Earthquake Preparedness and Disaster Relief in Nepal

A Position Paper

Edited by
Ramesh B. Malla
Kanhaiya Kayastha
Sunil Sharma
Suresh P. Ojha

A Joint Initiative of the American Society of Nepalese Engineers (ASNEngr), America Nepal Medical Foundation (ANMF), and Computer Association of Nepal–USA (CAN-USA)

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Prepared by

Committee on Joint Initiative on Earthquake
Preparedness and Disaster Relief in Nepal
of the
American Society of Nepalese Engineers (ASNEngr),
America Nepal Medical Foundation (ANMF),
and
Computer Association of Nepal – USA (CAN-USA)

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Front and back cover illustrations: Depiction of Tri Chandra College "Ghanta Ghar" (clock tower), Kathmandu, Nepal, before and after the 1934 earthquake, by Sharmendra Devkota.
Front and back cover design by Arun L. Malla

Special Note from Editors

As this position paper was going to press, we heard news of a major 7.8 magnitude (Richter scale) earthquake with the epicenter at Gorkha District in Nepal, April 25, 2015, followed by a series of frequent aftershocks, including a strong 6.7 magnitude aftershock the next day. This has resulted in a large number of casualties (6765 dead, 1480 in Kathmandu alone), and 13932 injured at this time and severe damage to buildings, homes and temples, including the world heritage Basantapur Durbar Square in central Kathmandu. The historical landmark Dharahara observation tower in Sundhara, Kathmandu which was recommended for an immediate seismic-retrofit in this positon paper has collapsed.

The damage to lives and property was spread throughout the Kathmandu Valley and beyond. The most affected districts in rural Nepal are Gorkha, Lamjung, and Kaski in the Western Region and Sindhupalchowk, Kavre, Nuwakot, Rasuwa and Dolakha districts in the Central Region. Early reports indicate considerable damage to infrastructure and extensive damage to local traditional houses, for as much as 90 percent to 100 percent, in some hard-hit villages leaving thousands homeless in these areas. The final casualty reports have not yet been received.

Although this position paper is being released immediately after the above mentioned major earthquake, we believe the recommendations still to be useful and to provide an overview of the status of earthquake preparedness in Nepal. We hope this paper will contribute to needed discussions on future efforts of preparedness and enhancement of the country's total earthquake resiliency program. Now there is a need to review the lessons learned in the areas of engineering, communications and medical care in the immediate response and recovery periods following this earthquake.

An initial assessment indicates that poorly constructed concrete buildings not adhering to the building code requirements are either partially collapsed or crumbled to the ground. A lack of heavy equipment, tools and trained personnel and firefighters have impeded rescue operations to save lives of people trapped beneath collapsed buildings.

We are greatly saddened and grieved by the loss of life and property caused by this devastating earthquake. Our hearts and minds go to Nepal at this trying and difficult moment.

The Editors
May 01, 2015

Table of Contents

Abstract

Nepal is in one of the most active earthquake regions in the world. Nepal's current non-earthquake-resistant infrastructure, lack of sufficient modern communication networks, and limited facilities and manpower in the medical sector are the major threats to life and property during a major earthquake. On March 31, 2010, under the auspices of three leading Nepali diaspora professional organizations in the United States of America—American Society of Nepalese Engineers (ASNEngr), America Nepal Medical Foundation (ANMF), and Computer Association of Nepal-USA (CAN-USA)—a joint initiative on Earthquake Preparedness and Disaster Relief in Nepal, of which this position/concept paper is a product, was launched to help understand the current status of earthquake preparedness in Nepal. This position paper describes the challenges that Nepal will face if and when another large-magnitude earthquake strikes like the devastating January 16, 1934 Nepal-Bihar earthquake. The paper also provides a list of recommendations to be considered to minimize the loss of life and property, especially in the densely populated Kathmandu valley. The document is peer-reviewed by a group of individuals having expertise in the related areas.

American Society of Nepalese Engineers (ASNEngr)

ASNEngr is a nonprofit organization established in September 2007, with IRS 501(c) (3) tax exempt status, that aims to provide a common platform for people of Nepalese background and their friends, in engineering and closely related scientific and technical areas, to come together, exchange ideas, and support each other for their and the larger society's common good and benefit. It operates for engineering, scientific, and technological research and educational purposes. The Society also strives to promote engineering, scientific, and technological advancement in Nepal. The membership application form and detailed information on ASNEngr and updates on its recent activities can be found at http://www.ASNEngr.org.

America Nepal Medical Foundation (ANMF)

The objective of ANMF, a U.S. 501(c)(3) nonprofit organization, is to promote the advancement of medical training and practice in Nepal. ANMF focuses on improving the quality of medical care, medical education, and medical research in Nepal. For more information, please visit http://americanepalmedicalfoundation.com.

Computer Association of Nepal-USA (CAN-USA)

CAN-USA is an American organization dedicated to the professional development of its members and the technological progress of Nepal. It is a tax-exempt 501(c)(3) nonprofit organization with members throughout the United States. The organization continues to utilize the creativity and talent of its members and the broader American community to develop technology-rich solutions that address some of Nepal's challenges. Please visit http://www.CAN-USA.org/ for more information.

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Letter of Support

The Embassy of Nepal in Washington DC, USA greatly appreciates the joint initiative taken by the US based American Society of Nepalese Engineers, the America Nepal Medical Foundation, and the Computer Association of Nepal-USA for the preparation and publication of a "Position Paper on Earthquake Preparedness and Disaster Relief" in Nepal and is pleased to provide this Letter of Support.

We believe that this publication will be very beneficial for the policy makers in order to formulate policy, plans and programs for the preparedness and mitigation of the impact of the earthquake in Nepal. We also believe that this publication will be a useful reference material to all interested individuals, including but not limited to, the educators, researchers, practicing engineers, scientists, students and general public.

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A detailed listing of these individuals can be found in Appendix C.

Foreword

The consecutive earthquakes that struck Haiti on Jan. 12, 2010, and Chile on Feb. 27, 2010, stunned the world and forced the Nepali diaspora to contemplate the effects of a similar disaster in Nepal. Although the earthquake in Chile was much stronger than the one in Haiti, it was Haiti that suffered the most devastating damage because of its failure to adequately prepare. Nepal is a land-locked country with one international airport, an inadequate road network, and the nearest seacoast approximately 700 miles south. This almost guarantees greater devastation than that in Haiti. Nepal frequently experiences earthquakes of magnitude 4 to 5 (Richter scale); this has made the population complacent. The evolution of the majestic Himalayas, resulting from the continuous sliding of the Indian plate underneath the Eurasian plate, gives Nepal its unique geography and culture, but also makes it one of the most seismically active areas in the world.

With this in mind, three U.S. and Nepali nonprofit organizations, the American Society of Nepalese Engineers (ASNEngr), America Nepal Medical Foundation (ANMF) and Computer Association of Nepal – USA (CAN-USA) undertook a joint initiative on "Earthquake Preparedness and Disaster Relief in Nepal" on March 31, 2010, under the leadership of the presidents of these three organizations: Ramesh B. Malla, Ph.D.; Sunil Sharma, M.D.; and Bineet Sharma, M.S. This initiative received welcome support from national and local nonprofit Nepali organizations in the U.S. and in Nepal.

The same year—post the Haiti and Chile earthquakes—also saw the publication of earthquake-related articles by the Nepali diaspora, such as "Necessity of Earthquake Preparedness in Nepal," by Rajendra K. Shrestha Ph.D., and "Role of Structural Engineers to Create Earthquake-Resistant Buildings and Infrastructure in Nepal," by Kanhaiya Kayastha, P.E., S.E. and Ramesh B. Malla, Ph.D. There was also widespread coverage of earthquake news in the general media (www.nepalnews.com).

This position paper presents a set of recommendations for preparedness and mitigation before, during, and after the occurrence of an earthquake. These are supported by the three organizations involved and are designed to serve as a general reference.

There is a saying: Earthquakes don't kill people, buildings do." In modern days, Nepal has witnessed unregulated, uncontrolled, and rapid urban growth, particularly in the Kathmandu Valley, which is inhabited by approximately 2.5 million people. Updating the existing building codes with strict enforcement, retrofitting schools and hospitals, and making the infrastructure earthquake resistant are the most important needs.

Training emergency rescue health-care workers and providing medical supplies, ambulances, and temporary treatment facilities are also vitally important.

Since the commercial communications infrastructure in Nepal will become nonoperational during an earthquake, setting up the emergency command centers for communication at local, national, and international levels for search and rescue operations is also an absolute necessity.

Since the exact timing of earthquakes is impossible to predict, disaster preparedness is the only factor that we can plan and implement now to minimize the loss of lives and property. The Government of Nepal has started to establish a rudimentary foundation for earthquake preparedness. With a focused, concerted effort and greater political will, Nepal has an opportunity to be a leader and a role model in developing a sustainable and sound disaster preparedness program for resource poor countries. Equally important is that local communities and municipalities take on the responsibility for earthquake awareness and be involved in providing support in rescue, relief, recovery planning, and operations.

The preparation of this position paper required the investment of a large amount of time and tireless efforts by many distinguished individuals. On behalf of our respective organizations, we would extend our heartfelt appreciation to the contributors, the reviewers, and the editorial, steering, and full committees of the Joint Initiative, and to supporting organizations in the U.S. and Nepal for bringing this document to fruition. We particularly thank our editor-in-chief and chair of the Joint Initiative, Ramesh B. Malla, Ph.D. We hope it can be immediately used to draw up action plans to minimize the effects of earthquakes in Nepal.

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Editorial

This joint ASNEngr/ANMF/CAN-USA position paper, *Earthquake Preparedness and Disaster Relief in Nepal*, is the result of the long continuous effort, dedication, and valuable contributions of many individuals associated with three nonprofit professional organizations in the U.S.: the American Society of Nepalese Engineers (ASNEngr), America Nepal Medical Foundation (ANMF), and Computer Association of Nepal-USA (CAN-USA), together with their counterparts in Nepal.

The position paper was initiated by the three organizations on March 31, 2010, after witnessing the heavy damage and high casualties caused by the January 12, 2010, Haiti earthquake. Subsequently, various committees were formed to work on the position paper, such as the joint ASNEngr/ANMF/CAN-USA steering committee, the full-member committee with invited guest members from Nepal and the U.S., and the editorial committee. Additionally, a separate subcommittee was formed within each of the organizations to begin working independently in their fields of expertise. Information was collected by working with counterparts in Nepal. More than 25 steering committee and 12 full-member and guest committee meetings were conducted, via telephone-conferencing from the U.S., to collect data and share information between the U.S. and Nepal.

During the working process, many changes occurred in Nepal and globally in response to new earthquakes and new information. Much vital information was gathered from the Nepal government and national and international nongovernmental organizations in Nepal involved in earthquake disaster planning and operations and included in the position paper. This has helped make the position paper more up to date and hopefully more useful.

This position paper on "Earthquake Preparedness and Disaster Relief in Nepal" is the first of its kind attempted by the Nepalese diaspora residing in the U.S. The diaspora is willing to contribute knowledge and expertise to join with their counterparts in Nepal.

This position paper attempts to address the hazardous situations that earthquakes can create in an earthquake-prone country, such as Nepal. As in many developed and developing countries, Nepal must move effectively and quickly to keep up with the rapid developments in earthquake preparedness and disaster relief technologies that are available globally. The three basic areas related to earthquake preparedness and disaster relief and mitigation efforts are engineering, medicine, and communications. These are interrelated and must be well coordinated to address the challenges before, during, and after an earthquake. The recommendations in this position paper include retrofitting existing buildings and infrastructure, constructing new infrastructure and buildings that are more earthquake-resistant, providing emergency medical services and care, and making the emergency communication systems available before, during, and after an earthquake. The paper deals only with earthquake-related disasters and does not address other natural disasters, such as floods, landslides, epidemics, and fires, except as they are caused by earthquakes. The full manuscript of the position paper

was peer-reviewed by group of individuals having expertise in the related areas covered. Furthermore, the final ready-to-publish document was made available to all members of the Joint Initiative committee and Editorial Board and the technical content contributors of the position paper for their review and comments.

The suggestions and recommendations provided in this paper are intended to be preliminary. We hope that it will create a pathway for implementation and initiate the necessary plans for establishing a coordinated mechanism to pull together the resources and efforts by public and private stakeholders in Nepal and the U.S. We also hope that the information presented in this paper will help to generate constructive and meaningful questions and discussions towards better preparedness and mitigation of earthquake-related hazards in Nepal.

Finally, the editors express their sincere thanks and gratitude to all those who helped directly or indirectly in the process of preparing this paper. Special thanks are due to all contributing authors, editorial committee members, reviewers, steering and full committee members, and guests from Nepal, U.S. and other countries of the Joint Initiative.

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April 2015

Executive Summary

Nepal lies in one of the most active earthquake regions in the world. Several studies have determined that Nepal's existing infrastructure, communication systems, and medical sector are inadequately prepared for earthquakes. This lack of preparation is a major threat to life and property in the event of an earthquake.

On March 31, 2010, under the auspices of three leading Nepali Diaspora professional organizations in the United States of America: American Society of Nepalese Engineers (ASNEngr), America Nepal Medical Foundation (ANMF), and Computer Association of Nepal-USA (CAN-USA), a joint initiative on Earthquake Preparedness and Disaster Relief in Nepal, of which this concept/position paper is a part, was launched to help Nepal in its effort to address the above-mentioned challenges (Malla, et al. 2010). This joint effort has been supported by the Nepali diaspora and various Nepali associations in the USA. This paper outlines the challenges that Nepal could face if a large-magnitude earthquake, similar to the devastating January 16, 1934, Bihar (India) – Nepal earthquake, occurred in the future. This paper also provides a list of recommendations that must be considered and implemented to prevent a huge loss of human lives, damage to property, and the associated catastrophic effects of the earthquake, especially in the densely populated Kathmandu valley.

A recent unpublished study by the National Society for Earthquake Technology (NSET), estimates that a Modified Mercalli Intensity (MMI) IX earthquake would result in 100,000 deaths, 300,000 injured, and nearly 1.5 million homeless in the Kathmandu valley. Further, about 80% of the hospitals in the Kathmandu valley would not meet the safety level required even for private residential houses; these hospitals will be nonfunctional and life-threatening during a MMI IX shaking. Although the remaining hospitals are expected to be structurally sound, they are likely to suffer nonstructural damage resulting in reduced functionality and operational capacity (MOHP 2002). Many national benchmarks on emergency preparedness set by the World Health Organization are in an early stage or behind schedule (NHRC/WHO, 2011). Hospital and community-based mass-casualty disaster planning and drills are insufficient or nonexistent. A National Health Contingency plan is not yet developed. Development of manpower and training of disaster rescue personnel needs to be augmented.

The citizens of Kathmandu valley were alarmed from the recent earthquake of magnitude 6.8 (Richter scale) in Sikkim, which hit the far-eastern region of Nepal and propagated into the Kathmandu valley, causing some loss of human lives and property damage. This was a wake-up call to the local authorities and has further reinforced the need for Nepal to prepare for an impending earthquake-related disaster. During a large earthquake and in its immediate aftermath, the existing commercial communication networks, especially mobile telephone-based systems, are expected to be destroyed or severely overwhelmed, thus restricting the communication capabilities among various vital public and private institutions and disaster relief organizations inside and outside the country. The communication

capabilities of the local population, medical facilities, first responders, and government organizations will be vital for saving lives. Additionally, the ability of local command centers to communicate to the outside world will be critical for the rescue and recovery efforts.

Despite the widely recognized importance of communications following disasters, there is little published material on disaster communications in Nepal. A review of the roles and preparedness status of all of the principal players tasked with communication responsibilities following a disaster in the Kathmandu valley reveals that a few organizations are doing valuable work, but their work and the important advancements made so far are either unavailable or underutilized. Due to the flexibility and scalability of communication technologies, important advancements in disaster communication preparedness can be made quickly in Nepal. Nepal's disaster communication networks are gradually growing. Scientific studies are needed to ensure that this growth is well planned and addresses the key needs of redundancy and interoperability between all key stakeholders. Amateur ("ham") radio is one technology that has proven to be of tremendous value following disasters.

Earthquake preparation initiatives, mitigation methodologies, rescue planning, and management techniques essential to combat different earthquake scenarios, before, during and after an earthquake, are presented in the different sections of this position paper. This paper includes information from publications of governmental and nongovernmental agencies and meetings with concerned organizations and institutions in Nepal, including the United States Embassy, the United States Agency for International Development (USAID) Disaster Office, NSET, Institute of Engineering (IOE), Nepal Academy of Science and Technology (NAST), Nepal Army, and Kathmandu Metropolitan City Office. As a result of national benchmarking of emergency preparedness by organizations such as the World Health Organization and the Nepal Disaster Risk Consortium, progress has been made. With the availability of structural-retrofitting techniques, new developments and advancements in integrated disaster communication systems, and the mass media raising awareness among the general public, Nepal has made steady progress toward earthquake preparedness. A national concerted effort complemented by a community-level campaign for earthquake preparedness and disaster mitigation has the potential to be very effective.

Acknowledgements

This position paper is possible only due to the tremendous efforts of many individuals. The joint ASNEngr/ANMF/CAN-USA committee on Earthquake Preparedness and Disaster Relief in Nepal gratefully acknowledges the significant contributions made by the following individuals:

Technical Content Contributors

First and foremost, several individuals have directly contributed to the content of this document and their contributions are gratefully acknowledged. The list of contributors is provided on page ix.

Committee Members

The contribution and support from all members of the Steering Committee, Full Committee, and Editorial team, and invited guests of the Joint Initiative is greatly appreciated. A complete list of individuals serving on these committees can be found in Appendix C of this document.

Reviewers

The committee gratefully acknowledges the contribution from the following individuals for giving their time and effort for reviewing the manuscript of this position paper and providing valuable comments and suggestions: Gaury Adhikary, M.D.; Pradyumna Amatya, Ph.D.; Amod M. Dixit, Dr. Eng.; Upendra Karna, D. Eng., P.E.; Mark Hauswald, M.D.; Sanjeeb Panday, Ph.D.; Bineet Sharma, M.S.; Fred Shepardson, Ph.D.; Rajendra K. Shrestha, Ph.D. ; Jishnu Subedi, Ph.D.; and Pradeep Vaidya, MBBS, Ph.D. The final ready-to-publish document was made available to all members of the joint committees (Full and Steering), Editorial Board and the technical content contributor of the position paper for their review and comments.

Sincere thanks are due to all supporting organizations (listed in Appendix D) of this joint ASNEngr/ANMF/CAN-USA earthquake preparedness initiative, for their support and endorsement of the initiative and willingness to work together. Special thanks are due to several governmental and nongovernmental organizations, including Embassy of Nepal to the United States of America, U.S. Embassy in Nepal, Nepal Academy of Science and Technology, Institute of Engineering and Institute of Medicine, Tribhuvan University, and National Society for Earthquake Technology-Nepal, for taking part in discussions and providing feedback and input.

The Joint Initiative Committee wishes to acknowledge the contributions of all members of the Nepali diaspora communities in the U.S. and beyond, who provided encouragement and support in many ways. Sincere thanks go to Pujan Joshi of Storrs, Connecticut for his help in creating and maintaining the website, to Rajesh Bajracharya of Toronto, Canada for helping to arrange the teleconference meetings of the steering and full committees of this joint initiative. Special appreciation and thanks are due to David Klotz of Coventry, Connecticut for his many hours of voluntary support in initial copy editing, proof reading, and putting this document in publication format,

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Last but not least, the editorial team would like to express its sincere thanks and gratitude to all those, who we might have missed to mention here, but helped directly or indirectly in the process of preparing this position paper.

The Editors
April 2015

1 Introduction

According to the United Nations, Nepal is the 11th-most earthquake-prone country (UNDP 2009). Therefore, earthquake vulnerability in Nepal, particularly in the densely populated Kathmandu Valley, is of great concern. The history of earthquakes in Nepal indicates that, on average, the Kathmandu Valley has experienced a major earthquake every 75 years. The Nepali diaspora is especially concerned after witnessing the magnitude 7.0 (Richter scale) earthquake that struck Haiti on January 12, 2010. This earthquake took more than 200,000 human lives, left one million people homeless, and destroyed half of the buildings in Port-au-Prince. The Haitian situation was worsened by shoddy building construction due to the lack of adequate building codes and standards. However, in the subsequent February 27, 2010 Chilean earthquake of magnitude 8.8, only 800 human lives were lost. And the recent Christchurch, New Zealand earthquake of Richter scale magnitude 7.2 and northern Japan earthquake of magnitude 8.9 have further reinforced the view that strict adherence to the existing building code standards is the primary means of minimizing death and damage.

The last major earthquake in Nepal was the great Bihar (India)-Nepal earthquake of 1934 of magnitude 8.4 (Richter scale), which devastated the entire Kathmandu valley with an extensive loss of life and properties. Even the 1980 earthquake of magnitude 6.5 that occurred in the western district of Bajhang in Nepal caused 178 human deaths and damaged about 40,000 houses. The 1988 earthquake of 6.6 magnitude in eastern Nepal was worse, costing 721 human lives and damaging about 60,000 houses and physical infrastructure. Recently on September 18, 2011, an earthquake of magnitude 6.9 hit the far-eastern part of Nepal, bordering Sikkim, India (USGS/EHP 2011a). On September 19, 2011, the daily Kantipur Television news reported that a total of eight people lost their lives, 150 were injured, and many traditional homes were damaged in the region. Earthquake-induced landslides further contributed to the house and road damage. The earthquake tremor was felt as far as the Kathmandu valley, where several houses were cracked or damaged and several people lost their lives.

Similarly, an earthquake of magnitude 6.0 occurred on August 30, 2013 with epicenter located around 330 km north of Kathmandu, followed by a 5.0 magnitude aftershock a few minutes later. The tremor was felt in the Kathmandu Valley and in the central and western parts of Nepal, raising concerns over the city's preparedness to deal with earthquake-related disasters. Fortunately, no significant damage was reported (eKantipur on-line 2013 b, c).

Recent separate studies by scientists at Singapore's Nanyang Technological University and Stanford University (USA) have predicted a massive earthquake of magnitude 8 to 9 in the area along the Himalayan fronts, which would include Nepal. Researchers have also highlighted the importance of creating risk assessments and disaster mitigation plans for the densely populated areas in the region (Expressindia 2012a, b).

