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NEPAL EARTHQUAKES AND DEMOLITION EXPERIENCES

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Abstract

Nepal is a country located in a seismically active region prone to high magnitude events and due to its fragile geography it has a history of major earthquakes. On 25 April 2015 a 7.8M magnitude earthquake hit Nepal with its epicenter 76 km northeast of Kathmandu, the capital of Nepal. The earthquake resulted in more than 8900 causalities, 505000 houses destroyed and 279000 houses damaged completely. After any large scale natural disaster, safe demolition and debris management activities have always been a challenge. Nepal’s mountainous terrain and underdeveloped road and infrastructure network make for challenging work, combined with limited available resources. The building type, construction material and construction technology employed varies with topography and culture. Demolition methods are dependent on building type and site access thus this paper analyses the different types of buildings in heavily affected districts of Nepal and the demolition practices used to identify and highlight the safest ways available utilizing today’s technology.

This paper also provides an overview of the challenges encountered and the lessons learned from the UNDP Debris Management team. Based on UNDP’s debris management experience following the Nepal Earthquake, this paper is intended to provide a resource for concerned authorities to safely and effectively manage the demolition of earthquake damaged structures.

Keywords: Building technology 1, Demolition techniques 2, Debris Management 3, United Nations Development Programme 4

1. Introduction & Background

Nepal is a country exposed to various types of natural disasters such as earthquake, flood, landslide, thunderstorm, Glacial Lake Outburst Flood (GLOF) and extreme temperatures. The country is ranked 4th, 11th and 30th in terms of climate change, earthquake and flood risk respectively[1]. 90% of Nepalese people are exposed to more than two disasters at any time.[2]

Nepal has a history of major earthquakes every 80 years. A high magnitude earthquake struck Nepal on 25 April 2015 at 11:56 a.m. with magnitude of 7.8Mw. The epicenter was located in Barpak in the district of Gorkha about 76 km northwest of Kathmandu. The epicenter was at quite a shallow depth of approximately 15 km hence had more damaging effects, killing more than 8959 and injuring 22302. It was the worst natural disaster to strike Nepal since the 1934 Nepal–Bihar earthquake.

In the earthquake hit region deaths were mainly due to poorly constructed buildings. According to the Post Disaster Need Assessment (PDNA)[3] of May 2015; a total of 498852 houses were completely damaged resulting in a loss of $US 2584 million and 256697 houses were reported damaged causing a loss of $US 245 million. It accounts for about 49% of the total damage and loss estimated. It is estimated that the total repair or replacement costs of damages sustained by the earthquakes is US$ 7 billion. Of that amount 76 percent of the total damages represents the value of destroyed physical assets.

In many parts of Nepal buildings are constructed using local resources, local materials and local knowledge. According to National Population and Housing Census, 58% of the buildings in earthquake affected districts are low strength masonry, 21% are cement based, 15% of buildings are built using modern reinforced cement concrete (RCC) techniques and 6% are of other types.[4] The low strength masonry buildings in Nepal are constructed with indigenous knowledge, though no adequate earthquake resistant measures are taken in RCC buildings either.

The PDNA of May 2015 found that among 498852 fully collapsed buildings in earthquake affected districts; 95% were low strength masonry, 3.7% cement based masonry and 1.7% were RCC. Of the 256697 partially damaged buildings the percentages were 67.7%, 25.6% and 6.7% respectively. These damaged buildings still pose a risk to the 4.1million people residing in or living near them. The statistics do show that RCC buildings are a superior design in terms of earthquake resilience.

The Nepalese government was planning to safely demolish these hazardous buildings but it had no clear action plan in place on how to achieve it. In the absence of a government plan, people across Nepal begun demolition and debris management themselves. The Solid Waste Management Technical Support Center[5] has estimated these damaged structures generated 12.5 million cubic metres of debris in the Kathmandu valley. While in the other 11 affected districts, it has generated approximately 27.5 million cubic metres of debris. The private sector and Non Governmental Organisation and International Non Governmeantal Organizations (NGO/INGOs) in coordination with the Government of Nepal started working in this sector to assist those regions most heavily affected.

