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DIFFUSING SEISMIC SAFETY

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ABSTRACT

Despite the efforts of the earthquake engineering and earth science communities, global earthquake risk continues to grow at a rapid rate. The increase in risk occurs primarily in the rapidly growing cities of the developing world, where engineering issues are often the most easily solved part of the problem. Earthquake resistant methods for building new structures and retrofitting existing ones are available. The challenges are for local people to understand that they are at risk from earthquakes and that risk should and can be managed, and to build the political support for the idea that all elements of society should pay for risk management activities. The theory of the diffusion of innovations, which is widely applied in other professions, provides the techniques to address these challenges. GeoHazards International (GHI) has developed a diffusion-based approach to introduce earthquake safety ideas and practices. The approach applies to both technical ideas and practices, such as performance-based earthquake engineering or specific retrofit methods, and to basic risk reduction measures that empower schoolchildren, their families, teachers, government officials, hospital personnel, and others to make themselves safer now. This paper presents examples from GHI's projects in India, Pakistan, Indonesia and Nepal, and provides suggestions for enhancing the diffusion process in future earthquake safety projects.

Introduction

While there is evidence that efforts over the last 20 years to reduce human and fiscal losses due to natural hazards have been effective, there is also evidence that, despite these efforts, large and increasing losses are expected in the future. The United Nations International Strategies for Disaster Reduction (ISDR, 2009) found that disaster losses since 1975 have been highly concentrated geographically and associated with a very small percentage of hazard events that generate so-called "mega-disasters," and that this trend of risk concentration has increased recently. Half of the ten deadliest disasters have occurred in the past five years alone, including earthquakes in Sumatra, Sichuan, and Kashmir. Most of the deaths from these mega-disasters were in developing countries (ISDR, 2009). ISDR uses the term *intensive risk* to refer to areas

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where major concentrations of vulnerable people are exposed to very severe hazards. Intensive risk is increasing and is projected to further increase in the future, particularly in the developing world.

The primary factors contributing to the increase in earthquake risk in the developing world are increasing urban population growth in areas with substantial earthquake hazard and rapid, inadequately regulated, and poor quality construction to accommodate that growth. Increased urbanization results in larger buildings that hold many more people than more traditional buildings in rural areas, so the collapse of individual buildings have a much larger proportional impact. Because the vast majority of casualties in most earthquakes are due to building collapses, with the notable exception of large tsunami-genic events such as the December 26, 2004 Sumatra earthquake, increases in building size and density combine with poor construction quality to generate risk concentrations in earthquake-threatened developing-world cities.

A number of underlying drivers contribute to urban population growth and unsafe construction. Economics drives people to migrate to cities in search of employment, and impacts the level of construction quality people are able or willing to pay for. Weak governance and corruption hinder enforcement of building regulations that would improve construction quality. Informal construction results in buildings that lack any sort of quality control, engineering, or regulation. Lack of risk awareness leads to low demand for quality construction. ISDR data (2009) show the greatest loss of life occurs in poorer countries with high exposure to hazard, rapid urban growth, and weak governance. Continued urban growth and poor construction means that risk will continue to increase in developing world cities, unless more is done to reduce risk. Changes to both policies and practices are needed.

As the factors above indicate, the global community's failure to reduce overall levels of earthquake risk in the developing world, despite some local successes, is not due to inadequate science or engineering: the reduction of natural disaster losses industrialized countries over the last century indicates that humans possess the required scientific and engineering expertise to reduce the risk of natural hazards, and reduce it significantly. If the problem is that this expertise is not being applied to the developing world, where the risk is concentrated, then it is imperative to understand why. There are numerous examples, after all, of widespread, rapid adoption of modern technologies (such as the internet), once these technologies were perceived to be beneficial. Yet not only have earthquake engineering advances failed to be adopted where they are needed, even existing building codes are often not followed. The theory of the diffusion of innovations provides some answers as to why this is the case, and how earthquake risk reduction efforts can be improved.

Background on Diffusion of Innovations

Innovations are defined as ideas, practices, or objects that are perceived as new by an individual or other unit that can adopt them (Rogers, 2003). The diffusion of innovations is the process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 2003). Diffusion is a process that depends on decisions by individuals or organizations to adopt an idea. Rogers (2003) refers to the decision to adopt an idea as the innovation-decision process, which consists of five steps: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. Better understanding of how potential adopters move through these stages can greatly improve earthquake safety efforts. The following are important diffusion principles:

(1) Mass media channels are effective in creating knowledge of innovations, but inter-personal communication from a "near peer" is needed to decide to adopt an innovation and to change behavior.
(2) More than just the demonstration of an innovation's benefits is needed for the adoption of that innovation.
(3) Characteristics of Innovations that Affect Rate of Adoption:
- Relative advantage – is it better than the current alternative or way of doing things?
- Compatibility – is it compatible with existing values?
- Complexity – is it easy to use and/or understand?
- Trialability – can it be tested on a partial basis before adopting?
- Observability – how easy is it to observe the benefits?

