The World Housing Encyclopedia: A Global Resource on Construction Technologies

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15 WCEE
LISBOA 2012

SUMMARY:
This paper discusses the changing emphasis in the last few years in the World Housing Encyclopedia project towards a concentration on tutorials and guidelines on various construction technologies. The paper briefly reviews the history of this volunteer and web-based project, an initiative of the Earthquake Engineering Research Institute (EERI) and the International Association for Earthquake Engineering (IAEE), and then discusses in more detail the recent progress in developing consensus-based tutorials and guidelines, including several guidelines on confined masonry construction and tutorials on stone masonry and adobe construction. Strategies for linking these tutorials to better building practices around the world will also be discussed. This project has participation from individuals in 57 countries, committed to improving global construction practices. All materials developed by project participants are available free of charge on the project website (www.world-housing.net). Future plans for the network are also discussed.

Keywords: housing, construction, guidelines, global

1. BRIEF HISTORY

1.1. Overview

The World Housing Encyclopedia (WHE) is a uniquely successful global network of individuals committed to making communities safer in earthquakes. This network is a web-based, freely available resource of housing construction technologies, practices and guidance in seismically active countries of the world. To build this network the project is using the internet to connect many diverse countries, using the web for a running discussion on housing issues, as a constantly updatable resource, and a tool to build the network necessary to promote locally-based, sustainable, earthquake-resistant housing solutions. The project is a crowd-sourcing project in the sense of motivating a large user base to contribute.

The project started in 2000, and was first called the Encyclopedia of Construction Types in Seismically Prone Areas of the World. In 2003/4, the name was shortened to World Housing Encyclopedia. The Editorial Board is now considering a further modification to the name where a tagline would be added that is more specific about the purpose of the website and the network, conveying the idea that it is a living and growing resource, welcoming contributions from around the world. The project has grown, using the internet and volunteers, to a website in 2012 that has 136 housing construction reports from 40 countries, in addition to tutorials on adobe, reinforced concrete, confined masonry and stone masonry. The database is peer-reviewed and searchable. Reports are not visible until reviewed.

For some construction types, this is one of the few, if not only places where such detailed information has been made available, e.g. housing construction in the former Soviet Union (Russia, Kyrgyzstan, Kazakhstan, and Uzbekistan).

The primary features of the web site (Figure 1.1.) include:

- A searchable database

- A technical review process that provides opportunities to exchange information across language and geographic boundaries
- A consistent format to describe each housing construction type
- Several illustrations for each construction type
- Earthquake tutorials on basic construction materials
- Summary descriptions of all major construction types
- Links to WHE-related projects: the Confined Masonry Network and the WHE-PAGER project

The project is managed by an Editor-in-Chief (EIC), who provides all of his or her time pro-bono, and a Managing Editor in the EERI office. There have been three EICs to date in the project--the first was Svetlana Brzev from the British Columbia Institute of Technology, and the second, CVR Murty from IIT Kanpur (and now IIT Madras) India. The current EIC, Andrew Charleson, is located at Victoria University of Wellington, New Zealand. The editorial board has 24 members from 16 seismically active countries. The editors oversee the technical review process as well as participate, along with project participants, on various specific activities of the WHE, such as the preparation of tutorials on various construction materials and the translation of these tutorials into additional languages.

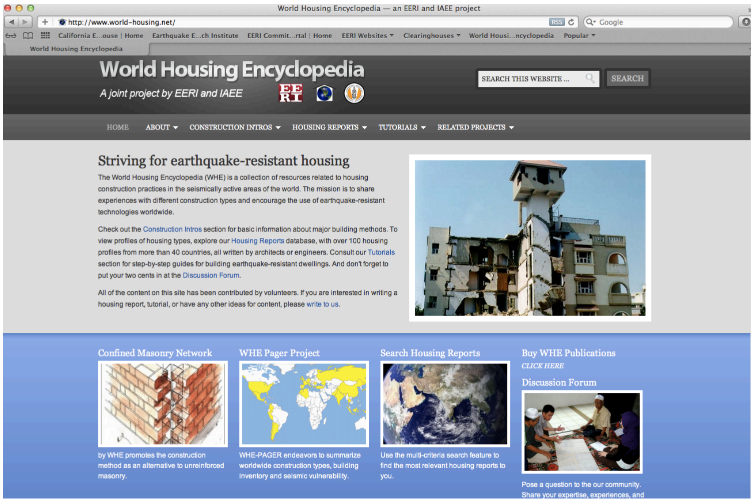

Figure 1.1. Home page of World Housing Encyclopedia (www.world-housing.net)