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[1] UNDP/BCPR,2004

[2] Disaster Risk Assessments in Nepal - A Comprehensive Country Situation Analysis, NSET, 2011

[3] National Planning Commission, GoN, Kathmandu 2015

[4] National Planning Secretariat, Central Bureau of Statistics, Government of Nepal, 2011

[5] A government body under Ministry of Urban Development responsible to provide technical support to local bodies and carry out studies, research & development in solid waste management sector.

Within the Nepalese context this paper intends to identify deficiencies in construction techniques particularly on low strength masonry, examine debris management and demolition practices in Nepal and identify ways for safe demolition as well as emphasize some of the important highlights on demolition and debris management policy and regulation in Nepal.

2 Assessment Methodology

2.1 Assessment of damaged buildings

National Society for Earthquake Technology (NSET), a leading agency in Nepal, has been working on earthquake preparedness and response alongside the Nepal Engineers Association (NEA) who deployed qualified civil engineers for the rapid evaluation of earthquake damaged buildings. The evaluation was conducted to determine the safety of buildings so that people could decide to whether occupy or abandon. Whilst carrying out these assessments, engineers were given instruction & training on tagging the structure. According to Department of Urban Development & Building Construction (DUDBC), the government of Nepal guidelines, buildings were tagged red, yellow or green, where Red tag meant no entry, yellow tag meant limited entry at their own risk and green meant safe to enter the house. Inside the Kathmandu Valley all effected structures were tagged, however out of the valley only public buildings were tagged by their respective ministerial technical departments.

For buildings tagged as red, a further assessment was carried out that focused on demolition preplanning. In the absence of any specific guidelines or policies on demolition, the United Nations Development Programme (UNDP) used their own form for building assessments utilizing international demolition expert experiences in Haiti and Christchurch. Initially assessments focused on private homes of mud and brick construction as these structures were overlooked by Government authorities who were prioritized to assess public structures only. The assessment form collected data on building dimensions, the level of damage, land fill conditions and determined the availability of household members to participate in Cash for Work (CfW) programs to demolish the structure.

UNDP in coordination with United Nations Volunteer (UNV)[6] had established a project to coordinate the effective and needed support on demolition. In this mission UNDP promoted volunteerism so that Nepalese engineers could share their university knowledge on helping people as well as getting to know their country closer. The advantage of using Nepalese civil engineers in demolition projects came about because of their knowledge about the topographical, constructional, material, technology transfer challenges that prevail in Nepal. UNDP saw the use of local expertise to oversee demolitions as an early step in improving the capacity of local engineers who could then be trained on earthquake resistant building construction in the future.

Engineers were mobilized and made responsible for assessing the affected population needs in terms of demolition and debris management, focusing especially on buildings requiring small scale demolitions carried out by low-skilled laborers. This was done to achieve maximum overall impact to the area in managing the clean-up. As the Government of Nepal gained better understanding of the situation it decided to provide a relief grant and pledged reconstruction assistance to private households affected by the earthquakes. This shifted the focus of relief and aid efforts away from private individuals and onto Government Institutions.

Thus demolition assessments were mainly focused on public structures. Since these buildings were more complex, UNDP modified the rapid evaluation form template by Department of Urban Development & Building Construction (DUDBC), the government of Nepal. The DUDBC form mainly focused on damage assessment of the building and via detailed damage assessment of building it aims to suggest owner whether they could repair, retrofit or need to demolish the building. UNDP modified the assessment form to incorporate information needed for building demolitions because it did not focus on how to demolish these buildings, indeed only on assessment of whether the building would be earthquake resistant and the level of damage sustained by an earthquake. Data collection was done via a manual fill up of form and was later uploaded to a custom built Debris Management

[6] The United Nations Volunteers (UNV) programme is the UN organization that contributes to peace and development through volunteerism worldwide.

application based on a Microsoft Windows phone. This application was developed in conjunction with the Microsoft Innovation Centre Nepal in an effort to engage the private sector in disaster recovery.

The basic steps followed during damage assessment by the engineers were:

- Early identification of ownership issues – which assisted in resolution of future claims or disputes
- Estimation of the volume of debris and work to be done
- Identification of storage facilities for recyclable materials and landfill sites for unusual debris
- Identification of special hazards and hazardous materials
- Definition of priority structures: health facilities (sub-health post, health post, hospitals), schools, dangerous buildings, and community places to allow superior planning of efforts
- Creating structure maps that formed part of the demolition plan
- Photographs before and after the demolition to provide a visual record of the work
- Tentative list of interested workers who would work under UNDP's CfW program
- Formal agreement for debris removal and demolition with owner/ organization and relevant stakeholders

All of these activities allowed UNDP to build a comprehensive picture of the situation on the ground and plan an appropriate and targeted response. This data when loaded into Microsoft's PowerBI allowed UNDP to manage its response and report to donors with realistic and geographically easy to digest information.

