Review and Prospect of Earthquake Relief Work in Urban and Rural Construction of China

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ABSTRACT: The backgrounds of seismic hazards and urban-rural development in China at the present stage are introduced, the significance of earthquake relief work is admirably brought out, and the major progresses in recent years are reviewed and concluded. Meanwhile, the present situations of earthquake relief work in urban and rural construction are analyzed. Finally, based on the overall goal of the development of earthquake relief work in urban and rural construction of China, the specific prospects of working focus and developing trends in the future are proposed.

KEYWORDS: Seismic hazard; Urban and rural construction; Earthquake relief work

1. INTRODUCTION

China is one of the countries which are most vulnerable to seismic hazards. At present, China has entered a new era to build an overall well-off society. It is a great issue for Chinese government that how to succeed at earthquake relief work and reduce the earthquake losses to a bare minimum with the rapid development of urban-rural economy and society. Based on previous experiences of earthquake damages, the improvement of earthquake fortification in engineering construction is the most important point in reducing seismic hazards. In recent years, the Chinese government has taken countermeasures to strengthen urban-rural earthquake resistant capacities, and continuously increased the supports on scientific researches in earthquake resistance and disaster prevention, thus numbers of remarkable achievements have been obtained. The 14th WCEE, being convened during October 12th to 17th in Beijing China, provides a good platform for earthquake engineering experts and scholars around the world to exchange ideas, experiences and cooperate with each other. Reviews and prospects of recent earthquake relief work in urban and rural construction of China are briefly conducted in this paper, and more good communions are expected.

2. BACKGROUNDS OF URBAN-RURAL SEISMIC CONSTRUCTION

2.1 Disaster Backgrounds

Earthquake is a kind of sudden natural disaster with huge destruction which imperils people's lives and property. Especially in the regions with dense population and developed politics, economy, industry, science and technology, the seismic damages are even heavier. A strong earthquake may instantly ruin a prosperous beautiful city, and destroy lifeline infrastructures, such as communication systems, water and power supply, hospital and so on. What's more, the secondary hazards induced by earthquakes, like fires, floods, landslides, tsunamis, diseases and so on, will undoubtedly aggravate the disaster losses.

China, which is one of the countries with the most intensive mainland seismic activity, is located in the joint of two great earthquake belts that are the Pacific Ocean and the South Mediterranean in the world. Since 1990s,

seismic activity has begun to enter No.5 active period in China after a 10-year quiet period, when the frequency of seismic activity became higher, seismic losses may become greater. As shown in Table 1, during the decade of 1990-2000, the seismic losses in China's mainland are about three times more than those of the previous decade [1].

Table 1. The statistics of the main seismic damages in 1990-2000

Years	Death toll / person	Number of injury / person	Direct economic losses /100 million yuan RMB
1990-2000	691	54,855	126.92
1980-1989	1,112	12,402	49.81

During the past years of 2005-2007, the intensive degrees of about 75 earthquakes which occurred in China are larger than 5, about 33 earthquakes resulted in disasters in China's mainland. Just in 2005, earthquakes occurring in China's mainland affected about 2.084 million people and an area of 15,039.7 km^2, with 15 people dead, 90 wounded and a building area of 3,457,153m^2 destroyed, 543,515m^2 seriously damaged, 9,916,280m^2 moderately damaged. The direct economic loss hits 2.63 billion yuan [2]. In addition, Wenchuan earthquake, 8.0 degrees on Richter scale, which occurred on 12th May 2008, has become the most destructive earthquake in China, with the widest range of destruction. Up to the relevant statistics on Aug. 7th, this earthquake resulted in huge damages to buildings and infrastructures, induced numbers of secondary disasters, with 69,222 people dead, 374,638 injured, 18,176 missing and 125,975,000 m^2 buildings collapsed, 152,684,000 m^2 damaged. The direct economic loss was 843.77 billion yuan. The fund requirement for reconstruction was estimated to exceed 1,000 billion yuan. The disasters in Wenchuan earthquake were shown in Figs. 1-3.

Fig. 1 Beichuan Town was nearly buried by landslips

Fig. 2 The collapsed White Flower Bridge

Fig. 3 The frame-structure building with little damage

2.2 Construction Background

Since the reform and opening-up policy, the development of Chinese social economy has been sustainable, steady and rapid. China's GDP, fixed asset investment (FAI) and its economic increment speed in 2002-2006 were presented in Figs. 4-5 [3].

