OPINION

Trends in Global Urban Earthquake Risk: A Call to the International Earth Science and Earthquake Engineering Communities

Introduction

There is a new "seismic gap" that we—members of the international Earth science and earthquake engineering communities, including members of the Seismological Society of America (SSA) and the Earthquake Engineering Research Institute (EERI)—need to know about: the large and growing gap between the seismic risk of rich countries and that of poor countries. We need to know about it because it threatens rich and poor countries alike, because what is being done about it is not enough, and because we are in a unique position to narrow it.

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Trends in Global Urban Earthquake Risk

Urban earthquake risk in poor countries is large and rapidly growing. Fifty years ago, the population of the world's largest earthquake-threatened cities was equally divided between rich and poor countries. Today, there are five times as many people in poor as in rich earthquake-threatened cities. Fifty years ago, the earthquake resistance of buildings in rich countries was better than that of buildings in poor countries, and since then it has steadily improved, while that in poor countries has steadily worsened. Data of the U.S. Office of Foreign Disaster Assistance indicate that the average number of deaths resulting from fatal earthquakes in rich countries decreased by about a factor of 10 between the first half of the 20th century and the last half. This improvement in seismic safety is presumably the result of, among other things, better building and land-use codes and better enforcement of those codes. By contrast, there are indications that earthquakes in developing countries will increase their lethality in the future. At last year's SSA conference, Roger Bilham described how we should expect in this century an earthquake that will kill as many as one million people in a developing country.

We can see this trend of growing lethality of earthquakes in developing countries by considering large earthquakes in northern India. The 1950 M 8.6 earthquake in Assam killed 1,500 people, but Max Wyss estimates in "Human Losses Expected in Himalayan Earthquakes" (*Natural Hazards* **32**, 2004) that an earthquake of the same size and location today would kill about 45,000 people, an increase of about a factor of 30. The population in this region is estimated to have increased since 1950 by only a factor of 3, thus indicating an order of magnitude increase in the lethality of earthquakes due, presumably, to poorer construction. Similarly, a repeat today of the 1897 M 8.3 earthquake near Shillong would kill, Wyss estimates, 60 times as many people as were killed in 1897. Because the population of the region has increased by only a factor of about 8 since 1897, this suggests again about an order of magnitude increase in the lethality of earthquakes in the region. The replacement of single-story bamboo homes with multistory, poorly constructed concrete-frame structures, often on steep slopes, makes this region perhaps a worse case, but more typical settings (*e.g.*, Kathmandu, Nepal) also indicate a significant worsening of construction practice and urban planning in recent years in cities of developing countries.

The future does not look better. In the next 20 years, the world's population will increase by 2 billion. Of that 2 billion, only 50 million will be added to industrialized countries, the rest to developing countries. Because of internal migration, from the countryside to cities, the urban population of developing countries will increase *by itself* by 2 billion people over this period. Imagine that in the next 20 years the combined population of today's India and China will be added to such cities as Algiers, Cairo, Istanbul, Ankara, Aleppo, Teheran, Tabriz, Mashed, Kabul, Quetta, Rawalapindi, Delhi, Calcutta, Dhaka, Yangon, Manila, Jakarta, Mexico City, Guatemala City, Bogotá, Quito, and Lima. Recall that the 8th World Conference on Earthquake Engineering occurred only 20 years ago. In that same amount of time, 2 billion people will appear in some of the world's poorest cities and will need places to live, learn, and work. Given the lack of resources and the urgency to build, the quality of construction will, unless something changes quickly, continue to decline.

What is being done to improve global urban earthquake risk management?

More is being done today to address the increasing seismic risk of developing countries than at any time in history. (A comprehensive review of recent activities concerning natural risk reduction will soon be published by the United Nations' International Strategies for Disaster Reduction.)