2.2 Building construction in Nepal

Nepal is a mountainous country with 83% of its area on slopes and only 17% plain lands. Due to varying topography and climate the construction material available changes accordingly. As plains are relatively warmer than mountain regions the physical configuration and construction techniques of building also changes. These techniques are indigenous and were transferred from generation to generation. It was discovered that buildings constructed more than a century ago incorporating unique techniques which we now call today earthquake resilient features. That made them resilient to earthquakes. Hence those buildings are still standing despite strong past earthquakes (1934 MW 8.1, 1988 ML 6.5).[7] Bhaktapur city and Nuwakot palace are the examples of indigenous construction knowledge proven resilient to earthquake as these are still standing today. However with time and especially after the invention of modern RCC techniques, traditional building construction become obsolete. Unfortunately indigenous knowledge transfer failed to pass on earthquake resistant techniques to new buildings constructed in recent times. Hence in recent earthquakes they failed. Given the last large earthquake happened in 1934, it is safe to assume that indigenous knowledge only survives a maximum of 3 to 4 generations before the experiences of the past are forgotten.

Among the hardest hit districts of Nepal, we conducted a study on low strength masonry buildings which failed or partially collapsed during earthquake. It showed the following results:[8]

Construction characteristics	**Findings**
Building Configuration	All of the buildings in the study area were of symmetrical configuration, rectangular in plan.
Length to breadth ratio	All the buildings length to breadth ratio was found to be 1.5 or less.
Openings	Openings found were relatively small but were placed asymmetrically. The ratio of total length of opening to total unsupported length of wall was found to be within limits for all buildings. Dalans were not found extended to the desired length. Openings were used to be placed on double frame system. This feature has made them resilient to some extent where both frames were found binded together properly.
Floor height	In all cases the story height was found to be less than 2.2 m and the number of stories limited to 2.5.

[7] Dixit A Mani, Parajuli YK, Guragain R(2004): Indigenous Skills And Practices Of Earthquake Resistant Construction In Nepal, 13th WECC, Vancouver, B.C., Canada

[8] Based on authors personal knowledge and experience

Wooden bands	For most of the buildings no bands at sill level, lintel level and at the floor level found. For the remaining buildings with bands, only a small percentage collapsed.
Vertical Post at corners	No vertical posts at corners were found.
Corner Stitch	No special provision for corner locks were found except for a few buildings
Foundation	Foundation was found of equal width to super structure wall. Foundation depth below ground level rarely found more than half a meter.
Joint packing	Mortar packing of joints was done excessively with mud mortar and very small sized stones. No through stones/wooden blocks extending through joints were found.
Wall thickness	Wall thickness varied between 350 mm to 500 mm depending upon the height of the building. The thickness of wall found to decrease on upper stories.
Material of construction	Most buildings in the study area were made of stone in mud mortar. Boulders used were extremely low quality and could be scratched with a nail easily or could be crumbled with little effort. The size of bolder used was found as small as size of chips to as large as 300 mm in length and 150 mm in thickness. The larger stones usually found in corners were found safer during the earthquakes. Mud mortar was found used as thick as 100 mm on wall mud floor base was found as thicker as 200mm causing excessive load at walls and post.

RCC buildings believed to be constructed with modern RCC techniques made up 1.7% share in fully collapsed and 6.7% in partially collapsed structures. Partially collapsed structures were found to have construction deficiencies that's why they failed during the earthquakes.

2.3 Conclusions on Failure of Buildings in the Study area

Of the buildings in the study area 53 % were one storey buildings, 30% were two storey and 7% of the buildings had three or more storeyes. Whilst analyzing the building structures it was observed that the buildings with one storey were completely dilapidated but buildings with more than two stories were severely damaged but still standing. This may be attributed to the beam kept at floor level of each storey which worked as a binder between walls. Furthermore people seemed to use better quality stone if they wanted to build two or more storey structures. This reflects existing well documented understanding of socio-economics, specifically those that can afford to build a larger structure will invest in making sure it is fit for purpose, however people with limited means will take measures necessary to cut costs yet provide suitable but compromised accommodation.

