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IMPROVING HOUSING SEISMIC SAFETY IN DEVELOPING COUNTRIES: THE WORLD HOUSING ENCYCLOPEDIA

A. Charleson[1], S. Brzev[2], K. Jaiswal[3] and M. Greene[4],

[1] Associate Professor, Victoria University of Wellington, New Zealand, andrew.charleson@vuw.ac.nz
[2] Formerly, Faculty, British Columbia Institute of Technology, Canada, svetlana.brzev@gmail.com
[3] Research Civil Engineer, U.S. Geological Survey Golden CO, USA, kjaiswal@usgs.gov
[4] Formerly, Special Projects Manager, Earthquake Engineering Research Institute, USA, greene.marjorie@gmail.com

Abstract

The World Housing Encyclopedia (WHE), a joint project by EERI and IAEE, is reliant upon the contributions of volunteers who are committed to improving the knowledge base of housing construction practices in seismically active areas of the world. The mission of the WHE is to disseminate information about different housing construction types and encourage the use of earthquake-resistant technologies worldwide. Despite limited resources, the committed, skilled, and experienced WHE contributors have produced materials that are making a difference. The two primary initiatives of the WHE, a worldwide database of housing types and construction tutorials, guidelines for select predominant building types, are described in this paper. In addition to information about each of the WHE's main publications, their effectiveness and potential readership are also discussed. With these new developments and the impact that they have created over the years, the WHE is in a unique position to start thinking about the following questions:

• What are the pressing needs for improving the seismic safety of buildings in developing countries that could benefit from the WHE involvement?
• Where are the gaps in the current resources offered by the WHE?
• The WHE publications fall in the category of technical guidelines. Are there other areas of focus that might be more effective, such as helping prepare materials to raise public awareness for the need of better building standards?
• What other forms of assistance might the WHE be able to provide to improve seismic safety in developing countries?

The answers to these questions, along with the knowledge gathered through the process thus far, illustrate the many opportunities for the WHE and organizations with similar goals to improve the seismic safety of houses in developing countries.

Keywords: housing; seismic safety; resilience; education; awareness; construction technologies

1. Introduction

The World Housing Encyclopedia (WHE) initiative was launched in 2000 at the 12th World Conference on Earthquake Engineering held in Auckland, New Zealand. The overall vision of the WHE is to increase the seismic resilience of housing in developing countries. It continues to be a volunteer effort involving more than 200 earthquake engineering professionals from around the globe. Launched as an initiative of the Earthquake Engineering Research Institute (EERI) and the International Association for Earthquake Engineering (IAEE), it continues to be sponsored by both organizations. The WHE initiative is overseen by a voluntary Executive Committee, which is supported by an EERI staff member; all other work is done by volunteers who contribute their time and expertise to grow the WHE repository. The original aim of the WHE was to develop a repository of world housing construction types. This task is well advanced with reports on approximately 160 housing types from 42 countries and territories [1]. In the last few years, there has been an ongoing effort to produce tutorials for improving seismic safety of construction technologies (e.g., adobe, stone masonry, confined masonry) that were identified to be most vulnerable and were covered in the housing reports. These tutorials are mainly related to non-engineered construction, and are intended to be used by a broad audience, including builders, architects, engineers, government officials, and homeowners [1].

The primary resource of the WHE is an online database that contains a detailed description of housing construction types from around the world. The database, or encyclopedia as it is called, is an entirely online resource, accessible and free for anyone at http://www.world-housing.net [1]. Reports of each type of construction are presented using a standardized format. All relevant aspects of housing construction such as socio-economic issues, architectural features, structural systems, seismic deficiencies and earthquake resistant features, performance in past earthquakes, available strengthening technologies, building materials used, and construction process and insurance, are covered in each report. In addition to the text and numerical information, several illustrations (photos, drawings, sketches) are also included. In 2015 an option for a short report was developed, to encourage more submissions. Submissions for both types of reports continue to be enthusiastically accepted. The reports aim to provide substantive in-depth understanding of various construction types and their relative vulnerability to earthquakes. For some construction types, this is one of the few, if not the only source of such detailed information in English. The framework created by this project provides an inexpensive and effective way for earthquake professionals in many countries to share knowledge on construction practices and retrofit techniques. A summary publication of housing reports in 2004 gathers together reports of similar construction types for comparative purposes [2].

