the policies, the structure of the Federal Democratic Republic of Nepal has three levels namely the federation, the state and the local level.

Lastly, according to the constitution of Nepal, the matter of urban development and disaster management is the power of Federation, State and Local level as well as concurrent powers of all three levels.

2) Thirteenth Three-Year Plan (2013/14-2015/16) (2013)

Long term vision of the plan is to upgrade Nepal from a least developed country to a developing country by 2022. The Objective is to bring about a positive change in the living standards of the general public by reducing the economic and human poverty prevalent in the nation. The main goal is to decrease the proportion of the population living below the poverty line to 18%. The plan describes additional goals and indicators in detail. The strategies of the plan are to improve key areas in the country that will strengthen the infrastructure, economy, livelihood, and overall circumstances for the population. The developmental planning and the results of the planning are also to fortify the resiliency of the population and reduce risk factors against disasters. Followings are the list of strategies.

1. Achieve inclusive, broad-based and sustainable economic growth by enhancing the contributions of the private, government and cooperative sectors to the development process.
2. Develop physical infrastructure.
3. Enhance access to social services and improve the use and quality of those services.
4. Enhance good governance in the public and other sectors.
5. Empower targeted groups and sectors both socially and economically.
6. Implement development programmes which support climate change adaption.
7. Priorities pursuant to achieving its objective, the plan identifies the following priority areas.
    - Developing hydropower and other energies
    - Increasing the productivity, diversification and commercialization of the agricultural sector
    - Developing the basic education, health, drinking water, and sanitation sectors
    - Promoting good governance
    - Developing roads and other physical infrastructure
    - Developing the tourism, industrial, and trade sectors, and
    - Protecting natural resources and the environment
    - Strengthening Community Level Capacities

3) National Urban Policy 2064 (2007)

The National Urban Policy was formulated for integration of all the issues of urban development and to clarify the role of implementing institution for addressing those issues. The long term goal of the policy is to contribute in poverty alleviation through sustainable urbanization and development. It addresses this through appropriate planning urbanization activities, reversing the deteriorating urban environment, and providing clearer roles of central and local bodies in urban development. The policy identifies several urban issues including unbalanced urban structures, weak Urban-Rural linkage, environment deterioration, urban poverty, weak municipal institutions, lack of clarity in national policies, and so on. The policy clearly states three basic objectives with major policies as following table.

Table 1.1.2 Objectives and Major Policies of National Urban Policy 2064 (2007)

1 Balanced national urban structure	• North-south corridor shall be developed for equal distribution of facilities to all regions • Develop trade linkage between mountain-terai region and boost tourism • Develop inter-linkage of other small urban centre to it and each other through physical facilities • Give priority to large industrial activities in regional urban centre and small and medium industrial activities in medium urban centre, and • Encourage government and private investment for fulfillment of these policies
2 Clean and developed urban environment	• Give priority to conservation of cultural and natural resources; • Give due consideration to urban sanitation and public health; • Minimization of natural disaster; • Encourage and formulate environment friendly vehicles and transportation system • Increase access of low income group to urban infrastructure facilities; and opportunities and management economic activities in unorganized and informal sectors
3 Effective urban management	• Identify concerned agencies and their responsibility by bringing physical development plan preparation, approval and implementation in the legal framework of law. • Strengthen capacity of local body • Separate unit within the central and regional body for physical development planning, approval and implementation;

Source: National Urban Policy 2064 (2007)

The policy states about the conservation of cultural heritages in Kathmandu Valley and its further development as a touristic city, and city endowed with natural environment. It also states about the shifting of activities outside the valley, which do not comply with the above vision (Strategy 3.1.7). In its strategy 3.2.8, it talks about the encouragement to establish well- facilitated compact towns and settlements to preserve from the loss of natural resources by discouraging scattered settlements. The strategy 3.2.9 talks about the establishment of a system, which helps to develop and implement Disaster Management Plan to protect from the probable loss of lives and properties due to disasters. Furthermore, the policy has also proposed various strategies for effective urban management through institutional capacity building, to implement urban plans and programs, to carry integrated urban planning and monitoring, and to develop effective urban management system. Under 24 strategies for achieving target objectives, working policies for each strategy are proposed. Basically in case of urban planning, policy states the formulation of land use plan and guides the development as per the plan. Similarly, the other urban issues like urban economy, urban environment, urban management, urban system, urban form and institutional capacity building etc. are mentioned. In case of Disaster Management, the working policies like development of safe and sustainable building construction system affordable to everyone, prohibition of construction in hazard areas, community mobilization in disaster management etc. are stated. However, the policy is silent on the post-disaster management situation such as urban reconstruction and recovery after a disaster. It also misses the important aspect of creating resilient urban area.

4) National Land Use Policy 2069 (2012) (revised 2015)

National Land Use Policy has a vision for optimum use of the land resource for sustainable development of country through development in social, economic and environmental development. The policy sets the goal for ten years to classify all the land units in Nepal according to topography, capacity, utility and need, and five years' goal for completing the same for municipal area, district headquarters, urbanizing VDCs and land adjacent to major roads. Similarly the policy has a goal for establishing new institutional setup for monitoring, management and regularization of land units according to the abovementioned classification within two years of time.

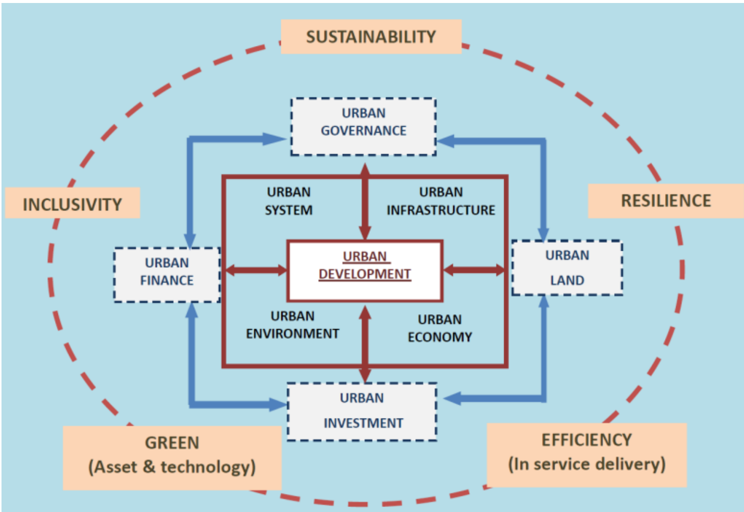
The national land use policy has put forward seven policies such as classification of land according to agricultural areas, residential areas, commercial areas, industrial areas, forest area, public utility area and others. The use of land should strictly follow the land classification system and to restore 40 percent of the total land as forest, the governmental land will be conserved. Government has the power to acquire any land for expansion of infrastructure. In order to limit the fragmentation of land and to promote the coordinated urban development, the land development schemes like land pooling will be implemented. To maintain the balance between development and environment, land in urban areas will be declared as open space and green areas. The environmentally sensitive areas will be identified and conserved. The projects will be launched with due consideration to sustainable development approaches as well as implications to climate change and development of settlement areas in hazard prone areas will be demotivated. The sites related to culturally, historically and religiously important areas and tourism destinations will be conserved and maintained. The hierarchy based land use planning will be implemented in coordination with the land use policy. The land use classification will correspond to the land taxation system and minimum land valuation. The land will be considered for its optimum use and return, and vacant land and barren land will be converted to other uses.

The National Land Use Policy, 2013 A.D. prioritized the protection of arable lands ensuring food security. The devastating earthquake of April 25, 2015 and aftershocks thereto have exposed non-vulnerable secured human settlement in the country. So then, awareness has come that only guided activities are allowed to be operated in such identified areas of natural disasters. In erecting physical infrastructures from now, it is realized that we should take account of the probabilities of newly created hazards among natural disasters–including earthquakes. In order to address all these contemporary issues on a long term basis, the Land Use Policy, 2015 has come into existence upon making a review.

5) Over the Land Use Policy, 2013 A.D. National Urban Development Strategy (NUDS) (2015)

MoUD compiled the National Urban Development Strategy in 2015. The objective of the National Urban Development Strategy (NUDS) is to develop medium and long term strategic visions of a desirable national/regional urban system based on existing trends and regional resource potentialities.

The urban development strategy is guided by five basic principles; “sustainability”, “inclusivity”, “resilience”, “green” and “efficiency”, as shown figure below.



Source: National Urban Development Strategy

Figure 1.1.1 Urban Development Strategies

In the context of disaster management, “4.3.1 Urban Safety and Resilience”, describes the major issues of urban development as follows: 1) Internalization of safety and resilience issues in urban development and management, 2) Building codes not in place or not enforced in all municipalities and 3) Low level of resilience to different types of hazards, 4) Lack of information on climate change in urban areas of different ecological region. Also the NUDA set an Urban Infrastructure Investment Milestone that “100 % municipalities with Disaster Risk Management Plan (DRMP) to increase resilience and preparedness for possible risks”.

Table 1.1.3 Strategy for Assuring Urban Safety and Resilience

Desirable condition	Indicator
Physically, socially, economically, environmentally and culturally safe and resilient urban areas.	Urban areas with operating fire brigade, number and distribution of designated evacuation areas and safe community shelters, water reservoir tank, enforcement of building code,
	Data availability (hydrological data, water source, etc.) and early warning systems in place
	Numbers and distribution of community buildings like hospitals and schools.
	Operating guidelines that guide/prohibit location of settlements
	Monitoring system that checks status of defined indicators.

Strategies	Activities	Lead/Supporting agency
S48. Promote multi-hazard approach in dealing with disasters including climate change	Identify high-risk areas in all urban areas based on available information.	MoUD and Municipalities
	Develop rapid hazard appraisal technique to identify hazards and prepare multi-hazard map of all urban areas.	
	Incorporate disaster risk management component in urban development plans	
	Generate information on climate change in urban areas of different ecological regions	

Source: National Urban Development Strategy

6) Post-Earthquake Recovery and Reconstruction Policy (2015)

In response to the earthquake in April 2015, NPC drafted the Post-Earthquake Recovery and Reconstruction Policy to envisage a guideline for the reconstruction and recovery from the damage from the earthquake.

The objectives and the approaches of the Policy are shown below.

Table 1.1.4 Objectives and strategies of Post-Earthquake Recovery and Reconstruction Policy

Objective 1 Improvement of the existing safe settlements and relocating the dangerous settlements for safety as well as recovery and reconstruction of fully or partially damaged residential homes
Strategy ・ It shall encourage the methods of construction by oneself. ・ It shall make a maximum utilization of local materials and skills ・ There shall be balance between the earthquake resilient construction methods and financial support by the government ・ Uniformity shall be maintained during the deliverance of support to the earthquake affected families ・ Residential homes in urban areas shall be properly managed ・ An extensive public awareness shall be promoted in teaching the methods of constructing earthquake resilient structures. ・ Relocation from the settlement shall be based on the extensive geographical and geological survey and studies. ・ New settlement shall be developed on the basis of land-use planning. ・ Community houses shall be constructed for an emergency purpose in the urban location.
Objective 2

Recovery and reconstruction of social and physical infrastructures, community and government buildings
Strategy ・ There shall be an optimum use of local architecture, construction materials and skills at the central and district level during the reconstruction of government buildings. ・ Safe and multi-storeyed buildings shall be constructed under the concept of integrated administrative building while constructing the government building at urban area. ・ Safety measures shall be adopted with understanding the probable risks of flood and landslides while reconstructing the physical and social infrastructure in earthquake affected areas.
Objective 3 Restoration of historical settlements, renovation of cultural monuments as well as retrofitting and reconstruction
Strategy ・ Renovation and retrofitting shall be the first priority for partially damaged and unsafe historical buildings and structures. ・ International organizations shall be involved to take the recovery and reconstruction initiatives of world heritage sites, but the local means and resources shall only be mobilized to recover and reconstruct such sites. ・ Recovery and revival of old and historical urban areas shall begin by the Building Integration Method.
Objective 4 Protection and uplifting of women and children, marginalized and impoverished populations of the earthquake affected areas
Strategy ・ The health service, employment based skills and training programs shall be implemented based on the willingness and needs of the people to uplift the condition of earthquake affected women, children, marginalized and impoverished people ・ Cooperatives, saving and credit groups shall be mobilized to enhance market access of the goods and services produced by economically weak, marginalized and deprived groups ・ Special attention shall be paid to the issues of social security, basic health, maternal health, child health and adolescent health
Objective 5 Redesign and improve the productive sector to extend economic and livelihood opportunities
Strategy ・ Livelihood opportunities shall be re-established immediately. ・ Financial relief shall be arranged to the cottage industries and small entrepreneurs. ・ Tourism services and facilities shall be re-established

Source: Post-Earthquake Recovery and Reconstruction Policy

The Policy also envisages cross-cutting issues such as DRR, PPP, gender issues, Environment Conservation and Climate Change Adaptation, Publicity and Training on Safe Construction Procedures.

The Policy prescribes the work plan for the reconstruction as of October 16, 2015.

Table 1.1.5 Work Plan of Post-Earthquake Recovery and Reconstruction Policy

	Description	Responsible Agency	Supporting Agency	Date of implementation	Remarks
1	Establishment of Reconstruction Authority	Government of Nepal		2015/8/16	
2	Formulation of Recovery and Reconstruction Policy	NPC	Concerned Ministries	2015/9/17	
3	Approval of Recovery and Reconstruction Policy	Consultation Committee for National Reconstruction		2015/10/2	
4	Formulation of region based plan and programs	Concerned ministries and agencies	NPC	2015/10/17	Formulated programme shall be implemented in 5 years.
5	Approval of plan and program	Reconstruction Authority	NPC	2015/12/1	Approval of 5-year reconstruction plan.
6	Provision of budget for Reconstruction Authority	MOF	Reconstruction Authority	2015/12/8	Provision of Reconstruction Fund
7	Release of budget in district level organizations	Reconstruction Authority	Ministry of Finance	2015/12/30	Release of budget based on the approved annual program
8	Implementation of annual program	Gov't agencies, Donors, NGOs, Cooperatives, Social Organizations & Volunteer groups	Concerned DAO and DDC	2016/5/13	Budget amounts are received on annual basis after the approval of annual programs under the approved five-year reconstruction plan.

Source: Post-Earthquake Recovery and Reconstruction Policy

(2) Plan and Policies for Kathmandu Valley Level

Table 1.1.6 summarizes the policy and policy in Kathmandu Valley with its organization. The details are explained below.

Table 1.1.6 Summery of Plans and Policies in Kathmandu Valley

No	Kathmandu Valley Level Policy/Plan	Main Organization	Related Organization	Year
1	Strategic Development Master Plan 2015-2035	MoUD/KVDA	MoFALD, MoPIT, MoCTCA, MoFALD and municipalities inside KV	Progress
2	Kathmandu Valley Open Spaces Gazette	MoHA	MoLJPA, MoFALD, MoF, MoPIT, MoUD	2013
3	Building By-laws for Construction in Kathmandu Valley	MoUD/KVDA	All Municipalities inside KV	2007
4	Risk Sensitive Land Use Plan	MoUD/KVDA	MoFALD, MoPIT, MoLRM, MoHA, DUDBC, DoR, DoLRM, KUKL, DDC's and municipalities of KV and other related agencies	2015

*The data needs to be updated.
Source: JICA Project Team

1) Past Plans and Policies

Various plans have been formulated at different times for efficient development of Kathmandu Valley with the resources from GoN or with grants and assistance from donor agencies. Some of the plans were implemented and others were not effective on implementation aspect, and some plans still overlap with the jurisdiction of the other plans and policies. In the table below, some extracts of the reviewed plans and policies are described.

Table 1.1.7 Past Plans and Policies of Kathmandu Valley

Physical Development Plan of Kathmandu Valley (1969)	This plan incorporated several aspects of planning such as regional development plan, urban design, settlement development plans and others. The plan envisaged the future development up to 20 and 30 years for balanced development of Kathmandu Valley. The plan raised the critical issues related to continuing population pressure, unplanned urban development, loss of agricultural land and forest and disturbance to the ecology as well as encroachment into historical and cultural sites of the valley. The plan recommended the interventions such as promoting development in west and south west of the existed urban area to ease the population pressure.
Kathmandu Valley Physical Development Plan, 2028 (1972)	Preparation of the plan initiated by the United Nations urban planning expert, it was published by the Department of Housing and Physical Planning. In the Plan strategies and programs were proposed, and it recommended the development of settlement in the plain land area and maintenance of greenery in wetland area as per the geographical structure of the Valley.
Land Use Plan of Kathmandu Valley 2033 (1976)	The Department of Housing and Physical Planning prepared the plan based on the Physical Development Plan 2028 (1972). The plan described not only an extensive land use plan but also building construction standards. KVTDC was established in order to enforce the plan, and the offices of KVTDC were also set up in Kathmandu, Lalitpur and Bhaktapur. For physical development planning it divided the area of Kathmandu Valley into broadly three different categories in which inner core settlement of Kathmandu and Lalitpur, the settlements adjacent to the existing core settlements, and the spread and sparse settlements. However, this was not updated regularly which later made it rather rigid due to rapidly changing ground scenario.
Kathmandu Valley Physical Development Concept 2041 (1984)	The Concept was prepared by the Kathmandu Valley Town Planning Team. The concept attempted to revise the land use plan of 1976. However, it could not be approved by the government
Kathmandu Valley Urban Land Policy Study 2043 (1986)	The Study was carried out with technical assistance of USAID. This Study provided detailed information on matters such as geographical situation, landscape, land use and ownership and also prepared policies on the use of available land for urban development. The designs prepared in the course of study were used for various purposes, but this policy could not be implemented.
Kathmandu Valley Urban Development Plan and Program 2048 (1991)	The plan was prepared by Department of Housing and Urban Development, assisted by ADB. The plan analyzed causes and effects of the urbanization and recommended some of the actions, only few of which were implemented. The plan recommended that Kathmandu Valley should be regarded as the primary administrative, cultural, tourism, ancient monuments conservation center and developed likewise. The plan aimed at densification of Kathmandu and Lalitpur settlement and thereby reducing the urban sprawl and conservation of ecology and agricultural lands in rural part by developing agricultural economy. The plan suggested restricting development in wetland and adjacent to the rivers and conservation of watersheds as wildlife reserve.
Environmental Plan and Management of Kathmandu Valley (1999)	The study dealt with the environmental and ecological issues and sustainable ways for development. The plan identified population growth, loss of agricultural land, location of industries and existing institutional setup as well as weak implementation of plans and policies. The plan recommended wise land use plan; restricting the development in agricultural potential areas, river bank, slope area, environmentally sensitive areas. The plan recommended establishment of Eco-town, merging urbanizing VDCs in the existing municipal areas, improving the road access, developing the master plan for sewerage network, and conserving the entity of traditional settlements.
Long Term Development Concept Plan of Kathmandu Valley (2000)	The Plan was prepared by KVTDC and approved by the government in 2002. This plan envisaged the strategies for development of Kathmandu Valley in 2020 and analyzed the drawbacks of the past plans and policies. The study recommended several strategies for planning Kathmandu with the vision of 2020 such as development initiatives in regional context, development nodes, interrelation of land-use and transportation, efficient land use planning and conservation of agricultural areas, easy transportation based planning, accessibility to public open space, settlement expansion with infrastructural facility and improving the carrying capacity. The plan attempts to deal the scenarios of valley in holistic approach but due to haphazard urban sprawl and political instability of recent past, the 2020 vision seems unattainable and requires major review and updating.

Source: Comprehensive Disaster Risk Management Program, UNDP

2) KVDA Strategic Development Master Plan (SDMP) 2015-2035 (Draft)

KVDA drafted the SDMP and the plan is in the process of obtaining approval from the government as of July 2016. SDMP addresses the needs of a 'new' envisioned KV, considering the existing and emerging trends of urbanization, environment and the current sociopolitical and economical situations.

In the context of disaster management, KVDA developed the Comprehensive Physical Development Plan of Kathmandu Valley which includes following components:

1. Regeneration of Historic Core & Compact Settlement Area
2. Management of Urban Sprawl with the up-gradation and expansion of urban infrastructure
3. Development of New Towns with the provision of new urban infrastructure
4. Preservation of Natural Resources, Cultural and Religious Heritages, Agricultural Land
5. Development of Integrated Urban Services Center
6. Environmental Protection and Management
7. Management of Open Spaces, Parks, Barren Land
8. River Basin Protection and Management
9. Disaster Risk Reduction and Management
10. Public Private Partnership in Infrastructure Development and Management
11. Promotion and Utilization of Renewable Energy

3) Kathmandu Valley Open Spaces Gazette (2013)

MoHA with International Organization for Migration (IOM) as co-lead of the Camp Coordination and Camp Management (CCCM) cluster, identified 83 Open Spaces within Kathmandu Valley used for humanitarian purposes in the event an earthquake occurred. They were published in the Government of Nepal Gazette detailing the location and suggested usage, however the site allocation is yet to be approved by the MoHA.

Table 1.1.8 Type of 83 Open Spaces

Suggested Usage	No. of OS	Total Area (m^2)	Ave. Area (m^2)
Multiple Use Area* Note: Some of the Multiple Use Areas include the following functions; Humanitarian Camp, Potable Water Source, Warehousing, Military Installation, Civil-mil coordination center, Dead body management/morgue, telecommunication, Helipad, and Assembly point for dispatched.	19	3,257,000	171,000
Camp / Settlement	26	1,406,000	54,000
Vulnerable Population Assistance Area	2	127,000	64,000
Logistics Hub	5	318,000	64,000
Medical Assistance Area	7	67,000	9,500
Humanitarian Coordination Area	10	192,000	19,000
Debris Collection	6	806,000	134,000
Distribution Area	8	50,000	6,300
TOTAL	83	6,223,000	75,000

Source: Kathmandu Valley Open Spaces Report

4) Building By-laws for Construction in Kathmandu Valley (2007)

With the enactment of Kathmandu Valley Town Development Act of 1976, a building construction bylaws was formulated and implemented to safeguard life, health and public welfare. It was a framework containing minimum standards and requirements to regulate and control the construction of new buildings in the Valley. The building by-laws was updated in 1993 and in 2007.

The building construction bylaws cover the rules and regulations on building construction in the following cities, municipalities and VDCs at that time: KMC, Lalitpur Sub-Metropolitan City, Bhaktapur Municipality, Madhyapur Thimi Municipality, Kirtipur Municipality, and adjoining VDCs.

In the by-laws, the following categories of zones are classified. Some of the rural areas are not designated any zones.

Table 1.1.9 Zoning Categories

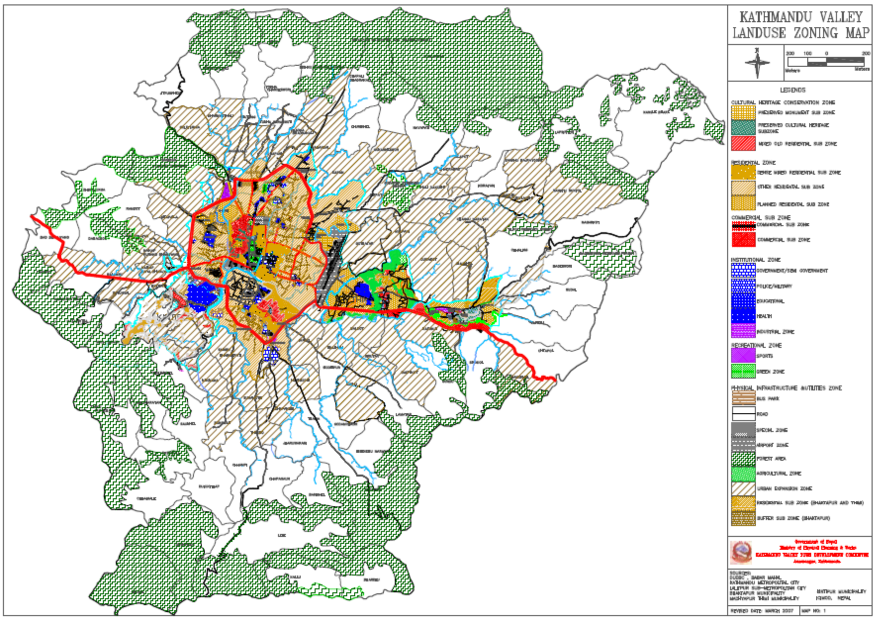
	Zone	Subzone
Kathmandu Metropolitan City. Lalitpur Sub Metropolitan City, Municipalities except for Bhaktapur and Madhyapur Thimi, and VDC's	Cultural heritage conservation zone	Preserved Monument subzone
		Preserved cultural heritage subzone
		Mixed old residential subzone
	Residential zone	Commercial subzone
		Dense mixed residential subzone
		Other residential subzone
		Urban expansion zone
		Planned Residential Subzone
	Institutional zone	Government/Semi government Subzone
		Health Service Subzone
		Educational Subzone
		Police and Army Subzone
	Preserved Zone	Green Open Subzone
		Forest and Park Subzone
		Cultural, Archaeological and Religious Sub-Zone
	Sports Zone, Surface Vehicle Zone, Airport zone	
	Industrial zone	
	Regulations for Narayanhiti Durbar Area (NDA)	
	Construction at the River Banks	
	Apartment Buildings	

	Zone	Subzone
Madhyapur Thimi Municipality	Traditional Residential Zone	
	Institutional Zone	
	Developing Zone	Residential Sub Zone
		Commercial Sub Zone
		Industrial Sub Zone
		Special Planning Sub Zone
	Reserved Zone	
	Green Zone	River Bank Sub Zone
		Forest Sub Zone
Bhaktapur Municipality	Traditional Cultural Residential Zone *Special provision for construction of Government and Semi-governmental Buildings in Traditional Cultural Residential Zone	Preserved Monument Subzone
		Preserved Cultural Heritage Subzone
		Buffer sub Zone
	Developing Zone *Special provision for construction of Government and Semi-governmental Buildings in Developing Zone	Residential Subzone
		Special Planning Subzone
		Industrial Subzone
		Commercial Sub Zone
	Green Zone	River Bank Sub Zone
		Forest Sub Zone
Other Regulations related to Building Construction; Regulations/byelaw for Pashupati Area, Regulations and distance for Electricity and Electric lines, Regulations/byelaws for Fuel Station of Nepal Oil Corporation, Regulations for Cinema Hall, and Regulations/byelaws for Apartment, Group and planned residential houses		

Source: Building By-laws for Construction in Kathmandu Valley (2007)

Development controls to regulate the areas include the following: maximum ground coverage, maximum floor area ratio, maximum height of the building, maximum number of stories, and setback to adjacent plot as well as widths to road approach.

Municipality approves any building construction as per the zoning plan and the regulations.



Source: Building By-laws for Construction in Kathmandu Valley (2007)

Figure 1.1.2 Kathmandu Valley Land Use Zoning Map

5) Risk Sensitive Land Use Plan (RSLUP) (Draft)

The Risk Sensitive Land Use Plan basically concerns with mainstreaming of the risk reduction strategies and their implementation actions for creating the safe urban society through risk assessment. RSLUP is prepared to guide the bye-laws of the valley and impose the restriction and development based on the outcomes. The basic concept of RSLUP is to prepare the land use map on the basis of multi-hazard assessment. In Nepal, UNDP's Comprehensive Disaster Risk Management Program (CDRMP) is supporting for preparation of RSLUP and capacity development of Nepalese planners to main stream risk sensitive planning.

In 2010, Kathmandu Metropolitan City (KMC) under the support of German Federal Foreign Office (GFFO) prepared the RSULP of KMC with a collaborative undertaking between KMC, the Earthquakes and Megacities Initiative (EMI), the National Society for Earthquake Technology - Nepal (NSET Nepal) and Deutsches Komitee Katastrophenvorsorge (DKKV). Later in 2015, UNDP/CDRMP supported the KVDA to prepare the RSLUP of KV (draft phase until 17th April, 2016). The project's outcome is to prepare the prepare comprehensive RSLUP of KV, development of municipal and VDC level RSLUP of KV, Revise and update existing bye-laws and capacity development of stakeholders on RSLUP and bye-Laws implementation. The vision of RSLUP is "Building Resilient communities through Integrated Development of KV" with the mission 'Fostering Sustainable Land Use Management for Heritage Conservation, Social Inclusion and Ecological Balance'.

The UNDP/CDRMP has prepared the land use map as per the different level of assessment which includes, hazard assessment, vulnerability/ risk assessment, evaluation of emergency management system, stakeholders consultation. Under the basis of prepared RSLUP, the bye-laws are updated with building code compliance. It also recommends the institutional setup, roles and responsibilities of different stakeholders for preforming monitoring and evaluation of the RSLUP application. Moreover, the CDRMP in course of preparing RSLUP have organized series of training and capacity building programs to planners, architects and engineers to familiarize with the concept of RSLUP and its implications. The plan is still in Draft Phase and with the approval from KVDA under cabinet decision, the plan will get legal mandate.

(3) District Level

As prescribed in the Local Self-governance Act, each district shall formulate annual and periodic development plans for the development of its district. The items to be included in the Participatory District Development Programme (PDDP) are as follows:

1. Geographical, economic and natural heritages of the District and present uses.
2. Possibilities of production in various sectors on account of comparative cost benefit.
3. Areas comprising backward castes, tribes and poorer people, and, various development works done or required to be done in such areas.
4. Income-generating and skills-oriented development works for the women and children.
5. Description of the projects completed under various sectors and provision for the operation and maintenance of them.
6. Various sectoral short-term and long-term development works on the basis of development possibility.
7. Plans on human resource development in various sectors to be formulated by the local people themselves.

(4) Plan and Policies related to Disaster Management

Table 1.1.10 summarizes the plans and policy especially related to Disaster Management with its organization. The details are explained below.

Table 1.1.10 Summery of Plans and Policies Related to Disaster Management

No	Policy/Plan Related to Disaster Management	Main Organization	Related Organization	Year
1	National Strategy for Disaster Risk Management	GoN	Related Ministries, Security agencies, District level and Municipal level agencies	2009
2	Guidance Note for Disaster Preparedness and Response Planning	MoHA	DDRC, District line agencies, national and international humanitarian agencies, local level agencies	2011
3	National Disaster Response Framework	MoHA	Cluster coordination ministries for Health , WASH, shelter, Food etc of GoN and international humanitarian agencies	2013
4	Nepal Inter-Agency Standing Committee (IASC) Contingency Plan "Chapeau"	IASC	Cluster coordination ministries for Health , WASH, shelter, Food etc of GoN and international humanitarian agencies	2013
5	District Disaster Preparedness and Response Planning	DDC	MoFALD	
6	Local Disaster Risk Management Planning	VDC/Municipality	MoFALD	
7	Water Resource Policy	-	-	1993
8	National Shelter Policy	-	-	1996
9	National Water Resource Strategy	-	-	2002
10	National Water Plan	-	-	2005
11	National Agriculture Policy	-	-	2004
12	Water Induced Disaster Management Policy	-	-	2006

*The data needs to be updated.
Source: JICA Project Team

1) National Strategy for Disaster Risk Management (NSDRM) (2009)

The foundation of the National Strategy for Disaster Risk Management (NSDRM), 2009 is based on the Hyogo Framework for Action. The document is recognized as the road map for the Ministries during the different disaster phases to prepare and mainstream disaster risk management in their policies and plans. The policy framework, legal provisions, and institutional structures adopted by the government are analyzed from a disaster management perspective.

The Long-term Mission of Strategy is to provide guidance and ensure effective disaster management through development, implementation, and effective preparedness for mitigation, disaster risk reduction and occurrence of disasters. The strategy identifies the following sub-categories or sub-missions to help achieve the long-term mission.

1. Develop and restructure institutional structures
2. Strengthen policy-wide and legal arrangements to ensure stakeholders' participation while adhering to an integrated policy and the decentralized implementation process

3. Create an environment which allows the central to household level along with the State to prepare and apply disaster risk reduction and preparedness plans
4. Mainstream disaster reduction into an overall development process together with sectoral development and poverty reduction plans

Five priority actions and associated activities are outlined in the plan.

1. Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation
2. Identify, assess and monitor disaster risks and strengthen an early warning system
3. Improve knowledge management to build a culture of Safety and Resilience
4. Reduce the underlying risk factors
5. Enhance preparedness for effective response. Sector activities are focused on to support the five priorities and disaster preparedness, mitigation and response.

The strategy further describes the challenges of the various hazards, roles of ministries and departments, sectorial strategies, the legal framework and formation of organizations in the national, regional, district and local levels. The document endorses the cluster approach and the defined roles and responsibilities of the government and supporting humanitarian actors.

2) Guidance Note for Disaster Preparedness and Response Planning (2011)

MOHA spearheaded the planning for disaster preparedness and response guidelines. Government and United Nation agencies together with national and international organizations supported the effort. The CNDRC approved the guidelines in 2011 and the document is considered a milestone for organizing effective disaster preparedness and response planning at the District, Regional, and National levels of government. Direct results have shown that 70+ Districts have completed preparing the disaster preparedness and response planning.

3) National Disaster Response Framework (NDRF) (2013)

MoHA with technical support from UNDP developed NDRF 2013. The purpose of this framework is to guide more effective and coordinated national response in case of a large scale disaster. The scope of this framework includes actions taken immediately before, during and after the disasters, or directly to save lives and property, to maintain law and order, to take care of sick, injured and vulnerable people, and provide essential services and protect the public property. And the scope is limited to the response preparedness and emergency response at national, regional, district and local level.

NDRF explains the disaster response in the National System, the International Assistance process, the coordination structure between National and International Assistance. It includes standard disaster response activities with a time line, operational activities and the responsible lead agency, cluster coordination structure, coordination mechanism with National Emergency Operation Centre (NEOC). Future Courses of Actions on Emergency Response Preparedness with related agencies and a time frame is also described.

4) Nepal Inter-Agency Standing Committee (IASC) Contingency Plan "Chapeau" (2013)

Nepal IASC Contingency Plan 2013 (draft) consists of: 1) Hazard and Risk Analysis, 2) Scenarios, 3) Objectives and Strategies, 4) Overall Management and Coordination Arrangements, 5) Cluster Response Plans, 6) Key Common Services (Security, Media Relations, Information, and Public Information, and Donor Relations and Resource Mobilization), 7) Preparedness Actions, and 8) Multi-cluster Initial Rapid Assessment (MIRA). The objective of the Plan is to ensure a coordinated response of the Nepal IASC in an emergency to provide timely and effective humanitarian assistance to the people and facilitates preparedness, response, mitigation, and rehabilitation.

The Hazard and Risk Analysis capture the statistics of the ten most lethal hazards from epidemics, landslides, flood, fire, earthquake, thunderstorms, structural collapse, cold wave, boat capsizes, and avalanche from 1971-2008.

Two major disaster scenarios are explained in the plan. The first scenario is a major earthquake centred in Kathmandu with a Magnitude 8 on the Richter scale. The magnitude of the damage requires a regional response which delays and complicates assistance in the hilly and mountainous areas with most roads, bridges and airfields blocked by landslides. Loss of life in the scenario from a strong earthquake in Kathmandu has been estimated at 44,000 fatalities and 103,000 injury cases with displacement figures of 900,000.

The second scenario describes a flood scenario in the Terai region which is appropriate due to the seemingly annual flooding episodes particularly in the Terai region. The number of displaced households is estimated at 60,000+ which excludes those displaced downstream in India. Infrastructure destruction such as water and sanitation facilities would likely lead to the outbreak of water-borne diseases affecting 35,000 people. Camp management will be required due to displacements lasting over four weeks.

5) District Disaster Preparedness and Response Planning and Local Disaster Risk Management Planning

According to the "Guidelines for Formulation of District Disaster management Plan, 2069 BS" issued by MOFALD, each district led by DDC should develop a District Disaster Management Plan in cooperation with District Natural Calamity Relief Committees. The guideline aims to formulate the local guideline in all districts for preparedness and response.

6) Other Plans and Policies

There are a number of plans and policies directly or indirectly related to disaster management in Nepal as follows.

- Water Resource Policy 1993
- National Shelter Policy 1996
- National Water Resource Strategy 2002
- National Water Plan 2005
- National Agriculture Policy 2004
- Water Induced Disaster Management Policy 2006

1.1.2 Laws and Regulations

(1) Laws and Regulations related to Disaster Management

Table 1.1.11 summarizes the Laws and Regulations related to Disaster Management. The details are explained below.

Table 1.1.11 Laws and Regulations Related to Disaster Management

No	Laws and Regulations	Main Organization	Related Organization	Year
1	Natural Calamity Relief Act	MoHA	All Ministries of GoN and their line agencies	1982
2	Disaster Risk Reduction and Management Act	MoHA	Federal Ministries, Provincial Ministries and local levels related to disaster management and security agencies	2017
3	Soil and Watershed Conservation Act	DoSWC	District level and local level agencies	1982
4	Water Resources Act	GoN	-	1992
5	Environmental Protection Act	MoEnv	-	1997

*The data needs to be updated.
Source: JICA Project Team

1) Natural Calamity Relief Act (NCRA) (1982)

The Natural Calamity Relief Act (also referred to as the Natural Disaster Relief Act) is considered the first well-structured disaster management policy in Nepal. The original act was focused on the response after the earthquake, but current act with amendment in 1989 and 1992 includes comprehensive disaster management for capacity development of preparation and disaster risk reduction. The Act mandates MoHA as the lead agency for immediate rescue and relief work and disaster preparedness activities.

MOHA oversees the overall disaster response activities and coordinates the preparedness and rehabilitation initiatives as deemed by the Work Division Regulation 2064. The Act arranged for the formation of the Central Natural Disaster Relief Committee (CNDRC), the Regional Disaster Relief Committee (RDRC), the District Disaster Relief Committee (DDRC), and the Local Disaster Relief Committee (LDRC). The Act provides Disaster Relief funds for use in disaster response.

2) Disaster Risk Reduction and Management Act (2017)

The Disaster Risk Reduction and Management Act was enacted in 2017 by amending and unifying the existent laws for disaster risk reduction and management for coordination and effective management of all activities of disaster management during natural and artificial disaster for the safeguard of lives of citizens and safety of public and private properties and infrastructures.

At the federal level, the Act prescribes the formation of the National Disaster Risk Reduction and Management Council, headed by the Prime Minister, and its members are mainly composed of Ministers of disaster related agencies. The role of the Council is to develop long-term disaster management policies, programs and approval of disaster management related policies. As implementing body of disaster management related activities, the Act prescribes the Executive Committee headed by the minister of MoHA. The Executive Committee consists of ministers, secretaries of related ministries, secretary level officers of each disaster management related agencies and head of security agencies. The Executive Committee is the focal point of coordination with international support for disaster management as a coordinating body.

The Act also prescribes National Disaster Risk Reduction and Management Authority as the secretariat of the Council and Executive committee for the effective implementation and management of disaster management related activities. The Authority acts as the coordinating body between federation, province and local level for disaster risk reduction and management activities.

At the province level, the Act prescribes provincial disaster management committee headed by the chief minister of each province. The committee is responsible for disaster risk reduction and management activities at provincial level.

At the local level, the Act prescribes District Disaster Management Committee (DDMC) and Local Disaster Management Committee (LDMC). According to the act, DDMC is composed of CDO as the head with members from DCC, the mayor and chairperson from the rural municipality and municipality and head of district level disaster management related organizations. The act prescribes DDMC responsible for disaster risk reduction and management activities at district level.

The Act prescribes Mayor or Chairperson as the head of Local Disaster Management Committee (LDMC) which is responsible for disaster risk reduction and management activities at municipal or rural municipal level.

Not only at the government level, the Act requires public agencies, industrial and commercial entities to be involved in disaster management related activities such as providing local resources, training for employees about disaster management and engages in rescue and relief resource distribution activities

3) Other Laws and Policies

There are a number of acts, rules directly or indirectly related to disaster management in Nepal as follows.

- Soil and Water Conservation Act 1982
- Environmental Protection Act 1996

(2) Laws and Regulations related to Buildings

Table 1.1.12 summarizes the Laws and Regulations related to Buildings. The details are explained below.

Table 1.1.12 Laws and Regulations Related to Buildings

No	Laws and regulations	Main Organization	Related Organization	Year
1	National Building Code	MoUD/DUDBC	MoFALD, Municipalities	2003
2	Building Act	MoPPW	NPC, MoLJPA, MoFALD, DUDBC	1998

*The data needs to be updated.
Source: JICA Project Team

1) National Building Code (1994)

a) Summary

Contents and summary of Nepal National Building Code (NBC) related to seismic code are shown below. NBC is prepared in 1994 and enforced in 2003. Indian Standard (IS) is also possible to apply for seismic design and construction, and is commonly used.

Nepal National Building Code

1 NBC 105 Seismic design of buildings in Nepal
2 NBC 201 Mandatory rules of thumb, Reinforced concrete buildings with masonry infill
3 NBC 202, Mandatory rules of thumb, Load bearing masonry
4 NBC 203, Guidelines for earthquake resistant building construction: Low strength masonry
5 NBC 204, Guidelines for earthquake resistant building construction: Earthen building
6 NBC 205 Mandatory rules of thumb, Reinforced concrete buildings without masonry infill

Note: "Masonry" is masonry structure which support vertical load and horizontal load such as seismic load. "Masonry infill" of "RC structure with masonry infill" supports seismic load but not support vertical load, and this will mean "bearing- brick- wall infill".

Indian Standard (IS)

① Indian Code 1893-1 (2000), Criteria for Earthquake Resistant Design of Structures
② Indian Standard 456, 1978 (2000), Plain and reinforced concrete- Code of practice

Summary of Codes related to Seismic load of NBC and IS are shown below.

b) Nepal Building Code

NBC105 (Extract of the code, and numbering follows the code)

8 Seismic design actions

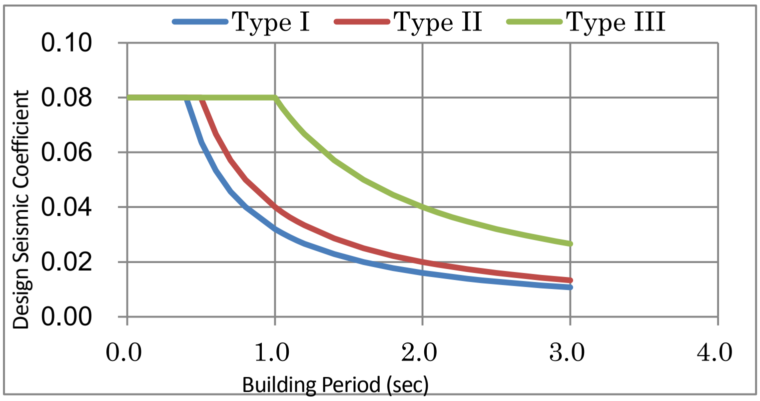
8.1 Design Horizontal Seismic Coefficient (Cd)

$Cd = CZIK$ Where; C = Basic seismic coefficient (Maximum C=0.08 for 0sec<T<1.0sec)

Z= Seismic zoning factor (Z=1.0 in Kathmandu)

I = Importance Factor (I=1.5 for hospitals/schools, I=1.0 for residential)

K= Structural performance factor (K=1.0 for ductile moment-resisting frame, 1(a), K=2.0 for frames as in 1(a) with masonry infill, K=4.0 for others and masonry bearing wall structures.)



Source：NBC 105, Basic seismic coefficient

Figure 1.1.3 Basic seismic coefficient and building period of NBC 105

C） 7.3 Period of vibration

T1= $0.06H^{3/4}$ for concrete frames

T1=0.09H/√D' for other structures (masonry)

4.5 Load combinations for the limit state method

DL+ 1.3LL+1.25E

Example:

3 story RC, H=8.8m, T1=0.06x5.11= 0.31sec.

Cd= *CZIK*= 0.08x1.0x1.0x1.0=0.08 for RC ductile moment resisting frame of residential buildings

= 0.08x1.0x1.5x1.0= 0.12 for RC ductile moment resisting frame of hospitals/schools

Load factor is applied, 1.25xCd= 0.10

1.25xCd=0.15

Basic seismic coefficient 3 storey masonry, H=8.8m, D=15m,T1=0.09x8.8/√15= 0.20sec.

Cd= *CZIK*= 0.08x1.0x1.0x4.0=0.32 for RC ductile moment resisting frame of residential buildings

1.25xCd= 0.40

For example, design base shear coefficient of 3 storey RC and masonry by limit state design method is 0.10 and 0.40 respectively.

Design of member:

IS 456, 1978 (2000), PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE

NBC 201, Reinforced Concrete Buildings with Masonry Infill

Similar sample model of NBC 201 is introduced, which has standard column span of 4.5mx 3.0m. Requirement of providing brick bearing wall for both direction with respect to two cases per unit floor area, (a) $100m^2$, b) $60m^2$).

NBC 205, Reinforced Concrete Buildings without Masonry Infill

Horizontal load carrying capacity of a sample 3 storey building of NBC205 has been studied through push over analysis, using member section of beam and column. The result is introduced later.

NBC 202 Load Bearing Masonry (LBM)

Storey: Up to 3 storey for Brick wall with cement mortar. Up to 2 storey for Stone wall with cement mortar. Up to 2 storey for Stone wall with mud mortar.

Wall thickness: 350mm for Brick wall with cement mortar.

350mm for Load Bearing Brick Masonry in Mud Mortar

Strength of brick: a crushing strength not less than 3.5 N/mm^2

240x 115 x 57 mm with 10 mm thick horizontal and vertical mortar joints

Cement-sand mixes of 1:6 and 1:4

RC bands are provided for reinforcement.

NBC 203, 1994 Low Strength Masonry (LSM)

This is a guideline of design and construction for Low Strength Masonry (LSM), and Techniques are shown to enhance the safety

Storey: Two storey and below

Wall thickness: not less than 300mm

Mud mortar: Component of sand is not more than 30% to expect bond strength.

Storey height is 2m to 3m, and not more than 12 times of wall thickness.

RC bands are provided for reinforcement.

NBC 204 Earthen Buildings (EB)

1. Mud Wall Construction, 2. Rammed Earth Wall Construction, 3. Adobe (Sun-Dried Bricks/Blocks) Wall Construction、Roof and floor are same to NBC 203.

c) Indian Standards

Indian Code 1893-1(2000), Criteria for Earthquake Resistant Design of Structures (Extract of the code, and numbering follows the code)

6.4 Design Spectrum

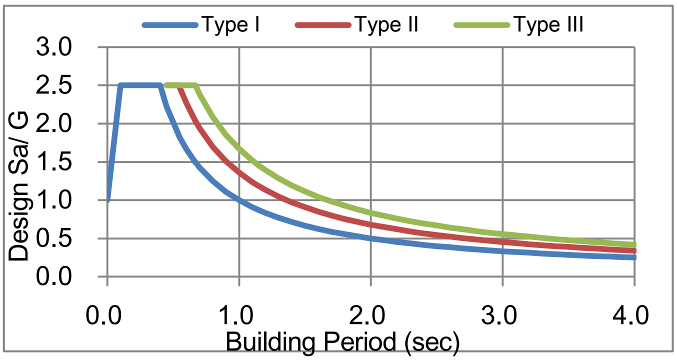
The design horizontal seismic coefficient

$Ah = \frac{Z \cdot I \cdot Sa}{2R \cdot g}$ where, Z: Zone factor, II (Low 0.10), III (Mid 0.15), IV (Severe 0.24), Very Severe 0.36、IV is used in Kathmandu, and for design use is half, 0.36/2=0.18)

I: Importance factor, (1.5 for school and hospital)

R: Response reduction factor

Sa/g: Average response coefficient ≤ 2.5 (0.1sec< *T* < 0.67sec for Type 1 soil)



Source: Indian Code 1893-1(2000)

Figure 1.1.4 Average response coefficient

	Structural type	*R*
i)	Ordinary RC moment-resisting frame	3.0
ii)	Special RC moment-resisting frame	5.0
iii)	Load bearing masonry wall building	
	a) Unreinforced	1.5
	b) Reinforced with horizontal RC bands	2.5

7.6 The approximate fundamental natural period of vibration (*Ta*), in seconds

$Ta = \frac{0.09*h}{\sqrt{d}}$ where, *d:* Base dimension, *h*: height of building

Example:

In Kathmandu, Zone factor, V (very severe 0.36) is used (maximum considerable earthquake (MCE)), and 0.36/2=0.18 is used for design (the factor for design base earthquake (DBE)).

0.18x2.5=0.45 (elastic response base shear coefficient in case of 5% damping).