Among the buildings that could not withstand earthquake forces, thorough analysis found following failure mechanisms:

Failure Mechanism	**Observation**
Delamination of two wythes of masonry walls	Most of the collapsed buildings were of this type. It was found that while constructing walls, masons built them up in two wythes from two sides without any lateral ties joining the wythes. The space between wythes was filled with boulder chips and mud mortar. During the earthquakes these smaller particles between wythes crushed to smaller size and settled. This caused buckling of wall causing discontinuity of load path and ultimately failure of the wall.
Corner separation	Buildings with more than one story suffered this type of failure. This is due to a lack of lateral support at two ends of the wall during out of plane loading. Because there was no stitch band during the construction of the building it collapsed during out of plane loading.
Out of plane flexural failure	Occurred where there were no adequate wall ties, bands or cross walls even in a long wall.

3. Demolition

3.1 Organization and Project Modalities

The Paris Declaration on Aid Effectiveness (2005) requires aid actors to coordinate and seek co-contribution of effort from the host country governments in order to empower, develop and maintain the sovereignty and dignity of the nation receiving support. It stipulates that aid must be agreed to by the host nation government in line with agreed national priorities. Thus all activities are conducted through a 'one window' policy of the Government of Nepal (GON) whereby International and National Non-Government Organizations (I/NGO) were directed to work under approval of the government. All organizations active in demolitions worked closely with the Ministry of Federal affairs and Local Development (MoFALD) with a stated objective of 'safe demolition and debris removal from collapsed houses. These programs mainly focused on the rapid restoration of livelihoods of earthquake affected people.

For efficient implementation of a rapid response, UNDP Nepal augmented the existing project structure of the Local Governance and Community Development Program (LGCDP). This enabled near immediate response enabling UNDP Nepal to be the first responders in demolitions and debris management. In fact, UNDP crews were in the process of demolishing buildings in Sindhapulchok district when the 12 May 2015 6.9 magnitude aftershock occurred. The LGCDP had previously established groups of local people formed as a ward[9] citizens forums (WCF) and this structure proved highly effective in achieving local engagement, social inclusion and most importantly a list of priority buildings to be demolished first based on highest order of need. This ensured the local community were 100% behind UNDP's activities which considering the nature of the work (destroying what is left of people's homes) was one of the most successful aspects of the project.

The WCF was also instrumental in selecting suitable workers from the local community to participate in the CfW program. A cash-based approach was followed during demolition because it empowered people towards greater choice and control over how they will rebuild their lives, thus helping to restore their dignity as well as their livelihoods. It is important to note that other programs such as Cash for Food were in operation at the same time and because of the greater attraction towards choice, our project had no problems in attracting willing workers.

3.2 Working Team structure and Demolition Approach

UNDP Nepal organized its demolition teams in the following manner:

Member	Roles	Outputs
District Coordinator	Responsible for overall demolition activities in a Village.	Management, coordination, command and control
Community Mobilizer	Responsible to ensure attendance of local people under the cash for work program. Assist in addressing any issues regarding the work.	Assisted both District Coordinator and Engineers to achieve project efficiency by liaising with the WCF, laborer's and house owners to ensure minimal disruption of activities and full community awareness.
Engineer	Responsible for planning and execution of building demolitions. Controls a team of workers.	Plan and execution demolitions, guide and lead work teams to achieve the plan. Manage debris.
Cash for Work Team	Demolish structures under the leadership of the engineer in charge of the team	Building demolition, debris management. Each team consisted of approximately 17 workers. 6 skilled, 11 unskilled.

Each team was led by a civil engineer. Prior to work beginning each cash for work member was trained on basic demolition techniques to ensure their safety and efficient operation. Efficient use of tools was also taught. Engineers received intensive 3 day training on structural assessments, building demolition methodologies and efficient debris management. CfW members were restricted to personnel who were between the ages of 18 and

[9] Ward is a political division. Nine wards make up a village development committee (VDC), VDC makes districts.

60 and in reasonably healthy condition. This was essential as the nature of the work was physically demanding. No distinction was made between male and female other than the project attempted to target as many female workers as possible to ensure gender equality.

