Earthquake Disaster Reduction in Developing China

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ABSTRACT :

To fully account for the severity of earthquake disasters in China and the complexity of earthquake disaster reduction efforts, this paper introduces the policy and countermeasures taken in China for earthquake disaster reduction as well as the latest development and achievement in the three frontlines for the efforts, that is, earthquake monitoring and prediction, earthquake disaster reduction and emergency response search and rescue. Challenged by the tragedy of the May 12, 2008, Wenchuan Earthquake in Sichuan Province, the paper further elaborates our latest thoughts on effective earthquake disaster reduction and its future direction in China.

KEYWORDS: China, Development, Earthquake, Disaster Reduction

1. Policy evolution of earthquake disaster reduction in China

China is one of the countries which have very high seismicity in their continents and have suffered severe damage from past strong earthquakes. More than half of China's land locates in an area with intensity VII or above, which includes 23 provincial capitals and 2/3 of the large cities with population over 1 million people. In the 20th century, 1/3 of continental earthquakes with a magnitude over 7 occurred in China and the number of people died in earthquakes within China accounted for more than 2/5 of the total death number worldwide. Since 2000, there have been two earthquakes with a magnitude over 8, which are the November 14, 2001 west of Kunlun Mountain Pass event and the May 12, 2008 Wenchuan Earthquake in Sichuan Province.

Researchers in earthquake science and people who work for earthquake disaster reduction in China are confronted with a mounting task and a very complex situation. Firstly, the Chinese continent locates among the interactive region under the pressure from the Euro-Asian, Indian and Pacific plates. The Chinese continent has a very complicated dynamic environment, varied geologic structures and many types of mechanism for earthquake occurrence. The uneven spatial distribution of seismic activity makes it even more difficult to understand and master earthquake activity and its disastrous consequences. Secondly, as the most populated developing country, China is restrained because of its economic conditions in its activity to enhance its capacity in earthquake resistance, to promote education on earthquake disaster reduction for the general public and conduct extensive research on earthquake disaster reduction. Thirdly, with the rapid economic growth and fast rate of urbanization in China, earthquakes are posing an increasingly higher risk onto the valuable human lives and the development of economy and society. The fast erection of new buildings and the coexistence of old and new buildings, coupled with the uneven distribution of regional development, have elevated the difficulty in earthquake disaster reduction.

With many years of hard work in searching, China has formed its unique earthquake disaster reduction policy that has considered the special characteristics of earthquake disasters in China as well as the overall economic conditions. There is a long history in China during which the brave Chinese people have continuously defended

their property and territory against the threat of strong earthquakes. China has accumulated a rich data set for historic earthquakes which contains probably one of the longest and best catalogues worldwide. Mr. Zhang Hen, a Chinese scientist, invented the famous Houfeng Seismograph over 1800 years ago even in East Han Dynasty. Zhaozhou Bridge, which is a bridge built over an arch, survived many earthquakes and the erosion of wind and rain for thousands of years. It is still fully functional these days. After the establishment of the People's Republic of China, the Chinese government further tuned its focus on earthquake disaster reduction by continuously searching for a better strategy for earthquake disaster reduction and increased the efforts for further earthquake disaster reduction. With many years of practice in China and learning from lessons from other countries as well, we believe that the following are essential in earthquake disaster reduction. Firstly, to understand the mechanism of earthquake occurrence and to predict the earthquake occurrence with good accuracy are not only a scientific demand in human's desire to understand science of nature, but also a demand placed on us by the society for earthquake disaster reduction. Built upon the basis of consistently improved monitoring and the progress on earthquake research, we have tried to explore and practice on earthquake prediction with real active application of the prediction results into earthquake disaster reduction efforts. Secondly, to study on the mechanism of earthquake damage and disaster evolution and develop engineering countermeasures in a systematically improving earthquake resistance of various engineering structures and infrastructures for effective reduction in human casualty, economic loss and societal impacts require the development and progress of earthquake science and technology as well as establishment of relevant regulations and laws to increase the earthquake resistance for the whole society. Thirdly, after the occurrence of a major earthquake, fast emergency response and advanced techniques in search and rescue are important steps toward earthquake disaster reduction. We have strived to develop earthquake emergency response and emergency handling technology to improve our capability in emergency response for expanding the efforts of immediate earthquake emergency response.