The United Nations' International Decade for Natural Disaster Reduction (IDNDR) launched many activities around the world from 1990–1999. Under the IDNDR, the national governments of a majority of countries drafted National Action Plans and submitted them at the Yokohama Conference in 1994. Through its Secretariat and prestigious Science and Technology (S&T) Committee, the IDNDR was to provide the required scientific and technological leadership to the National Committees and to the individuals and institutions committed to the issues of disaster risk reduction. With the IDNDR's 1994 Yokohama Conference recommending a shift of focus from disaster *response* to disaster *mit-*

igation, the importance of the S&T Committee grew. Individuals, myself included, were motivated by the ideals of IDNDR, stirringly expressed by Frank Press at the 8th World Conference on Earthquake Engineering, when he proposed the establishment of the IDNDR.

Many other organizations have, since the launch of the IDNDR, joined the cause. The rest of the UN family—including UNDP, UNESCO, UNICEF, UNCRD, WHO, and PAHO—is active in natural disaster management. Many multinational governmental organizations, such as the North Atlantic Treaty Organization, the Organisation for Economic Development and Co-operation, and the Organization of American States, have their own distinct activities to improve seismic safety. Nongovernmental organizations focusing on the needs of particular regions have also been created, for example, CEDPREDENAC in Central America; PREANDINO in the Andes; and, in Southeast Asia, ASEAN, the Asian Disaster Reduction Center, and the Asian Disaster Prevention Center. Many national governmental agencies working on international development have been reanimated and focused. These agencies include the U.S. Agency for International Development, the Japan International Cooperation Agency, the U.K.'s Department for International Development, Germany's Gesellschaft für Technische Zusammenarbeit, and similar Scandinavian organizations.

Never have more nongovernmental organizations, both local and international, been working on natural disaster risk. These organizations include the International Federation of the Red Cross and Red Crescent Societies, Save the Children, CARE, the Aga Khan Development Network (including FOCUS Humanitarian Assistance), Tearfund, and the organization for which I work, GeoHazards International. Even more nonprofit organizations in developing countries themselves have emerged, including, for example, the National Society for Earthquake Technology-Nepal, the Sustainable Environment and Ecological Development Society in India, and LA RED in Latin America. Some universities are now offering degree programs in natural disaster management. A new industry has been created over the last ten years focusing on natural risk management. Never have there been more conferences, symposia, seminars, workshops, and training sessions on natural disaster management than in recent years. I have had the privilege of getting to know some of the people working on reducing risk in their communities and can say that I have never met a more hard-working, innovative, and dedicated group.

Are current efforts to reduce urban global earthquake risk "enough"?

To answer this question, one must first define what is meant by "enough."

One could say that we are doing enough if, for example, by 2025 all people in earthquake-prone areas of the world would have an equal risk of dying due to earthquakes. This might, however, be considered too high a standard because we do not demand equality elsewhere (for example, in the risk of dying due to diarrhea or malnutrition). Perhaps one could say that we are doing enough if by 2025 people in developing countries are only 10 times more likely to die due to earthquakes than people in developed countries, and the risk in developing countries is not increasing. Or one might focus only on children, and say that we are doing enough if by 2025 all children are equally safe from earthquakes. (If we accepted this standard, we have our work cut out for us: GeoHazards International estimates that today a child in a school in Kathmandu is 400 times more likely to die from earthquakes than a child in a school in Tokyo.) Another definition could be that we are doing enough if, by 2025, populations in earthquake vulnerable communities know their risk and accept it.

I propose yet another definition: We are doing "enough" if by 2025 the world's most vulnerable countries can expect to develop their economies, societies, governments, and cultures free from the threat of periodic reversals by natural disasters.

Using this definition, I conclude that, at present, we are *not* doing enough.

If my definition seems too demanding, we should realize that developed earthquake-threatened countries (*e.g.,* the U.S., Japan, and Italy) certainly would not tolerate periodic reversals of their development due to earthquakes or other natural disasters. The cost of the 1994 Northridge earthquake was about 1% of the regional (not national) gross domestic product (GDP), and the cost of the 1989 Loma Prieta earthquake was only about .2 % of the regional GDP. By contrast, the cost of the 1972 Nicaragua earthquake was 40% of that country's entire GDP, and the cost of the 1986 El Salvador earthquake was 30% of that country's GDP. Munich RE data indicate that in the period from 1985 to 1999, the world's richest countries' losses to natural disasters averaged about 2% of their GDP's, while the poorest countries' losses averaged about 13% of their GDP's.