The design horizontal seismic coefficient, *Ah*

	Structural type	*Ah* for low to mid-rise
i)	Ordinary RC moment-resisting frame	*Ah*= 0.36・I・Sa/(2・R・g) = 0.15・I
ii)	Special RC moment-resisting frame	= 0.09・I
iii)	Load bearing masonry wall building	
	a) Unreinforced	= 0.30・I
	b) Reinforced with horizontal RC bands	= 0.18・I

6.3.1 Load Combinations

Limit state design of RC building

1) 1.5(DL+ IL)

2) 1.2(DL+ZL+EL)

3) 1.5(DL+EL)

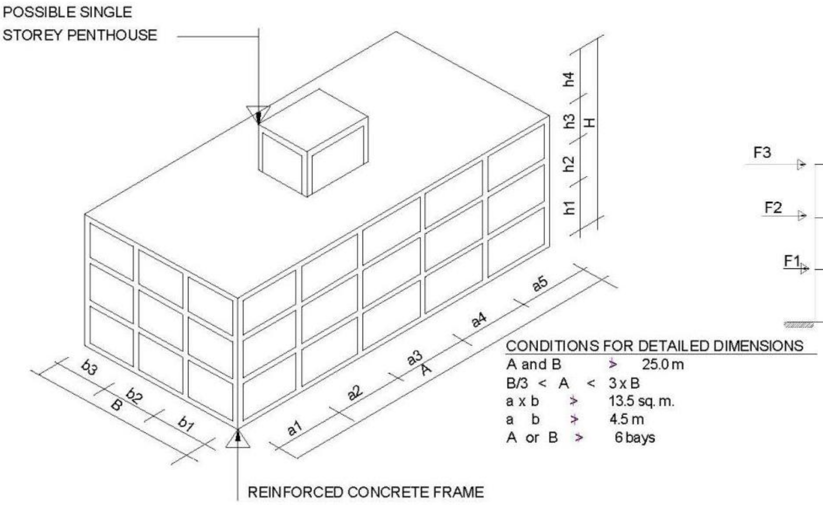
4) 0.9DL+ 1.5EL

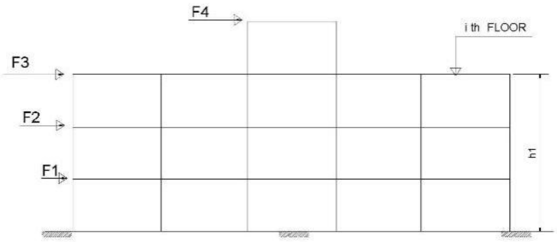
Member design of beam and column; IS 456, 1978 (2000), Plain and reinforced concrete- Code of practice

d) Horizontal load carrying capacity of a sample 3 storey building of NBC205

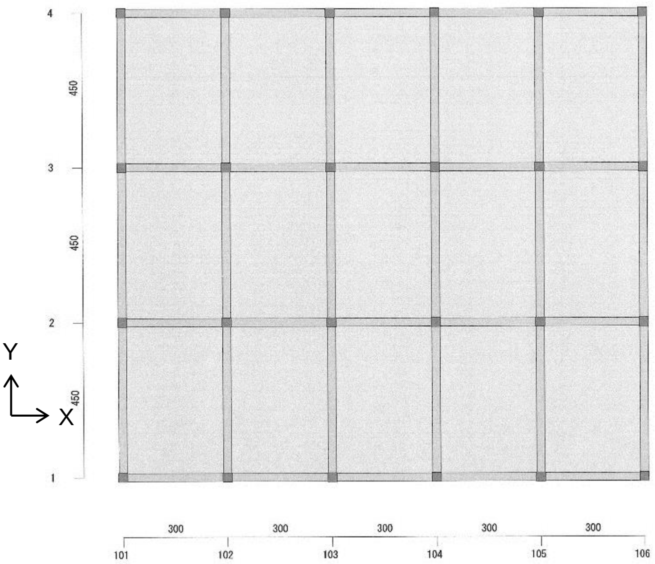
Horizontal load carrying capacity of a sample 3 storey building of NBC205 has been studied through push over analysis, using member section of beam and column.

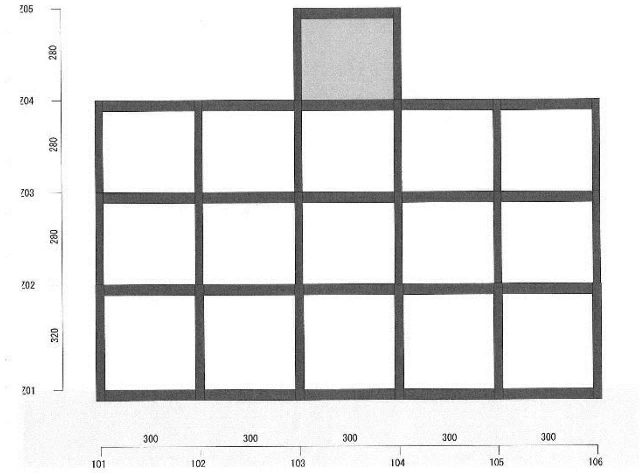
i) General



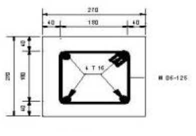


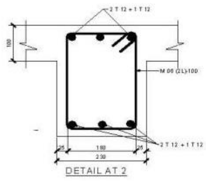
Reinforced Concrete Frame (NBC 205) Floor Level Lateral Forces (NBC 205)





Framing Plan (unit: cm) Framing Elevation (unit: cm)





Concrete: M15N/mm^2 (cube), = Fc13 (cylinder)

Re-bar : fy= 250N/mm^2 is supposed.

Main, 4T16 Tie, T8@100 at end Main, 3T16 Top & bottom

Typical Column Typical Beam Material

(270mmx270mm, L1) (240mmx330mm)

(230mmx230mm, L2 & L3)

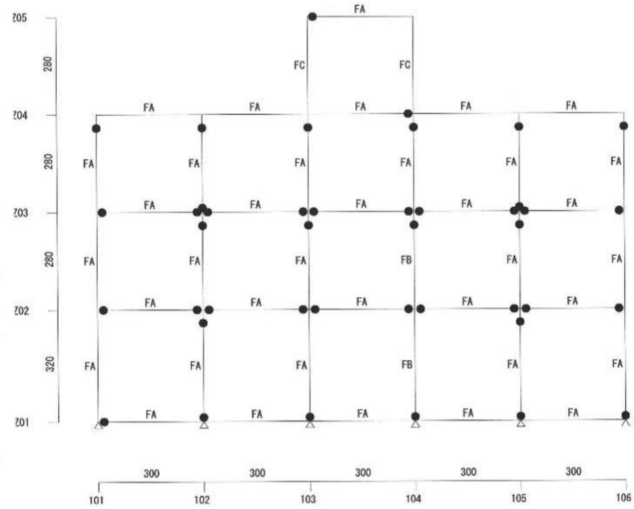
Source : NBC205

Figure 1.1.5 Various factors of a sample building of NBC 205

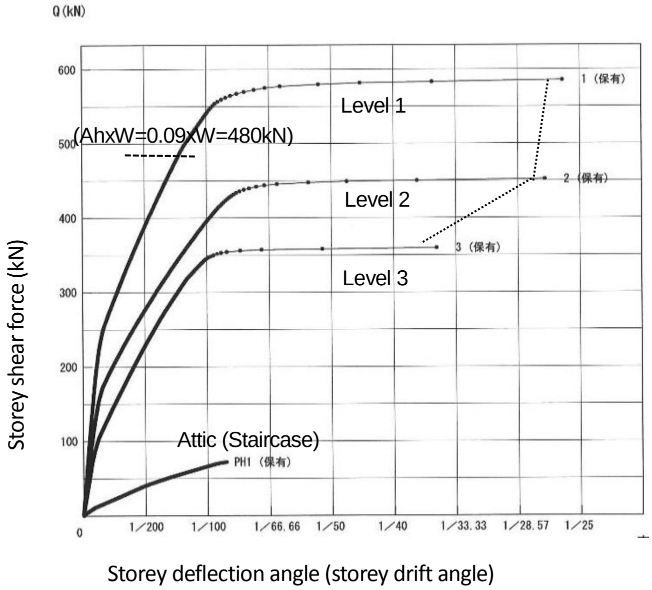
ii) Horizontal load carrying capacity

Push over analysis

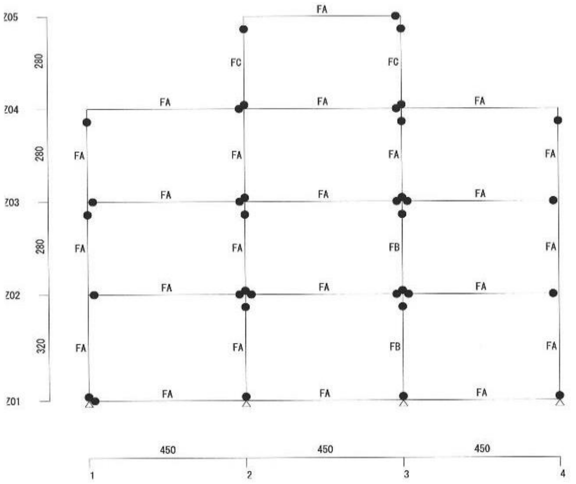
X direction



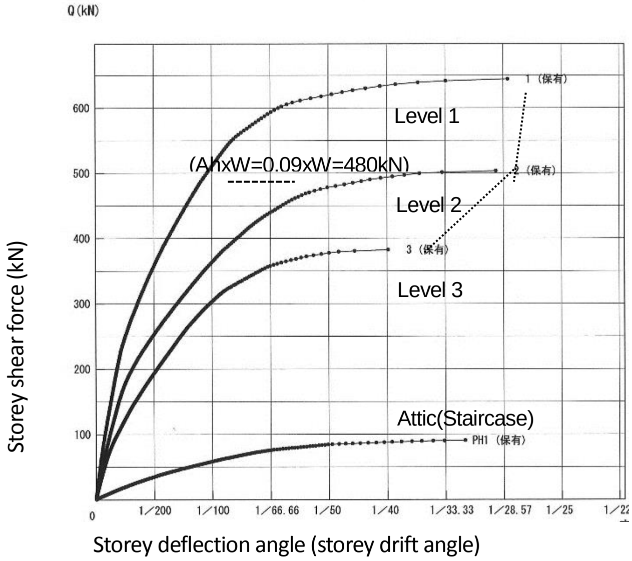
Plastic hinge formation of a frame



Y direction



Plastic hinge formation of a frame



Source: JICA Project Tem

Figure 1.1.6 Plastic hinge formation and storey shear force- storey deflection angle relation

Table 1.1.13 Horizontal load carrying capacity

	Building weight, Wi (kN)	Total ΣWi (kN)	Storey shear force Q (kN), say at storey deflection angle 1/00~ 1/66		Shear coefficient, C=Q/ΣWi		Supposed w= W/ Floor area (kN/m2)
			X	Y	X	Y	
Level 3 + PH	1,479 + 92	1,571	350	360	0.0.223	0.229	7.30 + 6.8
Level 2	1,882	3,453	430	440	0.125	0.127	9.3
Level 1	1,909	5,361	570	590	0.106	0.110	9.4

Source: JICA Project Team

iii) Deformation capacity

It is supposed that conditions of Japanese 2nd stage design can be applied to estimate the deformation capacity. Following 5 items were studied. M15 concrete by cube is converted to Fc13N/mm2 by cylinder.

1. Flexural failure

Shear strength of column/ shear force at flexural strength of column = 100kN/32kN=3.1 > 1.0 (FA)

Shear reinforcement ratio (T8@100 at both end) Pw= 0.372%

2. Column clear height/ column depth (ho/D)

ho/D= (3200mm-330mm)/270mm= 10.9> 2.5 (FA)

3. Axial force ratio (σ o/Fc)

σ o/Fc =335,000N/(270mmx270mmx13N/mm2)= 0.35 ≤ 0.35 (FA)

4. Main re-bar ratio (Pt), (2-D16mm)

2x201mm2/ (270x270) x100= 0.55% ≤ 0.8% (FA)

5. Average shear stress at collapse mechanism/ concrete strength (τ u/Fc)

τ u/Fc =32,000N/(270mmx270mm)/ 13.0N/mm2= 0.034 < 0.1 (FA)

Column is evaluated as grade FA (highest deformation capacity out of 4 grades), coefficient Ds is evaluated as 0.3.

This deflection is roughly 5 times of elastic limit, say 1/100 (storey deflection angle) x 5= 1/20.

iv) Seismic performance

Then seismic performance of a sample building is evaluated as C (shear coefficient)/ Ds,

C/Ds = 0.106~0.114/ 0.3 = 0.353~ 0.38

This value will be compared with elastic response storey shear force coefficient by design seismic load.

Reference

In case Special RC moment-resisting frame, *R* (Response reduction factor) = 5.0 by IC 1893-1

R=5.0 against design base shear, and R' against load carrying capacity is 5.0/(570/ 480) = 4.21, 5.0/(610/480)=3.93

X direction CxR'= 0.106x4.21= 0.446 ⇒ 0.45

Y direction CxR' = 0.114x 3.93=0.448 ⇒ 0.45

This R' is similar concept of Ds (or the reverse of Ds) of Japanese code. 0.45/0.37=1.216 (Roughly 20% conservative side for J. code).

2) Building Act (1999)

The Preamble of this Act provides for disaster-resistant building design and construction standards to make buildings safe from natural disasters like earthquake, fire, floods, among others. Section 4 calls for the formulation and adoption of a building code and implementation of the same with the end in view of improving the quality and safety of each building. Section 8 mandates the categorization of buildings into different classes and the issuance of a building permit prior to construction in the municipal areas.

(3) Laws and Regulations related to Development

Table 1.1.14 summarizes the Laws and Regulations related to development. The details are explained below.

Table 1.1.14 Laws and Regulations Related to Development

No	Laws and Regulations Related to Development	Main Organization	Related Organization	Year
1	Local Administration Act	-	-	1971
2	Kathmandu Valley Development Authority Act	KVDA,KVDTC	Line agencies of ministries having programs inside KV and Municipalities inside KV	1988
3	Town Development Act	GoN	-	1998
4	Local Self Governance Act	GoN	-	1999
5	Local Government Operation Act	GoN	Province, DCC, Rural Municipality and Municipality	2017
6	Ownership of Joint Housing Act (2054)	MoUD	DUDBC	1997 (enacted 2003)
7	Planning Norm and Standard	DUDBC	-	2013
8	Fundamental Bye-law for Settlement Development, Urban Planning and Building	MoUD	OPCM, NPC, MoHA, MoLRM, MoPIT, MoFALD,	2015

Construction (first revision, 2016)	KVDA, DMG, DoS, DoA, DUDBC, local levels

*The data needs to be updated.
Source: JICA Project Team

1) Local Administration Act 1971

The Act designates the Chief District Officer to make an inventory of local, unregistered, open government land and protect the government land from private illegal acquisition. If public lands such as parks, ponds, grass field and others are unlawfully registered, this registration will be cancelled.

2) Kathmandu Valley Development Authority Act (1988)

This Act was approved by the Legislation in 1988 but it was enforced in 2012, when KVTDC was dissolved to form Kathmandu Valley Development Authority (KVDA). This Act concerns the establishment of the Kathmandu Valley Development Authority, whose functions shall pertain to land use planning, the development in land-use areas and the prescription of methods of construction works, the formulation and implementation for the development and maintenance of cultural heritage, the protection and conservation of the environment and natural resources.

The Kathmandu Valley Development Authority has the power to:

- Impose by public notice a ban on any type of physical change in any property within the area prescribed for a period not exceeding three years;
- Stop any action taken without prior approval or in violation of the given terms and conditions;
- Undertake land development programs for planned and organized urban development;
- Mobilize financial resources, upon approval of the Government in order to meet necessary expenses.

3) Town Development Act (1988)

The Act provides the legal basis for town planning to occur in any area designated as a "Town planning area". Town planning is seen as an activity focused on a particular area, to achieve an end result, such as land pooling or guided land development. As such the Act is the means for a Town Development Committee to carry out the function of "town planning" within a designated area. The Act is not designed to support town planning as a process, applicable to a wider area, such as Kathmandu Valley. Act is effective and many municipalities elsewhere established Town Development Committees to tackle urban issues, and third amendment to the Act (Paragraph 3A) enabled municipalities to use the Act providing that activities were approved by the concerned Town Development Committee (or the then Department of Urban Development & Building Construction in the event that there was no committee). Despite the provisions contained in the paragraph 3, "the committee may formulate town planning to carry physical development of a town in an integrated manner, in any part of Nepal, and to determine land uses in a (designated) area", the Act is considered less robust to enable comprehensive land use planning within an entire town or valley.

4) Local Self Governance Act (LSGA) (1999)

The Local Self Governance Act 1999 under MoFALD promotes the concept of local authorities to manage environment-friendly development within the decentralized framework. The Act accentuates the interrelationship between the development process, environment, and disaster and encourages the DDCs, Municipalities, and VDCs to resolve problems through their own action. While the Act empowers local authorities, the associated guidelines and budgetary allocations are lacking.

5) Local Government Operation Act (LGOA) (2017)

The Local Government Operation Act (LGOA) was enacted in 2017 for the institutionalization of the federal democratic republic governance system of Nepal by strengthening local governance system through legislative, executive and judiciary function from the local level. After the restructuration, Nepal is divided into 77 districts and these districts have in total 753 municipalities. Municipalities are further divided into wards. The act prescribes these districts, municipalities and its wards as local level. It elaborates the functions and duties of local level and its relation with provincial and federal government mentioned in the Constitution and also prescribes their additional functions and duties. The act prescribes local level as the lowest unit of elected government with its own governance system and forms the basic unit of decentralized framework.

6) Ownership of Joint Housing Act (1997) (enacted 2003)

This Act is issued to facilitate apartment ownership by making house ownership affordable to citizens through joint partnerships with housing and land developers. As provided in the law, housing companies or developers and land owners may enter into agreements regarding development and ownership of apartments. Approval and permits are obtained from the local government. Ownership cannot be transferred without permission from the joint committee.

7) Planning Norm and Standard (2013)

Planning Norms and Strategy 2013 developed by DUDBC prescribes the standard for securing the Disaster Management Centre in Kathmandu City, whose population is more than 300,000, as a necessary facility.

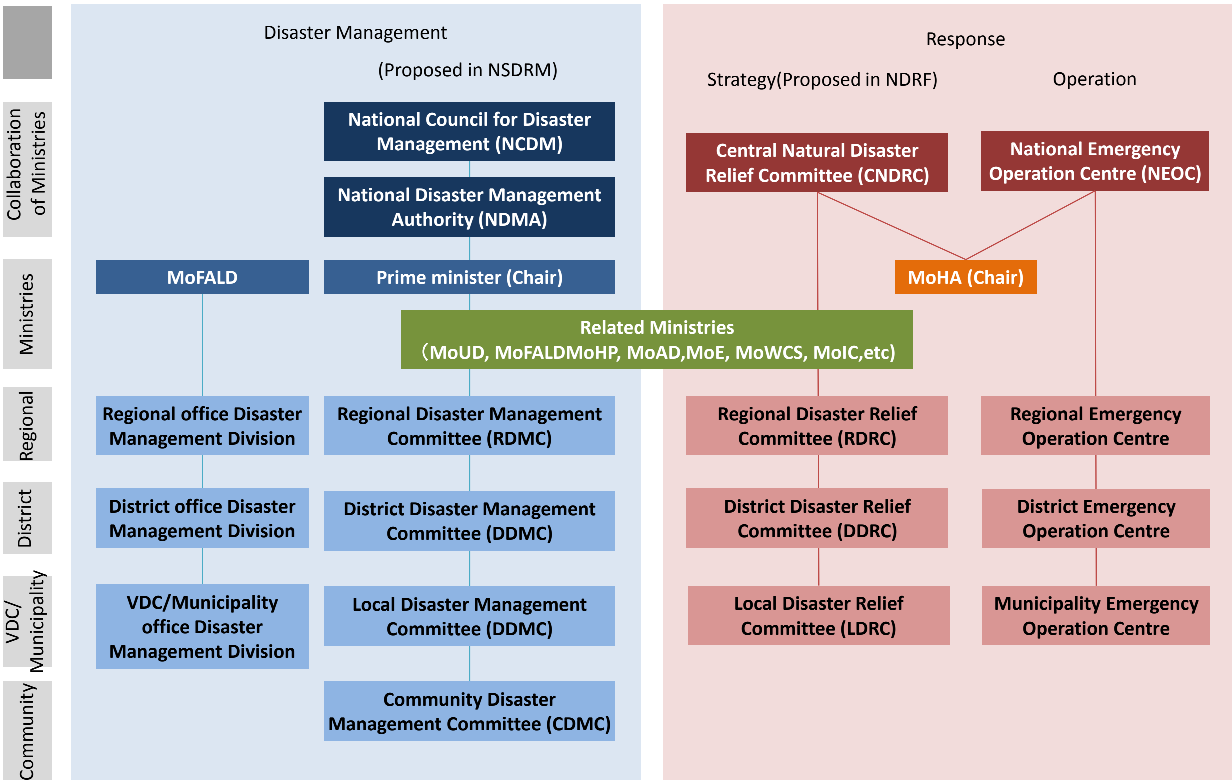
8) Fundamental Bylaws for Settlement Development, Urban Planning and Building Construction (2015) (first revision April 2017)

This fundamental bylaw was formulated by MoUD and officially enacted in September 2015 in order to set minimum standard for building construction as well as to provide a positive direction for the uncontrolled and unsafe settlement development across the nation as part of the lessons learned after the aftermath of the Gorkha Earthquake. This bylaw was formulated in order to set minimum criteria in the local levels for building construction, human resources, regulation for existent buildings, implementation of land use plan, norms and standard for safe settlement development.

This fundamental bylaw was revised in April 2017 (first amendment) to cope up with the restructuration of Nepal as well as adding special provision for construction in heritage settlement.

1.1.3 Related Organizations

The framework of related organizations to Earthquake Disaster management is summarized in following figure.



Source: JICA Project Team

Figure 1.1.7 Framework of related organizations

(1) Organizations related to Disaster Management (Collaboration of Ministries)

1) National Council for Disaster Management (NCDM)

NCDM, which will be chaired by the Prime Minister with approval by the Disaster Management Act, is recognized as the lead national body for disaster management in NSDRM. The Minister of Home Affairs is the Vice-Chair, and Ministers from key ministries such as Communications, Defense, Education, Energy, Environment, Finance, Foreign Affairs, Irrigation, Local Development, Science and Technology, Women and Social Welfare, and representatives from the military, police, and disaster management experts are the council members. The National Disaster Management Authority (NDMA) serves as the Secretariat for the operation of the National Council. Task and responsibilities of the Council includes endorsing and providing DRR related policies and guidelines, and the monitoring of related financial resources.

2) National Disaster Management Authority (NDMA)

NDMA, which will be organized under NCDM, functions as the focal point to execute, facilitate, monitor, and coordinate disaster risk management. NDMA directly coordinates and collaborates with the ministries, departments, district level agencies, and other stakeholders to plan and implement disaster risk management activities. The authority is also responsible for rapid response, quick recovery, reconstruction, and rehabilitation for a disaster event.

3) Central Natural Disaster Relief Committee (CNDRC)

CNDRC, chaired by the Minister of MOHA, includes related ministries including Ministries of Defense, Foreign Affairs, Health and Population, Information and Communication and security agencies, etc. along with voluntary organizations such as NRCS. CNDRC is responsible for preparing national policies on preparedness, response and recovery and ensuring their implementation, stockpiling relief and rescue materials, collecting and disseminating relief materials and fund during emergency, give direction to the district and local committees for the execution of relief work. To support the functioning of CNDRC, there is Sub-committees of Relief and Treatment, and Supply, Shelter and Rehabilitation.

(2) Organizations related to Disaster Management (Role of each Ministry)

1) Office of Prime Minister and Council of Ministers

The Office of Prime Minister and Council of Ministers direct, coordinate, and facilitate the preparation of national policy and strategy for reduction of natural and non-natural disasters. The office operates the Prime Minister’s Relief fund and facilitates the associated rescue, relief, reconstruction, and rehabilitation tasks.

2) National Planning Commission (NPC)

NPC leads the development of long-term, periodic, and annual disaster management plans. NPC is involved with project preparation and execution and the monitoring and evaluation at the policy level.

3) Ministry of Home Affairs (MoHA)

MoHA, which is recognized as a principal responsible agency for implementation of disaster response, work on rescue and relief, data collection and dissemination, and collection and distribution of funds and resources related to disaster management. MoHA fulfills the disaster response role through the placement of a Chief District Officer (CDO) at each of the 75 administrative districts. The Officer is the district administrator who performs as a crisis manager during a disaster.

4) Ministry of Finance (MoF)

MoF is a member of the CNDRC and engaged in disaster response decisions related to financing of disasters.

5) Ministry of Federal Affairs and Local Development (MoFALD)

MoFALD has been leading the mainstreaming of disaster mitigation measures within development activities through DDCs, Municipalities, VDCs and communities.

6) Ministry of Urban Development (MoUD)

MoUD has a mandate to prepare the policy, action plan and programs for urban development, implement the plan, monitor and evaluate, and also to prepare codes and guidelines for technology, research and development about building and other materials. DUDBC under MoUD focuses on enforcement of the NBC in various municipalities to reduce seismic risk.

7) Ministry Of Physical Infrastructure And Transport (MoPIT)

MoPIT conducts hazard risk analysis prior to the implementation of development projects, circulates, and directs seismic resistant building construction guidelines, and steers the people to follow the guidance.

8) Ministry of Education (MoE)

MoE together with Department of Education (DOE) develops curriculum covering disaster, mitigation preparedness, and rescue and relief. MoE has been constructing earthquake resistant school buildings, and providing programs to raise disaster awareness of the teachers and students.

9) Ministry of Health and Population (MoHP)

MoHP trains health personnel in disaster preparedness, arrangements for medicine, equipment, and treatment for the injured in the post-disaster rescue operation.

10) Ministry of Woman, Children and Social Welfare (MoWCSW)

MoWCSW safeguards the rights of vulnerable groups like woman, children, and the elderly.

11) Ministry of Agricultural Development (MoAD)

MoAD prepares and carries out policy to maintain agriculture production through hazard impacts, and treatment and control of livestock epidemics.

12) Ministry of Energy (MoEn)

MoEn is responsible for the use, safety, and promotion of electricity development and other energy sources. The ministry manages the disaster risk by entering into international bilateral and multilateral treatises and agreements using the necessary mechanisms.

13) Ministry of Science, Technology and Environment (MoSTE)

MoSTE is the focal point of the United Nations Environmental Program (UNEP) and develops, implements, and monitors national policies on climate change and meteorology. MoSTE provides seasonal predictions on rainfall and drought which helps to mitigate disasters. Early warning systems operate with information from flood forecasting centers and hydrological measurement centers at river locations.

14) Ministry of Forests and Soil Conservation (MoFSC)

MoFSC mitigates natural disasters through policy formulation on National Forestry Policy and Soil Conservation. The ministry is responsible for hazards control through Environmental Impact Assessment (EIA) of development projects. MoFSC reduces natural disaster risk through environmental conservation, reforestation, and soil conservation work in natural disaster vulnerable areas.

15) Ministry of Industries (MoI)

MoI conducts geo-hazard mapping studies, prepares seismic zone maps, and works to control pollution generated in industrial areas. The industry sector contributes in relief activities.

16) Ministry of Science and Technology (MoST)

MoST develops geographical, social, and environment friendly science and technology.

(3) Organizations related to Disaster Management (Regional Level)

1) Regional Disaster Relief Committee (RDRC)

RDRC is present in all five regions of Nepal and is chaired by the Regional Administrator. It comprises related government agencies and security agencies (law and order, emergency response and development institutions) along with voluntary organizations such as Red Cross. It is responsible for supporting and monitoring the activities implemented by DDRCs and formulates regional and district level disaster management plan.

2) Emergency Operation Centers (EOCs)

EOCs were established by MoHA. National Emergency Operation Center (NEOC) is situated in Kathmandu and there are EOCs in the5 regions, 42 districts, and 5 in the municipalities as of 2015. A durable communications system is installed in all of the EOCs. Standard Operating Procedures (SOPs) for the national and districts EOCs are written and exercises conducted to validate the procedures.

(4) Organizations related to Disaster Management (District Level)

1) District Disaster Relief Committee (DDRC)

All 75 districts of Nepal have DDRC with CDO as its chairperson. It comprises various line agencies such as law and order, emergency response (police and armed police), district chapter of NRCS and critical facilities such as irrigation, road, livestock, health, etc. The role of DDRC is to coordinate the local committees, formulate district disaster management plan, coordinate and operate relief work during emergencies and provide information to RDRC and CNDRC.

2) District Disaster Management Committee (DDMC)

DDMC coordinate between MoFALD and LDMC at district level.

(5) Organizations related to Disaster Management (Municipality and VDC Level)

1) Local Disaster Relief Committee (LDRC)

LDRC is responsible for disaster management at the local level, such as disbursement of funds during emergencies, and rescue and transport of the injured to hospitals.

2) Local Disaster Management Committee (LDMC)

LDMC coordinate among MoFALD, DDMC and LDMC at VDC or municipality level. It implements, monitors, and budgets the disaster risk reduction and management activities.

(6) Organizations related to Disaster Management (Community Level)

1) Community Disaster Management Committee (CDMC)

CDMC conducts CBDRRM activities under ward level.

2) Strengthening Community Level Capacities by MoFALD and NRRC

MOFALD and NRRC developed minimum community resiliency characteristics which support standardized approaches to build community disaster risk reduction capacities. As of January 2015, community capacity has been strengthened in 635+ VDCs and municipalities which represents about one quarter of the population. MOFALD assisted the municipalities by equipping 58 municipalities with fire brigades. The Ministry of Agriculture Development (MOAD) founded crops and livestock insurance.

(7) International Agencies

1) National Risk Reduction Consortium (NRRC)

NRRC is an international consortium which convened in May 2009 to assist the GoN on the National Strategy for Risk Management priorities. The NRRC founding members included the Asian Development Bank (ADB), the International Federation of Red Cross and Red Crescent Societies (IFRC), United Nations Development Programme (UNDP), the Office for the Coordination of Humanitarian Affairs (UNOCHA), the UN International Strategy for Disaster Reduction (UNISDR), and World Bank. The next level of members to join included the United States Agency for International Development (USAID), United Kingdom Department of International Development (DFID), European Commission Humanitarian Aid Office (ECHO), and the Australian Agency for International Development (AusAID).

The consortium proclaimed five flagships areas of focus in Nepal:

1. School and hospital safety (structural and non-structural aspect of creating earthquake resilient schools and hospitals): The flagship area aims to build earthquake resilience of schools and hospitals as a result of retrofitting, training, and increased awareness. The programs include a multi-hazard orientation.
2. Emergency preparedness and response capacity: The flagship area strives to enhance the Government of Nepal's national, regional, and district level response capabilities to include the armed forces and international humanitarian and military assistance integration.
3. Flood management in the Koshi river basin: The flagship area addresses the annual threat of floods and implementing mitigation measures, reducing economic impacts, and better forecasting and warning of the communities.
4. Integrated community based disaster risk reduction/management: The flagship area aims to

leverage community based disaster risk management (CBDRM) activities and experience to build a more consistent, systematic, and unified approach to CBDRM which the VDCs will conduct.

5. Policy/institutional support for disaster risk management: The flagship area realizes the need to enhance the disaster risk management capacity at the central and local of the government. Institutional, legislative and policy frameworks are identified as the essential elements necessary to advance disaster risk management.

2) International Organizations supporting Disaster Management in Nepal

Organization such as : JICA, Asia Disaster Reduction Center (ADRC), Asian Disaster Preparedness Center (ADPC), United Nations Development Program(UNDP), International Center for Integrated Mountain Development (ICIMOD), International Red Cross Society (IRCS), United States Agency for International Development Mission to Nepal (USAIDMN), United Mission to Nepal (UMN), Cooperation for American Relief Everywhere (CARE), OXFAM, Redd Barna, World Food Program (WFP), Save the Children Fund (SCF), Technical Cooperation of the Federal Republic of Germany (GTZ), Lutheran World Service (LWS) etc. Besides, various other institutions and NGO's such as Nepal Red Cross Society (NRCS), Nepal Scout (NS) are providing highly valuable support at the time of natural disasters (Chhetri, 1999). These agencies are supporting for disaster preparedness as well as post disaster relief activities in Kathmandu Valley level as well as nationwide.

(8) Organizations especially related to Reconstruction and Recovery

1) National Reconstruction Authority (NRA)

The Legislature-Parliament endorsed the Reconstruction Authority Bill in December 16, and published it in Nepal Gazette in December 20, 2015 to form An Act to Provide Reconstruction of the Earthquake Affected Structures. The act mandates establishment of National Reconstruction Authority (NRA), the leading agency for the reconstruction of the earthquake-affected structures. The act prescribes that NRA will remain for 5 years and will be updated for one additional year depending on the progress of the reconstruction. The act also prescribes the establishment of National Reconstruction Advisory Council (NRAC) and Steering Committee (SC), both of which are chaired by the Prime Minister and the Executive Committee (EC) to execute the reconstruction works, chaired by the government appointed Executive Officer.

The Major roles and responsibilities of NRA assigned as per the act are as follows:

1) Verify the damage and determine the earthquake affected areas
2) Develop, approve and manage prioritized reconstruction programmes and action plans
3) Develop necessary agencies and supervise reconstruction projects

4) Obtain and allocate land for settlement development, land pooling and resettlement
5) Conduct a technical survey for damaged physical structures, order and instruct the removal of physical structure and reimburse the incurred cost as a loan to the government except for r those individuals under poor economic conditions
6) Responsible for operational and financial arrangement for housing development and settlement issues
7) Coordinate with stakeholders related to reconstruction among GON, donor agencies such as Non-Governmental Organizations (NGOs) and International Non-Governmental Organizations (INGOs), and Civil Society Organization (CSOs) to implement the programmes
8) Capacity building for the stakeholders of reconstruction activities
9) Fiscal arrangement of the programmes and activities for reconstruction
10) Direct civil servants to conduct necessary activities for executing the functions of NRA

The NRAC is developed under NRA and its roles and responsibilities of the council are to advice the SC.

The SC is formulated as the central body of the NRA. Its major roles are to: 1) approve the plan and policies regarding the project prepared by the EC; 2) guide the EC in order to increase the project effectiveness; 3) approve the budget; and 4) approve the organizational structure of the authority.

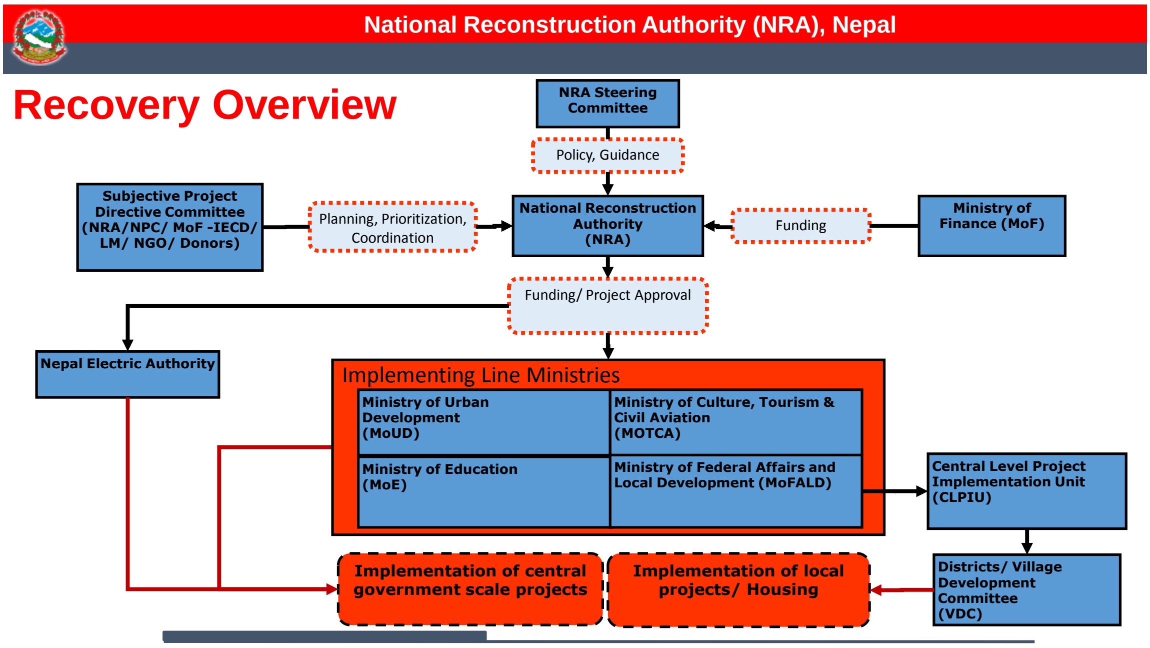
The EC has been formed which consists of a Chief Executive Officer (CEO), a secretary from the prime minister's office, Nepal government officers and secretary. Major roles and responsibilities of the CEO are as follows:

1) Prepare and present the framework relating to Reconstruction Plans and policy of the Authority to the Directive Committee
2) Maintain coordination among different bodies regarding works and their implementation of the Authority
3) Implement the directives and decisions of the Council and the Directive Committee, or get them done
4) Trespass into the land of other or prohibit entry to designated areas for construction work and also remove any obstructions encountered in the course of reconstruction work or developing human settlement
5) Take actions against, even expel, any employees appointed under the Authority failing to deliver the assigned duties and responsibilities
6) Implement other work relating to reconstruction or get them done

NRA is responsible for the approval of the budget in coordination with the Ministry of Foreign Affairs (MOFA) and Ministry of Finance (MOF) and the use of funds is decided by the EC. The available funds for reconstruction from the Earthquake are as follows:

1) Money received from the Government of Nepal
2) Money obtained from the Prime Minister Natural Disaster Relief Fund
3) Money received from any organizations, institutions, or individuals
4) Money received from foreign individuals, governments or international organizations or institutions in cash or kind, or money received from programmes
5) Money received from any other sources

As for the district level, the District Coordination Committee in every district have to coordinate the reconstruction work carried out by the Authority in the earthquake-affected zone. The District Coordination Committee has the lawmakers representing the district in the Legislature-Parliament, the Chief District Officer and the Local Development Officer. The lawmakers representing district in the Legislature-Parliament is the coordinator of the District Coordination Committee.



Source: NRA

Figure 1.1.8 Recovery Overview by NRA

Comments on above chart: The above chart has been prepared by NRA but still the top left box mention about the directive committee. The Advisory council support SC for necessary policy and plan formulation, whereas SC is the central body of NRA which directly assist the EC for execution of activities and works decided by Advisory Council and SC.

Appendix 2 Damage of Gorkha Earthquake

2.1 Outline of Gorkha Earthquake

The Gorkha earthquake occurred just before the commencement of the project, which was the strongest and most catastrophic event in Nepal since the 1934 Nepal-Bihar earthquake and caused severe damage covering a wide area including Kathmandu Valley, the capital area of Nepal. The event not only lead to the modification of the project contents, but also, its characteristics and damage have to be considered in the hazard assessment and risk assessment of the project. The general information and damage information of the quake, related to the contents of the project are summarized hereinafter.

2.1.1 Outline of Gorkha Earthquake

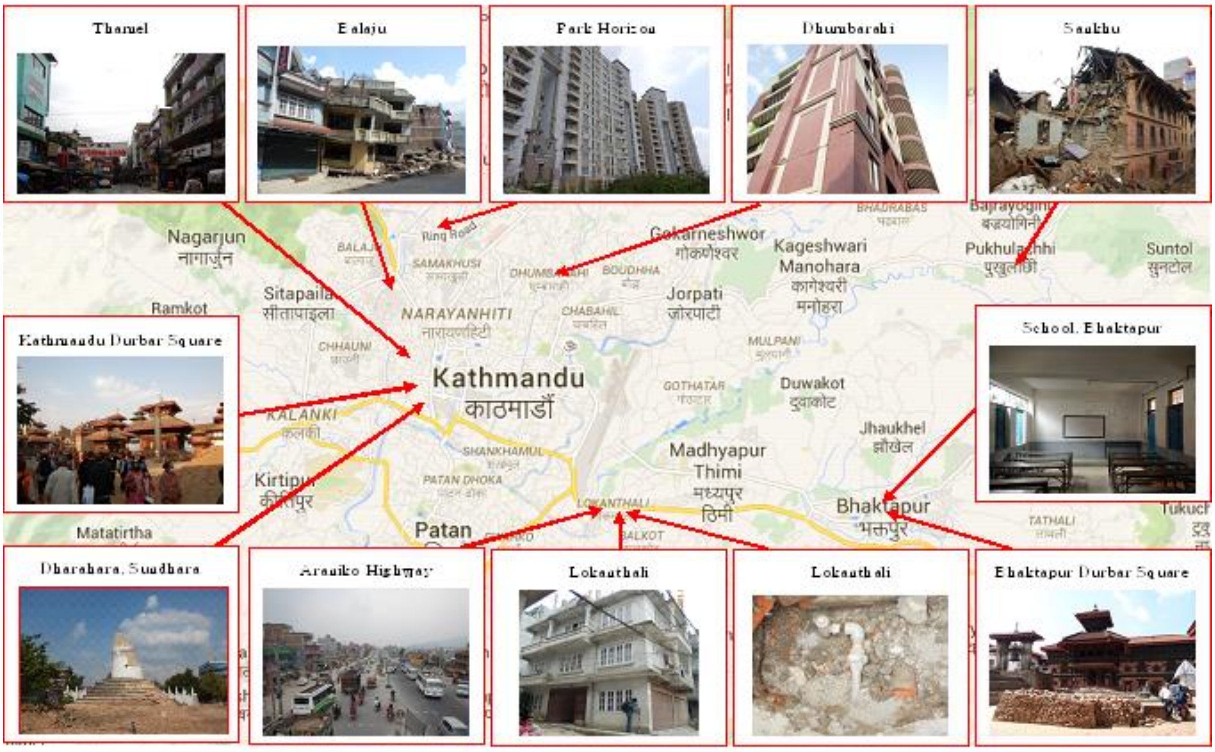
A strong earthquake of magnitude 7.8 (USGS), locally recorded as 7.6 by the National Seismological Centre (NSC) with its epicentre around Gorkha, struck the western and central regions of Nepal, including Kathmandu Valley (KV), about 80 km from the epicentre, at 11:56 a.m. NST on Saturday, 25th April 2015. Nepal is located in a very high seismic risk area, where seismicity predominantly is due to the collision of the Indian and Eurasian continental plates. Over the last 100 years, Nepal has suffered five destructive earthquakes: in 1934 (M8.4), 1980 (M6.5), 1988 (M6.6), 2011 (M6.9) and, the latest, 2015.

The most severe damage occurred mainly in the hilly areas northwest to northeast of KV. The reported losses, according to post disaster needs assessment (PDNA), are 8,781 dead, 22,303 injured, 6,266 public buildings damaged, 798,897 private houses damaged and a number of cultural heritage buildings destroyed. There were three cases of fire in the KV and no spreading fire was reported. Avalanches and a number of landslides in the mountainous areas were identified and caused fatalities and damages to roads, constricting the relief activities. A few liquefaction sites were observed in KV, without serious consequence. The salient feature of ground motion of the earthquake in the valley is a low peak value (PGA less than 200 gal), small response spectrum at short period (less than 1 second) and very long dominant period (around 4.5 second) compared to that of the events having similar magnitude in other areas.

2.2 Emergency Earthquake Damage Survey

(1) Damage Survey

The JICA Project Team carried out an urgent damage survey after the Gorkha earthquake in order to understand seismic damage and the needs of GoN for recovery and reconstruction. The damage survey was carried out in several locations inside Kathmandu Valley as shown in Figure 2.2.1 and in Sindhupalchowk District which suffered the more severe damage due to the earthquake. Damage to the buildings built of adobe, bricks or RC frame, high story buildings, and roads were investigated. A detailed damage survey was carried out in Sankhu and in Bhaktapur.



Source: JICA Project Team

Figure 2.2.1 Damage Survey Locations inside Kathmandu Valley

(2) Features of Seismic Ground Motion

In Kathmandu Valley, strong-motion earthquakes were recorded at the following six locations; one location maintained by the Nepal Seismological Center (NSC), one by the United States Geological Survey (USGS) and four maintained by Hokkaido University. Among these records USGS, located at Kanti Path, Kathmandu, observed PGA at 0.164g, and it is smaller than the PGA which is calculated with the attenuation model by the magnitude of the earthquake and the distance from the epicentre. Also, the response spectrum calculated with the observed data is considerably small in the period of less than two seconds, which affects the low-rise buildings. From the above observation, though the magnitude of the Gorkha earthquake was large, the seismic motion in Kathmandu Valley was smaller than that calculated from the empirical formula.

(3) Damage to Historical Monuments

There are many historical buildings in Kathmandu Valley. Many of those historical buildings and heritage sites around the Durbar Squares of Kathmandu, Lalitpur and Bhaktapur, which are enlisted as world heritage sites, were damaged, and some of them completely collapsed due to the Gorkha earthquake. Those buildings are said to have been built more than several hundred years ago. Most of those buildings were wooden-framed with bricks, adobe, or a mixture of those as construction materials, and with joints of mud mortar. The mud mortar gets weathered with time and then results in the strength deterioration. On the other hand, the weight of the bricks or adobe wall makes the seismic load larger, which might be one of the reasons of the heavy damage. Figure 2.2.2 shows the Dharahara, Kathmandu Durbar Square, Bhaktapur Durbar Square and Lalitpur Durbar Square after the earthquake.

 **Remaining part of Dharahara i.e. 61.88-metre-tall historical tower**	 **Heavily Damaged Kathmandu Durbar Square**
 **Damaged Bhaktapur Durbar Square (Taba Sattal)**	 **Lalitpur Durbar Square after Earthquake**

Source: JICA Project Team

Figure 2.2.2 Damage to Historical Monuments

(4) Damage to High-rise Buildings

Recently, high-rise buildings with more than fifteen stories have been built in Kathmandu Valley. Those buildings did not suffer much structural damages, but external and internal walls were heavily damaged. According to the seismic record, the response of hi-rise buildings which has a longer natural period got amplified, by the long period components of the earthquake ground motion. The buildings were deformed dramatically, while the brick walls, which cannot deform so much as RC Frames, were damaged, and many cracks were observed on the interior as well as exterior walls as shown in Figure 2.2.3.

	
Cracks on external wall of apartment building (Park Horizon)	**Cracks on internal wall of Apartment building (Dhumbarahi)**

Source: JICA Project Team

Figure 2.2.3 Damage to High-rise Buildings

(5) Damage to Residential Buildings

A detailed damage survey on residential buildings was carried out in Sankhu and Bhaktapur. The survey items were: structure type, number of stories, the year of construction, use, and the damage level. The results are summarized in Table 2.2.1 and Table 2.2.2. Few damages to the RC frame buildings and large damages to the bricks and adobe with mud mortar buildings were found in both the cities as also shown in Figure 2.2.4. The building with bricks and cement mortar were observed to have suffered less damage as compared to the buildings with bricks and mud mortar. From the above result, it is observed that the joint of mud mortar is the main issue for the weakness of the buildings in those two areas.

Table 2.2.1 Result of Building Damage Survey in Sankhu

Structure Type	Damage Degree						
	No	Slight	Moderate	Substantial	Heavy	Destruction	Total
Brick with cement mortar	4	5	1	6	1	2	19
Brick with mud mortar	0	4	5	6	2	7	24
Brick and adobe mixed with Mud mortar	0	2	0	3	17	19	39
RC Frame	9	11	0	0	0	0	20
Total	13	22	6	15	20	28	102

Source: JICA Project Team

Table 2.2.2 Result of Building Damage Survey in Bhaktapur

Structure Type	Damage Degree						
	No	Slight	Moderate	Substantial	Heavy	Destruction	Total
Brick with cement mortar		3	2	1	1	0	7
Brick with mud mortar		11	16	6	6	12	51
Brick and adobe mixed with Mud mortar			1	1	1	21	24
RC frame	12	2	0	0	0	0	14
Total	12	16	20	8	8	33	96

Source: JICA Project Team

	
Brick with mud mortar damaged Building (Sankhu)	**Brick and Adobe mixed building collapsed site (Bhaktapur)**
	
Safe RC structure (Sankhu)	**Safe RC structures (Bhaktapur)**

Source: JICA Project Team

Figure 2.2.4 Damage of Residential Buildings at Sankhu and Bhaktapur

(6) Damage in Sindhupalchowk District

A damage survey was carried out in Chautara, headquarters of the Sindhupalchowk District, for taking into consideration the damages in rural areas. Chautara is located on the ridge of the mountain, and many buildings have been constructed on the slopes. It was observed that, mainly stone masonry buildings with mud mortar were heavily damaged. Also, for the buildings constructed on the slopes, the collapse of columns on the ground floor resulted in collapse of the whole building. A recently constructed two story hospital was also observed to have suffered heavy structural damage. The major damages were found on the structures of stone masonry with joints of mud mortar and/or constructed on the slope of the ridge of the mountain. Figure 2.2.5 shows the damage situation at Sindhupalchowk.

 **Pan cake failure of RC Frame Government Building**	 **Recently constructed hospital Building**
 **Safe RC Building**	 **Construction on slope ground**

Source: JICA Project Team

Figure 2.2.5 Damage in Sindhupalchowk District

2.3 Damages and characteristics of buildings in the valley

2.3.1 Outline

The 2015 Gorkha earthquake, magnitude 7.8, occurred on 25th April 2015, and caused serious damages both inside and outside of the Kathmandu Valley. Building damages inside of the valley are introduced here. According to the result of building damage survey, damage ratio of grade 4+ 5 of EMS 98 is 16.9% in Bhaktapur Municipality, and 5.0% in Lalitpur Sub-metropolitan City respectively. Damage ratio of grade 4+ 5 by NSET's scale is 7.4% in Budhanilkantha Municipality (Courtesy of data by USAID/ NSET). Main reason of high damage ratio in Bhaktapur Municipality is due to the fact that the building ratio of "Brick masonry with mud mortar joint" is high there.

