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Report on the Great Sichuan Earthquake in China

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Introduction

The Disaster Management Planning Hyogo Office of the United Nations Centre for Regional Development (UNCRD), conducted four researches on damage from the Wenchuan Earthquake centered on Sichuan province of China, which occurred on May 12, 2008. This publication is a report of the research findings. Reference materials include materials provided by Mr. Gu Linsheng, the head of Department of Public Safety Studies, Beijing Tsinghua Urban Planning & Design Institute, and data collected at the APEC Experts' Meeting in Peru in August 2008, the 14th World Conference on Earthquake Engineering (WCEE) in Beijing in October 2008, and other meetings, in addition to the findings of the researches.

1. First field research: June 10 through 15, 2008 (Beijing City, Chengdu City, Dujiangyan City and Mianzhu City of Sichuan province, etc.) Ando conducted research to comprehend actual damage (in Sichuan) and collected information for recovery (in Beijing).
2. Second research: July 5 through 8, 2008 (invited lecture and information collection in Beijing City) Ando participated in the symposium for recovery from Great Sichuan Earthquake held by the Chinese government and GTZ.
3. Third research: August 2 through 5, 2008 (Chengdu City, Deyan City, Mianyang City and Anxian County of Sichuan province) Ando participated in the joint research group on economic reconstruction after the earthquake with Nagoya Institute of Technology and others.
4. Fourth research: December 6 through 12, 2008 (Chengdu City, Dujiangyan City, Wenchuan County, Deyan City and Beichuan County) Saito and Nakamura researched recovery conditions in each district of Sichuan province from the aspect of community-based disaster prevention and earthquake resistance of housing structures.

We would like to extend our appreciation to many people who helped conduct these researches including Mr. Ko, Ms. Lu, Deputy Director of Sichuan Academy of Social Sciences, Professor Hitoshi Taniguchi of Nagoya Institute of Technology, Professor Toshihisa Toyoda of Hiroshima Shudo University, Mr. Tadashi Tonami, a long-term expert of JICA China, and Mr. Masamichi Yoshitsubaki from Citizens towards Overseas Disaster Emergency (CODE) Office. In addition, some of the people who had helped us conduct the field research in China took part in the EAROPH International Congress in Hyogo in October 2008 and the International Symposium on Disaster Prevention in Kobe in January 2009 to provide valuable information on recovery conditions, etc. These data will be compiled as proceedings from each conference.

With the research on earthquake damage as a starting point, UNCRD will add China to the target

countries selected for research on community-based disaster prevention and housing earthquake strengthening projects from fiscal year 2009 and continue research, particularly in Sichuan province.

(Note: “Wenchuan Earthquake” is the official name of the earthquake, however “Great Sichuan Earthquake” is also used in this report.)

1. Background

1-1. Overview of affected areas

Affected country: People's Republic of China

General affected district: 417 counties (cities and districts), 4,656 towns or townships, or 47,789 administrative villages of 10 provinces (cities) including Sichuan, Gansu, Shaanxi, Chongqing and Yunnan, total area of approximately 440,000 sq. kilometers and 4,626 affected people, including total area of approximately 280,000 sq. kilometers and 2,983 affected people in Sichuan prefecture (report by the State Council on June 24)

Seriously affected district: 51 counties (cities and districts), 1,271 towns or townships, or 14,565 administrative villages of Sichuan, Gansu and Shaanxi provinces, total area of 132,596 sq. kilometers, 198,670,000 people in the district (the State Council's basic reconstruction plan on August 12)

Extremely-seriously affected district: 10 cities or counties, Chengdu City (Dujiangyan City and Pengzhou City), Deyan City (Mianzhu City and Shifang City), Mianyang City (An County, Beichuan County and Pingwu County), Guangyuan City (Qingchuan County), Ngawa Tibetan and Qiang Autonomous Prefecture (Wenchuan County and Mao County), of Sichuan province, total area of 26,409 sq. kilometers, 36,370,000 people in the district (refer to Table 1)

Table 1: Overview of districts affected by Great Sichuan Earthquake

“extremely-seriously affected district” in bold font	Area (sq. km)	Total population (0,000 people)	Of total population, farming population	Proportion of farming families (%)
Sichuan Province	485,000	8,037.0	6,734.2	79.0 %
Chengdu City, including:	12,163	1,082.0	538.1	49.7 %
Dujiangyan City	1,208	59.7	43.6	73.0 %
Pengzhou City	1,419	77.8	64.4	82.8 %
Deyan City, including	5,954	328.4	246.7	75.1 %
Mianzhu City	1,245	51.3	41.1	80.1 %
Shifang City	863	43.0	34.3	79.8 %
Mianyang City, including	20,286	530.7	404.4	76.2 %
Anxian County	1,404	50.4	43.2	85.7 %
Beichuan County	2,869	16.1	14.2	88.2 %
Pingwu County	5,974	18.7	16.4	87.7 %
Guangyuan City, including	16,314	304.1	245.0	80.6 %
Qingchuan County	3,269	24.9	21.6	86.7 %
Ngawa Tibetan and Qiang Autonomous Prefecture, including	84,242	84.7	68.2	80.5 %
Wenchuan County	4,083	11.3	7.2	63.7 %
Mao County	4,075	10.5	9.2	87.6 %
Total of extremely-seriously affected district	26,409	363.7	295.2	81.2 %

(source: 2004 Sichuan statistical yearbook, and 2006 Urban statistical yearbook of China)

Figure 1: Areas affected by Sichuan Great Earthquake



(Source: prepared by the civilian sector, the state disaster prevention committee of China on July 4, 2008)

1-2. Seismic damage (Overview)

Date and time of occurrence: 14:28 on May 12, 2008, Monday (Japan Time: 15:28 on the same day)

Magnitude: 8.0

Dead: 69,226 people, Missing: 17,923 people

Injured: 374,643 people

Collapsed houses: 7,789,100 houses

Partially-collapsed houses: 24,590,000 houses

Total amount of direct damage: 845.1 billion RMB (13 trillion yen, converted at around 15 yen to a RMB), which is comprised of: damage amount in Sichuan province 91.3%, Gansu province 5.8%, and Shaanxi province 2.9%. Additionally, the amount of house damage accounts for 27.4% of the total.