Because diffusion is a socially driven process, people are critical to the spread of new ideas. Diffusion theory provides important insight into the types of people that influence the innovation-decision process and move it forward, thereby hastening the spread and adoption of new ideas. Rogers (2003) divides adopters into Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. The people in each adopter category have different traits and different roles in the diffusion process. Rogers (2003) also identifies opinion leaders, who are influential people within a system that others respect and listen to, as important in diffusion efforts; if they adopt, others are more likely to. Opinion leaders can accelerate the diffusion process if they are Early Adopters. Gladwell (2000) has similar ideas: there are a few critical people that are necessary for moving an idea from the Early Adopters to the Early Majority, which he terms Connectors, Mavens, and Salesmen. Other researchers such as Watts (Thompson, 2008) disagree and argue that ordinary people can perform these functions as well.

Diffusion theory applies to earthquake risk reduction efforts because the main goal is to change people's behavior so they will take actions to reduce their risk, as opposed to doing nothing or taking actions that actually increase their risk. Behavior change is not an engineering problem, and therefore reducing earthquake risk requires theories and methods from fields other than engineering. Diffusion theory provides a framework of ideas that explains why earthquake risk reduction projects succeed or fail, and provides instruction how to increase the benefits and impact of future projects.

Seismic Safety Innovations GHI Diffuses

GHI and others working to improve earthquake safety have attempted to diffuse a variety of innovations to a variety of audiences. GHI diffuses engineering innovations such as analysis procedures, design methods, and seismic retrofit techniques to engineers. GHI also diffuses preventative innovations such as building strengthening, making disaster preparedness plans, anchoring items that can fall during an earthquake, and developing earthquake safety policies, to facility owners and leaders. Though related, these types of innovations and their target diffusion audience are quite different and thus require different strategies.

As diffusion literature predicts (Rogers, 2003), GHI has found it easier to diffuse engineering technology innovations to engineers, because engineers often consider these innovations to have relative advantage. New technologies can often be incorporated into traditional, force-based code design procedures that GHI's target engineering audience typically uses. GHI has observed that engineers are less inclined to adopt innovations that require a significant change in design procedures or philosophies, because this requires them to make broader changes to the way they do things. For example, public works engineers in Delhi adopted base isolation technology and immediately applied it to a new hospital building they were designing, after a single visit to California where they heard a persuasive presentation and saw its application in several buildings. They were less inclined to adopt engineering design philosophies such as displacement-based design and performance-based earthquake engineering, even after several years of examples and mentoring, because these new ways of looking at buildings required them to change the way they both thought and practiced engineering.

Preventive innovations are more difficult to diffuse (Rogers, 2003) because it can be difficult for people to perceive the relative advantage of adopting something that may benefit them at some future point. In the developing country contexts where GHI works, the opportunity costs of adopting earthquake risk reduction measures when the earthquake does not happen for many years may be more severe than in industrialized countries. However, as discussed in the introduction, the consequences of doing nothing are also more severe. A spate of recent, deadly earthquakes in Asia has helped the building owners and users GHI works with to better appreciate the risks they face, and has made them more likely to adopt risk reduction measures.

Diffusion's Role in GHI's Approach to Earthquake Safety

GHI promotes innovations, and therefore tries to use the diffusion process to better conduct earthquake safety projects. GHI applies several strategies to do so.

Schools as an Entry Point to the Community

Schools provide an opportunity to transmit safety messages to a sizeable portion of a given community. GHI encourages a holistic approach to school earthquake safety that includes students, teachers, parents, and administrators, and emphasizes safety at home as well as at school. Safety messages given at school are taken home by children and reinforced by additional messages directed to parents. The school's teachers, administration, and school safety committee are encouraged to communicate the school's safety measures, such as a student release policy, to parents, both to motivate parents to prepare their families and to reassure them that the school is implementing measures to keep their children safe. GHI encourages schools to request parent volunteers to assist in school safety planning so that they adopt safety measures at home as well and become early adopters, who then influence the behavior of other parents. If enough parents adopt earthquake safety measures, they may be numerous enough compared to the rest of the community that they can create an early majority by themselves, and thus accelerating diffusion.