In a report published in 1999, the Kathmandu Valley Earthquake Risk Management Project (KVERMP) estimated that approximately 40,000 people

would be killed, 100,000 injured, 600,000 to 900,000 would be left homeless, and 60% of all buildings in the Kathmandu valley and 75% of the buildings in Bhaktapur would be heavily damaged, many beyond repair, if an earthquake similar to 1934 were to occur (NSET/GHI 1999). Due to the rapid increase in population and buildings in the Kathmandu valley, a recent unpublished study by the National Society for Earthquake Technology (NSET) has predicted these numbers to be much higher—about 100,000 deaths, 300,000 injured, and 1.5 million homeless. KVERMP also estimated that in the Kathmandu valley, 50% of bridges and many narrow roads will be impassable from collapsed buildings due to the earthquake. In addition 95% of water pipes and 50% of pumping stations and water treatment plants would be seriously affected, hampering water supplies for several months (NSET/GHI 1999).

A major earthquake in Nepal will have devastating effects on both short- and long-term public health. Recent World Health Organization (WHO) and NSET studies found that 80% of assessed hospitals are in an unacceptable performance category and that 20% are at high risk of life-threatening collapse. Loss of hospital capability would have a devastating impact on post-earthquake care. Healthcare providers would be directly affected. Haiti lost 10% of its medical staff to death or migration (DWB 2010). The losses were highest for hospital-based physicians who were more likely to be killed and less likely to be able to function without a working hospital.

Nepal is worse prepared now than it was in 1934. Urbanization has increased the Kathmandu valley population to 1.5 million, almost one-third of the housing development is grossly substandard, and almost all construction uses poor quality materials and is not hazard resistant. Obsolete old buildings and the failure to enforce building codes for new ones may result in construction failure exceeding 90%. When (not if) another earthquake as large as that of 1934 strikes, it is conservatively estimated that, in the Kathmandu valley, telephone and electricity generation could be offline for a month or more, half of the bridges and narrow roads will be impassible, and the airport is likely to be isolated.

Much of this is not theoretical; earthquakes in Gujarat in 2001, Kashmir in 2005, and Haiti in 2010 have provided valuable lessons for post-earthquake care. These lessons have come at a terrible price; there were 86,000 deaths and 69,000 injured in Kashmir, 20,000 dead and 167,000 injured in Gujarat, and 316,000 dead, 300,000 injured and 1.3 million displaced in Haiti (USGS/EHP 2011b).

This would only be the short-term loss. Mortality rates would be increased for years. Epidemics would be a threat until housing and sanitation were rebuilt. The economy would be devastated and development efforts could be completely derailed for many years.

Within hours of impact, local facilities will be overwhelmed. Massive numbers of patients will need care. Most patients will have relatively minor injuries, such as lacerations and bruises, a smaller number will present with more serious injuries, such as simple fractures, and a minority will have serious multiple fractures or internal injuries requiring surgery. Hours after the impact, patients with crush syndrome, suffocation, dehydration, burns,

and electric shocks will need time-sensitive care, including short-term dialysis, intensive care, and surgery.

As an example of the problem, during the Kashmir earthquake, 1502 patients were triaged over 72 hours at a 12-bed military hospital (Mulvey 2008). Although superficial lacerations (64.9%), fractures (22.2%), and soft tissue contusions and sprains (5.9%) predominated, there were 266 major extremity injuries, six significant abdominal injuries, of which four required urgent surgery, 486 patients who were admitted, and 149 who required a procedure under general anesthesia. Fifteen percent of the surgical patients eventually developed postop infections.

In the longer term, there will be a need to rehabilitate the injured and address a major increase in depression and post-traumatic stress syndrome among the survivors. Injuries, exposure, and trauma among cleanup workers will continue for many months.

Recently the Kathmandu valley has benefitted from a rapid development of its telecommunications infrastructure. This development has come largely due to the proliferation of mobile communications systems. This benefit, however, has left the communications systems in Kathmandu valley highly vulnerable to catastrophic damage following the expected magnitude 8.0 earthquake (Callaway 2011). Much of Kathmandu's existing cellular telephony infrastructure will be severely damaged following a major earthquake. The limited cellular infrastructure that will be functioning is expected to be quickly overwhelmed. The September 18, 2011 earthquake near eastern Nepal demonstrated the stress to the Kathmandu networks due to emergency calls. Typically, a cellular base transceiver system (BTS) can manage 300 calls. However, in the immediate aftermath of the September 18 quake a single BTS experienced as many as 5000 calls at one time (Dhakal 2011).

This clearly presents a potential prolonged disruption in telecommunications services within Kathmandu, from Kathmandu to the rest of the nation and from Nepal to the outside world. Telecommunications is the central nervous system of every disaster response effort. It allows the optimal routing of rescue personnel and material and allows survivors to inform others of their locations. Telecommunications affect all command and control efforts in that it allows food and medicine to be delivered efficiently and it allows people to be evacuated properly (Hudson 2011).

Disaster telecommunications will be a key element in providing relief to Nepal following a devastating quake. Nepal's existing telecommunications infrastructure will not be adequate for the immense communication challenges immediately following the quake. Very little published material exists to chronicle the significant communications shortcomings and the most effective remedies.

Furthermore, numerous agencies in Nepal are working simultaneously on portions of the disaster telecommunications preparedness puzzle without being fully aware of or appreciating each other's roles and opportunities for synergy. For instance, the Nepal military's work as a member of the Multinational Operational Communications Program (MCIP) is a shining example of meaningful disaster telecommunication preparedness efforts. The

MCIP establishes a process that identifies and documents communications interoperability between member nations. The program's main target is military forces telecommunications equipment (Giffin 2012). Several new initiatives that do not presently exist in Nepal are likely to be helpful, including amateur radio.

The technologies necessary for a robust disaster telecommunications network are highly mature and exist in other disaster-prone areas of the world. The scalability and flexibility of these technologies allows their predeployment in appropriate ways in Nepal. With the active participation of key stakeholders, a robust disaster telecommunications infrastructure appropriate to Nepal's needs can be developed swiftly. New initiatives, combined with increased information sharing, can be the basis of a national emergency telecommunications plan which integrates into disaster management plans (Zavazava 2008). While the challenges with disaster telecommunications preparedness in Nepal are vast, positive change is gradually taking place and can be supported by timely information sharing and initiation of key new efforts.

With the consequences of a future earthquake in Nepal in mind, on March 31, 2010, the three major professional organizations of the Nepali diaspora in USA, ASNEngr, ANMF, and CAN-USA, joined hands to publish a joint initiative proposal to prepare a position/concept paper on *Earthquake Preparedness and Disaster Relief for Nepal* (Malla, et al. 2010), with the idea of providing guidelines and suggesting appropriate action plans for mitigating damage due to future earthquakes in Nepal. This initiative received support from national, regional, and local-level Nepali organizations in the USA, including the Non-Resident Nepali National Coordination Council (NRN-NCC) of the USA, the Association of Nepalis in Americas (ANA), the Association of Nepalese in Midwest America (ANMA), the Nepalese Association of Houston (NAH), and the Nepalese Association in Southeast America (NASeA).

The three major areas of preparedness to be considered are pre-, during, and post-earthquake, as described in the following sections.

1.1 Pre-Earthquake Preparedness

To avoid or at least minimize the human casualties and property and infrastructure damage and loss, it is of utmost importance that the general population be fully prepared and the infrastructure be built for any impending earthquake disaster. Topics including, but not limited to, the following are briefly presented under various sections and subsections in this document: public awareness programs; regular earthquake drills in schools, colleges, public buildings, and hospitals; training of personnel in different sectors of public and private institutions and construction industries; the necessity of strict adherence to building codes and their implementation; quality construction practices; upgrading the existing building codes; and preparation of new codes and standards for infrastructure design.

1.2 During-Earthquake Preparedness

During an earthquake, the most important thing for people is not to panic but to stay calm and follow the systematic step-by-step procedures practiced during drills. Turning on a battery-operated radio and listening to the siren; taking immediate shelter under a sturdy desk, table, or doorway; staying away from windows and using the "duck, cover, and hold" rule are some of the immediate steps to be followed until the shaking stops. Detailed procedures to follow when inside or outside a house or inside a vehicle are reviewed with illustrations in several of the references (NGED-CRED, UNICEF, NSET, 2011; NSET-Nepal and GHI-USA, 2007; TMG and NSET 2006).

Adequate ambulance services, readily available emergency medical supplies, first responders, paramedics, and expert medical health teams, coordination with local and international Red Cross societies, and unobstructed access to the pre-assigned open grounds and facilities for temporary health camps are a few of the main components required for a successful response during an earthquake. In addition, an effective inter-communication network maintained to fully operate during the inevitable panic is the key to an operational success during an earthquake. The Nepal Government's Emergency Operation Center and privately owned emergency communication links, including those owned by nongovernmental organizations (NGOs) and international nongovernmental organizations (INGOs) within the country, can be effectively mobilized to disseminate information locally, nationally, and globally.

1.3 Post-Earthquake Preparedness

The biggest challenge during post-earthquake preparations lies in coordinating and mobilizing the nationally and internationally available resources properly and effectively, in a chaotic situation, with the possibility of aftershocks. Qualified professionals must evaluate and red-tag unsafe buildings and infrastructure in the affected areas essentially immediately.

Effective use of the sophisticated heavy machinery and equipment necessary for rescue, immediate repair of essential facilities and the public transportation system, fast erection of temporary shelters at different locations, and maintenance of pedestrians' safety and mobility will have to be coordinated under difficult conditions. Moreover, due to its geographical location, the Kathmandu valley has additional constraints to receiving immediate assistance from outside the valley and from neighboring countries.

2 Objectives

This paper provides an introduction to disasters, disaster management, and preparedness, especially as these relate to earthquake mitigation. The three main topics of infrastructure, communications, and medical are discussed in different sections: pre-, during, and post-event. These provide a description of the current situation in Nepal and what needs to be done to prepare for earthquake and disaster relief.

The overarching objective of this joint position paper is to generate a greater awareness among the widest spectrum of constituents and stakeholders for earthquake mitigation in Nepal. These include local government and nongovernmental agencies; professional engineering, scientific, medical, and academic institutions; private industry; international donor agencies; the general population in Nepal; and the Nepali diaspora around the globe.

This document presents an overview of the progress made in Nepal by various organizations engaged in earthquake preparedness and provides recommendations to help prepare a set of concrete plans, in a timely and effective manner. It also describes the necessary steps to expedite preparedness activities to combat the earthquake disaster and its after effects.

In this context, several meetings, conference sessions, and presentations were organized in the USA and Nepal on the topic of earthquake preparedness and disaster relief in Nepal. A joint presentation was made by ASNEngr/ANMF/CAN-USA at the 5th Non-Resident Nepali (NRN) Global conference held in Kathmandu, Nepal, on October 12, 2011. Subsequent meetings were organized with the U.S. Embassy/USAID, NAST, IOE/Pulchowk Campus, Kathmandu Municipality, and NSET in Kathmandu during late 2011. In addition, Steering and Editorial committee members attended seminars and workshops to gather the most recent information available for this paper.

With the expertise in different areas that ASNEngr, ANMF, and CAN-USA possess, we hope to help and enhance the capability of Nepal to respond to a major earthquake. ASNEngr's main purpose is to create awareness regarding earthquake safety, how to prepare for it, and what to do before, during and after earthquakes. ANMF is concerned with the medical implications of an earthquake on a resource-poor nation such as Nepal. CAN-USA's purpose is to generate awareness of the important role telecommunications can play following disasters. These three professional organizations of the Nepali diaspora are contributing their technical expertise for the benefit of Nepal.

3 Geology, Geography, and Geopolitical Maps of Nepal

Nepal, situated on the southern slope of the mid-Himalayas, is a land-locked country that borders the Tibetan Autonomous Region of the People's Republic of China in the north and India in the south, east, and west. The nearest seacoast is about 700 miles south of the border. The country has an area of approximately 54,362 square miles, an average length of 550 miles, and a width of 90 to 160 miles, as illustrated in Figure 1. The major part of the country consists of high mountains and rolling hills (about 83%), with the remaining 17% consisting of the flat lands of the Terai, as illustrated in Figure 2 The elevation varies from 500 feet above sea level to more than 29,000 feet in the northern Himalayas (Thapa and Thapa, 1969).

Figure 1. Nepal location map. [Courtesy of maps.com, Santa Barbara, CA, USA]

The country is divided into 14 zonal administrations and 75 development districts, organized wherever possible to include parts of Terai and hilly areas in each zone. For balanced economic growth and proper regional planning, the country is currently divided into five development regions: the Central, Eastern, Western, Mid-western and Far-Western Regions (Maps of World 2012). Many research studies and changes have already occurred in the recent decades in the areas of regional and land-use planning, especially in the Kathmandu valley (EMI 2010). The population in Nepal has drastically increased from approximately 11.6 million in 1971 to 26.6 million in 2011.

Geologically, Nepal straddles the boundary of the Indo-Australian and Eurasian tectonic plates, which are moving towards each other. The geological movements explain the formation of the Himalayas and are also the cause of the sudden and violent jolts in the rock formations in the earth's interior that can be felt on the surface as earthquakes. (NSET 2009).

Figure 2. Nepal physical map. [Courtesy of maps.com, Santa Barbara, CA, USA]

The Himalayan range is one of the youngest mountain systems, formed around 55 million years ago. Nepal occupies one-third of the central sector of the Himalayan arc. From south to north, Nepal can be subdivided into the following five major tectonic zones: Gangetic, Sub-Himalayan (Siwalik), Lesser Himalayan, Higher Himalayan and Tibetan-Tethys Himalayan. Each of these zones is characterized by its own lithology, tectonics, structures, and geological history. Due to the presence of several active faults, almost all areas of the Himalayas are vulnerable to seismic events. (Dahal 2006).

The Kathmandu Valley lies within the Lesser Himalayan zone. The Kathmandu Valley is underlain by a sequence of thick lacustrine sediments, mainly composed of black clay and locally known as the Kalimati formation in the central and southern part of the valley (Piya 2004). The formation is composed of a series of deposits of sand, silt and clay, and gravel of varying thicknesses. The northern part of the valley is dominated by medium to coarse-grained micaceous sand mixed with gravel. The intermixed loose layers of sand and clay deposits are highly susceptible to liquefaction in an earthquake.

Almost the entire area has a seismic hazard potential of higher than a Modified Mercalli (MM) VIII scale magnitude earthquake. The Kathmandu Valley lies in an active seismic zone and has experienced earthquakes of greater than magnitude 7 (Richter scale) or MM VIII. The intensity distribution based on the 1934 earthquake has established that most of the valley would experience higher than intensity MM VIII and most of the urban area to MM IX (Shrestha 2005). The great earthquake of 1934 at the

Nepal-India border produced some liquefaction in the Kathmandu valley. The study has indicated that about two-thirds of the valley is moderately to highly susceptible to liquefaction. Only one percent of the area is classified as nonliquefiable due to the presence of rock outcrops (Piya 2004).

Recently, a research team from Singapore's Nanyang Technological University concluded that the 1934 earthquake ruptured the surface, breaking the ground over a length of more than 150 kilometers, south of Mount Everest, along the main fault in Nepal. They have predicted that similar quakes will happen again in this region (Expressindia, 2012a, b).

Recent research conducted by geophysicists at Stanford University (USA) found that about 20 kilometers of the Main Himalayan Thrust (MHT) dipped more steeply (15 degrees downward) than previous estimates of a relatively uniform fault plane that dipped gently, about 2 to 4 degrees to the north over the entire thrust zone. It is conjectured that formation of this thrust ramp would create a larger rupture width and trigger a larger magnitude earthquake south of the MHT (Expressindia, 2012a, b).

4 Literature Review

The following is the review of some of the publications that are readily available on earthquake preparedness and disaster response and management in Nepal.

4.1 Earthquake-Resistant Buildings and Infrastructure

Nepal has made significant progress in emergency preparedness by providing earthquake awareness programs to the general public, initiating disaster response plans, and developing health-sector preparedness and awareness about safety measures in school programs. To minimize the loss of life and property, it is vital for earthquake-prone countries like Nepal to have an earthquake-resistant building code for constructing new buildings and to retrofit and repair old buildings. In addition, the full spectrum of infrastructure, e.g., roads, bridges, airports, telecommunications and electrical power transmission lines and towers, water, sewer, and all utility lines must be made earthquake-safe. (Kayastha and Malla, 2010).

The 2010 earthquake in Haiti had devastating effects in that country. Nepal potentially could face a similar situation. Buildings are substandard, mostly because the building codes are not strictly followed. Infrastructure is substandard and inadequate. The Chile earthquake experience was dramatically different because codes were followed. The establishment of the Disaster Preparedness and Relief Plan has the potential of making a tremendous difference. By comparing Haiti and Chile to Nepal and taking a closer look at Nepal's situation, it is evident that Nepal is in need of a solid mitigation plan.

It is not possible to predict and prevent earthquakes, but safety measures intended to mitigate the severity of their effects can save lives and property. Since Nepal is precariously perched in a seismically active belt of the Himalayas, a big earthquake could cause immense destruction of life, property, and infrastructure. (Shrestha, 2010).

Chile's Richter scale magnitude 8.8 earthquake in 2010 taught important lessons about long-duration earthquakes (Bonelli, et al., 2012). One important lesson is that a building that may survive strong, short-duration shallow earthquakes can fail in earthquakes with longer duration even at lower shaking amplitude (Simpson, 2010). Since Nepal lies in the Himalayan subduction zone, a long-duration earthquake is likely. Any risk-mitigation measures, particularly those in regard to structures, should take this phenomenon into account. Nepal should also learn from the behavior of concrete buildings observed in the Chile earthquake. Concrete buildings with thin columns sustained major damage in the earthquake (Ghosh and Cleland, 2012). If there were no redundancy in the system, these buildings would have collapsed completely. This lesson should be an eye opener for Kathmandu, where the construction of mid- and high-rise apartment buildings is rapidly growing.

Tucker (2010) emphasizes that agencies soliciting funds for the response to and recovery from earthquake losses, as from the Haitian earthquake,

must allocate 10% of the collected funds to mitigate future earthquakes: to preparedness and prevention activities, such as mason training, public-awareness programs, improved engineering curricula in local universities, geologic hazards mapping and development, and effective earthquake safety public policies. It also points out that the 10% rule stands for "Each dollar invested in preventing natural disasters saves ten dollars in future damages."

4.2 Publications on Seismic Safety in Nepal

The following publications on school seismic safety, hospitals and healthcare facilities assessment, and disaster mitigation and management in Nepal are available.

Study on Earthquake Disaster Mitigation in the Kathmandu Valley (SEDM), 2002

The SEDM project assessed the seismic vulnerability of building stock of Kathmandu projected from 1200 buildings sampled in 69 sites (MOHA/GON and JICA, 2002). The study concluded that 54% of the buildings would be heavily damaged in a repeat of the 1934 earthquake. The sample buildings were surveyed for details of location, age, usage, repair and extension history, past experiences of cracks, construction materials and type of structure, number of stories, shape, layout, soil and topography. Damage analysis was made against fragility curves developed for Nepali buildings. The risk assessment was based on simulated earthquakes and estimated that more than 20% of the buildings will collapse and about 30% of the buildings will be heavily damaged in a "Mid Nepal Earthquake" that could generate MMI VIII intensity shaking in Kathmandu.

School Buildings Seismic Assessment, 1997–1999

In 1997–1999, NSET carried out seismic assessments of about 1100 school buildings in 643 public schools in the Kathmandu valley. The assessment results show that 66% of the school buildings are poised to collapse, 11% will experience severe damage, and 23% will sustain repairable damage in MMI IX shaking. The assessment was not based on a detailed engineering analysis but on a qualitative risk grading survey carried out by the headmasters trained to collect building data (Dixit and Pandey, 2003).

Developing a Strategy for Improving Seismic Safety of Schools in Nepal

Following the seismic vulnerability assessment of Kathmandu schools, NSET started a comprehensive school earthquake-safety program that includes retrofitting and reconstruction of building, public awareness, mason training of earthquake-resistant construction, and training of teachers and students. This program was successfully implemented in a few dozen schools in Nepal. Currently, NSET is implementing a project entitled "Developing a Strategy for Improving Seismic Safety of Schools in Nepal," under the United Nations International Strategy for Disaster Reduction (UNISDR)-World Bank Global Facility for Disaster Reduction and Recovery (GFDRR), to conduct vulnerability assessments of schools in the Nawalparasi and Lamjung districts and carry out a comprehensive school-safety program in six district

schools (NSET, 2010). The project has also developed a draft national strategy for enhancing seismic safety of public and private schools in Nepal. It has also drafted the curricula for teaching Disaster Reduction and Recovery (DRR) in schools throughout Nepal (NSET 2010).

Structural Assessment of Hospitals and Health Institutions of Kathmandu Valley, 2002

In 2002, NSET conducted a study project, "Structural Assessment of Hospitals and Health Institutions of Kathmandu Valley," jointly with the World Health Organization and the Ministry of Health, Government of Nepal (NSET, 2003). The study developed a simple methodology for the evaluation of earthquake vulnerability of medical facilities and conducted qualitative assessments of 14 major hospitals in the country. The study also carried out detailed nonstructural vulnerability of hospitals. The result of the study showed that 80% of the hospitals had unacceptable performance category for a major earthquake.

Seismic Safety of Hospitals and Healthcare Facilities

Guidelines for hospital assessment and the nonstructural safety of healthcare facilities in Nepal have been developed by NSET and WHO (Guragain et al, 2004). Nonstructural retrofitting work has been carried out in some major hospitals in Kathmandu and other regional hospitals. Structural retrofitting work has also been planned for at least three hospitals in Kathmandu. In 2009, Nepal also signed the "Kathmandu Declaration on Protecting Health Facilities from Disasters," which commits the government to carry out activities that enable hospitals to function in emergency situations.

Assessment of Seismic Vulnerability of the Drinking Water Supply System of Kathmandu Valley

NSET, with support from the United Nations Children's Fund (UNICEF), assessed the seismic vulnerability of the drinking water supply system of the Kathmandu valley. The result of the assessment was developed in the form of pipe breakage and functional loss in various earthquake scenarios. The study also presented the spatial distribution of emergency water demand in an earthquake event (Pandey et al., 2003).

Earthquake Safety Day of Nepal, 1998

In 1998, the Nepal Government declared January 16 as the "Earthquake Safety Day" of Nepal and established an Earthquake Safety Day National Committee (ESD NatCom) to observe this day annually throughout Nepal, to remind people about the catastrophic 1934 earthquake (NSET, 2011). ESD NatCom draws representatives from all emergency-response organizations and critical facilities management and organizes various public awareness programs and activities in Kathmandu and other major cities in Nepal. The main events include an earthquake safety exhibition and symposium, an earthquake safety public message by the Prime Minister, a mass awareness rally in the streets, national meetings with government authorities, and an earthquake shake table demonstration to the public. The program is

broadcast to the public through the news media, including radio and television. Some radio channels regularly broadcast earthquake safety issues.