(Source: data on Dead, Missing and Injured were released by the State Council on August 25, 2008, house damage by the State Council on June 24, 2008, and total amount of direct damage by the State Council on September 4, 2008. The national basic plan for recovery and reconstruction released on August 12, 2008, shows the total amount of direct damage was 84,377 billion RMB. Refer to Table 4)

1-3. Partner support regarding the Great Sichuan Earthquake

Table 2: Partner support regarding the Great Sichuan Earthquake in China

Supported areas		Supporting areas
(Sichuan)		
Wenchuan	←	Guangdong
Beichuan	←	Shandong
Qingchuan	←	Zhejiang
Mianzhu	←	Jiangsu
Dujiangyan	←	Shanghai
Shifang	←	Beijin
Jiangyou	←	Henan
Pingwu	←	Hebei
Anxian	←	Liaoning
Pengzhou	←	Fujian
Maoxian	←	Shaanxi
Lixian	←	Hunan
Heishui	←	Jilin
Songpan	←	Anhui
Xiaojin	←	Jiangxi
Hanyuan	←	Hubei
Chongzhou	←	Chongqing
Jiange	←	Heilongjiang
(Gansu)		
Seriously affected district in Gansu province	←	Shenzhen
(Shaanxi)		
Seriously affected district in Shaanxi province	←	Tianjin

The “Partner support” program is a system where provinces or cities provide support to a related affected area on a one-to-one basis, under the principle of “one province helps one significantly affected county.” With resources reasonably placed based on the economic development level of each area, 19 provinces (cities) support 18 heavily affected counties (cities) as well as seriously damaged areas (seriously affected district) in Gansu and Shaanxi provinces. Provinces (cities) assigned under the program provide assistance for three years. Each supporting province (city) is required to allocate 1% of local financial revenue in the preceding year for goods and work operations every year.

1-4. Handling of the Chinese government

- (1) Timeline of Disaster, Response, and Recovery

May 12, 2008: The Great Sichuan Earthquake occurred.

Mid- and late May 2008: Took emergency response measures such as lifesaving, food aid and construction of temporary houses, and started preparations for rehabilitation.

June 8, 2008: Issued the act concerning Wenchuan Earthquake disaster recovery and reconstruction (State Council Order No. 526).

June 24, 2008: The State Council released the report on relief of earthquake victims, and recovery and reconstruction (the National People's Congress).

June to mid-August 2008: Conducted such activities as damage research, construction of temporary houses and formulation of the recovery plan.

August 12, 2008: Released the national basic plan for Wenchuan earthquake recovery and reconstruction based on the seismic isolation and disaster reduction law and related acts.

September 19, 2008: The state Council issued a notice on the overall plan for recovery and reconstruction after the Wenchuan earthquake.

In and after September 2008: Each local government formulated a recovery plan and residents embarked on housing reconstruction projects.

(2) Items included in the national basic plan for Wenchuan earthquake recovery and reconstruction

Chapter 1 : Foundation for recovery (overview of affected areas, disaster loss, present problems, and advantages)

Chapter 2 : General requirements (guiding thoughts, basic principles, and recovery goals)

Chapter 3 : Space layout (reconstruction zoning, city disposition, industrial distribution, securing of places for residents to live, and arrangement of site)

Chapter 4 : Urban housing (housing for rural inhabitants, and housing for urban and town inhabitants)

Chapter 5 : Urban construction (municipal and public facilities, and cities, towns and villages famous for their history and culture)

Chapter 6 : Rural construction (agricultural production, agricultural service system, and agricultural infrastructure)

Chapter 7 : Public services (education and scientific research, medical services and hygiene, culture and gymnastics, cultural and natural assets, employment and social security, and social management)

Chapter 8 : Infrastructure (transport, communications, energy, and water supply)

Chapter 9 : Industrial recovery (industrials, tourism, commercial trading, finance, and cultural industry)

Chapter 10 : Disaster prevention and reduction (disaster prevention, reduction and relief)

Chapter 11 : Ecological environments (ecological rehabilitation, environmental improvement,

and land improvement and reclamation)

- Chapter 12 : Mental care (humanism and ethnical spirit)
- Chapter 13 : Policy measures (public finance, tax expenditure, finance, land, industry, special support, aid, and others)
- Chapter 14 : Reconstruction fund (fund demand and procurement, renewed loans, and allocation of funds)
- Chapter 15 : Plan implementation (organizational guidance, plan management, classification, compensation for goods, and check inspection)

(3) Overview of the process for formulating recovery plans in the urban and rural construction section (example of inside of the Chinese government)

First phase: phase of task organization and achievement (June 1 through 5)

Draw up the proposed plan and compile related documents and materials. Held the first meeting to make work assignments.

Second phase: phase of main plan formulation (June 6 through 20)

Finalize the proposed main plan for system in cities and small towns, and inspect work process of a task force in each province or city.

Third phase: phase of official draft plan preparation (June 21 through 30)

The official draft plan for system in cities and small towns is reviewed at the review conference.

Fourth phase: phase of presentation of the finalized plan after consulting with related organizations.

(4) Reference data 1: method for classifying affected areas

Table 3 classification index for disaster range (by the national committee of experts on the Wenchuan Earthquake)

Classification index for disaster range	Seismic intensity scale range	Number of dead and missing	Total disaster index
Extremely seriously affected district	10 to 11	1000 people or more	0.4 to 1
Seriously affected district	8 to 9	10 to 1000 people	0.15 to 0.4
General affected district	6 to 7	1 to 10 people	0.01 to 0.15
District under seismic influence	Less than 6	—	Less than 0.01

Note 1: The seismic intensity scale of China ranges from 0 to 12. Chinese intensity 9 is Japanese intensity upper 5 to lower 6, Chinese intensity 7 is Japanese intensity (4) to lower 5, and Chinese intensity 6 is almost equal to Japanese intensity 4.