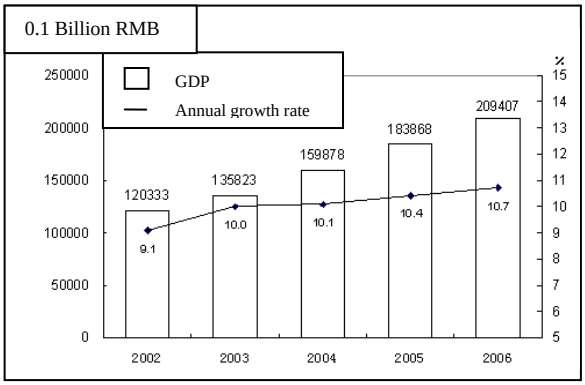

Fig. 4 GDP and its increment speed in 2002-2006

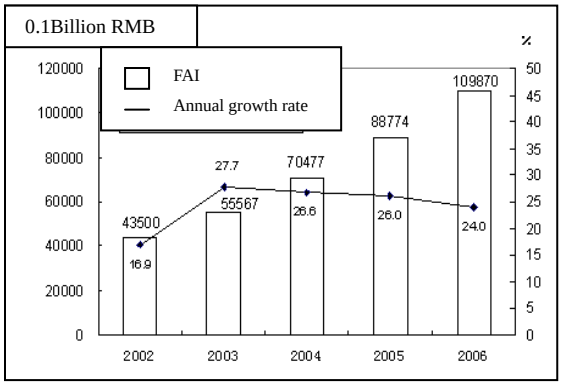

Fig. 5 FAI and its increment speed in 2002-2006

With the growth of economy, the urbanization of China has been greatly promoted. The process of building new socialist countryside has been stably advanced, and a large number of construction projects have been vigorously developed all over the country, while initial progresses have been achieved, as shown in Figs. 6-9. For examples, the whole Qinghai-Tibet Railway line was opened to traffic on July 1st, 2006; the first stage investment to the east and center route of projects for diverting water from the south to the north reached 11.9 billion yuan; the total investment to the Three Gorges Project reached 131.3 billion yuan; the power station of the Three Gorges has been put into use; the Cross-sea Bridge in Hangzhou Bay and Su-Tong Yangtze River Bridge have been opened to traffic. With the fast development of rural urbanization, great opportunities and severe challenges are confronting with the earthquake relief work in urban and rural constructions.

Fig. 6 The Three Gorges Dam

Fig. 7 Qinghai-Tibet railway

Fig. 8 Cross-sea Bridge in Hangzhou Bay

Fig. 9 Su-Tong Yangtze River Bridge

2.3 Significance of the Earthquake Relief Work

At present, China is in a transition period of social development, and people have made a gradual leap from a life of simply having enough food and clothing to a well-off life. In this stage, the demands for clothing, diet, shelter and transportation have been put forward to a higher level, and the consciousness of safe precaution has been further strengthened, too. As an important component of urban-rural public safety, the earthquake relief

work is closely related to the safety of people's life and property, as well as to the sustainable socio-economic development.

Earthquake is one of the main natural calamities that China will have to confront with in the future. With social and economic development, the pressure on earthquake relief work is increasing, and the situation remains harsh. Therefore, as the inevitable demand for the implementation of urbanization strategy, the realization of public safety and the establishing of harmonious society, as well as the sacred missions shouldered by engineers and technicians, the synthetic capacities of seismic prevention and relief in China, especially the capacity of earthquake engineering, need to be strengthened urgently.

3. MAJOR PROGRESS OF EARTHQUAKE RELIEF WORK

3.1 Enhancement of Legal Construction

The *Law of the People's Republic of China on Protecting against and Mitigating Earthquake Disasters* was formally promulgated and came into force in 1998. And then, based on a series of laws and regulations, such as the *Law of Protecting Against and Mitigating Earthquake Disasters of the PRC*, the *Construction Law of the PRC, the City Planning Law of the PRC, Regulations on Administration of the Quality of Construction Projects*, *Regulations on Administration of Surveying and Designing of Construction Projects*, etc, China has promulgated *Regulations on Administration of Earthquake Disaster Resistance of Construction Projects*, *Regulations on Administration of Earthquake Fortification of Out-of-code High-rise Buildings*, *Regulations on Administration of Earthquake Disaster Prevention Planning of Cities* and *Regulations on Administration of Earthquake Fortification of House Building Projects* in recent years.