The basic policy in earthquake disaster is to prevent disasters, rapidly respond and deliver relief care to the affected population after an earthquake with disaster prevention as the fundamental strategy. In implementing the basic policy, we rely on the government to take the lead with help of forces from all sectors of the society to fully push forward our efforts on earthquake monitoring and prediction, earthquake disaster mitigation and emergency response, search and rescue.

2. Achievements of earthquake disaster reduction in China

2.1 Completion of the new national earthquake observation network and continuous efforts to explore earthquake prediction

With many years of hard work, China has built a national network on earthquake observation which covers the whole country and includes seismic, precursory and strong motion observation networks. There are 900 fixed stations for seismic observation which ensures that any earthquake with a magnitude over 3 in over 90% of China can be monitored. It also comes with the capacity to monitor earthquakes with a magnitude as low as 1 in the selected key monitored areas. There are 1160 stations for strong motion observation, and over 800 precursory monitoring stations that can observe gravity, earth's magnetic field, crustal deformation, earth's electric field and underground fluid. The completion of this advanced modern earthquake observation network provides a solid basis to carry out exploration and application of earthquake prediction research and for accumulation of rich and large volumes of observation datasets for future earthquake research.

Earthquake research in China is still in a stage that is mostly composed of meaningful try-and-errors. We have accumulated an experience in more than 200 cases for earthquake with a magnitude 5 or above and a big amount of precursory information for the extensive research on exploring the evolution mechanism of earthquake precursors. Although we missed more than we succeeded in earthquake prediction, the successful prediction of the 1975 Haicheng Earthquake was the first example in human history of earthquake prediction for a large earthquake. It not only achieved huge benefit in earthquake disaster reduction, but also increased the

confidence level in mankind's pursuit of earthquake prediction efforts.

2.2 Holistic approach on Earthquake disaster mitigation before an earthquake

In 1998, the Law on Protection against and Mitigating Earthquake Disasters was put into practice. In addition, the State Council subsequently issued 4 regulations which include earthquake emergency response, earthquake prediction management, earthquake safety evaluation, and earthquake monitoring. All the regional governments, which are composed of provinces, autonomous regions and municipals, have issued their own version of regulations that correspond to national ones for earthquake disaster reduction. At this time, a basic legal framework has been formed which consists of national laws, national administrative regulations, regional regulations, ministry specific guidelines and regional guidelines from regional governments. Furthermore, there are currently 10 national standards and 38 industry specific standards for earthquake disaster reduction.

To further increase the earthquake resistance of engineering structures in China, we have compiled the national zoning map for strong ground motion and have issued the latest seismic design code for buildings to clearly enforce for earthquake disaster reduction for engineering structures. For important structures which have profound impact on citizen's life and nation's interest and projects which have potential serious derivative consequence, a site specific earthquake safety evaluation will be carried out to verify design ground motion for the projects. These examples include projects such as the Three Gorges Dam and Reservoir System, The Qinghai-Tibet Railway, The Olympic Facilities in Beijing and thousands of other important facilities which all have their own site-specific earthquake safety evaluation to determine the appropriate design ground motion for earthquake resistance. In many cities within China, the checking of earthquake resistance has become an indispensible component in the process of approving an engineering construction project.

For countryside where the earthquake resistance is relatively low, in recent years we have drafted and implemented an important large-scale project, which is called "Earthquake Safety for Rural Residence", to increase the earthquake resistance capacity of buildings in the countryside. Through education programs for earthquake resistance and disaster reduction in the countryside, we try to introduce farmers to earthquake safety program and at the same time we work to provide technical assistance on building an earthquake safe structure. Through training programs we plan to cultivate experienced construction workers in the countryside. For low-income families, financial assistance will be provided for their new construction as well as any earthquake retrofitting programs, which have benefitted more than 3 million rural residential families. In February, 2005, an earthquake with a magnitude of 6.2 occurred in Kashi of Xinjiang Uygur Autonomous Region, which caused essentially no damage to the rural residential houses which had been constructed with earthquake resistant techniques. During the May 12, 2008 Wenchuan Earthquake, the newly constructed rural residential houses with earthquake resistance successfully endured the strong shaking from the earthquake which resulted in a great reduction in the number of the casualty within the region.

In many cities, a large number of fundamental government projects were specifically designed and implemented for earthquake disaster reduction, which includes detecting the active faults, evaluation of earthquake risk, earthquake micro-zoning, earthquake damage estimation, and the investigation on earthquake resistance of buildings and basic infrastructures. The results are applied directly to estimate the earthquake disaster risk and form the measures for the preparation and control of earthquake risk. Regional and city-level earthquake preparedness and disaster reduction plans are drafted to guide the engineering construction to avoid active faults and soft soil sites as well as the retrofitting of buildings and basic infrastructures.