Having observed this problem for more than a decade, I believe that in the case of global urban earthquake risk reduction the world is spending too little, often in the wrong places and often with unknown effectiveness.

The amount of resources directed toward poor countries in developing regions from most donor countries is too low according to the UN. Total international assistance amounted to about $57 billion in 2002, which represents about 0.2% of the global GDP. The UN has recommended that 0.7% of the GDP of each donor country should be given to development assistance. The U.S. has consistently not met this target. For example, in 2000, it gave just 0.1%. Only five countries meet or exceed this target: Denmark, Norway, the Netherlands, Sweden, and Luxembourg.

Only a small fraction of total international assistance goes to natural disaster reduction. A recent study by Tearfund (a U.K.-based charity) reports that usually less than 10% of the humanitarian assistance budgets of multinational and bilateral donor organizations is devoted to natural disaster risk *reduction* (*e.g.*, preparedness, prevention, and mitigation). A much greater amount (unfortunately, not known

precisely) is routinely directed to postdisaster *response* (*e.g.*, recovery, reconstruction, and relief). What is most troubling to me is that this bias for disaster response over reduction has continued despite the 1994 call of the UN's IDNDR for a shift from response to reduction. Tearfund cites an example of current priorities. In 2000, after learning of the forecast for a heavy rainy season, Mozambique appealed to the international donor community for $2.7 million to prepare for the expected floods. Half this amount was provided. Once the devastating floods arrived, the international donor community awarded $100 million for emergency assistance and, later, pledged an additional $450 million for rehabilitation and reconstruction.

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This continued emphasis on disaster response over reduction would be unimaginable in other theaters of social work. Imagine if our sustained response to the AIDS epidemic were to invest primarily in hospital beds, rather than in education and cures. Imagine if our long-term response to an increase in auto accidents were to hire more paramedics, rather than to strengthen enforcement of seat belt laws.

When the IDNDR ended, at the end of the 1990's, it was replaced in the UN with the more modestly funded International Strategies of Disaster Reduction (ISDR). Through no fault of the staff of the ISDR, some of the momentum of the IDNDR has been lost. The IDNDR's National Committees have been dismantled, which was a blow to the morale of the national organizations and resulted in a setback in their national initiatives. The Science and Technology Committee no longer exists. There has been neither formal evaluation of the achievements of national governments nor any systematic monitoring of the National Action Plans.

Understandably, the investments by national development agencies reflect the priorities of the donor nations. Thus, resources of these agencies are directed where there is an overlap between the need of the vulnerable locals and the interests of the foreign donors. This means that some highly vulnerable countries are ignored, while others become the favorites of the development world and are provided with perhaps more aid than they can efficiently absorb.

There are yet other reasons for concluding that what is being done is not enough. The most sophisticated techniques of risk management have been developed for the insurance of capital, which is primarily in developed countries. Too often, pilot projects—which are exciting to conceive of and launch, but difficult to continue—are not improved and then replicated on a large scale. Too many of today's workshops, conferences, seminars, symposia, and training courses "preach to the choir" and to the same choir. (This paper addresses that same choir.) We have manuals and guidelines, usually in English, to teach earthquake-resistant construction, but how many hands-on training courses are there for masons in developing countries? How many programs are aimed at increasing the *demand* in poor countries for earthquake-resistant construction? Perhaps the most visible evidence of our lack of progress is the annual occurrence of newspaper stories describing the unexpected collapse of schools, often recently constructed schools, due to earthquakes.

Should we care?

Why should the citizens of industrialized countries, distant from most earthquake-threatened developing countries, care that there is a growing gap between the seismic risk of developing and industrialized countries and that not enough is being done? There are four reasons.

One is humanitarian. Knowing that we might make a difference, how can we not care that a child in Kathmandu is hundreds of times more likely to die from an earthquake than a child in an earthquake-prone industrialized country? Seeing the effectiveness of the Field Act in strengthening Californian schools against earthquakes, how can we not be motivated to make known its features to others? Observing the drop in the lethality of earthquakes in our countries since good building and land-use codes were developed and enforced, how can we not want to share our experience?