1.2. The problem

The problem of poorly constructed housing in areas of high seismic hazard is a global problem, affecting all seismically active countries. Over the last five years, earthquakes in Pakistan, Indonesia, Peru, Haiti, Chile and even New Zealand and Japan have all demonstrated the vulnerability of the housing sector, which is typically the most affected sector in earthquakes. Resources that would otherwise go to development must be diverted to pay for housing reconstruction. In several recent damaging earthquakes the loss of housing was enormous: over 3.5 million people displaced in Pakistan in 2005 (EERI 2006) and over 200,000 housing units were damaged in the Haiti 2010 earthquake, with another 100,000 destroyed or severely damaged (EERI 2010). Much of this housing is constructed by skilled laborers or owners, involving no engineers or architects. The WHE recognizes that this is a particular challenge—reaching the people who are constructing the most vulnerable buildings with information that can change construction practices.

Of people living in earthquake threatened cities in 1950, two of every three were in developing countries; in 2000, nine of ten were in developing countries (Geohazards International 2004). As the world's population grows, particularly in developing countries, this vulnerability becomes even more pronounced (Figure 1.2). According to the United Nations, in 2011, one-half of the world's population lives in urban areas crowded into 3% of the land area, an alarming increase in population density

(United Nations 2011). The World Bank estimates that 70% of the world's poor live in rural areas. The Bank also notes that the world's population increased by more than 3.5 billion people in the last 50 years, and 85% of these added people were in developing and transition countries. The number of people living in fragile rural areas in developing countries doubled, in contrast to declining numbers in this category in high-income countries (World Bank 2003). In the next 30 to 50 years, it is estimated that as many as 2 billion people will live in two areas that are difficult to manage: fragile rural areas and megacities (World Bank 2003). As of 2011 there are 23 cities that have over ten million in population, and of those, all but five are in less developed countries (United Nations 2011). The World Bank estimates that the number of megacities in developing countries is likely to increase to 54 in the next 30 to 50 years, while it will stabilize at five in high-income countries. Of the top ten megacities identified by the U.N. in 2011, nine are cities with a known moderate to high seismic risk, including Tokyo, Mumbai, Dhaka, Beijing, Shanghai, Mexico City, New York, New Delhi, and Kolkata (Calcutta) (United Nations 2011). A major earthquake in one of these cities, particularly in a city with a vulnerable building stock and fragile infrastructure, could cause major devastation and a significant number of deaths.

Figure 1.2. An example of vulnerability: densely built hillside housing in Gangtok City, India (photo: Murty).

1.3. The Mission

The challenge of improving the world's housing construction practices so that housing is not as vulnerable in earthquakes is obviously daunting. However, the scientific and engineering tools to meet this challenge exist. So do the local materials and construction expertise required for safe housing in most of the world. The cost of introducing seismically-resistant design features into construction practices can also be an impediment to better design. However, past experience demonstrates that local citizens, policy makers, building and planning officials, design professionals, and builders can motivate action when they are armed with credible and accessible information adapted to the specific needs of their community. Elegant technical theories and experiments are important first steps, but of little practical value in the field. A particular solution that works in one local economy often makes no sense in another. The WHE network is committed to improving global construction practices by providing locally-developed and appropriate, technically accurate, peer-reviewed, consensus-based information on construction materials and technologies, leading to the improved performance of housing in earthquakes, in an affordable, environmentally appropriate and sustainable manner.

It is the mission of the World Housing Encyclopedia to:

- Develop strong international consensus on scientific and engineering issues related to safe housing.

- Look for technically credible and affordable solutions.
- Convert scientific and engineering data into accessible guidelines and procedures to communicate both the need for and implementation of safe housing construction.
- Provide a continuing resource and repository for such information.
- Advocate for and assist local communities in meeting the challenges of safer housing construction.

1.4. The Strategy

The WHE network is making use of the internet as a tool to create and maintain this global community. The project currently operates on an almost entirely volunteer basis, so travel for participants is very limited. This makes the internet particularly valuable. The WHE network is also a unique resource because it is truly global in scope and all participants are seen as equals. No one country takes the lead. An engineer in Peru, for example, might be the best person to respond to a query or interact with an engineer in Iran. Small groups of volunteers often get together by e-mail to work on a project. The volunteer base currently includes over 180 participants from 45 countries, including many of the most prominent earthquake engineers in the world. Engineers are developing the technical material that is available on the website, and project participants are together looking for avenues to disseminate such information through the website as well as trainings, linkages and collaborations with other organizations, and publications.