Note 2: Total disaster index = (area-weighted average seismic intensity × 0.3) + (rate of number of dead and missing × 0.3) + (rate of collapsed houses × 0.2) + (degree of geological hazard × 0.1) + (rate of evacuation and removal × 0.1)

(5) Reference data 2: breakdown of direct economic losses

Table 4 Breakdown of direct economic losses (the national committee of experts on the Wenchuan Earthquake as of July 7, 2008)

Items	Total	Sichuan	Gansu	Shaanxi
Total direct economic losses	8,943.2	8,286.6	457.8	198.9
1. Loss of rural houses	1,682.0	1,447.0	197.7	37.3
2. Loss of urban houses (including non-residence buildings)	2,149.6	2,045.3	70.0	34.3
3. Loss in agriculture	323.1	317.6	4.5	1.1
4. Loss in industry (including ammunition industry)	928.3	888.2	22.3	17.8
5. Loss in service business	603.9	586.2	12.5	5.2
6. Infrastructure loss	1,943.1	1,781.6	98.8	62.7
(Transport facilities, including railroad facilities)	(712.3)	(615.1)	(57.7)	(39.5)
(Water supply and power generating facilities)	(499.0)	(466.0)	(19.9)	(13.1)
7. Loss on social facilities	561.9	514.9	20.6	26.3
(Educational facilities)	(278.7)	(249.6)	(8.9)	(20.2)
8. Loss of inhabitant assets	335.5	307.0	17.3	11.4
9. Loss of land resources	239.9	231.6	7.3	0.9
10. Loss in natural reserves	46.9	45.7	1.2	0.2

11. Loss of cultural assets	79.2	74.9	3.6	0.7
12. Loss of mine resources	49.8	46.8	2.1	1.0

(Unit: 100 million yuan. The total amount in the table is not equal to 845.1 billion yuan shown in the report by the State Council as of September 4)

2. UNCRD Field Research

2-1. Summary of field research activities

(1) First research: June 10 through 15, 2008

Research regions: Dujiangyan City of Mianzhu City (Hanwang Town and Zhundao Town)
Sichuan province

Objective: comprehension of the actual state of earthquake damage (Sichuan province) and information collection for recovery (Beijing City)

Counterparty organizations: Citizens towards Overseas Disaster Emergency (CODE) Office, Beijing Tsinghua Urban Planning & Design Institute, and others

Data obtained: locally published magazines, photographs taken in quake-hit areas, and information on reconstruction in Zhundao Town and other regions

Report released: "Report on the Sichuan earthquake in China" in *Nicchu Kenchiku Jutaku Joho* (Japan-China building and housing magazine) the August-September issue by UNCRD

(2) Second research: July 5 through 8, 2008

Research region: Beijing City

Objective: Participation as a guest in the symposium for recovery from Great Sichuan Earthquake held by the Chinese government and GTZ

Counterparty organization: National Development and Reform Commission, GTZ (international cooperation organization of the German government), and others

Data obtained: analysis data on economic damage by the Chinese government, case reports in various places in the world by participants such as the Great Hanshin Earthquake (UNCRD), the Great Pakistan Earthquake (ERRA), and the Great Mexico Earthquake (UNAM)

Report released: "Report on the Sichuan earthquake in China" in *Nicchu Kenchiku Jutaku Joho* the August-September issue by UNCRD

(3) Third research: August 2 through 5, 2008

Research regions: Chengdu City, Deyan City, Mianyang City and Anxian County

Objective: Participation in joint research group on economic reconstruction after the earthquake with Nagoya Institute of Technology and others.

Counterparty organizations: the Academy of Social Sciences of Sichuan province, government of Mianyang City, ceramics factories in Anxian County, Sichuan University, and others

Data obtained: proposed reconstruction plan of Mianyang City, data on damage of cultural assets in Chengdu City and Dujiangyan City, photographs of the regions

Report released: Information on damage of cultural assets in Dujiangyan City was released by the government of the city in the EAROPH congress in Hyogo.

(4) Fourth research: December 6 through 12, 2008

Research regions: Chengdu City, Dujiangyan City, Wenchuan County, Deyan City, Beichuan County

Objective; research of recovery conditions in various regions of Sichuan province from the standpoint of community-based disaster prevention and earthquake resistance of housing

Counterparty organizations: governments of Chengdu City and Deyan City, Citizens towards Overseas Disaster Emergency (CODE) Office, Tsinghua University, and others

Data obtained: comprehension of wishes of inhabitants in affected areas of Beichuan County, data on recovery conditions collected by each government, photographs of the regions

Contents of each research are detailed below. However, because the second research was conducted exclusively in Beijing, only data obtained in the research are shown in Chapter 4.

2-2. Research on damages to local facilities

In addition to public facilities such as government buildings, police stations, hospitals and schools, infrastructure facilities including roads, bridges and water and sewage systems are required to be functional at the time of disaster. No severe damage was inflicted on expressway networks elevated roads in cities in the affected areas of Sichuan province. Some infrastructure was broken by massive slope failures in mountain areas, but in most cases, serious human damage was caused in public facilities where many people gather such as schools, and houses.

(1) School facilities

In the Sichuan Great Earthquake, collapsed school buildings and resultant death and injury of school children were noticeable. This is because the earthquake occurred during school hours. Like the Great Pakistan Earthquake in October 2005, wreckage of walls, floor panes and bricks caused damage. Meanwhile, the following two photographs were taken in the research by UNCRD on June 11, 2008, less than a month since the earthquake occurred.