It has been supposed that the distribution of Peak Ground Acceleration (PGA; cm/sec2, gal) in the valley was in the range of 150 to 200gal, according to the strong motion records opened to the public. It is also supposed that more than 200gal PGA occurred at limited zone of perimeter area of the valley. Recorded PGA and acceleration response spectrum of building for NS and EW direction of each wave are shown in "Section 5.5.1 Building (Risk assessment)" and the "attachment of Chapter 5".

As far as the characteristics of building distribution, there are many buildings of "Brick masonry with mud mortar joint" in the historic areas, which has low seismic capacity. Many buildings were constructed along the "Ring road" recently within 10 to 20 years. Structural types are "RC non-engineered" and "Brick masonry with cement mortar joint", which relatively have seismic capacity. There are approximately 60 high-rise residential buildings, which have mainly been constructed after the year of 2000.

2.3.2 Characteristics of building damages due to the 2005 Gorkha earthquake

(1) Building damage of "Brick masonry with mud mortar joint"

Buildings of "Brick masonry with mud mortar joint", which has low seismic capacity, were seriously damaged in the historic area of Bhaktapur Municipality and Lalitpur Sub-metropolitan City, and Sankhu and Khokana areas in the suburbs. Especially out-of-plane direction failure occurred in upper storeys in case of old and wooden floor buildings, where the floors were not united to brick walls. On the other hand, the damage ratio of buildings of "Brick masonry with cement mortar joint" and "RC non-engineered" was low in those areas.

(2) Building damages of "RC non-engineered"

Non-engineered RC buildings at Gongabu, Sitapaila and Balkhu located at the perimeter area of the valley and along the Ring road were damaged. There is almost no "Brick masonry with mud mortar joint" at these areas. Generally, strength and ductility of non-engineered RC building are not enough. But because of the contribution of non-structural brick wall (thickness is 225mm), strength of the building is increased and the damaged ratio is reduced. On the other hand, in case that brick wall is limited or do not exist in the ground storey, it results in a soft storey, and the damage is easy to be concentrated on that storey. Also, there was an example of shear failure occurrence in a column with small size of 225mmx 225mm, together with a brick wall without any opening.

Similarly, damage such as shear failure was observed at the beam column joint of an engineered RC building which had vertical irregularity of stiffness and strength due to existing brick wall together with poor construction quality.

(3) Damages of high-rise residential buildings

Damages of non-structural brick walls occurred in high-rise (10-storey and more) residential buildings. There are approximately 60 high-rise residential buildings in the Valley. According to the survey by Architectural Institute of Japan, damage grade of EMS 98 of most of the buildings is grade 2, and one building is grade 3. There is no serious structural damage, but brick walls which are non-structural elements could not follow the deflection of ductile RC frame, and were damaged and some of them dropped to the ground.

(4) Damage of historical buildings (monuments)

Historical buildings (monuments) were damaged due to the 1934 Nepal-Bihar earthquake, and also damaged by the 2015 Gorkha earthquake. The structure is generally “Brick masonry with mud mortar (combination of mud, lime and brick powder, which is called “surkhy”) joint with/ without timber frames”. The use of natural materials such as brick, mud and timber is required for reconstruction, and ensuring seismic capacity is not easy. It is noted that “Building with 55 Windows” at Bhaktapur Durbar Square was recently retrofitted by using timber, and was not damaged due to the Gorkha earthquake.

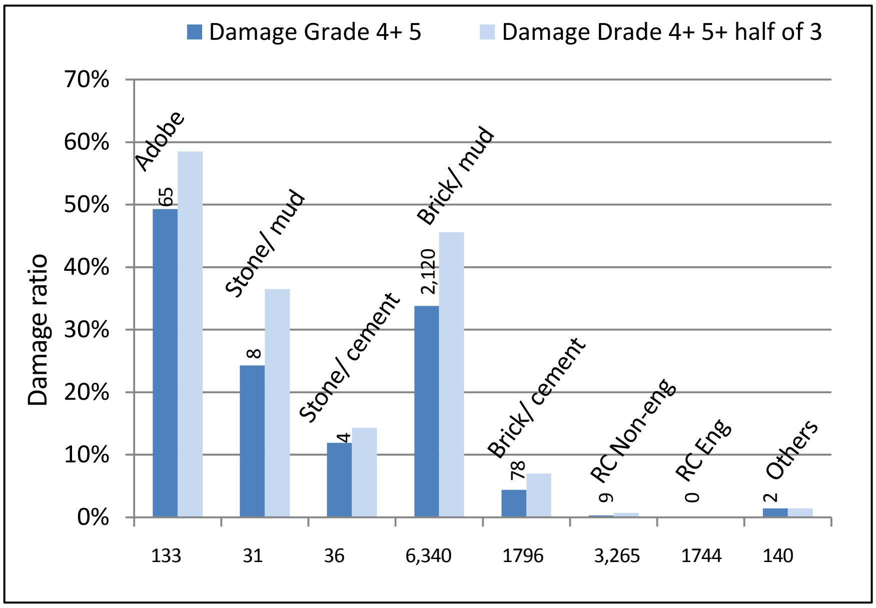
2.3.3 Damage ratio of each structural type

Damage ratio (Grade 4+ 5) by structural type of buildings in Bhaktapur Municipality and in Lalitpur Sub-metropolitan City and in Budhanilkantha Municipality by USAID/ NSET is shown below.

Refer to the attachment of the Chapter 2 for the damage data and the damage grade of EMS 98.

(1) Bhaktapur Municipality (total 13,485 buildings)

Damage ratio (Grade 4+ 5) of EMS98 is 33.4 % for “Brick masonry with mud mortar joints”, 4.4% for “Brick masonry with cement mortar joints” and 0.3 % for “RC non-engineered”.

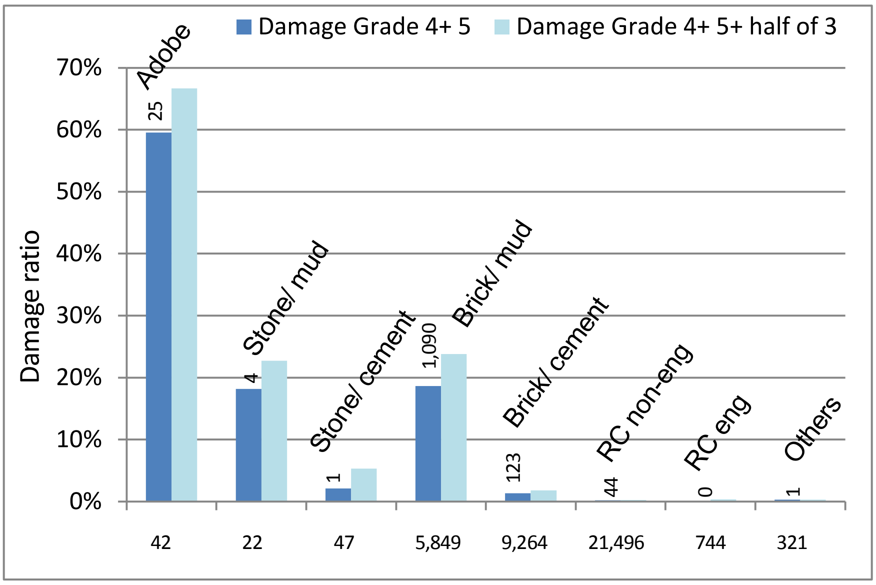


Source: JICA Project Team

Figure 2.3.1 Damage ratio of each structural type in Bhaktapur Municipality

(2) Lalitpur Sub-metropolitan City (total 37,785 buildings for Ward 1~22)

Damage ratio (Grade 4+ 5) of EMS 98 is 18.7 % for "Brick masonry with mud mortar joints", 1.3 % for "Brick masonry with cement mortar joints" and 0.2 % for "RC non-engineered".

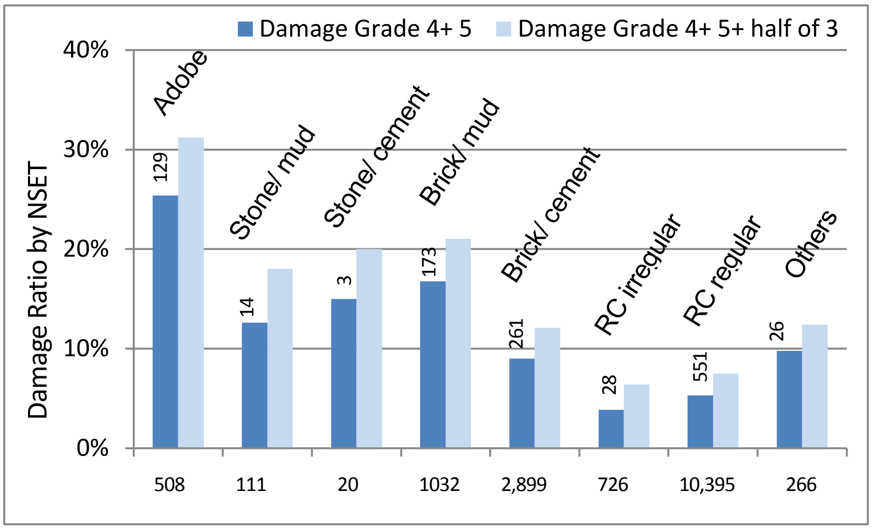


Source: JICA Project Team

Figure 2.3.2 Damage ratio of each structural type in LSMC

(3) Budhanilkantha Municipality (total 15,957buildings)

Damage survey was carried out by NSET, and the extent of cracks of members is estimated to calculate the damage grade. This damage grade is not that of EMS 98. Damage ratio (Grade 4+ 5) by the scale of NSET is 16.8 % for "Brick masonry with mud mortar joint", 9.0% for "Brick masonry with cement mortar joints" and 5.2% for RC buildings. It is noted that the structural type of RC frame is in two groups as "RC irregular" and "RC regular".



Source: JICA Project Team, USAID/ NSET

Figure 2.3.3 Damage ratio of each structural type in Budhanilkantha Municipality

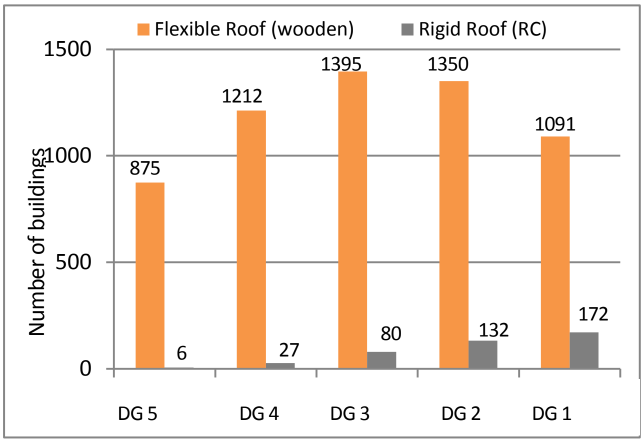
2.3.4 Roof (floor) type and damage ratio for "Brick masonry with mud mortar joint"

The building structures were classified into eight categories through the building inventory and damage survey. In addition, the difference of damage ratio was studied for roof type which is rigid type (RC roof) or flexible type (wooden roof), and constructed year for "Brick masonry with mud mortar joint". The result shows that damage ratio of flexible roof is big, and damage ratio of flexible roof constructed within 20 years is similar to that of rigid roof. "Brick masonry with mud mortar joint" is separated into two categories as shown in Section 5.1.1 Building damage function.

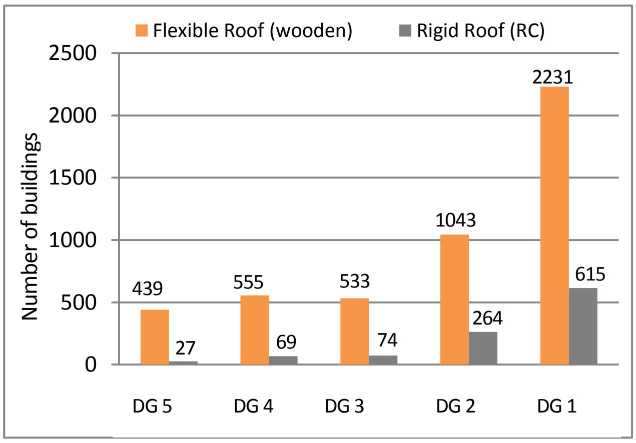
(1) Number of buildings and damage ratio by damage grade per roof type

The number of buildings and damage ratio by damage grade per roof type, flexible roof (wooden) and rigid roof (RC), are shown in Figure 2.3.4 and in Figure 2.3.5 respectively.

Bhaktapur (6,340 buildings=5,923+ 417)



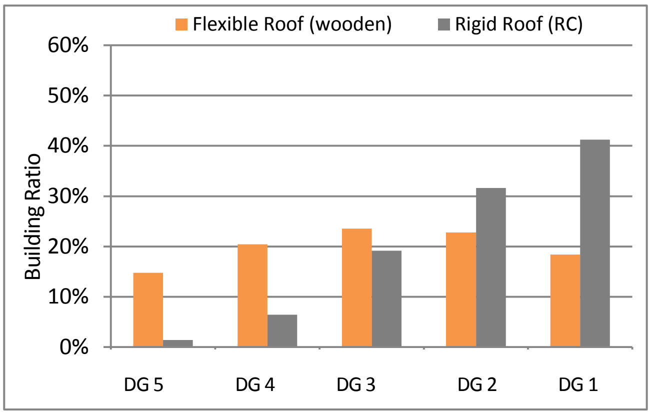
Lalitpur (Ward 1~22) (5,850 buildings=4,801+1,049)



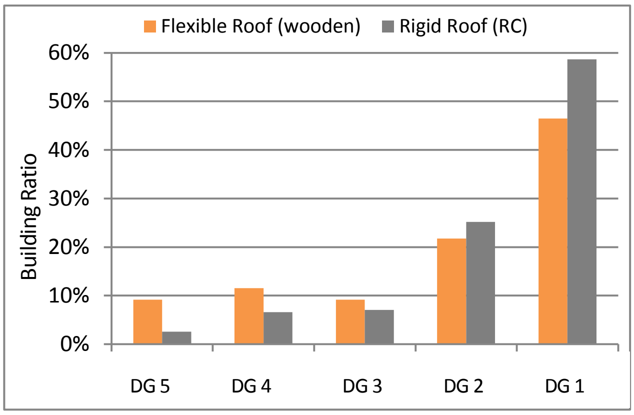
Source: JICA Project Team

Figure 2.3.4 Number of buildings by damage grade per roof type

Bhaktapur



Lalitpur (Ward 1~22)



Source: JICA Project Team

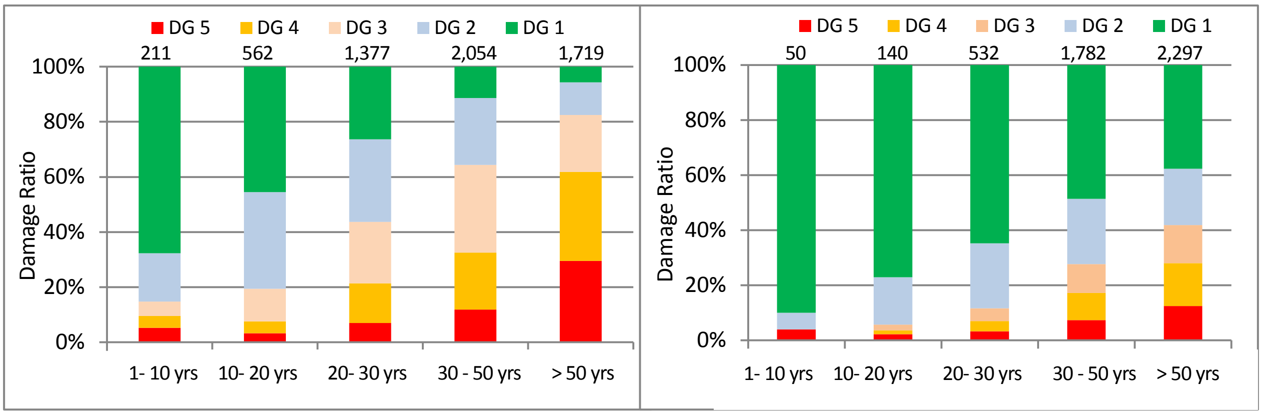
Figure 2.3.5 Damage ratio by each damage grade per roof type

(2) Damage ratio by constructed year per roof type

Damage ratio by constructed year per roof type is shown in Figure 2.3.6 for flexible roof (wooden roof) and in Figure 2.3.7 for rigid roof (RC roof) respectively.

a) Flexible roof (wooden)

Bhaktapur (5,923buildings)　　Lalitpur (excluding Ward 23~30, 4,801 buildings)

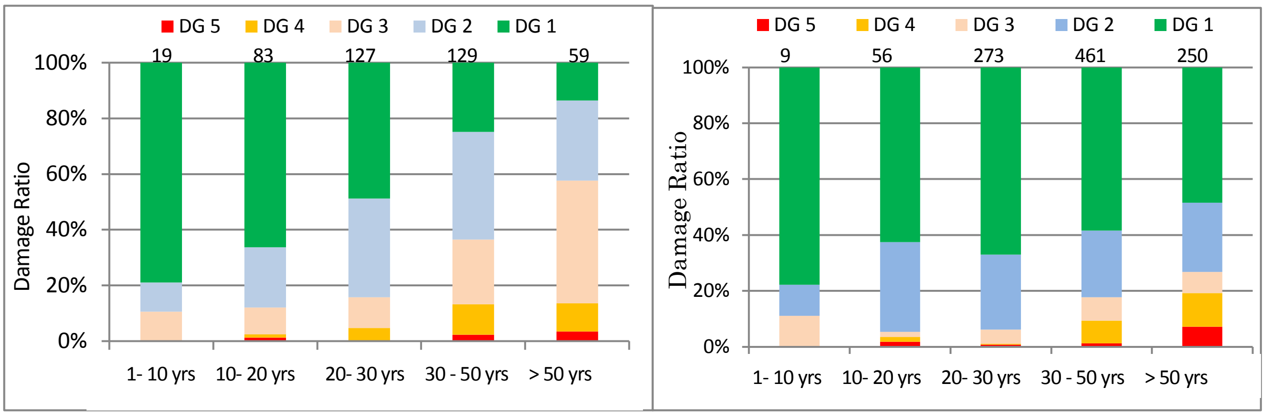


Source: JICA Project Team

Figure 2.3.6　Damage ratio by constructed year for brick with mud and with flex type (wooden roof)

b) Rigid roof (RC)

Bhaktapur (417 buildings)　　Lalitpur (Ward 1~22, 1,049 buildings)

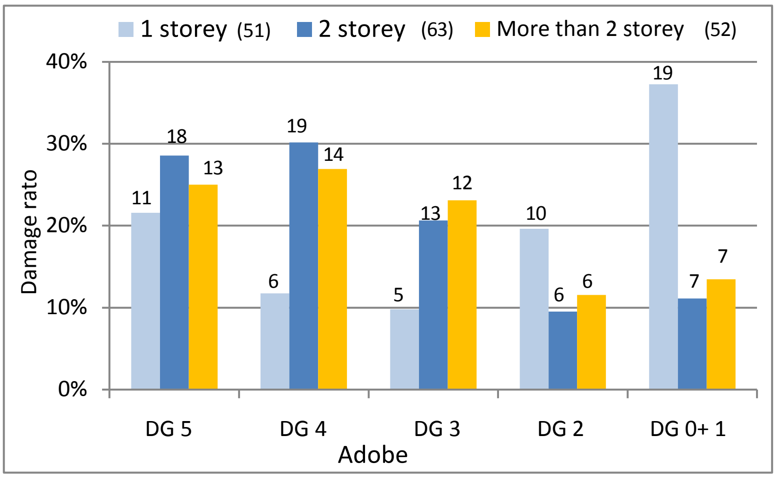


Source: JICA Project Team

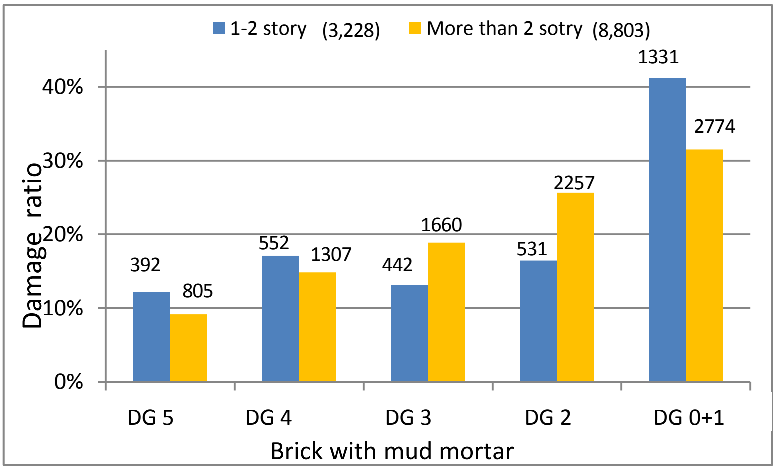
Figure 2.3.7　Damage ratio by constructed year for brick with mud and with rigid type (RC roof)

2.3.5　Damage ratio of masonry by type and number of stories

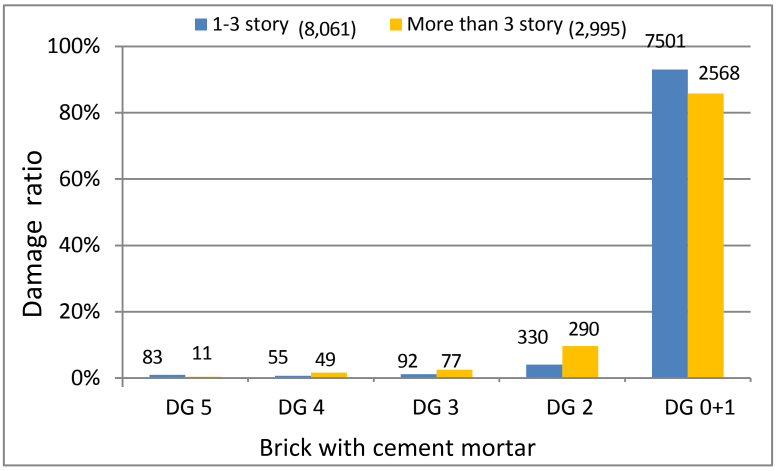
The damage ratio of masonry by type and number of stories were studied for the 2015 Gorkha earthquake. For "Adobe", the damage ratio was estimated for 1-storey, 2-storeys, 3-storeys and more, for "Brick masonry with mud mortar joint" it was estimated for 1- to 3-storey, 4-storey, and more, and for "Brick masonry with cement mortar joint" 1- to 3-storey, 4-storey and more. The result is shown in Figure 2.3.8. There is a clear difference of damage ratio by the type of masonry. In case of "Adobe", damage ratio differs by the number of stories.



a. Adobe Bhaktapur Municipality + Lalitpur sub-metropolitan city (LSMC) (Ward 1~22)



b. Brick masonry with mud mortar joint Bhaktapur Municipality + LSMC (Ward 1~22)



c. Brick masonry with cement mortar joint Bhaktapur Municipality + LSMC (Ward 1~22)

Source: JICA Project Team

Figure 2.3.8 Damage ratio of masonry by type of masonry and number of stories

2.3.6 Damages of buildings

Described below are the damages observed in buildings at Gongabu, Sitapaila and Balkhu areas located at the perimeter area of the valley and along the Ring road, high-rise RC residential building at north side of the Ring road, and houses at Budhanilkantha Municipality. Building damages in Bhaktapur Municipality and Lalitpur Sub-metropolitan City (LSMC) other than Durbar Square, and Sankhu and Khokana areas are described later.

(1) Gongabu area

a) "RC non-engineered"

Figure 2.3.9, Building damage was observed due to a soft storey at GFL, where no brick wall was provided for one direction. Damage by shear failure of RC column was observed, where diagonal cracks penetrated the brick wall in transverse direction. (Right), a collapsed building with pan-cake crash is shown.

Source: JICA Project Team

Figure 2.3.9 Building at Gongabu area (August 2015, unless otherwise stated)

Figure 2.3.10, building under demolition was surveyed. Column span is 3.5m to 4.0m, column section size is 225mmx 225mm, column main bar is 4-13φ, tie is 6mm diameter and at an interval of 150mm, and supposed concrete strength 15MPa (cube). Figure shows the lap joint portion. (Centre), another 3-storey building under demolition was observed. GFL is a soft storey and columns are inclined to North direction with big residual deflection. (Right), 5-storey RC building with column retrofit at GFL after the earthquake was observed. Size of retrofitted column is 400mmx 400mm.

Source: JICA Project Team

Figure 2.3.10 Buildings at Gongabu area (August 2015)

b) "RC engineered"

Figure 2.3.11, "RC engineered" building damaged in the Gongabu area. Possible reason of damage might be the lack of a structural plan as well as the lack of construction quality control. Columns on the first storey of this building have been inclined and shear failure at the beam-column joint was observed. There is a low height brick wall (thickness 225mm) on the first storey, hence a soft storey. (Right), there is almost no structural damage for this telecommunication building where the steel tower is located on the roof.

Source: JICA Project Team

Figure 2.3.11 Buildings at Gongabu area (August 2015)

(2) Sitapaila area

Figure 2.3.12, 3-storey RC building under demolition and there is no brick wall at front side. Column size is 230mmx 230mm and main-bar is 4-D13. Shear failure of RC column was observed, along with severe cracks on the brick walls in transverse direction. The brick walls at the other side were damaged similarly.

Source: JICA Project Team

Figure 2.3.12 RC building under demolition at Sitapaila area (August 2015)

(3) Balkhu area

Balkhu is located at West South of the Ring road. Figure 2.3.13, 3-storey RC building under demolition, shear lag of a column was observed. (Right), 4-storey RC building, no damage was observed from the outside, but non-structural brick wall was damaged with diagonal cracks. The water tank on the roof toppled to the ground because of the earthquake.

Source: JICA Project Team

Figure 2.3.13 Buildings at Balkhu area (August 2015)

(4) Hi-rise residential building at Northside of the Ring road (Tilingatar)

Figure 2.3.14, 16-storey residential building is shown. RC frame is damaged partially but there is no serious damage in the structure. Non-structural brick walls that couldn’t follow the deflection of ductile RC frame were damaged, and dropped to the ground. Some window frames, as well as some covers at expansion joints, were detached. The thickness of the external brick wall is 9” (225mm). Brick size is 9”x4”x2”. This is an example of damage of non-structural elements.

Source: JICA Project Team

Figure 2.3.14 Damage of high-rise residential building (August 2015)

(5) Individual houses in Budhanilkantha Municipality

Figure 2.3.15, 2-storey brick wall masonry and floor is RC. Thickness of the wall at GFL is 14" (350mm). Joint mortar at GFL is mud mortar, and on the 1st FL is cement mortar. There are cracks on the brick walls of the GFL. Also, cracks were observed on the concrete slab of the GFL. (Right), 3-storey RC frame with engineered construction and had no structural damage, and minor horizontal cracks were observed between RC beams and brick walls.

Source: JICA Project Team

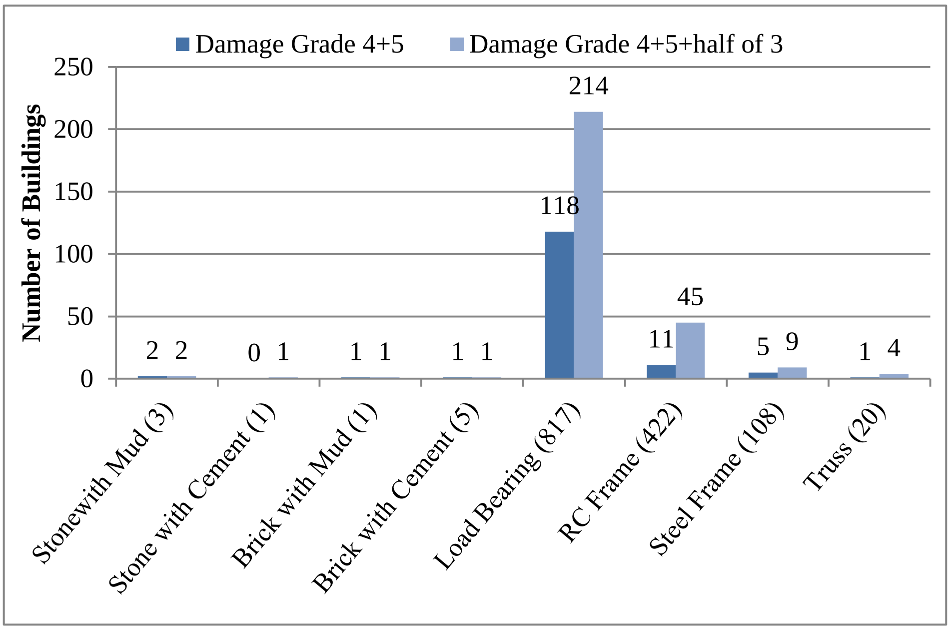
Figure 2.3.15 Individual houses in Budhanilkantha Municipality (August 2015)

2.3.7 Main public facilities (buildings)

(1) Schools

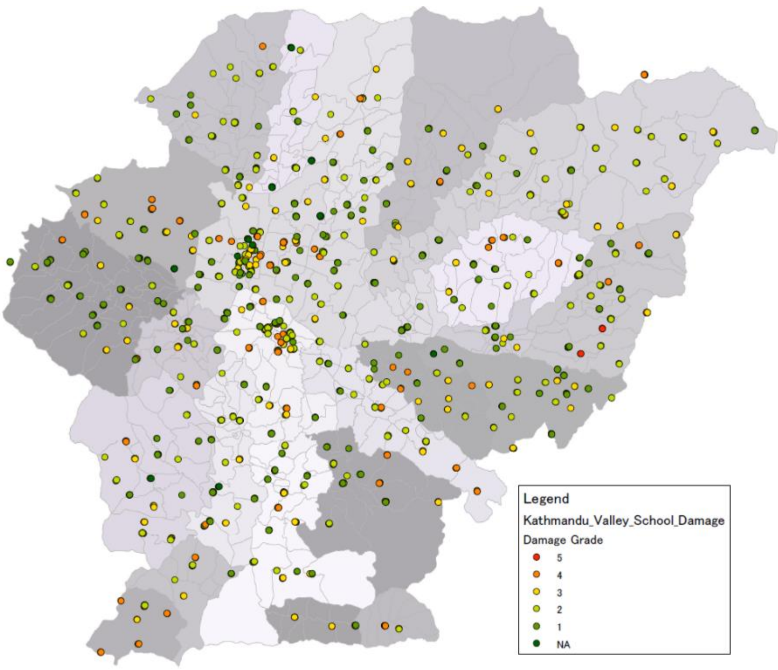
a) Damages of public school buildings

There are 441 public schools with 1,391 buildings in Kathmandu Valley based on the damage grade survey prepared by DOE. It categorized the damage by the Gorkha earthquake with EMS 98（The European macroseismic scale）as shown in Figure 2.3.16 and Figure 2.3.17. Excluding seventeen buildings which do not have information of structure. The information of 1,377 buildings are summarized as follows.



Source: JICA Project Team

Figure 2.3.16 Damage grade of public school building (EMS 98)



Source: JICA Project Team

Figure 2.3.17 Damage grade map of public school building (EMS 98)

b) Damages

Damage of school buildings in Sankhu is shown in Figure 2.3.18, 4-storey RC building with two class rooms on each floor. Column span is approximately 3m and 6m. Column size is 300mmx 300m, main re-bar is 4-20mm+ 4-16mm, column tie is 6mm@200mm with 90 degree hook. Cover concrete has dropped at the end column, and flexural yield was observed at top and bottom columns in the corridor. Diagonal cracks were observed on the non-structural brick walls in two directions. Shear failure at the beam column joint of external column was observed on the second floor. (Right), Brick masonry building was recently retrofitted, and no damage was observed. Retrofit was done by jacketing with wire-mesh and concreting of thickness two to three inches.

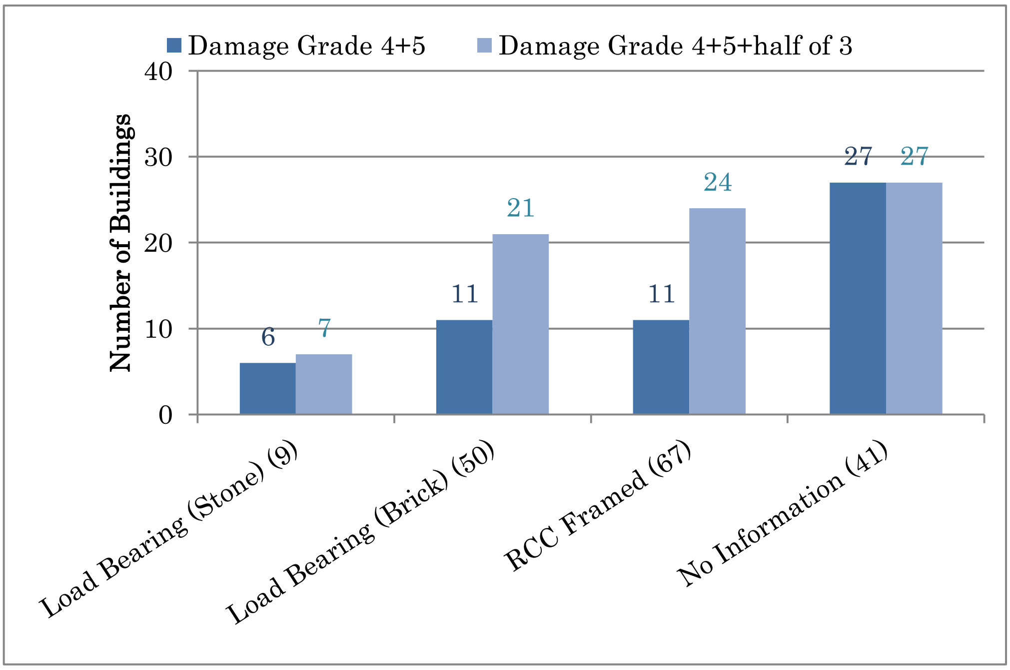
Source: JICA Project Team

Figure 2.3.18 Damage of a school buildings at Sankhu (August 2015)

(2) Hospitals

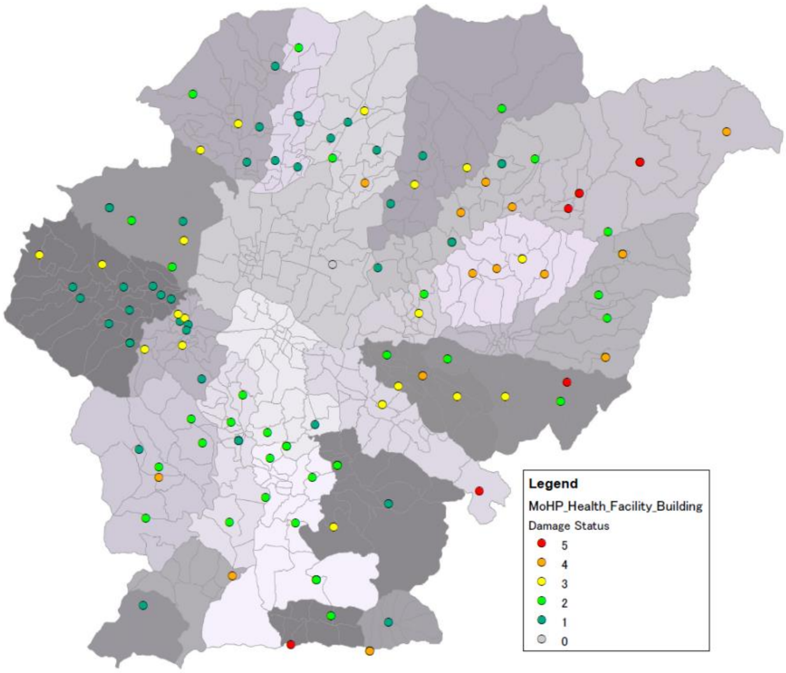
a) Damage of public hospitals

Damage grade of hospital buildings by EMS 98 was prepared by OHP, excluding the data of Kathmandu Metropolitan City. This hospital building inventory and damage survey is based on Detailed Engineering Assessment by Nepal Health Sector Support Programme (NHSSP). The damage grade of public hospital buildings are summarized in Figure 2.3.19 and Figure 2.3.20.



Source: JICA Project Team

Figure 2.3.19 Damage grade of public hospital buildings



Source: JICA Project Team

Figure 2.3.20 Damage grade map of public hospital buildings

b) Damages

No damaged hospital buildings were observed in the surveyed area. Figure 2.3.21, Civil Service Hospital of Nepal located in Kathmandu Metropolitan City (KMC), which has a 2-storey RC building and a 3-storey RC building, has no damage. Column span is approximately 6mx8m and column size is 500mmx500mm for the 2-storey and 600mmx60mm for the 3-storey including finish material. (Right), a hospital building in Bhaktapur.

Source: JICA Project Team

Figure 2.3.21 Civil Service Hospital of Nepal and Bhaktapur Hospital (August 2015)

(3) Governmental buildings

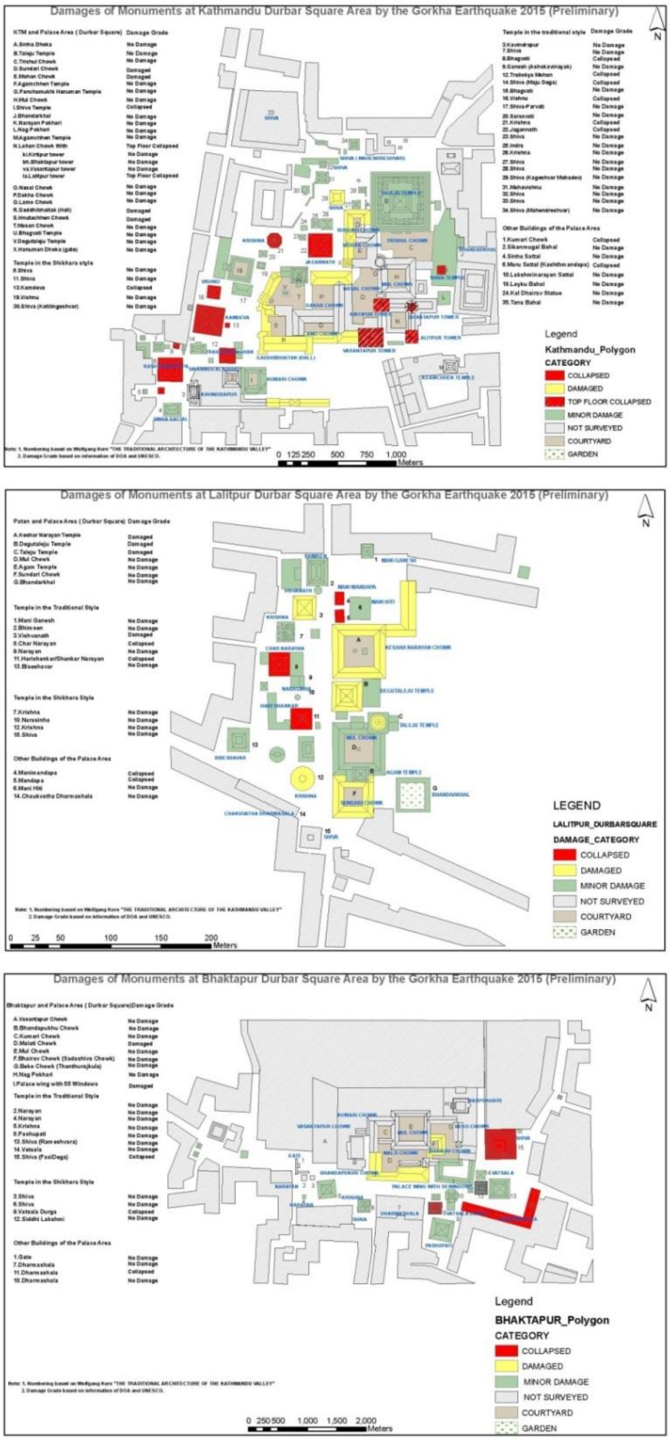
Three governmental buildings are shown in Figure 2.3.22, 5-storey RC building was not damaged. (Centre), 5-storey RC building was not damaged except some damage to non-structural brick walls located in the area just below the RC floor slab. (Right), 5-storey RC building was not damaged.

a) Governmental building b)Lalitpur Sub-metropolitan City building c) Bhaktapur Municipality building
Source: JICA Project Team

Figure 2.3.22 Governmental buildings (August 2015)

2.3.8 Damage of historical buildings (monuments)

1) As far as damage of historical buildings (monuments) of Durbar Square in Kathmandu, Lalitpur and Bhaktapur due to the 2015 Gorkha earthquake, a damage map has been prepared by ERAKV based on rapid visual survey and data provided by DOA (Department of Archaeology). In the map (Figure 2.3.23), a red coloured monument shows “collapsed”, and a yellow coloured monument shows “moderate to heavily damaged”.

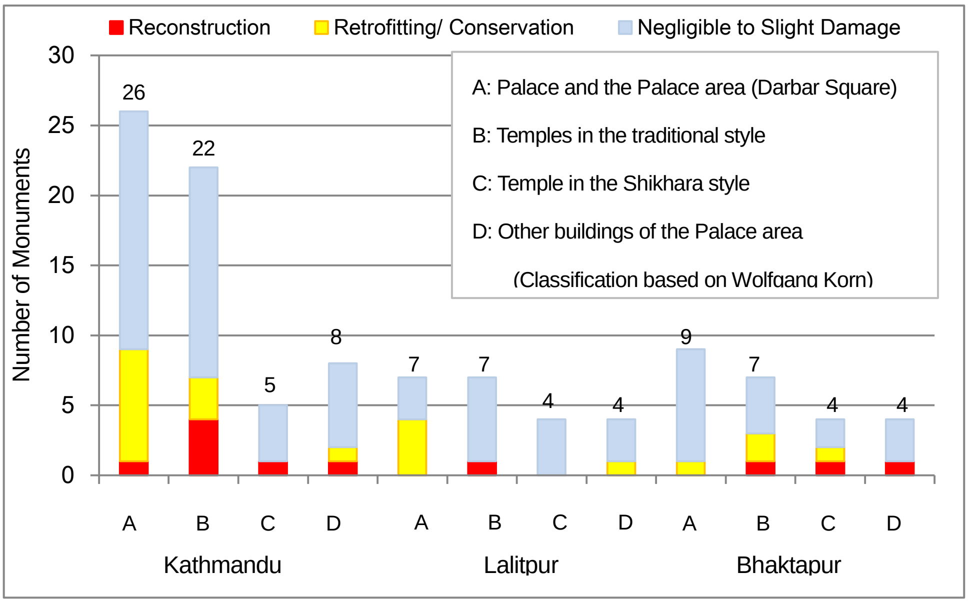


Top：Kathmandu, Middle: Lalitpur, Down: Bhaktapur
Source: JICA Project Team

Figure 2.3.23　Damage map of buildings (monuments) at Durbar Squares

2) Buildings (monuments) are classified into four groups based on the data provided by DOA, and damage grade of each group is shown in Figure 2.3.24. Red colour shows that reconstruction is required, yellow colour shows that retrofit is required, and blue colour shows that minor repair is required.

As far as the damage information by DOA, it is supposed that "reconstruction" is grade 5 (destruction) of EMS 98, and "retrofitting/ conservation" is grade 3 (Substantial to heavy damage) to grade 4 (very heavy damage) of EMS 98. The average number of the reconstruction of monuments is 9.5%, and the average of retrofitting/conservation is 19.7% of total number of monuments at three Durbar Squares. The damage ratio of the palace and the palace area, and temples in traditional style are high.



Damage classification was by data provided by DOA
Reference: Wolfgang Korn, "The Traditional Architecture of the Kathmandu Valley", Ratna Pustak Bhandar

Figure 2.3.24 Damaged number of monuments at Durbar Square by the 2015 Gorkha earthquake

3) Damage information is as follows.

a) Kathmandu Durbar Square

North side of Basantapur square, (left), heavy damage of Gaddhi Bhaitak (hall). (Right), heavy damage of Basantapur tower

(Left), brick wall of an office and school at South side of Basantapur square (right), Mohan Chowk supported by temporary support beams.

Source: JICA Project Team

Figure 2.3.25 Kathmandu Durbar Square (August 2015)

b) Lalitpur Durbar Square

(Left), Vishvanath Temple supported by temporary support beams (Centre), two completely collapsed temples. (Right), partially collapsed school located at the north side of Keshar Narayan Chowk.

(Left), Top of Taleju Temple was damaged (the other side), (centre) (right) 3 storey Sundari Chowk and swelled brick wall.

Source: JICA Project Team

Figure 2.3.26 Lalitpur Durbar Square (August 2015)

c) Bhaktapur Durbar Square

(Left), former royal palace. (Centre), palace wing with 55 windows, no damage was observed, as retrofit work had been recently carried out using horizontal timber member and others. (Right), heavily damaged building (corridor portion, brick wall at one side, the other side is wooden frame).



(Left), (centre), (right), Conditon of Tachupal square



Source: JICA Project Team

Figure 2.3.27　Bhaktapur Durbar Square (August 2015)

d) Dharahara Tower and Boudhanath

Figure 2.3.28, Height of Dharahara Tower, which collapsed due to the Gorkha earthquake, was approximately 62m. It was first constructed in 1832 and was reconstructed after the earthquake in 1934, which collapsed again due to the earthquake in 2015. Brick masonry and Lime Surkhi mortar (mix of mud, lime and brick dust) have been used at its joint. (Right), Boudhanath has hemispherical dome with the diameter of approximately 36m. The top portion was damaged and is under reconstruction.

Sign board

Source: JICA Project Team

Figure 2.3.28 Dharahara Tower and Boudhanath (August 2015)

2.3.9 Residential buildings around Durbar Square

Traditional houses have been located around the Durbar Squares. "Preserved monument sub-zone" is assigned around the Durbar Square, and "Preserved cultural heritage sub-zone" is assigned at the perimeter area. Damage to the houses in those areas are introduced hereafter:

(1) Houses in Kathmandu

As following the figure, inside spaces of residential buildings with some floors used for commercial purposes. The building is brick masonry of 5- to 6-stories. Joint mortar at the GFL is mud mortar and upper floor is cement mortar. No damage is observed by visual observation. (Right), collapsed building of "Brick masonry with mud mortar joint" (front side).

Source: JICA Project Team

Figure 2.3.29 Houses in Kathmandu (August 2015)

(2) Houses in Lalitpur

(Left), 4-storeies "brick masonry with mud mortar joint". Brick wall at the façade has been inclined to the road side by out-of-plane movement.

(Centre left), Newari style house in the Jhatapol District, "brick masonry with mud mortar", its fourth storey has collapsed and dropped. (December 2015)

(Centre right), 5-storey brick masonry, joint mortar is mud mortar at the lower three stories, and cement mortar at the upper two stories. Cement plaster finish is provided on the GFL.

(Right), 5-storey "RC non-engineered, and no damage is seen by the visual observation.

Source: JICA Project Team

Figure 2.3.30 Houses in Lalitpur (August 2015)

(3) Houses in Bhaktapur

(Centre left), yellow colour 4-storey building constructed after 1934, "Brick masonry with mud mortar joint" and has wooden flooring.

(Center right), Cracks are observed on the brick wall at each floor. Wall thickness is 18" (450mm).

(Left), cracks on the brick wall on the third floor of the red coloured 4-storey building, and "Brick masonry with mud mortar joint", there is timber column inside.

(Right), "RC non-engineered", and, from the appearance it seems to have no damage.

(Left), "Brick masonry with mud mortar joint" supported by temporary members. Building on the left side was constructed 50 years ago and the one on the right side was constructed 25 years ago.
(Centre), Building from Rana age, "Brick masonry with mud mortar joint" with timber frame at the front side of the GFL.
(Right), "Brick masonry with mud mortar joint", heavy damage was observed on the inside.



Source: JICA Project Team

Figure 2.3.31 Houses in Bhaktapur (August 2015)

2.3.10 Sankhu and Khokana areas

Sankhu is located at the eastern side of the valley and Khokana is located at the south-west side of the valley.

a) Sankhu area

(Left), 3-storey building of "Brick masonry with mud mortar joint" constructed before 1934. According to the residents, there was no serious damage in 1934. Deterioration of mud mortar joint by the period of 80 years might be considered as the reason for the damage due to the 2015 earthquake.
(Centre), damage of 3-storey building of "Brick masonry with mud mortar joint"
(Right), 4-storey "RC non-engineered", there seems to be no damage as observed from the outside.



Source: JICA Project Team

Figure 2.3.32 Sankhu area (August 2015)

b) Khokana area

(Left), Damage of building of "Brick masonry with mud mortar joint"

(Centre), 3-storey "Brick masonry with mud mortar joint", brick wall finished with cement mortar joint.