The project will continue growing into a truly global resource on earthquake-resistant housing construction practices, by: continuing to provide access to the network of experts and information as freely available; encouraging new housing reports, particularly from countries not represented or poorly represented on the current web site; expanding the project’s proactive role in promoting earthquake-resistant construction through the development of new tutorials on various construction materials and the promotion of existing tutorials including adobe, confined masonry, reinforced concrete frame with masonry infills, and stone masonry (completed), and brick masonry, concrete shear walls, precast concrete and timber (planned); expanding information on construction technologies to include sustainable materials such as strawbale (nearing completion) and bamboo; and advocating for sustainable building practices such as disaster resilient construction practices that are also environmentally sound.

At its core, the project is engaging the “crowd” as part of its strategy. The internet makes it possible to involve experts in many countries and to exchange ideas quickly. Examples of crowd engagement related to this project include: At Bauhaus Universität Weimar in Germany a masters level class with students from developing countries are preparing housing reports as part of their study; various professors in countries including the U.S. are using tutorials as teaching tools in their classes; and, experts from countries with a lot of experience with a construction technology, such as the Mexicans and masonry, are sharing codes, guidelines and expertise with many other countries through their direct involvement in tutorial preparation.

2. CONSENSUS-BASED GUIDELINES AND TUTORIALS

Collapse or damage to buildings often contributes to unacceptably high death tolls and economic losses in a large part of the world affected by earthquakes. Countries in which buildings are built to be earthquake-resistant have successfully reduced losses of life and property. Hence, a better understanding among owners, designers, construction managers and government officials of how various buildings perform will help influence seismic design and construction, saving lives and reducing losses in future earthquakes.

The World Housing Encyclopedia tutorials introduce basic concepts associated with the performance of different buildings types during earthquakes. Each tutorial addresses a single construction type, and is a collection of field and research experiences from across the world on planning, design and construction of each construction method. As a network of engineers and architects from around the world and from many different institutions, the WHE offers credibility through this network, rather than speaking as one individual expert or one institution. In creating tutorials and guidelines, groups of experts are brought together to author sections and/or to review the documents, with the intent to make the documents consensus-based. One weakness in this process is the fact that all the authors and reviewers are volunteers and this can slow the report-writing and reviewing process.

These tutorials, in addition to outlining key factors affecting seismic performance, offer recommendations for improved earthquake-resistant construction practices for new buildings and for strengthening existing buildings at risk. The tutorials also contain links to relevant publications, web sites and video clips.

Tutorials exist on adobe, reinforced concrete frames with masonry infill, confined masonry, and stone masonry (Figure 2.1.). The stone masonry tutorial is discussed further below as an example of collaboration among individuals as well as organizations.