For effective earthquake disaster reduction, we also put a high priority on the research, development, application and implementation of technology and techniques. There is a wide application in engineering practice of new earthquake resistant and base-isolation techniques, and of new materials which are energy efficient as well as environment friendly with high earthquake resistance. A good number of large-scale structural dynamic testing facilities are built nationwide. The national network on strong ground motion observation has recorded many earthquakes, including more than 400 stations which recorded the recent May

12, 2008 Wenchuan Earthquake. These records will provide a very valuation data source for attenuation study as well as earthquake resistance researches both in China and around the world.

Special focus is also turned toward the education programs to the general public for earthquake disaster reduction. Various forms of media are deployed to propagate the knowledge and information on earthquake and its disaster reduction. Strong efforts have been put to distribute and delegate earthquake relevant information and knowledge to schools, communities and villages. Earthquake resistant model schools are built to prepare for earthquake threat. During the recent May 12, 2008 Wenchuan Earthquake, more than 2200 students and teaching staff were evacuated within 1 minute and 36 seconds in Sangzao Middle School of Anxian County. There were no casualty and no injury reported from the school during this event. Sangzao Middle School was built to be a model school for earthquake safety. In recent years, a number of education centers for earthquake disaster reduction have been built nationwide which are geared toward education for the general public with free access.

2.3 Achievements in Emergency Response, Search and Rescue

National Preparatory Plans for Earthquake Emergency Response has been drafted based on the National Guidelines on Emergency Response Management for Destructive Earthquakes. The relevant ministries underneath State Council and regional governments at various levels all have completed their preparatory plans for earthquake emergency response. The steering and commanding organizations for earthquake emergency response have been set up at the central level as well as in all the provinces, autonomous regions and municipals. The technically equipped and advanced emergency response systems have been constructed at the central and provincial levels. 6 collaborating coalitions have been formed nation-wide for earthquake emergency response to support each other in sharing personnel, equipment and technology in case of occurring large earthquakes.

Although China is late in establishing its professional search and rescue teams, a fast progress has been made and a strong presence is felt worldwide. At this time, China International Search and Rescue Team as well as 26 provincial search and rescue teams have been formed with a total number of members reaching up to 3000. CISA has been dispatched to Algeria, Iran, Indonesia and Pakistan for search and rescue efforts after the disastrous earthquakes happened in those countries recently. In 2008, the construction of the national training center for earthquake emergency search and rescue has been completed and is already put into daily practice for training programs.

2.4 Continuous Improvement in Scientific Researches on Earthquakes

Currently the researches related to earthquakes have formed a number of top-rated specialty fields with their own characteristics. A new scientific platform has been built for innovation in observation, experiment, research and development. The broad-band digital seismographs with China’s own intellectual property rights have been developed domestically, which are not only deployed to China’s national network for seismic observation, but also exported to many countries and regions. The completion of the national key science project “Crustal Movement Observation Network of China” has fundamentally changed the landscape of the dynamic observation for crustal layers of the earth system and greatly enhanced the scientific research capabilities in earth monitoring from the space and in crustal movement. A national key research laboratory and fine national key field observation stations have been built. The national key fundamental research programs for large earthquake prediction based on the hypothesis of dynamics of continental active blocks and damage and control of urban engineering have led the elevation in fundamental research activities on earthquake occurrence and its damage control. Extensive exchange programs have been set up for international collaboration. Formal relationships have been formed with over 50 countries and/or regions for collaboration and exchange of research results on earthquake study.

3. Future Development of China's Earthquake Disaster Reduction

The economy and society in China will still enjoy an explosive growth in the foreseeable future and the challenge of earthquake disaster only mounts stronger as time progresses. In order to protect our citizen's lives and the harmonic growth of our economy and society, we will have to continuously enhance our ability for increasing earthquake safety of the whole society. Therefore, in 2006, the Chinese government has formally approved its 15-year plan for earthquake disaster reduction, which is called the National Plan for Earthquake Disaster Reduction (2006-2020). The overall goal set in the national plan is described as follows. By 2020, China should be systematically resistant for a magnitude 6 earthquake, which is equivalent to the ability of resisting an intensity that is same as the fortification intensity at any given site, while large and medium-size cities as well as economically developed regions should be earthquake resistant as medium developed countries are. The strategy for developing this capability can be summarized as the following three aspects. One is that the key focus will be put on large cities and metropolitan areas with an aim toward a complete earthquake resistance. Two is promoting scientific innovation to increase the effectiveness of efforts on earthquake disaster reduction. Three is through raising the awareness, knowledge transfer and societal technology culture cultivation of earthquake disaster to form a cohesive societal team in defending the society from the threat of future earthquakes.