(Right), "RC non-engineered", there seems to be no damage as observed from the outside (the other side)

Source: JICA Project Team

Figure 2.3.33 Khokana area (May 2016)

2.3.11 Building damage data (Damage grade by EMS 98)

(1) Building damage data by ERAKV

Table 2.3.1 Building damage data

Bhaktapur (Numner of buildings)	None	Grade1	Grade2	Grade3	Grade4	Grade5	Total	%
1. Adobe	13	11	20	24	27	38	133	1.0
2. Stone_with_mud_mortar	6	4	7	6	4	4	31	0.2
3. Stone_with_cement_mortar	9	10	11	2	3	1	36	0.3
4. Brick_with_mud_mortar	416	847	1,482	1,475	1,239	881	6,340	47.0
5. Brick_with_cement_mortar	749	638	248	83	59	19	1,796	13.3
6. RCFrame_non_enginnered	2,147	985	97	27	4	5	3,265	24.2
7. RCFrame_enginnered	1,591	143	10	0	0	0	1,744	12.9
8. Others (steel, wooden frame)	129	6	3	0	2	0	140	1.0
Total	5,060	2,644	1,878	1,617	1,338	948	13,485	100.0

Bhaktapur (Building ratio, %)	None	Grade1	Grade2	Grade3	Grade4	Grade5	Total
1. Adobe	9.8	8.3	15.0	18.0	20.3	28.6	100.0
2. Stone_with_mud_mortar	19.4	12.9	22.6	19.4	12.9	12.9	100.0
3. Stone_with_cement_mortar	25.0	27.8	30.6	5.6	8.3	2.8	100.0
4. Brick_with_mud_mortar	6.6	13.4	23.4	23.3	19.5	13.9	100.0
5. Brick_with_cement_mortar	41.7	35.5	13.8	4.6	3.3	1.1	100.0
6. RCFrame_non_enginnered	65.8	30.2	3.0	0.8	0.1	0.2	100.0
7. RCFrame_enginnered	91.2	8.2	0.6	0.0	0.0	0.0	100.0
8. Others (steel, wooden frame)	92.1	4.3	2.1	0.0	1.4	0.0	100.0
Total (%)	37.5	19.6	13.9	12.0	9.9	7.0	100.0

Lalitpur (Number of buildings, Ward 1~30)	None	Grade1	Grade2	Grade3	Grade4	Grade5	Total	%
1. Adobe	3	16	42	30	115	125	331	0.7
2. Stone with Mud Mortar	13	2	2	2	3	2	24	24.0
3. Stone with Cement Mortar	33	7	5	3	1	0	49	0.1
4. Brick with Mud Mortar	1,159	1,992	1,647	759	1,025	832	7,414	15.9
5. Brick with Cement Mortar	4,483	6,049	572	102	72	87	11,365	24.4
6. RC Frame Non-Engineered	11,703	13,690	185	32	24	26	25,660	55.1
7. RC Frame Engineered	537	693	19	6	0	0	1,255	2.7
8.Others (Steel, Wood Frame)	370	93	4	0	2	0	469	1.0
Total	18,301	22,542	2,476	934	1,242	1,072	46,567	100.0

Lalitpur (Building ratio, Ward 1~30)	None	Grade1	Grade2	Grade3	Grade4	Grade5	Total
1. Adobe	0.9	4.8	12.7	9.1	34.7	37.8	100.0
2. Stone with Mud Mortar	54.2	8.3	8.3	8.3	12.5	8.3	100.0
3. Stone with Cement Mortar	67.3	14.3	10.2	6.1	2.0	0.0	100.0
4. Brick with Mud Mortar	15.6	26.9	22.2	10.2	13.8	11.2	100.0
5. Brick with Cement Mortar	39.4	53.2	5.0	0.9	0.6	0.8	100.0
6. RC Frame Non-Engineered	45.6	53.4	0.7	0.1	0.1	0.1	100.0
7. RC Frame Engineered	42.8	55.2	1.5	0.5	0.0	0.0	100.0
8.Others (Steel, Wood Frame)	78.9	19.8	0.9	0.0	0.4	0.0	100.0
Total (%)	39.3	48.4	5.3	2.0	2.7	2.3	100.0

2.3.12 Data provided by USAID/ NSET

Following damage data is estimated by the method developed by NSET. Surveyors evaluate the extent of cracks of members and other items at inside and outside of the building. Then the damage grade is calculated, so the method is different from EMS 98, which is rapid visual observation from outside of the building.

Table 2.3.2 Building damage data

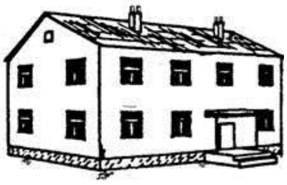
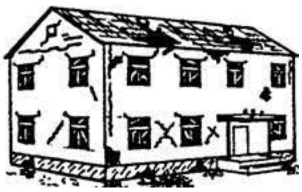
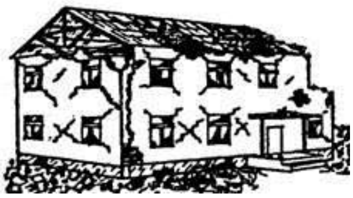
Budhanilkantha (Numner of buildings)								
	None	Grade1	Grade2	Grade3	Grade4	Grade5	Total	%
1. Adobe	131	116	73	59	82	47	508	3.2
2. Stone with Mud	46	30	9	12	8	6	111	0.7
3. Stone with Cement	8	6	1	2	2	1	20	0.1
4. Brick with Mud	359	259	153	88	75	98	1,032	6.5
5. Brick with Cement	1,137	972	350	179	129	132	2,899	18.2
(6) RCFrame_Irregular	297	269	95	37	15	13	726	4.5
(7) RCFrame_Regular	4,788	3,480	1,119	457	267	284	10,395	65.1
8.Others (Steel, Wood Frame)	109	80	37	14	16	10	266	1.7
Total	6,875	5,212	1,837	848	594	591	15,957	100.0

Budhanilkantha (Building ratio, %)							
	None	Grade1	Grade2	Grade3	Grade4	Grade5	Total
1. Adobe	25.8	22.8	14.4	11.6	16.1	9.3	100.0
2. Stone with Mud	41.4	27.0	8.1	10.8	7.2	5.4	100.0
3. Stone with Cement	40.0	30.0	5.0	10.0	10.0	5.0	100.0
4. Brick with Mud	34.8	25.1	14.8	8.5	7.3	9.5	100.0
5. Brick with Cement	39.2	33.5	12.1	6.2	4.4	4.6	100.0
(6) RCFrame_Irregular	40.9	37.1	13.1	5.1	2.1	1.8	100.0
(7) RCFrame_Regular	46.1	33.5	10.8	4.4	2.6	2.7	100.0
8.Others (Steel, Wood Frame)	41.0	30.1	13.9	5.3	6.0	3.8	100.0
Total	43.1	32.7	11.5	5.3	3.7	3.7	100.0

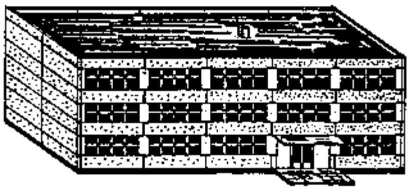
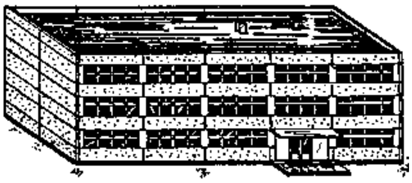
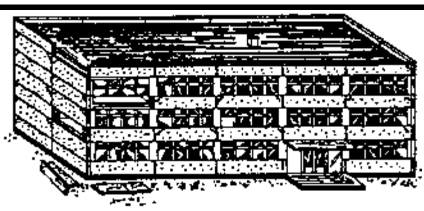
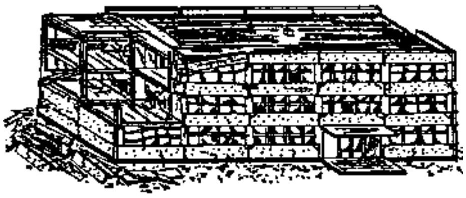
Note: category of RC building is “RC regular” and “RC irregular”.

2.3.13 Damage grade of EMS 98

(1) Damage grade for masonry building based on EMS-98

 **Grade 1: Negligible to slight damage**	**Structural damage: No** **Non-structural damage: Slight** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
 **Grade 2: Moderate damage**	**Structural damage: Slight** **Non-structural damage: Moderate** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
 **Grade 3: Substantial to heavy damage**	**Structural damage: Moderate** **Non-structural damage: Heavy** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
 **Grade 4: Very heavy damage**	**Structural damage: Heavy** **Non-structural damage: Very heavy** Serious failure of walls; partial structural failure of roofs and floors.
 **Grade 5: Destruction**	**Structural damage: very heavy** Total or near total collapse.

(2) Damage grade for reinforced concrete (RC) building based on EMS-98

Classification of damage to buildings of reinforced concrete	
 **Grade 1: Negligible to slight damage**	**Structural damage: No** **Non-structural damage: Slight** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
 **Grade 2: Moderate damage**	**Structural damage: Slight** **Non-structural damage: Moderate** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling of mortar from the joints of wall panels.
 **Grade 3: Substantial to heavy damage**	**Structural damage: Moderate** **Non-structural damage: Heavy** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of concrete cover, buckling of reinforced bars. Large cracks in partition and infill walls, failure of individual infill panels.
 **Grade 4: Very heavy damage**	**Structural damage: Heavy** **Non-structural damage: Very heavy** Large cracks in structural elements with compression failure of concrete and fracture of re-bars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
 **Grade 5: Destruction**	**Structural damage: very heavy** Collapse of ground floor or parts (e.g. wings) of buildings.

Appendix 3 Emergency Response Chronicle Survey of the Gorkha Earthquake in 2015

3.1 Emergency Response Chronicle Survey of the Gorkha Earthquake in 2015

This survey regarding an emergency response about the Gorkha earthquake which hit on 25 April 2015 was conducted in the pilot areas. It is assumed that confusion occurred during the emergency response phase, because Nepal does not have experience with large scale earthquakes in recent history. By clarifying the present issues and needs of human resources, it will be able to contribute suitable countermeasures and a swift response against the next disaster. In this activity, a survey sheet including the following six question items was prepared for grasping the accurate emergency response activities when the local governments of the pilot areas are interviewed.

- Rescue
- Emergency Supply
- Meetings (official/unofficial)
- Disaster Information (collecting)
- Disaster Information (announce)
- Damage at office (if any)

Also, a Standard Operation Procedure will be developed for the pilot area based on the result of this survey (9.2.1).

Rescue activity				
	how to get information for rescue	who was dispatched?	any collaboration	when frequency duration
e.g.	*from local fire department by phone*	*2 staffs from our office*	*with police*	*26 Apr to 29 Apr*
1				

Meetings				
	name	with	purpose	when frequency duration
e.g.	*internal meeting*	*with local police*	*to decide making recovery planning*	*26-Apr*
1				

Disaster Information (collecting)				
	how to collect	who is responsible parson in your office	contents	when frequency duration
e.g.	*we got information from local residents by telephone*	*Mr***** who is belonging to emergency section*	*number of affected people* *damage of housing*	*26-Apr*
1				

Disaster Information (announce)				
	how to inform (to whom)	who is responsible parson in your office	contents	when frequency duration
e.g.	*we informed information to residents by radio*	*Mr***** who is belonging to emergency section*	*latest situation news*	*28-Apr*
1				

Damage at your office		
		how long stopped?
1	water	
2	electric	
3	stable telephone	

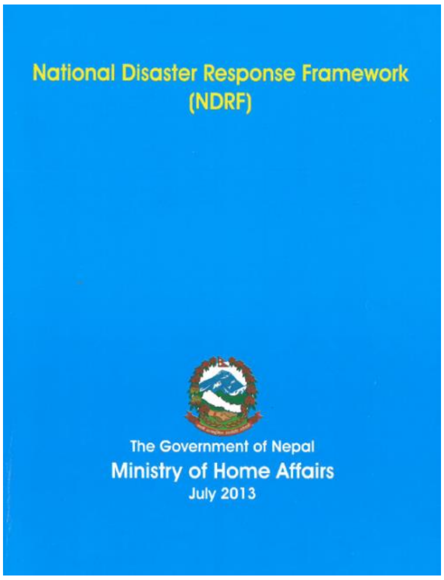
Emergency Supply (relief distribution)				
	who provide?	what is contents of supply	to whom (is there any issue or gaps?)	when frequency duration
e.g.	*from international support*	*water, food, blanket*	*to residents* *but it was not enough*	*28-Apr*
1				

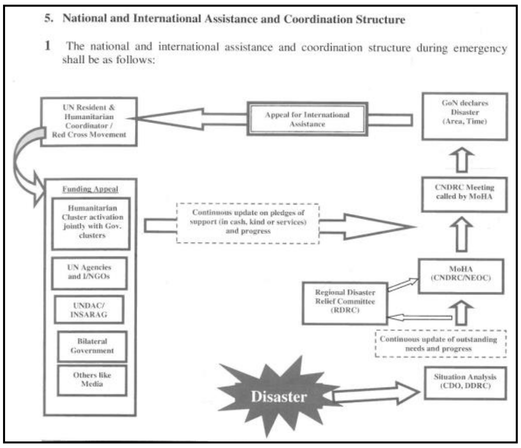
Source: JICA Project Team

Figure 3.1.1 Survey Sheet

(1) Summary of survey

Interviews were conducted at MoHA, Bhaktapur Municipality, Budhanilkantha Municipality and Lalitpur Sub-metropolitan City (LSMC). Mr. Rameshwor Dangal, Joint Secretary of MoHA explained that the national and local government carried out the emergency response based on the National Disaster Response Framework (NDRF) which was formulated in 2013. Also, he mentioned that SOP at the national level is under preparation. MoHA asked the Project Team for opinions and suggestions when the SOP at the local level is developed. During the interview with local governments, it turned out that the original emergency response activities such as getting disaster information via community network were conducted.





Source: NDRF

Figure 3.1.2 National Disaster Response Framework (NDRF)

Furthermore, interviews were held at the District Development Committee (DDC) and district offices. It was found that role of the government on the district level is to connect national and local levels for swift recovery activities.

Table 3.1.1 List of Interviews

	Venue	Date	Contact Person
1	Ministry of Home Affairs	2-Sep-15	Mr. Rameshwor Dangal, Joint Secretary, MOHA
2	Kathmandu District Development Committee	18-Nov-15	Mr. Tirtha Nath Bhattarai, Local Development Officer (LDO), DDC
3	Lalitpur District Development Committee	2-Dec-15	Mr. Pashupati Pokhrel, LDO (Local Development Officer), DDC Ms. Sarita Maharjan, Energy and Environment Officer
4	Bhaktapur District Development Committee	15-Dec-15	Mr. Pashupati Puri (Local Development Officer), DDC
5	Budhanilkantha Municipality	2-Sep-15	Mr.Birendra Dev Bharati, Executive Officer, Budhanilakantha Municipality
6	Bhaktapur Municipality	3-Sep-15	Mr. Uddhav Rijal, Executive Officer, Bhaktapur Municipality, Mr. Dil Bhakta Jayana, Architect, Bhaktapur Municipality
7	Lalitpur Sub-Metropolitan City (LSMC)	3-Sep-15	Mr. Tara Bahadur Karki, Executive Officer, Lalitpur SMC, Mr. Drona Prasad Koirala, Urban Governance Expert-LGCDP, Lalitpur SMC, Mr. Samir Maharjan, ICT Volunteer , Lalitpur SMC

Source: JICA Project Team

Source: JICA Project Team

Figure 3.1.3 Interview at Bhaktapur Municipality (3 September 2015)

(2) Result of survey

Interviews were conducted as shown on Table 3.3.1. It was revealed that there were two lines for recovery activity. One is a function of each committee which was connected to CNDRC (Central Natural Disaster Relief Committee), RDRC (Regional Disaster Relief Committee), DDRC (District Disaster Relief Committee), LDRC (Local Disaster Relief Committee) and CDMC (Community Disaster Management Committee). The other one is a function for operation which was connected to NEOC (National Emergency Operation Center) and DEOC (Disaster Emergency Operation Center). Regarding former, each committee can decide a specific recovery planning. Regarding latter, each operation centre can decide emergency response for affected people. The role of the government at the district level was to reserve and distribute emergency supplies to the affected area, and also to take a middle position between national and municipality, VDC.

As mentioned previously, the survey sheet included six items; Rescue, Emergency Supply, Meetings, Disaster Information, Disaster Information, Damage at office. The result is as follows:

1) Rescue

District Development Committee (DDC) dispatched police, fire department and task force teams. Also, each municipality dispatched local government officers for rescue activity. They worked shoulder to shoulder in affected areas since 25 April.

2) Emergency Supply

District Development Committee (DDC) reserved emergency supplies which were provided by donors from foreign countries, international organizations and the national government of Nepal. And they distributed emergency supplies to the site. Basically decision making for distribution was confirmed at DDRC (District Disaster Relief Committee). Also, they could deal flexibly based on the requests from local governments. On the other hand, some of municipalities prepared their own emergency supplies and donations for recovery. In addition, international support from Bangladesh and China were provided to municipalities directly.

3) Meetings (official/unofficial)

District Development Committee (DDC) had DDRC (District Disaster Relief Committee) meetings as the official meetings since 25 or 26 April. They discussed specific plan for rescue and distribution of emergency supply. However, some of the staff of the municipal government were affected by the earthquake, so, all of them could not come together for meeting right after the earthquake.

4) Disaster Information (collecting)

District Development Committee (DDC, Kathmandu) dispatched 40 staff members for collecting disaster information at the affected sites. The method for collecting disaster information on the municipal level was slightly different in each affected site. One government dispatched staff to the affected area the same as was done by the District Development Committee (DDC, Kathmandu). But in general, the government staffs who worked at the ward level collected and informed disaster information to municipalities.

5) Disaster Information (announce)

District Development Committee and municipal government provided disaster information to the media directly. But this information was not shared within DDCs and municipalities.

6) Damage at office (if any)

Previous Bhaktapur Municipality office suffered serious damage due to the earthquake. The new office building was built when the Project Team had the interview with them. There were some cracks at other government buildings; they were still used for usual work.

(3) Issues appeared through surveys

Some of issues to be solved were exposed through the interviews which are as follows::

- Emergency response activities were conducted based on NDRF. However, the detailed explanation for the activities of local governments is not shown in this guideline. Therefore the emergency response activities were slightly different in each municipal government.

⇒Emergency response activity on the municipal level is not unified yet. On the other hand, the response framework on the district level is being planned by MoHA. It is expected that this framework will be useful for developing an SOP for the municipal level. Also the SOP for the municipal level will be linked with NDRF.

- Basically, donation and emergency supplies provided by the national government was distributed to the municipalities and VDC via district governments.

⇒Specific procedures for sharing donations and emergency response has already been stipulated in NDRF. A more detailed explanation for local government officers should be mentioned in the SOP.

- Contents of initial response in a time series were not recorded in each government. But contents of daily working were documented.

⇒It is very important to record initial response in a time series, especially the first day after a disaster, for grasping issues to be solved. This explanation will be mentioned in the SOP.

- Management of disaster information was different in each government.

⇒One municipal government dispatched staff to the affected area. On the other hand, in another municipal government, staffs who worked at the ward level collected and informed disaster information. This shows that the local governments have already developed an easy methodology for the management of disaster information. These methodologies were created based on their experience. Therefore it is not necessary to show unified methodology in the SOP.

- Unified disaster information format is not developed yet.

⇒A disaster information format is useful for sharing information with each level. A unified disaster information format was not prepared before the Gorkha earthquake. But Bhaktapur Municipality prepared an original format right after earthquake and utilized it for collecting disaster information. Their format was very useful at that time but it is difficult to share disaster information with other government bodies if each of them have a different format. Therefore a unified disaster information format should be mentioned in the SOP.

Following these results in this survey, the SOP will be developed in the second phase.

Appendix 4 Construction of Earthquake Resistant Model Buildings

4.1 Construction of Earthquake Resistant Model Buildings

4.1.1 Background

In the seminar co-hosted by the GoN and JICA on May 25th 2015, the necessity of creating a reconstruction policy for a disaster-resilient country was discussed. It largely gained approval from the people of Nepal, as it is intended to become an immediate response after the earthquake as an opportunity to build a resilient society by acknowledging the concept of BBB. The idea for an earthquake resistant housing system in Nepal, in consideration with the type of structure and available materials for the construction, utilizing Japan's experiences in building earthquake-resistant structures is highly required.

In order to improve the structural vulnerability of the buildings against future earthquakes, building a quake-resistant model house and recording the construction process can play an important role in carrying out a demonstration to disseminate the structural information and the construction method for building quake-resistant buildings in Nepal. The 1/1 scale model can also contribute toward helping people to understand and imagine what a quake-resistant building is.

4.1.2 Summary of the Activity

(1) Construction Phase I (June 13th – 26th 2015)

As Phase I, the cut models of the model houses were constructed on the Pulchowk Campus of the Tribhuvan University, where many engineering students and professors can learn, and the Crowne Plaza Hotel Kathmandu-Soaltee, where the donor conference was held. In the Tribhuvan University, single storied masonry house targeting rural area and 3-storeyed and 5-storeyed RC houses targeting urban areas were built, and a single storied masonry house was constructed inside the Crowne Plaza Hotel Kathmandu-Soaltee. The details are shown on Table 4.1.1.

For demonstration-use, exhibition panels were prepared and installed. They provided an explanation about the quake-resistant model houses, Japan's earthquake resistant method and its technical history (Table 4.1.2). More than 500 people including the Minister of MOUD, the Vice Minister of Ministry of Foreign Affairs of Japan, the President of JICA, government officers, engineers, students, and so on visited the site at the time of the event on 24th and 25th June 2015. A monitoring video of the construction process of the quake-resistant building was recorded to be used as an educational tool.

Table 4.1.1 Construction of quake-resistant cut models

No.	Items	Contents
1	Ministry in charge	Ministry of Urban Development
2	Authority	Department of Urban Development and Building Construction (DUDBC)
3	Organization	IOE
4	Project location	Institute of Engineering, Tribhuvan University, Pulchowk Campus (at the vacant lot behind the building of Department of Architecture and Urban Planning) and at the front courtyard of Crowne Plaza Hotel Soaltee
5	Project period	June 13th – 26th 2015
6	Project summary Facility's scale	Build 4 prototype model house for demonstration-use Urban-type 1: RC frame+brick wall structure 3-story cut model Column: 30cm Floor area : 81 ㎡ Building area: 40.5 ㎡ Urban-type 2: RC frame+brick wall structure 5-story cut model Column: 50cm Floor area : 81 ㎡ Building area: 40.5 ㎡ Rural-type: masonry cut model Floor area: 9 ㎡ Temporary-emergency house (steel pipe, tent) => Permanent housing reconstruction (steel pipe+stone masonry+roof) Floor area : 9 ㎡

Source: JICA Project Team

Table 4.1.2 Exhibition panels

No.	Items	Contents
1	Project location	Institute of Engineering, Tribhuvan University, Pulchowk Campus (at the vacant lot behind the building of Department of Architecture and Urban Planning) and at the front courtyard of Crowne Plaza Hotel Soaltee
2	Project period	June 13th – 26th 2015
3	Component summary	Create and install exhibition panels that explain the 3 prototype model house, Japan's earthquake resistant method and its technical history for demonstration-use
	Panel size	Panel size: 1.8 m X 1.8 m height: 2.0 m Quantity: 6 panels Panel size: 1.8 m X 0.9 m height: 1.8 m Quantity: 1 panel
	Exhibition panel structure	Weather proof plastic sheets and wooden support

Source: JICA Project Team

Source: JICA Project Team

Figure 4.1.1 Event on 24th and 25th June 2015

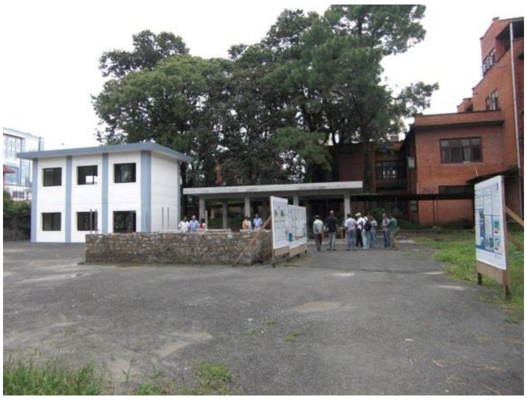
(2) Construction Phase II (July 5th – August 20th 2015)

Among the cut-models on the Pulchowk Campus, Tribhuvan University, a single-storied RC structure (the building frame only) was rebuilt to the 3-storeyed RC building cut model and a 2-storeyed RC building was rebuilt to the 5-storeyed RC building cut model (Table 4.1.3).

Table 4.1.3 Quake-resistant model buildings

No.	Items	Contents
1	Ministry in charge	Ministry of Urban Development
2	Authority	Department of Urban Development and Building Construction (DUDBC)
3	Organization	IOE
4	Project location	Institute of Engineering, Tribhuvan University, Pulchowk Campus (at the vacant lot behind the building of Department of Architecture and Urban Planning)
5	Project period	July 5th – August 20th 2015
6	Project summary Facility's scale Site use	Carry out additional construction for urban-type 1 and urban-type 2 Urban-type 1: RC frame 1-story (building frame only) Column: 30cm Floor area: 40.5 ㎡ Building area: 68.04 ㎡ Urban-type 2: RC rigid frame+brick wall structure 2-story cut model Column: 50cm Floor area: 81 ㎡ Building area:68.04 ㎡ Warehouse (both type 1 and 2)

Source: JICA Project Team



Source: JICA Project Team

Figure 4.1.2 Completion Ceremony of the Model buildings

Appendix 5 DRR Awareness Activities

5.1 DRR Awareness Activities

5.1.1 Background and Purposes of the Activities

After the Gorkha earthquake, due to the lack of proper knowledge on the mechanism of an earthquake and wrong estimation of the damage of the buildings, even the people who did not need to evacuate moved out to rural areas. During the period when some aftershocks continuously occurred, many people felt needless fears and anxiety about the impact by future earthquakes, and it was also observed that some people spread rumors and false information.

In the meantime, it is very important to build seismic resistant buildings at the stage of rehabilitation and recovery for reducing future damage by earthquakes. Although the government restricted the construction of new buildings for a while after the earthquake, some new construction work seemed to have been started. Also, people's awareness on the issues of safe building structures was still low.

In the above context, "Urgent Resilient and Safe Kathmandu Valley Campaign" composed of a series of DRR awareness activities was conducted with the view of easing people's fear of earthquakes and make them properly prepared for future earthquakes by enhancing people's basic knowledge on earthquake and seismic resistant houses and buildings. Also, the activities aimed to contribute to sharing the idea of BBB.

5.1.2 Outline of the Activities

The activities conducted under the Campaign are shown in the following table.

Table 5.1.1 Outline of the Urgent Resilient and Safe Kathmandu Valley Campaign

Period of Activities	22 July (Wed.) – 30 September (Wed.) 2015
Target Areas	Lalitpur SMC, Bhaktapur Municipality, and Budhanilkantha Municipality (The Pilot Municipalities of the Project)
Contents of Activities	
(1) Development and dissemination of Earthquake Awareness Brochure	As a tool to widely share the contents of the awareness programme, a brochure was developed and disseminated to the officials and residents in pilot municipalities. It introduces earthquake mechanism, actions for reducing damage when an earthquake occurs, evacuation actions and things to be considered after an earthquake, the damage situation of the Gorkha earthquake, building codes of the Nepalese government, and seismic retrofitting measures.
(2) Implementation of Earthquake Awareness Workshops	The workshops to enhance awareness on building safety were conducted for the local residents. In the workshops, earthquake mechanism and the characteristics of the buildings damaged by the Gorkha earthquake were introduced by the comparison with the cases in the Great Hanshin-Awaji Earthquake in Japan. Also, the details of the NBC and practical samples of the retrofitting of buildings were explained by engineers.
(3) Broadcasting of radio awareness programme	With the view of raising awareness on earthquake resistant buildings and retrofitting to reduce damage caused by earthquakes, a one-minute radio programme was prepared and broadcast through main radio broadcasters.
(4) Conducting of a survey to grasp change of awareness after the Campaign	A questionnaire survey was conducted for the workshop participants to collect the information of people's awareness and recognition of earthquake and DRR before the Gorkha earthquake, and change in understanding and attitude after the workshop.

Source: JICA Project Team

To promptly start and conduct the campaign, the activities were conducted by subcontracting with a Japanese NGO, Shapla Neer = Citizens' Committee in Japan for Overseas Support (hereinafter Shapla Neer), which has conducted various community activities including DRM/DRR activities in Nepal. The experts of the JICA Project Team mainly provided the technical input on earthquake and earthquake disaster management, and coordinated with the counterparts of the project.

5.1.3 Development and Dissemination of Earthquake Awareness Brochure (in Nepali)

(1) Composition of the Brochure

The brochure was designed primarily for providing basic knowledge on earthquake, and seismic resistant buildings. The composition of the brochure is as shown in the

Table 5.1.2, and mainly focuses on the three points; mechanisms of earthquakes, actions to be taken when an earthquake occurs, and construction of earthquake resistant houses. Especially, considering the condition that information on earthquake resistant housing has not been sufficiently delivered, the brochure was intended to enhance people's awareness on the damage of houses by earthquake, retrofitting of houses, seismic code, and earthquake-resistant construction.

Table 5.1.2 Composition of the Earthquake Awareness Brochure

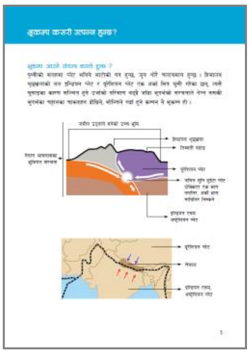
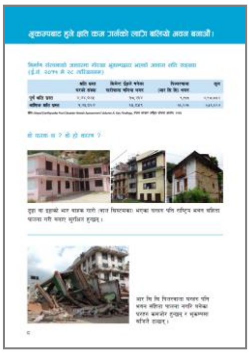
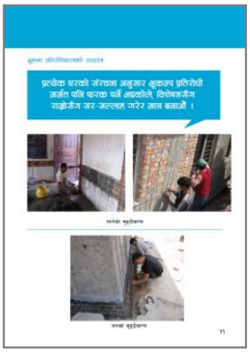
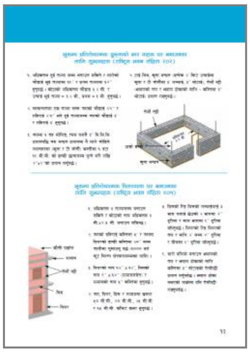
Knowledge to be learned	Chapters of the Brochure
Introduction	Preface
Earthquake Mechanism	Why an earthquake occurs
Actions to be taken when an earthquake occurs	To protect yourself from an earthquake Things to be considered in case of an earthquake (aftershocks, fires, and rumors)
Construction of earthquake resistant houses	Let's construct earthquake resistant buildings! Seismic retrofitting of buildings (What is seismic retrofitting? Samples of seismic retrofitting of buildings) Compliance of Seismic Building Code (National Building Code, Tips for constructing seismic resistant buildings by building structure types) Important tips for seismic resistant housing

Source: JICA Project Team

(2) Development of the Brochure

Based on the above mentioned composition, a draft brochure was developed in consultation with the project counterparts from MoUD, DUDBC, MoFALD and the National Society for Earthquake Technology-Nepal (NSET), a NGO which has continuously provided awareness activities related to earthquake DRR in Nepal. The first draft was designed to provide simple information in order to be easily understood by residents, however, based on the suggestions by MoUD, more technical information on seismic resistant buildings were included for deeper understanding on the topics. Similarly, to make people understand the contents easily, it included many images and pictures. Also, with the consideration of the portability and easy filing, the brochure used B5 size paper. There were a total of sixteen pages of the brochure including the cover pages.

It took some time to coordinate with the relevant organizations for finalizing the brochure, and the draft copies of the brochure were distributed in the workshops. It was modified and finalized on 24 September after referring to the comments from the workshop participants.

 Earthquake Mechanism	 How to protect yourself from an earthquake	 Effectiveness of Retrofitting
 Retrofitting method	 Building Code and seismic resistant buildings	 Tips for seismic resistant construction

Source: JICA Project Team

Figure 5.1.1 Developed Earthquake Awareness Brochure (Some pages)

(3) Dissemination of the Brochure

The following number of copies of the brochure was distributed to the residents of the pilot municipalities through their disaster response or DRR activities; 1,000 copies to Lalitpur SMC, 1,500 copies to Bhaktapur Municipality, and 1,000 copies to Budhanilkantha Municipality. Also, 50 copies each to MoUD, MoFALD, and MoHA, 200 copies for the activities of the Japan Overseas Cooperation Volunteers (JOCV), and 100 copies for future activities of the Shaplaneer were distributed with the view to promote the utilization of the brochure by wider stakeholders.

5.1.4 Implementation of Earthquake Awareness Workshops

(1) Implementation Schedule and Programme Contents

In each pilot municipality, earthquake awareness workshops were conducted in a few batches for approximately 200 residents. Before the implementation of the workshops, pre-coordination meetings were organized for discussing the schedule, participants to be invited, and contents of the workshops with executive officers and DRM responsible officers of pilot municipalities, and ward representatives. The implementation schedules of the workshops were as shown in the following table.

Table 5.1.3 Implementation Schedules of the Awareness Workshops

Municipality	Venue	Date	No. of Participants	Total participants
Lalitpur SMC	Tamrakar Samaj, Jawalakhel	Aug. 18 (Tue)	88	226
	Ditto	Aug. 19 (Wed)	59	
	Ditto	Aug. 20 (Thu)	79	
Bhaktapur Municipality	Khwopa Engineering College	Aug. 17 (Mon)	81	147
	Udhyog Banijya Sangh (Bhaktapur Industrial Estate)	Aug. 18 (Tue)	66	
Budhanilkantha Municipality	Golfutar Party Place	Aug. 18 (Tue)	47	145
	Valley Public School	Aug. 19 (Wed)	50	
	Milan Chowk Party Place	Aug. 20 (Thu)	48	
Grand Total				518

Source: JICA Project Team

Source: JICA Project Team

Figure 5.1.2 Pre-Discussion with the Representatives of the Wards

In the original plan proposed by the JICA Project Team, the main lecturers of the workshop were former JOCVs. Since there was a great need for the explanation of seismic resistant construction and retrofitting in details when discussed in the pre-coordination meetings in each municipality, the lectures of local engineers on building seismic code and retrofitting were included as main contents of the workshop programme. The lecture of the former JOCVs was focused on the importance of the preparedness for earthquakes and some example activities based on the past earthquake experiences in Japan. The basic workshop programme was as shown in the table below, which was slightly modified according to the availability of the local lecturers in each municipality.

Table 5.1.4 Awareness Workshop Programme

Time (min.)	Contents	Speakers/ Lecturers
Approx. 10	Opening Remarks and Background and Purpose of the Workshops	Executive Officer/ DRR Responsible Officer in Each Municipality Representative of JICA Project Team
Approx. 30	Earthquake Mechanism and Importance of Earthquake Resistant building from Japanese Experiences	Former JOCV
Approx. 30	Lecture 1: National Building Code and Seismic Resistant Buildings	Engineer of Each Municipality or Local Expert (from University or Private Company)
Approx. 30	Lecture 2: Seismic Retrofitting	Local Expert
Approx. 30	Q & A	
Approx. 10	Closing Remarks	DRR Responsible Officer in Each Municipality

Source: JICA Project Team

(2) Result of the Workshops

The distribution of the workshop participants was as shown in the Table 5.1.5.

Table 5.1.5 Participants of the Awareness Workshop

	Age				Gender			Profession							
	10-29	30-49	50〜	N.A.	Male	Female	N.A.	P.S.	O.W	H.B	AG	Const	Students	Others	N.A.
Lalitpur SMC	38	119	57	4	127	91	0	25	32	32	36	18	5	58	12
Bhaktapur	11	90	30	5	101	33	2	20	30	29	20	8	8	16	5
Budhanilkantha	15	88	28	2	101	29	3	24	18	25	34	0	2	19	11
Total	64	297	115	11	329	153	5	69	80	86	90	26	15	93	28
Rate (%)	13	61	24	2	68	31	1	14	16	18	18	5	3	19	6

(P.S.=Public Servant, O.W.=Office Worker, H.B.=Home Business, AG=Agriculture, Const=Construction)
Source: JICA Project Team

60% of the workshop participants were people in their 30's to 40's. The ratio of male to female was 70:30. The ratio of Community Disaster Management Committee (CDMC) members in the workshop participants marked large differences among the target municipalities; 53% in Lalitpur, 29% in Bhaktapur, and 7% in Budhanilkantha. This is attributed to the situation that Lalitpur SMC had promoted the establishment of the CDMC before the Gorkha earthquake.

The workshop implementation situation in each municipality was as follows.

<Lalitpur SMC>

- Almost all the invited participants fully attended the workshop and listened to the lectures attentively.
- Some participants made comments that they understood the importance of the seismic retrofitting, however, the cost of retrofitting would be a challenge.

- Some mentioned that the contents of the lecture were a bit difficult, however, most of the participants stayed until the end of the event and tried to learn and understand.

<Bhaktapur Municipality>

- Explanation of the Japanese experience by the former JOCV became a good introduction to the importance of seismic resistant buildings and important roles of the building code for the participants.
- Although the venue was quite large, the participants even at the back of the room carefully listened to the lectures.
- The lectures with practical samples were easily understandable.
- Some participants asked about future support for safe buildings, and requested the municipality to take some necessary measures for providing support.

<Budhanilkantha Municipality>

- Many questions were raised on the methods for seismic retrofitting. Some of them mentioned that the information related companies/organizations from where they get the retrofitting works done is very limited.
- Some participants were from construction related organizations or companies, and they asked about the detailed techniques for seismic resistant construction.

Lalitpur	Bhaktapur	Budhanilkantha
		
		

Source: JICA Project Team

Figure 5.1.3 Pictures of Workshop in Each Municipality

5.1.5 Broadcasting of radio awareness programme

(1) Development of Radio Awareness Programme

The radio programme was developed in cooperation with Radio Sagarmatha, a radio broadcasting company which has a reputation of a provider of social programmes and is mostly listened to by the people with decision-making power. The programme contents were developed focusing on raising awareness on the points that are required to construct safe building for protection from earthquake damage, and that it is important to comply with the building code when constructing buildings. The plot of the programme was developed based on the suggestion by Radio Sagarmatha, that the format of the programme should be a drama script with conversation among multi-speakers in order to deliver a message to the general public.

(2) Broadcasting of Radio Awareness Programme

The radio programme was broadcast not only by the Radio Sagarmatha but also by the Kantipur FM which has listeners of younger generations. The programme was put on air, several times a day scheduled after news programmes, for about one month from 19 August 2015.

Some of the positive comments from the listeners were as follows; "it is timely and well-organized for the contents and presentation of the programme", and "it delivers strong message and information on seismic resistant building. Especially the dialogue, I need to stop the construction of my house immediately, can appeal to the people. On the other hand, there were negative comments such as "the contents would be a bit difficult for the general public," and "the programme is too long to understand."

5.1.6 Survey to Grasp Change of Awareness after the Campaign

To review the workshop result, a survey was conducted to grasp the levels of earthquake knowledge and awareness of residents before and after the workshops. The outlines of the result of the survey are as follows.

Table 5.1.6 Participation in the Training on Earthquake before the Gorkha EQ

	Number of persons who participated: Organizer of the Training			Ratio of "partici-pated"	Never partici-pated (persons)	Ratio of "never partici-pated"	Total (persons)
	Govern-ment	Red Cross	Others				
Lalitpur SMC	76	86	58	80%	55	20%	275
Bhaktapur	37	45	14	69%	44	31%	140
Budhanilkantha	37	17	22	53%	68	47%	144
Total (persons)	150	148	94		167		559

Source: JICA Project Team

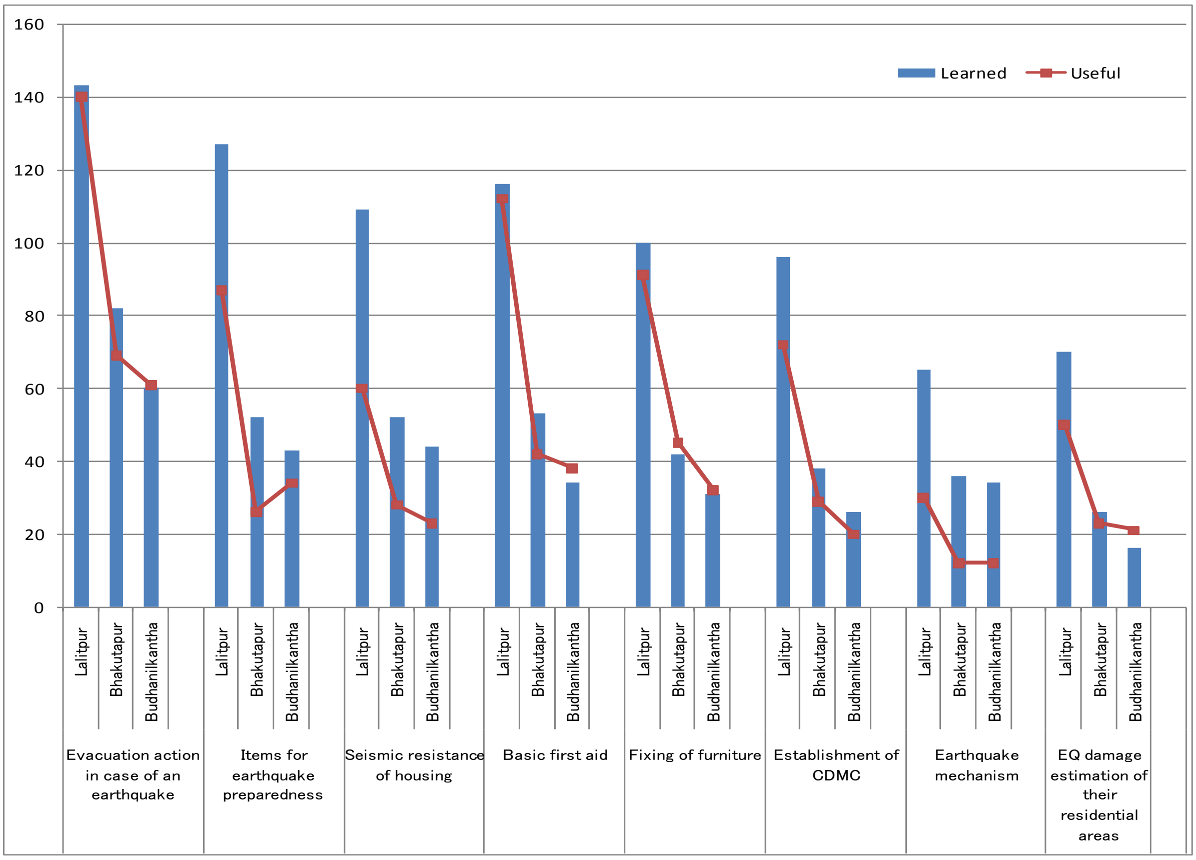
Ratio of the people who participated in training sessions on earthquake disasters before the Gorkha EQ is high in Lalitpur SMC which had promoted the establishment of the CDMC before the EQ. Meanwhile, half of the participants in Budhanilkantha answered that they had the experience of participation in the training sessions.

Table 5.1.7 (Question to the training participants) whether the knowledge learned in the training was helpful/ useful in the time of real earthquake or not

(multiple answers, *include some wrong answers)

	Lalitpur SMC		Bhaktapur		Budhanilkantha		Total
	Learned	Useful	Learned	Useful	Learned	Useful	
Evacuation action in case of an earthquake	143	140	82	69	60	61 *	285
Items for earthquake preparedness	127	87	52	26	43	34	222
Seismic resistance of housing	109	60	52	28	44	23	205
Basic first aid	116	112	53	42	34	38 *	203
Fixing of furniture	100	91	42	45	31	32 *	173
Establishment of CDMC	96	72	38	29	26	20	160
Earthquake Mechanism	65	30	36	12	34	12	135
Earthquake Damage Estimation of their residential areas	70	50	26	23	16	21 *	112
Others	3	3	0	1 *	1	0	4

Source: JICA Project Team



Source: JICA Project Team

Figure 5.1.4 Relation between "learned" and "useful"

What the participants learned most in the training was "evacuation action", and followed by "items for earthquake preparedness." The third theme was "seismic resistance of houses". What were helpful/useful among the learned knowledge in case of the Gorkha EQ were "evacuation action" and "basic first aid". A rather small number of responders selected "items for earthquake preparedness" and "seismic resistance of housing" as useful knowledge. It is assumed that the people did not recognize that they need to take preparedness action by themselves since the number of the people who learned about "earthquake damage estimation of their residential areas" was low.

As a review of what they learned in the Awareness Workshop, the participants were requested to answer the questions such as "What is important for making your houses seismic resistance?", " Why the National Building Code is Important?", and "What is Seismic Retrofitting?"

Table 5.1.8 Review of What They Learned in the Workshop: Important Things for Seismic Resistance of Their Houses

	Lalitpur SMC	Bhaktapur	Budhanilkantha	Total
Building design with seismic resistant structure	145	81	85	311
Compliance of National Building Code	149	86	98	333
Use of appropriate building materials	144	97	80	321
Seismic-resistant foundation	140	81	75	296
Training on seismic resistant construction for masonries and carpenters	137	83	64	284

Source: JICA Project Team

With the experience of the Gorkha earthquake, the participants became interested in seismic resistance of their own houses and learned further about what the lecturers explained in the workshop.

Table 5.1.9 Review of What They Learned in the Workshop: Why is the National Building Code Important?

Reasons	Lalitpur SMC	Bhaktapur	Budhanilkantha	Total
To secure health, safety and general welfare	129	69	61	311
To secure family's safety in case of an earthquake	133	78	61	333
Because it is regulated by the government	112	65	67	321
As a tool to secure structural safety of the building	125	57	70	252

Source: JICA Project Team

Also, most of the participants recognized the importance of the National Building Code as a tool for securing their safety.

Table 5.1.10 Review of What They Learned in the Workshop: What is the Seismic Retrofitting?

	Lalitpur SMC	Bhaktapur	Budhanilkantha	Total
Light damage of building can be repaired and retrofitted in consultation with experts.	102	49	48	199
Existing building can be retrofitted.	58	22	25	105
Inexpensive seismic retrofitting measures are studied.	21	4	17	42
Immediate seismic retrofitting is required for important bldgs such as hospitals, schools, and government bldgs to create seismic resistant society	111	55	54	220

Source: JICA Project Team

Many participants recognized that seismic retrofitting of houses can be done in consultation with the experts of related fields and that the seismic retrofitting of important public buildings is an urgent issue. Meanwhile, since the lecturers could not sufficiently explain the inexpensive seismic retrofitting methods for each type of buildings, the understanding of the participants on this topic was not high.

5.1.7 Result of Urgent Resilient and Safe Kathmandu Valley Campaign

Some of comments from the workshop participants were as follows; "more opportunities for this kind of programme should be provided to enhance people's awareness," "more presentations by various experts should be included in the programme," "too much content is included in the 2-3 hours" programme. The programme should be provided as 1-2 day programme", and "this kind of programme should be provided for not only general public but also construction workers. As shown in Table 5.1.11, many participants evaluated the workshop as very useful or useful, and had the desire to learn more. The workshop could adequately provide basic knowledge of the earthquake safe building, and achieved the purpose.

Table 5.1.11 Evaluation of the Workshop

	Lalitpur SMC	Bhaktapur	Budhanilkantha	Total
Very useful	101	36	71	208
Useful	70	44	36	150
Moderate	17	28	6	51
Need improvement	19	11	10	40
Not useful	2	3	4	9

Source: JICA Project Team

Since the preparation period of the workshop was short and the coordination time with the relevant people who had been busy for the earthquake rehabilitation and recovery works was also limited, the development of the brochure was not completed in time for the workshop implementation. However, the campaign activities could create opportunities to enhance people's awareness before they started the reconstruction of their houses and communities. After this, it is required to conduct awareness activities to further understand what they need to take actions in relation to the earthquake damage estimation of their own areas.

Appendix 6 Information Collection by Sub-contract

6.1 Building Inventory, Damage and Seismic Intensity Survey

6.1.1 Scope of the Survey

Scope of "Building Inventory, Damage and Seismic Intensity Survey" is as follows.

- Activity 1: Survey of all the buildings in Lalitpur Sub-metropolitan city and Bhaktapur Municipality
- Activity 2: Sample building survey (approx. 10,000 buildings survey) in nineteen municipalities

- Activity 3: Sample building survey (approx. 1,000 buildings survey) out of the valley
- Activity 4: Survey in sample areas by "Seismic Intensity Questionnaire"

Nominated tender process for the selection was taken, and two sub-consultants of "National Society for Earthquake Technology-Nepal (NSET)" and "GeoSpatial Systems PVT Ltd (GEO)" were selected for the survey work. The survey work started in September 2015 and was completed in March 2016. Additional survey work for Ward 23 to 30 of Lalitpur (LSMC), which were newly incorporated, completed in April 2016. As far as the survey results, the general information of buildings is shown in Section 2.1.1 Building (2016), seismic intensity survey is shown in Section 2.3.3 Intensity distribution by questionnaire survey, and building damage data is shown in Section 2.3.4 Building damage and its characteristics respectively. Main survey area map is shown in Figure 6.1.1.