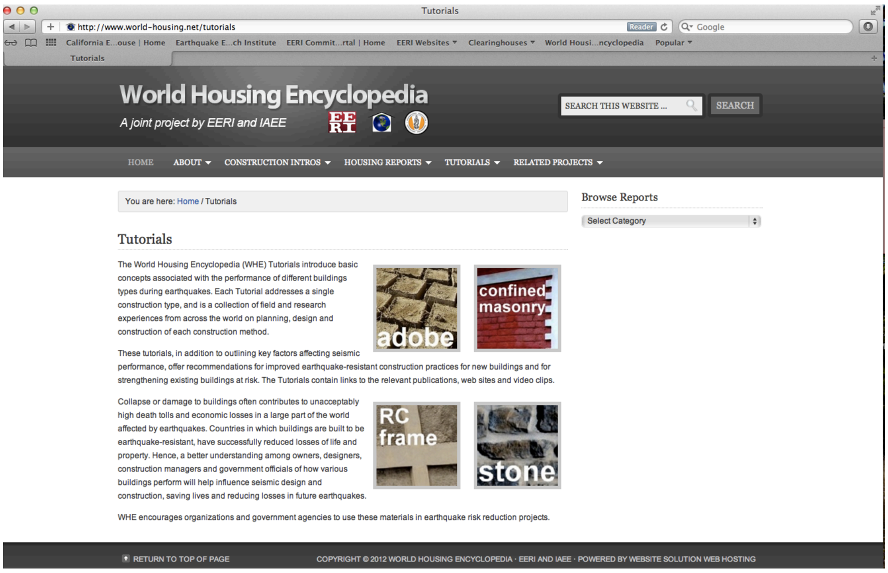

Figure 2.1. Introduction to Tutorials page from WHE website

Work is currently underway on a global guideline for confined masonry construction that is incorporating new information from construction practices and challenges in Haiti. The guideline will address confined masonry techniques for both brick and concrete block construction, and will be targeted to two audiences—builders with basic construction knowledge and architects, masons and builders with more advanced skills. Work is also underway on a tutorial on straw bale construction that is being prepared by a U.S. architect Martin Hammer with experience in straw bale construction in Pakistan and Haiti, and U.S. engineer Dmitry Ozeryansky, with a specialty in sustainable engineering practices. Both of these documents are expected to be completed by the end of 2012. A tutorial on earthquake resistant reinforced concrete walls for low-rise buildings is under development by Russian engineer Rossen Rosskoff.

The first seismic design guideline from the WHE was prepared in 2011 (Meli et. al. 2011). This guideline focuses on low-rise confined masonry construction and was prepared by a working group with experts from 10 countries, headed by Roberto Meli of Mexico and Svetlana Brzev of Canada. This construction technology is considered particularly promising in seismically active countries, and the guideline addresses more specific procedures that need to be followed if a country is considering addressing the particular construction technology in a code. This is an important break-through for the project as providing globally-vetted guidelines is a step closer to influencing local construction practices.

3. DISSEMINATION AND LINKAGES

Two primary goals of the WHE are to share experiences with different construction types and to encourage the use of earthquake-resistant construction technologies. As the project has grown, there is increasing emphasis on linkages with related organizations, and on encouraging the direct use of information developed under this project, particularly the tutorials.

3.1 Influencing better building practices

3.1.1 The Confined Masonry Network

The Confined Masonry Network was created at an international workshop in Kanpur, India, in January 2008, with some of the active WHE participants who are also experts in confined masonry in their countries. The Network is a consortium of individuals and organizations–anyone with an interest in this construction technology is free to join. The technology performs much better in earthquakes than more traditionally-built reinforced concrete frames with masonry infill, in part by changing the construction sequence and building the walls first. The Network is supported administratively by the World Housing Encyclopedia.

The Network is working actively to transfer knowledge of this construction technology from countries where it is widely used, such as Mexico and Chile to countries that would benefit from its use, such as India. As mentioned above, global design guidelines for low-rise buildings have been developed (Meli et al. 2011) and are available on the confined masonry website: http://www.confinedmasonry.org/, along with codes and standards from 10 countries that use confined masonry. A global construction guideline is nearing completion under the direction of Tom Schacher of Switzerland and Marcial Blondet of Peru and engineered guidelines are under development (led by Sergio Alcocer of Mexico and Tim Hart of the U.S.), all involving participation from volunteers around the world.

3.1.2 Collaboration on Stone Masonry Tutorial

Volunteer authors Jitendra Bothara and Svetlana Brzev from the WHE Editorial Board have recently completed a tutorial on stone masonry construction, discussing seismic deficiencies and damage patterns, new construction with improved earthquake performance, and the retrofitting of stone masonry buildings (Bothara and Brzev, 2011). The tutorial has many illustrations and represents a collective effort from a large group of volunteers who contributed photos, illustrations and reviews of many drafts.

It was also a collaborative effort among several organizations. The New Zealand Society of Earthquake Engineering contributed funding (and expertise) to the development of the document. The Earthquake Engineering Center of the University of Engineering and Technology, Peshawar, Pakistan also shared the results of their extensive testing of stone masonry as well as contributed funding towards the publication. The Bureau for Crisis Prevention and Recovery (BCPR) of the United Nations Development Programme (UNDP) supported the printing of 1000 copies of the tutorial which will be shared with UNDP country offices, national governments' disaster management ministries and offices, and used in training programs. The National Information Centre of Earthquake Engineering (NICEE) at the Indian Institute of Technology Kanpur, India is distributing the tutorial for the cost of shipping. The document is also available on the WHE website at http://www.world-housing.net/tutorials/stone-tutorials.