At present, investigation and researches on *Rules on Administration of Earthquake Disaster Resistance of Construction Projects* are being conducted in China. Dozens of local seismic regulations have also been promulgated and implemented in many provinces, as well as autonomous regions and cities. Thus, the foundation framework of laws and regulations system which consists of national laws, administrative and local regulations, department rules and local government rules, etc, has been formed and provides the legal support for further development of urban-rural seismic construction [4].

Moreover, the *National Emergency Response Program for Public Incidents* and the *National Emergency Preplans for Destructive Earthquakes* went into effect in 2006. Then, China promulgated the *Emergency Preplans of Construction System for Destructive Earthquakes*, and primarily completed the implement of various safeguard measures in above preplans. So far, the earthquake emergency preplans system with integration of departments and regions at different levels, integrity of structure and norm of management has been basically formed, from central government to local authorities, and plays important roles in earthquake emergency work.

3.2 Perfection of Technical Standards

After Tangshan earthquake, China put forward the three levels of seismic fortification, no damage under frequent earthquake, repairable under fortified earthquake, no collapse under severe earthquake, in accordance with its actual conditions, and totally worked out or amended more than 40 seismic standards and codes, many of which are national compulsive standards such as *Code for seismic design of buildings* (GB50011-2001), *Standard for seismic appraiser of buildings* (GB50023-95), *Design code for special anti-seismic structures* (GB50191-93), *Code for seismic design of outdoor water supply, sewerage, gas and heating engineering*

(GB50032-2003), *Standard for urban planning on earthquake resistance and hazardous prevention* (GB 50413-2007) etc. Especially from 1998, Chinese government began to organize experts to summarize or deliberate on the damage and engineering experiences of devastating earthquake in areas like Yunnan, Inner Mongolia, Hebei, Taiwan, Xinjiang, Jiangxi provinces, etc, timely putting the mature new anti-seismic structures, technologies, and materials into works of technical standards of the earthquake resistance and disaster prevention system. The government has revised a series of engineering design specifications, which are based on China's national condition ,improve the engineering seismic safety, and have good feasibility, such as *Code for seismic design of buildings*, in which isolated and energy-dissipation technology are taken into national standards for the first time [5]. The newly revised standard for classification of seismic protection of buildings has improved the fortification category of public buildings such as school buildings and hospital buildings, which reflects the people-oriented principle. The concept of seismic performance design in the form of design general clauses was firstly proposed in the *General Clauses of Construction of the State Seismic Design* (Trial) (CECS 160:2004) [6]. The *Standard of post-earthquake emergency assessment and repair technology for buildings* will be applied to post-earthquake emergency assessment and repair in China's MS 6~9 earthquake areas including cities, towns and suburbs.

In addition, local governments and professions have also issued a number of corresponding local standards, basically to meet the needs of seismic fortification. Wenchuan earthquake damage survey shows that buildings designed reasonably and under strict construction in accordance with the *Code for Seismic design of buildings* (versions of GBJ11-89 and GB50011-2001) were basically able to undertake the earthquake action, and no serious damages or collapses were observed, which demonstrated that satisfactory anti-seismic results have been obtained based on the codes.

3.3 Success of Seismic Reinforcement Work

From 1976 (Tangshan earthquake) to the end of the last century, the Ministry of Finance had funded 2.88 billion yuan for seismic reinforcement project to reinforce the constructions built before 1978 and those built without seismic control measures. The seismic reinforcing work of about 200 million square meters covering all types of architecture, engineering facilities, groups of structures and equipments has been completed, in which a total of 130 million square meters of various types construction reinforcements have been accomplished in Beijing, Tianjin, Jiangsu, Anhui, Yunnan, Xinjiang provinces, other autonomous regions and municipalities directly under the central government, and totally 2.6 billion was funded in which 1.65 billion was offered by the state. From 1998 to 2000, the state collected 1.31 billion yuan by treasury bonds funds for the seismic reinforcements of buildings for central administrative departments and institutions in capital circle region [7], which included the National Museum, the Agricultural Exhibition Center, the main buildings of Tsinghua University, Peking Union Medical College Hospital, and other 357 projects. The construction projects of capital circle have been thoroughly completed, which enhanced the comprehensive ability for earthquake resistance and disaster prevention in capital circle region.