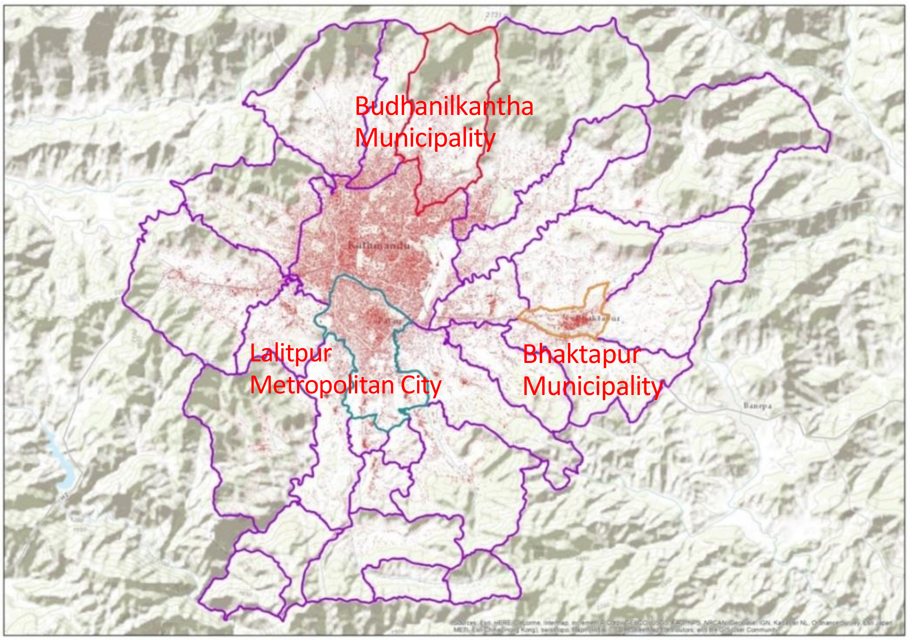


Figure 6.1.1 Main survey area map

6.1.2 Methodology

(1) Preparation for the survey and execution

Two day orientation training was conducted for the surveyors before the field survey work. The building survey was carried out by the simple visual observation of the buildings based on the survey sheet (Table 6.1.1). Residents were interviewed wherever possible.

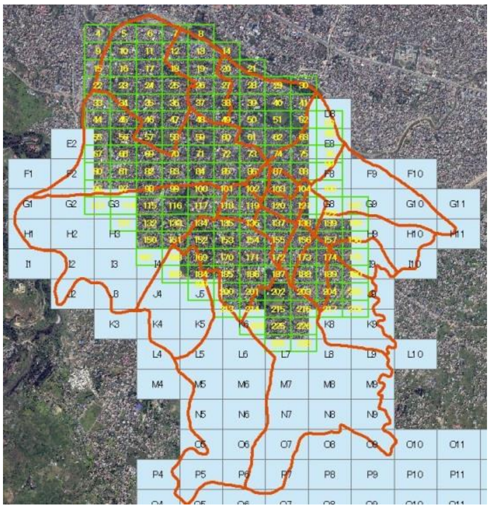
a) **Orientation Training** **b) c) Field survey work**

Source: JICA Project Team

Figure 6.1.2 Preparation and execution of building survey work

(2) Methodology Description of the Survey

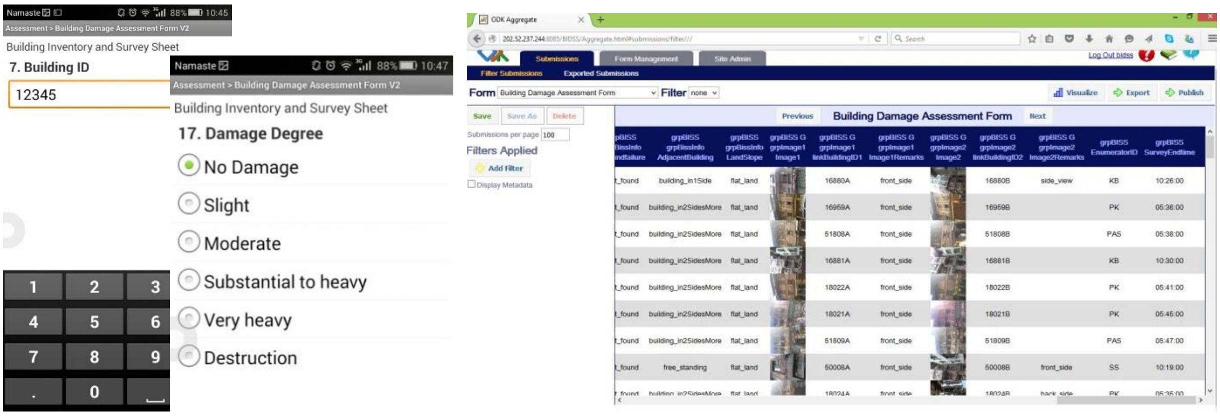
The Project Area is divided into an index sheet for the core area and the outer area (Figure 6.1.3 left). Core Area with 1:750 scale which include 151 sheets. Outer fringe area with 1:1250 scale which include 65 sheets. For each building of each area, ID numbering Unique ID is given with latitude and longitude co-ordinates (Figure 6.1.3 right).



Source: GeoSpatial/ JICA Project Team

Figure 6.1.3 Division of project area (left), ID numbering of each building (Right)

A sample screen of a tablet is shown in Figure 6.1.4 (left). Surveyed data was fed into a tablet at the very site using mobile application software developed by NSET. Input data were stored in the data server together with the photos of each building (Figure 6.1.4 (right)).



Source: NSET/ GeoSpatial/ JICA Project Team

Figure 6.1.4 A screenshot of the tablet (left), Storing to the data server (right)

6.1.3 Survey status

(1) Progress of the survey

Means of transportation for the field survey was restricted because of the fuel shortage, which continued for five months, but the survey work was completed almost on time set by the schedule. The number of surveyed buildings is approximately 13,500 in Bhaktapur Municipality, and 46,500 in Lalitpur Sub-metropolitan cCity (LSMC including new area of Ward 23 to 30 which is 8,700).

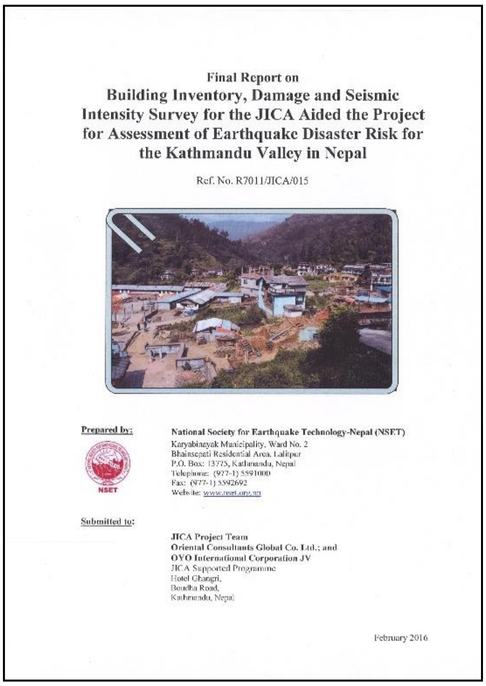
(2) Inspection of the field survey work

Inspection of the field survey work was done with the attendance of C/P personal of MOUD (Ministry of Urban Development) and DUDBC (Department of Urban Development and Building Construction) at an area of LSMC on 11th December 2015. The survey process such as the use of mapping with ID numbering of buildings, survey item (damage grade survey), and input of data into a tablet were introduced from the surveyor. Then, various topics such as the training of surveyors, management system and production of database, and usage of the survey result was discussed at the office.

6.1.4 Building survey report

The main component of the survey report is shown below, and the cover page of the report is shown in Figure 6.1.5.

1. INTRODUCTION
2. APPROACH AND METHODS
3. ACTIVITIES
4. SUMMARY OF DATA AND RESULTS
5. CONLUSIONS



Final Report on
Building Inventory, Damage and Seismic Intensity Survey for the JICA Aided the Project for Assessment of Earthquake Disaster Risk for the Kathmandu Valley in Nepal

Ref. No. R7011/JICA/015

Prepared by:

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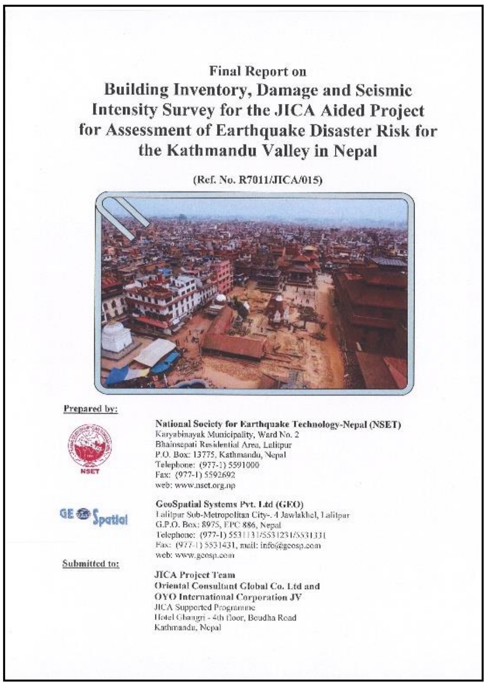
February 2016



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Kathmandu, Nepal

Source: JICA Project Team/ NSET/ GeoSpatial

Figure 6.1.5 Survey report on the Building Inventory, Damage and Seismic Intensity Survey

6.1.5 Building survey data in Budhanilkantha Municipality

The building inventory and damage survey in Budhanilkantha Municipality has been done by USAID/ NSET as a part of "Public Private Partnership for Earthquake Risk Management (3PERM)". MOU for the exchange of survey data was signed by related parties. Total surveyed number of building in Budhanilkantha Municipality is approximately 15,900.

Table 6.1.1 Survey sheet

Building Inventory and Damage Survey Sheet **Date: / /**

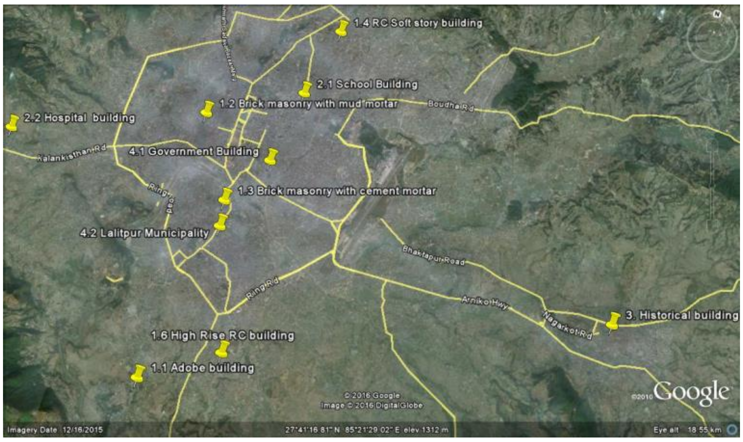
Municipality:		**Ward:**	**Tole:**
Building address*1:			
Building ID:			
Longitude:		**Latitude:**	
Number of story:		**Approx. bldg. area:**	m x m
Structure type*2:	1. Adobe	2. Stone with mud mortar	3. Stone with cement mortar
	4. Brick with mud mortar	5. Brick with cement mortar	6. RC frame, non-engineered
	7. RC frame, engineered	8. Others (Steel, Wooden frame,)	
Irregularity*3:	1. Soft storey	2. Overhang	3. Ordinary
Roof type :	1. Flexible (wooden and clay)	2. Flexible (wooden and CGI sheet)	3. Rigid (concrete)
Usage:	1. Residence	2. Residence & shop at GFL	3. Office
	4. Commercial	5. Educational	6. Hospital
	7. Governmental building	8. Historical& temples	9. Hotel & Restaurant
	10. Industrial	11. Assembly	12. Others ( )
Constructed year*7	1. 1- 10 years 2. 10- 20 years	3. 20-30 years	4. > 30 years
Damage degree*4:	0. No damage	1. Slight	2. Moderate
	3. Substantial to heavy	4. Very heavy	5. Destruction
Ground failure:	0. Not found	1. Liquefaction	2. Landslide
	3. Settlement		
Adjacent building:	1. Free standing	2. Building in 1 side	3. Building in 2 sides/ more
Land slope*5:	1. Flat land	2. Moderate	3. Steep (> 30 degrees)
Photos*6:	(link to building ID.)		
Remarks:	*1: Address, not mandatory *2: Structural type at GFL is shown in case of mixed structure vertically. *3: Irregularity, "soft storey" means RC frames with no or little brick walls at GFL compared with upper storey. *4: Damage degree, refer to attached Figures of EMS-98. *5: Land slope is judged by the visual observation. *6: At least 2 photos including overview and specific feature. *7: Constructed year by visual observation of GFL.		

6.2 Building Detail Survey

6.2.1 Outline

The nomination was done by tendering process, and "Earthquake Safety Solutions (ESS)" was selected for the sub-consultant of the "Building detail survey". The survey work started in December 2015 and was completed in March 2016. The existing typical building drawings and related data were collected for seismic assessment, and the result is utilized for the revision of damage function for buildings. The location map is shown in Figure 6.2.1. The scope of the survey is as follows:

1) Representative residential building, total of six buildings
2) Typical school building (brick masonry) and hospital building (RC), one each.
3) Historical building (brick masonry), one building
4) Governmental building, two buildings (drawing collected by the JICA Project Team)



Source: ESS

Figure 6.2.1 Location map

6.2.2 Selection of Buildings

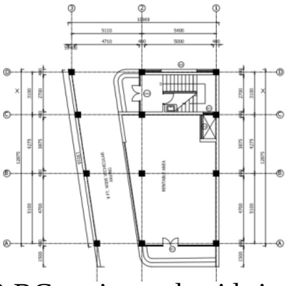
(1) Typical residential buildings

a) Adobe

B) Brick masonry with mud mortar

c) Brick masonry with cement mortar

d) RC non-engineered (soft story)



e) RC engineered. mid-rise

f) RC engineered high-rise

Source: ESS

Figure 6.2.2 Building detail survey (residential building)

(2) Typical public school building and hospital building

a) School: Brick masonry with cement mortar

b) Hospital: RC engineered

Source: ESS

Figure 6.2.3 Building detail survey (school and hospital)

(3) Historical building (brick masonry)

“Dyochhen” which is a Newari house as well as a temple, and is called as “Residence of God or Guard of God“, was selected in Bhaktapur. This building was damaged in the Nepal-Bihar earthquake in 1934, and had been reconstructed.

Source: ESS

Figure 6.2.4 Building detail survey (historical building)

(4) Governmental buildings

a) Governmental building

b) Municipality building

Source: ESS

Figure 6.2.5 Governmental buildings

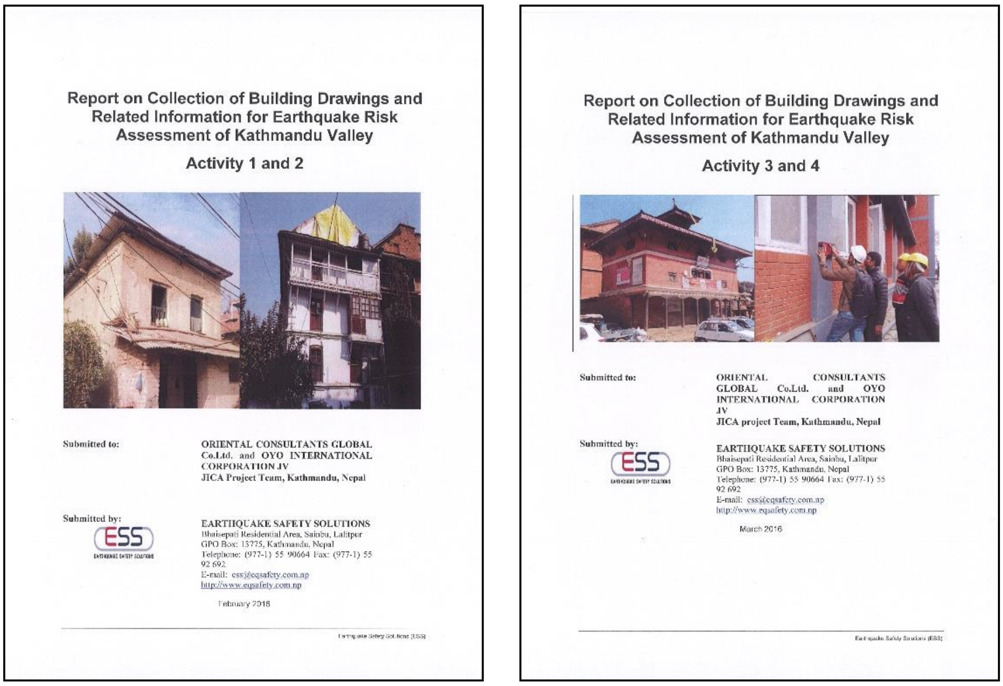
“Dyochhen” of item 3, and governmental buildings and municipality buildings of item 4 were selected by the suggestion and support of MOUD. As far as a governmental buildings, re-bar detail of column and concrete core strength survey were done at the site, since there was a lack of as-built drawings (Figure 6.2.6).

left) Marking the exact location of the re-bar with a re-bar detector
centre) Fixing the core cutter in the exactly marked location where it doesn’t touch the re-bar
right) Testing of the concrete core taken from the ground floor column (D18)
Source: ESS

Figure 6.2.6 Concrete core sampling and strength test (governmental building)

6.2.3 Survey report

Cover of the survey report is shown in Figure 6.2.7. The collected data of structural members and materials is shown in Table 6.2.1. The result of seismic assessment for No. 1 to 5 is shown in Section 5.1. Risk assessment (building), and seismic assessment of No. 6 to 11 are under processing as of July 2016.



Report on Collection of Building Drawings and Related Information for Earthquake Risk Assessment of Kathmandu Valley

Activity 1 and 2

Submitted to: ORIENTAL CONSULTANTS GLOBAL Co.Ltd. and OYO INTERNATIONAL CORPORATION JV
JICA Project Team, Kathmandu, Nepal

Submitted by: EARTHQUAKE SAFETY SOLUTIONS
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February 2016

Earthquake Safety Solutions (ESS)

Report on Collection of Building Drawings and Related Information for Earthquake Risk Assessment of Kathmandu Valley

Activity 3 and 4

Submitted to: ORIENTAL CONSULTANTS GLOBAL Co.Ltd. and OYO INTERNATIONAL CORPORATION JV
JICA project Team, Kathmandu, Nepal

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March 2016

Earthquake Safety Solutions (ESS)

Source: ESS

Figure 6.2.7 Report of building detail survey

Table 6.2.1 Structural type and member/ material data

S.N	Typology	Member size and Material information
1	Adobe	Wall thickness: 450mm Supposed shear strength of mortar = 0.072 MPa
2	Brick Masonry in Mud Mortar	Wall thickness: 700mm, 650mm, 600mm, Supposed shear strength of mortar = 0.11 MPa
3	Brick Masonry in Cement Mortar	Wall thickness: External wall 350mm brick wall Internal walls are 350, 225 and 100 mm brick walls Supposed shear strength of mortar = 0.5 MPa
4	RC soft story with non-engineered construction	Column size: 225mmX 225mm Concrete Strength: 15MPa (Cube) Yield strength of reinforcement: 415MPa
5	RC Framed by engineered construction	Column size: 400mmX 400mm Compressive strength of concrete: 25MPa for columns, 20 MPa for others Yield strength of re-bar: 415 MPa
6	RC Frame high-rise by engineered construction	Column: various size, Shear walls 250mm and 300mm thick Concrete Strength (Design)-30MPa~20MPa Yield strength of re-bar: 415MPa
7	Brick Masonry school building	Ground floor walls 350mm, 230mm, and first floor and second floor walls 350mm, 230mm, 115mm Supposed shear strength of mortar: 0.248 MPa
8	RC Frame Hospital Building	Column size: 450mm x 450mm and 500mm x 500mm Design compressive strength of Concrete: 20MPa with super plasticizer Yield strength of re-bar: 415mpa
9	Historical Building	Wall thickness: 600mm, 450mm Supposed shear strength of the Mortar joint: 0.11 MPa
10	Government Building 1	Column Size: 500mm X 500mm, 450mm X 350mm Concrete strength 16.3 MPa, 19.9 MPa (from core test) Rebar: 415 MPa
11	Government Building 2 (Construction year 1992)	Column Size: 600mm X 600mm~500mm X 500mm~350mm X 350mm Concrete cubic strength: 23.83 MPa Re-bar, Specified Yield Strength: 295 N/mm2

Source: ESS

6.3 Population, Social and Economic Statistics Data and Baseline Survey

6.3.1 Summary

Human loss assessment needs population and area-wise population distribution. Since risk assessment will be carried out for now (2016) and for 20 years in the future (2036), the population and distribution of 2016 and 2036 were estimated based on the 2011 census statistics considering the urban development and land use plan. On the other hand, the estimation of economic loss requires the basic data for GDP, economic growth rate, economic status of different sectors, construction cost for building, infrastructure, etc. The survey for such kinds of data together with the community and personal baseline survey which will be used for community disaster reduction activities, were implemented by subcontract. The results of the population estimation is shown in 2-1-7, basic statistics on social and economy in 2-1-8 and those on community and personal baseline survey in 6-2-4. General matters on the subcontract are outlined here.

Title of subcontract： The Population, Social and Economic Statistics Data and Baseline Survey

Subcontractor： Full Bright Consultancy (Pvt.) Ltd.
316 Baburam Acharya Sadak, Sinamangal, Kathmandu, Nepal
Tel: +977-1-44 68749, 44 68118
Fax: + 977-1-44 65604

Period： From 20 December 2015 to 29 April 2016

Scope of work

Activity-1: Population Distribution

- Population growth rate of district and municipality of KV.
- Ward-wise population distribution of 2016 for day-time, night-time, weekday, holiday, summer and winter of KV.
- Ward-wise population distribution prediction for 2026, 2036 for day-time, night-time, weekday, holiday, summer and winter of KV.

Activity-2: Social and Economic Statistics Data

- Economic growth rate of the past twenty years and breakdown into category of industry and prediction of future economic growth rate for each category of industry, district and municipality
- Economic scale in terms of GDP and breakdown into category of industry, district, municipality and prediction at 2026 and 2036

- Construction cost of residential houses, schools, hospitals, commercial and industrial facilities, roads, bridges, and lifelines. (Detail is described in Annex A)
- Increasing number of buildings and its distribution at the ward-wise level at 2026 and 2036.
- Seasonal features and differences of economic activities of KV.
- Data collection regarding the tourism

Activity-3: Community Profile

A: Basic Information

- Location of the community (boundary of the community in the map)
- Number of population and households, and population growth trend
- Population by age, gender, ethnic groups, caste, religions, and economic situation
- Number of vulnerable population (disabled, foreigners, and travelers)
- Structure of community, authority, leadership, and caste
- Characteristics of community (year of first settlement, type of settlement: traditional village, developed by government, or developed by private company, etc., geological condition: commercial, residential, paddy field, mountainous area, economic activities: agriculture, home industry, tourist business, small business, etc.)
- Land use status
- Social condition (average literacy rate, poverty rate, infant mortality rate, and unemployment rate)
- Current condition of infrastructure and lifeline (pavement of road, electricity distribution, coverage of water supply, coverage of gas supply, penetration of land phone, cell-phone, and internet, sewage)
- Number of school by levels (kindergarten, elementary, secondary, college, university, etc.)
- Number of medical facilities by types (hospitals, clinics, healthcare centres, pharmacies, etc.)

B: Information on disasters and disaster risk management

- Brief outline of the disaster condition in the community (main/frequent disasters)
- List of past major disasters (date, scale, and damage)
- Community organizations (social cooperative system, groups, activities, etc.)
- Organizations for disaster risk management and their activities (ex. Community disaster management committee: CDMC)
- Facilities for disaster risk management in the community (designation of evacuation

sites/shelters, community hazard/risk map, early warning information dissemination devices, search and rescue equipment, etc.)

- Current issues and problems on disasters and disaster risk management in the community
- Expectation and request to the governments for disaster risk management in the community
- Necessary countermeasures and activities for disaster risk management in the community

Activity-4: Personal Profile

A: Basic Information

- Family structure, income source of the family, and caste
- Age, gender, ethnic group, education level, and occupation

B: Information on disasters and disaster risk management

- Type of house (structure: masonry, wood or RC frame, wall: brick, stone, wood, etc., construction year, ownership: self/family-owned, rent, lodging, etc.)
- Damage situation of the house by the earthquake of April/May 2015 (completely collapsed, partially collapsed, lightly damaged, no damage, etc.)
- Past experience of disasters
- Education of disasters and disaster risk management in the schools (own experience)
- Participation to disaster management activities in the past (types of the activities, organizers of the activities, and satisfaction of the activities)
- Participation in the DRM organizations in the community
- Knowledge on disaster risk (earthquake, flood, landslides, climate change, and others) and disaster risk management (first aid, preparedness of the stockpile and emergency supply, community early warning, community risk assessment, community hazard/risk map, building safety, evacuation drill, etc.)
- Expectation and request to the governments for disaster risk management in the community

6.3.2 Community Baseline Survey: Community and Personal Profiles

It is necessary to grasp the current situation of awareness on DRR and knowledge of earthquakes in the communities and residents when formulating a local disaster management plan. Also, it is important to verify how people's awareness has changed through the pilot activities. For these purposes, a community baseline survey was conducted to figure out the profile and analyse the current condition of the communities and residents as information before the pilot activities.

(1) Outline of the Survey

The outline of the survey method, period, and contents is as shown in the Table 6.3.1.

Table 6.3.1 Contents of the Community Baseline Survey

Purpose of the Survey:	To obtain community and personal profiles of the target wards		
Target of the Survey:	3 wards (communities) from each of the three pilot municipalities 20 people from each of the three selected wards (Total 9 wards, 180 people)		
Survey Method:	Questionnaire survey, Interview survey by the prepared questionnaire sheet, and Collection of secondary data		
Subcontracting Period:	20 December 2015 – 29 April 2016 (Period of Survey in target ward: 11 February – 28 March 2016）		
Survey Contents:	Community Profile	Basic Information	➢ Population, ethnic, organizational structure, culture and religion of the community ➢ Main productive and economic activities and land use status ➢ Conditions of infrastructure and lifeline facilities (road, electricity, communication, water supply, education, health and sanitation, etc.) ➢ Mechanism of authorities in the community
		Disaster and DRR Information	➢ Disaster history ➢ Current condition of disaster management system ➢ Experiences of DRR activities ➢ Required DRR measures and activities and expectation to the government
	Personal Profile	Basic Information	➢ Family composition (male/female, age) and ethnic composition ➢ Education levels and sources of income ➢ Housing condition
		Disaster and DRR Information	➢ Knowledge on disasters and DRR, disaster experiences, awareness on DRR, and risk recognition ➢ Participation in the DRR activities ➢ Required DRR measures and activities and expectation from the government

Source: JICA Project Team

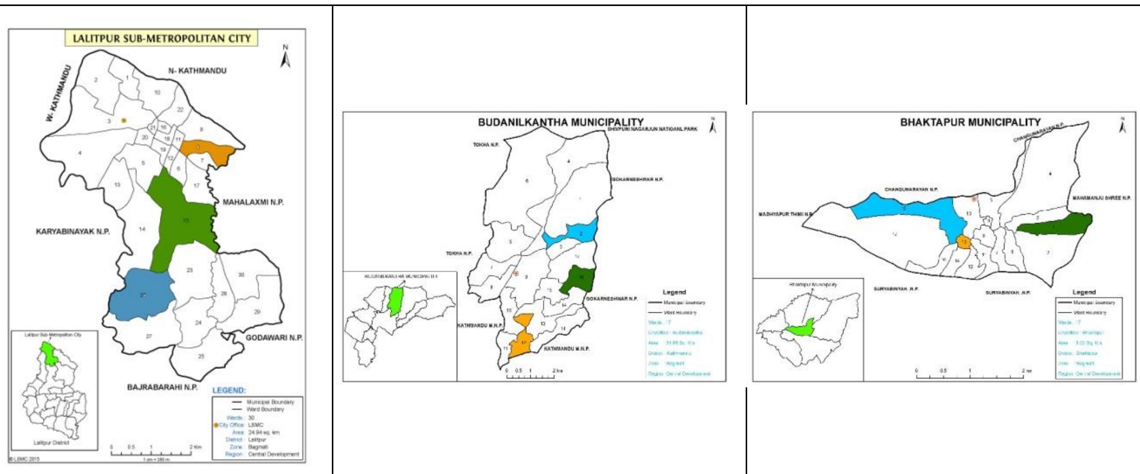
(2) Target Communities of the Survey

In consultation with the counterparts of each pilot municipality, communities with different area characteristics (core urban settlement, developing/semi-urban settlement, newly added emerging ward) were selected for the targets of the survey. The selected communities are as shown in Table 6.3.2 and the Figure 6.3.1.

Table 6.3.2 Target Communities of the Community Baseline Survey

	Ward No. /Ward Name		
	Lalitpur	**Budhanilkantha**	**Bhaktapur**
■ Core Urban Settlement	Ward-8*/ Gokul Chaur	Ward-12/ Kapan	Ward-13/ Kolachen
■ Developing/ Semi-Urban Settlement	Ward-15/ Satdobato	Ward-16/ Chunikhel	Ward-1/ Suryamadhi
■ Newly Added Emerging Ward	Ward-26/ Sunakothi	Ward-2/ Chapali-Bhadrakali	Ward-15/ Itachen

*It is planned to develop a disaster management park by the RRNE Project



Lalitpur SMC	Budhanilkantha Municipality	Bhaktapur Municipality

Source: JICA Project Team

Figure 6.3.1 Location of the Target Communities of the Survey

(3) Basic Information of Each Target Community

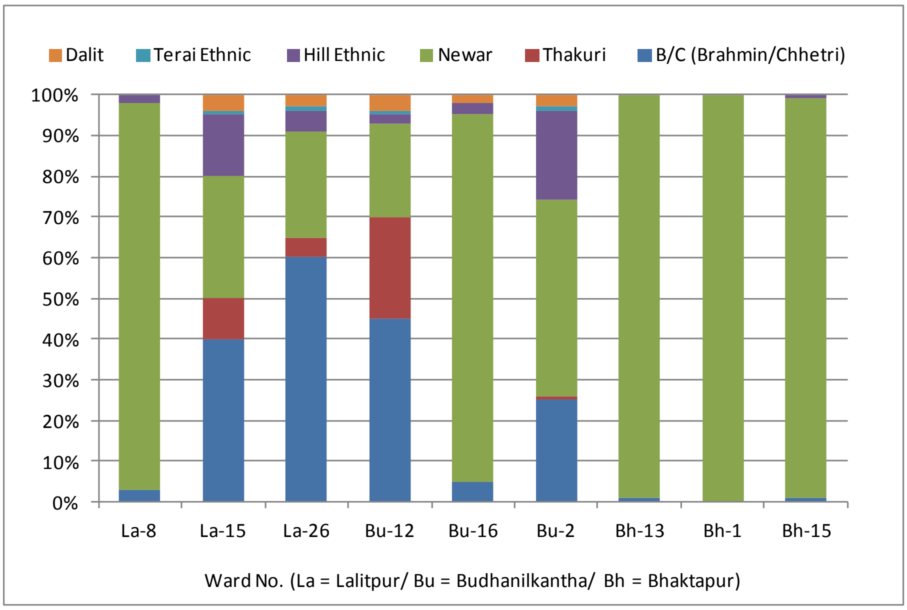
The outline of the basic information of each target community is as shown in the Table 6.3.3.

Table 6.3.3 Outline of the Basic Information of the Target Communities

	Ward Established Year	Area	Population (person)	Remarks	CDMC Establishment
Lalitpur SMC					
Ward-8/ Gokul Chaur	1960	0.48km^2	11,400	Area which have local commodity stores along the Ring road	Established (2012)
Ward-15/ Satdobato	1991	2.61km^2	13,853	Area along the Ring road and Surrounding Residential Area	Established (2012)
Ward-26/ Sunakothi	2014	1.90km^2	5,813	40% Agricultural land 70% Newly Developed area	Established (2013)
Budhanilkantha Municipality					
Ward-12/ Kapan	2014	5.40km^2	24,050	Residential Area	Not Yet
Ward-16/ Chunikhel	2014	3.60km^2	1,580	75% Agricultural land 20% Old Residential Area (25-50 years old)	Not Yet
Ward-2/ Chapali-Bhadrakali	2014	13.5km^2	2,051	Northern part: Shivapuri National Park (9.2 km2) Other part: Residential Area (10-15 years old)	Not Yet
Bhaktapur Municipality					
Ward-13/ Kolachen	1990	0.05km^2	2,225	Adjacent to Durbar Square 95% Old Residential Area	Established (2013)
Ward-1/ Suryamadhi	1991	0.31km^2	4,805	40% Agricultural land	Not Yet
Ward-15/ Itachen	1990	0.64km^2	6,044	Bhaktapur industrial area (0.04km^2) Southern part: Residential Area	Not Yet

Source: JICA Project Team

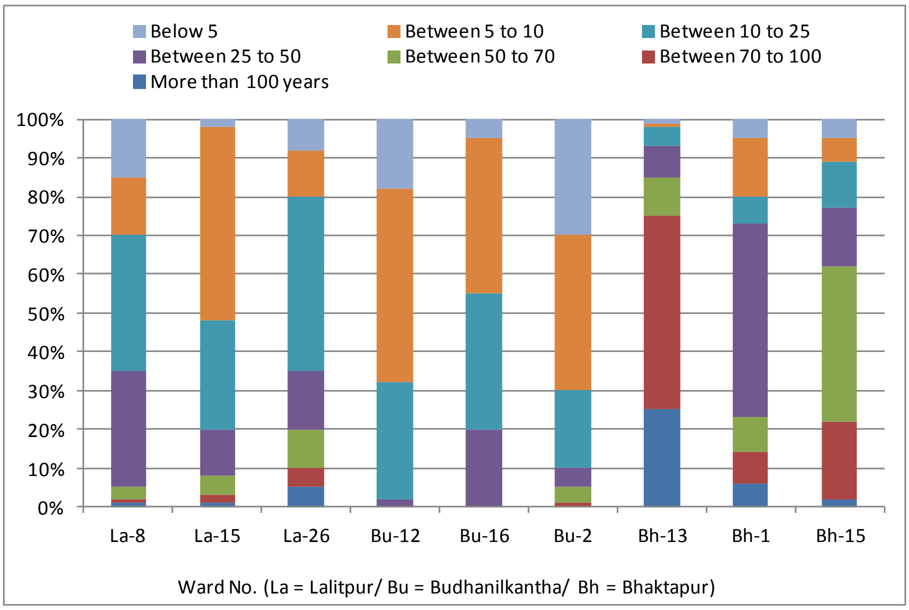
The ethnic composition of the each target community is as shown in Figure 6.3.2. The three target wards in Bhaktapur Municipality are dominated by Newar. Also, the ward 8 of Lalitpur SMC and the ward 16 of the Budhanilkantha Municipality are dominated by Newar. In other wards, several ethnic groups such as Brahmin/Chhetri, Newar, and Thakuri are mixed.



Source: JICA Project Team

Figure 6.3.2 Ethnic Composition of Each Target Community

The ratio of ages of the housing in each target community is as shown in the Figure 6.3.3. The three target wards in Bhaktapur Municipality have more aged housing compared to those in the other two municipalities. In Budhanilkantha, there is much newer housing.



Source: JICA Project Team

Figure 6.3.3 Ratio of Ages of Housing in Each Target Community

Detailed contents of the community and personal profiles are referred to in Annex 2-5-1. In addition, the outline of the result of the questionnaire survey in the target communities is described in the plan of the 2nd term of the Project in Chapter 9.

6.4 Soil investigation including microtremor measurement

The soil data were collected, organized, and for the part of support for the work of creating a land model, re-commissioned ground survey including the microtremor measurement were carried out. The summaries are as follows.

1) The subject of Re-entrustment: Supporting Work for Field Survey and Ground Modelling
2) Trader name of Re-entrustment: Three D. Consultants P. Ltd.
3) Contract performance period: From Sept. 21, 2015 to Jan. 21, 2016 (Five months)
4) Summary of Re-entrustment contract:
5) Composed of the Activity A and Activity B.

6.4.1 Activity (Supporting the microtremor measurement)

- This activity is carried out to measure the L-shape array microtremor measurement and triangular array microtremor measurement for the purpose of understanding the S-wave velocity of the target area under the guidance of JICA experts. In addition, getting permission from the land owner for the selection has been an investigated point, carrying data by GIS.

(1) Collection of basic data for evaluation of liquefaction and slope.

- Collection of disaster hysteresis of liquefaction and slope.
- *C, φ*、result of test for physical properties etc., collection of basic data regarding liquefaction and slope.

(2) Ascertainment survey of Slope

- To Create Slope survey sheets.
- To check t slope on site.

6.4.2 Summary of results.

(1) Activity A (Supporting the microtremor measurement)

The following microtremor measurement was carried out. These analytical results were utilized to create soil model.

a) Triangle array microtremor measurements:

5 locations

b) L-shape array microtremor measurements:

74 locations

c) Three point array microtremor measurements:

39 locations

d) Single-point array microtremor measurements:

74 + 4 =78 locations, and list of measurement sites are shown Table 6.4.1 and Table 6.4.2 below,

(2) Activity B (Creating the Soil model, Liquefaction, Slope data collection)

It will collect the basic information to create the soil model and compile it using the GIS.

a) Supporting for creating the soil model

The Project Team supported the creation of geological sections for a total of 25 sections; East-West eleven sections, South-North fourteen sections. The results are shown in the text.

b) Collection of basic data for evaluations of liquefaction and slope.

Collection of related ground physical properties of the disaster history of liquefaction and slope was carried out, the results were organized, and were used as a basic data of liquefaction and slope rating. The results are shown in Figure 6.4.1 below; the seventeen liquefaction points (including a non-liquefaction) and thirteen slope points (including no effect).

c) Site ascertainment survey of the slope

Site inspection survey of the slope was carried out at thirteen points in Figure 6.4.2 below.

Table 6.4.1 List of microtremor measurement locations

Sr. No.	Point No.	Location	L-shape Array	3 point Array	Single point
1	L 01	Radhe Radhe Thimi	25-Sep	-	25-Sep
2	L 02	Birendra School Sallaghari	28-Sep	-	28-Sep
3	L 03	DMG Lainchaur	7-Sep	10-Nov	5-Oct
4	L 04	Chovar football ground	9-Sep	-	6-Oct
5	L 05	Singha darbar	18-Sep	18-Nov	18-Nov
6	L 06	Gangahiti chabahil	27-Sep	-	27-Sep
7	L 07	Janahit galli Sifal	29-Sep	-	29-Sep
8	L 08	Near Baidya khana	17-Sep	2-Nov	7-Oct
9	L 09	Sunrise City Home, Bijulibazar	16-Sep	2-Nov	7-Oct
10	L 10	Dallu bridge	5-Oct	-	5-Oct
11	L 11	Fire station darbar square	13-Sep	3-Nov	5-Oct
12	L12	UN park Thapathali Bagmati bridge	1-Oct	-	1-Oct
13	L 13	Staff college	16-Sep	6-Nov	7-Oct
14	L 14	Manahara bridge	25-Sep	-	25-Sep
15	L 15	Simaltol harisiddhi	30-Sep	-	30-Sep
16	L 16	Lazimpat building opposite Shangrila	13-Sep	6-Nov	11-Oct
17	L 17	Dhobichaur Chetrapati	29-Sep	-	29-Sep
18	L 18	Tripuresor, near Industry ministry	13-Sep	-	5-Oct
19	L 19	Orchid Tower Ravibhawan	17-Sep	2-Nov	2-Nov
20	L 20	Metro apartment KULESOR	14-Sep	3-Nov	7-Oct
21	L 21	Status Enclave Sanepa	14-Sep	2-Nov	2-Nov
22	L 22	Surendra bhawan sanepa, Internationla club	2-Oct	3-Nov	2-Oct
23	L 23	Emperial Cour Sanepa	14-Sep	-	7-Oct
24	L 24	Sunrise tower Dhobighat	2-Oct	5-Nov	2-Oct
25	L 25	Tinthana Naikap	2-Oct	-	2-Oct
26	L 26	NSET Bhaisepati	9-Sep	-	6-Oct
27	L 27	DOR New Banesor	16-Sep	-	7-Oct
28	L 28	Suncity 2 Gothatar	17-Sep	-	12-Oct
29	L 29	Water treatment plant Bode	12-Oct	12-Oct	12-Oct
30	L 30	Ratopati Nagarkot	8-Oct	8-Oct	8-Oct
31	L 31	Grande Tower, Tokha	22-Sep	-	11-Oct
32	L 32	Matikhel Thankot	14-Oct	14-Oct	14-Oct
33	L 33	kattike Nagarkot	25-Oct	25-Oct	25-Oct
34	L 34	Suntol Sankhu	16-Oct	16-Oct	16-Oct
35	Ll 35	Shahidghat Sundarijal	13-Oct	13-Oct	13-Oct
36	L 36	Nayapati Sundarijal	13-Oct	13-Oct	13-Oct
37	L 37	Shrijana Tol Mulpani	8-Oct	8-Oct	8-Oct
38	L 38	Mahankal chowk Duwakot	28-Sep	-	28-Sep
39	L 39	Libali Bhaktapur	28-Sep	4-Nov	28-Sep
40	L 40	Mahadevthan Sirutar	4-Oct	-	4-Oct
41	L 41	Godawari bridge, Bisnudol	4-Oct	-	4-Oct
42	L 42	Khalpitar (Bhakot 49)	25-Sep	4-Nov	25-Sep

Source: JICA Project Team

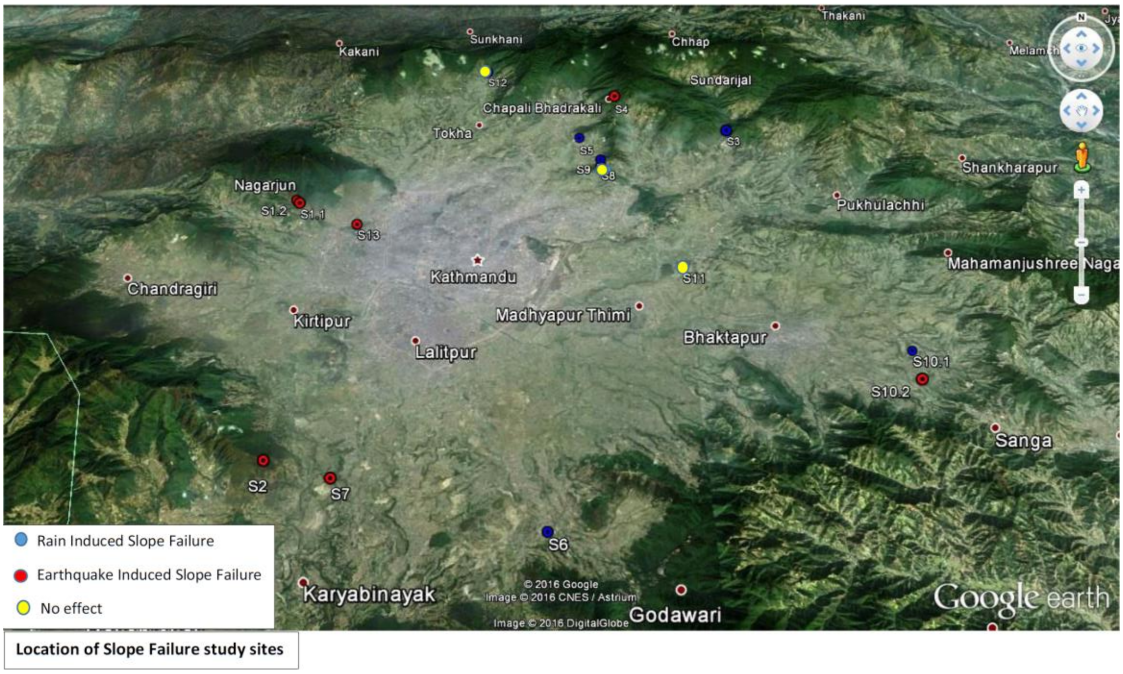
Table 6.4.2 List of microtremor measurement locations (the above continued)

Sr. No.	Point No.	Location	L-shape Array	3 point Array	Single point
43	L 43	Aphalfat Imadol	4-Oct	-	4-Oct
44	L 44	SOS Hostel Kotesor	1-Oct	-	1-Oct
45	L 45	Abandoned	Abandoned	Abandoned	Abandoned
46	L 46	Chyasal Lalitpur	1-Oct	-	1-Oct
47	L 47	Hattisar Naxal	29-Sep	-	29-Sep
48	L 48	Bungamati Lalitpur	15-Oct	15-Oct	15-Oct
49	L 49	Padma Colony	24-Sep	-	24-Sep
50	L 50	Siuchatar	23-Sep	-	23-Sep
51	L 51	Machegaun	24-Sep	-	24-Sep
52	L 52	Panga Kirtipur	6-Oct	5-Nov	6-Oct
53	L 53	Tribhuvan U, geology Dept Kirtipur	18-Sep	5-Nov	6-Oct
54	L 54	Matatirtha	14-Oct	14-Oct	14-Oct
55	L 55	Cricket stadium Gokarna	27-Sep	-	27-Sep
56	L 56	Simaltar Kapan	27-Sep	-	27-Sep
57	L 57	Chunikhel	22-Sep	-	11-Oct
58	L 58	Muhan Pokhari Narayansthan	11-Oct	11-Oct	11-Oct
59	L 59	Pasikot	22-Sep	-	11-Oct
60	L 60	Phutung	23-Sep	-	23-Sep
61	L 61	Madkhu	23-Sep	-	23-Sep
62	L 62	Dakchinkali	27-Oct	27-Oct	27-Oct
63	L 63	Pharsidol	26-Oct	26-Oct	26-Oct
64	L 64	Durikhel Thecho	15-Oct	15-Oct	15-Oct
65	L 65	Kitini	30-Sep	-	30-Sep
66	LS 66	Mill road Bode 2	12-Oct	12-Oct	12-Oct
67	LS 67	Mitra Park	30-Oct	30-Oct	30-Oct
68	LS 68	Chovar, abandoned qarry site	6-Oct	-	6-Oct
69	LS 69	Mitra Nagar behind New Buspark	28-Oct	28-Oct	28-Oct
70	LS 70	Chaamati	30-Oct	30-Oct	30-Oct
71	LS 71	Manag gate	28-Oct	28-Oct	28-Oct
72	LS 72	Wotungal Thecho 7	23-Nov	23-Nov	23-Nov
73	LS 73	Sunakothi lalitpur	23-Nov	23-Nov	23-Nov
74	LS 74	Taukhel	22-Nov	22-Nov	22-Nov
75	LS 75	Godamchaur	22-Nov	22-Nov	22-Nov
			74	39	74

Traingle Array

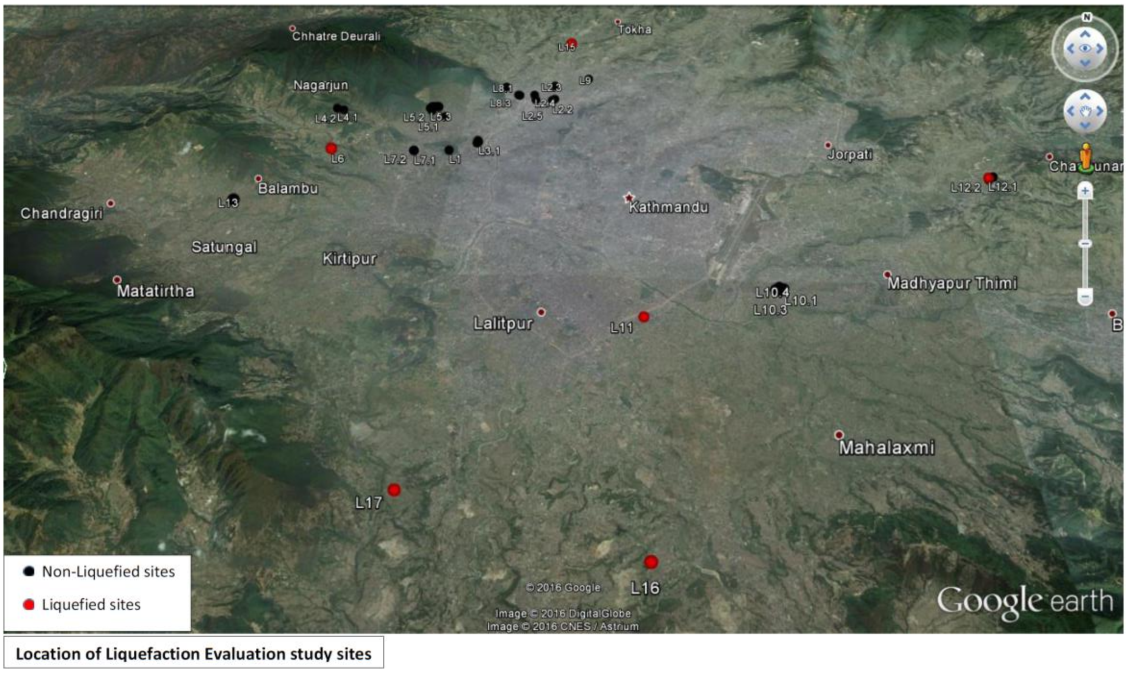
Sr. No.	Site No.	Location	Survey work		Single point
1	AM-01	Tribhuvan University	8-Nov		-
2	AM-02	IOE, Phulchowk	15-Nov		15-Nov
3	AM-03	CTEVT, Thimi	24-Nov		24-Nov
4	AM-04	Tundikhel	26-Nov		26-Nov
5	AM-05	Manohara	19-Nov		19-Nov
			5		4

Source: JICA Project Team



Source: JICA Project Team

Figure 6.4.1 Liquefaction history point distribution by re-entrustment survey



Source: JICA Project Team

Figure 6.4.2 Slope influence history point distribution by re-commissioned survey

6.5 CBDRRM Activity

In the Project, the CBDRRM activities were conducted with sub-contracting to a local NGO. For the purpose of enhancing capacities of municipality officers to continuously conduct the CBDRRM activities, the local NGO which has provided CBDRRM activities in the past in Nepal was selected for the sub-contract works.

