GeoHazards International

November 2014 Newsletter

An earthquake-damaged traditional rammed earth home in Bhutan. GHI's work will guide engineers' safety evaluations of local bulding types. PHOTO: DEPARTMENT OF DISASTER MANAGEMENT, ROYAL GOVERNMENT OF BHUTAN.

Is An Earthquake-Damaged Building Safe to Use?

A major earthquake will damage hundreds, maybe thousands, of buildings all at once. As people recover from the shock, they will need to know quickly which buildings are safe to use and which are not. Can they live in their homes? Can the hospital stay open if it needs repair? Can the schools function?

Bhutan's government asked GHI to develop a manual that will guide engineers who make such decisions. The goal is to improve safety and speed recovery after a disaster. Atop the Himalaya, Bhutan faces a high risk of earthquakes.

Using this tool, trained engineers will know what to look for as they evaluate which buildings might suffer additional, life-threatening damage in an aftershock as intense as the mainshock.

They will post a red, yellow or green-colored placard on each building to inform the public. Green means "Inspected" and the building is usable; it may be unscathed or need small repairs. Yellow means "Restricted Use"; a part of the building is unsafe (such as near a masonry chimney), or access is limited. Red means "Unsafe" until repaired or demolished.

GHI worked with Bhutan's Departments of Disaster Management and Engineering Services and the Applied Technology Council (ATC) to adapt the ATC-20-1 *Field manual: Postearthquake safety evaluation of buildings* for Bhutan's context. ATC's rigorous process is the only standard used in the U.S. and has been applied to evaluate building safety after every significant earthquake since 1989. Bhutan's manual is the first adaptation of ATC-20-1 with ATC's consent and full participation.

The majority of buildings in Bhutan are traditional rammed earth, stone masonry, and adobe construction—quite different from the US building stock. Some have vernacular timber-based systems. Bhutan considers its traditional architecture a cultural treasure. Though beautiful, the buildings have vulnerabilities. Damage from moderate earthquakes in 2009 and 2011 indicates that stronger shaking will cause significant damage, especially in rammed earth and stone buildings.

In the adapted field manual, our team added several new chapters to cover buildings found in Bhutan but not in the US. We also added more detailed graphics, with examples of crack types and sizes in masonry. A panel of Bhutan *(continued on page* 3)

Many Thanks

We hope these stories will inspire you as they do us. Your contributions to GHI are the seed that makes this work grow. In our 24th year, we continue to help vulnerable communities prepare for major hazards—to save lives, reduce suffering and build enduring, prosperous societies.

\- *Brian Tucker, President*

New Earthquake Engineering Program in Pakistan Graduates First Masters Students

Pakistan's premier technical university will graduate a unique class in December: its first masters students in structural earthquake engineering. This milestone will bring pride and joy well beyond campus, because Pakistan emphatically needs seismic design experts. GHI helped develop the program's curriculum.

"I had the honor to be the first student of this program at NED University of Engineering and Technology, with the Roll No EQ-01," noted Mubashir Hussain. He describes the program as a great experience, which included theory and computer analysis as well as retrofit case studies of existing local structures.

Earthquakes inflict much suffering in Pakistan, in large part because poorly constructed buildings collapse and kill people. Pakistan's common buildings made of concrete block and unreinforced masonry, and roofs made of concrete or heavy material, have proved especially lethal.

The earthquake engineering program at NED University was conceived after the 2005 magnitude 7.6 Kashmir earthquake killed more than 87,000 people, including 19,000 schoolchildren. More than 6,000 schools and nearly all hospitals near the epicenter were severely damaged. Millions became homeless overnight.

Like Mr. Hussain, the other structural earthquake engineering students intend to improve seismic design in their country, so that Pakistanis will live in safer buildings in the future. Tallal Ahmed Khan, another student in the program, vividly remembers from childhood the magnitude 7.7 Gujarat, India earthquake in 2001 "so strong that we experienced the shocks in Karachi." The 2013 magnitude 7.7 earthquake in Arawan, Pakistan affirmed the nation's constant risk.

"The program is still in its infancy period," notes Professor Muhammad Masood Rafi, chairman of NED University's Department of Earthquake Engineering. Eight men and four women are currently enrolled for the 2 1/2 years of study. Most had previous experience as practicing engineers. The Cowasjee Earthquake Study Centre, a research lab established in 2001, is now part of the department, which will also offer graduate programs in geotechnical earthquake engineering and engineering seismology.

