STUDY ON QUANTITATIVE EARTHQUAKE DAMAGE OF DUJIANGYAN CITY, CAUSED BY 2008 MS=8.0 WENCHUAN, CHINA EARTHQUAKE BASED ON AERIAL IMAGERY

Xiaoqing Wang

Institute of Earthquake Science, China Earthquake Administration, Beijing, 100036, CHINA, wangxiaoq517@163.com

Aixia Dou

Institute of Earthquake Science, CEA, Beijing, 100036, CHINA, axdothy@163.com

Xiang Ding

Institute of Earthquake Science, CEA, Beijing, 100036, CHINA, dingxiang525@163.com

1. INTRODUCTION

The emergency application of the 2008 *M*s8.0 Wenchuan, China earthquake indicates that the remote sensing is a main channel to obtain effectively and quickly the disaster information after a seriously destructive earthquake. While the remote sensing information features relatively macroscopic and indirect seismic damage. It should be a main research subject to extract seismic damage information from remote sensing images quantitatively and to ensure comparable to the actual seismic damage determined by ground-based investigation.

The paper introduces a RS seismic damage index and its relationship with the actual seismic damage level determined by the ground-based investigation in Dujiangyan city destructed by Wenchuan earthquake.

2. BASIC IDEA AND MODEL OF REMOTE SENSING QUANTITATIVE RESEARCH

2.1 seismic damage index and its calculation method

The level of estimated seismic damage of single ground object (for example, a building) depends on many factors such as the type and spatial resolution of RS source, the object's spatial scale and damage level, the secondary disasters and others. The collapsed building is relatively easy to be identified from RS images, but the un-collapsed building may also be seriously damaged. Thus, it is of great significance to raise the accuracy of the seismic and loss estimation according to few damaged (collapsed or partial collapsed) buildings from RS images.

In order to build quantitative seismic damage index based on RS, the conventional seismic damage index of buildings determined through ground survey in a certain area (usually a village or block) is introduced first. The seismic damage index is related to structure type of buildings. The composite seismic damage index DI^G on a site is related to the defined as following:

$$DI^G = \frac{\sum_i \overline{d}_{bi} N_i}{\sum_i N_i} \tag{1}$$

Where $\overline{d_{bi}}$ is the equivalent mean seismic damage index of structure i, N_i is number of buildings of structure i.

2.2 remote sensing seismic damage index and its calculation method

The seismic damage index of building's seismic damage extracted from remote sensing images can be determined according to the method similar above. Here the seismic damage of buildings extracted from RS images is limited in three levels: collapse, partly collapse and no collapse. The damage seismic index determined through the remote sensing damage interpretation is called remote sensing seismic damage index (D_I^{RS}) as a quantitative indicator to describe the seismic damage level:

$$D_I^{\mathrm{RS}} = \frac{\sum_i \overline{d}_{bi}^{RS} N_i^{RS}}{\sum_i N_i^{RS}} \tag{2}$$

where $\overline{d}_{bi}^{RS}$ is the remote sensing seismic damage index of structure *i* which is converted to the equivalent masonry structure; N_i^{RS} is the building count of structure *i* interpreted based on RS image.

3. INVESTIGATION OF GROUND SEISMIC DAMAGE IN DUJIANGYAN CITY PROPER

Before the introduction of remote sensing seismic damage, we first analyze the ground survey data. After the Wenchuan earthquake occurred, the authors implemented a field seismic damage investigation for approximately 40 days in seriously damaged area. The field work was one of scientific field investigation projects of Wenchuan earthquake organized by China Earthquake Administration. Figure 1 shows the main field seismic damage investigation region in Dujiangyan city proper where 3400 buildings with various damage level were observed.