In addition, through the investigation and evaluation for earthquake resistant abilities of the existing buildings, the seismic reinforcement plans are made, according to urban development. With enough capital investment, a set of key projects, lifeline engineering of cities and potential safety problems of the seismic reinforcement work have been completed. The investigations after severe earthquakes in areas, such as Yunnan, Inner Mongolia, Xinjiang, Hebei and Wenchuan of Sichuan province etc, show that seismic evaluation and reinforcement are fruitful over these years; some strengthening works of the projects have also enhanced the capacities of the anti-explosion, wind resistance, and flood prevention.

3.4 Improvement of Urban-rural Earthquake Resistant Capability

Since 1990, China has changed its work priority of earthquake resistance from seismic reinforcement to establishment and implementation of the new construction and urban earthquake disaster prevention plan. The proportion of seismic fortification areas to new urban areas is 100%. We establish a design censoring system of construction drawing, and take seismic resistance and structural safety as important contents of the construction drawing. The National and provincial committee of experts are established to implement special censoring on over-ranging high-rise buildings' seismic fortification to ensure their seismic safety. The country has compiled more than 700 earthquake resistance and disaster prevention plans for cities and towns, which provide a more scientific and rational basis for urban construction and engineering construction of seismic fortification. China has issued the *Standard for urban planning on earthquake resistance and hazardous prevention* and the *Standard for villages and towns' planning on earthquake resistance and hazardous prevention* to standardize the earthquake disaster prevention planning, and a comprehensive development of earthquake relief work has been achieved in urban and rural regions.

In recent years, Rural Residential Earthquake Safety Project has been listed in the National Earthquake Resistance and Disaster Mitigation Planning Major Projects in the 11th Five-Year Plan [8]. Based on the situation that rural residences are basically defenseless, in order to guide the design and construction of new rural houses, the Ministry of Construction organized the compiling work of the *Anti-seismic Technical Specification for the construction of villages and towns*, as well as the detailed collective drawings. Local departments also strengthen the tutoring work for rural construction of earthquake resistance and disaster prevention, and have achieved better results. The State Department held a national meeting on earthquake resistance and security of rural residences in Xinjiang in Judne, 2006. In the meeting, the State Department deployed seismic fortification work on rural residences and key tasks, and clarified the general requirements, objectives and principles of the earthquake disaster reduction work for rural residences. At present, the work has been carried out in the country, and has become effective on disaster reduction, raising the overall seismic resisting level of towns and villages.

3.5 Achievements of Earthquake Scientific Research

In recent years, the state positively supports scientific and technological innovations in universities and research institutes, and increases the research investments in the field of seismic engineering, promotes the incubation of technological outcomes. Thus, numbers of scientific payoffs with international advanced level have been applied and transformed, such as the seismic studies on new structures and systems, the seismic design of high-rise buildings, the new technologies, new methods and new materials in seismic reinforcement, the seismic isolation and energy dissipation technologies, the seismic researches on lifeline, etc[9, 10].

The new engineering technologies, which include the earthquake resistant engineering and retrofitting technologies, the seismic isolation and energy dissipation technologies, etc, have obtained a great development, and are getting into engineering application stage. At present, production centers and experimental centers of rubber isolated bearings have been initially established in China, which supply products for promotion of isolation technology in China and other countries in the world. A special design rule, *Technical specification for seismic-isolation with laminated rubber bearing isolator* (CECS 126:2001) [11] and product standards, *Rubber isolation bearing for buildings* [12] have been initially formed. Engineering applications, which include lifeline engineering, industrial and civil buildings, large storage tank and complex projects, reinforcement work in existing buildings, etc, have been developed from pilot projects to widely spreading. Meanwhile, *Technical standards of building energy dissipation and seismic resistance* has been approved by the Ministry of

Construction for compilation (Construction superscript [2006] 77), and the draft will be completed by the end of 2008. Energy dissipation technologies are applied to new construction projects and reinforcement projects. Development of active, semi-active, mixed control and intelligent control technologies, which are applied to seismic and wind resistance engineering of towers or large span structures, has been gained. Structural seismic control technology opened up a new way for the development of earthquake disaster prevention projects, and is one of effective countermeasures to improve the seismic safety of all kinds of architectures in cities of China.

Moreover, international exchanges and cooperation have achieved remarkable results. For a long time, china has launched and sponsored lots of international seminars, such as Earthquake Engineering Seminar On the Lifeline of China-Japan-US, the New Century Earthquake Engineering Symposium of China-US, China-US Earthquake Engineering Youth Forum etc, which promoted exchanges of the latest research results in fields of earthquake resistant engineering and urban disaster reduction.