5 Current Status of Earthquake Preparedness and Disaster Relief Programs in Nepal

There is an urgent need to address issues related to disaster risks, vulnerabilities, and resiliencies in Nepal. The 1988 Udayapur earthquake and the 1993 flood of south-central Nepal were two events that provided lessons. Since then, Nepal has made significant progress towards disaster risk reduction, beginning with the formulation of the National Building Code and several other standards for safeguarding infrastructure, and preparing the National Action Plan for Disaster Management in 1994, in response to the Yokohama Strategy and Plan of Action. Nepal has attained a level of maturity in terms of policy formulation, starting in the early 1990s, with the advent of the International Decade for Natural Disaster Reduction. Disaster response was regularized in a formal way as early as 1982, when the state promulgated the Disaster Relief Act. Later in 1998, the Local Self Governance Act authorized and encouraged governments to promote disaster risk reduction (DRR) at the local level. In the same year, the government made the National Building Code mandatory for all urban and urbanizing areas of Nepal. Creation of the National Strategy for Disaster Risk Management (NSDRM) in 2007 and its formal acceptance by the government in 2009 became a milestone of DRR in Nepal (MOHA, 2009a, b). Establishment of the National Emergency Operation Centre (NEOC) to provide round-the-clock vigilance on disaster events and to provide guidance and instruction to response organizations is another achievement.

Several activities by various organizations and institutions are parts of an ongoing effort to make the country, especially the Kathmandu valley, prepared for a future earthquake. A few of these are discussed below.

5.1 Government and Other Organizational Efforts

Nepal Risk Reduction Consortium (NRRC)

The NRRC is an international consortium of the Asian Development Bank, the International Federation of the Red Cross (IFRC), the United Nations Development Program (UNDP), the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), the United Nations International Strategy for Disaster Reduction (UNISDR), and the World Bank. The NRRC was formed in May 2009 to support the Government of Nepal in developing a long-term disaster risk-reduction action plan, building on the anticipated new NSDRM. The U.S. Government and the European Commission Humanitarian Aid Office (ECHO) also formally joined the NRRC (2010).

Based on government priorities and discussions with multiple stakeholder groups, the NRRC and the Government identified five areas for immediate intervention for disaster risk management in Nepal, each coordinated by one of the partner organizations, as follows:

- School and hospital safety-structural and nonstructural aspects of making schools and hospitals earthquake resilient by Asian Development Bank.

- Emergency preparedness and response capacity (UNOCHA).
- Flood management in the Koshi river basin (World Bank).
- Integrated community-based disaster risk reduction and management (IFRC).
- Policy and institutional support for disaster risk management (UNDP).

Status of NSDRM bill presented to the Nepal Government

With the broader national vision of making "Disaster-Resilient Nepal," the Government of Nepal approved the NSDRM bill on October 11, 2009 (MOHA 2009a, b). The Government has also announced that a revised draft bill for a new Disaster Management Act (DMA) will soon go to the cabinet and will be made publicly available. This is the final stage preceding its arrival before the legislature. It appears most likely that the DMA will take a very broad approach to disaster management and will establish new coordinating mechanisms at all levels.

Plans and programs for school and hospital safety and the nationwide earthquake-retrofit program

As a result of the seismic vulnerability assessment of about 1100 school building in the Kathmandu valley (Dixit and Pandey, 2003), NSET started a comprehensive school earthquake-safety program, as described in section 4.2. Currently, NSET is implementing a "Developing a Strategy for Improving Seismic Safety of Schools in Nepal" project sponsored by UNISDR-GFDRR to conduct vulnerability assessments, develop strategies for seismic safety of schools, and draft curricula for teaching DRR in schools throughout Nepal (NSET, 2010).

Seven hospitals in the Kathmandu valley selected for disaster risk mitigation by the Ministry of Health and Population (MOHP) are being assessed by NSET and Tribhuvan University Teaching Hospital (TUTH) and are undergoing nonstructural retrofitting processes. In addition, the UNDP is assessing 20 more hospitals in and out of the Kathmandu valley and will most likely retrofit some of them (MOHP 2002; MOHP 2003a, b).

Outcome from *Be Aware, Be Prepared: Implementing lessons learned from other earthquakes*

The Government of Nepal organized a high-level symposium on Disaster Risk Reduction held during Feb 14–15, 2011, in collaboration with the United Nations and the United States Government. The two-day meeting brought together members of Nepal's Central Disaster Relief Committee, parliament members, senior officials from all ministries, Chief District Officers and Local Development officers from selected districts, officials of five municipalities in the Kathmandu Valley, officers from the security agencies (Nepal Army, Armed Police Force, and Nepal Police), representatives of development partners both in-country and from their headquarters, diplomatic agencies, and civil society representatives.

The symposium deliberations were focused around three major themes: saving lives—preparedness and response to a major earthquake; mainstreaming disaster risk reduction from the local to the national level; and

engineering a safer future by enforcing building codes and making roads, bridges, schools, and hospitals earthquake resistant (Nepalnews on-line 2011).

Efforts and commitments from the U.S. State Department and other international agencies in earthquake hazard preparedness and disaster relief work in Nepal

The U.S. Embassy in Nepal has made Disaster Reduction and Risk (DRR) a major priority. All U.S. Government agency activities concerning DRR are coordinated through the DRR office. The immediate past and current U.S. ambassadors to Nepal are passionate supporters of earthquake preparedness. The DRR program will focus on a three-pronged approach to preparedness and response capacity, advocacy and national awareness, and mitigation of human and financial loss. The Nepal Red Cross states that for every $1 invested in DRR, approximately $100 will be saved. This concept has motivated the U.S. Embassy to convince the Government of Nepal, other key stakeholders, and the private sector of the importance of risk reduction (USAID/Nepal 2012).

On December 21, 2011, Ambassador DeLisi addressed the Nepal-USA Chamber of Commerce and Industry. He stressed the importance and influence that the private sector has when collaborating with the government of Nepal. He also emphasized the need for the business community, in particular the banking and insurance industry, to use their unique influence in assuring that buildings and structures comply with code. He stated that the business community is a powerful force in changing the behavior of builders. He further emphasized that the business sector also needs to protect their buildings, their employees, and their daily business activities with regular earthquake drills and contingency plans.

On February 14, 2011, the U.S. Under-Secretary of State for Democracy and Global Affairs Maria Otero addressed the Disaster Risk Reduction Symposium entitled "Be Aware, Be Prepared: Implementing lessons learned from other earthquakes" in Kathmandu, Nepal hosted by the Government of Nepal in collaboration with the U.S. Embassy and the United Nations, to raise awareness of Nepal's vulnerability to a catastrophic earthquake as well as demonstrate the commitment of the Government of Nepal and the international community to disaster risk reduction (Nepalnews on-line 2011).

Subsequently, on April 15, 2011, a conference in Washington, DC, entitled "Mainstreaming Disaster Risk Reduction in Asia" was organized in which the U.S. Government focused on devising coherent strategies and galvanizing donors to cope with the impending risks of earthquakes in the region through implementing programs focusing on preparedness, relief, and rescue operations (USDS 2011).

In addition, on June 28, 2012, the British Minister of State for International Development Alan Duncan announced 17 million pounds sterling (approx. Rs 2 billion) in vital funding support for earthquake preparedness in Nepal. The amount will be made available through the Department for International Development (DFID) over four years. The

United Kingdom's new disaster-preparedness program will strengthen the Government of Nepal's disaster risk-management policy and support improved building code compliance. It will scale up community-based activities to build the resilience of 4 million people to earthquakes and other disasters. The aid will also be spent for reconstruction of at least 162 schools damaged in the Sikkim earthquake in September 2011, and to develop a national plan to improve the seismic safety of hospitals. DFID support will also improve preparedness for national and international emergency response and train 4,000 volunteers across Nepal in search and rescue and first aid (Nepalnews On-line 2012).

Recently, USAID commissioned an elaborate exercise by U.S. experts from diverse fields to identify priority areas for supporting Nepal in aspects of disaster risk management. Experts of the United States Office of Foreign Disaster Assistance (OFDA) and other United States Geological Survey (USGS) offices visited different parts of Nepal, interviewed representatives of central and local governments, private businesses, NGOs, academia, and civil society organizations. The result was identification of three major program directions, notably, disaster risk reduction, emergency response, awareness and a cross-cutting priority of capacity enhancement for all stakeholders for all types of natural hazards.

OFDA/USAID has been the first and leading agency to support Nepal in disaster risk management. Since the early 1990s, OFDA/USAID started supporting disaster risk reduction in addition to disaster response assistance. One of the programs that OFDA supported in Nepal, as a part of the Asia Region program, was the Asian Urban Disaster Mitigation Program (AUDMP), under which the KVERM program was conducted during 1997–2000 (NSET/GHI 1999). OFDA has been providing support to Nepal in partnership with several local Nepalese and international institutions, such as the International Center for Integrated Mountain Development, NSET, International Organization for Migration, and a host of others, in a wide range of disaster-mitigation programs, including flood-hazard management, open-space management, and prepositioning of water.

5.2 Training Programs

With the aim of providing training for earthquake-resistant methods of construction to the skilled building craftsmen, such as masons, carpenters, plumbers, electricians, steel workers, building inspectors, plan readers, and others who are directly involved in the construction industry, the following training curricula and methodologies have been developed by NSET Nepal.

Training programs on earthquake-resistant construction

NSET has developed training courses aimed at different stakeholder groups. It has ready-to-use modules for training masons, contractors, technicians, junior engineers, engineers, school teachers, and policy and decision makers. These programs have helped propagate knowledge of and create champions of earthquake technology. Courses for professionals consist of theoretical classes, case studies, and experience, while those for masons

emphasize practical matters, such as bar-bending, reinforcement placement, proper brick laying, construction stitches, and bands.

Engineer, Architect, and Junior Engineer training

The main objectives of engineer, architect, and junior engineer training are to familiarize practicing civil engineers and architects with the basic concepts of earthquake-resistant design and construction of residential buildings, the concepts of repair and retrofitting of damaged buildings, the Nepal National Building Code, and the need to implement the code.

Mason training

The main goal of mason training programs is to educate practicing masons on basic earthquake-resistant building construction technology and equip them with the required skills. The main objectives are to explain the importance of incorporating earthquake-resistant elements in new construction, outline available methodologies to accomplish that, and discuss the relevant building code requirements. Several tests are conducted to support the knowledge base, covering the effect of placement of reinforcement rods in beams and slabs and how the quality of work is governed by materials and workmanship, including the effects of excess water and curing.

Program for Enhancement of Emergency Response (PEER)

This is a regional training program that has been implemented in Asia since 1998 with core funding from the U.S. Office of Foreign Disaster Assistance (US OFDA), a subset of the United States Agency for International Development (USAID). The Asian Disaster Preparedness Centre (ADPC), together with Miami Dade Fire Services, managed PEER Stage I (1998–2003) in four countries; NSET, with International Resources Group, the Center for International Emergency, Disaster and Refugees Studies of John Hopkins University, and Safety Solutions Inc. as subcontractors, implemented the PEER Stage II (2003–2009) in six countries. Both NSET and ADPC are implementing PEER Stage III (2009–2014) in nine countries, namely Bangladesh, Cambodia, India, Indonesia, Laos, Nepal, Pakistan, the Philippines, and Vietnam. PEER started by bringing in the courses in Medical First Response and Collapsed Structure Search and Rescue, developed by Miami Dade Fire Services for use by OFDA in Latin America and Caribbean countries. Subsequently, these courses have been contextualized and adapted to the Asian regional and national standards and the cultural and socio-economic realities of participating countries, including translation into the languages used in the nine countries. Further, both ADPC and NSET have developed a series of new courses compatible with the objectives of PEER, lessons learned, and the recognized needs of countries. These courses include a new one on Hospital Preparedness for Earthquakes (HOPE), Advanced Search and Rescue (ASAR), Community Action for Disaster Response, the Training for Instructors (for HOPE Trainers, and several other refresher courses. All these courses aim at helping countries to strengthen and institutionalize capacities in emergency and disaster response.

Community-Based Disaster Preparedness

NSET has developed a comprehensive approach to earthquake disaster preparedness that targets different stakeholders from the individual and family, to the block, ward, Village Development Center, agency, and municipality levels. The approach consists of developing earthquake preparedness kits to improve capacities in emergency protection, survival, and light search and rescue, and developing training courses on Light Search and Rescue, disaster preparedness for household families , disaster preparedness and emergency response planning for private and public offices, and disaster preparedness for differently-capable persons. The emphasis is on developing instructors who can replicate the training and propagate the knowledge widely.

5.3 Available Publications

The following publications are available as guidelines to earthquake-resistant construction.

5.3.1 Publications of Nepal Government Offices

Earthquake-Resistant Building Guidelines for Brick and Boulder Masonry Construction up to Two-Story high with Attic (MPPW-GON 2004).

This is a handbook written in Nepali that provides details for earthquake-resistant construction for up to two-story standard brick-and-boulder masonry construction. It is based on the National Building Code of Nepal, NBC 203:1994.

Booklet on Earthquake-Resistant Building Construction for Potential House Owners (KDDC/NSET/USAID 2009)

This booklet is written in Nepali and provides answers to frequently asked questions by homeowners regarding earthquake-resistant construction.

Nepal Disaster Report – Policies, Practices and Lessons," (MOHA/DPNet 2011)

This report is published with support from UNDP, Action Aid Nepal, and NSET. It summarizes disaster-related policies, concepts, and practices and the experiences and lessons learned during 2010 and earlier for reducing the impact of disasters and for being prepared for future ones.

The report covers natural hazards, such as floods, landslides, fires, extreme weather events, and earthquakes, and recognizes that earthquake is a major potential hazard and that the rapid urbanization over the past decade, with general disregard of earthquake-resistant measures in building construction, is the cause of increased risk.

Nepal: Guidance Note – Disaster Preparedness and Response Planning 2011 (MOHA 2011c)

This publication includes multihazard planning scenarios, including earthquakes, and is aimed at assisting government officials, the Red Cross, INGOs, and UN agencies that will be engaged in the disaster-preparedness and response-planning process in all 75 districts of the country. The

document is an important resource material for all District Disaster Relief Committee members to manage annual disaster-preparedness planning initiatives in the districts.

Building Construction Guidelines, 2003 (Bhaban Nirman Nirdesika, 2060, in Nepali) (DUDBC 2003)

These guidelines published by the Department of Urban Development and Building Construction, Ministry of Urban Development, are written in Nepali and provide simplified construction methods and typical details, applicable for the most common one- to three-story buildings. It can be used as a building construction handbook to provide training to masons and other building craftsmen. First published in 1996, the book provides guidelines for construction with or without cement and steel, and is geared to develop earthquake-resistant constructions.

5.3.2 Publications of Local and International Agencies

Protection of Educational Buildings Against Earthquakes (NSET/OFDA-USAID/UNESCO 2000)

This is a design manual prepared for use by designers and builders engaged in the design, construction, and protection of educational buildings against earthquakes and the construction of earthquake-resistant houses and other buildings.

Earthquake Resistant Construction of Buildings, Curriculum for Mason Training, Guidelines for Training Instructors (ADPC/NSET 2005)

This publication, developed with support from USAID, consists of training materials and exercises for training masons by local professionals, to develop the skills required for earthquake-resistant techniques in non-engineered and owner-built construction in remote villages.

Training Manual for School-Based Earthquake Preparedness Programs (NGED-CRED, UNICEF, NSET 2011)

This manual, written in Nepali, was developed by the Central Regional District Education office of the Nepal Government Education Department, with the help of UNICEF, and NSET. It was prepared for use by teachers to provide training in schools.

Non-Structural Vulnerability Assessment of Hospitals in Nepal (NGMOH, WHO, NSET 2003)

This document presents nonstructural assessments of hospitals in Nepal and provides an important step in the process of assessing the vulnerability of the health sector in future earthquakes.

Earthquake Preparedness Handbook (UNDP, UNICEF, USAID, NSET 2003)

This Nepali-language handbook was first published in 1999 and reprinted in 2003, 2006, and 2009. It provides an easy step-by-step procedure for earthquake preparedness, earthquake information, and during-

earthquake exercises. The handbook was developed in association with Save the Children.

Earthquakes (NSET, UNICEF, USAID/OFDA 2002)

This publication, written in Nepali, lists 30 Frequently Asked Questions and Answers related to the fundamentals of earthquakes, the necessities for preparedness, and necessary steps for safety during and prior to earthquakes. This was first published in 2002 and reprinted in 2003, 2006, 2008, and 2009.

Handbook for Disaster Preparedness and Drill in Schools (NSET, ARC, NRCS 2010)

This handbook, written in Nepali, is geared toward school disaster-preparedness plans, emergency exit and evacuation plans, disaster preparedness drills, and earthquake exercises.

Disaster Preparedness for Safer Schools in Nepal (DPSS) (NSET, ARC, NRCS 2011)

This booklet provides a description of pilot activities conducted at various schools in the Kathmandu Valley under DPSS program.

5.3.3 Booklets Developed by NSET in Nepali

Retrofitting of Common Frame Structure (Pillar System) Houses (Shrestha, H. 2007)

This booklet, Publication Series Number 24, provides some guidelines and typical retrofitting details for reinforced-concrete framed buildings.

What are the tricks of earthquake-resistant building construction? (Shrestha, B. 2007).

This booklet, Publication Series Number 25, provides guidelines for earthquake-resistant construction.

5.4 Safety- and Risk-Related Programs Developed by NSET

School Earthquake Safety Program

This program evolved from a simple school retrofit to a comprehensive program of earthquake safety involving the entire community. The program components include physical assessment of school buildings, structural risk-mitigation measures, awareness raising, training of local masons, teachers, students, and community people, and emergency preparedness planning for schools.

Nepal Earthquake Risk Management Program

This program started in 2005 with funding support from OFDA of USAID. The goal of the program is to improve earthquake safety in Nepal through earthquake-vulnerability reduction and preparedness initiatives. The specific objectives of the program are improving seismic safety of public and private schools, critical facilities, residences, and public infrastructure, as well as institutionalizing earthquake risk-management practices in Nepal.

Community-Based Disaster Risk Management in Nepal

The program has six major objectives related to empowering the grassroots community, including women, children, people with disabilities, and underprivileged and marginalized populations. The activities include awareness and education, training programs, drill, model structural and nonstructural mitigation, and community light search and rescue exercises. The program is supported by Lutheran World Relief.

Municipal Earthquake Risk-Management Projects

The program activities consist of developing earthquake damage scenarios for the cities, including building inventory surveys, preparing an action plan for earthquake risk management, construction or retrofitting of schools and other public structures as demonstrations of feasible mitigation measures, awareness-raising, training, capacity building, and institutionalization.

Municipal Disaster Risk Reduction Programs in Nepal

This publication covers the Ilam and Panauti Municipalities of the Jhapa and Kavre Districts, respectively, as pilot areas to implement the program, and gradually seeks to cover all 58 municipalities of Nepal. The project has a two-pronged strategy: a) to strengthen municipal capacity by institutionalizing the process of disaster risk reduction and consolidation of these capacities by follow-up activities and b) start the process of disaster risk reduction.

Kathmandu Valley Earthquake Preparedness Initiative

This program used a combined approach of building capacity of Nepal Red Cross Society (NRCS) volunteers, prepositioning critical emergency supplies and rescue equipment, training people in basic first aid and rescue techniques, and helping the general public to identify and advocate for safer building practices. The primary goal of the initiative was to help communities develop preparedness capabilities and to reduce potential suffering from earthquake disasters.

Kathmandu Valley Earthquake Risk Management Project

KVERMP was implemented from September 1997 to December 1999 by NSET in collaboration with Geo-Hazards International (GHI) USA, as a part of the AUDMP of the Asian Disaster Preparedness Center, with core funding by USAID/OFDA. The main objectives were to evaluate Kathmandu Valley's earthquake risk and prescribe an action plan for managing the risk; reduce earthquake vulnerability of public schools; raise awareness among the public, government officials, the international community in Kathmandu, and international organizations about Kathmandu Valley's earthquake risk; and build local institutions that can sustain the work launched in this project.

5.5 Public Awareness Programs

The following are some key programs aiming to raise awareness.

Earthquake Safety Day

Nepal observes annual Earthquake Safety Day (ESD) on the 2nd of Maagh (10th month in the Nepali calendar) (either 15 or 16 January) to commemorate the Great Bihar (India) -Nepal Earthquake of 1934. Many public awareness activities, such as annual symposia, earthquake safety rallies, exhibitions, and various competitions are organized on ESD.

Radio & Television Programs

NSET has established partnerships with a number of FM radio stations to spread awareness about the risks associated with earthquakes.

Shake Table Demonstrations

Shake table demonstrations help show and convince people in a simple and cost-effective way how their residences can be secured to reduce damage during earthquakes.

Orientation Lectures

NSET organizes orientation lectures on earthquake safety upon request. The content usually covers basic information about earthquakes and the situation in Nepal, what to do before, during, and after earthquakes, etc. Occasionally, the lectures also include earthquake drills.

Consultations for Homeowners

NSET organizes free consultations for current and potential homeowners in the Kathmandu Valley. This weekly consultation program focuses on how to construct buildings that are earthquake-resistant and discusses the main vulnerabilities in house plans and how to avoid those.

Mobile Earthquake Clinics

An innovative initiative of NSET involves a team of earthquake and structural engineers, technicians, and masons visit different locations and building construction sites in and around the Kathmandu valley to provide advice on safe construction methods.

Earthquake Vulnerability Tours

These are guided tours with a defined route or in a defined location to observe different vulnerability factors. The tours point out how vulnerable the city's buildings and critical facilities, such as the schools and the fire stations, are to earthquakes.

Community-Based Disaster Risk Management Programs

NSET provides technical assistance to the communities in implementing earthquake risk-management initiatives. Wards 17 and 34 of Kathmandu Metropolitan City have put tremendous efforts into making these initiatives sustainable.