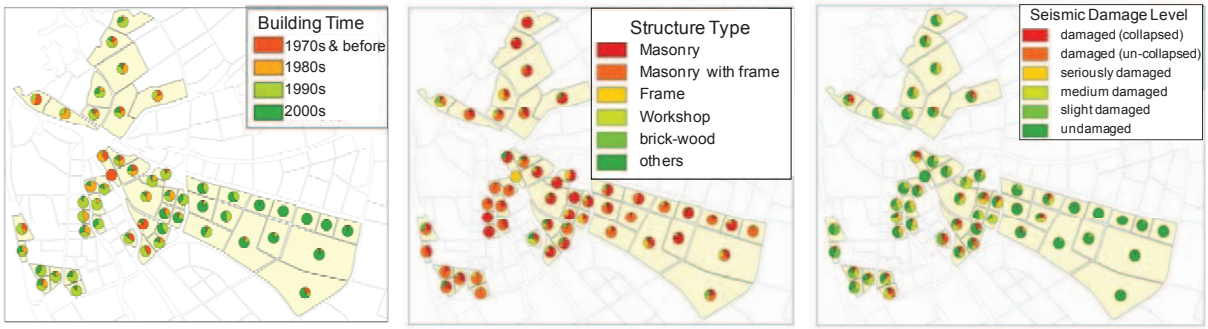

Figure 1. The building characters and damage distribution in block determined by ground investigation in Dujiangyan city proper

4. RS IMAGE PROCESSING AND BUILDINGS SEISMIC DAMAGE EXTRACTION

The Dujiangyan city proper underwent great losses dues to 2008 Ms8.0 Wenchuan earthquake. After the event, many satellite and aerial optical and radar images are acquired quickly. This paper chooses images of Cosmos Sky-Med (1m) spatial resolution and aerial color digital images from Chinese Academy of Sciences (0.5). Figure 2 shows typical seismic damage images of buildings and corresponding damage photos on the ground.

The structure type and remote sensing seismic damage level of each single building within the blocks where the ground seismic damage investigation have been done were identified by automatic processing (Wang Yan, et

al，2009; Wang Xiaoqing et al, 2008, also [1]) and man-machine interactive mode. Then the remote sensing damage index of each block can be calculated according to the statistical method mentioned above. The results are shown in Figure 3.

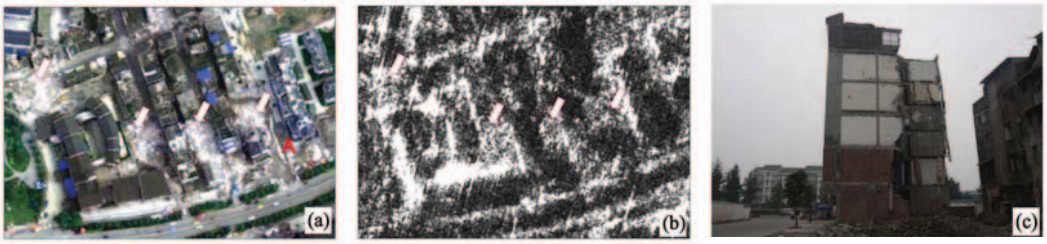

Figure 2. The typical building seismic damage images in the blocks of Dujiangyan city proper caused by Wenchuan earthquake. (a)aerial remote sensing image(May 15, 2008)；(b)Cosmo-SkyMed radar image(May 13, 2008)；(c)Photo shows the partial collapse of frame structure house. The positions that the arrows in(a)and(b)point to are places where houses collapse; the position of the partial collapse of frame structure house shows in(c)is located in the place A in (a)

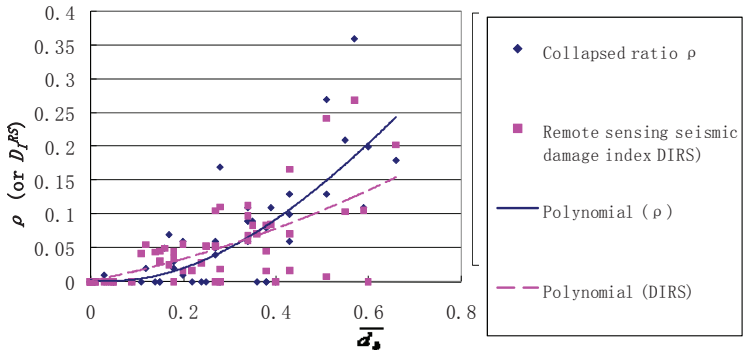

Figure 3 Relation curve chart of remote sensing seismic damage index and ground seismic damage index of Dujiangyan city proper. ($\overline{d_b}$ is seismic damage index of equivalent masonry structure determined by ground investigation; ρ is building collapsed ratio)

