The 14th World Conference on Earthquake Engineering
October 12-17, 2008, Beijing, China

# THE WORLD HOUSING ENCYCLOPEDIA: STRATEGIES FOR GLOBAL INFORMATION SHARING AND PROBLEM SOLVING

**M. Greene[1], C. Comartin[2], C.V.R. Murty[3], and S. Brzev[4]**

[1] *Special Projects Manager, EERI, Oakland, CA, USA E-mail: mgreene@eeri.org*
[2] *President, CDComartin Inc., Stockton, CA USA E-mail:ccomartin@comartin.net*
[3] *Professor, Dept. of Civil Engineering, IIT Kanpur, India Email:cvrm@iitk.ac.in*
[4] *Faculty, Dept. of Civil Engineering, BCIT, Burnaby, BC, Canada E-mail: sbrzev@bcit.ca*

**ABSTRACT :**

This paper discusses some of the tools and strategies that are being used in EERI and IAEE's successful World Housing Encyclopedia (WHE) project launched in 2000. The WHE is a uniquely successful web-based global network of over 200 individuals from 57 countries committed to improving global construction practices by sharing technically accurate, peer-reviewed, consensus-based resources on appropriate construction materials and technologies. All publications and resources developed by project participants and other authoritative sources are available free of charge on the project web site (www.world-housing.net). The core of the network is reports on housing construction practices and technologies from 40 countries (as of this writing). The scope of the network is slowly expanding and participants are also developing tutorials on common building construction technologies and practices with the emphasis on ways to improve their seismic performance. Project participants are currently contributing information on shelters used immediately after earthquakes, and participating in the collection of summary information on the seismic vulnerability of basic construction types in collaboration with the U.S. Geological Survey. The network is web-based and open source. To build this network the project is making pioneering use of the internet as a tool to create and maintain a global community. Everyone who participates is a volunteer, and all the housing reports and tutorials are peer-reviewed. Project participants develop the technical material that is available on the website, and are together looking for avenues to disseminate such information through the website as well as through trainings, linkages with other organizations, and publications.

**KEYWORDS:** Housing, information, education, global, network, earthquake-resistant construction

## 1. INTRODUCTION

The World Housing Encyclopedia (WHE) is a web-based resource of housing construction technologies, practices and guidelines from earthquake-prone countries and regions of the world. A project of the U.S.-based Earthquake Engineering Research Institute (EERI) and the International Association for Earthquake Engineering (IAEE), the WHE was started in 2000, at the 12th World Conference on Earthquake Engineering in Auckland, New Zealand. The project grew from an idea of Chris Arnold, former president of EERI, as a way to share information freely through the internet, with the goals of a) sharing knowledge on housing construction practices; b) encouraging the use of earthquake-resistant technologies; and c) developing guidelines and technical resources for improving seismically vulnerable construction. The project is now working towards d) offering services and technical support to communities across the world on earthquake-resistant housing technologies.

The success of the project lies in the fact that it is much more than a website. The WHE is a truly uniquely global network of individuals who are developing the website as an open source, freely available resource of housing construction technologies, practices and guidance in seismically active countries of the world. To build this network the project has made groundbreaking use of the internet to connect many diverse countries, using the web for a running discussion on housing issues, as a constantly updatable resource, and as a tool to build the network necessary to promote locally-based, sustainable, earthquake-resistant housing solutions.

## 2. THE PROBLEM

The problem of poorly constructed housing in areas of high seismic hazard is one of staggering global dimensions with very serious consequences for developing countries in particular. Recent earthquakes in Pakistan, Indonesia, Peru and China have all tragically demonstrated the vulnerability of the housing sector (Comartin et al 2004). In a single earthquake--the 2005 Kashmir earthquake in Pakistan--over 80,000 people died, primarily in poorly constructed housing. In the 2008 China earthquake, rural housing was also among the most affected sectors. In addition to the tragic life loss, the loss of housing has been enormous in these earthquakes, straining relief organizations and reconstruction authorities: over 3.5 million people displaced in Pakistan in 2005 and over 1.5 million displaced in the Joygakarta Indonesia earthquake of 2006. The number of displaced in the 2008 Sichuan, China earthquake is certainly even higher. Even the moderate earthquake in Niigata-Chuetsu Oki, Japan, in July 2007, caused the collapse of almost 1100 houses and damage to an additional 27,800 houses, resulting in disruption to an even larger number of people. The poor performance of housing in earthquakes is a problem of sustainability, wasting resources that could otherwise be used in creating a more sustainable society. Much of this housing is constructed by skilled laborers or owners, involving no engineers or architects. The WHE recognizes that it is a particular challenge to reach the people who are constructing the most vulnerable buildings with information that can change construction practices.