In consultation with the WCF; public structures and the houses of single women and old people were given higher priority. Site engineers planned each demolition approach and briefed it to the cash for work team. The plan followed the principles of: safety first, top to bottom and begin with debris clearance for greater access first. Each site demolition plan included worker management plans, demolition approach, tools needed, landfill site requirements, identification of hazards present at the site and any mitigation measures to be used to address the hazards. Demolition was then carried out by skilled workers, debris management by unskilled workers. All recyclable materials were stored either on site or in a location determined by the local authorities.

3.3 Manual Demolition

Defined as demolition achieved through the application of human effort and use of human powered tools. This type of demolition focused on low strength masonry/ load bearing structures which were partially and completely damaged. A well-equipped team with all safety measures and required tools was prepared. Manual demolition makes use of 'in Place' techniques i.e. the worker needs to present on the structure itself. Manual demolition techniques pose risk to life, however as local people were used in the demolitions, local knowledge of local hazards and familiarity with the building design and construction technique helped avoid casualties and loss of life.

3.4 Mechanical demolition

Most of the Government buildings were multi story RCC buildings, and as such were not safe to demolish manually due to the extended fall hazard. Heavy equipment (excavators) were used for the demolition of such large and risky buildings. To speed debris management and achieve ambitious recycling targets, mechanical demolition sites also had a team of CfW on site. It is important to note that mechanical demolition results in a lot of mess and an inefficient rate of material re-usage. Therefore the combination of heavy equipment and manual labour served to meet the compromise between safety, efficiency and efficient recycling. Furthermore it enabled the employment of more local people in the rehabilitation process after the earthquakes, leading to greater social involvement and a growing sense of empowerment.

3.5 Tools and equipment

Demolition sites were assessed for the identification of the tools and equipment required for manual demolition of the damaged structures. The first phase of the project used light hand tools such as levers, crow bars, hammers, hand saws, cutters and picks as it was mainly targeted to low strength masonry buildings built using stone in mud mortar. While performing demolition of masonry buildings these tools were found useful. People improvised these tools to make them more useful. In addition to this project made use of a chain pulley and chain saw to make demolition jobs a bit easier.

In second phase of the program mechanical demolition was done using excavators. This phase planned to use advanced tools for safe and efficient demolition of structures. But due market unavailability of appropriate mechanical tools and machines designed specifically for demolitions, excavators were used as a suitable alternative. 5-10 tonne capacity dump trucks were used for debris transportation to landfill locations or to line roads to improve site access.

3.6 Personal Protective Equipment (PPE)

Demolition work involves risks such as falling from height, injury from falling materials, cuts from nails and sharp objects, uncontrolled collapse, hazardous materials, noise and vibration, fire, dust, heat, insects and venomous snakes, spiders and scorpions. Therefore all of the workers were provided with PPE consisting of boots, gloves, dust filtration mask, hard hat, t-shirt and unlimited access to water. The purpose of personal protective equipment was to reduce employee exposure to hazards when engineering and administrative controls were not feasible or effective to reduce risks to acceptable levels. The PPE supplied was extremely effective in maintaining the safety of the workers. There were very few injuries and those that occurred were minor in nature requiring field level intervention (cuts, puncture wounds, bites).

3.7 Monitoring and supervision

District Coordinators were on hand to monitor and oversee work progress. In addition, UNDP Nepal's head office assigned a safety and security expert to monitor the progress and outputs of the entire program to ensure they were as compliant as possible with local laws, UNDP policy and extant international standards for the protection of workers, the environment and beneficiaries. The existing UNDP field office structure previously established for evaluating other field projects conducted regular visits alongside quarterly visits by senior management both in Nepal and in the regional office. This level of monitoring and oversight was deemed essential to ensure no loss of life.

UNDP's debris management program in Nepal has resulted demolition of more than 3500 private buildings which included more than 205 public structures. 293,000 m3 debris was managed safely.

4. Demolition Policy, legislation and regulation in Nepal

The government of Nepal launched its first document entitled "*Natural calamity relief act*" on disaster response in 1982. This document was mainly focused on relief activities following major disasters in order to make arrangements for the operation of relief work. This document focuses disaster response activities as the responsibility of Government of Nepal and all other authorities at different levels. The document lacks preparedness and disaster risk management measures and mechanics. As the document lacks comprehensive strategy on disaster management and response other document on disaster preparedness and response were developed over time.