We should also care out of self-interest. We in industrialized countries understand that the growing gaps between rich and poor in our own countries led to social tensions. We can therefore realize that the widening of the gap between the industrialized and developing worlds is threatening. We will be more secure if all countries can develop without being periodically set back by natural disasters. It is in our *economic* self-interest, particularly, that developing countries become earthquake-resistant because they are increasingly important economic partners of the U.S., Japan, and the EU. Often the infrastructure, residences, and factories of developing economies represent investments made by the industrialized world.

The North Atlantic Treaty Organization (NATO) also considers that helping developing countries manage their earthquake risk is in its self-interest. For example, NATO is organizing a workshop to address the problem of seismic risk of public buildings in the Maghreb Region (Tunisia, Morocco, and Algeria) because (1) NATO is in the business of stability, (2) mass migrations are destabilizing, and (3) natural disasters (such as earthquakes) cause mass migrations. NATO's previous "Science for Peace" program is now known as the "Security through Science" program.

A third reason we should care is for reasons of timing. As noted by Roger Bilham [see article in this issue, page 706], the growth of human population in the next 20 years will create history's greatest construction boom. Homes, schools, and workplaces must be built for those 2 billion people who will be added to the cities of developing countries over this period. If we can make this construction conform to good building practice and good land-use planning, we can avoid problems in the future. We can train masons in earthquake-

resistant construction. We can help create a demand for the skills of these masons. Eventually, existing vulnerable buildings will be replaced or strengthened.

Finally, we should care because we can make a difference. SSA and EERI, in particular, can make a difference. The earthquake science and engineering of the U.S. are exemplary, but, in my opinion, the characteristic of the U.S. earthquake profession that most distinguishes it and is most responsible for its success in reducing U.S. earthquake risk is the ability and willingness of its members to apply their science and engineering to public policy. Members of SSA and EERI form the backbones of such organizations as the California Earthquake Prediction/Probability Council, the recently discontinued National Earthquake Prediction Council, the Central U.S. Earthquake Center, the California Seismic Safety Commission, the Bay Area Earthquake Preparedness Program, and the Southern California Earthquake Preparedness Commission. I have had difficulty finding analogous organizations in developing countries. The members of SSA and EERI could, therefore, help earthquake-threatened developing countries by sharing their experiences designing and implementing effective public policy. Further, SSA and EERI, as organizations respected for their technical expertise, have the credibility to act as advocates for international seismic safety.

How can the international Earth science and earthquake engineering communities help?

I will propose four modest activities and one ambitious one. (Some organizations, such as SSA and EERI, have recently embarked on activities similar to the modest ones proposed here.)

First, these communities could urge the World Bank, the United Nations, and national development organizations to increase, relatively, the amount of investment in disaster mitigation compared to that in disaster response. Increasing this proportion has been suggested by many people, and large international development banks even recognize the logic of doing this, but for the last decade the balance has been heavily in favor of response. To help people when they are in greatest need, by providing search and rescue, recovery, and reconstruction, attracts the attention of the news media and is therefore politically attractive. But these efforts should not displace resources that could be used to prevent death and losses. The international earthquake professional societies could use their credibility to argue that an adjustment of priorities is called for and to recognize governments and organizations that make that adjustment.

Second, these communities could lobby their own governments to fund earthquake professionals to improve earthquake risk management in foreign communities. In the U.S., this would mean that SSA and EERI would urge U.S. government organizations such as NSF, USGS, and FEMA to fund activities, including research, connected with international earthquake risk. Imagine if the U.S. and Japan designed programs to use their new, large shake-table facilities to test designs, construction methods, and retrofit techniques of indigenous, nonengineered housing. Imagine if the international construction industry worked on methods to build earthquake-resistant earthen structures and other types of construction practiced in rural parts of the developing world.