Zhundao junior high school in Zhundao town of Mianzhu City (inside broken)



temporary elementary and junior high school in Zhundao Town (use of a ground of an elementary school)

As of June 11, 2008, a temporary elementary and junior high school had been completed in a ground of an elementary school. A junior high school in the town was unusable with the second floor almost collapsed. Although an elementary school building did not collapsed, it was condemned due to sheared columns on the first floor. In the future, the junior high school will need to be replaced, and the elementary school will need to be fixed and seismically reinforced. Meanwhile, for maintenance, reinforcement and seismic strengthening, case studies by Japan's Ministry of Education, Culture, Sports, Science and Technology and in School Earthquake Safety Initiative (SESI) by UNCRD are thought to be useful data.

Additionally, we visited elementary and junior high schools in Mianzhu City and Dujiangyan City. Some school buildings had shear cracks. A school totally collapsed and leveled (Libing Junior High School in Dujiangyan: Tents donated by Hyogo Prefecture had been pitched in the site of the school as of June 12: upper left photo on the front page). Some schools were not allowed to enter the site. In Japan, the rate of national grants for seismic strengthening of schools was raised, and a large amount of funds for it were included in the supplementary budget in fiscal 2008. This, together with system for seismic reinforcement, may serve as a useful reference for China

(2) Hospital facilities

Most of hospital buildings collapsed in Hanwang Town of Mianzhu City (upper right photo on the front page). Hospitals did not function at all as of June 11, but a small number of evacuees lived in the uncollapsed part of a hospital building. Wreckage had been already removed from many collapsed buildings in the vicinity. There is a clock tower whose clock stopped at 14:28 when the earthquake occurred in front of the hospital. This tower has become the symbol of the earthquake damage.

In Zhundao Town of Mianzhu City, the army has set up a field hospital in parking lots of a collapsed hospital. Many inhabitants used the hospital that was equipped with X-ray system in a temporary building.

(3) Infrastructure facilities

Chengdu City is a big city with a population of over 1,000. Subway network is under construction in the city, while it has inner-city expressway network and a three-lane elevated inter-city highway connecting to Xian and Chongqing. Both highways were not seriously damaged, because the city center and inter city highway were 50 km away from the seismic center and an intensity of 7 was registered for the city on the Chinese scale (4 to lower 5 on the Japanese scale). City functions in the center of Chengdu City was working normally at the time of research which was conducted one month later after the quake.

As described in a reference “Report of the State Council on disaster relief, and post-disaster recovery and reconstruction in June 2008,” lots of damage on infrastructure and landslide disaster occurred particularly in mountain areas, some of which are required to decide whether they should rehabilitate city functions or move the functions (experience in the 2004 Niigata Earthquake is through to be useful in making such decisions).

(4) Production facilities

When we visited Mianzhu City in June 2008, some factories had collapsed or partially collapsed and shut down operations. This region has long been famous as a production area of high quality

liquor, and it is said that this area was with the smell of liquor when brewing factories collapsed. When we visited the city again in August 2008, most factories restarted operations. As described in the State Council's report, the industrial reconstruction has been promoted strongly.

On August 3, 2008, we visited a ceramics factory in An County of Mianyang City with Deputy Director Liu of Sichuan Academy of Social Sciences as a guide. The factory was destroyed in the earthquake on May 12. Partly because it was an only factory in the village, it had been reconstructed with everyone's cooperation and resumed operations. According to Deputy Director Liu, the area has been excluded from the extensive "large Western region development" plan, which has been promoted with a view to developing inland areas of China. He said the ceramics factory would be a model in terms of how regional development is advanced.

Meanwhile, a large Japanese department store in Chengdu City reopened operations from the day after the quake and provided goods and some sense of security to the sufferers. This bears mentioning from the standpoint of economic recovery.

2-3. Research on house damage and reconstruction

As in the Great Hanshin-Awaji Earthquake, the 2005 Pakistan Earthquake, the 2006 Java Earthquake, and the 2007 Peru Earthquake, collapsed houses were the largest cause for human and property damage in the Great Sichuan Earthquake. As areas affected by this earthquake are wide, damage came in various types on houses from rural housing to urban housing. At the time of the first research in June 2008, some damaged houses had been almost fully removed, and others remained untouched as seen in the photograph below. At the time of the fourth research (in December 2008), however, more than half of houses were in the process of reconstruction in rural areas. This is mainly because the Chinese government offered subsidies to promote reconstruction of domiciles on a temporary basis. According to Chinese government officials, 60 percent of collapsed houses will be reconstructed by the end of 2008, and all by the summer of 2009.

Also, it should be noted that in this process of house recovery, a large number of temporary houses were constructed in the very short term. In this relation, disposal of these temporary houses is anticipated to become a subject of discussion in the near future. Yet, the greater challenge will be a possibility that in reconstruction of mid-rise housing, such a situation as seen in the Great Hanshin-Awaji Earthquake may arise regarding consensus building, expense distribution, etc. (because land is owned by the state but the government has started to allow individual ownership of buildings).

(1) Damage on rural houses

Sichuan province traditionally had many wooden houses, and there was such house damage as seen in the photos below. Some houses were almost undamaged as seen in the photo of Zhundao Town of Mianzhu City in 4.3 Photographs.



Damage on a wooden house in Zhundao Town of Mianzhu City (same for the right) Same framework method with columns and beams as in Japan. The photos were taken in June.

However, most houses were built of brick even in rural areas, and this seems to be one of reasons for heavy damage. According to information obtained from people in the areas, houses would be built of brick just like before the quake (through strengthened with reinforced concrete structure) using reusable, as it has become difficult to use lumber due to regulations on logging.

(2) Damage to urban houses

There was no city with a population of 1 million in the extremely seriously affected district. Yet, significant damage concentrated on urban houses in cities like Dujiangyan City (out of around 600,000, around 200,000 people reside in the urban area) , and urban areas with a population of 20,000 to 50,000, such as Hanwang Town and Zhundao Town which were severely damaged, in Mianzhu City (population of around 500,000).