3.6 Application of New Seismic Technologies

In recent years, with the great enhancement of public awareness of disaster-preparedness and further development of seismic technologies, the applications of new seismic technologies in the engineering are evidently increasing.

In 1993, an isolated residential building with 8 storeys, which is the first base-isolated building with laminated rubber bearings in China, was built in Guangdong province. It survived Taiwan Strait earthquake of Ms7.3 in 1994, with minor damage [13]. Then, the 48 isolated residential buildings with 9 storeys, which are the largest base-isolated building in the world at present, as shown in Fig.10, was constructed on the large RC platform, with 2,000m length and 1500m width, in the ground junction center station of the Beijing Subway [14]. The isolated building area reaches 480,000m^2. And the difficulties existed in former design that the RC platform was of inadequate anti-seismic performances had been solved. Guangdong Scientific Centre was built in 2008, as shown in Fig.11, of which the square E applied the new isolation technologies. So far, with the extensive application of seismic isolation technologies, more than 500 base-isolated buildings have been built in 16 provinces, municipalities and autonomous regions, such as Guangdong, Fujian, Shanghai, Shanxi, Beijing, Liaoning, Xinjiang, Yunnan, etc.

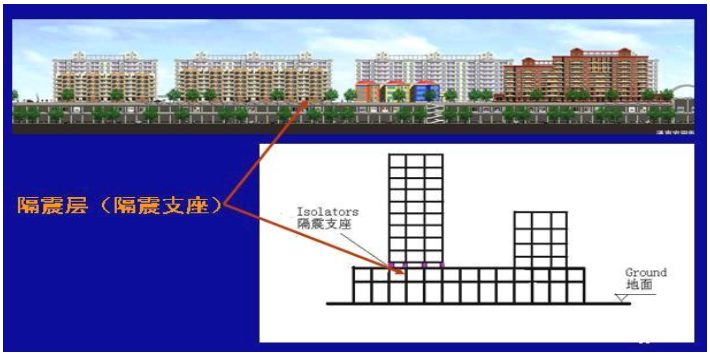

Fig.10 Isolated Residential Buildings on the Large RC Platforms of Subway Hub in Beijing

Fig.11 Guangdong Scientific Centre

To meet the requirements of the eighth degree seismic fortification in Beijing, the energy dissipation technology has been used for seismic retrofitting of many key buildings in Capital Circle, such as the Beijing Hotel (as shown in Fig.12), the Beijing Exhibition Hall (as shown in Fig.13), the west building of Beijing Jingxi Hotel, the Beijing Railway Station, the Revolution and History Museum of China, the Agricultural Exhibition

Centre of China, the Ministry of Construction office block, etc.

Fig.12 Beijing Hotel

Fig.13 Beijing Exhibition Hall

Shanghai Economic and Commercial Building, as shown in Fig.14, which was built in 1999 with the application of new structural control technology, can resist earthquakes with intensity of 7 degrees. Shanghai World Financial Center is shown in Fig.15. The main structure of this building is planned to be the highest in the world at present, and the height of which is 492m, with 101 storeys over ground. The steel-concrete hybrid structure is adopted in this building as the anti-seismic system [15]. Guangzhou New TV Tower, as shown in Fig.16, which is under construction with the total height of 610 meters, is likely to be the tallest tower in the world at present. The new effective technologies of vibration control are applied in this building for good seismic performance.

Fig.14 Shanghai Economic and Commercial Building

Fig.15 Shanghai World Financial Center

Fig.16 Guangzhou New TV Tower

The Beijing 2008 Olympic Venues are a series of major State construction projects. For examples, the National Stadium and the National Swimming Center, as shown in Fig.17 and Fig.18, which are known as bird's nest and Water Cube respectively, are well designed for adequate seismic performances to resist earthquakes with intensity of 8 degrees.

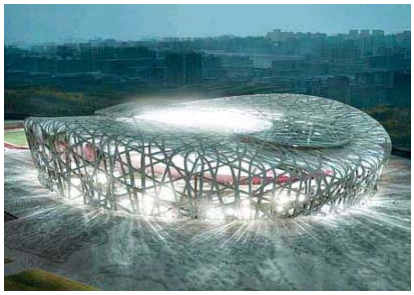

Fig.17 National Stadium（bird's nest）

Fig. 18 National Swimming Center (Water Cube)

In addition, the urban rail transit routes in Beijing, Shanghai and Guangzhou, as shown in Fig.19, are constructed in the earthquake fortification zone of above 7 degrees, with enough seismic performances to satisfy the local seismic fortification requirements.