5.6 Earthquake Retrofit Projects for Historic Landmarks in Nepal

Discussions are underway to set up a study team between ASNEngr and IOE, Pulchowk, to assess the structural vulnerabilities of historical

monuments and to come up with the necessary earthquake-strengthening measures to withstand major earthquakes in Kathmandu. Some of the historical monuments include the following:

* Dharahara Observation Tower in Sundhara, Kathmandu
* Tri-Chandra College Clock Tower in Kathmandu

5.7 Principal Stakeholders in Disaster Relief Operations

Several government agencies at the national and local levels, nongovernmental organizations, professional societies, and industry have knowledge and experience in handling post-earthquake relief and rescue operations. In particular, several government agencies have significant first-hand knowledge and experience in these activities. Coordination and planning among all the stakeholders is of utmost importance in dealing with future earthquake disasters in the Kathmandu Valley and other parts of the country.

These stakeholders include, but are not limited to, the following: Ministry of Home Affairs, Nepal Army, Nepal Police, Nepal Fire Brigade, Nepal Red Cross, Ministry of Health and Population, Department of Transportation, municipalities and village development offices nationwide, along with the National Engineering, Scientific, and Professional Organizations, Nepal Telecommunication Corporation, other private telecommunications companies, Nepal Electricity Authority, and various NGOs and INGOs (working within and outside Kathmandu Valley), and the local private organizations that will come forward to participate in relief operations.

5.8 National Public-Awareness Programs

Earthquake Preparedness Kit

NSET has prepared an emergency survival kit the JHATPAT JHOLA or GO-BAG, available to the public (NSET 2009). This bag contains several emergency survival items: portable battery-operated radio, flashlight, first aid kit, bottled water, water purifying tablets, nonperishable food, medical supplies, blankets, cooking items, important papers, etc., enough for three days (Kantipur TV 2011).

U.S. Embassy Earthquake Preparedness Document

This document, which is available on the U.S. Embassy website, briefly explains the emergency procedure to be followed before, during, and after an earthquake. It covers the importance of owning emergency kits, water, food supplies, shelter, clothing, bedding, etc. (U.S. Embassy 2011).

Red Cross Earthquake Emergency Resources, Kathmandu, Nepal

The American Red Cross promotes awareness of what an earthquake is and provides a safety checklist with facts for dealing with earthquake events (Red Cross, 2011a, b, c).

Annual Earthquake Safety Day, Nepal

Observance of the Annual Earthquake-Safety Day in various parts of Nepal, on January 16, is carried out in Kathmandu and other major cities of Nepal.

Earthquake Drill Program

This is conducted at present in various public buildings, schools, and hospitals. The program needs to be enhanced and conducted at regularly scheduled intervals nationwide.

6 Pre-Earthquake Activities

A comprehensive and effective earthquake-hazard mitigation plan must be in place for the whole country and be implemented diligently and regularly as the primary objective of the earthquake preparedness and disaster relief effort in Nepal, to reduce the life-threatening hazards and the huge loss of public and private properties in the country. Routine drills of response protocols across varied institutions should be a part of this mitigation plan.

According to the Nepal Red Cross, it is estimated that for every $1 of investment in disaster risk reduction, $100 may be saved in recovery costs. With this in mind, many governmental and INGOs have emphasized earthquake preparedness. As mentioned earlier, active involvement of the Nepali business community in safeguarding their buildings, employees, and business activities and in influencing government leaders will go a long way toward enhancing resilience after the earthquake. As emphasized by former U.S. Ambassador to Nepal, Scott DiLisi, the business communities, banking, and insurance industries should change their behavior to ensure standard code building practices for reducing damage and loss of life.

6.1 Infrastructure

Infrastructure is defined as the basic facilities, services, and installations for the functioning of a community, such as transportation and utility systems, communication systems, and public institutions that people rely on in daily life. In a country like Nepal, where most of the governmental organizations and industries are located in a few urban areas, damage to the infrastructure would have an enormous effect on the whole country. When transportation and utility systems are damaged due to earthquake, there are three kinds of risks: death and injury, property loss, and outage of transportation and utility systems. Due to narrow roads, heavily concentrated buildings, and substandard design, the effect of all three risks would be severe in the Kathmandu Valley. The mushrooming growth of low to tall structures in Kathmandu Valley elevates several vital multi-dimensional issues that increase risks to the loss of life and property (Baidya, 2012).

Every infrastructure system consists of structures (individual and interconnected), equipment, power supply, control systems, etc. For earthquake preparedness and disaster relief, one has to separate the object-oriented systems, such as hospitals, food storage, government buildings, and airports, and network-oriented systems, such as roads, electricity, land telephone lines, water supplies, and sewers. During a disaster, not every public service will function to the same extent as in normal times. Not every hospital has the same importance and equal emergency capacities. It is important to identify and define the minimum required services (reduced-mode service) that could be provided during a disaster. System vulnerabilities must be evaluated to maintain such reduced modes for each infrastructure part (Studer, 2000).

To prepare an essential infrastructure segment to adequately function after an earthquake, the first task should be to develop a mitigation plan. Mitigation means taking actions to reduce the effects of a hazard before it happens. The mitigation plan can include physical protection, such as constructing a stronger infrastructure, and procedural improvements, such as introducing standard techniques for incorporating hazard assessments in land-use planning, or preparation of disaster response and reconstruction plans. To achieve an earthquake-resilient infrastructure system takes time and requires a continuous effort to improve system resistance while maintaining or improving the system safety level. Earthquake preparedness and relief efforts should include but not be limited to the following basic considerations: (a) careful identification of required infrastructure at a reduced-mode level, (b) evaluation of the importance of maintaining services at reduced mode at all times, (c) hazard assessment considering local conditions, and (d) vulnerability of important components. The main steps of earthquake risk mitigation for infrastructure system can be summarized as follows (Studer 2000):

- Assess regional and local requirements based on the economic and social conditions.
- Define infrastructure systems important for disaster response and reconstruction.
- Define socially and economically acceptable functioning for every infrastructure system.
- Assess the hazards, taking into account local geological and topographical conditions.
- Assess infrastructure system vulnerabilities, taking into account structural and functional aspects, as well as redundancy and fast repair possibilities.

The most important concepts required for earthquake preparedness and disaster relief applicable to Nepal are summarized as follows (Gosh 2008):

- Prepare a comprehensive study of seismic hazards for urban and rural areas. A specific study would be required for the Kathmandu Valley due to complexity of infrastructure
- Identify the minimum reduced mode of infrastructure that is required for disaster-relief operations in the post-earthquake period.
- Establish an integrated network plan of essential infrastructure and its implementation in the event of an earthquake.
- Develop a comprehensive mitigation plan, based on the acceptable risk level and applicable to local conditions. Even for Kathmandu Valley this plan could be different based on the population density, the importance of a local area, and the complexity of available infrastructure.
- Implement a plan that for retrofitting the most critical infrastructure. Apply modern retrofitting technology, based on the experience gained from recent major earthquake-relief operations, to all critical infrastructure.

- Since specific parts of the nation's infrastructure are designed and maintained by different agencies, interdepartmental coordination will be required.

6.1.1 Earthquake Hazard Grading Index Survey

The inventory of existing buildings (in the first phase) may be classified in three groups: (a) excessive hazard; (b) high hazard; and (c) intermediate hazard, as described in the City of Long Beach Earthquake Hazard Regulations (City of Long Beach 1990a).

Buildings are prioritized either for demolition or for seismic-retrofit programs, based on their hazard grades. Buildings classified as excessive hazard are scheduled for demolition or for retrofitting within a given time frame. The high-hazard and intermediate-hazard graded buildings are taken up at the same time, but the building owners of these are given reasonable additional time to mitigate the hazardous condition of their buildings.

In addition, buildings are categorized under different building occupancy groups: public or private, historical or nonhistorical, and whether or not they contain essential facilities, e.g., hospitals, schools, police stations, fire stations, communication facilities, and airports. Obviously, these facilities are vital and need immediate attention for their vulnerability assessment and hazard abatement. A team of experts familiar with this task and having experience in seismic retrofitting can be formed to initiate the hazardous grading survey in the Kathmandu Valley, as follows:

- *Kathmandu Metropolitan City* – The hazardous grading survey should be started immediately, since there are many hazardous buildings in the heart of Kathmandu and surrounding areas.
- *Lalitpur, Bhaktapur, and Thimi Municipal areas* – These cities also have many existing historical and non-historical hazardous buildings that are highly vulnerable to earthquake damage and collapse. The survey must be conducted immediately.
- *Plan of action for an acceptable time frame for demolition and/or retrofit work* – The building owners must be required to submit a plan of action within a reasonable timeframe in response to letters sent by the concerned authorities.
- *Available loans and grants for the hazard mitigation program* – A floating loan program as a part of the earthquake-hazard mitigation program has been very successful in the U.S. (City of Long Beach 1990b). A separate group of engineering and financial experts can be formed to initiate and develop this kind of loan program in Nepal.

6.1.2 Geotechnical Studies and Foundation Design Considerations

The Himalayas, the youngest and highest mountain chain in the world, is one of the world's most seismically active areas on earth and Nepal occupies nearly one-third of the range.

Earthquakes occur on faults that are discontinuities in the earth's crust, as a tremendous amount of energy is released when one side of the fault

suddenly slips relative to the other side. The regional fault system of Nepal consists of the Main Frontal Thrust, Main Boundary Fault, Main Central Thrust, and South Tibet Detachment System, from south to north. All of these faults contribute to seismic activity in Nepal. The Kathmandu Valley is also traversed by a number of faults and lineaments.

The primary effect of an earthquake is massive destruction by ground shaking, and secondary effects include liquefaction, landslides, rockslides, mudslides, ground ruptures, uplifts and subsidence, and tsunamis.

An in-depth knowledge of site-specific geological and geotechnical engineering is essential for design and construction of almost all infrastructure components, including, but not limited to, earthquake-resistant buildings, water distribution and sewerage systems, roads, bridges, airports, dams and levees, tunnels, telecommunication systems, railroads, and hydroelectric power plants. This knowledge also helps in monitoring performance and retrofitting of the existing structures. Among various geological and geotechnical parameters, amplification factor, peak ground acceleration (PGA), and liquefaction are the basic seismic design parameters.

The Kathmandu Valley sits atop an ancient lake bed containing dirt and sand that are mechanically weak compared to the bedrock and can be quite unstable during an earthquake. Mexico City was struck by an earthquake of 8.1 magnitude on Sept. 19, 1985, causing 10,000 deaths, 30,000 injuries, and billions of dollars of property damage. Mexico City is similar to the Kathmandu Valley since it sits on soft sediments of the ancient Lake Texcoco. The earthquake-generated ground motions on the soft sediments of the lake bed in Mexico City were amplified five times and lasted longer relative to the nearby rock sites during the 1985 quake (Kramer, 1996; FEMA, 2007). The buildings in Kathmandu Valley suffered a similar fate during the 1934 Bihar (India) -Nepal earthquake of magnitude 8.4.

A vast area in the Kathmandu Valley is categorized under intensity IX and X of the MMI scale earthquake, which means a vast majority of buildings there will experience substantial damage or collapse and even specially designed buildings will suffer destruction to a lesser but considerable extent (USGS 2013a). Buildings will be shifted off their foundations in an earthquake. The liquefaction zoning shows medium to high liquefaction of soil and sand in most of the Kathmandu Valley during an earthquake.

According to Segawa, et al. (2002) of Japan International Cooperation Agency (JICA), the PGA in a large part of the Kathmandu Valley has significantly high values of 300–400 Gal (1 Gal = 0.01 m/s^2; 1 g = 981 Gal = acceleration due to earth's gravity). The study showed that for a PGA of 400 Gal, about 75 percent of the buildings constructed of adobe and stone, 60 percent of brick with mud mortar, and 50 percent of concrete frame with masonry walls of four stories or more will be severely damaged in an earthquake in the valley. The safest buildings are those constructed with concrete frames with masonry walls of three stories or less, but even these have an almost 40 percent chance of destruction. These results corroborate the findings of the Kathmandu Valley Risk Management Project (2000), indicating substantial damage of up to 60 percent of all the buildings in the valley during an earthquake.

The National Building Code of Nepal needs to mandate geotechnical studies and specific foundation design recommendations and requirements based on the various building types. These are classified as low-rise buildings, mid-rise buildings, high-rise buildings, and other structures, e.g., retaining walls, waterfront structures, bridges, and towers.

6.1.3 Earthquake-Induced Landslides

Earthquakes trigger landslides and, therefore, earthquake-prone areas must be studied for landslide potential and resulting hazards. Past earthquake records show evidence of substantial damage and losses to roads, houses, utilities, etc. due to landslides. The most recent earthquake of September 18, 2010 in eastern Nepal also triggered landslides resulting in a substantial amount of damage (MOHA. 2011a).

Local and global soil studies are necessary to design effective slope-stabilization measures and preparation of the necessary landslide-mitigation plans and prevention practices. A slope-stability study must be a part of the earthquake preparedness plan, in order to protect hillside villages and towns in the country. The detailed requirements for hillside housing development are stipulated within the national and international building codes (MHPP-DOB 1994, CBSC 2007, ICC 2006, and ISI 1970 and 1983).

6.1.4 Upgrade the Current National Building Code of Nepal

Introduction

The first National Building Code of Nepal (NBC) was published in 1994, initiated by the Department of Buildings, Ministry of Housing and Physical Planning, Government of Nepal (MHPP-DOB 1994). The code is not fully comparable to the International Building Code (IBC) and other international building codes and standards followed in other developed and developing countries.

Adoption of Building Codes

It is interesting to note that although the history of building codes goes back to the Code of Hammurabi (2200 BC), the first Uniform Building Code in the U.S.A. was only enacted in 1927 by the International Conference of Building Officials, (formerly known as Pacific Coast Building Officials Conference, Los Angeles, California) as a result of earthquake damage. The building code is revised at approximately three-year intervals. Similarly, the history of Nepal earthquakes goes back to 1255 to the ancient days of the Malla King Dynasty when the king himself died in the earthquake. The first building code in Nepal was crafted after the 1988 Eastern Nepal earthquake of magnitude 6.6 (MHPP DOB 1994).

Lalitpur Municipality is the first city in Nepal to have implemented NBC effective Baisakh 1, 2059 (April 14, 2003 in the Western calendar) (SCAEF 2002). Four of 58 municipalities, including Kathmandu, have begun implementing safe building construction practices using building code provisions. Implementation of NBC is being made mandatory in all 58 municipalities within the next five years (MOHA 2011b). It is essential that municipalities make amendments to the building code by adding or

modifying code sections to comply with local climatic, geographical, and geological conditions of the northern mountain, middle valley, and southern plains (Terai) regions of Nepal.

Building Code Upgrade

It is customary professional practice that changes to the NBC are processed each year and published in supplements in a form permitting ready adoption by local municipalities. These changes are necessary to keep abreast with current research and technology methodologies and advances in earthquake-resistant design and construction. The timely update of building codes is also necessary to incorporate the experience gained and lessons learned from implementing the previous cycle of codes.

The next edition of the NBC must be, as far as possible, compatible with the norms and standards stipulated in IBC, which broadly cover the seismic design requirements dealing with multistory high-rise building construction, their foundation design criteria, and the liquefaction potential of the soil underneath.

The National Building Code of India (ISI 1970, 1983) is upgraded in a timely manner and can be used as a reference, while the Nepal Building Code is being upgraded. The 1994 NBC already refers to the 1983 National Building Code of India. The plan-review engineer, however, must evaluate the local conditions of the construction site and apply the code with amendments, as appropriate and as approved by city ordinances.

Complete Building Code

To make the code complete in itself, the upgraded building code must cover requirements for architectural design, fire life safety, emergency exits, disabled access, energy, fire-proofing, stairs and elevators, including high-rise emergency evacuation systems, in addition to minimum structural seismic-safety requirements for buildings. In 2003 some upgrades were made for architectural design requirements (NBC 206: 2003 Upgraded), electrical design (NBC 207:2003 Upgraded), and sanitary and plumbing design (NBC 208: 2003 Upgraded). The building bylaws were again updated in 2007 (MHPP-KMCDC 2007) to divide the Kathmandu Metropolitan City into nine zones: Cultural Heritage Conservation, Residential, Institutional, Industrial; Preserved (park, forest, greenery, open space, archaeological, cultural, and religious subzones), Urban Expansion, Surface Vehicle, Airport, and Sport Zones.

6.1.5 Upgrade of the Current Planning and Zoning Code

Earthquake safety is also achieved by proper urban planning and design. Although planning and zoning play a relatively minor role in the earthquake resistance of buildings, they are important in ensuring earthquake safety for the community.

Land is at a premium in the Kathmandu Valley and most city areas are already built up. A pragmatic approach to seismic safety should balance the need for the earthquake safety of buildings and the need for homeowners to maximize the development potential of their property.

The elements and guidelines below are based on the best practices followed by several city municipalities across the world, while taking into consideration the current city zoning and land-use regulations of Kathmandu (MHPP-KMCDC 2007).

Building Configurations

New buildings should have the following features as far as practicable:

- Symmetrical plans and elevations.
- Square or square-like floor plans.
- Minimal amount of cantilevered floors, slabs, and projections from walls.
- Low overall height whenever feasible.
- Low height-to-base ratio.
- Lower center of gravity by providing larger base and smaller tops in buildings.
- Equal floor heights and short room spans.

Open Space

An important planning criterion in seismic areas is that adequate open space should be provided. The American Planning Association states that many municipalities provide a range of 4–10 acres of total external open space for every 1000 persons (American Planning Association 1965). This might be unachievable in Kathmandu, given the high land values and compact settlement patterns, but it provides a good reference point. A good guideline could be to provide some form of open space every 600 feet, so that people do not have to walk more than 2 minutes to get to a safe open space (American Planning Association 1965). This would provide a place for people to gather within a reasonable walking distance in case of earthquake emergency. Much of Kathmandu City lacks such open spaces. However, there should be a retrofit strategy for old areas and open-space requirements for new constructions. Open space can be contributed by developers or provided by the municipal government.

NSET and UNICEF studied Kathmandu, Bhaktapur, and Lalitpur municipalities in the project "Seismic Vulnerability Assessment of Kathmandu Valley Water Supply System." It pointed out that some of the areas that could be used for evacuation purpose are Kathmandu Balaju Bus Park, Chhauni Military Camp, Golf Course and Pashupati area, International Conference Center, Trolley Bus Park, Khula Manch, Tundikhel, Ratna Park, Dashrath Stadium and Bhrikuti Mandap in Kathmandu. Similarly, in Bhaktapur, the industrial area, Sallaghari open space, Sano Thimi Campus, Education Department premises, and the Army camp, and in Lalitpur the Pulchowk Engineering Campus, Khumaltar, Balkumari ring road, UN Park, and Lagankhel football grounds are possible evacuation sites (Kantipur Daily 2010).

The Ministry of Home Affairs, Disaster Management Section, in its report "Nepal: National progress report on the implementation of the Hyogo Framework for Action (2009–2011) (MOHA 2011b) states that 64 open spaces for humanitarian purposes during emergencies have been identified within

the Kathmandu Valley. Furthermore, the Ministry of Home Affairs (MOHA) and the International Organization of Migration report identifies 84 potential open spaces in the Kathmandu Valley, categorized as large, medium, and small open spaces, including various schools and college sites (eKantipur on-line 2013a).

Ground Coverage

In older parts of the Kathmandu Valley, land is at a premium and requiring low building coverage on a site would be impractical from the economic perspective of the owner. However, in all newly designated development areas and for new building construction, there should be a limit of maximum building coverage of the site, which should be specified as a percentage of the total site area.

In most American municipalities, the maximum allowable building coverage of the site in single-family zoning districts is between 40 and 60 percent of the site area (City of Phoenix, Zoning Ordinance 2013). This standard can be used as a reference point and modified, as needed, for practical and economic considerations. The average ground coverage requirements of 40–80 percent specified in the Kathmandu Metropolitan City Zoning and Land Use Regulations (MHPP-KMCDC 2007) appear to be reasonable.

Building Setbacks

The current setbacks required in the Development Standards of 2007 (MHPP-KMCDC 2007) seem to be set for earthquake safety. Buildings shall also be set back from any hazardous element, such as retaining walls, old structures, riversides, hillsides with mudslide potential, and other features by a setback length equal to at least the height of the building.

Right-of-Way (RoW)

For local roads, the minimum RoW should be 35 feet, which allows two car lanes and a 5-foot-wide sidewalk on each side of the road. For collector streets, the minimum RoW shall be 55 feet, allowing for two to four car lanes and sidewalks on both sides. For arterial roads, the minimum RoW should be 65 feet, allowing for three or four car lanes and appropriate sidewalks, median and landscaping. Provision of adequate RoW is critical in Kathmandu, because, in the event of an earthquake, there must be sufficient access for emergency vehicles and fire trucks.

The recommended RoWs are based on the best practices used in the USA (Pioneer Institute for Public Research 2004). Smaller values might be acceptable, since vehicles are smaller in Nepal. The RoW width also varies by the maximum vehicle speed allowed on a street and the classification of the street (Pioneer Institute for Public Research 2004). These numbers will need to be refined and adjusted for Kathmandu as it develops a road classification system and specifies respective vehicular speeds.

The current RoWs in Kathmandu are inadequate. The existing road system is characterized by roads that are too narrow and have unacceptable turning-radius dimensions, making traffic flow difficult and access by emergency vehicles virtually impossible. There is now a process of widening

the roads in Kathmandu, which would greatly help the passage of emergency vehicles during a disaster. The Kathmandu Metropolitan City Zoning and Land Use Regulations (MHPP-KMCDC 2007) also specify the building setbacks and RoWs for various roads in Kathmandu, Lalitpur, and Kirtipur municipalities and nearby village development centers.

Building Height

In all new construction, building height of more than two stories should be allowed only with appropriate setbacks, ground coverage, and on-site open-space requirements. All midrise and high-rise buildings must meet rigorous structural and building code requirements. The heights allowed by the Development Standards (MHPP-KMCDC 2007) appear appropriate in most cases. However, it is suggested that the allowed heights be limited to a 45-degree vertical light angle from the opposite end of the RoW, instead of the 63.5-degree angle in the 2007 Development Standards (MHPP-KMCDC 2007).

Floor Area Ratio (FAR)

Some municipalities prescribe FAR to ensure that the development is adequately served by the existing and planned infrastructure, including roads, water supply, sewage capacity, and other utilities. The generally high FAR provided in the 2007 Development Standards (MHPP-KMCDC 2007) seem reasonable for the Kathmandu valley. However, if the maximum ground coverage, setbacks from road and boundaries, and height are specified for new buildings, the FAR becomes irrelevant. The other constraints and requirements can limit the maximum FAR on any site.