The photos below show damage on an urban-type house (house with a shop) in the center of Zhundao Town of Mianzhu City. Houses left also had shear cracks in walls. Many houses were built of hollow concrete block or hollow floor panels on brick walls. As seen in the left photo below, we often saw joints between walls and floor panels left connected with reinforcing steel (wire), and floor panels hung from walls. This construction method using hollow floor panels was also used for school buildings.



Damage on houses in the center of Zhundao Town of Mianzhu City (Right: Buildings were lost their original form in this district). The photos were taken in June.

The photo below shows a general residential district in Zhundao Town. Many houses in the district were built of brick, and most of them collapsed. In this photo, walls in the back on the left had the block-built first floor and the brick-built second floor, but no beams were seen. Meanwhile, most houses had a wooden sloping roof even if they were built of brick or block.



House damage in Zhundao Town of Mianzhu City (the photo was taken in June 2008)

Looking at the proportion of human damage and economic damage according to districts classified by disaster range by the national committee of experts on Wenchuan Earthquake (Table 5), most of dead and missing concentrated on the extremely seriously affected district such as Dujiangyan City and Mianzhu City, although the number of collapsed houses and economic losses in the district are smaller than in the seriously affected district.

Table 5 The proportion of damage according to districts classified by disaster range (the proportion to total as 100)
(by the national committee of experts on Wenchuan Earthquake, disaster assessment team, in July 2008)

Classification index for disaster range	Proportion of collapsed houses	Proportion of dead and missing	Proportion of direct economic losses
Extremely seriously affected district	4 2 . 9	9 7 . 2	3 9 . 5
Seriously affected district	4 4 . 7	2 . 0	4 4 . 7
General affected district	1 2 . 1	0 . 8	1 5 . 2
District under seismic influence	0 . 3	0 . 3	0 . 6

The results seemingly show that houses and buildings in the extremely seriously affected district collapsed immediately without leaving time for inhabitants to evacuate, while those in the seriously affected district, which shook less, had time to assure personal safety though houses and buildings in the district eventually collapsed. Photographs taken by CODE showing affected regions shortly after the quake, which were offered as special photographs for this report, highlight such situations more vividly.

(3) Damage to mid-rise houses

The photos below show a six-story housing complex in Xingfu Town near the center of Dujiangyan City. All wings were severely damaged. There was no resident in the complex as of June 12, 2008. Though causes for damage should be reviewed in details, there were such hollow floor panels hanging from walls as in Mianzhu City all over the region. Also, there were many collapsed joints between columns and beams and damaged brick walls.



Collapsed mid- and high-rise housing complex in Dujiangyan City (in June 2008)

There are many housing complexes similar in number of stories in Dujiangyan City. Some residence wings of the complexes were almost undamaged and residents have continued to live in the wings. In order to avoid repeating such disaster, experts groups need to conduct sufficient research on damage to find the causes as well as to reflect the results in reconstructing houses (meanwhile, the Chinese government upgraded the quake-residence standards by one rank in July 2008).

(4) Housing reconstruction

At the time of research in December 2008, houses were being built of brick and piles of bricks were seen in various places. In Yingxiu Town of Wenchuan County we visited, two model districts as seen in the photos below had been set up in the town. Inhabitants have been allowed to choose a house from three types of houses according to the number of rooms, etc. All these three types of houses are built of brick. The housing construction costs around 70,000 yuan (around 950,000 yen), reportedly.



Brick-built house under reconstruction in Yingxiu Town of Wenchuan County (in December 2008)

Collapse of houses was the major cause for human and property damage in the Great Sichuan Earthquake. Nevertheless, inhabitants did not have concrete knowledge on quake resistance of brick-built houses under construction, although they thought the houses had quake resistance “improved compared to before.” In a village of Beicuan County we visited, some people were building wooden houses in housing reconstruction due to move after the quake, because wooden houses they had lived before the quake were undamaged. As a result of the hearing survey of inhabitant families, they had preferred brick-built houses due to modernity and ease of procurement, but eventually chose traditional wooden houses, which are reparable, with a view to leave their house to their children, taking into account quake residence.



Traditional wooden house under reconstruction (in December 2008)

2-4. Research on community-based recovery

(1) Temporary houses

Community-based disaster recovery is one of lessons learned from the Great Hanshin-Awaji Earthquake. Particularly, a big lesson was learned in terms of temporary houses and utilized in the 2004 Niigata Earthquake, in which people lived in temporary houses on a community basis. After the Grate Sichuan Earthquake, temporary houses were promptly constructed under the Partner support program. As many as 500,000 or more temporary houses were built in three months. In Dalian new temporary village in Shifang City we visited, all inhabitants moved from the same community and no community was divided. In a temporary residential building, kitchens, toilets and shower rooms were in common use, and therefore inhabitants see each other naturally. Notably, the residential buildings were equipped with various facilities including recreation rooms, police stations and healthcare rooms. As seen in the lower right photo below, trading is conducted in the residences. Operation of the temporary residences was managed mainly by 12 people (11 men and one women), called as volunteer guard, centered on several men who served as town official in the original town. They receive 550 yuan per month in reward for the service from the government.



Dalian new temporary village in December 2008

(2) Community-based disaster recovery in villages

Each village has a villager committee, which consists of chief (village head), vice chief, and committee members. As an organization standing between governments of towns and townships and inhabitants, the villager committee serves an important role in community-based disaster recovery. Although items of the central government's basic program for recovery and reconstruction include recovery plans from the various points of view, these plans have not yet been implemented at the local level. Each community has not yet envisaged recovery of own town by itself. Rather, house construction of individuals has come first because they are required to build a house by the limit to receive assistance from the government. Asked about the actual situation of a village after the quake, some said "we helped each other shortly after the quake but I feel that everyone has stopped to cooperate over time." As shown in the photos below, however, people in the community gave a hand to construct a traditional wooden building and do a ceremony for completion of framework. This fact confirms that traditional customs are still deep-rooted in the community. It is considered important to recognize such traditions that have been observed in a community anew without letting disaster eradicating them. In addition, many affected rural areas of Sichuan province depend on migrating labors for revenue, so most of people left in the areas are retired older people and youth including children. In considering community-based disaster recovery, such a way of working and living in the future, together with area development, need to be thought about.