After Nepal Earthquake (M 6.8, 1988) learning the lessons from it, the GON launched the *Nepal Building Code* (NBC) in 1994 and enforced it in 2003 to ensure government buildings were in compliance. For private buildings in many Municipalities and VDCs implementation of this building code are not yet mandatory. Besides building code no any document on earthquake safety, damage evaluation of buildings and post disaster damage assessment and demolition found until 2009.

1. Seismic Vulnerability Evaluation Guideline for Private and Public Buildings (2009)

   GON in coordination with NSET and UNDP and the drafted "*Seismic Vulnerability Evaluation Guideline for Private and Public Buildings*" in January 2009. Part I of this guideline was formulated for pre disaster vulnerability assessment of buildings. The guideline provides simple guides and tools for assessment of buildings with the primary objective of raising awareness on overall earthquake safety of buildings as well as collective safety of personnel. Part II of this document provides practical criteria and guidance for evaluating earthquake damaged masonry as well as RCC buildings. The guideline helps in observing / assessing damage caused by earthquakes in terms of the loss in building performance capability. This guideline provides details of a damage level grading system combined with a proposed tagging system and templates for building assessments.

2. Kathmandu Valley Post-Earthquake Debris Management Strategic Plan (2014)
   Ministry of Federal Affairs and Local Development (MoFALD), Government of Nepal, formulated debris management strategic plan in cooperation with International Organization for Migration (IOM), in 2014. The plan was believed to enable government agencies, humanitarian actors, private sector and local communities to plan, establish and coordinate responses to manage debris. The guideline identifies 9 of 83 gazette open spaces in Kathmandu valley as debris management sites. The guidelines also points space available in these open spaces are not sufficient in case of major earthquake in Nepal. The guideline identifies MoFALD, in coordination with the MoHA, as a lead government agency for post disaster debris management and the Department of Roads and Department of Urban Development and Building Construction, as technical

advisors to MoFALD for debris management. All other local NGO/INGO/Private agency and other interested parties coordinate with MoFALD on debris management. Thus in recent earthquake (2015) MoFALD appeared as leading agency to co-ordinate all the post disaster activity as there was a clear line of authority given to them making post disaster response effective.

3. Debris Management and Demolition Guidelines (2015)

Part I of this guideline came into force from June 5, 2015. The GON with technical support from UNDP formulated this guideline in order to remove hazardous building structures dilapidated by the 25 April and 12 May 2015 earthquakes. The guideline had provisions for technical committees involving municipal authorities, a technical person as well as local community representatives in each municipality or VDC to ascertain whether the building is hazardous and needs demolition. In case of any dispute the guideline has provisions for a high level committee involving concerned ministries and the Chief of Army and Police. The guideline provides direction for private, public as well as commercial use buildings.

Part II, Specially designed for UNDP demolition projects guides UNDP engineers on the demolition of public structures. It defines the role of the administrative hierarchy regarding demolition, establishing the District Development Committee (DDC) as the highest authority in the district. In addition to demolition and debris management it also highlights the importance of capacity building of engineers and local bodies. The guideline supports livelihoods of local people. For the implementation of this guideline it has clearly defined the role of local bodies as well as administrative bodies in Nepal. It guides on selection of CfW, damage assessments, preparation of work plans, approval and amendments, monitoring and evaluation and specifies area of UNDP help needed.

The seismic vulnerability evaluation guidelines serve as the complete guideline for evaluation of buildings either in pre or post-earthquake phase. Kathmandu Valley Post-Earthquake Debris Management Strategic Plan formulated to support National Disaster Response Framework (NDRF) activity 8[10], serves to identify debris management sites and debris management actors for the Kathmandu valley. However for other parts of the country the Nepal government or local bodies have not yet planned a response.

In the scenario of absence of safe demolition and debris management plans outside the valley and a lack of guidelines for demolition of critical infrastructure, UNDP formulated debris management and demolition guidelines. By enforcing these guidelines the Government of Nepal tried to establish a legitimate set of methodologies for demolition of structures. The guidelines worked well for the immediate post-earthquake situation. Since guidelines are not enforced by law not all agencies working on demolition and debris management felt compelled to follow it. This led to heterogeneity in data collection, working procedures and various standards of safety amongst agencies. Specifically data collected during demolition assessment could have served for better future planning for demolition as well as reconstruction. Hence it is felt there is a need for these guidelines to be developed into a comprehensive policy document and enforced by appropriate legislation with the aim of better preparedness and more efficient coordination and execution of disaster response.