In addition to this housing database, a range of other online resources, known generically as 'Tutorials', have been developed. As of this writing, several tutorials related to improving seismic resistance of various construction technologies based on the best practices from various countries, are available on the web site. Some of these tutorials, such as the tutorial on adobe construction [3], are available in Spanish and English. Also concentrating on the needs of developing countries, a tutorial on reinforced concrete (RC) frame buildings [4] was developed. This tutorial highlights the deficiencies associated with inadequately engineered RC frame construction which showed poor performance in the aftermath of the 1999 Turkey and Taiwan earthquakes and the 2001 Bhuj, India earthquake. Translated into Indonesian and Spanish, it addresses the technical challenges that this type of construction presents. Although used very extensively worldwide, masonry infill construction contains significant inherent flaws that are all too often exposed by damaging earthquakes. A tutorial on the construction and retrofit of stone buildings [5] was used as a reference by professionals interested in improving seismic safety of rural stone masonry dwellings after the 2015 Gorkha, Nepal earthquake.

In 2008, the WHE group introduced a new initiative called the Confined Masonry Network, in collaboration with the National Information Center of Earthquake Engineering (NICEE) in India and with the initial sponsorship of the World Seismic Safety Initiative (WSSI) and Risk Management Solutions Inc. The network has one major objective: to improve confined masonry design and construction practices where they are currently in use, particularly in areas of high seismic risk. A web site (www.confinedmasonry.org) was created to provide a growing repository of resources related to confined masonry construction, including training materials, guidelines, and research papers. The members of the network have developed several global guidelines for the design and construction of confined masonry buildings. The network provides a platform for discussion on issues related to confined masonry design and construction in seismic areas [6].

A WHE-Prompt Assessment of Global Earthquakes for Response (PAGER) project is an initiative that was sponsored by the U.S. Geological Survey between 2007-2012 [7]. Through its multiple phases, the WHE volunteer experts came together to contribute towards the development of two specific components of the USGS PAGER system: a global building stock model, and a global vulnerability model. In the first phase, experts from around the world helped to estimate an approximate distribution of predominant building types in each of 26 countries that were identified by the PAGER team, and provided, by judgment or statistical survey, collapse fragility characteristics for the predominant structure types in each country. In a subsequent phase, additional data were compiled and the WHE experts provided parameters necessary to create analytical indoor fatality-rate vulnerability functions for more than 40 non-US structure types [8]. In the subsequent phases, the WHE experts conducted further data enhancement and validation exercises. By employing multiple modeling approaches on previously compiled capacity/fragility parameters of select structure types, the efforts highlighted some of the strengths and weaknesses of the existing analytical modeling approaches [9].

Over the last 16 years, the WHE repository has experienced significant expansion in terms of the worldwide coverage of the housing types included, and through the WHE tutorials. Riding this wave of success, which is predominantly based upon volunteered contributions, it is timely to reflect upon the directions which the WHE could be taking into the future. To assist this process, we examine two recent publications [8, 9] in the following section that focus upon seismic safety in developing countries.

2. Literature review

This section reviews two publications that are relevant to ensuring that the WHE engages in activities strategic to achieving a seismically safer world. The first publication is 'Saving lives in earthquakes: successes and failures in seismic protection since 1960' by Robin Spence [10]. After showing how most deaths during earthquakes are due to just a few events in developing countries, Spence reports on a survey of earthquake engineering experts from 22 regions and countries. The two questions (of a total of four) in his survey most relevant to this paper are, first, a request for a list of the most significant local successes and failures of earthquake protection during the past 50 years. Second, the experts were asked to note any success in implementing new codes of practice in the design and construction of new buildings, and comment upon major obstacles. He presents three conclusions that are particularly relevant for developing countries. First, that improved seismic safety is more likely to be achieved through public awareness rather than law: 'an informed public is necessary to ensure that building control does get applied' (p. 219). Secondly, it is essential that professionals are registered, and adequately educated and trained. And finally, preparations to change regulations and construction practices need to be made prior to those 'windows of opportunity' created by damaging earthquakes.