As the world's population grows, particularly in developing countries, the vulnerability of the housing sector becomes even more pronounced. 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). 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 (World Bank 2003). And, 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). The World Bank estimates that 70% of the world's poor live in rural areas, and over the last 50 years 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. Fragile lands and environmental degradation are important components of vulnerability, exacerbated by poverty. The world's poor often live in the most marginalized locations, extremely vulnerable in disasters.

In addition to fragile rural areas, vulnerability is increasing in megacities. By 2015, the United Nations estimates that 23 cities will have populations over ten million, and of those, all but 4 will be in less developed countries. 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 5 in high-income countries. Of the top ten urban agglomerations projected for 2015, eight are cities with a known moderate to high seismic risk, including Tokyo, Mumbai, Dhaka, Karachi, Mexico City, New York, Jakarta, and Kolkata (United Nations 1999). 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.

## 3. PROJECT DESCRIPTION

### *3.1 Background and Structure*

The WHE project started in 2000, and has grown, using the internet and volunteers, to a website in 2008 that has 113 housing construction reports from 40 countries, in addition to tutorials and a resource library. The database is peer-reviewed, searchable and users can submit additional questions to a feature called ASK WHE. An active network of volunteers communicates regularly on current WHE activities.

Participants work online in the back-end of the database. Reports are not visible until reviewed. For some construction types and countries, this is one of the few, if not the only, place where such detailed information is easily accessible, e.g. housing construction in the former Soviet Union (Russia, Kyrgyzstan, Kazakhstan, and Uzbekistan).

A consistent format is used to describe each housing construction type. Each report includes illustrations, as well as an estimate of the vulnerability of that construction type. Typically reports have been prepared by senior earthquake researchers in the various countries represented. See Table 1 below for typical examples of summary information in the WHE site.

**TABLE 1. EXAMPLES OF CONSTRUCTION TYPE SUMMARIES**

| | |
|---|---|
| **INDIA**<br>*Reinforced concrete frame building with masonry infill walls designed for gravity loads*<br> | The construction of reinforced concrete buildings with brick masonry infill walls is a very common practice in urban India for the last 25 years. Such construction is found throughout urban areas of the country. Most such construction is designed for gravity loads only in violation of the Indian Standards Code for earthquake-resistant design. These buildings performed very poorly during the Bhuj earthquake of January 2001 in which several thousand such buildings collapsed. The collapse was not limited to the epicentral region. About 75 RCC frame buildings collapsed and several thousand others were damaged in and around Ahmedabad, which is over 250 km from the epicenter, clearly demonstrating the seismic vulnerability of this construction. Jaiswal et al. (2003) |

| | |
|---|---|
| **CHILE**<br>*Reinforced clay/concrete block masonry building*<br> | This is a rather recent construction practice followed since 1970s, and it has been widely used for dwellings and up to 4-story high apartment buildings. Buildings of this type can be found both in urban and rural areas of Chile. The main load bearing elements are masonry walls reinforced with vertical steel reinforcement bars placed in the hollow cores of clay masonry units (hollow clay tiles) or concrete blocks. Horizontal reinforcement bars are placed in horizontal bed joints. Masonry shear walls are tied together at floor levels by means of reinforced concrete beams, in a regular structural layout. Stiffness distribution both in plan and elevation is uniform.<br><br>Prior to 1986 there was no seismic design code for this structural type. During the March 3, 1985 Llolleo earthquake, performance of buildings of this type was rather poor, mainly due to construction problems, such as partial grouting in the hollow cores with reinforcement, poor quality of the mortar, and lack of horizontal reinforcement. Following the earthquake, the Chilean Design Code NCh1928 code was published based on the U.S. Uniform Building Code (UBC-1979) and the seismic performance of this construction type reported in previous earthquakes. Since 1993, when the last version of NCh1928.Of93 was published, and more restricted requirements were enforced, the use of this type of construction has been less frequent, in part due to economic reasons. (Moroni et. al. 2002) |

In addition to the country-specific housing reports, the web site also includes tutorials, related documents and links, and animations and presentations that can be used freely by others. The tutorials on basic construction materials can be downloaded from the site. Tutorials currently exist on adobe construction, confined masonry construction, and reinforced concrete frame buildings with masonry infills, and work is underway on a stone masonry tutorial. Each tutorial is developed by a group of volunteers from the project—the stone masonry tutorial, for example, is being developed under the leadership of a WHE editorial board member from New Zealand (formerly from Nepal), with help from colleagues in Pakistan, Slovenia, Italy, India, the U.S. and Canada. Volunteers work primarily via e-mail and Skype, a voice over internet protocol technology.