3.1.3 Translations and publication of WHE documents

The WHE editorial board and participants recognize that having English as the language of the website and the various documents can be limiting to those for whom English is not a first language. To get the materials used where there are most needed, particularly with builders and masons in many countries with high seismic risk, members of the Editorial Board and other volunteers in the WHE community have been working to translate some of the tutorials. The original adobe tutorial is available in both Spanish and English (Blondet et al 2003) although the 2011 revised version is currently only available in English. Additional adobe materials written by Editorial Board members are available on the website in Spanish and/or English (Charleson 2011; Vargas-Neumann, Torrealva, Blondet, 2007; Blondet 2010). The confined masonry guide, which was originally developed for Peru (Blondet, ed, 2005), is available in Spanish, English and Chinese. The confined masonry design guideline (Meli, et al 2011) is currently available in English, and is currently being translated into Gujarati. The tutorial on reinforced concrete frame construction (Murty et al. 2006) is now available in English, Spanish and Indonesian (Bahasa). See Figure 3.1. The translations from English were led by Editorial Board members Sugeng Wijanto from Indonesia and Jorge Gutierrez from Costa Rica. The stone masonry tutorial is currently available in English.

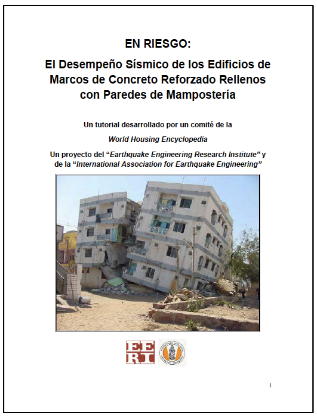

Figure 3.1. Translations of Tutorial *At Risk: The Seismic Performance of RC Frame Buildings with Masonry Infill* into Bahasa Indonesian (left) and Spanish (right)

3.2 Linking to the scientific and engineering communities

3.2.1 Partnership with the U.S. Geological Survey in its PAGER model

The WHE Project is participating in an effort to understand and summarize worldwide construction types, building inventory and seismic vulnerability. The construction types and estimates of who lives and works in these buildings are being used in the development of a rapid post earthquake casualty estimation program, PAGER, at the USGS. The data will also enhance the housing stock distribution and vulnerability data for existing WHE housing reports for different countries. Data from 30 countries and more than a dozen construction types are available on the WHE-PAGER website, http://pager.world-housing.net/. Dina D'Ayala, Andreas Kappos and Helen Crowley, researchers and modelers who are also members of the WHE Editorial Board, have recently finished a comparative study of similar building types using different models. Currently, through a Global Earthquake Model (GEM) risk component, experts are helping determine vulnerability curves for a variety of global construction types that will then feed into the PAGER model. A final report for this project describing the various models and the associated data is available on the WHE website.

In addition to this technical report that has been developed by several modelers, the USGS PAGER scientists are adapting the WHE report summaries for use on the PAGER website and as a resource in an open-file report. They have edited summary descriptions and added material from the reports themselves into the summaries where necessary. When a user goes to the PAGER website to see the alert for a particular earthquake, a link will pop up to the WHE website and the housing reports from the affected country, as well as a link to the soon-to-be-published open-file report that contains all the summaries as of 2012 (Figure 3.2).

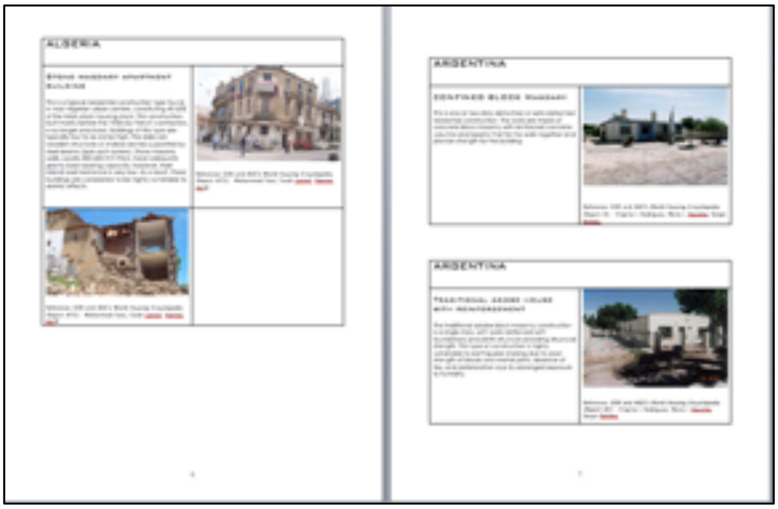

Figure 3.2. Pages from upcoming USGS Open File Report, *A Compendium of Global Building Types*, edited by Kishor Jaiswal, drawing from all the reports in the World Housing Encyclopedia