Fig.19 The urban rail transport lines of Beijing, Shanghai and Guangzhou

4. GOAL AND PROSPECT OF URBAN-RURAL EARTHQUAKE RELIEF WORK

4.1 Goal

The overall goal of the earthquake relief work in urban and rural construction of China is that, up to 2020, the whole nation will have the synthetic capacities to combat earthquakes of about magnitude 6.0, which is equivalent to the basic seismic intensity of various areas; the ability of earthquake prevention and disaster mitigation in large and medium-sized cities or economically developed regions will reach the level of moderately developed countries at the same period [16]. The details are as follows.

☆ The system of seismic laws, regulations and technological standards in urban and rural construction should be gradually perfected.

☆ The formulation and enforcement of urban seismic plans should be well organized, while a reasonable and effective refuge-evacuation system should be designed in cities and towns.

☆ The anti-seismic capacities of urban and rural engineering facilities should entirely fulfill the requirements of relevant national codes and standards, while the same capacities of major urban construction and disaster -resistant infrastructures should satisfy the corresponding demands to protect against serious earthquakes; the automatic emergency disposal system should be set up in the key infrastructures, and security system should be established to avoid catastrophe.

☆ The earthquake-resistant capability in the countryside should be enhanced notably, and all of the new constructions in developed areas should reach the requirements of the standard earthquake fortification.

☆ The early-warning and emergency mechanism of earthquake, as well as emergency response system, should be completed basically, while the information collection, processing, distribution and response platform should be run effectively and smoothly.

☆ The education system of disaster prevention and reduction to public should be perfected, and the public's earthquake consciousness should be improved significantly, the general survey to basic data of cities' disaster-resistant capability in the key area for earthquake surveillance and protection should be completed.

4.2 Guiding principles and developing strategies

With the rapid development of social economy and advancement of rural urbanization process, the

earthquake relief work suffered great challenges in China. Compared with developed countries, there still exist many gaps in seismic management, technical progress, etc [17, 18]. However, it is noteworthy that the Chinese Government has the courage to face up these troubles, and actively takes measures to solve them. In urban regions, the government pays more attention to the construction of synthetic seismic capability, so as to resist destructive earthquakes successfully. While in rural regions, the government is vigorously promoting farming house construction with safety, and some preliminary results have been achieved [19]. In the coming years, the Chinese government aims at establishing an integrated earthquake defense system in urban and rural construction, which can cope with the Chinese national conditions and status of socio-economic development.

The guiding principles of the earthquake relief work involve the following aspects: putting prevention in the first place, while combining prevention, resistance and rescue with evasion; being based on relevant laws, regulations, engineering construction compulsory clauses and contingency plans; taking urban-rural disaster prevention planning as the leading; taking the earthquake fortification of new construction, along with seismic appraisement and reinforcement of existing buildings as the main line; carrying out supervision and administration for seismic construction in the overall process and whole service life; relying on scientific and technological advances; strengthening seismic management of urban and rural infrastructure construction; improving the overall seismic capacities and emergency response capability.

The developing strategies of the earthquake relief work can be summarized as the following three parts: 1) For the layout of development: on the one hand, the earthquake safety of metropolis and urban agglomeration should be taken as top priority continuously, and urban seismic construction should be emphasized; on the other hand, rural seismic construction should be strengthened under the favorable conditions of building new socialist countryside, and then the earthquake work would expand from the partial focus defense to the key comprehensive defense. 2) For the focus of work: the construction of scientific and technological innovation capacity in earthquake engineering should be still taken as mainstream support, and more attention should be paid to disaster resistant work before earthquakes, such as strengthening the earthquake fortification management of single project, enhancing the formulation and enforcement of rural seismic plan, etc, while the compilation of emergency plans, as well as emergency drill and training should be emphasized. 3) For the style of management: under the support of the whole society, our country should not only summarize and inherit the effective administrative means for years, but also explore new management models which are adapted to market economy in the light of present reality, therefore to open up a new prospect of the whole community to withstand earthquake disasters.