### *3.2 Objectives*

It is the mission of the World Housing Encyclopedia to: 1) develop strong international consensus on scientific and engineering issues related to safe housing; 2) look for technically credible and affordable solutions; 3) convert scientific and engineering data into accessible guidelines and procedures to communicate both the need for and implementation of safe housing construction; 4) provide a continuing resource and repository for such information; and 5) advocate for and assist local communities in meeting the challenges of safer housing construction.

Currently the project most specifically benefits the global earthquake-resistant housing construction community, and those who provide training to builders in developing countries. An ultimate aim of the project is to reduce the unacceptably high loss of life from earthquakes in developing countries. In the future, more tools will be developed that directly influence construction practices. Specifically, project participants are working towards a) developing further tutorials, online training courses and toolkits for trainers; b) developing a clearinghouse function of the web site where information can be shared and discussed on research and testing, field research and reconnaissance, and training curricula; c) translating materials into different languages; d) and most importantly, playing a proactive role by establishing partnerships with other organizations, and working with colleagues and government officials in specific countries to promote earthquake-resistant construction.

### *3.3 Strategies to Encourage Innovation and Transfe*r

#### *3.3.1 Global passion*

The project involves the global engineering and housing community—anyone with technical expertise is welcome to participate. The strength and success of the WHE is directly attributable to the large number of experts who are willing to contribute their time and knowledge to the project. Project participants are passionate and committed to reducing earthquake risk by improving knowledge. Some of the recent global initiatives undertaken by the WHE network are described in the paper by Brzev, Greene and Murty (2008).

#### *3.3.2 Strong volunteer base*

One of the remarkable features about the WHE project has been the large number of volunteer hours that have been contributed (estimated at over 15,000 hours in a 7 year period). The recent, very successfully received, tutorial on reinforced concrete frame construction was written by a small group of volunteers who each contributed at least 100 hours of time (Murty et al., 2006). Reviewers for the tutorial contributed another 20 hours each. One firm donated much of the time necessary to design and build the original web site. The retiring editor-in-chief and his students spent over 500 hours of volunteer time in helping to design and build the new web site.
During the same 7-year time period the project has benefited from support from EERI (approximately $160K to date) and a $100,000 grant from the Engineering Information Foundation. Much of that funding was used in the early years of the project to bring together small groups of participants for organizing meetings, for one large workshop with all project participants at the time, and for website development. If the 15,000 hours of estimated volunteer time were valued at $100/hour, the donated time would equal approximately $1.5 million.

#### *3.3.3 Use of the internet*

The WHE network is making pioneering use of the internet as a tool to create and maintain this global community, including active participation from some countries where travel and other means of communication might be more difficult. The communication scheme among the members of the network has proven to be extremely cost-effective and sustainable. .

#### *3.3.4 Open source*

A very compelling reason to participate in this project is the fact that all information is open source and free. Anyone can go to the website and download reports, contribute reports, use the ASK WHE function, sign up for periodic newsletters, read tutorials, and look up additional resources. When involved in report or tutorial preparation there are many opportunities to interact with colleagues in very diverse countries and to learn more about their approaches to housing construction.

#### *3.3.5 Minimal bureaucracy*

One of the project's innovations has been its minimal bureaucracy (one EERI staff person spends some time on this project; it is otherwise governed by an editorial board of 24 volunteer members from 16 countries) and its use of the internet to build and maintain this global network at a very low cost.

#### *3.3.6 Everyone an equal*

It is a unique resource because it is truly global in scope and all participants are seen as equals. Everyone feels ownership in the project. 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 includes 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.

*3.3.7 Peer review*

All the housing reports and tutorials are peer-reviewed. The report submission process includes a technical review that provides opportunities to exchange information across language and geographic boundaries. Through the review process engineers, architects and housing experts have the opportunity to interact with colleagues from diverse cultures, gaining an understanding of housing and earthquake design issues in different parts of the world.