Third, members of international earthquake communities could work with large international construction companies, the UN, and international development banks to develop better methods of reconstructing communities that have been destroyed by earthquakes. In some recent earthquakes, the understandable pressure to provide housing quickly in order to get survivors out of temporary tents and into more permanent structures has led to the construction of settlements that the local people do not like (and sometimes soon abandon) and that are not always earthquake-resistant. Furthermore, the construction is often done by nonlocal workers, so the opportunity to train locals in earthquake-resistant construction methods is lost. It must be that the organizations (such as the World Bank, the Asian Development Bank, the Inter-American Development Bank, and the UN) funding such reconstruction would desire settlements that are earthquake-resistant and acceptable to the locals, but the pressure to build something quickly may lead to compromises. The capacity to rebuild a community quickly is not possessed by many companies, and many of those that do possess this capacity come from industrialized countries and therefore are most familiar with nonlocal construction methods and materials. The international Earth science and earthquake engineering communities could urge the international development banks and large construction companies to develop construction methods and procedures, in advance of the next disastrous earthquake, that would use material and skills found in developing countries.

Finally, the international Earth science and earthquake engineering communities could create a "window of knowledge" for earthquake professionals in developing countries by setting up an Internet consultancy opportunity with interested members. We could create a "tree" of consultants around the world who are willing to answer questions by e-mail about topics in their specialties. The purpose is to develop leadership in developing countries. At GeoHazards International, we often receive questions from people around the world who want to know more about earthquake risk and how to reduce it. We do not have the staff to respond. Further, we also receive frequent offers by earthquake professionals and advanced graduate students to become involved and to help. Resources are needed to direct the information requests to the volunteers.

These four ideas propose to use existing organizations (modified and properly funded) to address global earthquake risk. These ideas would contribute to achieving global earthquake safety, but probably not "enough", according to the definition that I have proposed above.

Jean-Francois Rischard argues in *High Noon: 20 Global Problems and 20 Years to Solve Them* (Basic Books, 2002) that no existing organization is capable, by itself, of successfully

tackling any of today's global problems. In addition to natural disasters, the twenty global problems he considers include greenhouse gas emissions, fisheries depletion, water shortages, global warming, and global infectious diseases. Each problem extends across national boundaries. Their solutions require more time than the average politician's term of office. Their solutions are needed quickly. Their solutions are complex, cutting across many social boundaries. Global earthquake risk has these characteristics. One can interpret Rischard's views in Darwinian terms: The world's current global problem-solving mechanisms are organisms that are not adapting fast enough to the changes in their environment.

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The situation confronting us can be described in another way. If the organization Mothers Against Drunk Driving operated as the international earthquake professional communities do, it might focus on holding conferences to discuss, for example, advances in techniques to measure the alcohol content of blood, and the link between drunk-driving deaths and the time of day. If the organizations Handgun Control and the National Rifle Association behaved as we earthquake risk professionals do, they might concentrate their energies on improving the quality of their journals and conferences. If the leaders of these organizations and those of Amnesty International, Greenpeace, and Sierra Club behaved as we do, we would not know of them and, more to the point, they would not have advanced their causes to the extent they have.

This paper is not a criticism of what the international earthquake professional associations have done or a call to reduce what they are doing. The quality of our technical journals (*e.g., BSSA* and *Earthquake Spectra*) and the quality of our technical conferences (*e.g.*, the SSA and EERI annual meetings) are what gives the membership of these organizations the capacity to do more. It is because of this excellence that we have the authority and opportunity to apply what we know to solve urgent social problems. It is because of what we know about the problem of global earthquake risk that we have the obligation to do more.

We need a new mechanism to tackle global earthquake risk. This is the final and most radical suggestion for the international Earth science and earthquake engineering associations.

An International Earthquake Safety Advocacy Federation

Following the thinking of Rischard, we who are concerned about global earthquake risk could create an international earthquake safety advocacy federation. (This is probably not the best name, but it attempts to avoid rather overused terms such as "committee", "network", and "coalition.") The word "federation" is suggested here as opposed to "Federation", because we might not want or need to create a formal legal entity. As should become clear, this international organization would be very different from the International Association of Physics and the Earth's Interior and the International Association for Earthquake Engineering.

Rischard suggests that this federation would have three primary components. There would be a network of carefully selected representatives of government, business, universities, and the civic sector. This network would not be all inclusive but would contain only the individuals who are able and willing to contribute to the development of this movement. The second component would be an independent advisory panel of respected members of the Earth science and earthquake engineering communities. This would give the movement its needed credibility. The third component would be an ongoing electronic town meeting, that is, an international Internet linkage.