Importance of Localization and Local Change Agents

In GHI's experience, making messages and approaches relevant to the local context is critical to success. Whenever possible, GHI employs local change agents that possess local language skills, understand the culture, and can help identify opinion leaders and interpersonal networks important for diffusion. For instance, GHI employed a young Tibetan person with excellent people skills in order to influence the behavior of Tibetan communities living with high earthquake hazard.

Identifying and Working With Difference-makers

GHI strives to work with people who can make a difference, such as Opinion leaders, Mavens, Connectors, and Salesmen. These are people who are in both formal and informal positions of leadership within the systems in which GHI works, or have particular social skills that can help diffuse ideas. In fact, GHI's lead person in India is a Connector with superb people skills, and is a great asset to GHI in diffusion efforts. GHI also strives to identify and support local innovators and early adopters who can help move the diffusion process forward.

Facilitating the Knowledge and Persuasion Phases of the Innovation-decision Process through Near Peer Strategies

GHI prefers to utilize peers or persons known to potential adopters (such as teachers) to make them aware of the innovation and its benefits during the knowledge phase, but also uses change agents for these purposes with the support of authority figures with the system (such as administrators). During the persuasion phase, GHI respects the fact that though there may be compelling evidence provided by real experts behind the innovations being promoted, but that potential adopters will still make their adoption decisions in consultation with others. GHI cannot control who these colleagues and potential adopters talk to and how they weigh their discussions, but tries to create an ongoing process that allows GHI staff members and resource people to participate in adoption decisions over time. Typical mechanisms for this include peer and expert review panels, school and hospital preparedness committees, ongoing discussion forums and case studies. GHI makes it a point to not just give a lecture and go away, but tries to influence the discussion agenda and make additional information available. GHI also tries to create on-going relationships so that there is support for confirming innovation-adoption decisions, and that there are avenues for discussions when innovation decisions are reconsidered. GHI recognizes that projects take time to complete, not necessarily because of work tasks, but because relationship-building and diffusion of innovations take time.

Project Examples

Delhi, India

In Delhi, GHI built the capacity of public works engineers to seismically retrofit important buildings. These engineers were unfamiliar with performance-based earthquake engineering (PBEE), an engineering design innovation that has been adopted for seismic assessment and retrofit of existing buildings by many practicing engineers in California and elsewhere. GHI encouraged public works engineers to adopt PBEE concepts and approaches based on displacement and behavior, as opposed to prescriptive code-based design methods, to help them better understand and address the vulnerabilities in existing buildings. GHI also tried to diffuse the idea that the retrofit process was multi-disciplinary and required interaction with and decision-making by the building owner and major users.

Because these innovations required a shift in thinking, GHI tried to demonstrate their relative advantage by using concrete technical examples from experienced practicing engineers in the United States. The relative advantages of the new design methods were primarily technical – they allowed the designer more freedom, power, and flexibility, but they also required more work, which was perceived by the public works engineers as a relative disadvantage. The new emphases on owner participation were also perceived as creating more work; engineers preferred to dictate to the owners what needed to be done. However, because of their experience in renovation projects involving the offices of high officials, the public works engineers could see the benefit of early owner involvement as a way to avoid difficulties and delays during construction.

Compatibility and complexity were the main downsides of the engineering design innovations GHI was trying to diffuse. The new design methods were more transparent but also more complex than the simple methods prescribed in the building code, and required a new way of thinking and working. Trialability was provided by the project itself, because it was a pilot project in which the engineers could try out the new techniques on a small number of buildings. GHI provided observability primarily through a trip to California, where a group of engineers toured buildings that had been seismically retrofitted using the ideas and techniques that GHI was trying to diffuse. The visit brought people of similar responsibilities in both countries together because it was simpler and more compelling for a hospital administrator in India to understand the benefits of earthquake safety from their counterpart in California, and to be able to observe safety measures at a hospital.

GHI employed near-peer strategies and involved opinion leaders from the Indian engineering community as members of the project's peer review panel. This approach was time-consuming but eventually successful; the Indian members of the peer panel adopted many of the ideas GHI promoted, including performance-based earthquake engineering ideas, and influenced the public works engineers to do the same. The project's overall diffusion efforts were partly successful; public works engineers eventually began to understand and apply PBEE concepts, and to think more about how project buildings would physically behave during earthquake shaking, rather than thinking in terms of how to make the buildings comply with the codes for new construction. Creativity began to emerge as the engineers realized they were not constrained to a single prescriptive solution, and could pursue alternate ideas. However, this process took a long time, and the understanding of PBEE did not penetrate very far downward into the public works department rank-and-file.