6.1.6 New Additional Codes and Standards

Seismic- Retrofit Code for Buildings and Infrastructure

The 1994 NBC (MHPP-DOB 1994) covers the design of new buildings, but does not address design procedures and norms required for retrofitting existing buildings. The Kathmandu Valley is full of old low- and midrise unreinforced masonry buildings, built mostly prior to the publication of the 1994 NBC. The existing buildings are vulnerable to damage or collapse in a major earthquake. There is an immediate need for a separate building code to address retrofitting design standards and criteria for the existing historical and nonhistorical buildings in Nepal (EERI 1994).

There are no standards for the design and retrofitting of transportation and utility infrastructures. These must be developed and implemented immediately for all critical infrastructures. Standard guidelines adopted by Indian and U.S. agencies could be considered and modified for Nepal's conditions. Standards should be vigorously implemented for new designs.

Retrofit Code to Prevent Building Collapse

In the USA, the Uniform Code for Building Conservation is used, in general, for evaluation and retrofit of existing buildings. However, different cities have also developed their own criteria to retrofit existing buildings to make them stronger and prevent collapse during earthquakes. The majority of old buildings in Nepal were built using baked or even unbaked clay bricks

and mud mortar with structural wood members (Kayastha, K 2007). These buildings do not have much lateral-load resistance for earthquakes. Depending on the specific seismic and geological conditions of their site, they may crumble or collapse, even in a moderate earthquake. The unreinforced masonry filler walls that are traditionally used in reinforced-concrete-framed buildings, and permitted in the NBC, can be vulnerable to earthquake damage due to out-of-plane failure, as is evident from past earthquakes. The new seismic-retrofitting code must include retrofitting guidelines and requirements to prevent both in-plane and out-of plane failures. It has to be clear that retrofitting code provisions for existing buildings must have less stringent requirements than those for new construction. Many old buildings would literally have to be torn apart and rebuilt to achieve the level of performance expected in new buildings. The retrofitting code provisions must balance the retrofit cost with a reasonable level of safety and are characterized as "seismic risk reduction" measures (EERI 1994).

National Fire Code

A separate National Fire Code is necessary to fully cover the norms and standards for fire fighters to effectively combat fire in buildings. The fire-life-safety requirements stipulated within the building code are mostly related to construction. The fire code is prepared in close consultation and coordination with fire department personnel so that the requirements of the fire code can be easily implemented during construction and properly checked and approved by inspectors. The fire-suppression methods and techniques that are used for inside and outside the buildings and on streets and infrastructure must be fully covered within the fire code.

The lack of modern fire apparatus and manpower needed for high-rise construction has been apparent during several fires that broke out in the heart of Kathmandu and Lalitpur (eKantipur on-line 2012). The Kathmandu Metropolitan City Office is receiving modern ladder fire engines to douse fires in buildings of up to 16 stories, with the cooperation of the Italian and British governments (*The Kathmandu* Post 2012) .

The International Building Code defines a high-rise building as having occupant floors more than 75 feet above the lowest level of fire department vehicle access (typically eight stories or higher) (ICC 2006, CBSC 2007).

Electrical, Plumbing, and Mechanical Building Codes

A separate Nepal Electrical Code, Nepal Mechanical Code, and Nepal Plumbing Code will have to be prepared and implemented in close coordination with the NBC. Heating, ventilation, and air-conditioning requirements must be included in the mechanical code. These codes must also cover all other infrastructure that can have life-safety concerns triggered by natural disasters, such as earthquakes.

Plan Review, Construction Permit Issuance, and Approval for Building Code Compliance

Close coordination between the plan approving authority, the building permit issuing authority, and building inspectors is vital for producing earthquake-resistant buildings and infrastructure. Also, a close coordination

among the code-enforcing authorities during the construction phase, building approval, and issuance of the Final Certificate of Occupancy must be strictly followed to ensure fully engineered construction.

It has been said that lack of coordination, during and after construction, is one of the main reasons for the growth of haphazard and unaesthetic buildings throughout Kathmandu and nearby cities. The building code upgrade must include all construction safety requirements under the Safeguards during Construction section of the building code. It should also cover situations, such as "the owner's obligation for foundation excavation in adjacent buildings," under the Protection of Adjoining Property section of the building code (ICC 2006, CBSC 2007).

Developers' Obligation for Infrastructure Development, Related to Large Commercial and Multiunit Residential Developments

It is mandatory that the infrastructure associated with the proposed development be included within the permitted housing development, e.g., access roads, utility lines, relocation of electrical, telephone, and other utility poles, including the provisions for fire truck access and turning radius, etc.

Quality Control, Testing, and Lab Results for Approval during Construction

The quality control process during construction, including collecting test samples, reviewing and approving the results received from approved labs, specifying the duties and responsibilities for building inspectors, and properly filing the records, must be included within the building code requirements.

Earthquake Insurance Options, Available for Residential and Commercial Projects

To promote quality construction, ensure better earthquake-resistant construction, and reduce their own financial risk, banks and financial institutions providing loans to the developers and property owners should require earthquake insurance on the property.

6.1.7 Education, Research, and Development in Earthquake Engineering

It is of utmost importance for achieving state-of-the-art design and construction of earthquake-resistant buildings and infrastructure, a regular national research program on earthquake science and engineering and curriculum updates at the nation's engineering colleges, universities, and training institutions be maintained. This includes developing and/or updating practical design courses in earthquake-resistant design and construction in undergraduate- and graduate-level courses in all engineering colleges and universities in Nepal and conducting training courses for skilled trades and craftsman.

Some of the suggested design courses are listed below:

- Reinforced-masonry design, covering lateral designs for load-bearing wall construction (for low- and midrise masonry construction).

- Reinforced concrete (RCC), steel, timber, and mixed-type construction, suitable for local conditions. RCC construction with unreinforced masonry infill is the common type of construction seen in buildings in Nepal. Steel-framed construction may become more common in the near future as the construction industry grows, followed by a combination of masonry, concrete, steel, and timber construction. Civil, architectural, and structural engineering courses should be revised and updated in anticipation of these trends.
- At present, the Institute of Engineering Pulchowk Campus is running master's and Ph.D. programs in structural engineering and Khwopa Engineering College in Bhaktapur has started a master's in earthquake engineering program. Undergraduate courses in structural and earthquake engineering are offered in Sagarmatha Engineering College located in Kopundol, Lalitpur, Nepal. It is suggested that more engineering colleges and universities in Nepal begin offering master's level courses in structural and earthquake engineering theory and design, with both lab facilities and practical applications.

Establishment of a National Institute of Earthquake Research and Development

A national earthquake research institute needs be established soon in Nepal, either by the Nepal Government or by private enterprise, to conduct research programs related to earthquakes in Nepal. The research and development findings can be used to create better earthquake-resistant infrastructure designs and construction by updating the Nepal Building Code at regular intervals. This will also help develop the state-of-the-art engineering curricula in Nepal colleges and universities.

Nepal currently has a Research Center for Applied Science and Technology in Tribhuvan University, (RECAST 1977) and a Center for Applied Research and Development in the Institute of Engineering (CARD 1972), plus a few nongovernmental research and development centers.

Conducting Professional Engineering License Examinations

To guarantee public safety and harmonize engineering professional requirements and practice in the country, a professional license examination system should be initiated by making necessary changes in the current licensing system, which is awarded by the Nepal Engineering Council primarily on possession of a college degree in engineering. These professional examinations should initially award Professional Engineer (P.E.) licenses in civil, mechanical, and electrical engineering.

A professional licensing system will help make design professionals accountable to the public and support property and professional insurance services. In addition, the teaching institutions will be encouraged to provide higher quality education in engineering and science.

Provide Training for Earthquake-Resistant Construction to Skilled Building Craftsmen

Traditional craftsmen, such as masons, carpenters, plumbers, electricians, steel workers, building inspectors, and plan readers are not adequately exposed to lateral-resisting construction systems. The available training manuals and publications, prepared by the Nepal Government offices with the help of local and international experts, are listed under Section 5.0 of this position paper.

Provide Education and Earthquake-Drill Exercises in Schools, Hospitals, Municipal Offices, Public and Private Offices, and to the General Public

The programs developed by the private, public, and nonprofit sectors and the Nepal Government, are listed in Section 5.0 of this publication.

6.1.8 Considerations of Livestock for Disaster Preparedness in Nepal

Nepal is endowed with rich and diverse resources of animals, both domesticated and wild. Most people live in rural areas where their livelihood is dependent heavily on livestock wealth that comprise some 17 domestic livestock species (Wilson 1997). Among these species, cattle (*Bos taurus* and *Bos indicus*) are the largest in number of quadrupeds, while buffaloes (*Bubalus bubalis*) are economically the most important ones (Rasali 2000)

People and animals live closely together physically and emotionally. Disasters can have both immediate and longer term effects on livestock and pets. Direct injuries and exposure to smoke, fire, floods, or hazardous substances may require emergency veterinary care. In addition, disease outbreaks can occur in the aftermath of a disaster both in humans and animals. To add to the complexity, there are numerous diseases that are transmitted readily between humans and animals. Saving lives of both humans and animals alike becomes a paramount priority as part of the overall management of the aftermath situation.

A coordinated approach should include consideration of livestock and other animals as an integral component. This component would address the veterinarian's role in emergencies, the effects of disasters on livestock wealth, animal health and public health. The veterinary group should contribute to the development of its position on disaster and emergency issues, and develop guidelines for the veterinary allied relief groups to be used in various aspects of disaster situations.

6.1.9 Transportation Studies and Reports for Building Permit Issuance

The core Kathmandu area needs a comprehensive traffic study and mitigation plan, as a part of pre-earthquake activities. A long-range plan should consider a second-level metro railroad over the existing perimeter roads around the Tundikhel area. To help ease the current traffic congestion around the Tundikhel and Ranipokhari perimeter, parking structures under Tundikhel open areas and public toilets may be built. A few retail shops may be included in this parking structure, which will help generate funds for

maintenance. These parking structures can also be utilized for temporary shelters and emergency medical services. Similarly, the overhead metro rail service can be used for emergency transportation during relief operations.

- A traffic study and the minimum parking requirements for standard and compact vehicles (including the numbers required for disabled parking), for all new commercial and large residential developments, must be made mandatory prior to the issuance of a building permit.
- In view of the growing population and demand for housing in Kathmandu, an annual traffic study must be conducted at various locations in the Kathmandu Valley, to determine the additional overhead pedestrian bridges that are needed.
- The Planning and Zoning code must mandate traffic studies for all proposed commercial and large residential developments, so that the traffic volumes in and out of the Kathmandu core area are well dispersed, without bottlenecks.
- The Department of Transportation must regularly study and upgrade the traffic intersection signaling systems (recommended annually) based on traffic-volume studies.

6.1.10 Complete Infrastructure Evaluation and Upgrade

Water, sewer, and storm water drainage systems in the entire country must be evaluated and documented, so that disruption of primary water supplies, especially in the city areas, can be corrected without significant delay.

The primary structures in the transportation network, such as roads and highways, bridges, retaining walls, power transmission lines and the electrical distribution network, power houses and towers, telephone communication towers, airports, and control towers need to either remain operable or be easily repairable after an earthquake. Similarly, other important civil structures, such as dams, irrigation canals, aqueducts, pump houses, and water storage tanks must also be evaluated to avoid catastrophic failures.

These structures in the Kathmandu Valley are fairly old and in need of thorough structural evaluation to determine their resilience to medium- and high-magnitude earthquakes, including the newly erected telecommunication towers over existing buildings.

6.2 Communications

The experience after the Haiti and 2008 Sichuan earthquakes demonstrate that a functioning telecommunication system can save lives following a major disaster. Telecommunication systems allow the optimal routing of first responders, allow survivors to inform others of their location, allow remote crowdsourcing to identify locations of survivors in a changed landscape, and enable efficient routing of key material and expertise to where they are needed.

Kathmandu has extensive telecommunications capabilities. Unfortunately, much of this capability is highly vulnerable and likely to be inoperable following a massive earthquake (MOHA, 2009).

Detailed published material in the public domain regarding Kathmandu's disaster telecommunications capabilities is not generally available. Telecommunication is universally recognized as a vital component of a disaster response effort, but there is not adequate knowledge of what the communication infrastructure will be or should look like following a major earthquake.

Many disaster preparedness challenges may not be adequately addressed prior to a massive earthquake. However, disaster telecommunications systems and strategies are relatively low cost, scalable, mature, and flexible.

6.2.1 Establishment of Links between Key Organizations

Numerous organizations within Nepal have overlapping mandates relative to disaster telecommunications. However, these responsibilities may not be widely understood among all of the principal players. In addition, the technologies, ruggedized access points, and links to facilities outside Nepal are not explicitly known. Identifying key stakeholders, their responsibilities, standard operating procedures, and capabilities prior to the earthquake can enhance teamwork and efficiency when the network is needed.

To enhance communications within the disaster community, the Integrated Disaster Communication Commission (IDCC) was formed on January 9, 2012. Under the sponsorship of the Computer Association of Nepal (CAN), key stakeholders in disaster communications in Nepal met for the first time.

The IDCC's principal goal is to increase communication among its members by providing a centralized, web-based medium for instantaneously sharing vital information, including the following:

- Critical announcements
- Changing circumstances
- Important new initiatives
- Immediate needs
- New developments
- Evolving roles and responsibilities

The IDCC does not provide prescriptive solutions for any particular member, but rather a platform to allow all consortium members to share information (especially important new information) among each other. A few important outcomes resulting from the inaugural meeting of the IDCC are as follows:

- Establishment of the IDCC.
- An agreement to meet in person every six months; CAN will be responsible for organizing subsequent physical meetings.
- A unanimous recommendation to the Ministry of Home Affairs that a sixth flagship, dedicated to communication, be created in its NRRC.

Nepal Military

The Nepal military will be a major player in nearly all aspects of disaster preparedness and response. It has participated in the Multinational Communication Interoperability Program (MCIP), a consortium of militaries and NGOs dedicated to pre-establishing telecommunication standards and interoperability guidelines among member organizations prior to a devastating emergency. The MCIP is facilitated by the United States Pacific Command (USPACOM). In April of 2011, a staff workshop for the MCIP was cohosted in Kathmandu by the Nepal military and USPACOM (Nepal Army 2011). Though the Nepal military has been at the forefront in anticipating telecommunication challenges following a disaster, members of the civilian disaster network should also be aware of the details of the Nepal military's role in disaster telecommunication preparedness.

Ministry of Information and Communication

The Ministry of Information and Communication (MOIC) has the authority, according to the Telecom Act of 1997, to operate and direct Nepal's telecommunications services (Hada, 2006).

Nepal Telecommunications Authority

The Nepal Telecommunications Authority (NTA) is the government regulatory agency on issues relating to telecommunications. It has mandated that voice-service providers submit to the NTA an emergency reaction plan within twelve months of receiving a transmission license from the NTA. The NTA has further mandated that all service providers update their emergency reaction plans when requested by the NTA (Hada, 2006). The NTA has taken a crucial step in requesting proposals for analysis and design of telecommunication towers, earthquake disaster risk assessments of base transceiver system (BTS) towers, and vulnerability assessments and restrengthening and retrofitting of vulnerable towers (NTA Request for Proposals, 2012).

Nepal Telecommunications Corporation

Nepal Telecommunications Corporation (NTC) is the largest telecommunications provider in Nepal. NTC is also the largest wireless telephony service provider in Nepal. Mobile telephony can be a vital resource for survivors following an earthquake as was demonstrated in Haiti (Large, 2010) As of 2006 Nepal had over one million subscribers of wireless telephony (Hada, 2006) The failure of cell phone networks can be devastating to survivors. Even a partially functioning cell phone networks in Haiti was important. A functioning cell phone network in Nepal following an earthquake must be a vital goal of effective disaster telecommunication planning.

Haiti's experience showed that cellular BTS on rooftops can have a devastating effect on a network's operation (Corley, 2010a). Presently, nine out of thirteen BTS towers in Nepal are placed on vulnerable sites incapable of withstanding a severe earthquake (Kathmandu Post, 2011).

As the largest telecommunications and mobile service provider in Nepal, the Nepal Telecommunications Corporation (NTC) has a unique role to play

in disaster preparedness. The NTC has conveyed that it is concerned about the viability of mobile communications following the expected earthquake. Apart from the integrity of mobile phone towers, the structural integrity of the central switching office is of paramount importance. Even if all mobile towers remain standing and functional, damage to the central switching office could challenge the operation of the system. The NTC and other mobile providers have already invested in a fleet of mobile base stations to alleviate mobile phone service interruptions associated with heavy use during traffic jams and occasional strikes within Kathmandu. These mobile base stations can be used as a flexible mobile network following an earthquake. Mobile service providers must be assisted in structurally hardening key facilities and fixed mobile towers and exploring the use of mobile stations to mitigate the effects of a disaster. All mobile service providers must also be assisted and encouraged to routinely assess and structure their contingency plans to cope with an 8.0 Richter scale magnitude earthquake in Kathmandu

UNOCHA/UNICEF/WFP Emergency Telecommunications Cluster

The United Nations Office for the Coordination of Humanitarian Affairs World Food Program (UNOCHA/UNICEF/WFP) is tasked with the management of the Emergency Telecommunications Cluster as indicated by NSDRM. These organizations presently have a broad knowledge of disaster telecommunications, especially relating to NGOs, and must be involved in any national consortium on disaster telecommunications.

Nepal Red Cross Society

The Nepal Red Cross Society has served as an important NGO in disaster relief and response. It has also for years shown its concern for and sensitivity to a robust disaster telecommunication system.

Ministry of Home Affairs

The Ministry of Home Affairs (MOHA) is the principal disaster-management entity for the Government of Nepal. It will be involved in all aspects of disaster management. MOHA administers the National Emergency Operations Center (NEOC) building located in Singha Durbar. This facility is designed to withstand the expected earthquake and be self-sustaining in the event of a major disaster. The principal goal of the NEOC is to serve as a coordination and communication point for disaster information across Nepal. A world-class, Internet-based communication portal has been developed for MOHA. If the use of this portal is granted to all members of the disaster communications community, it could be the principal Internet-based communication platform following an earthquake.

National Society for Earthquake Technology (NSET)

NSET is an NGO, who has substantial involvement in various aspects of earthquake preparedness in Nepal. Its communication and command center are located in a building supposedly designed to withstand a 9.0 earthquake. In April of 2012, a split-band ultra high frequency (UHF) and very high frequency (VHF) amateur radio repeater was installed in the NSET building, with financing and technical expertise provided by CAN-USA. This system

was used successfully to conduct the first exercise of civilian amateur radio disaster network. This repeater transmits with 50 W of power at 145.000 MHz and has an input frequency of 434.500 MHz. This system is the first amateur radio repeater in the history of Nepal. It provides coverage from Bhaisipati to Nagarkot and is freely accessible to anybody with an amateur radio license.

Mercantile Communications

In a similar way to NTC, Mercantile Communications provides critical telecommunication access to the outside world through very small aperture terminal (VSAT) services. Mercantile provides this to numerous private facilities and Internet providers throughout Nepal. Mercantile has been at the forefront of providing commercial data-protection systems for the private sector in anticipation of a devastating earthquake. Mercantile data center is located in a building that can withstand a 9.0 earthquake. It stores three months supply of diesel fuel to power its generators. There are five different redundant fiber lines connecting to the outside world from this building.

Nepal Research and Education Network (NREN)

NREN has a 45 Mbps connection with the Trans Eurasia Information Network. Twenty network members include government organizations, universities, and research and medical institutions. It has been involved in many successful implementations of telecommunication networks for specialized purposes. NREN is also concerned about the telecommunication needs of a postearthquake Kathmandu and has made its services available in case of disaster. NREN is affiliated with Nethope and Inveneo, both of whom have extensive experience in rapid deployment of telecommunication systems following the Haiti earthquake.

Representatives of Tribhuvan International Airport

Tribhuvan International Airport is likely to be a major hub of relief supply transport into Nepal. The collapse of communications capabilities from the Haiti airport tower presented a challenge to relief efforts from overseas (Potter et al., 2010). Strengthening the tower to withstand a large magnitude earthquake and strengthening its communication capabilities should be key priorities.

Communications Representatives from India and the Indian Government

The Indian government and communication representatives from India will play a pivotal role following the earthquake. They will be able to provide excess satellite bandwidth and desperately needed logistics and communications equipment. Strengthening the relationship with the Indian government with regards to disaster telecommunications must be an important part of the overall process.

6.2.2 Establishment of a Vital Medical Communications Consortium

Communication consortium of medical providers (Hospital Network)

In a postquake Kathmandu, medical providers, hospitals, and medical field clinics must be able to communicate among one another and the outside

world to provide effective and efficient care. Presently a hospital disaster communication network is being planned. Hospital Network can be an important means to develop a medical communication center.

Major hospitals within Kathmandu will play an important role following a devastating earthquake (Vaidya, 2011). Tribhuvan University Teaching Hospital, Shri Birendra Army Hospital, Patan Hospital, Bir Hospital, and the Civil Service Hospital are expected to be the nexus for a robust medical telecommunications network. Other organizations with shared interests in disaster communications may be added as necessary. Once a robust local hospital network is in place, it could be replicated throughout the country.

Amateur Radio Training of Civilian First Responders

Nepal has numerous institutions that could potentially assist in disaster management, including The Nepal Red Cross Society, the trekking community, and the Nepal Scouts (Nepal Scouts 2013). Amateur radio training can be provided to all members who are interested. The MOIC presently conducts qualifying examinations for individuals interested in obtaining amateur radio licenses. The Nepal Amateur Radio League (NARL) has advocated for the advancement of civilian amateur radio in Nepal for decades. Under NARL's advocacy, the number of amateur radio licensees has grown tremendously.

The department of Electronics and Computer Engineering at the IOE of Tribhuvan University has become a focal point of applied amateur radio research in Nepal. The radio frequency and microwave engineering program offered at the IOE provides a solid theoretical foundation for the underlying principles involved in amateur radio. Haiti demonstrated that amateur radio can be a valuable piece of the disaster telecommunication effort (Corley, 2010b). In August of 2012, the USPACOM, IOE, NARL, and NSET collaborated in a successful joint military and civilian high-frequency (HF) link. The contact occurred between Kathmandu and the Changi Naval Base in Singapore during USPACOM's Pacific Endeavor military communications exercise. This was the first time that a civilian/military link took place in a Pacific Endeavor exercise and Nepal was the only country invited to participate (US Pacific Command 2012 and US Pacific Command Youtube video, 2012).