5. RESEARCH ON QUANTITATIVE RELATIONSHIP BETWEEN RS SEISMIC DAMAGE AND SEISMIC DAMAGE OBTAINED THROUTH GROUND SURVEY

The seismic damage of buildings was calculated quantitatively above by using remote sensing seismic damage index. Because the discrimination ability of seismic damage from remote sensing image is affected by many factors, such as sensor type, the spatial resolution of image, and so on, there exists difference between the remote sensing seismic damage index and actual seismic damage. It can be expected that seismic damage index, determined by the building damage extracted from remote sensing image will change with the sensor type and the image spatial resolution. As a result, the remote sensing seismic damage does not correspond to the seismic intensity directly. Thus it is necessary to build the statistical relationship between remote sensing damage index and composite seismic damage index of building determined through practical ground investigation. After that, the remote sensing seismic damage index can be converted into equivalent ground seismic damage index (Figure 4), and then the seismic intensity in each block can be further estimated.

[1]Wang X, Dou A, Ding X, Wang L, et al, 2007, Manual of RS-based Earthquake Damage Analysis and Processing System.

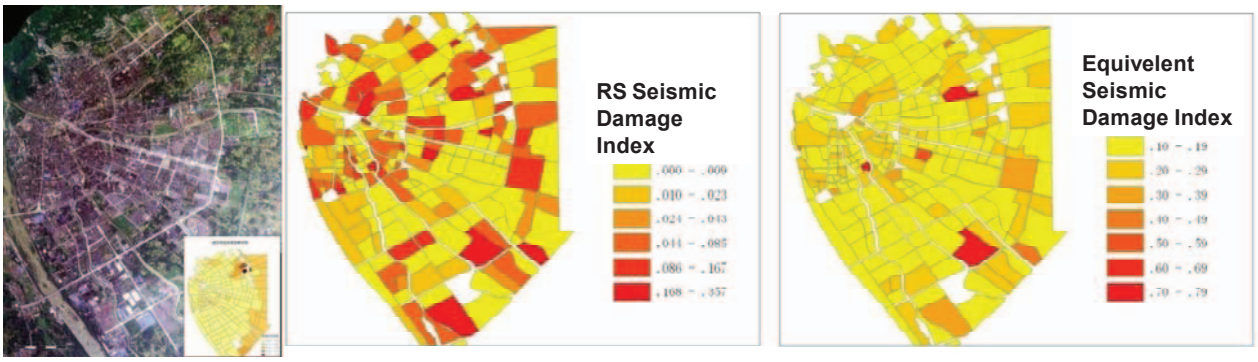

Figure 4 The aerial image in Dujiangyan (left), RS seismic Index and the equivalent relational curve between remote sensing seismic damage index D_I^{RS} and building collapsed ratio ρ in partial city proper of Dujiangyan.

6. COUNCLUSIONS AND DISCUSSIONS

The paper builds initially the quantitative relationship between remote sensing seismic damage and conventional seismic damage determined through ground investigation. The results indicate that it is possible to build quantitative model of remote sensing seismic damage, which will enhance significantly the practicality applying the remote sensing in emergency acquisition and analysis of seismic disaster.

Because of un-consideration of some other influencing factors, the authors also notice that there exists uncertainty in the analytical result. Through the substantial accumulation of the actual earthquake cases and further thoroughgoing and painstaking analyses, it is believed that the uncertainty of quantitative analysis of remote sensing damage will be significantly reduced.

More seismic damage extraction from RS image and quantitative seismic damage assessment can be found in the Atlas edited by the authors (Wang etc, 2010).

7. ACKNOWLEDGEMENT

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8. REFERENCES

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(More than 16 of other papers are not listed here as limited pages)