Completion ceremony of framework of a wooden house



Feast after the traditional custom (in December 2008)

The recovery plan states spreading knowledge on disaster prevention and reduction and boosting awareness of all the people about disaster prevention and reduction. In order to achieve these aims, however, people in each community themselves are required to have the will to develop a disaster prevention and reduction-conscious town. Whether a community has a view of disaster reduction has been pointed out as a point of assessing town development. Firstly, whether has the attitude of consciously introducing the viewpoint of safety into a local community taken root? Secondly, whether have partnerships between governments and citizens been built? These viewpoints are

required (Murosaki, 2009). For improving awareness of communities' disaster prevention, case studies for community-based disaster prevention researched by UNCRD seems to serve as a reference.

3. Findings and issues

(1) Speed of approach to disaster recovery

In the Great Sichuan Earthquake, which occurred on May 12, 2008, because of widespread damage, the whole country worked on disaster relief, rehabilitation and recovery systematically. Besides rescue by the army, international help was accepted more swiftly in rescue attempts compared with other countries' cases. As shown in the State Council's report and the results of research by the national committee of experts on the Wenchuan Earthquake, detailed data on damage have been obtained by section from researches. In this regard, prompt responses worked in a top-down approach. Among them, as many as 500,000 or more temporary houses were constructed by partly reference to experience in the Great Hanshin-Awaji Earthquake. This scale is simply 10 times larger than in the Great Hanshin-Awaji Earthquake. According to information obtained from local people, this is in part because of construction workers who were dispatched with materials by the relevant province in coastal areas under the "partnership support" policy. As they stayed in tents or cars during the construction, they had a motive to rapidly complete temporary houses and go home. Another major factor for prompt actions is the principle of competition among supporting provinces, since results of partnership support are released by the central government. This situation has been also seen in the process of disaster recovery.

The central government has well studied approaches to disaster reconstruction in the past. The approach after this earthquake has been taken by reference to governments' responses and recovery processes in the Tangshan Earthquake in July 1976 as well as great earthquakes in Hanshin-Awaji, Turkey, Mexico, Pakistan and others in recent years (according to a report released by people concerned mainly from the National Development and Reform Commission in the international symposium, and information obtained from them at the time of the second research). Yet, "no hurry" is one of keywords that were pointed out in the panel on methods of assessing town development mentioned above. After the general is formulated, the particular needs to be considered with a lot of time taken. This seems to be one of lessons leaned from the Great Hanshin-Awaji Earthquake and the 2004 Niigata Earthquake. From such a standpoint, due partly to widespread damage of the Great Sichuan Earthquake, discussing the particular with sufficient time on a regional level based on the general will be an issue in the future.

(2) Advantages and problems of partnership support

Key points of the partnership support policy are summarized as follows: As seen in Table 2, mainly provinces in coastal areas are assigned for partner regions by the government according to their scale and damage of supported cities and counties. Hence, the program serves a very important role

in prompt disaster relief, rehabilitation and recovery, as described above. This system is more efficient compared to reallocation of financial resources and materials provided by each province to the central government. However, research findings obtained to date show three problems, in spite of collective arrangement by the government. Firstly, contents and level of support vary from province to province. This may be inevitable and be acceptable to inhabitants because it is difficult to make arrangements among provinces in terms of time in the phases of rescue and rehabilitation. Secondly, support is provided without understanding of climate, culture and social background of supported regions. Support is offered from remote places. For example, facilities provided from northern provinces have double-panel windows and contain heat-insulating materials, while those provided from southern provinces have no such equipment. This is not a big problem in the phases and rescue and rehabilitation because short-term responses or restoration is required in the phases. In the reconstruction phase, however, supporting materials need to be accepted by the supported region. Lastly, there is a possibility that supporting provinces tend to have a larger voice and decision-making power than supported areas, regions in charge, because of the relationship. Supporting provinces need to fully understand of having a perspective of supported areas.

(3) Variety of issues in different regions

Regions affected by the Great Sichuan Earthquake vary from urban areas such as Dujiangyan to mountain areas like Yingxiu Town. Rural areas also vary from suburbs and neighborhoods of industrial complexes to purely agricultural areas which have no industry other than agriculture. Also, social background, ethnic composition and population composition, as in areas where there are many migrating workers, vary according to regions. Damage in this earthquake has been classified into four categories according to degree of damage as seen in Table 3. There are wide-ranging problems in the rehabilitation phase, including relocation of a whole community, reconstruction of infrastructure facilities such as industrial and agricultural foundations, house reconstruction, prevention of sloping failure, ecosystem recovery, restoration of cultural assets, and so on. In order to address problems varying according to regions, it is important to map out disaster recovery plans relevant to the region while taking into consideration scientific research and advice.

(4) Earthquake disaster prevention measures to be applied nationwide

As in earthquake disaster in every place around the world, the major cause for human damage in this earthquake was crushing death and injury caused by collapse of vulnerable buildings and houses. Many photographs show that if buildings had not collapsed, lives in those could have been saved. The Chinese government has strengthened quake resistance of building nationwide since 1976 Tangshan Earthquake. With the Sichuan earthquake s a lesson, higher earthquake resistance level for buildings and houses is required at least in affected areas. Even if the current standard level will be

maintained for the time being, it is necessary to strengthen the system for constructing buildings appropriate to the level as designed. In this context, training of architects and engineers, and improvement of the government's system are required. As learned from the structural calculation fabrication scandal, Japan also continues to work on this issue, though each country is in different stages. Progress of urbanization with ineffective quake-resistance standards will become fatal in the future, particularly in earthquake-prone zones.