6.5.1 Outline of the Subcontract

The outline of the subcontract to a local NGO for the CBDRRM activities was as shown in the Table 6.5.1.

Table 6.5.1 Contents of the Subcontract to a Local NGO

<table>
<tr><td>Outline of the Work</td><td colspan="2">To coordinate the implementation of the CBDRRM activities to be conducted in the ERAKV Project in collaboration with the JICA Project Team and the counterpart organizations of Nepal</td></tr>
<tr><td>Target of the Activities:</td><td colspan="2">3 pilot municipalities and a selected target ward from each of the three pilot municipalities (total 3 wards)</td></tr>
<tr><td>Subcontracting Period:</td><td colspan="2">22 December 2016 – 31 December 2017
(Note: to be extended according to the situation of the submission of the reports)</td></tr>
<tr><td>Cost for the Subcontract</td><td colspan="2">USD 74,867 (including of Tax)</td></tr>
<tr><td rowspan="5">Contents of the Work and Services:</td><td>(1) Preparation for the Implementation of the CBDRRM Activities</td><td>➢ Understanding of the Project activities including of the result of the hazard and risk assessment, activities related to DRRM planning, etc. and their progress, and coordination with the relevant persons including of counterparts of the MoFALD and pilot municipalities, and others.</td></tr>
<tr><td>(2) Implementation of the CBDRRM Training for Municipality Officers</td><td>➢ Preparation of the CBDRRM Training for Municipality Officers and other Stakeholders (Preparation of the venue, coordination for the participants, request and coordination for lecturers), management of the training program (facilitator, venue arrangement, etc.), and making a report of the training including of evaluation by the participants.</td></tr>
<tr><td>(3) Planning of the CBDRRM Activities in the Pilot Wards</td><td>➢ 1) Verification of the detailed information on the situation of the CBDRRM activities in the three pilot wards (members of the CBMC, Community DRRM Plans, DRR Maps, and outputs, documents and reports of the past activities), and
➢ 2) Planning of the pilot activities in each pilot ward based on the verified information with the Japanese experts (Based on the result of the past CBDRRM activities and current situation in the target wards, detailed activities are decided. The activities are focusing on the sustainability of the CBDRRM activities).</td></tr>
<tr><td>(4) Implementation of the CBDRRM Activities in the Pilot Wards</td><td>➢ Preparation and implementation of the pilot CBDRRM activities planned through the above activities (3) in the three pilot wards. The activities include implementation of one of the activities in the Action Plan which will be developed through the CBDRRM activities, and making a report of the pilot activities including of evaluation by the participants.</td></tr>
<tr><td>(5) Finalization of</td><td>➢ Supporting of the CDMC for getting official approval of</td></tr>
</table>

	DRRM Plans, DRR Maps and Others	Community DRRM plans and DRR maps which will be developed/ revised through the CBDRRM activities, and distribution and dissemination of the plans and the maps to community members, including of the development of information boards.
	(6) Review of the Pilot Activities	➢ Reviewing the pilot community activities, and considering mechanisms, activities, and action plans for incorporating the CBDRRM activities in the municipality DRRM plan.
	(7) Coordination with the Pilot Municipality Officers	➢ Close coordination and discussion with the officers in charge of the CBDRRM activities in the pilot municipalities for conducting all of the above activities by the main initiatives of the municipality officers. (throughout the entire period)

Source: JICA Project Team

Original Implementation Schedule was as shown in the Figure 6.5.1. Due to the local election held in May 2017, the schedule of some of the activities was delayed and rescheduled.

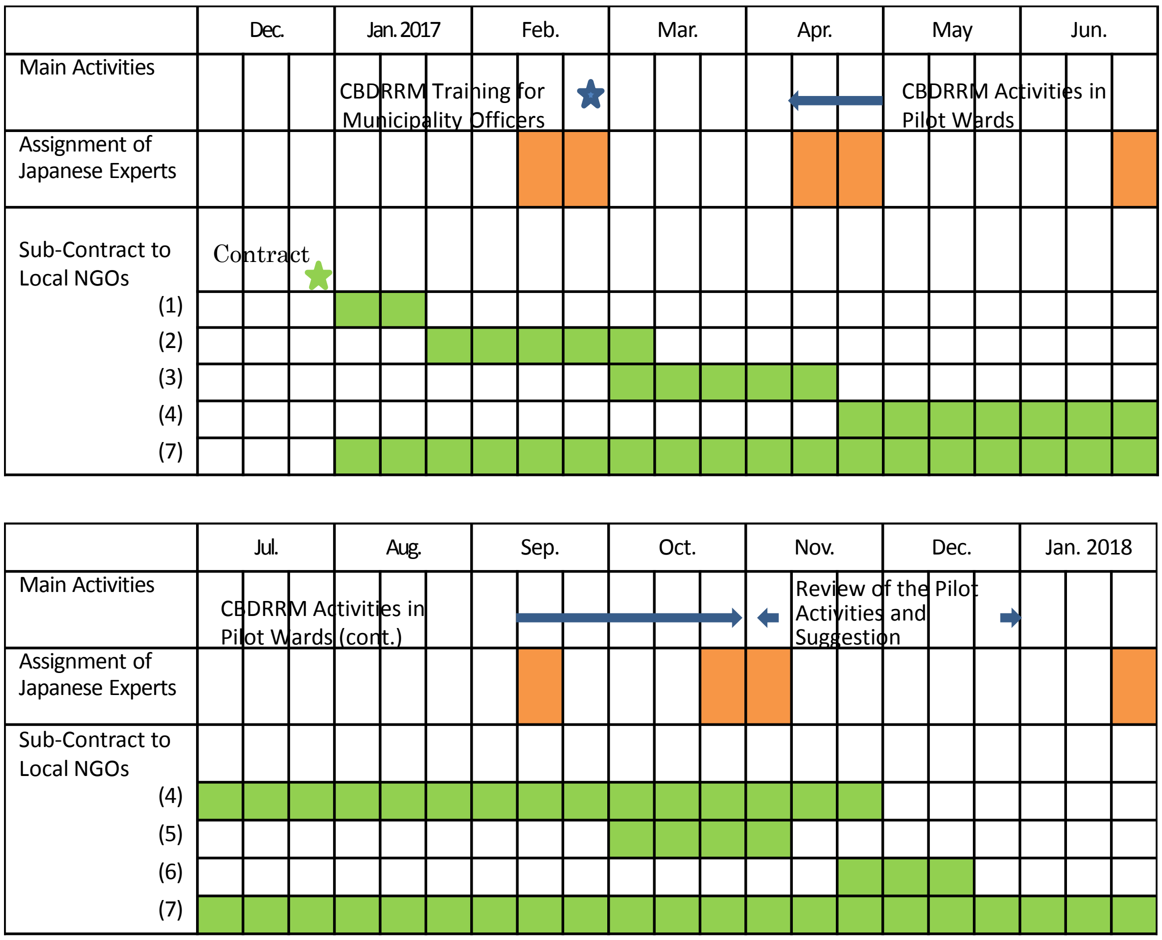


Figure 6.5.1 Original Implementation Schedule of the CBDRM Activities

6.5.2 Outline of the Sub-Contract Activities

Among three candidate organizations under the selective tendering, the Environment and Public

Health Organization (ENPHO) was selected by the cost proposal and started the coordination of the CBDRRM activities based on the ToR from 22 December 2016.

The ENPHO completed the activities mentioned in the ToR with the submission of the report of each training and workshop as shown in the Figure 6.5.2. (Refer to the Attachment 12 for all the reports.)

The ENPHO was rather new for conducting the CBDRRM activities, however, with the detailed discussion and consultation with the JICA Project team, they could complete all the coordination works designated in the ToR without any critical failure. They had difficulties in the work item (7) in the Table 6.5.1, however, it was due to the problems of the municipality side.

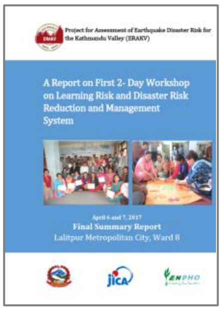
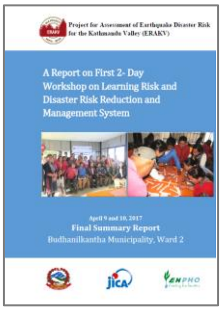
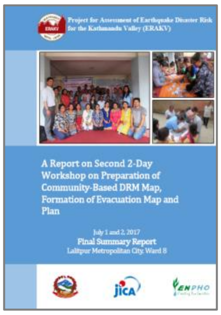
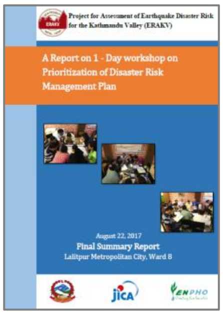
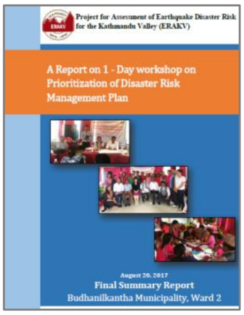
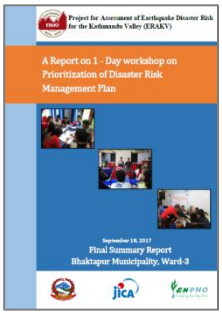
			
3-Day CBDRRM Training for Municipality Officers	1st Workshop in Lalitpur	1st Workshop in Budhanilkantha	1st Workshop in Bhaktapur
			
	2nd Workshop in Lalitpur	2nd Workshop in Budhanilkantha	2nd Workshop in Bhaktapur
			
	3rd Workshop in Lalitpur	3rd Workshop in Budhanilkantha	3rd Workshop in Bhaktapur

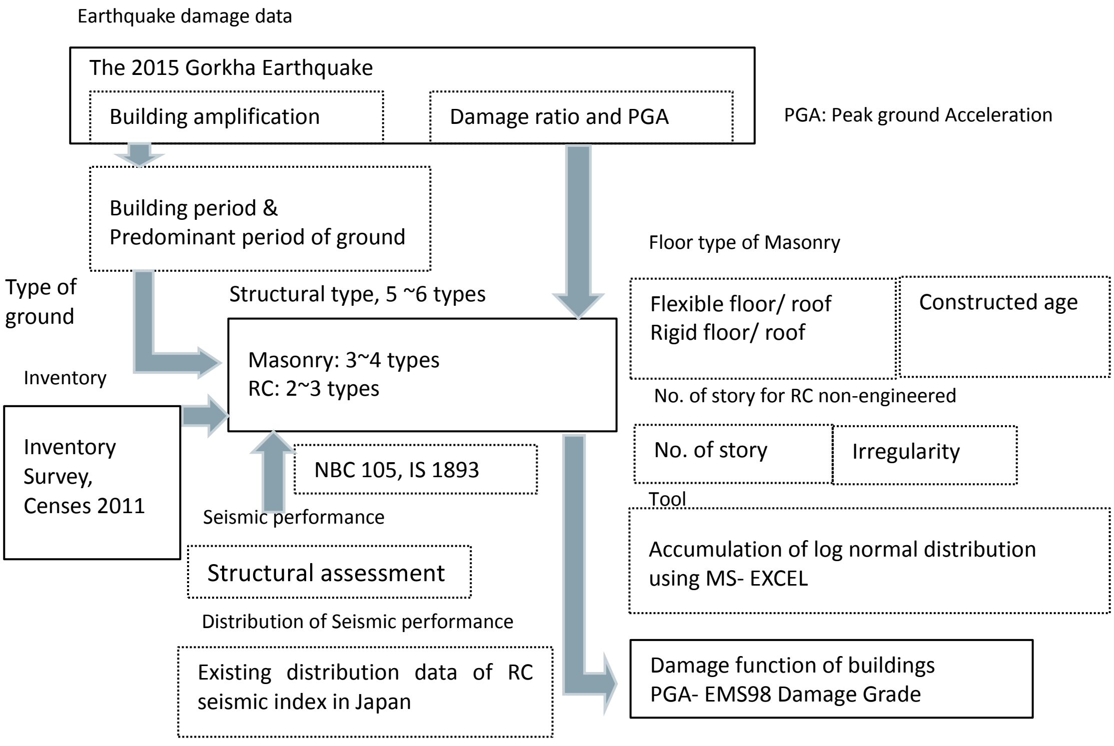
Figure 6.5.2 Submitted Reports by ENPHO, the Sub-contracted Local NGO

Appendix 7 Development of Building Damage Function

7.1 Development of Building Damage Function

(1) Proposed methodology for the development of Building Damage Function

Deterministic approach has been taken for risk assessment of buildings. Risk assessment is generally expressed generally by Σ(Number of building of each structural category at each grid (250mx250m) x PGA by scenario earthquake x building damage function). Proposed method and related items for the development of damage function is shown in Figure 0.1. The revision of damage function of 2002 JICA Study including the classification of buildings has been done based on the building inventory and damage survey of the 2015 Gorkha earthquake. Strong motion records of the 2015 Gorkha earthquake at 6 locations inside the valley open to the public was referred, and acceleration response spectrum of building was prepared. Response spectrum and its amplification per each grid or each predominant period of the ground were calculated based on calculated PGA of the 2015 Gorkha Earthquake with correction factor 0.2. Seismic assessment of typical structural type of building was carried out. All these data were utilized for the development of building damage function through the engineering judgement and comprehensive approach.



Source: JICA Project Team

Figure 0.1 Proposed methodology and related items for the development of building damage function

(2) Ground motion and response of buildings by the 2015 Gorkha Earthquake

1) Observed strong motion records

Observed PGA (Peak Ground Acceleration; cm/sec^2, gal) records due to the 2015 Gorkha earthquake in the valley which were opened to the public is shown in Table 7.1.1. The record was taken at ground floor level of a building. KTP is located near the rock area and TVU is located on an organic deposit at a hill. It is noted that no record was observed at the perimeter of the valley, especially at north-west side where caused damages of RC buildings.

Table 7.1.1 Observed strong motion records (PGA: cm/sec^2, gal)

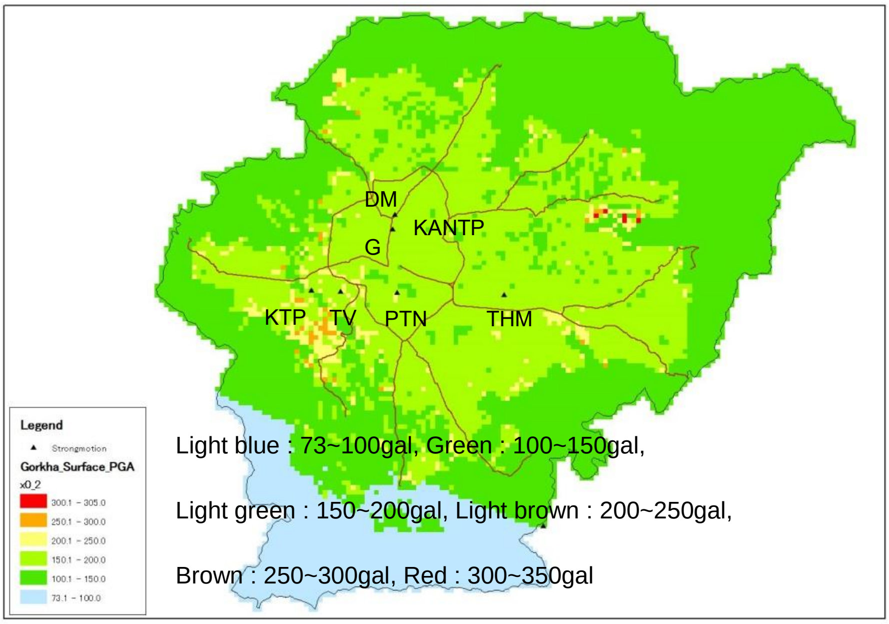
	KATNP(USGS)	DMG	KTP(H & T Univ.)	TVU(H & T Univ.)	PTN(H & T Univ.)	THM(H & T Univ.)
NS	161	174	154	201	151	150
EW	155	124	255	229	129	134
UD	182	201	127	139	134	188

Source: KATNP (USGS), DMG (Department of Mining and Geology), KTP, TVU, PTN and THM (Hokkaido University and Tribvan University)

2) Estimation of ground motion

Calculated peak ground acceleration (PGA) by the 2015 Gorkha earthquake with correction factor 0.2

and location of strong motion station is shown in Figure 7.1.2. It is estimated that PGA is in the range of 150gal to 200gal for general (center) area of the valley and is more than 200gal for limited perimeter areas of the valley due to the 2015 Gorkha earthquake with correction factor 0.2.

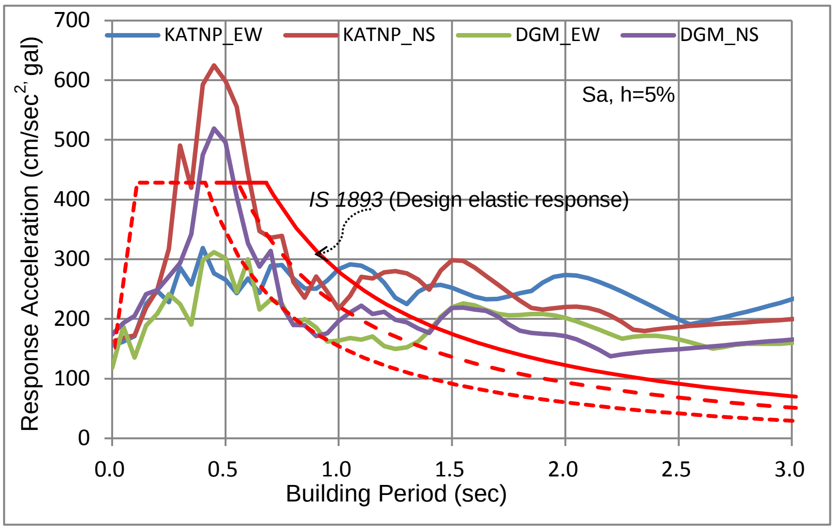


Source: JICA Project Team

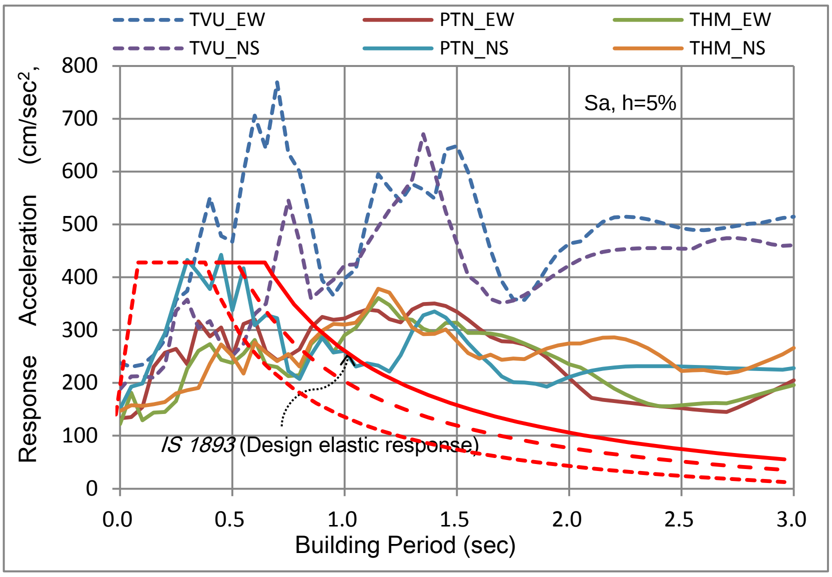
Figure 7.1.2 Calculated PGA distribution by the 2015 Gorkha Earthquake with correction factor 0.2

3) Acceleration response spectrum of building

Acceleration response spectrum for observed KTNP and DMG is shown in Figure 7.1.3 a), and TVU, PTN, THM is shown in Figure 7.1.3 b) respectively. KTP located near the rock area is not shown in this figure. Design response spectrum of IS 1893 (Part 1) 2002 is shown for information.



a) KATNP and DMG



b) TVU, PTN and THM

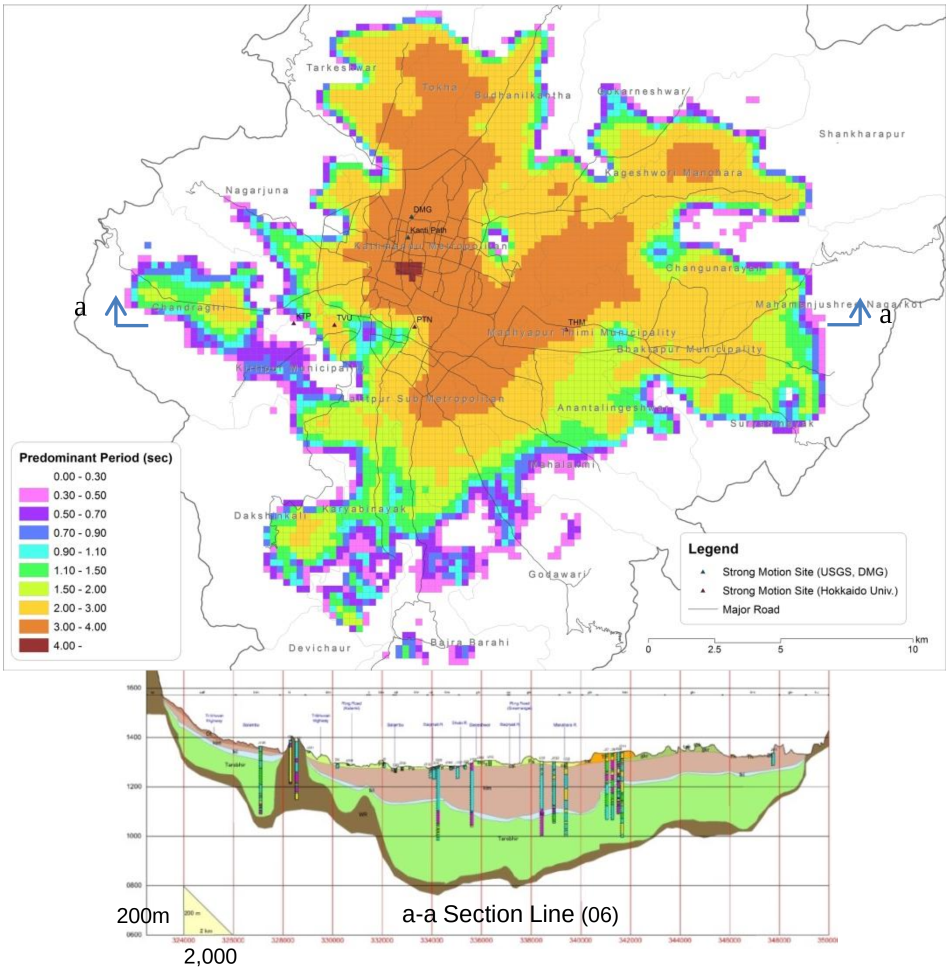
Source: JICA Project Team

Figure 7.1.3 Acceleration response spectrum of building

Response acceleration of TVU is big for both NS and EW components. PGA and response acceleration (ratio) of PTN and THM is relatively small. There is a big variation but average response ratio is around two for PTN and THM in the building period of less than 2.0 sec. and no reduction of response after 0.7 sec. of IS1983 is observed.

4) Predominant period of the ground

Predominant period of the ground in the valley is shown in Figure 7.1.4. The general (center) area of the valley is more than 2 sec. and is long period. This is bigger than building period of low to mid-rise buildings (such as 0.3 to 0.7sec.). On the other hand, predominant period of the ground at perimeter is less than 1sec. and there is no big difference for building period of low to mid-rise. This difference of predominant period of the ground will cause different response for buildings against earthquake.

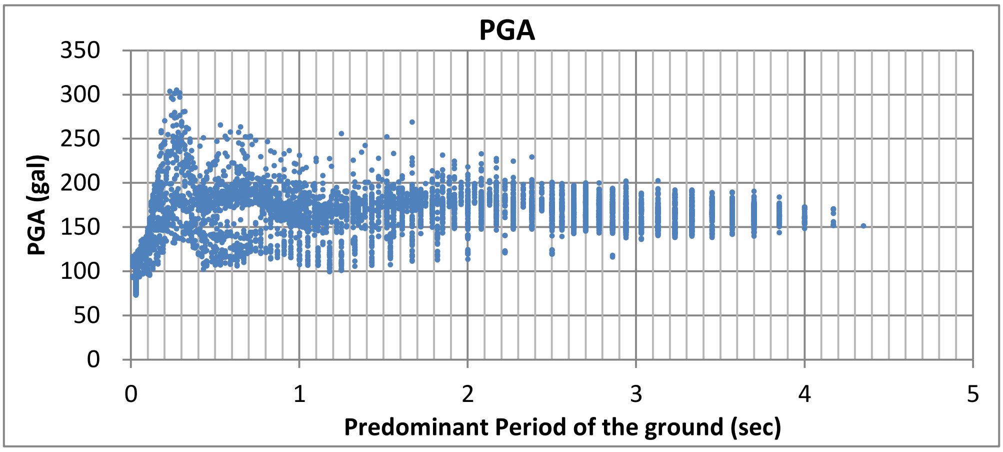


Source: JICA Project Team

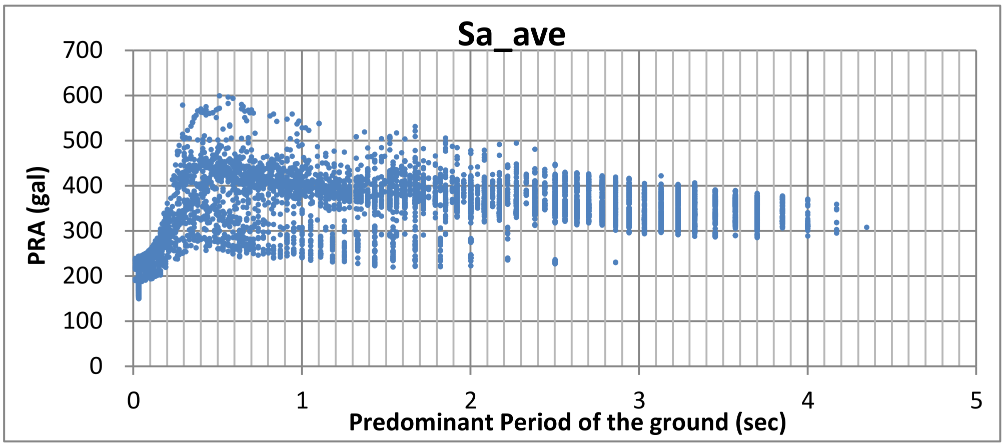
Figure 7.1.4 Predominant period of the ground (sec.) and a section (a-a section) of the ground

5) Response acceleration ratio of building

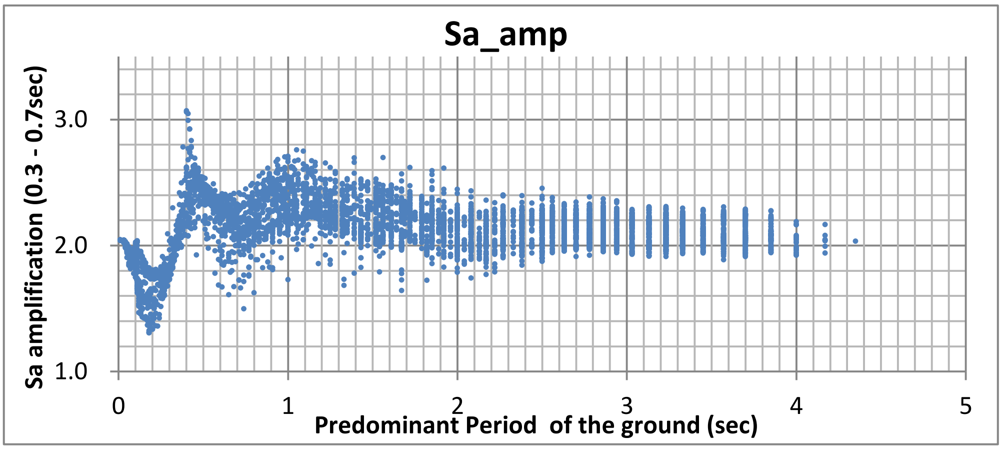
Calculated peak ground acceleration (PGA) by the 2015 Gorkha earthquake with correction factor 0.2 at each grid of 250m x 250m is shown in Figure 7.1.5 a). Horizontal axis is predominant period at each grid. It is supposed that building period of low to mid-rise is 0.3 sec. to 0.7sec. Average response acceleration with building period of 0.3 sec. to 0.7sec. is shown in Figure 7.1.5 b). Average acceleration amplification ratio of building period with 0.3 sec. to 0.7sec. is shown in Figure 7.1.5 c).



a) Predominant period and calculated PGA by 2015 Gorkha Earthquake with correction factor 0.2



b) Predominant period and average peak response acceleration of building with period 0.3 sec. to 0.7 sec.



c) Predominant period and average acceleration amplification ratio of building with period 0.3 sec. to 0.7 sec.

Source: JICA Project Team

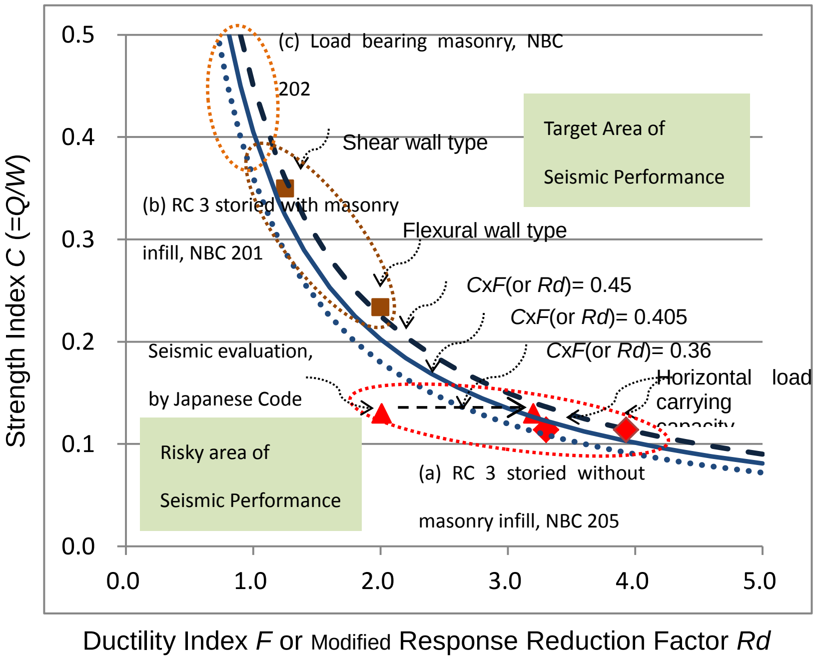
Figure 7.1.5 Predominant period and calculated PGA by 2015 Gorkha Earthquake (x0.2), average response acceleration, and average acceleration amplification ratio of building with period 0.3 sec. to 0.7 sec.

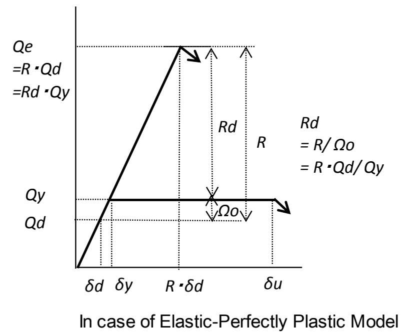
As far as the calculation of PGA by the 2015 Gorkha Earthquake with correction factor 0.2, PGA is relatively big with variation at perimeter area (predominant period 1.0 sec. and less), compared with PGA of center area of the valley (predominant period 2.0 sec. and more) as shown in Figure 7.1.5 a). As far as the average acceleration amplification ratio of building with period 0.3 sec. to 0.7 sec., is varied per the predominant period of the ground. Acceleration amplification ratio is relatively high with peak value at 0.4 sec. and 1.0 sec. for perimeter area (predominant period 1.0 sec. and less) of the valley, and acceleration amplification ratio is smaller at center area of the valley (predominant period 2.0 sec. and more) as shown in Figure 7.1.5 c). It is proposed to provide two kind of building damage function allocating the ground of the valley with predominant period 1.5 sec. by the engineering judgement.

(3) Seismic capacity of existing buildings

1) Seismic capacity of RC building by NBC

Seismic assessment of a sample 3 storey RC building shown in National Building Code 205 (Reinforced Concrete Buildings without Masonry Infill) was done. Push-over analysis was done and horizontal stiffness and strength was evaluated. Ductility was evaluated by NBC and Japanese code for reference. As far as NBC 201 (Reinforced Concrete Buildings with Masonry Infill), wall volume or wall length was supposed and assessed with engineering judgement. The result is shown in Figure 7.1.6. It is estimated that seismic capacity expressed by *C* (strength index) x *F* (ductility index or *Rd)* is approximately 0.4 and more.





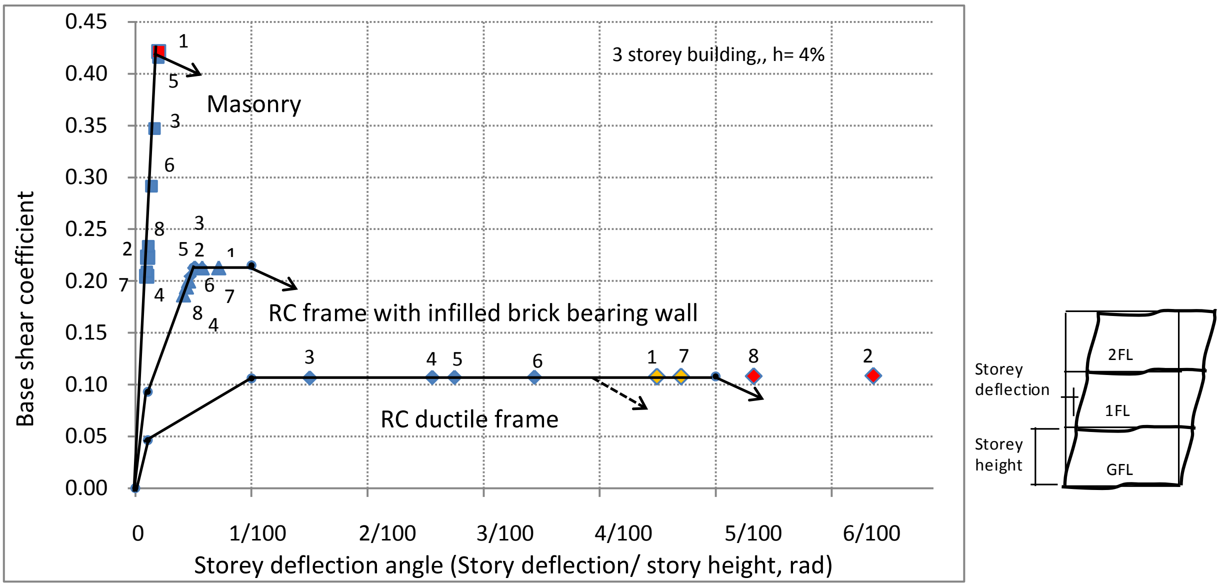
Qd : Design base shear force
Qe = *R* ･ *Qd* : Elastic design response base shear force
Qy : Yield strength or horizontal load carrying capacity
R : Response reduction factor (IS 1983-1)
Ωo=Qy/ Qd : Over-strength factor
Rd : Modified response reduction factor, and is expressed by *R* divided by over-strength factor *Ωo*.
This is similar concept of Ductility Index, *F* of Japanese code.
δu : Horizontal deflection at ultimate stage

Source: JICA Project Team

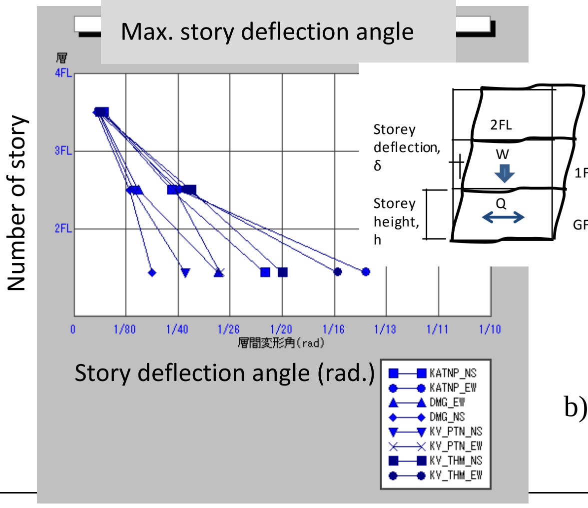
Figure 7.1.6 Seismic capacity of RC buildings by NBC205 and others

2) Supposed restoring force characteristics of structure incorporating seismic load of NBC 105 and time history response analysis incorporating observed waves due to the 2015 Gorkha Earthquake

K value (Structural performance factor) of NBC105 (Seismic design of buildings in Nepal) is applied, 4 for masonry, 2 for RC frame with infilled brick bearing wall, and 1 for RC ductile frame. Restoring force characteristics of degrading tri-linear model with shear type is supposed for RC ductile frame based on push-over analysis of a sample 3 story RC building (column size is 270mm square) of NBC 205. Supposed allowable response ductility ratio is 4 to 5. Stiffness and strength is multiplied by two for RC frame with infilled brick bearing wall. Supposed allowable response ductility ratio is 2. Allowable ductility ratio is 1 for masonry. Damping constant is supposed as 4% for each case. Result including PGA of each wave is shown in Figure 7.1.7. Waves of KTP located near a rock area and TVU located on organic soil on the hill are excluded from the analysis. A few cases exceed the allowable limit for masonry and RC ductile frame. Relatively big storey deflection angle is observed even if the allowable limit for RC ductile frame. The response is within the allowable limit in case of RC frame with infilled brick bearing wall.



a) Base shear coefficient- Storey deflection angle relation



b) Storey deflection angle

Note: Base shear coefficient = Seismic coefficient = Story shear force at GFL/ total building weight

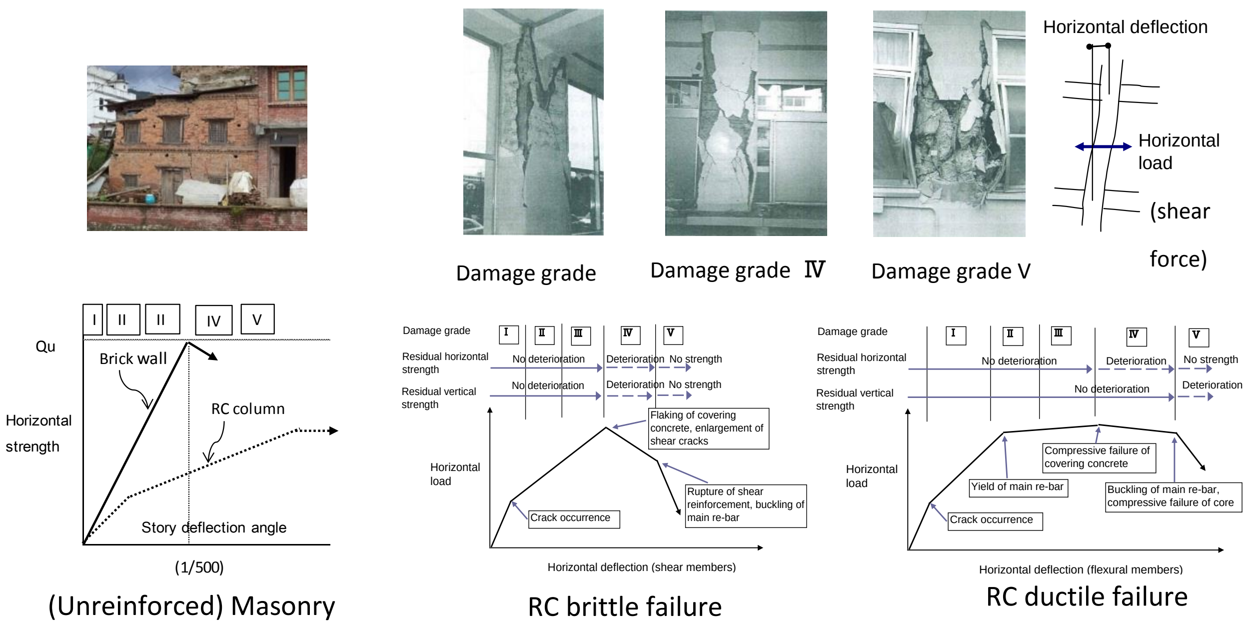
No.	1	2	3	4	5	6	7	8
Name	KATNP_NS	KATNP_EW	DMG_NS	DMG_EW	PTN_NS	PTN_EW	THM_NS	THM_EW
PGA (gal)	161	155	174	124	151	129	150	134

Source: JICA Project Team

Figure 7.1.7 Supposed restoring force characteristics and responses using recorded waves by the 2015 Gorkha earthquake

3) Load - deflection curve of structural members and a guide for damage grade

Load and horizontal deflection curve (or restoring force characteristics) and a guide for damage grade is shown in Figure 7.1.8. A Japanese example for RC column is shown. It is general understanding that members of buildings damaged with the grade IV and more will not be reasonable to recover technically and monetary.



[Source: "Standard of Judgment of Damage Grade and Guidelines of Recovery Engineering for Damaged Buildings, 2001", The Japan Building Disaster Prevention Association (written in Japanese)]

Figure 7.1.8 Load and horizontal deflection relation (restoring force characteristics) of structural members and a guide for damage grade

(4) Development of building damage function

1) Comparison of damage function used in "2002 JICA Study" and damage data due to the 2015 Gorkha earthquake

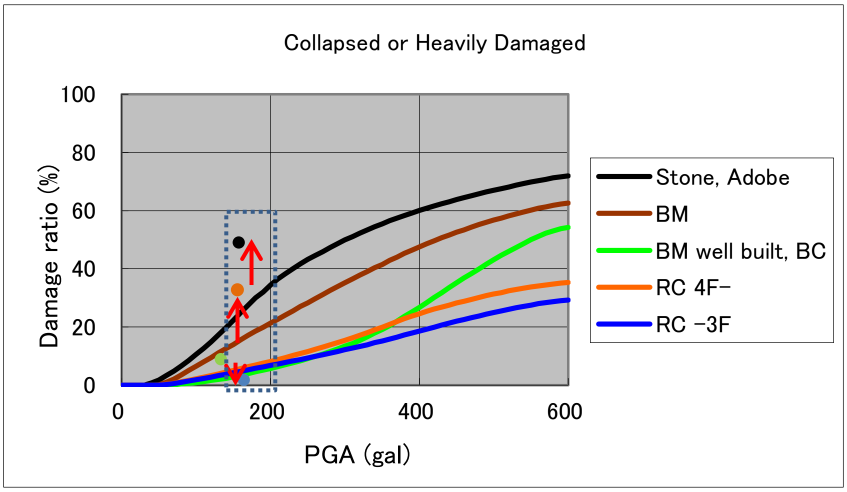
Following comments are provided based on the damage data due to the 2015 Gorkha earthquake in Bhaktapur municipality and Lalitpur sub-metropolitan city on the damage function utilized in "2002 JICA Study" (Figure 7.1.9). It is supposed that PGA in Bhaktapur municipality and Lalitpur sub-metropolitan city is around 150gal.

(i) Damage ratio of Adobe is bigger than that of damage function of 2002.

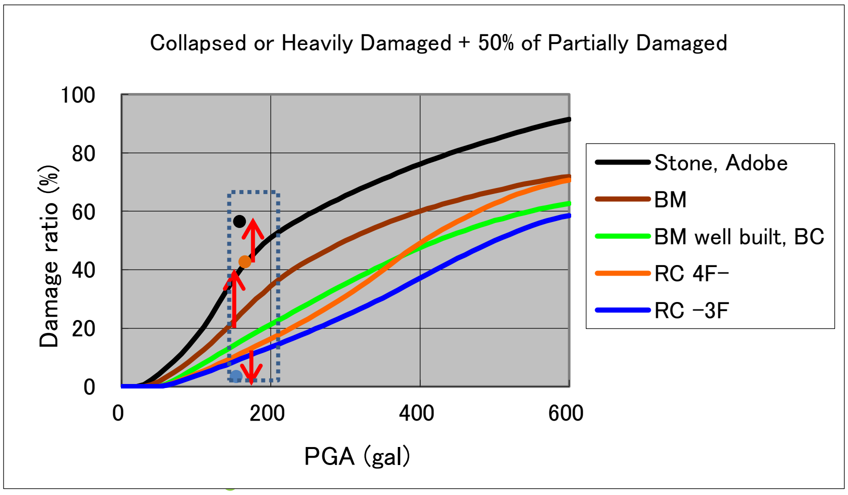
(ii) Damage ratio of brick masonry with mud mortar joint is bigger than that of damage function of 2002.

(iii) Damage ratio of brick masonry with cement mortar joint is similar to that of damage function of 2002.

(iv) Damage ratio of RC structure is smaller than that of damage function of 2002.



(a) Damage Grade 4+ 5



(b) Damage Grade 4+ 5 + half of 3

Source: JICA Project Team

Figure 7.1.9 Comparison of damage ratio by the function of "2002 JICA Study" and surveyed data

2) Adjustment of building structural category

A building structure was classified into 8 categories through the building inventory and damage survey. In addition, the difference of damage ratio was studied for roof type which is rigid type (RC roof) or flexible type (wooden roof), and constructed year for “brick masonry with mud mortar joint”. The result shows that damage ratio of flexible roof is big, and damage ratio of flexible roof constructed within 20 years is similar to that of rigid roof. Then brick masonry with mud mortar joints is separated into two categories. The difference of damage ratio by the change of number of storey for brick masonry is not clear, and is not considered. As far as RC buildings, damage data is limited and is not considered for number of storey. For more detail, refer to Appendix 2 Building damages due to the 2015 Gorkha earthquake.

“Brick masonry with mud mortar joint” is classified into two as mentioned above. Building number of item 2, “Stone with mud mortar” and item 3, “Stone with cement mortar” are not many, and damage function of “Brick masonry with flex roof & 20 years and more”, and “Brick masonry with cement mortar joint” is applied respectively. Item 8. “Others (Wooden, steel)” are not many and damage function of “Brick masonry with cement mortal” is utilized. Summary is shown in Table 7.1.2.

The ground of the valley is classified into two types by the predominant period as follows.

・General (center) area of the Valley : predominant period of the ground, Tg > 1.5sec & ≦ 0.3sec

・Perimeter area of the Valley : predominant period of the ground 0.3sec < Tg ≦ 1.5sec

Table 7.1.2 Category of damage function and Structural type

Category of damage function Suffix P denotes “ perimeter area”		Structural type (Numbering indicates the number of building inventory survey)	
1	Masonry 1, Masonry 1P	1.Adobe	
2	Masonry 2, Masonry 2P	4.Brick masonry with mud mortar, flex roof & 20 years and more	2.Stone with mud mortar
3	Masonry 3, Masonry 3P	4.Brick masonry with mud mortar, rigid roof, & flex roof with 1~20 years	
4	Masonry 4, Masonry 4P	5.Brick masonry with cement mortar	3.Stone with cement mortar, 8. Others
5	RC 1, RC 1p	6.RC non-engineered	
6	RC 2, RC 2p	7. RC engineered with low to mid-rise	

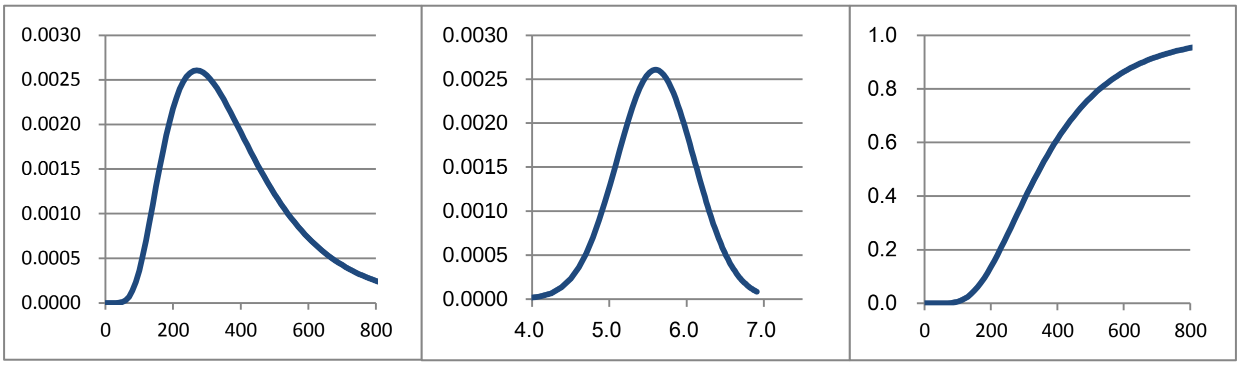
Source: JICA Project Team

3) Indication of Building damage function

It is supposed that the distribution of seismic capacity of existing buildings is expressed by log-normal distribution. In this case, two parameters of “average value” and “standard deviation” by log-normal distribution can specify the damage function of each category.