4.3 Key work

Based on the status quo and goals of earthquake relief work in China, tasks in the following eight aspects need to be done in the future:

(a) The construction of seismic laws, regulations and technical standard system needs to be enhanced, so as to provide legal safeguard for earthquake relief work.

The existing laws and regulations associated with earthquake resistant engineering should be reorganized, and the perfect law frame of urban-rural earthquake resistance and disaster mitigation should be proposed, the clauses which need to be further improved and coordinated in the existing regulations should be revised and perfected, *Rules on Administration of Earthquake Disaster Resistance of Construction Projects* should be established, which will provide a legal foundation for improving the synthetic ability of urban-rural earthquake resistance and hazards prevention, as well as earthquake emergency capability. The administration systems of earthquake prevention and disaster mitigation, including all levels of province, city, district, street (community)

administration systems, are established and improved gradually, so that the actions of seismic defense, rescue, recovery and reconstruction can be carried out under unified commands and coordination. Meanwhile, the administration of earthquake resistance and disaster prevention in engineering construction should be strengthened, weak links of which should be eliminated. The security administration system for earthquake resistance and disaster prevention of construction projects in the whole process should be established.

Scientific researches on emergency preplans should be strengthened, and the technical level of which should be improved, the existing emergency preplans should be revised and perfected promptly, while the concrete logistic measures should be fulfilled. Moreover, the earthquake resistant system in construction field should be further completed, the emergency response platform of construction system should be established, while the rapid-reaction mechanism should be set up, so that the synthetic capacities of the urban-rural construction system against earthquake disaster can be enhanced. According to the demands of planning, construction, management and emergency relief in urban and rural regions, the standard system of urban-rural seismic construction should be perfected; the technical index system of urban-rural earthquake disaster control should be gradually established and completed.

(b) The compilation and management of earthquake resistance and disaster prevention planning need to be vigorously promoted.

Under the guidance of scientific development concept and from the macro-security view in urban-rural earthquake relief work, the simultaneous development of earthquake disaster reduction and urban-rural construction should be promoted; the simultaneous improvement of synthetic earthquake-resistant ability and economic development level should be promoted. The experts and technical staff specified in various fields of disasters are encouraged to exchange their respective work experiences and the latest research findings, which are hoped to provide powerful technical supports for the administration of seismic construction in urban and rural regions. Research and exploration on the developing strategies and major issues in the field of earthquake resistance and disaster prevention should be conducted, so that the level of compilation and management of earthquake resistance and disaster prevention planning can be practically improved.

The following aspects should be emphasized in the establishment of urban-rural seismic planning. Put investigations of patterns of disaster prevention space as key problem and promote the rational use of disaster prevention space; study ways of seeking refuge and dispersing people, and comprehensively arrange disaster and relief facilities, such as refuge places, emergency access and so on; propose the overall requirements for site selection of major hazard installations and suitability of disaster prevention in building lands; rationally arrange the disaster relief agencies and facilities, such as the disaster relief command center, ambulance hospitals, fire stations and so on. On the basis of urban-rural district planning and detailed planning, seismic planning should be worked out and relevant demands of planning administration should be proposed for major city districts, community, large factories and mining areas.

(c) The monitoring and evaluation of seismic risks in engineering construction need to be carried out; the system of seismic strengthening and reconstruction need to be established and perfected.

Assessments of earthquake resistance and disaster prevention capacities to urban-rural construction should be conducted; the bottom lines and basic characteristics of earthquake resistant capability should be grasped; document of earthquake resistant capacities and information management system should be set up in urban and rural regions. The monitoring and identification of disaster situations should be enhanced; standards for disaster classification and evaluation, hazard information system, assessment mode and seismic disaster risk evaluation system should be established; then, seismic risks of vital system, life-line system, community, major city districts, large factory and mining areas should be assessed, as well as the seismic safety should be classified at regular intervals, so that the short term and mid-long term earthquake resistant capabilities in urban and rural

regions can be confirmed.

Standards for seismic appraisal and evaluation of damage degrees and safety degree after earthquake of various buildings and engineering facilities and rules of implementation should be formulated; technologies of inspection, reinforcements and strengthening to post-disaster damage of buildings should be developed, evaluation systems of reliability of post-disaster buildings should be established. Moreover, the mechanisms of reconstruction after disasters should be further completed; the requirements for risk evaluations of reconstruction projects after disaster should be proposed and the seismic fortification criteria for rebuilding engineering facilities should be determined. Researches on public policies and channels of collecting funds for reconstructing houses with different ownerships after earthquakes should be conducted.