GHI also worked to diffuse school earthquake safety ideas to school administrators and government officials responsible for schools. The initial responses have been encouraging, though this diffusion process is expected to be much longer in duration. School earthquake safety programs that include falling hazards mitigation, awareness generation for students and teachers have been adopted by innovators in several schools in both Delhi and the nearby commercial center of Gurgaon, and have strong support within the Delhi governement. GHI will continue to encourage and facilitate the diffusion of such programs.

Dharamshala, India

GHI has worked for three years in Dharamshala, India with persons responsible for the Library of Tibetan Works and Archives. GHI employed a community change agent, a person with appropriate language and cultural skills, experience working on social issues, connections with persons involved in community programs, an affinity to learn about earthquakes and mitigation actions, and deep commitment to his community. At the Library, GHI worked closely with a leader who is an innovator willing to adopt new ideas. Other members of the community were not so ready to adopt new ideas, and viewed proposed changes as a threat to traditional norms. Because of the leadership structure and the tradition of not contradicting the leadership, GHI did not discover the underlying issues until they were brought to light in the aftermath of a tragic fire that killed a senior Tibetan monk, when community members were emboldened to express their concerns. The diffusion process is still in progress; GHI is working to patiently and appropriately help the library community move down the path toward a willingness to adopt measures to reduce their sizeable earthquake risk. GHI's community change agent also continues to work with the broader Tibetan community in Dharamshala to both make them aware of and encourage them to adopt seismic safety measures.

Hospital Earthquake Safety in India

During the Delhi project described above, GHI began the process of diffusing hospital earthquake safety in India. GHI worked in a single hospital with an innovative and supportive medical superintendent, but efforts stalled when the medical superintendent retired and was replaced by someone uninterested in earthquake safety. Several years later and with a new understanding of diffusion theory, GHI restarted diffusion efforts on a broader basis with workshops to raise awareness of the earthquake risks facing hospitals and the need to be prepared. GHI then wrote a manual providing the guidance administrators need to begin reducing earthquake risk. GHI is currently diffusing the manual and the information it contains through a variety of channels. The next step is to directly assist administrators who wanted to take action by providing working with them and their staff to implement earthquake safety measures; as of this writing GHI was still in the process of obtaining funding for these direct assistance measures.

Pakistan

GHI has been working with a university in Karachi to increase their capacity to teach seismic assessment and retrofit to both students and local practicing engineers. One of the project goals is to begin the process of diffusing assessment and retrofit techniques through several channels: directly to the faculty at the university, the practicing engineers participating in the project, and engineers the project will train; to students of the university professors; and to other universities via a minimum set of curriculum standards that include topics that will prepare students to undertake seismic assessments and retrofits. Within Pakistan, the key project participants are opinion leaders that can influence others to adopt the concepts necessary to conduct assessments and retrofits. As of this writing, the project was currently in progress, so it is too soon to assess the success of diffusion efforts. However, GHI is using the lessons learned in the Delhi project, such as employing site visits to retrofitted buildings and facilitating near-peer interactions, to help facilitate the diffusion process.

Indonesia

GHI is working in Indonesia to diffuse the idea of civil infrastructure as a means to facilitate evacuation from tsunamis. Specifically, GHI is working to introduce structures that serve as evacuation sites and are designed to withstand the earthquake and tsunami forces, as well as earthquake-resistant bridges that facilitate evacuation routes. This innovation is particularly crucial for communities that lack high ground and have a short amount of time between the first tsunami warning and the arrival of the tsunami. GHI's approach is to begin working in Padang City, one of six cities selected to serve as an example on disaster preparedness, planning and management in Indonesia. Padang has numerous ongoing tsunami awareness efforts and already has the demand for tsunami evacuation options other than simply going inland. However, Padang City and the Indonesian national government lack the capacity to reduce the tsunami risk by providing effective means for evacuation.

The goals of this project are to: (1) train local leaders on planning and designing evacuation infrastructure so that they can address their city's needs, as well as serve as an example to the nation, and; (2) build the capacity of national engineers and planners so that they can replicate their efforts in other at-risk communities in Indonesia. These ideas will be diffused through local and national universities, governmental agencies, and non-governmental organizations.

Tsunami Preparedness Guidebook

GHI prepared a guidebook, *"Preparing Your Community for Tsunamis—A Guidebook for Local Advocates,"* The guidebook presents information regarding tsunamis and preparedness measures, but is presented as a guide to help community advocates diffuse the information using techniques that will improve the diffusion process. GHI plans to use the guidebook in future work in tsunami-threatened areas such as Indonesia.