5. Issues and Challenges

As debris management is new concept to Nepal it faced many problems in the course of its development. Some of the issues are highlighted below

I. Laws and regulations

[10] NDRF, Future Courses of Actions on Emergency Response Preparedness activity 8 identifies Debris clearance and planning activity as priority área and main responsibility on local government supported by MoHA and logistic cluster, the task targeted to completed within 6 months.

Besides a draft work on “Kathmandu Valley Debris Management Plan”, there is no strong policy or regulation found on debris management in Nepal. This led to dilemmas on distribution of responsibilities among authorities regarding debris management. In the lack of specific guiding procedures different agencies willing to work on debris management either started hap hazardously or waited until guidance came from the government. This led to a delay in response operations. As some of the agencies had already started demolition the coordination and data management between agencies became a challenge later on however initially it was overcome using the UNHCR cluster approach to disaster management whereby regular meetings of agencies were held to transfer information and reduce the potential for duplication of effort.

II. Guidelines on Demolition / Debris Management

UNDP Nepal Engineers were deployed to the field before formal demolition and subsequent building assessment guidelines were approved by the GON. This resulted in duplication of work in many cases as some data collected was not relevant and once the guidelines were published they required different data sets. In an ideal scenario, the guidelines would be in place and easily followed before an earthquake but Nepal simply wasn’t prepared.

III. Topographical / Climatological challenges

As Nepal is a mountainous country working in remote high altitude settlements became a challenge during implementation of program. The monsoon season came immediately after earthquake which resulted in most of the tracks in the hills difficult to walk as the tracks were slippery due to fine red soil and walking was only the option to reach sites since the roads were unable to be travelled safely due to risk of mud and landslide resulting in vehicles falling off edges. In summer the temperatures become very high meaning environmental hazards played an important part in ensuring safe demolition was undertaken without damaging the health of workers.

IV. Technological Challenges

The Debris Management Program tried to launch a mobile phone based application in conjunction with the Microsoft Innovation Center of Nepal for management of data and planning. The application was targeted to help in assessment, worker attendance and registration and generate payments. The app was expected to automatically synchronize to a system to generate a database. That database would be used for management decisions and reporting. However in most of the work places this app failed due to network problems. It was too dependent on real time communications which is something that usually fails during major disasters. Communications network in Nepal are underdeveloped so even emergency communications became hard during emergency periods.

V. Social Awareness

The main challenge working in the field was social awareness. After the disaster many people failed to realize that in order to start reconstruction demolition is necessary. Nepal’s mountainous topography means there is limited land available for reconstruction. Furthermore the safety risk posed by these hazardous structures was also not duly understood by people. In many cases the local people waited for a government subsidy by keeping their building standing further worsening the condition as the monsoon and aftershocks further degraded their safety and increased their hazard to the population. Given the low literacy levels and concerns over keeping a record of whether a house existed or not, the Government’s policy of providing a subsidy or relief fund to earthquake victims created a stalemate whereby the people had to wait and needed the proof to be entitled.

Another aspect of social issue was failure of people therein and even in UNDP about the role of engineers in demolition as it was perceived as a nontechnical job. So it took time to convince people of the importance of public safety and construction knowledge in demolition activities. With the governments switch to focusing on its own needs and simply offering a subsidy to private households, donors were forced to reconsider their positions ón whether or not they were willing to help a government unwilling to assist the population, or whether to violate the principles of the Paris Declaration and proceed to assist the population directly. Thus the project experienced significant underfunding as it had been designed to be many orders of magnitude larger within 12 months.

Besides these very specific issues, the blockade imposed immediately after earthquake by southern neighbor India posed a problem in effective response to the earthquake. Due to the blockade relief material and other essential daily consumables normally imported from India and abroad got lined blocked at the border, the most important of all commodities was fuel. Dubbed the fuel crisis: it significantly impacted the effectiveness of relief operations and forced internal thinking on politics surrounding the reasons for the blockade, the new constitution. Due to severe fuel shortage the recovery works going on in Nepal came to a halt. Demolition works also faced significant problems especially in government building work since it was dependent on mechanical equipment. In Nuwakot for example, a job was left ½ completed with the excavator on top of the rubble because it simply ran out of fuel and couldn't be moved. The blockade and its crippling effects in Nepal's time of need leads to questions on the minimum value of humanity and indeed the true nature of the strategic partnership between India and Nepal.