(d) The security management of earthquake resistance and disaster prevention in engineering construction needs to be strengthened.

The control of safety quality to protect the major projects and large public facilities against disasters should be strengthened, and the requirements for seismic resistance of key buildings and large-scale public buildings should be improved moderately; with combination of public buildings, the action base should be constructed for the requirement of evacuation and refuge in urban and rural regions, which let the large-scale public buildings have common capacities to prevent and avoid the disaster. The seismic construction of major projects, large-scale public buildings, and the main lifeline systems which consists of rail transportation, gas pipeline, etc, should be enhanced, and researches on links of planning design, disaster prevention, emergency handling, emergency response, recovery after disaster, etc, should be conducted, so as to lay the foundation for the construction of urban-rural earthquake reduction system and basic supplies. The seismic technical researches on underground space will be strengthened, the construction and management system of municipal synthesis pipe gallery should be further perfected, and the requirements for seismic technologies in planning and design of municipal pipeline should be improved to guarantee the security and reliability of the underground pipe gallery.

(e) The earthquake resistance and disaster prevention system in communities needs to be constructed.

For different types of districts, such as large-scale commercial areas, economic developing zones, key business districts and general communities, etc, systems of earthquake resistance and disaster prevention which covers with various stages of planning, design, internal management and so on should be established. Systems of constructing and utilizing seismic facilities and the community simultaneously should be implemented in community construction. In community, the disaster administrative mechanism of seismic facilities and daily disaster prevention should be studied, and put into regular management. The capacities of earthquake resistance and disaster prevention should be regarded as one of the main measurements in appraising the achievements of urban-rural and community work.

The construction of pilot projects that communities are designed for adequate capacities to resist earthquake disaster should be positively promoted, while system of the laws, regulations and technologies associate with the seismic planning, design and management of community should be gradually established and perfected, so that the constructions of earthquake resistance and disaster prevention system in the whole society can be promoted on the basis of community earthquake relief work.

(f) The safeguard mechanism of earthquake relief investment needs to be established.

Stable channels of investing funds for urban-rural earthquake resistance and disaster prevention should be established. The nonprofit properties of earthquake relief work should be clarified; the principle position in seismic investment should be the government. The construction planning for earthquake resistance and disaster prevention should be incorporated into plans for national economic and social development, while the relevant costs should be brought into annual budget, and strict special control systems should be formulated. Meanwhile, earthquake insurance systems should be established and perfected, plans for joint defense and mutual aids in

urban-rural regions or across regions should be carried out to disperse seismic risks. Catastrophe insurance mechanism should be explored, so as to provide financial guarantee for salvation and reconstruction after disaster. Special funds for earthquake resistance and disaster prevention in urban and rural regions should be established, countermeasures and steps of capital raising through various channels should be developed.

The Government should formulate incentive policies to guide and support the populace to participate in seismic construction, such as conducting seismic strengthening and retrofitting to old buildings, carrying out earthquake resistant construction with higher standards, adopting new technologies for better seismic performances, etc. And some effective measures should be taken to encourage the whole society joining in the earthquake relief work.

(g) The research on key technologies of earthquake resistance and disaster prevention, as well as its engineering application needs to be speeded up.

Key technologies of earthquake disaster prevention and mitigation should be thoroughly developed, while weak links in seismic analysis of different lifeline projects and building structures should be improved, and new structural system for earthquake resistance and disaster mitigation should be advanced. Some corresponding public platforms for engineering experiment and technology research should be established. New technologies for earthquake resistant engineering and retrofitting to the existing buildings in urban and rural regions should be studied and developed, while fast and widespread engineering applications should also be promoted.

(h) The education and publicity for earthquake resistance and disaster prevention need to be strengthened, and the public's self-help capability in earthquakes needs to be enhanced.

Through the activities of making disaster prevention work accessing to community, campus and enterprises, the bottom population, such as community members, students, corporate staff, especially the migrant workers and low-position groups, can obtain the improvement of disaster-consciousness, and simultaneously acquire basic skills for disaster-avoiding, self-help and mutual-aid. The establishment of the subject of science and engineering on disaster prevention and reduction should be energetically promoted; the education system of disaster prevention and reduction, which combines the professional education and training with popular science education, should be constructed; the nationwide consciousness and abilities of earthquake prevention and disaster mitigation should be further enhanced.

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