Though ham radio has been a proven technology following disasters, regulatory policies and import procedures can be a substantial barrier to the timely implementation of ham radio disaster-communication networks in Nepal. Ham radio disaster networks demand the use of adequate ultra high frequency (UHF) and very high frequency (VHF) spectrum. The Hospital Disaster Support Communication Systems (HDSCS), a volunteer disaster communication organization in the United States, performs all of its emergency communications on amateur radio frequencies, including simplex and 14 repeaters on the 144, 223, and 440 MHz bands. These frequencies are exclusively in the UHF and VHF spectra (HDSCS, 2013).

Another problem is the restrictive import process for ham radio equipment in Nepal. These challenges pose a significant barrier to the broad adoption of ham radio for disaster communications.

Protocols for Key Stakeholders to Communicate during Emergencies

All previously mentioned and other stakeholders must communicate with each other during an emergency. Each organization will likely have a central communication and command center to manage their own communications. Having an agreed-upon protocol for communication will improve communication efficiency. Each of these organizations will also need access to the outside world, likely through VSAT links. Bandwidth during emergencies is both scarce and expensive. Predefining bandwidth agreements with the Global VSAT forum for each principal stakeholder can be an effective strategy.

All principal stakeholders should be encouraged to meet semi-annually to discuss the evolving issues:

- What are the principal mandates and policies governing each organization immediately following a disaster?
- What is the present capacity of their telecommunication networks?
- What present needs must be met to make their telecommunication systems fully functional?
- Any other relevant topics.

The answers to these questions provided by each organization can be compiled into a single document used by all to assess progress and provide ideas and resources as necessary.

Encourage communication and command centers for each key stakeholder. Each key stakeholder should define where their command and control center will be during an emergency. All centers must know each other's locations as well as be able to communicate with each other through a communication link.

Encourage agreed-on mechanisms for communications between organizations listed above. Each command center must have a clear understanding of the communication capabilities of the other centers, in particular what frequencies each is operating on. Each command center must have access to amateur radio.

Establish means for provisioning prededicated VSAT connections to the outside world. Since communications between Kathmandu and the outside world are likely to be severed in the immediate aftermath of an earthquake, there must be a robust communication link from each command center to the outside world. Many presently existing fiber- and cable-based communications are likely to be damaged due to collapsed physical infrastructure or lack of power.

Establish relationships and agreements with the Global VSAT Forum. Establishing a relationship with the Global VSAT Forum, a private consortium of the VSAT industry, will sensitize the VSAT forum in advance of the acute need for VSAT services in the aftermath of a major earthquake. The details of the bandwidth needed immediately following the earthquake and the costing of the service can be discussed. The Nepal Telecomm Authority and Mercantile are likely to be key players who can discuss prededicated VSAT links with the VSAT forum.

Encourage semi-annual meetings and joint exercises among all stakeholders via the IDCC. Communications are recognized as a vital piece of the overall relief

and recovery efforts. However, the roles, responsibilities, and capabilities of stakeholders are not known to each other. Key communication organizations must have an opportunity to discuss the state of their disaster communication infrastructure with one another.

Disaster assessment and policy development for existing infrastructure. The semi-annual meeting will provide a regular snapshot to all involved of the disaster telecommunication infrastructure and give an opportunity to leverage expertise among the group.

Identification and ruggedization of key mobile cell stations that must remain functioning following disasters. Haiti has shown that a partially functioning cell phone system, or even texting only, can save lives. However, the existing Base Transceiving Stations (BTS) in Nepal are highly vulnerable to structural damage following an earthquake. Structurally retrofitting key mobile telephony central facilities and BTSs that are capable of being retrofitted must be an important task for all involved in mobile telephony. Also, fully ruggedized BTSs should be established in large open areas where people normally would flee during a large earthquake. Any legal impediments that may prevent the identification of vulnerable BTSs must be immediately removed.

Developing contingency and resources to provide cell phone services utilizing automobile-based, scalable base stations. Technologies for providing mobile base stations exist globally. Many disaster-prone nations already have this capability. Mobile telephony providers in Nepal already possess fleets of mobile base stations used to overcome routine communication congestion. Strategies can now be devised for the optimal deployment of these mobile BTSs following the expected earthquakes.

Hospital or Medical Command and Control and Communication Center.

A hospital or medical command-and-control communication center is vital for optimally coordinating the treatment of the injured. It is also vital to convey to the outside world the status of medical supplies at any particular medical location. Tribhuvan University Teaching Hospital, Shree Birendra Army Hospital, Patan Hospital, and the Civil Service Hospital are all expected to survive an 8.0 earthquake. These facilities must be the core of a hospital network that allows for the following:

- Direct communication between each of these hospitals.
- Direct communication to other command centers. .
- Access to VSAT and other means of communication to medical arenas in the outside world.
- Access to amateur radio.
- Direct communication to proposed WiFi based refugee camp network.

Volunteer Responders with Telecommunications Training

It is believed that the community of potential responders does not have adequate disaster telecommunications training. Nepal Scouts have consistently provided services to the community and the trekking community has training in foreign language and first aid skills. These organizations could be far more effective with training in amateur radio.

Ward-level clubs can use amateur radio for socializing and for emergency rescue and relief.

The Radio Frequency and Microwave engineering program at IOE, Tribhuvan University can be an ongoing source of training for volunteer first responders. The curriculum requirements of the course demand that these students obtain their amateur radio broadcasting licenses. The IOE maintains world-class telecommunications capabilities, as recognized by international scientists (Teetzle 2008). It has already demonstrated success in creating nine student generations of engineers familiar with radio frequency and microwave engineering, the technological foundation of amateur radio.

Vital Existing Initiatives Presently under Way

Nepal Military and US Pacific Command's efforts with the MCIP. The Nepal Military's participation within the MCIP is a shining example of excellent disaster telecommunications preparedness efforts that is unfortunately not widely known in civilian circles.

NREN's project to provision networking to pre-designated refugee campsites. The National Research and Education Network has completed a grant proposal for the provision of ruggedized WiFi networks to predesignated refugee camp centers. This will be a robust network that will allow communication between displaced populations, command centers, and the hospital network.

6.2.3 Education, Research, and Development

A partially functioning commercial communication system is preferable to no system at all. Scientific studies should be launched to evaluate the functioning of Nepal's commercial communication infrastructure following a disaster. These studies can then make sound recommendations on the optimal use of any surviving communication systems to providers, policy makers, and the general public.

Much like a road network, a disaster communication network is as effective as the planning used in developing it. Nepal's emerging disaster communication networks should be methodically planned using the latest scientific understanding of disaster communication needs and patterns applied to Nepal's specific circumstances. They must incorporate an understanding of the communication needs of all key players in an integrated fashion. The communication systems of key NGOs must be interoperable with one another. These networks must adhere to the time-tested methods of redundancy in leadership, technologies, and communication facilities. They must also stress routine drills. Studies should be commissioned to propose redundant communication architectures to address Nepal's specific disaster communication needs. These studies should propose specific technical solutions implemented at specific sites used as communication facilities. The studies should also propose a timeline for the complete installation and full operation of these facilities. They should also address the need for a unified disaster communication protocol among all stakeholders, routine drills, and a means for ongoing evaluation and refinement of systems and approaches. Without such an integrated and methodically planned approach, Nepal's

emerging disaster communication systems could be underutilized when they are needed most.

6.3 Medical

The key to reducing the impact of an earthquake on public health is preparedness. Although some progress has been made in this area, clearly the major balance of this important work has yet to be done. It is important to remember the phrase, "Earthquakes don't kill people, buildings do." Therefore, building codes with sound engineering practices are essential to the mitigation of medical disasters.

6.3.1 World Health Organization Benchmarks

The World Health Organization (WHO) has set 12 benchmarks on emergency preparedness through its South East Asian Regional Office in an effort to gauge a country's emergency preparedness and response capacity. Some of these are particularly relevant to earthquake preparedness in Nepal and were critically addressed in the document, "Report on Rapid Assessment of Emergency Preparedness Response in Nepal" (WHO, Nepal Research Council, Jan 2011). The report particularly noted issues with the following benchmarks.

- **Benchmark 2** requires regular update of action plans and standard operating procedures. Although the country developed and adopted a *National Health Sector Emergency Preparedness and Disaster Response* plan in 2003, the follow up *National Health Contingency Plan* is not yet developed, drills and simulation exercises to test plans are not in place, roles and responsibilities for NGOs are not clearly defined, and emergency logistics do not include all sectors.
- **Benchmark 4** requires rules of engagement for external humanitarian agencies based on needs established and following the direction of national authorities. The report notes that Nepal's arrangements with international humanitarian organizations responsible for health care are in place and the health cluster approach is well understood and used. However, memorandums of understanding with relevant partners are not yet signed, private-public partnership in emergencies is still weak, and codes of conduct for international organizations in emergencies are not included in the national policies for Emergency Preparedness Response (EPR).
- **Benchmark 5** requires a community plan for mitigation, preparedness, and response developed and backed by a higher level of capacity. Although there is a mechanism for coordination and cooperation at community levels, established through the cluster approach, community emergency preparedness plans are not developed as envisioned. There is a weak link between the communities and their nearest health facilities, with feeble participation from key stakeholders in cluster meetings.
- **Benchmark 6** requires that community-based response and preparedness capacity are developed and supported with training

and regular simulations and mock drills. The WHO report noted that training for emergency preparedness and response has been conducted at several communities, but that supervision and monitoring of trained personnel are deficient. Drills are not conducted by community health workers and by the community. Basic equipment for volunteers and health workers trained in disaster response is inadequate.

- **Benchmark 7** requires the development of local capacity for emergency provision of essential health services and supplies (shelters, safe drinking water, food, communication). In Nepal, there are warehouses at strategic locations in regions and districts, but suppliers and transporters for warehouse end supplies have not been identified, there is no data base of suppliers and transporters for emergencies, mapping and prepositioning of essential services and supplies are not adequate, and communication equipment and systems for emergency response are lacking.
- **Benchmark 10** requires that human resource capabilities be continuously updated and maintained. Nepal does have capacity building programs for EPR, HOPE, triage, mass-casualty management plans, and a disaster-management orientation. Most key hospitals have initiated at least some form of basic disaster planning. However, training needs assessment is lacking, standards for training courses are not established, training institutions need strengthening, a human resources data base is missing, coordination and cooperation between stakeholders is weak, and better institutional policy support is needed, i.e., clearer allocation of funding and a mechanism for timely release of emergency funds. Not all hospitals have written disaster plans. Not all hospitals have personnel trained in disaster response (HOPE courses). Few hospitals have done disaster drills. There is no enforcement of requirements to conduct regular disaster drills.
- **Benchmark 11** requires that health facilities be built or modified to withstand the forces of expected events. Achievements are that some retrofitting of health facilities has been implemented. Some seismic assessment of health facilities has also been conducted for structural and nonstructural situations. However, implementation of building codes by all sectors is weak, with little rigorous monitoring, and structural and nonstructural mitigation measures are lacking.

6.3.2 Focus on Hospitals

To help mitigate the projected serious damage to hospitals, a plan for retrofitting has been made, partially funded, and is now in the early stages of implementation. The Nepal Risk Reduction Consortium targets $50.8 million for school and hospital earthquake resilience, with $4.6 million committed thus far. Five major public hospitals have been prioritized for structure resilience and emergency preparedness

- Tribhuvan University Teaching Hospital (TUTH) is best prepared. It is estimated that 80% of its buildings would survive an 8.0-magnitude quake. Nonstructural retrofitting is nearing completion, it has a disaster committee, and it conducts regular drills. For disaster water supply, a wide deep-bore well has been completed, with a pump and fuel supplied by OXFAM. WHO has supplied two containers with surgical materials for the disaster in the compound of TUTH. Merlin, UK's leading international charity organization, conducted a mass-casualty incident course and has helped review the disaster plans. US Pacific Command is building an earthquake-resistant blood bank in TUTH. The main national blood bank operated by Nepal Red Cross is located in Bhrikutimandap, Kathmandu, and is the main blood bank supplying various blood components. However, according to a 2007 report, it is called unsafe in a moderate-level earthquake (NSET 2007).
- Shree Birendra Army Hospital received the second highest mark for readiness. It needs to further improve retrofitting, disaster plans, and drills.
- Patan Hospital is in a key location to service the Lalitpur population. The new construction is earthquake safe and it has a disaster plan and drills in place. The old parts of the hospital need retrofitting.
- Civil Service Hospital was recently constructed and does not need structural retrofitting. It is near the airport and on the way to Bhaktapur from Kathmandu. It does need to improve human resources and disaster plans.
- Bir Hospital's new trauma building will be an important part of disaster management, but its old building is felt to be too structurally unsound to undergo retrofitting.

The majority of hospital buildings in the Kathmandu valley are not safe and would be very expensive to retrofit. A full assessment of all hospitals and clinics has not been done. Loss of electricity and water and sewage systems for weeks to months is likely to occur in a major earthquake, thus further crippling services at key hospitals. Furthermore, there is no formal interhospital communication plan for a coordinated sharing of resources in a major emergency.

The Ministry of Health and Population (MOHP) has added two additional hospitals: Kanti Pediatrics Hospital and Maternity Hospital for disaster risk mitigation. The total of seven hospitals being assessed by NSET and TUTH are undergoing nonstructural retrofitting now, which is nearly completed (MOHP 2002; MOHP 2003a,b). Similarly, Civil Service Hospital is also getting nonstructural retrofitting.

As for coordination between hospitals and MOHP, a Health Emergency Operation Center (HEOC) in the compound of MOHP has been proposed. HEOC will be structured like NEOC (National Emergency Operations Center) and it will assist NEOC in case of a major health-related disaster. HEOC will be a coordination and command post for all hospitals. It will also

contain all the data bases of real-time disaster relief activities done in Nepal by various agencies.

6.3.3 The Importance of Public Preparedness

Japan experienced 14 earthquakes of 6.5 magnitude or greater between 1994 and 2011. Fewer than seventy people were killed by all these combined. Even the 9.0 earthquake in 2011 probably killed fewer than a thousand people (although many more died in the Tsunami). Although Japan is wealthier than Nepal and uses far better construction methods, a key to the Japanese survival rate has been a vigorous program of preparedness at the local level.

The Nepal Disaster Risk Reduction Consortium estimates that $28 million is needed for emergency preparedness and response. This includes capacity building for first responders, disaster information, response and management planning, warehousing (stockpiling of food and nonfood items for emergency response), and facilitation of international assistance. Nepal needs to create urban search and rescue teams and light search and rescue teams for basic capabilities for managing trauma and working amidst collapsed buildings and other structures. These should be linked with the disaster operations of the Nepal Army and Armed Police Force. Moves are underway to at least start these tasks. A National Emergency Operations Centre recently opened. NSET has begun prepositioning of emergency rescue stores in 10 locations; the Nepal Red Cross, UNICEF, and the United Nations World Food Programme (WFP) have warehouses to store food and nonfood items at strategic locations; the Institute of Medicine (IOM), Kathmandu, is identifying open spaces for housing of the displaced; and WHO has stockpiled essential medicines and supplies at strategic locations and is planning for stockpiles at hospitals sites. Nepal is, however, a long way from the ideal of training a majority of the public, with frequent drills and individual preparedness.

Although some progress has been made, Nepal still needs to do much to strengthen its capacity to prepare for and respond to a disaster situation. There is an urgent need to endorse the National Disaster Management Act; strengthen multi-sector coordination at the central and district levels; train more health providers in emergency preparedness and response; allocate an adequate budget to regional, district, and local levels; and ensure clear roles, responsibilities, and regulations for external agencies working on health-sector emergency preparedness. There should be a national health contingency plan, an emergency logistics plan, and simulation exercises to test the contingency plans. The public-private partnership must be strengthened with ongoing funding for EPR and higher involvement of private sectors, academic institutions, and others. Surveillance systems for water quality, food safety and security, sanitation, and waste management should be ensured and strengthened. While developing the action plan, it is recommended to do so in connection with priority actions identified by the National Strategy for Disaster Risk Management in Nepal in 2009.

The most important steps are not ones that will require any external funding. Hospitals need to address nonstructural issues such as securing critical equipment and assuring power, water and sewage systems, and communications. Medical staff must be trained in disaster care and regularly drilled in disaster response. Coordinated inter-hospital communications systems must be set up and include an emergency callback system for critical providers, including all physicians. Hospitals should set up transport teams since "human ambulances" will be needed when roads become impassable. Hospitals need to participate and integrate with local community plans. This is the most important part of any disaster plan—all citizens of Nepal should be prepared for an earthquake with aggressive nationwide education at ward-level awareness for earthquake preparedness. By focusing on empowerment and active involvement of the local community, it is hoped that Nepal will approach the gold standard of Japan's earthquake preparedness programs.

To adequately prepare for a major earthquake, Nepal must both improve individual hospital readiness and develop a structure for inter-hospital cooperation. In the long term, nothing except earthquake-resistant construction is adequate. This will require revision and enforcement of building codes and eventual reconstruction or demolition of currently unsafe hospitals. In the interim, all hospitals, both public and private, need to be analyzed for retrofitting. Although true earthquake-proofing will take years and considerable resources, improving earthquake resistance could be done now and at minimal cost. Essentially all facilities can and must review or develop and then enforce a comprehensive disaster plan. Nonstructural retrofitting of patient rooms and high-risk areas, such as operating theaters, can be done now. Restraining expensive, heavy, or fragile equipment alone would mitigate damage in a moderate-sized earthquake. Storage of an adequate amount of critical supplies, equipment, and pharmaceuticals needs to be done in a way that will make them available, even if considerable structural damage occurs. This includes making food, water, and shelter available for patients, staff, and the surrounding community.

A disaster plan has little meaning unless it is known and acted upon. This requires regular education and drills that include all hospital staffs and periodic drills that include the local community. Enforcement will require periodic external review and certification. Communications is a crucial part of this system. All staffs must be able to communicate with a central station and each hospital must be able to communicate with the surrounding community and other facilities.

Coordination between facilities is equally important. Individual hospitals will lose critical infrastructure; patients, supplies, and equipment will need to be shared and transported. Although external international resources will become available eventually, this will take days or even months and will have little direct effect on morbidity and mortality due to the earthquake itself. The medical community in Nepal must be prepared to function alone during the first critical phase of the disaster. Only when this has been done can a coordinated international response be expected.

6.3.4 Education, Research and Development

Academic medical schools should take the lead in directing education and research priorities in disaster preparedness and management for Nepal. Their expertise will help direct policies for the government. Training and education in disaster management should be part of the curriculum of all medical-related fields. To this effect, disaster-management training is already part of the course of study of medical and nursing students in the Institute of Medicine. However, it should be incorporated into all health professional educational institutions. This would include not only clinical areas, but also hospital administration. All medical training programs from nursing to health assistants to physicians should provide exposure to the fundamentals of disaster risk management, preparedness, and response at each level of training, including recertification of licenses.

Recertification of hospital licenses should be contingent on adequate demonstration of meeting the requirements of disaster-preparedness standards set by national and international agencies. An example is the strict standards of the Joint Commission on Accreditation of Hospitals Organization in the United States of America.

The medical schools should give resource and responsibilities to their respective departments of emergency medicine to be leaders in creating emergency medicine residency programs and community emergency medical systems. This would allow tor training of new graduates as well as being a resource for continuing medical education and recertification courses nationally.

The proposed National Institute of Earthquake Research and Development should also have under its direction a medical section that can explore the best methods for training of health workers to prepare and respond to a disaster in the areas of clinical education, hospital administration, communication, emergency medical systems, public health, and policy.

7 Preparedness During an Earthquake Event

Some useful information for preparation during an earthquake is outlined in subsection 1.2. The detailed procedures to follow when inside or outside the house or inside a vehicle are covered, with illustrations, in the list of references (NGED-CRED/UNICEF/NSET, 2011; NSET-Nepal/GHI-USA 2007; TMG / NSET 2006).

The State of California Department of Conservation publication, entitled *What to do in an Earthquake – Be Prepared: Before, During and After an Earthquake*, lists some important points under "How to be prepared During an Earthquake" (CaDC 2012).

Similarly, the United States National Terror Alert Response Center publication, *Earthquake Preparedness – What To Do Before, During and After an Earthquake*, provides additional information to follow during earthquake period (NTARC-USA 2008).

7.1 General Preparedness

The following are general suggestions for preparing for and responding to an earthquake.

- Listen for the siren and the minute-by-minute announcements from the National Earthquake Monitoring Center and the Emergency Communication Center.
- Follow "Emergency Exit Way Plan" provided on the building floor plan, when safe.
- Shut off electrical and gas supply lines to reduce fire hazard.
- Close airports for landings and take-offs until the shaking stops.
- Keep the Emergency Communication Center and the National Earthquake Monitoring Center in full operation.
- Be aware that some earthquakes are actually foreshocks and a larger earthquake might follow. Also, expect aftershocks and maintain alertness.
- Prepare a Jhatpat Jhola or Go to Bag, an emergency bag with essential survival tools to carry in an earthquake. It should contain the following items:
  - Food items with long shelf lives
  - Water purification tablets
  - Emergency lights and solar chargers
  - First-aid kit
  - Blanket

7.2 Location-Specific Preparedness and Precautions

This section describes general rules to follow for specific situations.

If Indoors

- Try to be alert, stay calm, and follow the procedures learned during earthquake drills using the "Duck, Cover, and Hold" rule. Possess an

emergency kit. Get under a sturdy table or desk and hold onto it until the shaking stops. If there isn't a table or desk near you, cover your head with your arms and crouch in an inside corner of the building.

- Stay in bed if you are there when the earthquake strikes. Hold on and protect your head with a pillow, unless you are under a heavy light fixture that could fall. In that case, move to the nearest safe place.
- Stay away from exterior walls, outside doors, glass, windows, heavy furniture, fireplaces, appliances, and anything that could fall, such as lighting fixtures or pieces of furniture.
- Minimize your movements to as few steps as needed to get to a nearby safe place. Stay inside until the shaking stops and it is safe to go outside. Research has shown that most injuries occur when people inside buildings attempt to move to a different location inside the building or try to leave.
- Be aware that the electricity may go out and DO NOT use the elevators.

If Outdoors

- Stay away from buildings, streetlights, walls, trees, narrow streets, power lines, utility wires, and bridges
- Once in the open, stay there until the shaking stops. The greatest danger exists directly outside buildings, at exits, and alongside exterior walls. Ground movement during an earthquake is seldom the direct cause of death or injury. Most earthquake-related casualties result from collapsing walls, flying glass, and falling objects.

If Driving

- Move the car out of traffic, stop, and stay in the vehicle. Avoid stopping near or under buildings, trees, bridges or overpasses, light posts, signs, and power lines and utility wires. When you resume driving, watch out for road hazards.