In addition, school- or community-based education of disaster prevention is essential for spreading understanding of the issue to people including building owners. Such education should include not only teaching quake-resistance standards but also providing knowledge on earthquake in a school program to find vulnerability and possibility of regions and lead to area development.

(5) Information disclosure and gathering of opinions from inhabitants

Officials in governments of Chengdu City and Mianyang City explained they were focusing on gathering opinions from inhabitants in working out a draft plan for city recovery (at the time of the third research in August 2008). This is as important as information disclosure which the Chinese government emphasized in the Sichuan earthquake. Japan has been gradually improving the system for reflecting opinions from inhabitants in town development since the new City Planning Act was enacted in 1968, though actual application of the system depends on municipalities. Among them, Hyogo Prefecture and Kobe City have taken a comparatively advanced approach. We hope their case studies serve as a useful reference in China.

(6) Role expected for UNCRD

For spreading quake-resistance standards described in (4), accumulated experience in "Housing Earthquake Safety Initiative (HESI)" in Nepal, Indonesia, Peru, etc. conducted by UNCRD may be useful. Meanwhile, UNCRD has worked on spreading community-based disaster prevention as a lesson learned from the Great Hanshin-Awaji Earthquake since Hyogo Office was set up in 1999. Experience in the Great Hanshin-Awaji Earthquake has spread in various Asian countries. Additionally, not only Hyogo Office but also Nagoya Headquarters has provided training on area development for Chinese government officials through actual examples in area development in Japan.

As stated above, UNCRD will continue to research recovery process from the Great Sichuan Earthquake and share experience in disaster recovery in the Great Hanshin-Awaji Earthquake and other places in the world with affected areas.

4. Reference and Resource Materials

4-1. References

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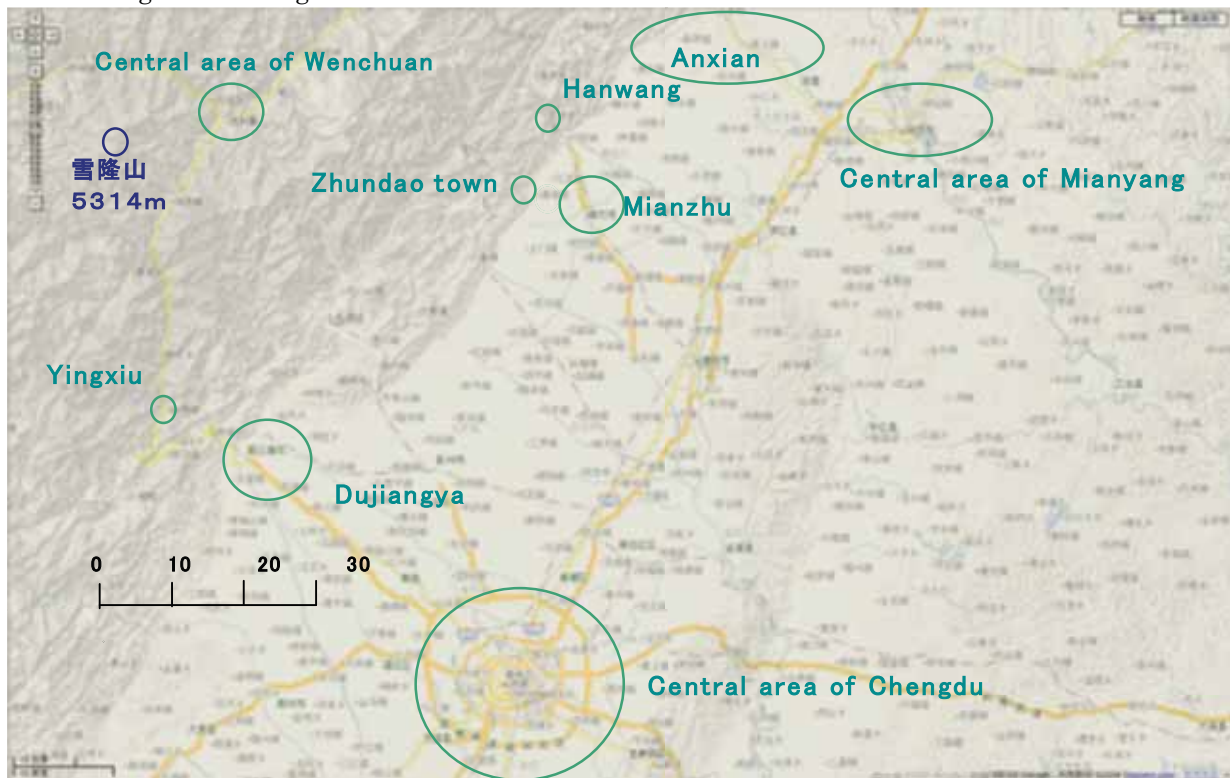
Others

1. Photo collection: 5.12 Wenchuan Earthquake in China, July 2008
2. Photo collection: Reporting from Epicenter August 2008

Figure 4 Population distribution in the extremely seriously affected district s



Figure 5 Target areas for UNCRD research



4-3. Photographs

First research (June 10 through 15, 2008)

In Hanwang Town of Mianzhu City



City center and mountain
(Sloping failure)



Clock of a clock tower, which stopped at 14:28



Main Street of the city center



Removal of a collapsed hospital



On the street from the center of Mianzhu City to Hanwang Town



Large temporary housing complex under construction in a suburb

(All photos taken on June 11, 2008)

(Continued)

In Hanwang Town of Mianzhu City



Site of collapsed town office (already removed)

(Upper right photo: old residential district in the centre)



Road to Zhundao junior high school

(Left: same as right)



Draft plan for town recovery, showing locations of temporary shops, hospitals and schools, etc.