6. Conclusions and lessons learnt

Debris management programs (including UNDP's) are one of the most successful ongoing programs in Nepal. The modality of cash for work chosen for demolition involving local people made them able to make money when everything around them was turned into rubble. The CfW modality adopted by the program contributed to supporting and enhancing the livelihood of the earthquake affected rural populations. Moreover the program acted as a bridge in the gap between professional engineers and local people. In Nepal where not much consideration is given to earthquake resilient buildings, engineers rarely get involved with local people. Due to the interaction and coordination with engineers, workers involved are now educated on the technical failure modes of their structures. Hence the program was highly supported by the local people and considered a success story.

Capacity building was another main achievement of the program. The program provided training and practical experience to the civil engineers of Nepal and followed through with training on earthquake resistant construction techniques. Since all of UNDP's engineers are relatively young this is a significant investment in Nepal's engineering experience for the future. The recruitment of engineers in demolition jobs has enabled better understanding of the failure mechanism of buildings that helped in demolition with proper safety and raised awareness of earthquake resistant building designs during reconstruction. Via the safe demolition and debris management program, Nepal has got its first batch of experienced demolition engineers.

Nepal developed a building code, damaged building assessment guidelines and debris management plans prior to the earthquake. However the government lacked the mechanisms to enforce it. Its ongoing failure to enforce building code compliance has not only increased the risk for people in case of future earthquakes but also contributes to Nepal's vulnerable reconstruction. After the earthquake the Kathmandu Valley debris management plan was also not found lacking as neither sufficient sites were identified nor clear lines of command and action were identified in the strategic plan.

The demolition guidelines formulated after earthquake served the immediate purpose of having guiding documents for demolition need much improvement on it. Experiences in UNDP's post-earthquake project on demolition and debris management have highlighted just how under prepared the GON was for such a crisis. Fortunately the epicenter was not in Kathmandu and in fact in a rural location which resulted in significantly less casualties as well as generated less rubble, of which a higher proportion of which can be recycled. The earthquake highlighted the fact that it is not sufficient to have codes and guidelines in place, it should be clear, concise, complete and sufficiently supported by policies, regulations and enforced by legal provision.

One of the greatest achievement of project is that the program influenced and benefited all the people associated with it. The program enabled local people in generating cash as well as improving their knowledge on proper demolition techniques hence, the program succeeded in achieving its desired goals and objectives despite some major challenges and problems along the way. The program achieved its goal with no causalities. Professionally managed demolitions also helped the local people to salvage valuable construction materials like stone, wooden beams and slate which could be used again for reconstruction.

Nepal earthquake collapsed many buildings, infrastructures as well as the hopes of people but there are always positive side to look on. Nepal has good lessons learned now, from this Nepal need to make better action plan in place to respond future earthquakes. We hope with these experiences Nepal will develop a legalized framework to build back better, resulting in disaster resilient Nepal.

7. Areas Requiring Further Development

From the view point of Nepal's national economy and topography importing constructions material from abroad is not desirable. To respond to it Nepal has developed building code for masonry buildings which utilizes local techniques as well as local material for construction. But due to lack of awareness and deficiency of technical manpower at the local level no people are using it in practice. So Nepal need a comprehensive building code implementation program throughout its territory. The enforcement of compliance with building codes at the local level needs to be improved in the future.

Though Nepal has developed various policy in coordination with various agency's working in Nepal, but a comprehensive document on demolition and debris is yet need to develop. So, from this experience in demolition and debris management it is imperative to develop policy and guidelines in building demolition in case of future earthquakes.

In major disaster condition the host government may not be fully operational, hence it is must to make cluster approach in emergency fully operational, and a task force for emergency coordinated by an agency which can be fully operational in emergency case also need to be developed.

The data collected in emergency can serve as the guideline data during reconstruction hence it is imperative to develop a database management system coordinated by an agency which can operate even in worst case emergency need to be developed, and should be made easily accessible to all the humanitarian workers.

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