Nepal

In the late 1990's, GHI and local partner National Society for Earthquake Technology (NSET) -Nepal collaborated on a project to seismically retrofit a school and train the local masons in earthquake-resistant construction techniques in several villages in Nepal. Ten years later, the work appears to have sustained itself: in the vast majority of cases, for several years following that initial project, whenever there was construction in those villages, villagers would request that the trained masons use the seismic resistant methods employed in the school, even though those methods required additional expense. GHI and NSET were able to create both a demand for seismic resistant construction and a supply of masons who can provide it.

At the time GHI and NSET conducted the project in Nepal, GHI was unaware of diffusion theory. However, GHI followed (unknowingly) several diffusion principles: (1) GHI selected villages that were innovators, because GHI informed the village leaders that GHI could pay for a part of the retrofit cost if the village contributed the rest of the cost either by collecting donated material or by having the masons work at a reduced rate; (2) the NSET engineer trained the local mason (the masons respected the advanced education of the NSET engineers), (3) the local villagers believed that the retrofit work was valuable because foreigners were involved and because the Minister of Education inaugurated the retrofit school, (4) the local people had faith in the local masons (they said "we don't really understand about earthquakes and about the retrofit methodology, but it must be good if foreigners came all this way to teach the method, and if the Minister of Education inaugurated the school, and if you believe in it. Please come and do the same thing to my house.")

Recommendations for Improvements in Future Projects

Despite beginning to use diffusion theory only recently, GHI has learned a number of lessons thus far that can help improve future earthquake safety projects. These lessons are timely; the development community that funds much of GHI's work is placing ever greater emphasis on sustainability and "scaling up", both of which are desired outcomes of diffusion processes. GHI recommends that by incorporating diffusion principles more fully into the way projects are envisioned, designed, and executed, implementing organizations can help improve results.

GHI has recently begun to incorporate diffusion directly into projects from the outset. A good example is GHI's attempt to diffuse hospital earthquake safety approaches in India, described above. In many cases, GHI is able to obtain funding for smaller projects that will move the diffusion process forward by a modest amount, or that will contribute to a specific part of an overall diffusion process. Keeping the broader diffusion picture in mind has been very helpful in better defining the scope and objectives of these projects.

Another recommendation that GHI is only beginning implement is to select project participants based on diffusion principles. Strategically selecting project participants that have the traits of Opinion Leaders, Connectors, Mavens, and Salesmen can significantly advance diffusion efforts. However, these traits are related to personality and "people skills" rather than the traditional standards, such as technical competence and area of expertise, which organizations such as GHI use to select partners and participants. Selecting participants with diffusion-enhancing traits argues for a more intensive and intentional process of relationship building prior to embarking on projects. However, especially in the case of selecting partners in another country, budgetary and time constraints often make such intensive efforts infeasible. It is simpler and less time consuming to determine the most highly qualified and respected individuals than it is to determine whether or not someone is a Connector, for instance. The good news is that there may be overlap between the people who are respected by their peers, the Opinion Leaders, and those who have the social skills to spread new ideas. The communication and interpersonal skills that make a person a Connector or a Salesman are also likely to have served them well professionally, though this is certainly not always the case. Engineering has a reputation, deserved or not, for being filled with technical experts who do not engage in social movements and might not understand or be sensitive to the diffusion process.

For diffusion efforts to succeed, the traits of the main project participants must be taken into account. Project participants should include those that can make a difference. The "difference makers" will differ depending on where the idea is on the diffusion curve. In some projects, it makes the most sense to involve Innovators and perhaps Early Adopters. In others, the focus will be on Connectors, Mavens, and Salesmen. Determining what types of people are needed to further the diffusion process and then involving them in the project are critical to moving the diffusion process forward.

GHI also recommends that technical people such as engineers who are trying to change behavior and diffuse innovations become more acquainted with social science research that can provide important insight into human behaviors related to risk and safety. GHI is just beginning to do this in earnest. Social movements—such as the campaigns to use seat belts or to stop smoking—that have succeeded in changing human behavior by making psychologically "remote" risks real to people may provide good models for diffusing earthquake safety information. If earthquake professionals want to make faster progress toward reducing human losses due to earthquakes, then it is time to look beyond advancing research in earth science and structural engineering, to improving public education and constructing strategies to diffuse ideas considered new by those whose decisions will affect earthquake safety. Additional research is most welcome and necessary but, based on recent trends, insufficient. GHI recommends convening a broader multidisciplinary forum of seismologists, earthquake engineers, psychologists, legislators, government regulators, as well as people from the construction industry, Madison Avenue and Transparency International to devise improved, unorthodox means to reduce the risk of natural hazards.

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