Piles of rubble of the city center, which almost totally collapsed

(All photos taken on June 11, 2008)

Third research (August 2 through 5, 2008)



At a temporary housing in Mianzhu City

Large temporary housing complex in a suburb of Mianzhu City
(Right: signboard showing the arrangement plan of the complex)



Small temporary housing complex in Anxian County
(Right: some houses were vacant as of August 2008)



All members of the research group, and the manager and employees of a factory

(All photos on this page taken on August 3, 2008)

Fourth research (December 6 through 12, 2008)



Yingxiu Town of Wenchuan County



Memorial mass grave Yingxiu Town of Wenchuan County

(For the idea of building an earthquake disaster museum, the shattered town has been left as it is.)



Temporary houses of Yingxiu Town of Wenchuan County



Protected epicenter district of Wenchuan County



Landslide dam in the protected epicenter district of Wenchuan County



People living in the protected epicenter district of Wenchuan County

(All photos on this page taken on December 9, 2008)



New agricultural village of Shifang City
Woman living in a temporary house that
she built in the rubble
(December 7, 2008)



Preserved castle of Beichuan County for the
idea of building an earthquake disaster
museum
(December 9, 2008)



Brick-built housing complex
(December 7, 2008)



House destroyed by massive stone due to
landslide (December 8, 2008)



Exhibition of the disaster recovery plan held by Chengdu City (December 11, 2008)



Special photographs (offered by Mr. Masamichi Yoshitsubaki from Citizens towards Overseas Disaster Emergency (CODE) Office)

Shortly after the earthquake (Beichuan County)



Damage on a rural village

(All the photos on this page were taken during the period from 17 to 21, May 2008)

Evacuation centre



Gymnasium as evacuation center of Mianyang City

Teaching at a temporary school next to the evacuation center



Evacuation center in Jiangyou City



Temporary housing constructed by an owner himself/herself (Mianzhu City)



Temporary housing using a back of the car (Mianzhu City)

(All the photos on this page were taken on the period from 17 to 21, May 2008)

Temporary housing



Temporary housing under construction
(Dujiangyan City, June 23, 2008)



Shared shower room
(Dujiangyan City, June 23, 2008)



Communal water place (Dujiangyan City,
August, 13, 2008)



Planting flowers in flowerbeds of the
temporary housing (Dujiangyan City, August,
13, 2008)



Beginning to repair houses in a rural area (In Beichuan County, Mid-August)



Housing reconstruction



Housing reconstruction with brick and block
(in Beichuan County, early October)



Beichuan County (December 18, 2008)



Housing reconstruction of wooden buildings
(In Beichuan County, December 19, 2008)



Beichuan County (December 23, 2008)



Housing reconstruction using bamboo by a
Taiwanese architect
(Beichuan County, December 24, 2008)



Housing reconstruction by traditional
masonry construction method of the Qiang
people (In Lixian County, December 25,
2008)

Current conditions



Left rubble, delay in support
(In Wenchuan, December 22, 2008)



Construction halted due to cold
(In Wenchuan, December 22, 2008)



Snow piles up in mountains.



Area where support, including temporary houses, has not been reached.

(Both in Wenchuan County, on December 22, 2008)



Brick-built house completed (In Zhundao Town, January 7, 2009)



Acknowledgements

UNCRD Hyogo Office conducts activities to incorporate technical transfer and disaster prevention related to disaster prevention plans into area development plans. As major disaster highlights problems inherent in past area development plans, post-research research on actual situations can clarify challenges in past area development plans. Accordingly, UNCRD visited affected areas after the 2004 Indian Ocean Earthquake and Tsunami in December 2004, the Great Pakistan Earthquake in October 2005, the 2006 Great Java Earthquake, and the Great Peru Earthquake in August 2007, and has conducted research from the viewpoint of area development.

The Great Wenchuan Earthquake (the Great Sichuan Earthquake) that occurred on May 12, 2008 was large-scale disaster in terms of size and extent of the impact, like the 2004 Indian Ocean Earthquake and Tsunami. The Chinese government promptly took every possible measure in all the sections and work to disclose information, so we could conduct this field research in a smooth manner. We would like to express our appreciation to many people who have assisted us, including those from the Chinese government, the Sichuan government, the Sichuan Academy of Social Sciences, , Chengdu City, Mianyang City, Deyan City, Sichuan University, Tsinghua University, Nagoya Institute of Technology, Citizens towards Overseas Disaster Emergency (CODE) Office. Among them, we would like to convey our gratitude to Mr. Masamihi Furutsubaki from Citizens towards Overseas Disaster Emergency (CODE) Office, who provided many photographs of affected areas, from situations immediately after the quake to the current state, which shown in “Special photographs” section, and also offered assistance to us in field research.

UNCRD’s activities in disaster prevention

UNCRD Hyogo Office was set up in Kobe City in 1999 to make use of experience in the 1995 Great Hanshin-Awaji Earthquake with the support of Hyogo Prefecture. Aiming to achieve “Hyogo Framework for Action,” which was adopted in the United Nations World Conference on Disaster Reduction (WCDR) held in Kobe City in 2005, Hyogo Office has conducted research and information activities with the objective of the following:

- Providing advice to disaster-susceptible communities in cooperation with government organizations, NGOs and academic organizations.
- Improving safety of facilities, residences, cultural assets and others that function as the core of a community such as schools and hospitals

- Analyzing best practices of regional disaster prevention measures and working to spread them through workshops and ITI.

Hyogo Office is currently developing “Housing Earthquake Safety Initiative (HESI)”, in addition to projects in Asian countries under “Community-Based Disaster Management” (CBDM) and “School Earthquake Safety Initiative” (SESI) around the world as well as providing assistance in disaster recovery to areas affected by large-scale disaster such as earthquakes in Indonesia and Pakistan, and tsunami in the Indian Ocean.

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