As well as these critical suggestions, Spence also identifies several other important actions for improved seismic resilience. He recommends taking seriously the vernacular construction that had a good seismic track record in building planning decisions. Rather than relying on passive mitigation through building code and planning regulations, it is important to employ more active measures that entail improved communication with people, public education and training of people involved in the local building sector. He envisions that normal professional activity, of say an engineer or architect, could include provision of technical support for small-scale building projects (p. 233). In addition to noting the importance of disseminating and utilizing new technology relevant and appropriate for traditional building materials such as masonry, he also notes the importance of creating a culture of safety by:

- 'Education and outreach programs.
- Public advocacy for new legislation.
- Prioritising action for retrofitting schools.
- Developing earthquake insurance schemes.' (p. 240).

To some degree, the WHE is engaged in education and outreach through the publication of various tutorials. However, its role to date has been passive. Tutorials have been completed and made available online but without significant face-to-face engagement with those who would benefit from them, such as tutors and students in tertiary institutions or building inspectors, contractors and even building owners. A more active program of disseminating these materials would ensure their wider use.

'Building regulation for resilience – managing risks for safer cities', published by the World Bank Group (WBG) and the Global Facility for Disaster Risk Reduction (GFDRR) [11] is the second document particularly relevant to this paper. By analysing the current dysfunctional situation and looking towards the future, this report can function as a lens through which to focus the WHE strategy. The basic premise of this report is that poor quality construction is the main contributor to increasing disaster risk, and that reformed and pro-active building regulatory approaches represent the way forward. It is noteworthy that the report 'is a resource to assist policy makers, governments, and donor entities in leveraging good-practice building code regulation into effective

disaster risk reduction (DRR) strategies' (p. 14). As such, the report can be expected to be relevant for non-governmental initiatives like the WHE.

Speaking to the situation of many developing countries, the report begins by identifying the reasons for the failure of regulatory policy and implementation. While acknowledging the impact of poverty, the following factors are identified:

- ineffective land use systems,
- weaknesses in building code administration and institutional capacity,
- insufficient legislative foundations,
- unaffordable compliance costs for the poor,
- insufficient recognition of prevalent building practices,
- dysfunctional regimes of building controls, and
- corruption and regulatory capture where, for example, industry reduces safety standards for its own benefit.

The report then presents three basic components of a successful building regulatory framework, namely, 'a legal and administrative framework at the national level, a building code development and maintenance process, and a set of implementation mechanisms at the local level' (p. 16). Regarding the building code component, mention is made of the "ecology" of supporting institutions and activities like building professionals' and labor force education programs, the contribution of professional societies and licensing for building professionals. These are areas where the WHE can continue to contribute.

Then, becoming more specific, the report presents the main development priorities including:

- Directing regulatory and governance reforms toward compliance advice and support rather than just police enforcement.
  The WHE tutorials are examples of the sort of advice and support that can lead to safer structures. These tutorials could be adopted by a local building authority, undergo modifications to reflect local building practices, and then be translated and republished. Recently, the WHE tutorial on stone masonry construction was used as reference by the Government of Nepal officials working on reconstruction following the 2015 Gorkha, Nepal earthquake, and they intend to translate the tutorial to the Nepali language. Many more tutorials could be developed to cover the numerous different yet prevalent combinations of building materials and structural systems.

- Developing the capacity of national and subnational institutions.
  This includes adequate financial compensation of building officials coupled with training, and promoting 'public understanding of the importance of safe siting and construction practice.' (p. 17). Once again it is feasible that the WHE documents could be adapted and used as part of training programs for some of or all of the levels of the building industry, beginning with professionals, through to technically skilled people like building inspectors and large to medium-sized contractors, and finally, to site personnel such as masons. Perhaps the WHE could also consider preparing materials for the public in order to raise their awareness, and hopefully support changes to more supportive, transparent and effective building regulation processes.

- Focusing on creating building standards appropriate to the poor and vulnerable.
  The stone masonry and adobe WHE tutorials especially are applicable to these groups of building owners. The confined masonry tutorials may also be relevant. If building authorities were aware of them, the tutorials could be adapted to local building standards, provided, as the report reminds us, that the creation of building standards needs to be a participatory process and that legal tenure of land is more accessible. The WHE could possibly even go a step further by preparing draft model building codes that would be suitable for adaptation to local conditions. For example, members of the Confined Masonry

Network have developed a guide for seismic design of low-rise confined masonry buildings. It is intended to be used as a model code for countries that do not have code provisions for this construction technology [12]. The creation and maintenance of any building standards, as the report states, should be based upon appropriate research. The WHE database contains a wealth of information relevant to DRR in developing countries. It is an obvious resource for researchers intent upon improving the seismic performance of housing.