3.2.2 Participation in the Global Earthquake Model

The WHE resources are being used in several of the Global Earthquake Model (GEM) risk components. The WHE Editor-in-Chief and former Editor-in-Chief are two of the primary authors of the GEM Basic Building Taxonomy and its Glossary (Brzev et al. 2012; Allen et al. 2012). WHE participants more generally will be asked to play a role in further reviews associated with the use of this taxonomy. The WHE project also has a role in the GEM vulnerability component, where WHE experts will be asked to participate in an expert review panel to identify fragilities and vulnerabilities for particular global construction types.

3.3 Strengthening linkages to disaster management professionals

3.3.1 GSDMA using the Confined Masonry Design Guideline

The Gujarat State Disaster Management Authority (GSDMA) in India has recently asked for permission to translate the Seismic Design Guide for Low-rise Confined Masonry Buildings (Meli et al. 2011) into Gujarati for dissemination among architects, supervisors and masons as a companion document to the confined masonry home building manual for social housing schemes they have developed. Both documents will be shared via the WHE website when complete. The GSDMA will be making some modifications to the Design Guideline to make them appropriate to the Gujarat construction and cultural context, in consultation with the primary authors. The Editorial Board encourages this type of adaptation where local experts can use the "base" information in the various tutorials and tailor them to their context, in consultation with WHE experts.

3.3.2 UNDP using the Stone Masonry Tutorial

As discussed above, the Bureau for Crisis Prevention and Recovery (BCPR) of the United Nations Development Programme (UNDP) in New Delhi, India, printed copies of the stone masonry tutorial for use in their training programs in their region, which includes northern India, Bhutan, and Nepal, all countries where vulnerable stone construction can be found. U.N. officials are working with disaster management professionals in these countries to use this document as one part of a training program that focuses on vulnerable construction practices, with an emphasis towards changing such practices.

4. FUTURE PLANS

The WHE project has several long-term goals that will allow the network to play a more active role in facilitating sustainable, disaster-resilient construction practices around the world. While some of these goals require additional funding, there are many that can be accomplished by the enthusiastic dedicated core of volunteers who donate their time and work primarily via email and skype. These goals include:

- establishing consensus-based guidelines on several of the most widely-practiced or promising construction technologies, using as a model the seismic design guideline for low-rise confined masonry construction that has been completed;
- facilitating regional training and capacity-building exercises, by providing consensus-based training guides and supporting regional travel;
- developing opportunities for students to participate actively in the project, through internships, competitions, and field studies; promoting the WHE more widely as a recognized global resource with direct access to the world's technical experts in earthquake-resistant construction,
- developing a web-based clearinghouse--with postings of information on community training programs, training curricula, posters, reports and presentations, and the translation of resources into various languages. The project will soon have its own Linked-In group and is working on strategies to use that group to grow the project and its influence;
- creating an online library of international construction standards related to earthquake-resistant and sustainable design practices;
- developing prototypes of technically, culturally, environmentally appropriate temporary and intermediate housing, making these readily available to countries and NGOs;
- offering and developing technical support, by reaching out to individual country earthquake engineering associations, architects, engineers, NGOs, housing experts and others to make the resources of the site better known;
- developing a resource for post-earthquake management, by creating a section of the website to document temporary shelter designs, and by participating in post-earthquake field surveys and technical support to affected countries on reconstruction strategies;
- developing a pilot model building program that can be adapted by locality and construction technology, encouraging sustainable and disaster-resistant building techniques.

In the next few years, the WHE network looks forward to reaching out and collaborating more directly with architects, building officials, community organizers, builders, social scientists, housing advocates and public policy experts. Making the built environment safer worldwide is a complex and multi-dimensional problem (Comartin et. al. 2004). While earth sciences and engineering technology are critically important, the context is social and cultural, and the WHE network will be most successful through cooperation and collaboration among many diverse perspectives.

ACKNOWLEDGMENTS

The World Housing Encyclopedia project is a collaboration among earthquake professionals around the world. The authors gratefully acknowledge that the work described above has been completed by the large network of volunteers who participate in this extraordinary project. The authors are most appreciative of the opportunity to be involved in the effort and to describe the hard work of this network of individuals.

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