The initial work of this movement, according to Rischard, would be to agree on where the at-risk countries need to be in 20 years, how they can get there, and what the norms to measure their progress should be. Its ongoing work would include rating countries and businesses on meeting norms, applying moral pressure when necessary, lobbying governments for support of prevention and mitigation activities, and promoting best practices and the exchange of information.

We can imagine various products of such a federation. It might conceivably be able to exert fiscal and moral pressure to encourage the application of sound construction and zoning techniques. What if, for example, the degree to which international construction projects incorporated seismic-resistant techniques were known and made public? What if the efforts of governments to enforce their own building codes were made known to Wall Street and other centers of international investment that consider development projects in those countries? This could be a powerful new way to motivate the development of a culture of earthquake safety. A list could be published of the, say, five countries having the best earthquake-risk management programs and the five that have the least adequate programs. This list could be distributed to international reinsurance companies, international corporations, and publishers of tour guides.

Possible Reactions

I have heard several concerns regarding these ideas. One is that advocacy is outside the mission of many professional associations. Another is that advocacy can feel like "lobbying", which does not sit well with the personalities of many researchers: Researchers collect facts, and elected officials decide how to apply them to public policy. One concern is that the amount of funding for earthquake risk is fixed and therefore, if we were successful in describing the needs of developing countries and their relevance to, say, the U.S., the amount of funding available for current research would be reduced. This would cause difficulties with current research programs and teams. Another criticism is that there already are too many organizations working on earthquake risk; cre-

ating yet another would not be helpful. Finally, these ideas are outdated, naïve, and idealistic.

There are various possible responses. If one refers to the mission statements of some professional associations, for example, those of SSA and EERI, one might conclude that if we continued to restrict ourselves to research and its application to the U.S., we would actually be *failing* to fulfill the missions of our organizations. All members of the professional associations would not need to become lobbyists; rather, the associations would merely have to include advocacy among their activities. If society supports research on earthquakes merely to learn about the Earth, in the case of Earth science, then there would be no need to help assure that the results of our research are applied to society. But if our work as Earth scientists and earthquake engineers is supported by society because we can make society safer, then we must augment our research with activities that influence public policy. Influencing public policy involves politics. Advocacy for new research would not necessarily reduce the level of funding for current research and it might even increase it. It could add new topics of research. Clearly the proposed federation must be unlike anything that exists today. Finally, and most importantly, it might be argued that it would be more naïve and idealistic—if not irresponsible—to continue doing what we are doing if we claim that our current actions will significantly decrease global earthquake risk.

Conclusion

The large and rapidly growing global urban earthquake risk, particularly in developing countries, is a problem that needs to be solved, quickly, for the sake of rich and poor countries alike. More is being done today to solve this problem than at any time in human history. But what is being done is still not enough, if by "enough" we mean that sometime in the near future all countries can avoid periodic, devastating setbacks in their development by earthquakes. Tackling this problem requires more than a modification and augmentation of what we have been doing. We need a radical new approach, such as the creation of an international earthquake safety advocacy federation. The international Earth science and earthquake engineering communities (in the U.S., SSA and EERI) can play a critical role in making these changes.

The prospects of tackling this program are invigorating. There are new research opportunities. There is the chance to apply our science and engineering to public policy internationally. We can create a model that can be applied to solve other urgent and complex global problems, and thereby improve the human condition on a global scale.

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This paper is based on an invited talk, the President's Lecture that I gave at the 15 April 2004 meeting of the Seismological Society of America (SSA). In his invitation, the President of SSA asked me to suggest ways in which members of SSA and SSA itself could contribute to reducing global earthquake risk. By coincidence, I had also been invited to give the 1906 San Francisco Earthquake Memorial Lecture, two days earlier, at a meeting of the San Francisco Chapter of the Earthquake Engineering Research Institute (EERI). Because EERI and SSA are sister organizations, I took these opportunities to collect my thoughts on how *both* SSA and EERI could contribute to reducing global earthquake risk, although my opinions on this matter were not solicited by EERI. In the process of writing this paper for *SRL*, I decided to expand my original remarks and address the international Earth science and earthquake engineering communities.