3. Discussion

It is worth noting the degree of agreement between the two primary documents reviewed above. Although Spence highlights the importance of public education over the use of law, the latter is currently largely ineffective in reducing disaster risk; the WBG and the GFDRR publication focuses on reforming the building control sector so that it functions actively and in a supportive fashion. The passivity that Spence is critical of would be diminished.

The magnitude, complexity and difficulty of the reforms identified in both documents represent a huge challenge. Even if seriously addressed in just one local area, the implementation of these reforms would require considerable financial and other resources expended over many years. And just as importantly, it would require the input and unprecedented collaboration of national government, local government, building officials, consulting engineers and architects, as well as input, advice and support from non-governmental organizations (NGO)s and other supportive agencies. Bearing these factors in mind, together with the analyses and suggestions from the two documents above, we can begin to address the specific questions posed in the abstract of this paper.

• *What are the pressing needs for improving the seismic safety of buildings in developing countries that could benefit from involvement by the WHE?*

Given that the WHE currently draws upon the resources of skilled and experienced professional volunteers, the DRR needs that the WHE is best suited to assist with are related to the further development of its published resources as well as the maintenance and broadening of its building database.

• *Where are the gaps in the current resources offered by the WHE?*

No doubt there are many building types for which tutorials or construction guidelines need to be prepared in order to improve seismic safety. Most of the WHE resources developed to date have been proposed by the contributors rather than being solicited by the WHE leadership.

While there *are* gaps in the current list of the WHE publications, the bigger problem seems to be a lack of dissemination and penetration of the WHE materials into those sectors and individuals whom we expect to benefit from these materials. Although all resources are available free of charge, there is no proactive effort to disseminate them in specific communities. This is certainly not a small task since the WHE targets almost all seismically prone countries of the world.

Perhaps the WHE needs to take more initiative and become more proactive. Initially it needs to work more closely with its supporters in developing countries and find out what is needed. Maybe existing materials need to be reworked? For example, if local authorities in some countries knew what we have already published including possibly one or more housing reports from their own geographical area might some authorities be interested in partnering with the WHE to customise its materials for their own situation? This is particularly true for post-earthquake situations, where the WHE efforts could be integrated with post-earthquake Learning from Earthquakes (LFE) missions by EERI and other organizations.

• The *WHE publications fall in the category of technical guidelines. Are there other areas of focus that might be as, or perhaps, more effective, such as preparing materials that raise public awareness, for example for the need of better building standards?*

The lack of distribution of the WHE materials in areas of the building sector is mentioned above. Perhaps a series of more general and simple publications to communicate with the general public are also required. Their purpose would be to challenge entrenched attitudes regarding seismic risk, including fatalism that result in inaction. These publications could also be designed to make the public more aware of the value of safe building in a way that leads to improved building regulatory processes. In order to be able to create these publications the WHE can draw upon its database of housing reports in order to explain potential seismic vulnerabilities in the houses the intended readership is familiar with. Then professionals with the required skill sets related to preparing non-technical publications should be involved.

• *What other forms of assistance might the WHE be able to provide to improve seismic safety in developing countries?*

To date, the WHE's contribution to seismic safety could be described as largely passive. Already some suggestions towards more active strategies have been made. But what other options are there? Perhaps the WHE could work in collaboration with multi-lateral agencies (like the World Bank, UNDP) and their disaster management arms (e.g. GFDRR).

4. Conclusions

A series of questions regarding how the WHE can continue to contribute towards achieving an increase in the worldwide seismic safety of housing have been posed and reflected upon. Two pertinent recent publications, whose reviews are included in this paper, have been used to focus attention on the above questions.
The main findings arising from this process are as follows:

- In order to ascertain the seismic safety of housing needs that the WHE might help meet, the WHE could develop stronger links with multi-lateral agencies and appropriate individuals and organizations in developing countries,
- The WHE could initiate partnerships with interested and motivated local authorities to see how WHE materials can be modified for local conditions to help improve housing safety, and
- Given the importance of raising public awareness of seismic risk and damage mitigation approaches, the WHE could prepare some simple publications for dissemination.

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