Damage ratio by EMS 98 is shown in vertical axis. Refer to latter half of this Appendix 7 for damage degree of EMS 98. For example, a certain grid of 250m x 250m, assuming there are 200 buildings, and 50 buildings of structural type A. If supposed PGA is 200gal, and damage ratio is 10%, this means 5 buildings out of 50 buildings of type A are damaged with specified damage degree. This is deterministic approach against a scenario earthquake. As far as horizontal axis, PGA, MMI, PGV are possible candidate. However PGA has been used in existing damage function in Nepal, PGA is also used in “2002 JICA Study”, and acceleration amplification is almost constant for period of low to mid-rise buildings and is easy to understand for engineers and researchers. Therefore PGA is suggested for horizontal axis.

Example: Accumulation of log normal distribution is used for the damage function. $Log_e N = LnN = 2.3026 * Log_{10} N$



(a) Frequency distribution of seismic performance for each structural type (horizontal axis is PGA; cm/sec^2, gal)

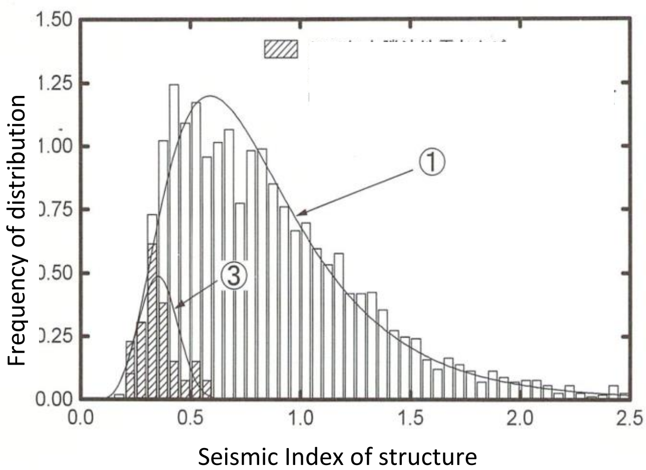
(b) Supposed log normal distribution (horizontal axis is LN expression)

c) Accumulation of log normal distribution (Horizontal axis is PGA)

=LOGNORM.DIST (x, average, standard deviation, function type)

=LOGNORM.DIST (Cell No.,5.8,0.5,TRUE),

In case that damage data is limited, frequency distribution of existing RC buildings by seismic evaluation in Japan is utilized for reference as shown in Figure 7.1.10.



Source: Commentary Figure 5.2-3 of “Standard of Seismic Evaluation of Exiting RC Buildings (Prof. Y. Nakano, JBDPA, Japan

Figure 7.1.10 Frequency distribution of existing RC buildings by seismic evaluation in Japan

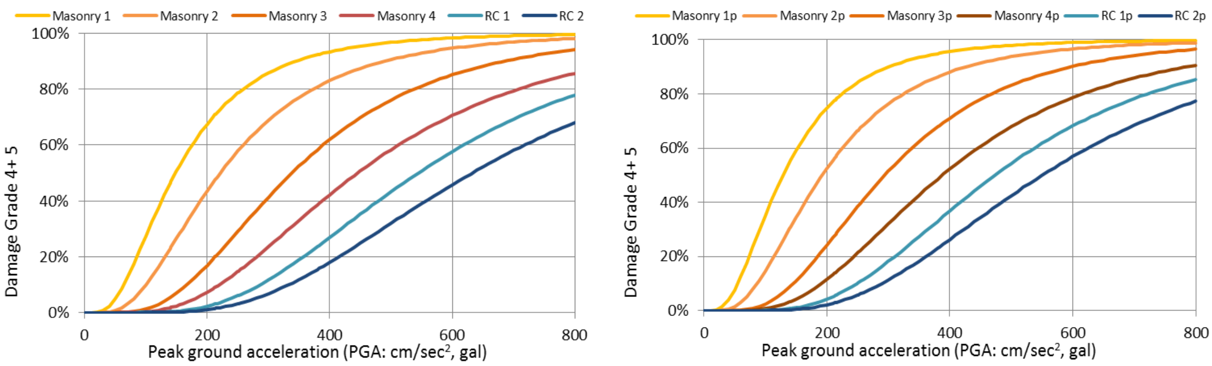
4) Damage data of buildings

Damage data by building survey of ERAKV for Bhaktapur Municipality and Lalitpur Sub-Metropolitan City (LSMC) is utilized for the development of damage function. In addition, following damage data is also used for the verification.

a) Yo Hibino, et at, "Field Investigation in Affected Area due to the 2015 Nepal Earthquake by AIJ reconnaissance team: damage assessment and seismic capacity evaluation of buildings in Gongabu, Kathmandu", New Technology for Urban Safety of Mega Cities in Asia.
Information that damage ratio of grade 4+ 5 is 5% for RC buildings and 10% for masonry respectively at Gongabu area, are introduced.
b) NIED: Building damage survey due to the 2015 Nepal Earthquake at Sakhu and Kokhana by The National Research Institute for Earth Science and Disaster Prevention, Japan
Damage survey of 511 buildings at Sankhu area and 300 buildings at Khokana area have been introduced.

(5) Building damage function

Proposed damage function (damage ratio of grade 4+ 5 of EMS 98) for each structural type is shown in Figure 7.1.11 a), b).



a) Center area of the Valley (predominant period of the ground, Tg > 1.5sec & Tg ≤0.3sec)

b) Perimeter area of the Valley, suffix p (predominant period of the ground 0.3sec< Tg ≤ 1.5sec)

- Source: JICA project Team

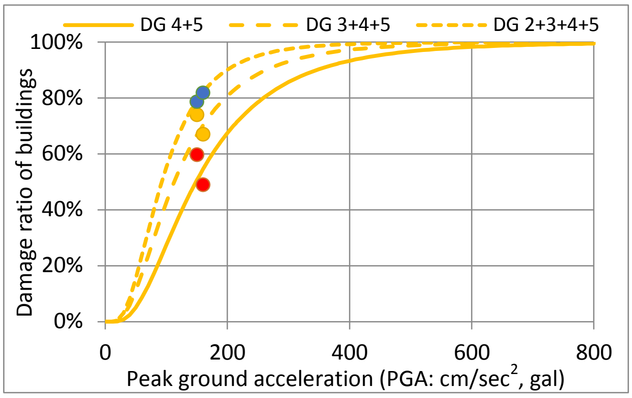
Figure 7.1.11 Proposed Damage function for DG 4+ 5 at center area and perimeter area

1) Proposed damage function of each damage grade

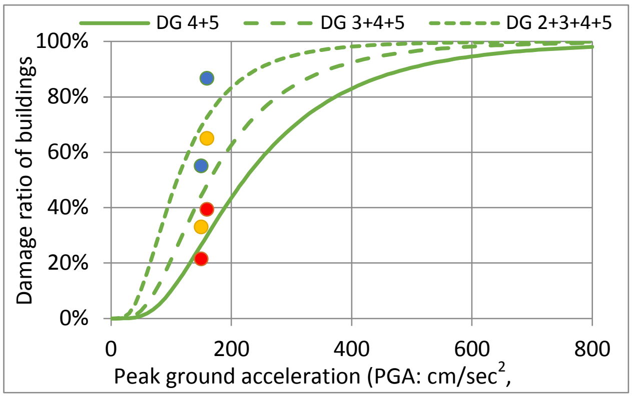
Proposed damage function of each damage grade of EMS98 together with damage data is shown Figure 7.1.12 and Figure 7.1.13.

a) Center area

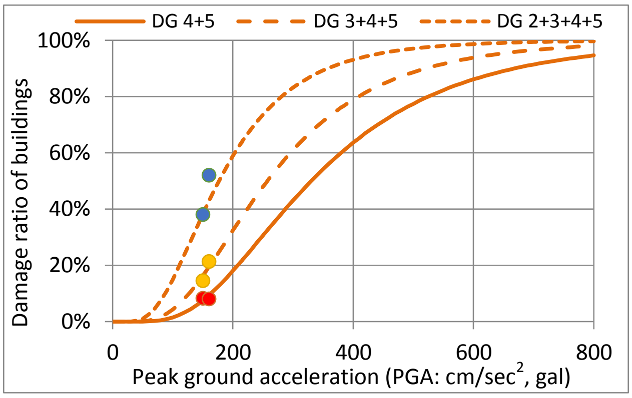
1. Masonry 1(Adobe)



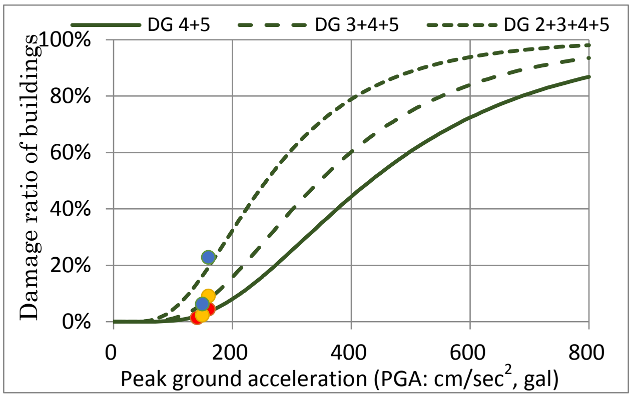
2. Masonry 2 (Brick masonry with mud mortar (1))



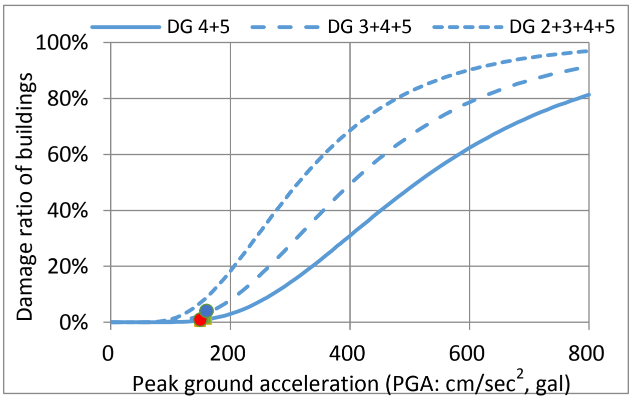
3. Masonry 3 (Brick masonry with mud mortar (2))



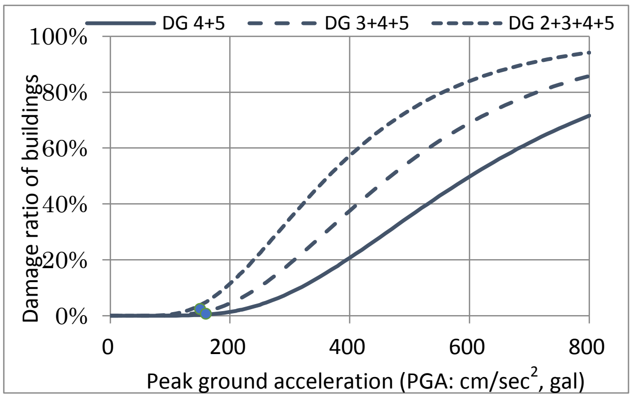
4. Masonry 4 (Brick masonry with cement mortar)



5. RC 1 (RC non- engineered)



6. RC 2 (RC engineered)



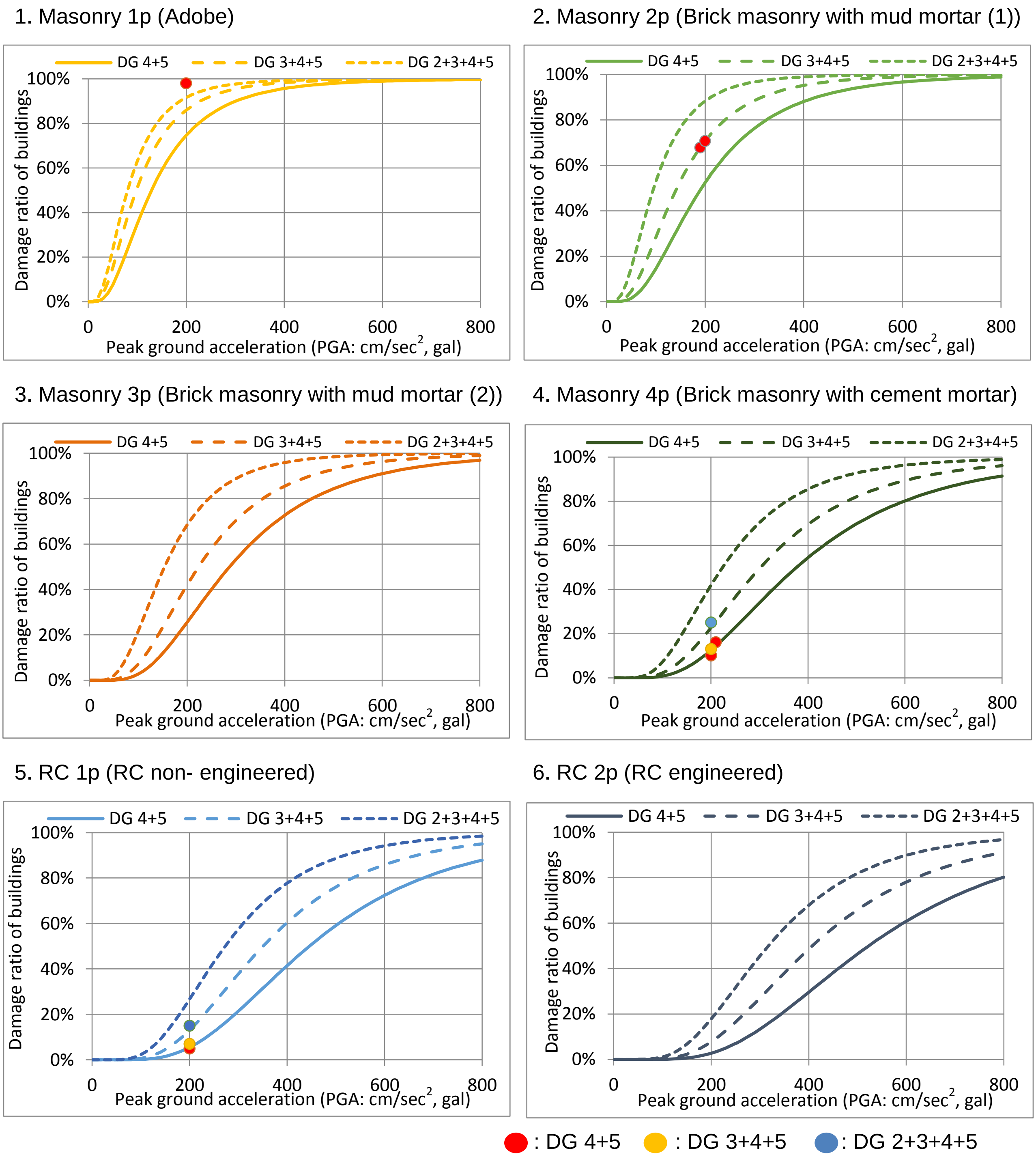
● : DG 4+5 ● : DG 3+4+5 ● : DG 2+3+4+5

Legend: Damage data surveyed at Bhaktapur and Lalitpur (LMC, Ward 1~22) due to 2015 Gorkha earthquake

Source: JICA Project Team

Figure 7.1.12 Proposed damage function of each damage grade (center area)

b) Perimeter area



Legend: Damage data by 2015 Gorkha earthquake, 4, 5: data at Gongabu by AIJ, refer to PR. 2: data at Sankhu and Khokana by NIED, 1,4: data at Sankhu by JICA Project Team

Source: JICA Project Team

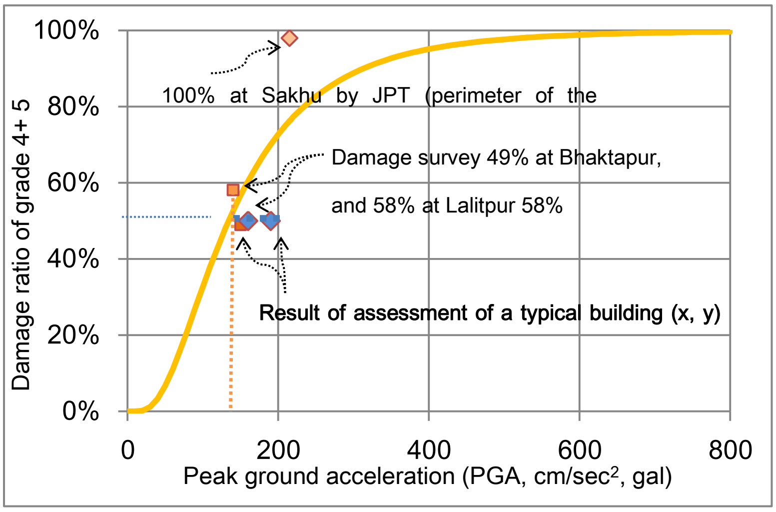
Figure 0.13 Proposed damage function of each damage grade (perimeter area)

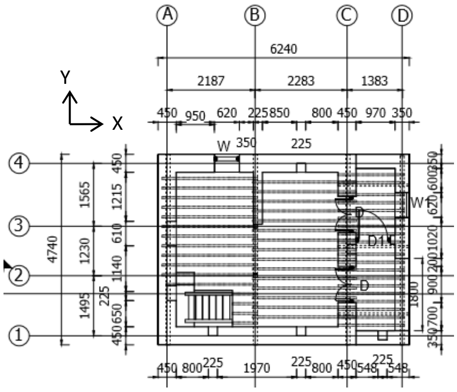
(6) Damage function and structural assessment of typical structure- Reference only

Simplified structural assessment of typical structure based on design drawing and material information, provided by detail building survey, was done and compared with proposed damage function for general (center) area of the Valley. As far as the elastic acceleration amplification is supposed as 2.0 for masonry structure based on building response spectrum of observed waves by the 2015 Gorkha earthquake, to estimate PGA at the time of ultimate strength. The relation of this PGA on damage function seems reasonable.

a) Adobe

It is a 2 storey building. Shear strength of mud mortar joint is supposed as 0.072N/mm^2. Strength coefficient at GFL in-plane is 0.38 for x-direction and 0.30 for y-direction respectively.





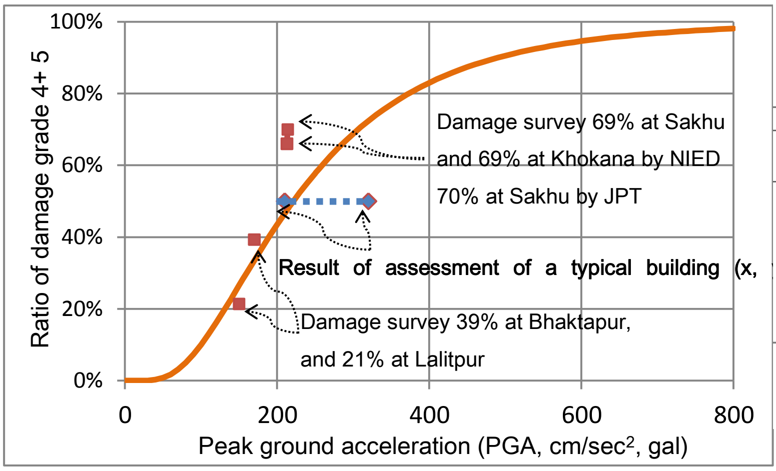
Wall thickness: 450mm (typical)
Shear strength of joint mortar:

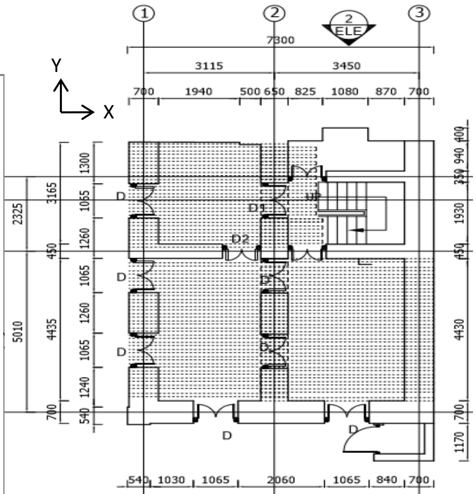
(Note: Sakhu is supposed as located at perimeter area of the valley) Source: JICA Project Team

Figure 7.1.14 Damage function of "Adobe" (left), building plan and wall information (right)

b) Brick masonry with mud mortar (flexible roof)

It is a 4 storey building. Shear strength of mud mortar joint is supposed as 0.11N/mm^2. Strength coefficient at GFL in-plane is 0.42 for x-direction and 0.65 for y-direction respectively. Out- of-plane movement at upper storey has not been considered.





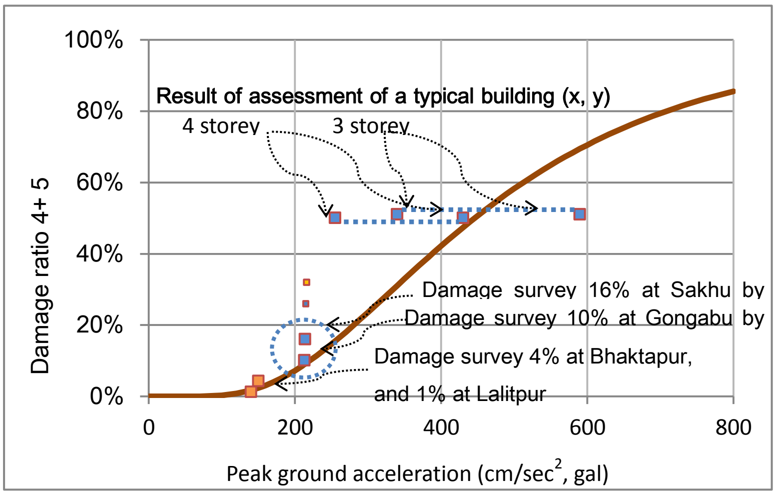
Wall thickness: 660, 410mm (typical)
Shear strength of joint mortar:

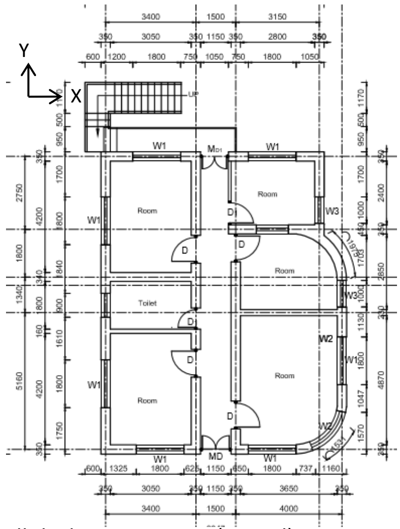
(Note: Sakhu and Kokhana are supposed as located at perimeter area of the Valley, and floor type is not considered for damage ratio.) Source: JICA Project Team

Figure 7.5.15 Damage function of "Brick masonry with mud mortar flex roof" (left), building plan and wall information (right)

c) Brick masonry with cement mortar joint

It is a 3 storey building and weight of 4 storey is also considered. Shear strength of cement mortar joint is supposed as 0.50N/mm^2. Strength coefficient at GFL is 0.50 for x-direction and 0.87 for y-direction respectively as a 4 storey.





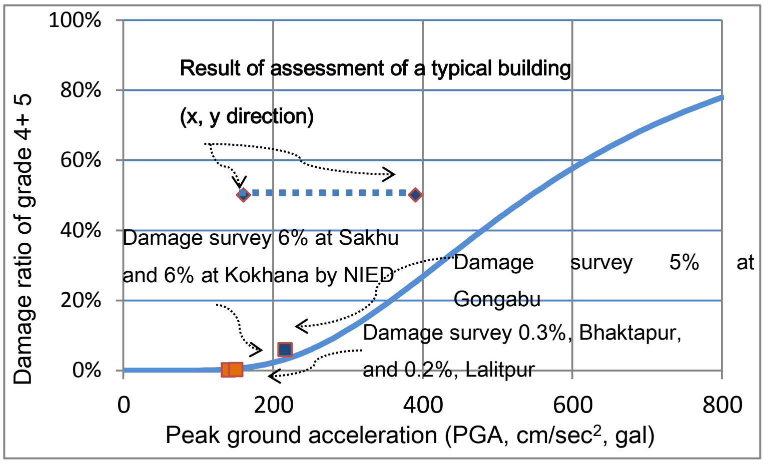
Wall thickness: 350mm (typical)
Shear strength of joint mortar:

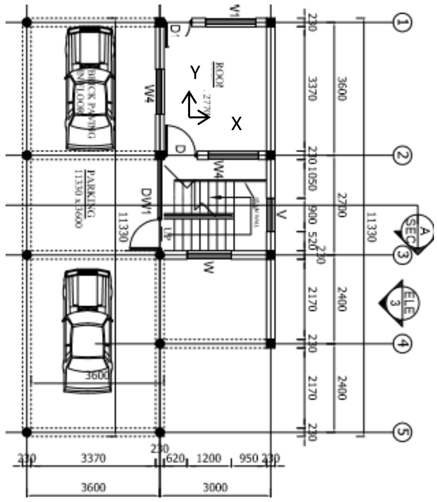
(Note: Sakhu and Gongabu are supposed as located at perimeter area of the valley)

Figure 7.1.16 Damage function of "Brick masonry with cement mortar joint" (left), building plan and wall information (right)

d) RC non-engineered

It is a 4 storey building. There is little brick wall and is almost a soft storey at GFL. Column size is 230mmx 230mm and is same to thickness of brick wall. Strength coefficient at GFL is 0.20 for x-direction and 0.49 (including wall strength) for y-direction respectively. Ductility is less than 2.0 and equivalent response factor is assumed as 1.25 for both directions considering energy absorption.





(Note: Gongabu and Kokhana are supposed as located at perimeter area of the valley

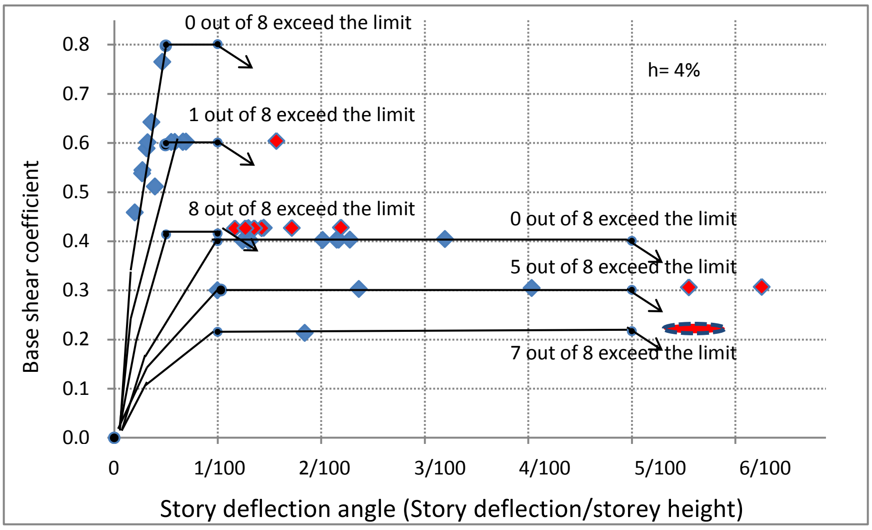
Source: JICA Project Team

Figure 7.1.17 Damage function of “RC non- engineered” (left), p

An example of RC non-engineered building
Horizontal strength/ total weight at GFL,
X direction: 0.20
Y direction: 0.57 (including brick wall)
Column: 230mmx230mm
Con. 15Mpa (cube), Re-bar. 415Mpa
Main: 6D16, Hoop:2D7@175, 90 degree

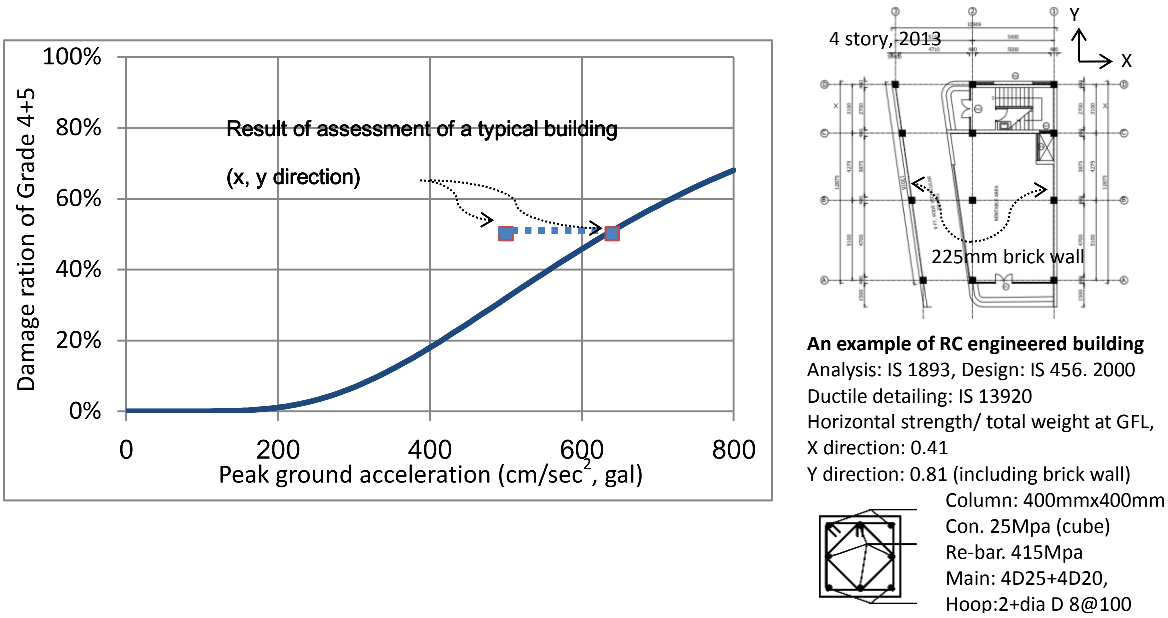
e) RC engineered

Structural design of this 4 storey “RC engineered” building has been done applying IS 1893 and IS 13920. Ductile detailing was done by IS 13920. Plan and column is shown in Figure 7.1.19 (right). Size of column section is 400mmx 400mm. The value of horizontal strength divided by building weight is estimated as 0.41 for x direction as a ductile frame by the simplified seismic evaluation. Strength including strength of non-structural brick wall is 0.81for y direction. Time history analysis for supposed restoring force characteristics of RC ductile frame and RC frame with brick wall for each 3 cases was done by applying 8 waves recorded at the 2015 Gorkha earthquake. The result of input of PGA 400gal is shown in Figure 7.1.18. 3 storey model of NBC205 was used as a basic model of degrading tri-linear for convenience. The PGA is estimated at the strength of both directions from the response. The result is shown on the damage function in Figure 7.1.19 (left).



Source: JICA Project Team

Figure 7.1.18 Supposed restoring force characteristics and responses with input of PGA 400gal by 8 waves of 2015 Gorkha Earthquake

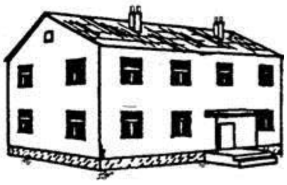
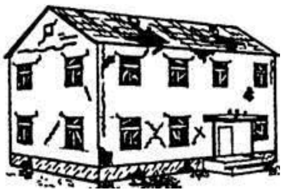
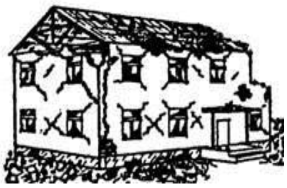


Source: JICA Project Team

Figure 7.1.19 Damage function of "RC engineered" (left), Plan and column (right)

(7) Damage grade by EMS 98

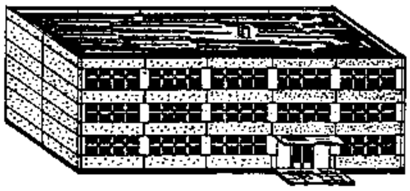
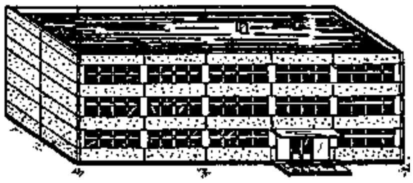
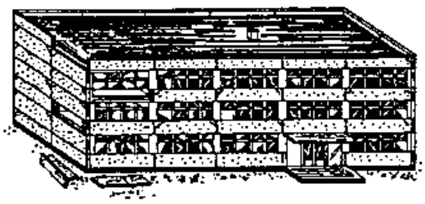
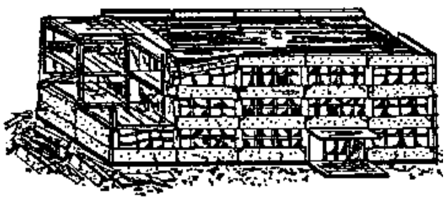
1) Damage grade for masonry building based on EMS-98

 **Grade 1: Negligible to slight damage**	**Structural damage: No** **Non-structural damage: Slight** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
 **Grade 2: Moderate damage**	**Structural damage: Slight** **Non-structural damage: Moderate** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
 **Grade 3: Substantial to heavy damage**	**Structural damage: Moderate** **Non-structural damage: Heavy** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
 **Grade 4: Very heavy damage**	**Structural damage: Heavy** **Non-structural damage: Very heavy** Serious failure of walls; partial structural failure of roofs and floors.
 **Grade 5: Destruction**	**Structural damage: very heavy** Total or near total collapse.

Source: EMS

Figure 0.20 EMS 98 (Masonry)

2) Damage grade for reinforced concrete (RC) building based on EMS-98

Classification of damage to buildings of reinforced concrete	
 **Grade 1: Negligible to slight damage**	**Structural damage: No** **Non-structural damage: Slight** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
 **Grade 2: Moderate damage**	**Structural damage: Slight** **Non-structural damage: Moderate** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling of mortar from the joints of wall panels.
 **Grade 3: Substantial to heavy damage**	**Structural damage: Moderate** **Non-structural damage: Heavy** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of concrete cover, buckling of reinforced bars. Large cracks in partition and infill walls, failure of individual infill panels.
 **Grade 4: Very heavy damage**	**Structural damage: Heavy** **Non-structural damage: Very heavy** Large cracks in structural elements with compression failure of concrete and fracture of re-bars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
 **Grade 5: Destruction**	**Structural damage: very heavy** Collapse of ground floor or parts (e.g. wings) of buildings.

Source: EMS

Figure 0.21 EMS 98 (RC structure)

(8) Damage data of historical building (monument)

Damage data due to 2015 Gorkha earthquake for the three Durbar Squares, as surveyed by DOA, is shown in Table 0.3. Total 108 buildings (monument) at World Heritage Site (WHS), Protected Monument Zone (PMZ) have been evaluated.

Table 0.3 Damage data of historical building (monument) due to 2015 Gorkha earthquake

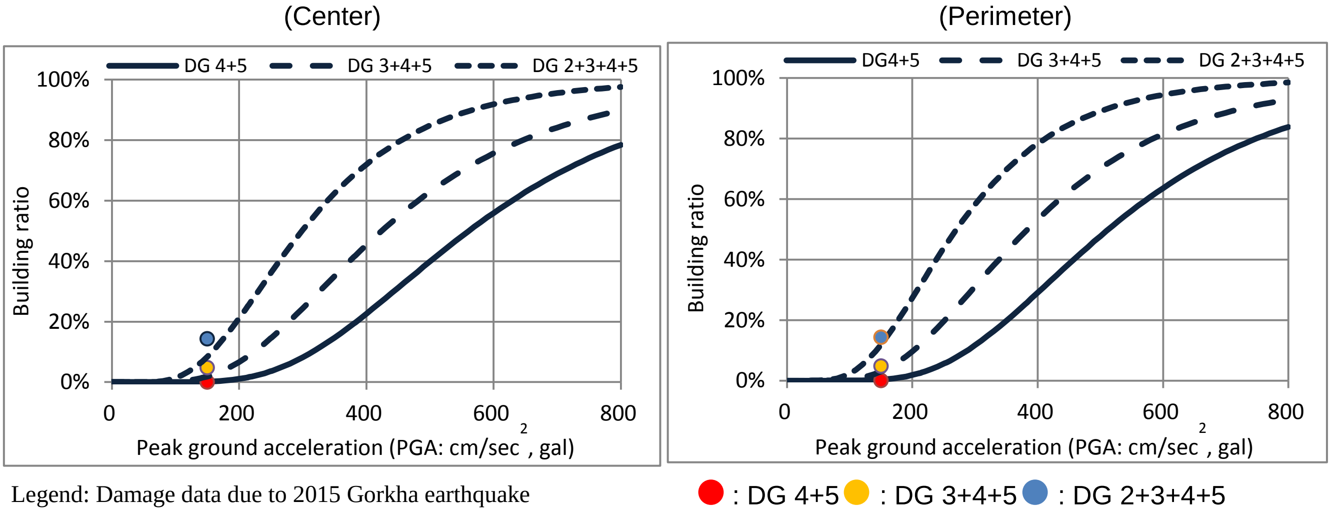
	Total number: A	Reconstruction (%): B	Retrofitting/ Conservation (%): C	(B+ C)/ A (%)
Kathmandu	62	10	12	35.4%
Lalitpur (Patan)	22	5	6	50%
Bhaktapur	24	6	10	66.7%
Total	108	21 (B/A= 19.4%)	28 (C/A= 25.9%)	45.4%

Source: DOA

(9) Proposed damage function of tall RC building (10 storey and more)

Proposed damage function of tall RC building (10 storey and more) is shown in Figure 0.21. The function for DG 4+5 is similar to that of RC engineered, and the function for DG 2 and DG 3 is adjusted, which shows damage of non-structural wall. Damage data shared in the Symposium by JICA, GRIPS, BRI, “Recovery from 2015 Nepal Earthquake”, held on November 2015, the data by Prof. Kusunoki (Univ. of Tokyo) and the data by AIJ were referred. Survey of 38 high-rise buildings at 13 residential areas was done. Heavy damage observed was none; 5 buildings had minor to moderate damage, 4 had minor damage, and remaining 29 had slight damage.

Damage ratio; moderate = 3 (supposed)/ 63 (all in the valley)= 4.8%, minor and more= 9(supposed)/63)= 14.3%.



Legend: Damage data due to 2015 Gorkha earthquake

Source: JICA Project Team

Figure 0.21 Proposed damage function of tall RC building (10 storey and more)

7.2 Study of Seismic Performance Based on Detail Building Survey

(1) Outline

Detail is shown in Appendix 6. Total 11 buildings were assessed by simple evaluation method. Following idea and assumption were made for the seismic assessment.

a) For No. 1 to No.3, No.7 and No.9, shear strength of wall was evaluated as masonry.

b) For No.1, No.2 and No.9, in case of “mud mortar joint”, out-of-plane collapse might occur at upper storey at PGA 150 to 200gal.

c) For No.4 RC non-engineered, frame with non-structural brick wall was evaluated for X-direction, and frame only evaluated for Y-direction. Contribution of brick wall without opening is big.

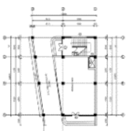
d) For No.5 RC engineered, seismic performance is much higher than min. requirement of the seismic code.

e) For No.6 RC engineered high-rise, the building is big and complex, and, axial force change will affect the strength and ductility of columns. Evaluation was done with some assumption.

f) For No.8 RC engineered hospital, importance (usage) factor 1.5 was considered in design.

The result for structural type and data of material and member is shown in Table 0, Table 0 for result of assessment for masonry, and Table 0 for result of assessment for RC building respectively.

Table 0 Structural type and data of material and member

No.		Classification	Member size and Material information
1		Adobe, residential	Wall thickness: 450mm, Supposed shear strength of mortar = 0.072 Mpa
2		Brick masonry with mud mortar, residential	Wall thickness: 700mm, 650mm, 600mm, Supposed shear strength of mortar = 0.11 MPa
3		Brick masonry in cement mortar, residential	Wall thickness: External wall 350mm brick wall, Internal walls are 350, 225 and 100 mm brick walls, Supposed shear strength of mortar = 0.5 Mpa
4		RC with non-engineered, residential	Column size: 225mmX 225mm, Concrete Strength: 15Mpa (Cube), Yield strength of reinforcement: 415Mpa
5		RC frame with engineered construction, residential	Column size: 400mmX 400mm, Compressive strength of concrete: 25Mpa for columns, 20 Mpa for others, Yield strength of Rebar: 415 Mpa

No.		Classification	Member size and Material information
6		RC frame high-rise with engineered construction, residential	Column: various size, Shear walls 250mm and 300mm thick, Concrete(Design)-30Mpa~20Mpa, Yield strength of rebar: 415Mpa
7		Brick masonry, school building	Ground floor walls 350mm, 230mm, and first floor and second floor walls 350mm, 230mm, 115mm, Supposed shear strength of mortar: 0.248 MPa
8		RC frame, hospital building	Column size: 450mm x 450mm and 500mm x 500mm, Strength of Concrete: 20mpa with super plasticizer, Yield strength of rebar: 415mpa
9		Historical building	Wall thickness: 600mm, 450mm, Supposed shear strength of the mortar joint: 0.11 Mpa
10		Government building	Column Size: 500mm X 500mm, 450mm X 350mm, Concrete strength 16.3 Mpa, 19.9 Mpa (from core test), Rebar: 415 Mpa
11		Local government building (construction in1992)	Column Size: 600mm X 600mm~500mm X 500mm~350mm X 350mm, Concrete cubic strength: 23.83 Mpa, Rebar: Yield Strength: 295 N/mm2

Source: JICA Project Team

Table 0 Result of assessment for masonry

No.	Usage, No. of storey, Total floor area (m^2), Total building weight (kN)	Supposed shear strength of joint mortar (N/mm^2)	Wall area (mm^2)	Sear strength of wall (kN)	Strength coefficient (=shear strength/ total building weight)
1	Residence, 2 storey/B0, A=52.9m^2, W=876.3kN	τ =0.072 (mud mortar)	ax=4.26x10^6 ay=3.66x10^6	Qx=332.5 Qy=263.2	Cx=Qx/W=0.38 Cy=0.30
2	Residence, 4 storey/B0, A=255.3m^2 , W=2,286kN	τ =0.11 (mud mortar)	ax=8.67x10^6 ay=13.54x10^6	Qx=953.8 Qy=1490.	Cx=Qx/W=0.42 Cy=0.65
3	Residence, 4 storey/B0, A=431.4m^2, W=4,846kN, (original 3 storey, W=3,638kN)	τ =0.50 (cement mortar)	ax=4.88x10^6 ay=8.61x10^6	Qx=2439. Qy=4306	Cx=Qx/W=0.50 Cy=0.87
7	School, 3 storey /B0, A=539.2 m^2, W=4,366kN	τ =0.248 (cement mortar)	ax=9.90 x10^6 ay= 9.86 x10^6	Qx=2455. Qy=2445	Cx=Qx/W=0.56 Cy=0.56
9	Historical, 3 storey/B0, A=251.3 m^2, W=2,429kN	τ =0.11 (mud mortar)	ax=10.18 x10^6 ay= 9.24 x10^6	Qx=1120. Qy=1016.	Cx=Qx/W=0.46 Cy=0.42

Note: 1) "Masonry" is supposed as "Un-reinforced masonry", which has no ductility.

2) Total building weight is estimated as, W= Dead load + 25% of Live load
3) According to the elastic response analysis using observed 8 waves at 2015 Gorkha earthquake, amplification of masonry structure (response base shear/ PGA) was 1.3 to 2.7, and average was 2.0. PGA that causes heavy damage of masonry was estimated by above strength coefficient (Cx, Cy) divided by 1.3~2.7 (or simply 2.0).
4) Strength coefficient causing “out-of-plane collapse” of wall with “mud mortar joint” at upper storey, might be 0.3~0.4 (equivalent PGA 0.15~ 0.20G) subjected to building configuration.

Source: JICA Project Team

Table 0 Result of assessment for RC building

No.	Usage, No. of storey, Total floor area, Total building weight	Materials (concrete strength in cylinder, Yield stress of re-bar	Axial force ratio	Tensile re-bar ratio, Shear re-bar ratio	Flexural strength, Shear strength of column	Base shear strength factor, ductility index
4	Residence 5 storey/B0 A=297.2m² W=2,551.8kN	Concrete,12.8 Mpa(15.0Mpa in cube), fy=415Mpa 230mmx230mm	Center column: N/bDFc= 0.55>0.4	Pt=1.14% Pw=0.00096(as 90 degree hook)	Center column Qmx=M/h/2=48.9/1.152=42.3kN Qmy=37.8/1.152=32.7kN	Cx=Q/w=676/2,552=0.265 Cy=511/2,552=0.20 F is supposed as 1.27~. If brick wall is considered, Cy=0.49
			Perimeter column: N/bDFc= 0.30<0.4		Perimeter column Qmx=62.3/1.152=53.8kN Qmy=46.9/1.152=40.5kN Qsx=65.7kN	
5	Residence 4 storey/B0 A=5,652m² W=5,652kN	Concrete,21.2 Mpa(25Mpa in cube) Re-bar, fy=415Mps 400mmx400mm	Center column: N/bDFc= 0.36>0.4	Pt=0.809% Pw=0.0035	Center;Qm=M/h/2=330/1.375=240.0kN	Cx=Cy=Q/W=2,325/5,652=0.41, F=3.2. If brick wall is considered, Cy=0.82
			Perimeter column: N/bDFc= 0.21<0.4		Perimeter, Qm=283/1.375=205.6kN Qs=338kN>240	
6	Residence, 15storey/B1, A=14,661m2, W=190,403kN A/W=12.99 Clear height: 3.35-0.5(0.6)= 2.84m (2.74) 3.04-0.5(0.6)= 2.54 m(2.44)	Concrete: 30Mpa~20Mpa (25.5Mpa~17Mpa in cylinder) Re-bar: 415Mpa Column: 1,200mmx500mm~ 800mmx400mm Shear wall, 250mm & 300mm	Center column: N/bDFc= 0.43.>0.4	(C9) Pt(long)=0.42% Pt(short)=1.40% Pw(long)=0.0030 Pw(short)=0.004	Center column; (C9; 400x975mm) Qm(long)=Mu/1.42m=1630/1.42=1,148kN Qm(short)=1199/1.42=844kN	The building is big and complex. Variation of axial force of column affects the assessment. Cx= 0.11~0.14, Cy=0.13~0.17. Ductility is not expected to the supposed level by the design.
			Perimeter column: N/bDFc= 0.26<0.4	(C7) Pt(long)= 0.41% Pt(short)=1.23% Pw(long)=0.0030 Pw(short)=0.004	Perimeter column (C7; 400x900mm) Qm(long)=Mu /1.42=1241kNm/1.42m=874kN, In case axil force is 0, Qm(long)=Mu=439/1.42=309kN Qm (short)=943/1.42=664kN Qs (long)=600kN, Qs(short)=512kN	
8	Hospital (center block) 4 storey/B0, A=2,074m² W=27,694kN	Concrete: 17.0N/mm2 (20Mpa in cube) Re-bar: 415N/mm² Column: 500x500mm	Center column: N/bDFc= 0.32<0.4	Center column: Pt=0.871% Pw= 0.0050 Perimeter column: Pt=0.715% Pw=0.0050	Center column: Qm=552.2kNm/1.625m=339.8kN Qs=457.8kN, ,	C=Qs/W=8,359/27,694=0.308 F=3.1 Importance factor 1.5 is applied in design
			Perimeter column: N/bDFc= 0.23<0.4		Perimeter column: Qm=452.8kNm/1625m=278.6kN Qs=423.3kN	
10	Governmental office (wing block),	Concrete: 17.2N/mm2 in core sample	Center column: N/bDFc=	Center column: Pt=0.377% Pw= 0.00134	Center column: Qm=325.5kNm/1.4m=232.5kN Qs=269.6kN, (in case 90 degree	Cx=Qs/W=3,369.3/12,347=**0.273**

No.	Usage, No. of storey, Total floor area, Total building weight	Materials (concrete strength in cylinder, Yield stress of re-bar	Axial force ratio	Tensile re-bar ratio, Shear re-bar ratio	Flexural strength, Shear strength of column	Base shear strength factor, ductility index
	5 storey/B0, A=1,320m^2 W=12,347kN	Re-bar: 415N/mm^2 Column: 500x500mm, 450x350mm	0.20<0.4 Perimeter column: N/bDFc= 0.16<0.4	(0.00067, as 90 degree hook) Perimeter column: Pt=0.598% Pwx=0.00148(0.000743) Pwy=0.00191(0.000956)	hook), Perimeter column: Qmx=171.7kNm/1.4m=122.6kN Qmy= 220.7/1.4=157.7kN Qsx=149.0kN ((in case 90 degree hook) Qsy=162.2kN	Fx=1.83~2.0 Cy=3,999.3/12,347=**0.324** Fy=1.27~1.83. Ductility is not enough.
11	Local governmental office、 4 storey/B0、 A=2,335m^2 (Open space at center)、 W=35,968kN	Concrete: 243kg/cm^2 (20N/mm^2 in cylinder) Re-bar: 415N/mm^2 Column 600x60mm,	Center column: N/bDFc= 0.34<0.4 Perimeter column: N/bDFc= 0.18<0.4	Center column: Pt=1.17% Pw= 0.0063 (0.0031, as 90 degree hook) Perimeter column: Pt=1.17% Pw= 0.0031 (0.0015)	Center column: Qm=1,214.4kN/1.8m= 675.8kN, Qs= 753.9kN, 644.5kN (in case 90 degree hook) Perimeter column: Qm=111.2/1.8=634kN Qs=558.5kN, 475.9kN((in case 90 degree hook)	C=Q/W= (675.8x8)+ (558.5x16)/35,968= **0.399** for both direction F= 1.0~1.27 Ductility of perimeter column is limited.