What lies ahead for the graduates? Opportunities for them and for Pakistan. Mr. Hussain was a civil engineer working on small scale projects before joining the masters program. Now, his work at the National Refinery will include review and design of buildings, underground piping, steel structure and foundations for the refinery upgrade. Mr. Khan was a civil engineer at a firm that builds state-of-the-art housing. With his new earthquake engineering skills, he will design for seismic safety and will hold consultants' work to rigorous seismic design criteria.

GHI's Contribution and Mentoring

The case studies now used in the NED University masters program were developed as part of a larger GHI project to build Pakistani capacity in earthquake engineering. GHI paired American experts in earthquake engineering research, education and practice with Pakistani professors and building professionals.

The teams developed the case studies using buildings in Karachi. They created a checklist for assessing safety vulnerabilities in building types specific to Pakistan, and an engineering analysis guide. They also created training materials. Four hundred working professionals attended short training courses.

Collaborative research among this group has greatly enhanced understanding of how Pakistani structures behave in earthquakes. NED University's earthquake engineering students now test the performance of non-engineered construction common in Pakistan. One tool they use is a shake table model to identify damage patterns and to study retrofit schemes.

NED University professors received hands-on experience and intensive mentoring using all of these tools. GHI's team of experts worked with them to augment the university's well established structural engineering curriculum, which developed into the new earthquake engineering program.

GHI's Dr. Janise Rodgers and a Pakistan-US team developed earthquake engineering case studies and materials to train Pakistani engineers. PHOTO: GHI

The pioneering collaborative project, "Building Pakistan's Capacity for Instruction, Research, and Practice in Earthquake Engineering and Retrofit," was funded by the US Agency for International Development (USAID) through The National Academies and by the Pakistan Higher Education Commission.

Trashiyangtse Hospital, Bhutan. One of many hostpitals where GHI assessed likely damages from natural hazards and prioritized steps to prepare. PHOTO: KARMA DOMA TSHERING

When the Hospital Becomes the Patient

After a major disaster, the injured will flock to a hospital for trauma care. Others will need a hospital too: women delivering babies, children with alarming fevers, people requiring medication, and the chronically ill. But what if the hospital itself falls victim in the event?

GHI works with hospitals to prepare for earthquakes, tsunamis, cyclones, and landslides—by reducing vulnerabilities ahead of time. Every community needs a healthy hospital at the ready. Many face combined stresses from hazards and poverty. Strengthening these hospitals now will not only save lives and reduce suffering in disasters, but will also help communities retain hard-won development gains.

GHI recently evaluated key hospitals in Nepal, Bhutan, and the Solomon Islands. These countries range from mountainous to coastal, but all face a high risk of casualties from natural hazards and have highly vulnerable hospitals. We evaluated the only hospitals serving their cities in Bhutan and Solomon Islands, and four high priority hospitals in Kathmandu.

Even if the structure remains sound, disruptions can disable a hospital. It might lose crucial power, water, medical gas and communication. Intense shaking from earthquakes might dislodge heavy objects, destroy medical equipment and topple supplies. People will need safe routes for evacuation. Failure to prepare for these issues could severely impair medical care in a crisis.

Working with hospital staff, GHI prioritizes improvements. We identify important equipment that should be bolted, and where the systems delivering water and power should be braced. We train engineers to do this, and we specify adequate back-up for utilities. We advise alternate plans to connect with the oustide world when phones and roads will be down.

In a separate program that began in 2008, GHI has trained 1600 hospital administrators, staff, engineers, and construction contractors in India's zones of highest earthquake risk to secure hospital elements against shaking. The training uses a manual that GHI developed, "Reducing Earthquake Risk in Hospitals from Equipment, Contents, Architectural Elements and Building Utility Systems."

World Health Organization funded GHI's assessments in Nepal, Bhutan and Solomon Islands. European Commission Humanitarian Aid and Civil Protection (Dipecho) added funding for Bhutan. Reinsurer Swiss Re provided funds for the India hospitals training and manual.

Bhutan Building Safety *(cont'd from p.1)*

and US engineers provided extensive input and field research. The new manual provides many images of "Unsafe" and "Restricted Use" conditions as well as acceptable damage in the "Inspected" category, to prevent overly conservative evaluations. Rammed earth buildings in particular can suffer impressive looking cracks but not require an "Unsafe" posting.