If in a Mountainous Area

- Beware of the potential for landslides. Likewise, be aware of the danger of flash floods following large earthquakes. Get to high ground when you are near a flooding river and low-lying areas.

If in a Crowded Public Place

- Try not to panic and do not rush for the exit. Stay low and cover your head and neck with your hands and arms.

If Trapped under Debris

- Do not light a match.
- Do not move about or kick up dust.
- Cover your mouth with a handkerchief or clothing.
- Tap on a pipe or wall so rescuers can locate you. Use a whistle if one is available. Shout only as a last resort. Shouting can cause you to inhale dangerous amounts of dust.

7.3 Communications Alert

During disasters the communications infrastructure becomes vulnerable to physical damage and will likely be overwhelmed by a sharp increase in communications traffic. Most mobile phones and land line telephones may not be operable. During such a crisis, the general public should avoid making direct mobile phone calls. They should rather use text messaging, which is a more efficient use of limited communication resources.

During and immediately following massive disasters, communication providers should provide a means of ensuring communications access to first responders and command-and-control centers.

However, further scientific study is required to assess probable communication traffic needs and the optimal use of even partially available resources. Many of these studies exist for other disaster-prone areas of the world. Similar studies should be launched to address Nepal's specific circumstances. These studies can be the basis of comprehensive recommendations for the use of commercially available communication systems both during and immediately following a massive disaster.

7.4 Medical and First Aid

During earthquakes, the simple principle, "Drop, Cover, and Hold On" also applies to medical and health-care staffs to save other lives and reduce the risk of death or injury until the shaking stops.

Hospitals should have policies and procedure in place for earthquake. For example, Muhlenberg Community Hospital, Greenville, KY (Fast Command 2103) has a hospital-wide earthquake plan. According to the procedure, during the earthquake they ask the hospital staff to remain calm, assure patients' safety (do not abandon patients), and do not enter or leave building.

During an earthquake, all medical and health staffs must be able to communicate with a central station and each hospital must be able to communicate with the surrounding community and other facilities. The database of all staffs must be readily accessible for early deployment as and when and where required. Well-coordinated inter-hospital communications systems must be set up and operable at all times and must include an emergency call-back system for all critical providers and all physicians.

8 Post-Earthquake Operations

Major earthquakes overwhelm even the most sophisticated and developed countries. Under the best of circumstances healthcare facilities are unable to completely cope with the enormous increase in casualties during the first few hours to days. The post-earthquake operation will run efficiently if the country is well equipped and prepared with trained personnel, reserved allocation in the annual budget, and the existence of a legal and stand-ready authority for instant execution in rescue and evacuation efforts.

8.1 General Post Earthquake Recommendations

The following are general suggestions/recommendations provided by the Southern California Earthquake Center, U.SA. for consideration after an earthquake event (SCEC 2011):

- First take care of your own situation. Remember your emergency plans. Aftershocks may cause additional damage or items to fall, so get to a safe location. Take your disaster supplies kit.
- If you are trapped by falling items or a collapse, protect your mouth, nose, and eyes from dust. If you are bleeding, put pressure on the wound and elevate the injured part. Signal for help with your emergency whistle, a cell phone, or knock loudly on solid pieces of the building, three times every few minutes. Rescue personnel will be listening for such sounds.
- As soon as you are safe, help others and check for damage. Protect yourself by wearing sturdy shoes and work gloves, to avoid injury from broken glass and debris. Also wear a dust mask and eye protection.
- A common belief is that people always panic and run around madly during and after earthquakes, creating more danger for themselves and others. Actually, research shows that people usually take protective actions and help others both during and after the shaking.
- Keep the following in mind when helping others:
  - Check for injuries.
  - Check your first aid kit or the front pages of your telephone book for detailed instructions on first aid measures.
  - If a person is bleeding, put direct pressure on the wound. Use clean gauze or cloth, if available.
  - If a person is not breathing, administer rescue breathing.
  - If a person has no pulse, begin CPR (cardiopulmonary resuscitation).
  - Do not move seriously injured persons unless they are in immediate danger of further injury.
  - Cover injured persons with blankets or additional clothing to keep them warm.
  - Get medical help for serious injuries.

- Carefully check children or others needing special assistance.

- If your home is structurally unsafe or threatened by a fire or other hazard, you need to evacuate. However, shelters may be overcrowded and initially lack basic services, so do not leave your home just because utilities are out of service or your home and its contents have suffered moderate damage.
- If you evacuate, tell a neighbor and your out-of-area contact where you are going. As soon as possible, set up an alternative mailing address with the post office. Take the following, if possible, when you evacuate:
  - Personal disaster supplies kits
  - Medications and eyewear
  - Supply of water, food, and snacks
  - Blanket/pillow/air mattress or sleeping pad
  - Change of clothing and a jacket
  - Towel and washcloth
  - Diapers, food, and other supplies for infants
  - A few family pictures or other comfort items
  - Personal identification and copies of household and health insurance information

8.2 Rescue, Evacuation, and Care Immediately after the Event

A different team of volunteers, trained personnel, and special equipment will be required to mobilize trapped and injured victims, needing special attention and care, promptly and effectively in the post-earthquake rescue and evacuation efforts. The field inspectors and paramedic volunteers should be able to handle and direct all victims to proper locations for immediate care and attention.

8.2.1 Command Centers, Tools, and Equipment

Rescue and evacuation operations need to be controlled by one or more command centers, depending on the extent of damaged areas and the necessary rescue operations. The command center must be fully equipped with an emergency communication system to deal with post-earthquake operation and management. Additional information for field equipment, safety measures, and the mandated coordination efforts are listed in the City of Long Beach Field Manual (City of Long Beach 1992). The following areas must be considered for an effective rescue and evacuation operation:

Heavy Equipment and Tools

The equipment and tools necessary for emergency rescue and evacuation must be stored in a safe place, designed for natural disaster management and rescue operations, and must be readily available and accessible when needed.

Coordination Efforts

Efficient coordination among the Ministry of Home Affairs, Nepal Army, Nepal Fire Brigade, Nepal Police, the Nepal Red Cross, the city offices, civil society, and general public volunteers is vital for dealing with post-earthquake operations effectively and efficiently.

International Red Cross and Global Volunteers. The local rescue and evacuation teams, the Nepal Red Cross, and other voluntary organizations must be coordinated, with the coordination mechanism and rescue operation system already in place.

Strategic Goal Statement by Ministry of Home Affairs. In this regard, the Ministry of Home Affairs has set up one National Emergency Operation Center and has planned to develop its network by establishing four similar regional centers within the next five years. The network will be further expanded to all district headquarters (MOHA 2011b).

8.2.2 Emergency Communications

To enhance communications among the disaster communication communities during emergencies, the Integrated Disaster Communication Commission (IDCC) will be vital to coordinate the key stakeholders in the disaster communications system in Nepal, to provide critical announcements for immediate needs, help, and support. In addition, the following government and nongovernmental organizations are being equipped with the communication tools and means to deal with post-earthquake operations:

- Nepal Military
- Ministry of Information and Communication
- Nepal Telecommunications Corporation
- UNOCHA/UNICEF/WFP Emergency Telecommunications Cluster
- Nepal Red Cross Society
- Ministry of Home Affairs
- National Society for Earthquake Technology-Nepal (NSET)
- Mercantile Communications
- Nepal Research and Education Network (NREN)

Amateur radio for disaster communications has been recently developed by numerous institutions in Nepal. As noted above, ham radio may be the only functioning telecommunication system available to the civilian population and should be easily accessible to anybody with an amateur radio license. The Hospital Network ham radio system can be a vital communication provider for post disaster operations. In addition, global experience has shown that cell phone systems with texting capabilities have saved many lives after earthquakes.

8.2.3 Emergency Medicine and Care

Although there is a rudimentary referral system in the government hospitals, Merlin, with ECHO (Humanitarian Aid Department of the European Commission) funding, is developing a system of referrals that can

track patients as they move from the health post to higher levels of care, at the same time documenting the visit details. The roster and early deployment supported by Handicap International (also with ECHO funding) contains the data base of all medical staffs of various hospitals living near TUTH. In an earthquake that prevents them from traveling to their respective hospitals, they can be summoned to TUTH to serve. This list will also be available with MOHP to help mobilize medical staffs.

Triage is essential, as minor injuries and routine conditions will get deferred treatment, if any. But the effects of any disaster linger for weeks or even years. The already strained medical infrastructure in Nepal will need to deal with both conditions caused by the earthquake and routine medical conditions ranging from hypertension to pregnancy to heart attacks.

8.3 Infrastructure

One of the primary objectives after an earthquake is to determine whether damaged or potentially damaged buildings and infrastructure are safe for use, or if entry should be restricted or prohibited. This is determined by teams of professionals and field inspectors trained for the post-earthquake inspection and evaluation of buildings and facilities. They will post the buildings and facilities with appropriate placards, such as "Inspected," "Limited Entry," "Secured," and "Unsafe." Posting the building and facilities will let the owner know whether it's safe to use. The field inspectors will also direct victims to proper locations, e.g., emergency medical care facilities, police and army centers, and Red Cross field stations.

8.3.1 Post-Earthquake Safety Evaluation of Buildings

Field Manual

A field manual is required to provide the necessary guidelines and procedures to follow during post-earthquake site conditions. An example is the field manual developed for the City of Long Beach, California, USA, entitled, "Field Manual: Post Earthquake Safety Evaluation of Buildings" (City of Long Beach, 1992). This manual is based on the Applied Technology Council ATC-20 Report (ATC 1991a). ATC-20 provides background on building safety assessment and evaluation methodology. In addition, the companion field manual ATC-20-1 (ATC 1991b) summarizes the ATC-20 methodology in a concise format designed for easy field use. The manual describes building safety evaluation procedures and techniques; inspection and posting of masonry, wood frame, concrete, and steel structures; inspection and posting of geotechnical and non-structural hazards; inspection and safety consideration of essential facilities; after shock consciousness; and how to deal effectively with owners and occupants for quicker inspection and evaluation.

Nepal will have to prepare its own Field Manual, considering local conditions, available resources, and the types of construction materials used in the existing and new construction.

Training

To be fully prepared for the post-earthquake period, regular post disaster safety-assessment evaluator training is essential. This training will provide a comprehensive overview of the safety-assessment program, exercising building-evaluation techniques and methods, assessing the severity of facility and lifeline systems damage, and procedures for posting and barricading the affected areas. Each municipality office needs to conduct such training to the technical and nontechnical staff within their jurisdictions and to volunteers and interested citizens. The professionals, such as engineers, architects, technicians, and building inspectors, will receive a Safety Assessment Program (SAP) volunteer card after successful training. Personnel carrying SAP cards will be permitted to make evaluation and post buildings and facilities in the event of a disaster.

8.3.2 Field Inspections

Field Safety

Many buildings can become so heavily damaged that the danger from building collapse or falling debris can be quite high, particularly if there are strong aftershocks. The field inspectors must be conscious of their own safety and that of their team members at all times. Their safety inspection should include recognition of hazardous materials, types of facilities, possible hazardous material spills, and damaged and broken pipes in older buildings.

Field Equipment

Successful and efficient inspections require the availability of essential equipment. Each field inspector is expected to have certain essential items, including eyeglasses or safety glasses, boots or sturdy shoes, dust masks, safety vests, a first-aid kit, a Swiss army knife, a hard hat, a clipboard with paper and pencils, a flashlight, a tape measure, yellow DO NOT CROSS LINE tape, and communication equipment.

8.3.3 Help Facilities

Temporary Emergency Shelters

The following areas and materials are needed for emergency help and temporary shelters:

- Dedicated existing facilities
- Dedicated open public spaces
- A supply of tents for shelters
- Life-line supplies (water, lights, sanitary facilities, food, blankets, etc.)
- Transportation, and temporary parking areas
- A security system.

The Disaster Management Section of the Ministry of Home Affairs stated in its report (MOHA 2011b) that a network of warehouses will be developed throughout the country for food and nonfood items. In addition, the existing warehouses belonging to the Nepal Food Corporation, the Nepal Red Cross Society, and the private sector would be strengthened, and further networks

would be developed so that there will be at least one such warehouse in all of the 75 districts of the country within five years.

Volunteers to Manage and Administer Temporary Shelters and Facilities

Efficient coordination must be maintained among all private and public stakeholders, such as government agencies and organizations, Red Cross Field Stations, and international volunteers and donor agencies.

8.4 Communications

Telecommunication services must be provided to refugee camps and temporary shelters. Nepal Research and Education Network (NREN) is working with Inveneo and Nethope, two veteran organizations of the Haiti earthquake, in investigating WiFi-based networks, as well as highly expensive VSAT and broadband global area network connectivity on an as needed basis. Amateur radio for disaster communication has been recently championed by numerous institutions, including CAN-USA. Ham radio may be the only functioning telecommunications capability broadly available to the civilian population for months. The Hospital Network ham radio system, if developed on time, can be a means for civilian communication post-disaster. The frequency details of existing ham radio repeaters must be provided to all international first responders prior to entry into Nepal to maximize a smooth integration with existing local ham radio networks. Details of any local disaster communication protocols must also be provided to international first responders.

8.5 Medical

Nepal has very limited prehospital transport and care capacity, but even the most sophisticated prehospital care systems find themselves overwhelmed in a major earthquake. The experience from major earthquakes in the USA, Chile, New Zealand, and Japan reveal that most of the initially injured will arrive at hospitals by private means. However, many of the most severely injured will be trapped in structures or incapacitated by major trauma. Few of these patients require sophisticated transport but many do need extrication and emergency care for dehydration and crush injuries. The Nepal Army and Police will be crucial resources during the first 72 hours for search and rescue as well as subsequent patient transport.

The second phase of the disaster will involve fewer but more complex patients with a mixture of ongoing trauma, complications from injuries suffered initially, such as infections and fractures, and patients with chronic conditions made worse by loss of medications and environmental stressors.

The third phase will involve illnesses made worse or caused by environmental factors. It may take months or even years to move all citizens out of temporary structures and provide adequate sewage and clean water. All infectious diseases will become more common among people living in close quarters and epidemics of enteric pathogens, such as dysentery, typhoid, and cholera, are serious risks. During this phase, rehabilitation and mental health needs will require major resources.

The above problems will need to be dealt with by a medical system that itself will have suffered serious losses of personnel, equipment, and facilities. Routine care will still be needed and will in many cases increase—women will continue to deliver and diabetics who are unable to obtain insulin will need aggressive treatment. Besides medical care *per se*, public health will require additional resources not only to rebuild sanitation but also to vaccinate people before they become ill.

Disasters bring out the best in people. Local survivors help their neighbors and NGOs and individual volunteers from around the world want to come to help immediately. It is crucial that a structure be in place in advance to limit and manage these people. The experience in Haiti, in particular, showed that although foreign medical and support personnel were critical during all three phases of the disaster, coordinating responses, supporting personnel, and managing inappropriate equipment, medications, and supplies were a major drain on local resources. Managing outside resources is a surprising difficult task. Incoming providers must be vetted and authorized to practice. Arrangements must be made to house and feed them. Equipment must be sorted, distributed, and tracked. Running an operating theater is difficult even when it is not set up in a tent without electricity or running water. Medical needs change radically during the three phases. The first weeks have an enormous increased need for orthopedics, anesthesiology, general surgery, and an entire surgical support infrastructure. After this there is a major need for general practice, psychiatry, and public health. Baseline needs continue, injuries continue to occur during rebuilding, and epidemics may require a rapid increase in acute care capabilities. Management of medical care and public health must be proactive and robust.

Two new initiatives are referral system by Merlin and voluntary early deployment of medical personnel and rooster management by Handicap International. The referral system will be national so that patients will not get lost and the next center will know what was done. Similarly, a data base of all the medical staffs are being collected in the Kathmandu valley now and later outside for early deployment of these staff as and where required.

9 Summary, Conclusions, and Recommendations

Section 9.1 summarizes the findings of this paper related to engineering, infrastructure, medical, public health, and the communications network. Conclusions and recommendations are provided separately for infrastructure, medical, and communications in section 9.2.

9.1 Summary

The various available reports and studies predict that Nepal could face catastrophic loss of human life and destruction of property in a major earthquake. Earthquakes are common in Nepal and major ones occur about every 75 years. The recent October 14, 2011 Eastern-Nepal earthquake, of magnitude 6.8, has reinforced the fact that if a large earthquake, similar to the 1934 Bihar (India)-Nepal earthquake, occurs near the Kathmandu Valley, the amount of destruction would be almost unimaginable.

In recent years, Nepal has witnessed a rapid growth in urban population in the Kathmandu Valley. Modern high-rise apartment housing is being developed rapidly in the valley. According to the Kantipur TV news in May 2014, Nepal Government has now added 72 new city municipalities, thereby making a total of 130 city municipalities in the country. Full infrastructure development, such as roads, buildings, bridges, electrical transmission and communication towers, water and sewage systems, and other facility support, as demanded by the rapid growth in the housing sector and commercial development at present and in future must be pre-planned and well-coordinated among various authorities concerned to maintain the balanced growth and harmony in major cities.

The current National Building Code of Nepal cannot fully cover such modern infrastructure developments, including the high-rise constructions. This position paper document suggests formulation of a series of the family of codes and standards, including upgrade of the current building code, planning and zoning code, as well as to formulate and implement a new seismic-retrofitting code immediately, to strengthen the existing building and non-building structures, especially in the Kathmandu valley, to minimize damage from future earthquakes. In addition, the building codes must mandate the construction norms and standards suitable to the local climate, geological and geographical conditions of a very high and cold mountainous region to the hot and humid plain area (Terai) of the country. This is at a high priority as well as a big challenge to all concerned stakeholders involved in the task of earthquake preparedness.

The recent WHO/NSET study found that in the Kathmandu Valley 80% of hospitals was unprepared for a major earthquake and 20% were at risk of collapse. Loss of hospital capability will have a devastating impact on post-earthquake care. In addition, healthcare providers will be directly affected. Haiti lost 10% of its medical staff to death or migration. The losses were greatest for hospital-based physicians, who are more likely to be killed and less likely to be able to function without a working hospital.

Many national benchmarks on emergency preparedness set by the World Health Organization are in their infancy stages or completely lacking in Nepal. Hospital and community-based mass-casualty disaster planning and drills are deficient or nonexistent. A national health contingency plan is not developed and manpower training of disaster rescue personnel needs to be augmented. Despite the enormous task of disaster preparedness in this resource-poor country, there is now greater awareness among the key players and in the general population, as evidenced by greater media coverage and by the efforts of organizations such as the Nepal Disaster Risk Consortium in focusing on financial support for key priority areas.

Telecommunications will be a vital component of Nepal's response to an earthquake. Numerous agencies and organizations have independent command-and-control centers designated for post-quake operations, but it is not clear whether these centers would be able to communicate with each other. Several other initiatives, such as amateur radio for first responders and the hospital network are necessary but have not been fully developed. Mobile telephone technology has transformed Kathmandu's telecommunication capabilities, but it has also left Kathmandu vulnerable for new challenges. Cellular phone service providers must take steps to ruggedize existing towers and prepare specific plans to respond to the quake with compact and mobile base station technologies. These phone service providers must also be supported and enforced by regulation.

The Nepal Military has been at the forefront of disaster telecommunications preparedness issues via the MCIP program. The NTA has also taken important steps to develop solutions to the vulnerability of the mobile base transceiver system.

The national health contingency plan is not yet developed. The training of disaster rescue personnel needs to be augmented. Disaster telecommunications preparedness is very different from other preparedness efforts in that the technologies necessary for disaster telecommunications already exist in numerous forms. The scalability and flexibility of these technologies allow them to be pre-deployed and existing technologies to be modified or ruggedized so that they can be prepared for disaster. Having disaster communications capabilities will allow Kathmandu and Nepal to respond swiftly and efficiently following an earthquake.

9.2 Conclusions and Recommendations

9.2.1 Infrastructure

Several general recommendations and suggestions related to infrastructure are outlined in various sections within this position paper. However, a concrete plan of action with reasonable time frame for action items must be carried out without going through routine governmental procedures. It is suggested that Nepal form a high-powered National Earthquake Preparedness and Disaster Relief Center and a National Building Code Council to oversee all areas related to earthquake preparedness and the associated hazard mitigation and rescue operations in the country. There is

an urgent need to establish a Nepal Code Council as stated in "Recommendations for Update of Nepal National Building Code" (MPPW-GON 2009). Comprehensive national guidelines for the seismic design and retrofitting of transportation and utility structures must be developed and implemented. In addition, the bodies discussed above must be established and fully equipped with the tools necessary to deal with a large magnitude earthquake. This will help save a large number of lives, minimize injuries, and prevent damage to property and essential infrastructure.

Hazards related to earthquake are not only limited to the shaking of and damage to the structures, but also are caused from several associated factors, including but not limited to fires, explosions, and electrical short circuiting. Normally, the rescue efforts will be hampered by other constraints, such as shortage of water, the loss of electrical power, and inadequate infrastructure development. In addition, the absence of the essential mechanism to ensure that construction plans and design specifications are fully reviewed, approved, and coordinated by the appropriate authorities in full compliance of the building codes prior to issuance of the final completion and occupancy certificates, might be the cause for the dramatic growth of the existing low- to high-rise construction in the Kathmandu Valley in recent years, thereby imposing further earthquake hazards. Therefore, a moratorium may be necessary to restrict such unplanned construction to grow further until the upgraded building bylaws, codes, and regulations and a full mechanism for ensuring adherence to the building codes and standards are in place. This can be an immediate temporary solution to deter the earthquake-induced hazards from increasing in the densely populated city.

Fundamentally, incentive programs and enactment (and enforcement) of the necessary laws and regulations are needed. These will empower the city municipalities and village development centers throughout the country in proper and timely enforcement of the construction regulations, norms, and standards. This would help protect citizens' lives and properties from earthquake damage. In addition, regular training programs are needed to enforce construction regulations nationwide.

9.2.2 Medical and Public Health

It is recommended that an immediate concerted effort, complemented by a grass-roots community-level campaign for preparedness, modeled after countries like Japan, be implemented to avert the tragedy that otherwise awaits Nepal. There is an urgent necessity to train emergency rescue personnel as well as emergency health workers, doctors, public health professionals, and volunteers. Equally important is making the essential logistics items and equipment available, including ambulances, temporary medical treatment facilities, medical supplies, temporary health camps and facilities, and portable emergency communication systems. Nepal's many professional medical societies should take leading roles in their respective specialties for disaster planning and management. In addition to coordination of various governmental and nongovernmental agencies, a

strong public-private partnership with the Nepali business community needs to be established to engage and empower local stakeholders.