It is planned that by 2010, we will reach the following goals. Large cities and metropolitan areas will become the first group to be earthquake resistant for a magnitude 6 event. Demonstrative prototype areas will be selected and engineering structures in the selected areas will be built as earthquake safety examples for the countryside. Earthquake early warning system will be built and prototype projects with earthquake emergency precautionary system will be tested in selected key infrastructures and lifeline engineering projects. 40% of the general population will be exposed to education programs on earthquake disaster reduction. A 200,000 people team will be formed for voluntary efforts for earthquake disaster reduction. A first phase earthquake emergency supply system will be built. Life and medical support will be dispatched to people affected by an earthquake within 24 hours after its occurrence. The research and development center will be built which state of the art facilities and world renowned research staff. The national digital observation network will be improved and enhanced for both continental and offshore earthquake monitoring. Dense earthquake observation arrays will be deployed in key monitored regions and major cities selected for intense earthquake monitoring. All these combined should be able to form a solid foundation for systematically improving our ability in innovative earthquake research with continuous exploration for earthquake prediction.

In order to reach the goals set forth above, Chinese government has started a number of strategic projects for national earthquake safety to realize the goals set in the first phase until 2010. The major component of these national projects include:

A. The exploration of seismic background in China
B. Earthquake prediction research and experiment field in China
C. Social service of earthquake information in China
D. Earthquake professional infrastructure building in China

The May 12, 2008 Wenchuan earthquake of Sichuan Province is the most destructive and influential event and it is also the most difficult event in terms of emergency response search and rescue. The earthquake resulted in a loss of life for over 69,000 people while more than 18,000 are still missing as of today. In addition, there are more than 370,000 injured during the earthquake. The direct economic loss expected from this event easily surpassed 845s of billions in RMB. The earthquake disaster reduction efforts demonstrated in this event not only are a full test of what has been done in terms of earthquake preparedness and disaster reduction, but also revealed new lessons and inspiration for us to learn in the coming years. At this time, we are organizing for a systematic and scientific investigation, summary, and research. We have planned to carry out the following tasks.

1. Enhance the enforcing of administrative monitoring and management of earthquake resistance and fortification for both urban and rural areas; improve current laws and regulations for earthquake safety; designate specifically a government agency for administrative earthquake monitoring and management; increase the efforts in legal enforcement of relevant laws and regulations, and finally to increase the earthquake resistance levels for all engineering structures.
2. Continuously push for exploration and investigation on earthquake prediction; cultivate the interest for various parties on earthquake prediction research; take full advantage of the general public in capturing earthquake precursors and in earthquake preparedness; increase the density of earthquake observation networks; enhance our understanding of the deep and shallow underground structures beneath major geologic faults and structures.
3. Publicize earthquake information including our selected key regions for earthquake monitoring and preparedness.
4. Further strengthen the team building for professional earthquake emergency response teams, especially those teams at national and provincial levels; increase training programs for the teams; improve the coalition mechanism among different teams.
5. Gradually improve on the fast earthquake intensity reporting network; start the construction of prototype systems for earthquake early warning.
6. Research to establish earthquake catastrophe insurance systems in China.

Research in earthquake engineering is a very important part in earthquake resistance building. The rapid development of Chinese economic construction and social progress has posed many challenging questions for earthquake engineering researchers. The Chinese government has paid high attention to issues in this field and has promised a continuously increasing support for research activities in earthquake engineering.

Earthquake disaster is a common natural threat confronted by all human beings on the Earth. Only through sustained international collaboration to resonate the intelligence and power of everyone on earth, through tireless efforts without hesitation, will it be possible to maximize the reduction of earthquake disasters. The Chinese have learned many valuable lessons from around the world on earthquake disaster reduction, and we are willing to conduct mutual exchange and collaboration with earthquake scientists from every place to share our own experiences and lessons for finally marching toward the goal of continuously reducing earthquake disasters