Engineers may assess thousands of buildings in the critical first week after an earthquake. They will check roof and floor framing, columns, walls, diaphragms, and foundations. The ATC-20-1 field manual, ready-to-go for Bhutan, will save precious time. Its use will support consistent evaluations that occupants can trust.

Planning for efficient recovery is one way to manage known risk. This complements GHI's earlier work to help Bhutan develop *pre*-earthquake vulnerability assessments, in which engineers identify building weaknesses. Bhutan's government can also feed data on the extent of damages and usable buildings into its new Bhutan Disaster Assessment tool, to plan rebuilding.

The field manual, though specific to Bhutan, provides an excellent model for postearthquake safety evaluations in nations with similar building types.

World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR) and the ATC Endowment Fund funded adaption of the ATC-20-1 field manual for Bhutan.

The most effective action to take during earthquake shaking may vary, depending on building type, nearby buildings, and external or falling hazards . Shown here, dense urban construction in Delhi, India. PHOTO: GHI

What Should You Do In a Shaking Building?

In the unnerving seconds when earthquake shaking begins, a person's action may spell the difference between safety and suffering. But what to do? There is no simple answer.

GHI is studying how to develop the right advice, and how to deliver it in an effective message. Here is the difficulty: a protective action may work in one shaking situation but not in another.

Around the world, standard advice ranges from "drop, cover and hold on" to its opposite, "run out of the building." Some regions teach "go to a safe zone." Instructions also persist in local folklore. For example: crouch, put thumbs on the floor, hug the middle pillar, or touch something brass in Nepal. Or take seven steps from danger in Afghanistan.

Our goal is to move beyond conflicting messages and survivors' anecdotes, to create an evidence-based approach for protective actions. We have drawn from available research, data from past earthquakes, and the judgment of experts in several fields.

The focus is low- and middle-income countries, where buildings are particularly vulnerable to damage from shaking. Our intended audience is people who develop protective action messages. They might work in a disaster management agency, a non-profit, or a scientific organization.

To start, we tapped 73 professionals involved in earthquake messaging, from 23 countries, to share experiences from their nations. With help from Texas A&M sociologist Michelle Meyer, we surveyed them about messages they give and why, and we surveyed 652 residents of India, Turkey and Peru about what messages they receive and action they would take. Actions perceived as most effective varied by country: "run out of the building" in India, "drop, cover, hold on" in Turkey, and"go to a safe zone" in Peru.

We asked 5 experts (in seismology, structural engineering, communication, of risk, behavior in earthquakes, and epidemiology of earthquake casualties) to prepare papers that would provide background facts and data.Messaging professionals met with these experts in a workshop, where they discussed likely rural and urban building scenarios and agreed on processes for developing protective actions messages.

Some key principles emerged. Most important, no single message can apply in every community. Buildings vary in their vulnerability to collapse and proximity to one another; levels of shaking vary with site conditions and nearness to faults; social and demographic factors dictate when people are inside buildings.

Message content should consider experts' findings, such as: How much time will people have to evacuate before the strongest shaking? Are people safer outside or in? If outside is safer, can people evacuate in time? Do local beliefs impact choices?

USGS seismologist Susan Hough found that in major earthquakes, aside from rare "direct hits" or where studies make specific predictions, there will typically be a delay of at least 5 seconds between the initial P-wave shaking and the more damaging S-wave shaking. The finding led to a new message: "you may only have five seconds to act."

People must understand the reasons for protective actions so that they can adapt. For example, running out of a rural, one-story masonry building escapes likely disaster, but running out of a tall building onto an urban street risks entering a "kill zone" of falling glass, walls, and façades.

The messaging strategy should include input from people in the community, because how the message is communicated determines if people receive it and act. Local beliefs and special needs should be addressed. Schools deserve special consideration, because dense occupancy, poor construction quality, and evacuation constraints leave students especially vulnerable.

Protective actions will not safeguard everyone in every earthquake. They should support a broad campaign to prepare. The best protection is to ensure safe construction *before* an earthquake, by enforcing a building code, strengthening vulnerable structures, or relocating.

Stay tuned for more details. United States Agency for International Development-Office of Foreign Disaster Assistance (USAID-OFDA) provided funding for the research papers and GHI's "Guidance on Developing Messages for Protective Actions to Take During Earthquake Shaking," to be completed in 2015.