9.2.3 Communications

There are multiple NGOs and organizations dedicated to disaster telecommunication but their mandates and capabilities still need to be fully coordinated. Semi-annual meetings for the disaster telecommunication community via the Integrated Disaster Communications Consortium should be used to share the status and changes in their respective mandates, technical capabilities, and shortcomings. Due to the unique flexibility of telecommunication technologies, robust disaster telecommunication systems and strategies can be implemented in Nepal relatively swiftly. Significant developments have taken place only in recent months.

Though much of Nepal's commercial communications infrastructure is expected to be nonfunctional following a devastating earthquake, it is possible that partial communication networks may still be functional. Scientific studies should be launched to assess the likely communications landscape for Nepal immediately following a massive disaster, based on partially surviving commercial communication networks. The goal of these studies should be to make scientifically sound recommendations on how to communicate utilizing a partial commercial communication system following a massive disaster.

Operation of the emergency and mass communication systems, and command centers in order to keep immediate contact with the local, national, and international help and rescue teams are vital for effective emergency operations. Nepal's disaster communications systems are gradually increasing and evolving. Studies must be commissioned to ensure that the growth of these systems occurs in an optimally planned way to benefit all disaster communication stakeholders. Among the issues these studies must address are redundancy, interoperability, scalability, operating communication protocols, timelines for implementation, and an ongoing means of effectiveness in assessment and refinement of systems and practices.

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Appendix A – Abbreviations

The following abbreviations are used in this document.

ADPC	Asian Disaster Preparedness Center
AIN	Association of International Non-governmental Organizations
ANA	Association of the Nepalis in the Americas
ANMA	Association of Nepalese in Midwest America
ANMF	America Nepal Medical Foundation
ARC	American Red Cross
ASN	Association of International Non-Governmental Organizations
ASNEngr	American Society of Nepalese Engineers
ATC	Applied Technology Council
AUDMP	Asian Urban Disaster Mitigation Program
BTS	Base Transceiver System
CaDC	California Department of Conservation
CAN	Computer Association of Nepal
CAN-USA	Computer Association of Nepal – USA
CARD	Center for Applied Research and Development, IOE, Pulchowk
CBSC	California Building Standards Commission
CoRD	Centre of Resilient Development
DFID	Department for International Development
DOBDMA	Disaster Management Act
DPNet-Nepal	Disaster Preparedness Network – Nepal
DPSS	Disaster Preparedness for Safer School in Nepal
DRR	Disaster Reduction and Recovery
DUDBC	Department of Urban Development and Building Construction
ECHO	European Commission Humanitarian Aid Office
EERI	Earthquake Engineering Research Institute
EHP	Earthquake Hazard Program
EMI	Earthquakes and Megacities Initiative
EPR	Emergency Preparedness Response
ESD	Earthquake Safety Day
ESD NatCom	Earthquake Safety Day National Committee
FAR	Floor Area Ratio
GFDRR	World Bank Global Facility for Disaster Reduction and Recovery
GHI	Geo-Hazards International
GON	Government of Nepal
HDSCS	Hospital Disaster Support Communication Systems
HEOC	Health Emergency Operation Center
HOPE	Hospital Preparedness for Earthquakes
IBC	International Building Code
ICC	International Code Council
IDCC	Integrated Disaster Communication Center
IDNDR	International Decade for Natural Disaster Reduction
IFRC	International Federation of Red Cross
INGO	International Non-governmental Organization
IOE	Institute of Engineering, Nepal
IOM	Institute of Medicines, Nepal
ISI	Indian Standards Institution
JICA	Japan International Cooperation Agency
KMCDC	Kathmandu Metropolitan City Division of Construction
LSAR	Light Search and Rescue

MCIP	Multinational Communication International Program
MHPP	Ministry of Housing and Physical Planning
MHT	Main Himalyan Thurst
MM	Modified Mercalli
MMI	Modified Mercalli Intensity
MOHA	Ministry of Home Affairs
MOHP	Ministry of Health and Population
MOIC	Ministry of Information and Communication
NARL	Nepal Amateur Radio League
NASeA	Nepalese Association in Southeast America
NAST	Nepal Academy of Science and Technology
NBC	National Building Code
NEOC	National Emergency Operations Center
NGO	Non-Governmental Organization
NGED-CRED	Nepal Government Education Department-Central Regional Education Division
NGMOH	Nepal Government Ministry Of Health
NRCS	Nepal Red Cross Society
NREN	Nepal Research and Education Network
NRN	Non-Resident Nepali
NRN-NCC	Non-Resident Nepali National Coordination Council USA
NRRC	Nepal Risk Reduction Consortium
NSDRM	National Strategy for Disaster Risk Management
NSET	National Society for Earthquake Technology-Nepal
NTA	Nepal Telecommunications Authority
NTC	Nepal Telecommunications Corporation
OFDA	Office of Foreign Disaster Assistance
OXFAM	An International Business group of 13 global organizations to deploy people & resources in areas of natural disasters and conflicts.
P.E.	Professional Engineer
PEER	Program for Enhancement of Emergency Response
PGA	Peak Ground Acceleration
RCC	Reinforced Cement Concrete
RECAST	Research Center for Applied Science and Technology
RoW	Right-of-Way
SAP	Safety Assessment Program
SEDM	Study on Earthquake Disaster Mitigation in the Kathmandu valley
TMG	Tokyo Metropolitan Government
TUTH	Tribhuvan University Teaching Hospital
UHF	Ultra High Frequency
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational and Scientific Organizations
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNOCHA/UNICEF/WFP	United Nations Office for the Coordination of Humanitarian Affairs World Food Program
US	United States

USA	United States of America
USAID	United States Agency for International Development
USAR	Urban Search and Rescue
USGS	United States Geological Survey
USPACOM	United States Pacific Command
VDC	Village Development Center
VDO	Village Development Office
VHF	Very High Frequency
VSAT	Very Small Aperture Terminal
WFP	United Nations World Food Programme
WHO	World Health Organization

Appendix B – Launching Document

The following is the document that launched the ANMF/ASNEngr/CAN-USA Initiative on Earthquake Preparedness and Disaster Relief in Nepal (March 31, 2010)

March 31, 2010

ANMF/ASNEngr/CAN-USA Joint Initiative to Prepare a Position Paper on Earthquake Preparedness and Disaster Relief for Nepal

The devastation that struck Haiti in January 2010 highlights the horrific consequences of a major earthquake on a developing nation, especially one with limited resources, inadequate planning, and dense population centers. Nepal lies in one of the most seismically active regions in the world. Approximately every 75 years, Kathmandu is impacted by an earthquake of magnitude 8.0. A strong scale earthquake is due to strike Nepal anytime.

The destruction witnessed in the densely populated Haiti's capital city of Port- au- Prince is likely to occur in Kathmandu. The areas of infrastructure (building, bridges, roads, water supply, etc.), transportation systems, telecommunication networks, medical and other essential services could be quickly overwhelmed. Kathmandu, therefore, requires unprecedented preparedness to endure the burden of widespread structural destruction and mass casualties resulting from an earthquake. Being a land locked country with a single and small-sized international airport, Nepal will likely suffer greater human casualties than Haiti. Geohazards International, a nonprofit organization that assess earthquake hazards, currently ranks Kathmandu at the highest risk for fatalities than any other city in the world.

An in-depth review and analysis of various relief efforts undertaken in response to past earthquake disasters worldwide can provide valuable lessons in identifying areas of strength as well as areas for further improvement in Nepal's disaster preparations. The Nepali diaspora, having broad expertise and a sincere concern for Nepal, is in a position to provide expert advice and relevant resources to aid Nepal in disaster preparedness. By collaborating with concerned authorities in Nepal on targeted preparation efforts, the Nepali diaspora can have a meaningful impact in saving lives and properties in such disasters.

This initiative, jointly led by the America Nepal Medical Foundation (ANMF), the American Society of Nepalese Engineers (ASNEngr), and the Computer Association of Nepal-USA (CAN-USA), will serve as a basis for a general strategy to investigate areas needing improvement in Nepal's earthquake preparedness and to identify interested and willing local partners to assist in implementing targeted solutions. The document will encompass following broad and critical principal areas:

I. Various infrastructure systems safety and resilience (Engineering, analysis, design, construction, and maintenance)
II. Telecommunication robustness including disaster telecommunication networks
III. Medical preparedness
IV. Short and long term relief operations

To achieve the above goals, a committee will be formed with membership from the lead organizations (ASNEngr, CAN-USA, and ANMF), supporting organizations listed below and others joining in the future including concerned organizations in Nepal such as government and non- governmental agencies, professional engineering, medical and scientific organizations; academic institutions and private industry. The committee will also examine past and present efforts and propose specific mechanisms by which the broader Nepali diaspora may efficiently respond in the event of an earthquake disaster in Nepal, including but not limited to the following specific areas:

- Pre- and post- event establishing relationships with key rescue and relief organizations
- Pre- and post- event establishing information sharing networks amongst diaspora
- Optimal routing to Nepal of critical individuals, information, and resources
- Pre-and post- identifying organizations having emergency funds targeting Nepal
- Pre- and post- event identifying means for reliably sending donations
- Media relations and public safety awareness program

The committee is expected to present a preliminary report within 6 months. It shall then continue on its broader mission of preparing a comprehensive "position paper" in the subject area of earthquake disaster relief and preparedness in Nepal with target date of task completion within 2 years. It is envisioned that this joint initiative will

support and enhance any other past or present efforts in this topic and contribute to pave way for new incentives in this area in the future.

Lead Organizations *(List in alphabetical order by organizations' names):*
The following are signatories representing the lead organizations to launch this joint endeavor:



Sunil Sharma, M.D.
President, America-Nepal Medical Foundation (ANMF)
www.ANMF.net

Ramesh B. Malla, Ph.D.
President, American Society of Nepalese Engineers (ASNEngr)
www.ASNEngr.org

Bineet Sharma
President, Computer Association of Nepal-U.S.A (CAN-USA)
www.CAN-USA.org

Supporting Organizations *(List in alphabetical order by organizations' names)*:
The supporting organizations of the initiative include the following:

National/Regional Level


Simon Dhungana
President, Association of Nepalis in Americas (ANA)
www.anaonline.org

Mukesh Singh
President, Association of Nepalese in Mid-West America (ANMA)
www.anmausa.org


Tek Thapa
President, Nepalese Association in Southeast America (NASeA)
www.naseaonline.org

Suman Timsina
President, Non-Resident Nepali National Coordination Council (NRN-NCC) of USA
www.nrnusa.org

Local Level:
America-Nepal Friendship Society, Inc., New York (President: Mona Belbase) www.anfsusa.org
America-Nepal Society of California, Inc. (President: Arjun Tripathi) www.ansca.org
Baltimore Association of Nepalese in America (President: Rabina Thapa) www.banaonline.org
Chicago Nepali Friendship Society (President: Lomash Shrestha) www.cnfsociety.org
Friends of Nepal-Los Angeles (President: Shambhu Dhungana, Ph.D.) www.fon-la.org
Friends of Nepal-New Jersey (President: Ananta Risal) www.fonnj.org
Greater Boston Nepali Community (President: Utsav Gurung) www.gbnc.org
Nepal Center of North Carolina (President: Arun Dhital) www.ncnepal.org
Nepalese Association of Houston (President: Rajendra K. Shrestha, Ph.D.) www.houstonnepalese.org
Nepalese Society Texas (President: Prem Adhikari, Ph.D.) www.nepalesesociety.org
Nepali Association of Oregon (President: Kush Shrestha) www.nepaloregon.org
Rocky Mountain Friends of Nepal (President: Neelam Shrestha) www.rmfn.org

(More to be added as they become available)

Appendix C – Committee Members and Invited Guests

Joint ASNEngr/ANMF/CAN-USA Initiative on Earthquake Preparedness and Disaster Relief in Nepal

The following are the full memberships of the Steering Committee, Editorial Board of the Position paper, the full Committee, and invited guests of the Joint ASNEngr/ANMF/CAN-USA Initiative on Earthquake Preparedness and Disaster Relief in Nepal.

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Organizations/Institutions in Nepal

Amod Mani Dixit, Dr. Eng., National Society for Earthquake Technology-Nepal (NSET), Kathmandu, Nepal (*Steering Committee*)

Sanjeeb P. Panday, Ph.D., Institute of Engineering (IOE),Pulchowk Campus, Tribhuvan University, Lalitpur, Nepal

Jishnu Subedi, Ph.D., Centre of Resilient Development (CoRD), Kathmandu, Nepal (Formerly, Institute of Engineering (IOE), Pulchowk Campus, Tribhuvan University, Lalitpur, Nepal) (*Steering Committee*)

Pradeep Vaidya, MBBS, Ph.D., Tribhuvan University Teaching Hospital (TUTH), Institute of Medicine (IOM), Tribhuvan University /Hospital Preparedness for Emergency (HOPE); Kathmandu, Nepal (*Steering Committee*)

Invited Guests

Lt Col. Prakash Acharya, Nepal Army, Kathmandu, Nepal

Prakash C. Adhikari, Ph.D., Tribhuvan University, Kathmandu, Nepal (Formerly, Nepal Academy of Science and Technology (NAST), Khumaltar, Lalitpur, Nepal)

Raju Adhikari, Ph.D., CSIRO Manufacturing Flagship, Clayton, Victoria, Australia; RMIT University, Melbourne, Victoria , Australia; and SKI Committee/Nepal Science Foundation Trust & Open University-Nepal, Non-Resident Nepali Association – International Coordination Council (NRNA-ICC), Melbourne, Australia

Jerome Aumente, Rutgers, the State University of New Jersey, New Brunswick, New Jersey, U.S.A.

Meen Bahadur Poudyal Chhetri, Post Doctorate, , Nepal Center for Disaster Management (NCDM), Kathmandu, Nepal (Formerly, Disaster Preparedness Network Nepal (DPNET), Kathmandu, Nepal_)

Himal Kiran Bhusal, United Nations Development Programme (UNDP), Kathmandu, Nepal

Binod Dhakal, Computer Association of Nepal (CAN), Kathmandu, Nepal.

Pramod Dhakal, Ph.D., Open University Nepal/SKI Committee, Non-Resident Nepali Association - International Coordination Council (NRNA-ICC), Kathmandu, Nepal

Umesh Dhakal, International Federation of Red Cross and Red Crescent (IFRC) Southeast Asia Regional Delegation, Bangkok, Thailand (Formerly, Nepal Red Cross Society, Kathmandu, Nepal **)**

Saroj Dhital, M.D., Kathmandu Model Hospital, Public Health Concern Trust, Kathmandu, Nepal

Simon Dhungana, Association of Nepalis in the Americas (ANA), U.S.A.
Kiran Gautam, Kathmandu, Nepal
Dhruba Ghimire, MA, MBA, World Vision, Lalitpur, Nepal
Mani Jung Hamal, Armed Police Force (APF), Kathmandu, Nepal
Ram Chandra Kandel, M.E., Ministry of Transportation, Downsview, Toronto, ON, Canada
Suresh Karna, Kumari Bank Limited, Kathmandu, Nepal (Formerly, Computer Association of Nepal (CAN), Kathmandu, Nepal)
Doj Raj Khanal, Ph.D., Animal Health Research Division, Nepal Agricultural Research Council, Kathmandu, Nepal
Bhagwan Koirala, M.D., Tribhuvan University Teaching Hospital, Kathmandu, Nepal and America Nepal Medical Foundation – Nepal (ANMF-Nepal), Kathmandu, Nepal
Lubha Raj Neupane, Disaster Preparedness Network Nepal (DPNET), Kalimati, Kathmandu, Nepal.
Bharat R. Pahari, Ph.D., Institute of Engineering (IOE), Pulchowk Campus, Lalitpur, Nepal
Prativa Pandey, M.D., Travel Medicine Center, CIWEC Clinic, Kathmandu, Nepal; and America Nepal Medical Foundation – Nepal (ANMF-Nepal), Kathmandu, Nepal
Kishor Panth, Sastra Network Solution, Inc., Kathmandu, Nepal
Toff Peabody, M.D., Beth Israel Deaconess Medical Center, Boston, MA, U.S.A.
Prabhas Pokharel, Open Technology Resource Center (OTRC) Kathmandu, Nepal
Bhagat Pradhan, Nepal Engineers' Association (NEA), Kathmandu, Nepal
Drona P. Rasali, DVM, Ph.D, British Columbia Provincial Health Services Authority, Vancouver, BC, Canada/University of Regina, Saskatchewan, Canada/ (SKI Committee & Open University-Nepal, Non-Resident Nepali Association – International Coordination Council (NRNA-ICC))
Shyam S. Ranjitkar, Ph.D., Kathmandu, Nepal (Formerly, World Bank, Kathmandu, Nepal)
Rishi Shah, M.E. Nepal Academy of Science and Technology (NAST), Khumaltar, Lalitpur, Nepal
Shekhar Shah, Kathmandu, Nepal (Formerly, Nepal Academy of Science and Technology (NAST), Khumaltar, Lalitpur, Nepal)
Mukesh Sigh, Association of Nepalese in Midwest America (ANMA), U.S.A.
Shaligram Singh, Nepal Engineering Council (NAC), Kathmandu, Nepal
Egendra Kumar Shrestha, Dr. Vet., Nepal Polytechnic Institute Ltd., Bharatpur, Chitwan, Nepal
Rebati Man Shrestha, Dr.Vet., Department of Livestock Services, Government of Nepal, Hariharbhawan, Lalitpur, Nepal

Hariom Prasad Srivastav, Nepal Engineers' Association (NEA), Kathmandu, Nepal

Dhruba Raj Thapa, M.Sc., Nepal Engineers' Association (NEA), Kathmandu, Nepal

Tek Thapa, Nepalese Association of Southeastern America (NASeA), U.S.A.

Timila Yami Thapa, Institute of Engineering (IOE), Pulchowk Campus, Lalitpur, Nepal

Suman Timsina, Non-Resident Nepali National Coordination Council (NRN NCC), U.S.A

Bhawana Upadhyay, M.Sc. Eng, UN WFP-Nepal, Kathmandu, Nepal

Appendix D – Supporting Organizations

Joint ASNEngr/ANMF/CAN-USA Initiative on Earthquake Preparedness and Disaster Relief in Nepal

Lead Organizations

American Society of Nepalese Engineers (ASNEngr), www.ASNEngr.org

America Nepal Medical Foundation (ANMF), www.americanepalmedicalfoundation.com

Computer Association of Nepal–USA (CAN-USA), www.CAN-USA.org

Supporting Organizations from USA

Embassy of Nepal to the United States of America, Washington, D.C., U.S.A., www.nepalembassyusa.org

Non-Resident Nepali National Coordination Council (NRN-NCC) of USA, nrnnccusa.org

Association of the Nepalis in the Americas (ANA), www.anaonline.org

Association of Nepalese in Mid-West America (ANMA), www.anmausa.org/anma

Nepalese Association in Southeast America (NASeA)

America-Nepal Friendship Society, Inc., New York, www.anfsusa.org

America-Nepal Society of California, Inc., Torrance CA, www.ansca.org

Baltimore Association of Nepalese in America (BANA), Baltimore, MD, www.banaonline.org

Chicago Nepali Friendship Society, Chicago, IL, www.cnfsociety.org

Friends of Nepal-Los Angeles, Los Angeles, CA, www.fon-la.org, fon-la.org/wp

Friends of Nepal-New Jersey, Somerville NJ, www.fonnj.org

Greater Boston Nepali Community, Boston, MA, www.gbnc.org

Nepal Center of North Carolina; Morrisville NC, www.ncnepal.org

Nepalese Association of Houston, Houston, TX, www.houstonnepalese.org

Nepalese Society Texas, Irving, TX, www.nepalesesociety.org

Nepali Association of Oregon, Portland OR, www.nepaloregon.org

Nepal America Ekata Samaj, Artesia, CA, ekatasamaj.org

Nepalis and Friends Arizona – NAFA, Tucson, AZ, www.nafausa.org

Nepalis and Friends Cultural Association (NAFCA), Davis, CA, www.nafcaonline.org

Rocky Mountain Friends of Nepal, Boulder, Colorado, www.rmfn.org

Shree Pashupatinath Foundation, USA, Norwalk, CA, www.pashupatinathfoundation.org

West America Nepali Association (WANA), Los Angeles, CA, wanaonline.homestead.com

Supporting Organizations from Nepal

Institute of Engineering (IOE), Pulchowk, Lalitpur, Nepal, www.ioe.edu.np

Institute of Medicine (IOM), Kathmandu, Nepal, www.iom.edu.np

National Society for Earthquake Technology-Nepal (NSET), Kathmandu, Nepal, www.nset.org.np

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Nepal is one of the world's most earthquake-prone countries. It has experienced severe earthquakes in the past that have caused major loss of lives and infrastructure. Recently, the Nepal Government, public and private enterprises and international agencies have become concerned with improving the country's earthquake resiliency. Schools and hospitals are being seismically retrofitted, and there are plans to implement the National Building Code in all major cities. However, much still needs to be accomplished to make Nepal's existing infrastructure, communication networks, and medical sector well prepared for a major earthquake event like the devastating Bihar (India) – Nepal Earthquake of 1934.

On March 31, 2010, under the auspices of the three leading Nepali diaspora professional organizations in the United States of America (USA) - the American Society of Nepalese Engineers (ASNEngr), America Nepal Medical Foundation (ANMF), and Computer Association of Nepal-USA (CAN-USA) – a joint initiative on Earthquake Preparedness and Disaster Relief in Nepal was launched to help Nepal in its efforts to address the above mentioned challenges. This position paper is prepared by the aforementioned ASNEngr/ANMF/CAN-USA Joint Initiative in close coordination with local professional counterparts in Nepal. This initiative is the first of its kind, initiated by the Nepali diaspora professionals in North America.

This *Earthquake Preparedness and Disaster Relief in Nepal – A Position Paper* document outlines the challenges that Nepal could face if and when another large magnitude earthquake strikes, and presents technical information on the earthquake preparedness, mitigation, training and rescue operations that will be needed before, during, and after a major earthquake. This document has been reviewed by experts and professionals with state-of-the-art knowledge of the science and technology of disaster preparedness, including first-hand experience dealing with earthquakes and other disasters.

The suggestions and recommendations in this document are divided into the three main areas of concern in earthquake mitigation: Engineering, Communication and Medical/Public health. We sincerely hope that this information will help Nepal to prepare and minimize the effects of future earthquakes.

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'Together we CAN Develop'