Note: 1) Total building weight is estimated as, W= Dead load + 25% of Live load

2) Concrete strength of cylinder is estimated as 85% of cube strength.

3) Shear reinforcement ratio has been reduced to half in case of 90 degree hook.

4) Notation: bD: Column width and depth, Fc: Concrete strength (in cylinder), Pt: Tensile re-bar ratio, Pw: Shear reinforcement ratio, F: Ductility index calculated from ductility factor.
Mu: Flexural strength, Qm: Shear force at flexural yield, Qs: Shear strength, h: Clear height of column

5) Calculation of Strength index and ductility index has been done based on following standard,
The Japan Building Disaster Prevention Association, "Standard for Seismic Evaluation of Existing Reinforced Concrete Buildings 2001, and Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings 2001, English version, 1st"

6) Axial force of column at seismic load, N E , was supposed as 0 and 2xNL (NL: axial force by long term load) for the calculation of flexural strength, for no.6 high-rise building.

Source: JICA Project Team

References

References for Appendix 7 are as follows.

・ JICA 2002, "The Study on Earthquake Disaster Mitigation in the Kathmandu Valley, Nepal"

・ Prof. Prem Nath Maskey, Tribhuvan Univ. "Research in Engineering on Traditional brick masonry and RC buildings", IOE 2012, 2014

・ Dr. Ramesh Guragain, NSET, "Earthquake Risk Assessment System"

・ Ritsumeikan Univ. and Ttibhuvan Univ.,"Disaster Risk Management for the Historic City of Patan, Nepal"

・ "Standard of Judgment of Damage Grade and Guidelines of Recovery Engineering for Damaged Buildings, 2001", The Japan Building Disaster Prevention Association (written in Japanese)

- Relation between Seismic Index of Structure, ”Is”, (2nd level Screening) of existing RC buildings and Earthquake Damage (Source: Commentary Figure 5.2-3 of “Standard of Seismic Evaluation of Exiting RC Buildings (Prof. Y. Nakano, JBDPA, Japan)
- Naoko Itaya Ushitani, “Disaster Vulnerability of Historic City of Patan, Kathmandu Valley ; the case of Jatapur historic urban area”, Papers on Disaster Mitigation for Historical Cities, Ritsumeikan University
- JICA Project Team, “Damage Survey at Sakhu due to the 2015 Gorkha earthquake””
- NIED, “Building damage survey due to the 2015 Nepal Earthquake at Sakhu and Kokhana”, The National Research Institute for Earth Science and Disaster Prevention, Japan
- Yo Hibino, et at, “Field I investigation in Affected Area due to the 2015 Nepal Earthquake by AIJ reconnaissance team: damage assessment and seismic capacity evaluation of buildings in Gongabu, Kathmandu”, New Technology for Urban Safety of Mega Cities in Asia.

Appendix 8 Seismic Performance Strengthening of Bridge

8.1 Evaluation method for indicating the degree of urgency for improvement of the earthquake resistance performance

Bridges in KV did not suffer serious loss of function due to the 2015 Gorkha Earthquake, but more devastating damage, such as bridge collapse, might occur when large earthquake motion, considered as scenario earthquake in this project, occurs. It is very important to implement seismic performance improvement measures such as earthquake-resistant reinforcement and replacement for bridges on emergency transportation roads.

The result of “Chapter 2 Risk Assessment" shows the general meaning of risk that assessed functional loss of the bridge in the Kathmandu Valley. Specifically that assessment result has been indicated by a four-stage state (No significant damage, Slight, Moderate, Heavy), represented by the collapse possibility of a multi-span RC made bridge pier.

On the contrary, the "Chapter 3 Proposal for Utilizing Risk Assessment Results" shows the starting sequence for implementation of measures to improve seismic performance giving priority to high-risk bridges. In this chapter, a comprehensive evaluation taking account the influence of "girder seat length" and "scour", which also contribute to the collapse of the piers, have been considered, although those points were not included in Chapter 2. In addition, priorities are indicated through all bridges included in the bridge inventory, including single span bridges and bridges consisted of materials other than RC.

8.1.1 In case of multi-span bridge

In addition to the phenomenon that the bridge surface cannot be maintained due to collapse of the piers themselves, the following two factors are considered to cause the loss of function about the multi-span bridges.

① Girder seating length: The girder undergoes a large displacement due to the inertial force at the time of the earthquake and comes off the peer cap support surface.

② Scour: The river bed lowers down due to scour and the foundation loses the reaction force (mainly horizontal reaction force), so that a large displacement occurs at the time of the earthquake, and the superstructure fall from the support surface of the pier cap.

As above, "the comprehensive evaluation score" will be set considering the collapse of the piers themselves, lack of the girder seating length, effect of scour, and poor quality of materials other than RC are evaluated as follows.

- When the substructure consists of masonry (stone, brick), "the comprehensive evaluation score" will be set to 5 considering that a bridge that once received an earthquake damage and is cracked tends to cause brittle fracture even if the damage was small. Also, the case of wooden construction is similar to the case of masonry.

However, in the case of forming the arch structure, the possibility of causing brittle fracture is small, so "the comprehensive evaluation score" will be set to 1.

If the substructure consists of RC, response ductility factor will be calculated, and then will be evaluated as shown in Table 8.1.1 by combining with the rank of the girder seating length SE.

Table 8.1.1 Five grades of comprehensive evaluation judgment when considering girder seating SE

Judgment from response ductility factor μr	Rank of the girder seating length SE	Explanation	Comprehensive evaluation score	Earthquake resistant measures
No significant damage	Rank C (SE>70cm)	Safe	1	No immediate problem
	Rank B (40cm-70cm)			
	Rank A (SE<40cm)			
Slight & Moderate	Rank C (SE>70cm)	Problem with strength of piers	2	Seismic reinforcement for substructure
	Rank B (40cm-70cm)	Problem with strength and girder seating length of piers	3	Seismic reinforcement for substructure Width widening of girder seating
	Rank A (SE<40cm)		4	Reconstruction is needed if possible
Heavy	Rank C (SE>70cm)	Problem with strength of piers	5	Reconstruction is needed
	Rank B (40cm-70cm)	Problem with strength and girder seating length of piers	5	
	Rank A (SE<40cm)		5	

8.1.2 In case of single span

If the substructure consists of RC, "the comprehensive evaluation score" will be 1. Referring to the observation on earthquake damage of the existing bridges, there is no serious damage of falling girder in the case of a single span, so basically "the comprehensive evaluation score" will be set 1. If the substructure consists of masonry (stone or brick) or wood "the comprehensive evaluation score" will be 4 (1 level safer than the case of multi-span). Wooden construction is similar to case of masonry.

However, in the case of formation with the arch structure, the possibility of causing brittle fracture is small, so "the comprehensive evaluation score" will be set to 1.

8.1.3 Influence of "scour"

Comprehensive evaluation score will be lowered by one level if scouring is found. However, consider the pattern and degree of scouring

The results are shown in the Map Book.

8.2 Practical method of seismic retrofitting

In this section, some examples of measures to be taken for bridges that are evaluated as having seismic resistance problems by risk assessment is described.

8.2.1 RC Jacketing

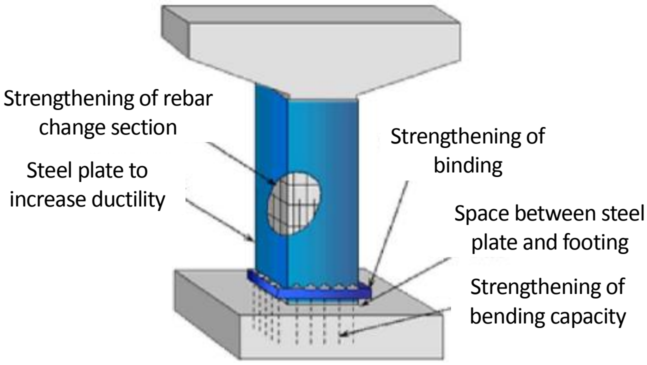
It is a construction method to reinforce existing bridge pier with insufficient strength. This method gives bridge pier additional bending capacity by axial reinforcing bars and prevents sticking out of axial reinforcing bars by adding hoop bar to improve ductility of bridge pier. As a disadvantage, since the mass of the bridge pier body increases, the inertia force in the horizontal direction during the earthquake also increases, which gives an overload to the foundation.

Source: Fuji PS Co., Ltd. Web page

Figure 8.2.1 RC Jacketing

8.2.2 Steel Plate Jacketing

It is adopted mainly to prevent sticking out of axial reinforcing bars by confining to improve ductility of bridge pier. As a disadvantage, comparatively high technology is required to fill the gap between the jacket steel sheet and the existing building and to keep adhesion. Since the mass of the bridge pier body increases, the inertia force in the horizontal direction during the earthquake also increases, and then it gives an overload to the foundation.

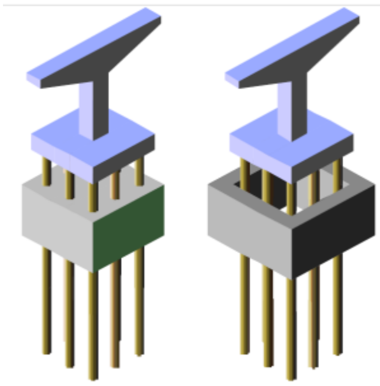


Source: Web page of Show Bond Construction Co., Ltd.

Figure 8.2.2 Steel Plate Jacketing

8.2.3 Adding Capacity of Foundation

When some material is added to reinforce the bridge pier the mass of the bridge pier body increases, the inertia force in the horizontal direction during the earthquake also increases, and it will be needed to add extra capacity to the foundation. Some additional reinforcing methods have been devised in Japan, increasing the number of piles and spread footing or Perform ground improvement around the pile. As a special example there is a method of jacketing each pile. However most of these methods need large-scale constructions and comparatively high technology.



Source: From the web page of CPR Method Study Group

Figure 8.2.3 Adding Capacity of Foundation

8.2.4 Pier Cap Widening

Enlarge the width of bridge piers cap to prevent a girder from moving beyond girder seating length. This assumes the behavior mainly in the longitudinal direction of the girder.

8.2.5 Movement Limiting Device for Girder Fall Prevention

Hold relative displacement between the girders and the bridge piers due to the earthquake to prevent a girder from moving beyond girder seating length. This also assumes the behavior mainly in the longitudinal direction of the girder.

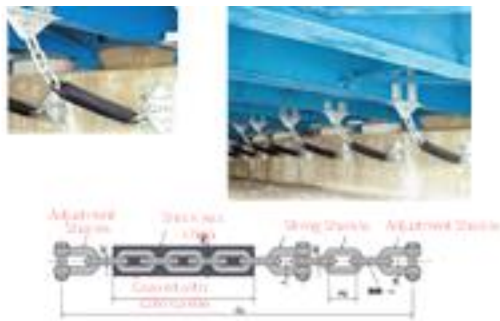


Figure 8.2.4 Movement Limiting Device for Girder Fall Prevention

8.2.6 Girder Connection

Connect the adjacent girders on the piers softly with cushion rubber to prevent unusual behavior and falling of girder caused by collision and repulsion of adjacent girders. This also assumes the behavior mainly in the longitudinal direction of the girder.

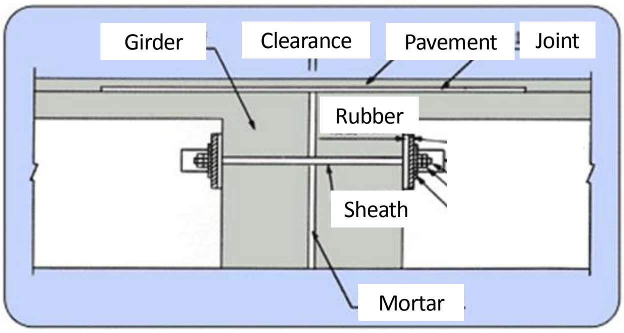


Figure 8.2.5 Girder Connection

8.2.7 Slab Connection

Break the slab of the adjacent girder partially and connect them to each other with additional rebar. This also assumes the behavior mainly in the longitudinal direction of the girder.

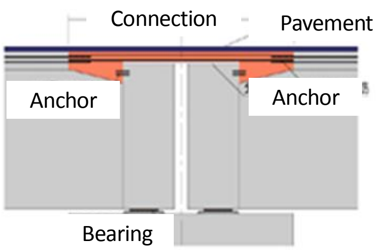


Figure 8.2.6 Girder Connection

8.3 Design Method Expected with a Newly Planned Structure

The possibility of partial seismic retrofit as earthquake resistant measure was mentioned above but those methods solve only partial weak point of corresponding bridge. Even if it is done, it will never reach a completely reliable level for the seismic motion assumed by the scenario earthquake. The bridge that has received retrofitting will be improved somewhat compared to the case where it is not applied

Although it is ideal to demolish a highly vulnerable bridge, and design and construct it according to the appropriate earthquake resistant design code, in reality it is difficult.

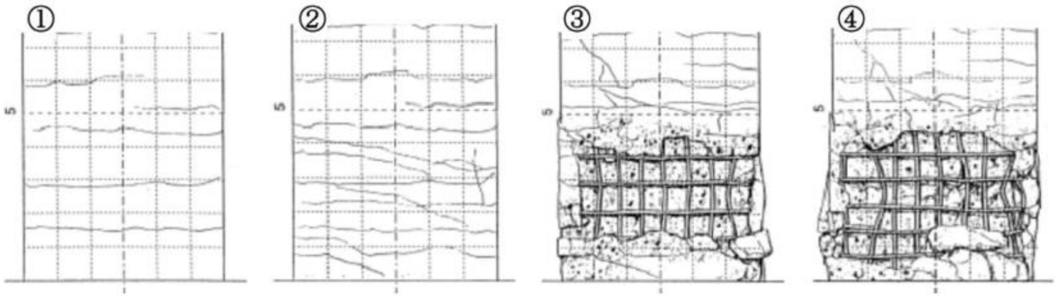
According to the interview, the earthquake resistant design code to be followed is "NEPAL BRIDGE STANDARDS-2067". However, in the case of foreign technology or support, it is designed according to the technology or the design standard of the support country. Design criteria conforming to individual bridges in the study area of this project are also various. The example that the followed code and construction age was confirmed were very limited.

In “NEPAL BRIDGE STANDARDS-2067”, the seismic load used for design calculation is to refer to Indian standard “STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES SECTION: II LOADS AND STRESSES INDIAN ROADS CONGRESS 2014” or AASHTO.

According to either criterion, "Response Reduction Factor" is applied for consideration of earthquake safety. The meaning of this coefficient is explained as follows.

<u>Concepts of “Response Reduction Factor” and problems in current situation</u>

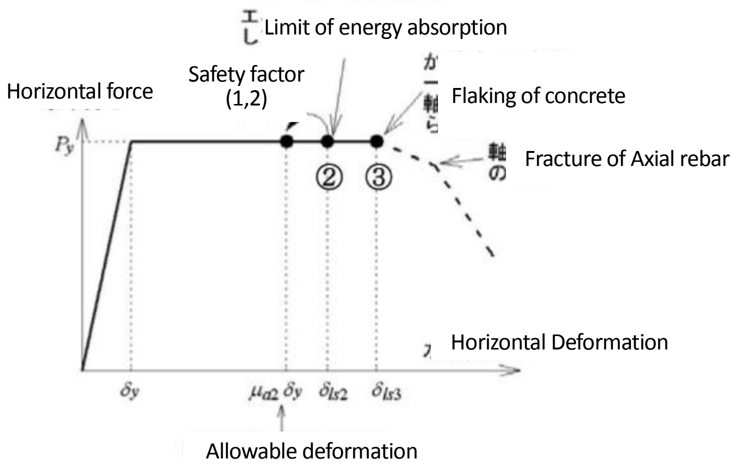
If the bridge pier is loaded for earthquake motion that is defined as design condition in the recent earthquake-resistant design code the bridge pier will exceed the elastic range and crack of concrete, yield of reinforcing bars, buckling of concrete occurs as shown in Figure 8.3.1.



Source: Technical information on seismic reinforcement design of existing bridge, Technical Note of PWRI No.424

Figure 8.3.1 Typical damage state of pier base

The structure is required to withstand load for a long time even after yield, and that strategy is called ductility design concept. A process of ductile behavior observed at loading experiment etc. is shown in Figure 8.3.2 as a schematic diagram. It is shown that the structure does not break down suddenly; displacement progresses while keeping reaction force, even after a part of the structure exceeds the elastic range, in this figure. It can be observed when the horizontal portion to the right of the displacement δy is observed.



Source: Technical information on seismic reinforcement design of existing bridge, Technical Note of PWRI No.424

Figure 8.3.2 Schematic diagram of horizontal force-displacement relation at the top of the piers

Ideally it is better to confirm the process of force-displacement relation by incremental loading analysis (pushover analysis) and make use of knowledge to design. However, it is labor-intensive to perform incremental loading analysis (pushover analysis) in individual designs so that design code (ex. NEPAL BRIDGE STANDARDS-2067) allow applying simplified method incorporating "Response Reduction Factor".

In other words, horizontal seismic coefficient is divided by "Response Reduction Factor" and multiplied by corresponding dead load and live load, and be loaded into the elastic frame model. The stress of the calculated member (the combination of bending moment and axial force) is used for checking the member cross section for safety by the elasto-plasticity manner.

Table 8.3.1 The value of "Response Reduction Factor" specified in the current standard

Bridge Component	R with Ductile Detailing	R without Ductile Detailing
Superstructure	2.0	N.A.
Substructure		
(i) Masonry/PCC piers, abutments	-	1.0
(ii) RCC short plate piers where plastic hinge cannot develop in direction of length and RCC abutments	3.0	2.5
(iii) RCC long piers where hinges can develop	4.0	3.3
(iv) Column	4.0	3.3
(v) Beams of RCC portal frames supporting bearings	1.0	1.0
Bearings	2.0	2.0
Connectors and Stoppers (Reaction blocks) Those restraining dislodgement or drifting away of bridge elements.	When connectors and stoppers are designed to withstand seismic forces primarily, R value shall be taken as 1.0 When connectors and stoppers are designed as additional safety measures in the event of failure of bearings, R value specified in **Table 9** for appropriate substructure shall be adopted.	

Source: "STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES SECTION : II LOADS AND STRESSES INDIAN ROADS CONGRESS 2014"

The aim of the Ductility Design is to keep stable behavior to the state shown in ③ of Figure 8.3.2. For this purpose, the following points are essential conditions.

- ✧ Appropriate value of "Response Reduction Factor"
  It is necessary to verify the validity of the coefficient by referring to the past great earthquake disasters, the loading test using the pier model as a specimen, and the verification by analysis.
- ✧ Prevent sticking out of axial reinforcing bars
  Avoid axial collapse due to early sticking out installing sufficient hoop bar,

- ✧ Bend fracture precedence

  Avoid brittle shear failure ahead of bending failure with sufficient shear reinforcement.

There is concern about above three point regarding most of the bridges in Kathmandu Valley study area. Even if a new bridge is to be constructed, fundamental changes such as standard revision is necessary if it prepares for scenario earthquakes as assumed in CNS - 2.

Appendix 9 Capacity Development and Assessment

Capacity development of the counterpart is important for the sustainability of the project. The project has made an effort for capacity development throughout the whole project period by means of a series of activities, such as working group meetings, workshops for pilot municipalities and wards, counterpart training in Japan, meetings and discussions between Japanese and counterpart experts for various topics, OJT for micro-tremor observation, creation of seismic risk assessment manuals and technical sessions for detail explanation of risk assessment, etc., targeting for different levels from central administrative and research organizations to municipal officials and the community.

9.1 Capacity Development Activities

Project members, according to the components of the project, are divided into 3 working groups, i.e., seismic hazard analysis group (WG1), seismic risk assessment group (WG2) and pilot activities group (WG3). The working group members of the Nepal side are the experts from different organizations with the leading organization of Department of Mines and Geology (DMG) for WG1, Ministry of Urban Development (MoUD) for WG2 and Ministry of Federal Affairs and Local Development (MoFALD) and Ministry of Home Affairs (MoHA) jointly for WG3. Each working group held several meetings to discuss and confirm the procedures and results on concerned topics along with the progress of the project. The working group meeting severs as an important occasion for information and knowledge sharing.

Regular meetings, Joint Coordinating Committee meetings and the public seminars contributed also to the capacity development of the counterparts. In addition, workshops, organized for pilot activities, especially during the formulation of the Local Disaster and Climate Resilience Plan (LDCRP) and Standard Operation Procedures (SOP), are very effective for capacity development of pilot municipalities. In ward level, series of workshops were held during the implementation of Community Based Disaster Risk Reduction and Management (CBDRRM) activities in order to enhance the capability of disaster risk reduction and management at ward level.

The project implemented counterpart training in Japan three times for the purpose of capacity development. The first one focused on the Build Back Better (BBB) recovery and reconstruction, the second targets seismic hazard and risk assessment and the third emphasized the disaster risk reduction and management plan. Besides, in-depth capacity development for focused groups was conducted, for example, the training for DMG to carry out micro-tremor observation and technical sessions for MoUD and DUDBC for GIS data processing and the methodology and calculation of seismic risk assessment for the purpose of future updating.

9.2 Capacity Assessment

A questionnaire survey was carried out for counterpart organizations to determine the current capacity of counterparts and the contribution of the project. Different questionnaires were prepared for counterparts depending on their function and responsibility, for example, seismic hazard assessment is related to DMG, seismic risk assessment to MoUD and DUDBC, LDCRP, SOP and CBDRRM to WG3 members.

The questionnaire consists of three topics for capacity assessment, i.e. institutional capacity, individual expert capability and the issues and challenges for future capacity strengthening. The responses to the questionnaire are summarized hereinafter for each counterpart.

9.2.1 Department of Mines and Geology

(1) Institutional Capacity

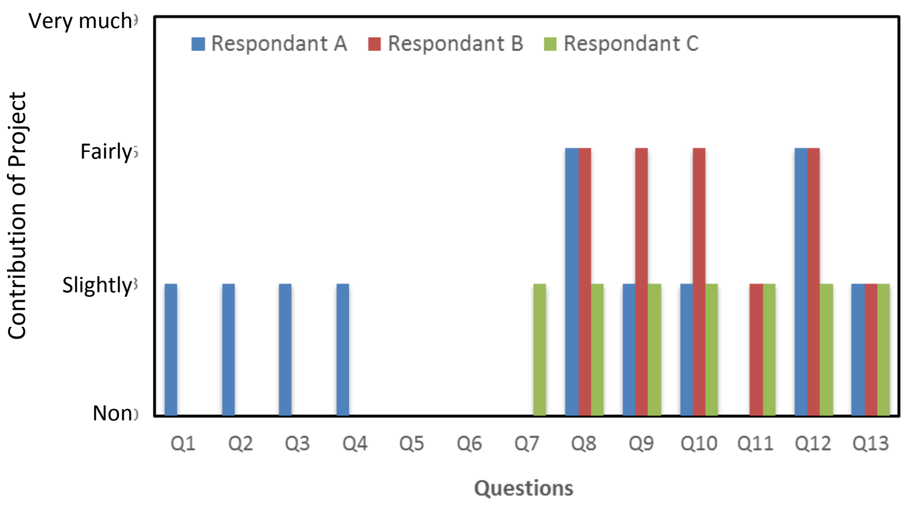
The Department of Mines and Geology is the chair organization of working group 1 for seismic hazard assessment. Institutional capacity of DMG is assessed from two aspects: 1) knowledge and technology and, 2) institutional management system.

1) Knowledge and Technology

From the responses to the questionnaire, it is determined that DMG has generally the technical capacity to make seismic hazard analysis. Main challenges for performing seismic hazard analysis are the insufficiency of seismological and geotechnical data and manpower. DMG has high expertise in the field of seismology, but is somewhat insufficient in geotechnical engineering. Thirteen topics were chosen to determine the contribution of the project to their knowledge and technology improvement on seismic hazard analysis, which are:

Q1: Understanding of seismic hazard analysis.
Q2: Performing seismic hazard analysis.
Q3: Earthquake Catalogue
Q4: Strong ground motion database
Q5: Active fault database
Q6: Geological information database
Q7: Geotechnical information database
Q8: Improvement of knowledge of setup of scenario earthquake
Q9: Improvement of technique for ground modelling
Q10: Improvement of knowledge of ground motion estimation
Q11: Improvement of knowledge of earthquake associated liquefaction and slope failure
Q12: Improvement of micro-tremor observation and analysis
Q13: Improvement of total capacity for seismic hazard analysis

The response is selected from four levels: none, slightly, fairly and very much. There were three respondents. Their responses are shown in Figure 9.2.1. From the figure, it can be seen the project contributed more to setup of scenario earthquake, ground modelling, and ground motion estimation as well as micro-tremor observation and analysis than the others. The total capacity of DMG on seismic hazard analysis is improved.



Source: JICA Project Team

Figure 9.2.1 Contribution of project to capacity development of DMG

2) Institutional management system

The institutional management system of DMG is assessed through human resource development, number of staff working related to seismic hazard, how the seismic hazard assessment results are shared within and outside DMG and yearly budget for earthquake related affairs, etc. Their responses and comments are summarized in Table 9.2.1.

Table 9.2.1 Institutional management system of DMG

	Topics	Observations and Comments
1	Frequency of human resource development programs	Human resource development programs are carried out two times a year.
2	Mechanism for updating seismic hazard assessment in KV the in future	The mechanism is unclear due to limited knowledge and database maintenance. The major issue is lack of dedicated knowledge and experts for the updating.
3	Conduction of Seismic hazard assessment out of KV in the future	The uncertainty of conducting of seismic hazard assessments outside of KV might be due to the bureaucratic process along with allocation of necessary budget. Other factors affecting the updating are availability of data for seismic ground motion, identification of active faults and other associated seismic hazard assessment variables
4	Number of staff working on seismic hazard	DMG is short of staff as seismic hazard assessment requires broad knowledge in several aspects like geology, geomorphology, geo-tectonics, field measurements etc. and thus the number of staff needs to be increased.
5	Seismic hazard assessment data and results sharing in DMG	The seismic hazard assessment data sharing and maintaining is done by communicating between departments with database and presentation in DMG.
6	Seismic hazard assessment data and results sharing to other organizations	The sharing of seismic hazard assessment is limited through reports or presentations. Publishing through a website and communication among departments need to be encouraged.
7	Yearly budget for earthquake related activities	The budget allocated for the earthquake affairs is very limited and needs to be increased to improve the capacity of DMG.

Source: JICA Project Team

(2) Capability of Individual Experts

Six categories were chosen to determine the contribution of the project to the improvement of the capability of the individual experts. Their responses are listed in Table 9.2.2, from which it can be seen that their capability is improved to some extent, differing between the experts, by involvement in the project. They have acquired, especially, the knowledge on setting up an earthquake model and carrying out micro-tremor observation and analysis.

Table 9.2.2 Contribution of project to individual capability improvement

	Question	Respondent		
		A	B	C
Q1	Understanding seismic hazard analysis.	Slightly	Slightly	Slightly
Q2	Improvement of knowledge of setting up of scenario earthquake	Fairly	Fairly	Slightly
Q3	Improvement of knowledge of ground modelling	Slightly	Slightly	Slightly
Q4	Improvement of knowledge on ground motion estimation	Slightly	Slightly	Slightly
Q5	Improvement of knowledge on earthquake associated liquefaction and slope failure	None	Slightly	Slightly
Q6	Improvement on total capacity for seismic hazard analysis	Slightly	Slightly	Slightly

(3) Challenges for Future Seismic Hazard Analysis

Seismic hazard analysis requires wide academic knowledge and data, which needs the cooperation between DMG, government research institutes as well as universities in order to enhance the capability of the country for seismic hazard analysis. DMG faces a major challenge of insufficiency of manpower as there are very limited staff working in the field.

9.2.2 Ministry of Urban Development

(1) Institutional Capacity

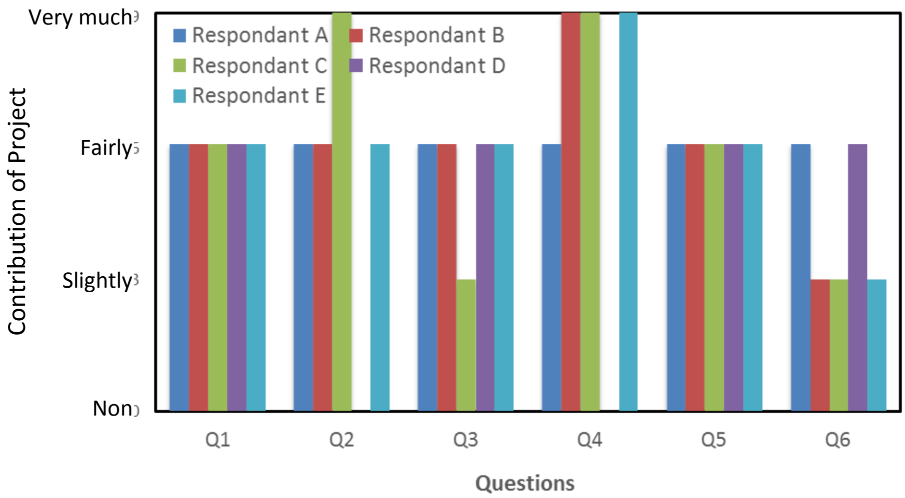
The Ministry of Urban Development is the main counterpart of the project, overlooking the whole project, and they are the chair organization of working group 2 for seismic risk assessment. Institutional capacity of MoUD is assessed from two aspects: 1) knowledge and technology and, 2) institutional management system.

1) Knowledge and Technology

MoUD is responsible for development of policy and planning for urban development and creation of building codes, etc., having no experience with seismic risk assessment before. Six topics were chosen to determine the contribution of the project to the knowledge and technology of MoUD on seismic hazard and risk assessment, which are:

Q1: Understanding of seismic hazard analysis.
Q2: Understanding of seismic hazard analysis for KV.
Q3: Understanding of the seismic risk assessment process.
Q4: Understanding of the seismic risk assessment results of KV.
Q5: Seismic risk related data accumulation.
Q6: Capacity for updating of the seismic risk assessment.

The respondents could rate the assistance that they received from the project on one of four levels: none, slightly, fairly and very much. There were five respondents and their responses are shown in Figure 9.2.2. From the figure, it can be seen that most of them answered fairly or very much, which means the project contributed considerably to their understanding of seismic hazard and risk assessment and then improved their capability for seismic risk assessment for future updating.



Source: JICA Project Team

Figure 9.2.2 Contribution of project to capacity development of MoUD

2) Institutional management system

The Institutional management system of MoUD is assessed based on human resource development, number of staff working related to DRR, how the seismic hazard and risk assessment results are shared within and outside MoUD and yearly budget related to disaster risk reduction and management. The responses and comments are summarized in Table 9.2.3.

Table 9.2.3 Institutional management system of MoUD

	Topics	Observations and Comments
1	Frequency of human resource development programs	Human resource development is not regularly conducted. Human resource development should be frequently organized so that more staff can be exposed to the works of DRR
2	Capacity of MoUD in updating seismic risk assessment for KV	The project made efforts on technical transfer in various ways in order to enhance the capacity of MoUD for updating the seismic risk assessment of KV but due to frequent transfers and the assigned officer’s workload in their own office, technical support is deemed necessary for updating.
3	Conducting of seismic risk assessment outside of KV in future	With the success and importance gained by this project, the project has contributed to the understanding that this kind of project should be implemented outside of KV
4	Plan for promotion of utilization of seismic risk Assessment results for DRR	MoUD will make plans for promotion of utilization of seismic risk assessment results for DRR.
5	Number of staff working on disaster risk reduction and management	MoUD is short of staff for seismic risk assessment and thus the number of staff should be increased for dedicated work in seismic risk assessment.

	Topics	Observations and Comments
6	Seismic risk assessment data and results sharing in MoUD	The assessment results are shared between departments and via workshops and brochures.
7	Seismic risk assessment data and results sharing with other ministries	It is shared with related ministries. Publishing the results on the website is considered for easy access and utilization.
8	Yearly budget for disaster risk reduction and management	There is no specific budget separated for disaster risk reduction and management.

(2) Capability of Individual Experts

Six questions were chosen to determine the contribution of the project to the improvement of the capability of individual experts. The answers are listed in Table 9.2.4, from which it can be seen that the project has contributed to the improvement of their knowledge on seismic hazard and risk assessment, from slightly to very much depending on the individual and the topic.

Table 9.2.4 Contribution of project to individual capability improvement

	Question	Respondent				
		A	B	C	D	E
Q1	Has your knowledge and understanding of seismic hazard analysis process been improved through the project?	Fairly	Slightly	Fairly	Very much	Fairly
Q2	Has your knowledge and understanding of seismic hazards in KV been improved through the project?	Fairly	Fairly	Slightly	Very much	Fairly
Q3	Has your knowledge and understanding of the seismic risk assessment process been improved through the project?	Very much	Slightly	Slightly	Fairly	Fairly
Q4	Has your knowledge and understanding of seismic risk in KV been improved through the project?	Very much	Fairly	Fairly	Fairly	Fairly
Q5	Has your understanding of seismic strengthening of buildings been improved through the project?	Very much	Slightly	Fairly	Very much	Slightly
Q6	How much has your knowledge and expertise been enhanced after participating in the project?	Very much	Slightly	Fairly	Very much	Fairly

(3) Challenges of MoUD for Future DRR

The issues and challenges of MoUD are:

- ❖ The critical challenge which MoUD faces with respect to seismic risk assessment is retention of dedicated personnel for institutional memory and sustainability due to the frequent staff transfer. Another underlying challenge is capacity development, budget and use of latest technology.
- ❖ Lack of resources and proper consolidated data combined with the lack of experienced experts in seismic risk assessment are the most significant challenges at national level.

Other necessities to overcome are public awareness on seismic risk assessment.

- ❖ The severe challenge for promotion of seismic strengthening of buildings is insufficiency of engineers and skilled masons. Next to this stands budget, technology development and public awareness. Improvement in the legal system and accessibility to remote areas are prerequisites to improve the situation.

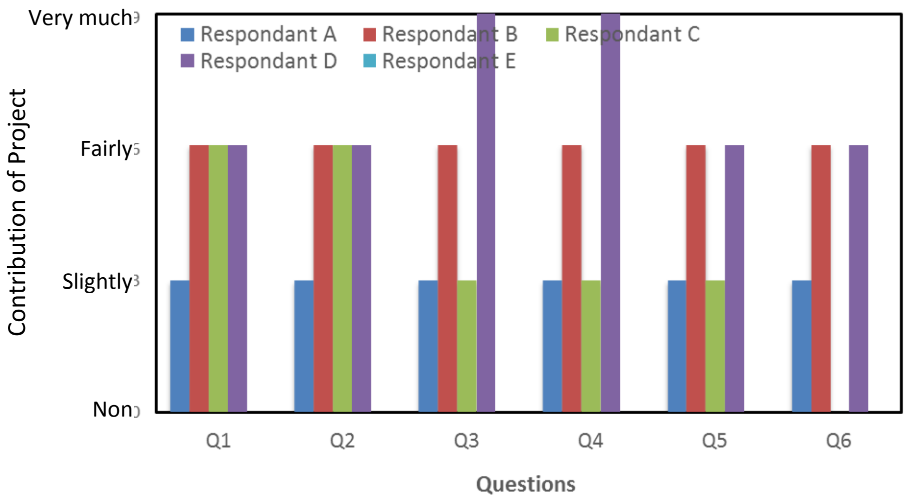
9.2.3 Department of Urban Development and Building Construction

(1) Institutional Capacity

The Department of Urban Development and Building Construction, affiliated to MoUD, is the member organization of working group 2. It has conducted damage surveys for government buildings after the Gorkha earthquake and is a key organization for seismic design of buildings. Institutional capacity of DUDBC is assessed from two aspects: 1) knowledge and technology and, 2) institutional management system.

1) Knowledge and Technology

DUDBC is responsible for urban development and creation of building codes, etc. and is the main organization for technology transfer for seismic risk assessment. Six topics, the same as those of MoUD, were investigated to determine the contribution of the project to the improvement of knowledge and technology of DUDBC on seismic hazards and risk assessment. The responses from five experts are shown in Figure 9.2.3. From the figure, it can be seen that the capacity of DUDBC is concretely improved through the participation of the project.



Source: JICA Project Team

Figure 9.2.3 Contribution of project to capacity development of MoUD

1) Institutional management system

The Institutional management system of DUDBC is assessed through human resource development, number of staff working related to DRR, how the seismic risk assessment results are shared within and outside DUDBC and yearly budget related to DRR. The responses and comments are summarized in Table 9.2.5.

Table 9.2.5 Institutional management system of DUDBC

	Topics	Observations and Comments
1	Frequency of human resource development programs	DUDBC, being an important government line agency for seismic risk assessment, the human resource development is not constant or planned.
2	Capacity of DUDBC in updating seismic risk assessment of KV in the future	The project made efforts on technical transfer in various ways in order to enhance the capacity of DUDBC for updating seismic risk assessments for the KV. But due to frequent transfers and the assigned officer's workload in their own office, technical support with varying degree is necessary for future updating.
3	Conducting seismic risk assessment outside of KV in the future	The respondents are mostly unsure about the plans for conducting seismic risk assessment outside of KV in the future.
4	Plan for promotion of utilization of seismic risk Assessment results for DRR	There will be a plan for promotion of utilization of seismic risk assessment results for DRR in municipal and local level entities for risk sensitive land use and integrated urban development.
5	Number of staff working on disaster risk reduction and management	The number of staff (approx. 20) working on disaster risk reduction and management is sufficient but staff dedicated for seismic risk assessment is desired.
6	Seismic risk assessment data and results sharing in DUDBC	The risk assessment results are communicated between departments within DUDBC.
7	Seismic risk assessment data and results sharing with other ministries	There is uncertainty in sharing the seismic risk assessment with other ministries.

(1) Capability of Individual Experts

Six questions were asked to determine the contribution of the project to the improvement of the capability of individual experts. The answers are listed in Table 9.2.6. It can be seen that the project contributes considerably to the improvement of their knowledge on seismic hazard and risk assessment.

Table 9.2.6 Contribution of project to individual capability improvement

	Question	Respondent				
		A	B	C	D	E
Q1	Has your knowledge and understanding of the seismic hazard analysis process been improved through the project?	Fairly	Fairly	Slightly	Fairly	Very much
Q2	Has your knowledge and understanding of the seismic hazards in the KV been improved through the project?	Fairly	Fairly	Slightly	Very much	Very much
Q3	Has your knowledge and understanding of the seismic risk assessment process been improved through the project?	Fairly	Fairly	Slightly	Very much	Very much
Q4	Has your knowledge and understanding of the seismic risk in KV been improved through the project?	Fairly	Fairly	Slightly	Very much	Very much
Q5	Has your understanding of seismic strengthening of buildings been improved through the project?	Fairly	Fairly	Slightly	Fairly	Very much
Q6	How much has your knowledge and expertise been enhanced after participating in the project?	Fairly	Fairly	Slightly	Fairly	Fairly

(2) Changelings of DUDBC for Future Updating

The issues and challenges of DUDBC are:

- ❖ The topmost challenge DUDBC faces is the lack of research activity to polish and increase technical capacity and manage its human resources.
- ❖ For the capacity enhancement of DUDBC for seismic risk assessment, regular and practical trainings and workshops for dedicated persons by directly involving them in the seismic risk assessment projects and works are necessary.

9.2.4 WG3 members

(1) Institutional Capacity

Main organizations of WG3 members, MoFALD, MoHA and pilot municipalities are the counterparts of the project, having responsibilities for the formulation of LDCRP, SOP and implementation of CBDRRM activities. Institutional capacity of WG3 members is assessed from two aspects: 1) knowledge and technology and, 2) institutional management system.

1) Knowledge and Technology

WG3 members are responsible for development of policy and actual implementation for local disaster risk reduction and management, etc. To date they have had no experience in implementation based on the seismic hazard and risk assessment. However understanding the seismic hazard and risk assessment is very important for effective implementation of local disaster risk reduction and management. Eleven topics were chosen to determine the contribution of the project to the knowledge and technology of WG3 members, which are:

Q1: Understanding of the importance of seismic hazard assessment for DRR.

Q2: Understanding of the importance of seismic risk assessment for DRR.

Q3: Understanding the seismic hazard of KV.

Q4: Understanding the earthquake induced hazard in KV.

Q5: Understanding the seismic risk in KV.

Q6: Understanding the importance of BBB for recovery and reconstruction.

Q7: Understanding the importance of formulation of LDCRP utilizing the result of the hazard and risk assessment.

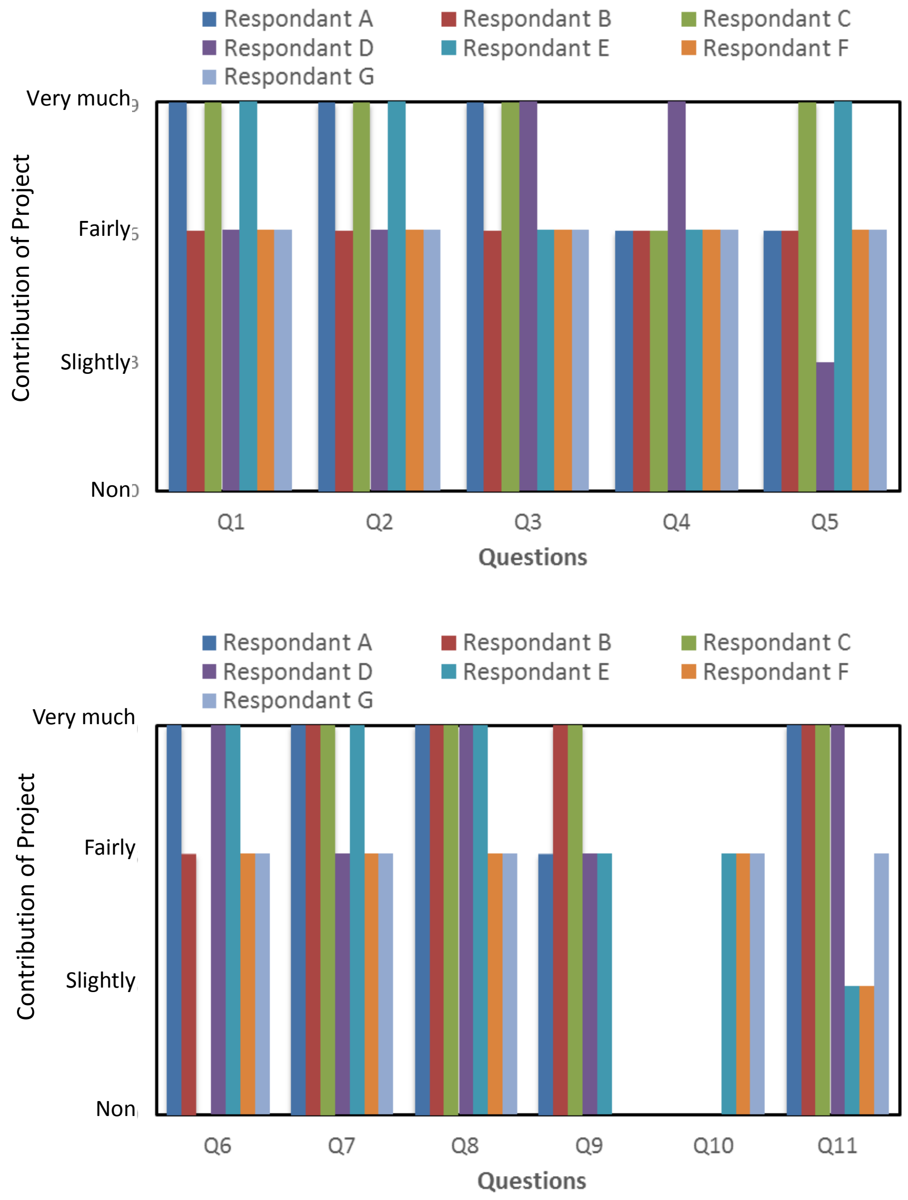
Q8: Understanding the CBDRRM activities for DRR.

Q9: Capacity for transmitting advice/support to local governments for DRR activities. (Especially for MoFALD)

Q10: Understanding the emergency response activities and SOP at the municipal level. (Especially for pilot municipalities)

Q11: Understanding the Sendai Framework for DRR.

The responses could be selected from four levels: none, slightly, fairly and very much. There were seven respondents and their answers are shown in Figure 9.2.4. From the figure, it can be seen that most of them answered fairly or very much, which means the project contributed considerably to their understanding of the importance of seismic hazard and risk assessment and planning utilizing the result of the hazard and risk assessment.



Source: JICA Project Team

Figure 9.2.4 Contribution of project to capacity development of WG3 members

2) Institutional management systems

The institutional management system of WG3 members is assessed through human resource development, number of staff working related to DRR, and capacity to implement disaster risk reduction and management activities. The responses and comments are summarized in Table 9.2.7.

Table 9.2.7 Institutional management system of WG3 members

	Topics	Observations and Comments
1	Frequency of human resource development programs for staff of organization	Human resource development is conducted once or twice a year. (Budhanilkantha municipality) Human resource development is not conducted.
2	Frequency of human resource development programs for local level entities	Human resource development for local levels is conducted once or twice a year.
3	Frequency of human resource development programs for the communities	Human resource development for communities is conducted once a year.
4	Frequency of monitoring of the implementation of LDCRP, BBB RR Plan, and CBDRRM activities	(Municipalities) Monitoring of the implementation is going to be started.
5	Capacity to advise/support for formulation of LDCRP, CBDRRM activities to local level entities	MoFALD can advise/support the majority of components, minor technical support is necessary.
6	Capacity to formulate/update LDCRP, SOP	Municipalities can formulate/update minor components, major technical support is necessary.
7	Capacity to implement CBDRRM activities	Municipalities can implement minor components, major technical support is necessary.
8	Sharing of progress and contents of LDCRP, BBB RRP, CBDRRM activities and SOP	WG3 members have communicated among departments and related organizations

(2) Capability of Individual Experts

Eleven questions were designed to determine the contribution of the project to the improvement of the capability of the individual experts. The answers are listed in Table 9.2.8, from which it can be seen that the project has contributed to the improvement of their knowledge on seismic hazard and risk assessment and pilot activities, from slightly to very much depending on the individual and topic.

Table 9.2.8 Contribution of project to individual capability improvement

	Question	Respondent						
		A	B	C	D	E	F	G
Q1	Has your knowledge and understanding of the importance of seismic hazard assessment for DRR been improved through the project?	Fairly	Fairly	Very much	Very much	Fairly	Fairly	Fairly
Q2	Has your knowledge and understanding of the importance of seismic risk assessment for DRR been improved through the project?	Fairly	Slightly	Very much	Very much	Fairly	Fairly	Fairly
Q3	Has your knowledge and understanding of seismic hazards (e.g. Intensity) in KV been improved through the project?	Fairly	Slightly	Fairly	Very much	Fairly	Fairly	Fairly
Q4	Has your knowledge and understanding of earthquake induced hazards (e.g. Liquefaction & Landslide) in KV been improved through the project?	Fairly	Slightly	Fairly	Very much	Slightly	Fairly	Fairly
Q5	Has your knowledge and understanding of seismic risk (e.g. Building Damage) in KV been improved through the project?	Fairly	Slightly	Fairly	Fairly	Fairly	Fairly	Fairly
Q6	Has your knowledge and understanding of the importance of BBB (Build Back Better) for recovery and reconstruction been improved through the project?	Very much	Fairly	Very much	Fairly	Fairly	Fairly	Fairly
Q7	Has your knowledge and understanding of the importance of formulation of LDCRP utilizing the result of hazard and risk assessments been improved through the project?	Very much	Fairly	Fairly	Very much	Very much	Fairly	Fairly
Q8	Has your knowledge and understanding of CBDRRM Activities for DRR been improved through the project?	Very much	Slightly	Fairly	Very much	Very much	Fairly	Fairly
Q9	Has your knowledge and understanding of emergency response activities and SOP at the municipal level been improved through the project?	-	-	-	-	Fairly	Fairly	Fairly
Q10	Has your knowledge and understanding of the Sendai Framework for DRR been improved through the project?	Very much	Fairly	Fairly	Very much	Slightly	Slightly	Fairly
Q11	How much has your knowledge and expertise been enhanced after participating in the project?	Very much	Fairly	Fairly	Slightly	Fairly	Fairly	Fairly

(3) Challenges of WG3 members for Future DRR

The issues and challenges of organizations of WG3 members are:

- ❖ The critical challenges which WG3 members face with respect to DRRM activities in local level entities are commonly lack of budget and skilled personnel. Other underlying challenges are capacity development, and difficulty in consensus building.
- ❖ The challenges in Nepal for sustainable and effective implementation of disaster risk reduction and management activities are lack of coordination and collaboration among related organizations and lack of implementation of programs for disaster risk reduction and preparedness since mainly the efforts have been focused on emergency response.
- ❖ Enhancement of public awareness and mainstreaming DRR in local development, and securing sufficient budget for implementation of programs for DRR with a positive approach are ways to improve the capacity for disaster risk reduction and management in the future.