*3.3.8 Informal communications and language editing*

The Editor-in-Chief and the editors and reviewers all work with participants informally, encouraging participation, comments and feedback. Participants must submit reports in English, which is often not their first or second language. They are encouraged by editors and EERI staff to submit, even if the language is not polished. The intent is that the review process will help polish the language. And, as long as the meaning is clear, most users of the site are not put off by some language mistakes in the reports that are visible on-line.

### *3.4 Governance*

The network has over 180 participants from more than 45 countries and an even larger number who are on the e-newsletter mailing list. The WHE 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 who provide direct day-to-day management for the project. The current (retiring?) EIC is based in Kanpur, India. The Editorial Board has 23 members from 17 different 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. A smaller Executive Committee of this Board will provide direct project oversight as the WHE grows. It is also scheduled that a Board of Governors will be appointed to provide the management over the editorial board and project participants, and to assist with fundraising. The EIC will function as the Executive Director.

Two non-profit professional associations, the U.S.-based Earthquake Engineering Research Institute and the International Association for Earthquake Engineering, are the umbrella organizations for the project. These organizations provided the initial leadership to start the project, and representatives from both governing boards sit on the WHE Editorial Board.

## 4. THE FUTURE

The network is gaining increasing recognition from international organizations, who are asking for opportunities to partner with the WHE, and/or to build on the knowledge base in the WHE. After the May 2008 Sichuan earthquake in China, the WHE was contacted by Approach Architecture Studio in China for permission to translate the confined masonry tutorial into Chinese and then to distribute the Chinese version to farmers and builders in rural areas of China. The ASK WHE feature is routinely used by NGOs with technical questions and/or building in high seismic zones. Depending on the question, the editorial board is polled and responses combined by the Editor-in-Chief and forwarded back to the NGO. The U.S. Geological Survey has contracted with the WHE project to provide basic vulnerability and inventory data on construction types in various countries—to date WHE participants in 26 countries have filled out additional forms and the information is currently being analyzed and will be posted back on-line in September 2008.

The challenge of improving the world's housing construction practices so that housing is not as vulnerable in earthquakes is 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 whatsoever 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, with the ultimate goal of improving performance of housing in earthquakes, in an affordable, environmentally appropriate and sustainable manner.

## 5. ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Earthquake Engineering Research Institute and the International Association for Earthquake Engineering, as the parent organizations for this project. Our deepest gratitude goes to the volunteers who are the heart of the project—without them, the project would not be possible.

## 6. REFERENCES

Brzev, S., Greene, M., and Murty, C.V.R. (2008). *Non-Ductile RC Frames and Alternative Improved Construction Technologies*, **Proceedings of the 14th World Conference on Earthquake Engineering,** Beijing, China.

Comartin, Craig et al., 2004. *Opinion Paper: A Challenge to Earthquake Engineering Professionals*, **Earthquake Spectra**, vol. 20, no. 4, November 2004

Geohazards International, 2004. **At Increasing Peril…People in Cities of Developing Countries**, web address: http://www.geohaz.org/ginfo/atperil.htm.

Jaiswal, K., Sinha, R., Goyal, A. *Reinforced Concrete Frame Building with Masonry Infill Walls designed for Gravity Loads*. **World Housing Encyclopedia (www.world-housing.net)**. Earthquake Engineering Research Institute and International Association for Earthquake Engineering, India/Report 19, 2003

Moroni, O., Gomez, C., Astroza, M. *Reinforced clay/concrete block masonry building*. **World Housing Encyclopedia (www.world-housing.net)**. Earthquake Engineering Research Institute and International Association for Earthquake Engineering, Chile/Report 5, 2002.

Murty, C.V.R, Brzev, S., Faison, H., Comartin, C.D., and Irfanoglu, A. (2006). **At Risk: The Seismic Performance of Reinforced Concrete Frame Buildings with Masonry Infill Walls**. Earthquake Engineering Research Institute, Publication No. WHE-2006-03, First Edition, 70 pp (free download available at www.world-housing.net).

United Nations, 1999. **World Urbanization Prospects, The 1999 Revision**, web address: http://www.un.org/esa/population/publications/wup1999/WUP99CH1.pdf.

World Bank, 2003. **World Development Report 2003: Sustainable Development in a Dynamic Economy. Transforming Institutions, Growth, and Quality of Life.** Washington DC: The World Bank Group.