Research on Main Shock-aftershock Earthquake Statistical Model

Yong Xu, Cuiying Zhou and Airong Liu

ABSTRACT

The main shock-aftershock earthquake statistical model has been carried out by analyzing distribution of 68 sets of main shocks and aftershocks data of Wenchuan earthquakes and Fukushima earthquakes which given by China Earthquake Networks Center (CENC) and Pacific earthquake engineering research center of America (PEER). The research revealed that both magnitude and epicenter intensity are interrelated with main shock and its aftershocks. A statistical strongest aftershock’s intensity achieved according to its main shock basic design intensity, and it is effective just to consider a strongest aftershock earthquake.\footnote{Yong Xu. Civil Engineering School, Guangzhou University, Guangzhou, China, 510006. Cuiying Zhou. Civil Engineering School, Sun Yat-sen University, Guangzhou, China, 510275. Airong Liu. Guangzhou University-Tamkang University Joint Research Center for Engineering Structure Disaster Prevention and Control, Guangzhou, China, 510006.}

INTRODUCTION

Structures tend to exacerbate their damage under actions of main shock and its aftershocks\cite{1-2}. Aftershocks are typical seismic phenomena, so it is necessary to pay attention to strong aftershocks. Basic main shock intensity widely used in seismic design\cite{3-8}. Based on some typical earthquake records during 1970 and 1986, an aftershocks statistical model proposed which propose a method to calculate two strongest aftershocks\cite{9}. To build seismic zoning map, some attenuation models have been put forward to consider earthquake intensity ellipse axis, surface wave magnitude and epicenter distance\cite{10}.
In recent years, earthquake records such as earthquake ground motion data are collected. By analyzing data of Wenchuan earthquake and Fukushima earthquake from CENC and PEER, aftershocks magnitude and intensity statistical model have been further discussed, and a single strongest after shock method proposed.

**AFTERSHOCK DATA SELECTION**

**Magnitude Distribution of Aftershocks**

Aftershocks magnitude recorded distribution of Wenchuan earthquake and Fukushima earthquake are shown as Figure 1. During Wenchuan earthquake, 107 aftershocks, which were about 27.23% total records, broke at the day of main shock broken. 339 aftershocks records collected within a month, which were about 86.30% of total records. The first and second largest magnitude aftershocks recorded during 7 hours and 13 days after main shock. Similar phenomena were founded during Fukushima earthquake: 26.15% aftershocks records have been collected in the day which main shock broken, and 69.23% aftershocks records have been collected within a month, the first and second largest magnitude aftershocks recorded in 40 minute and 27 day after main shock broken.

**Frequency Distribution of After Shocks**

Aftershocks frequency recorded distribution of Wenchuan earthquake and Fukushima earthquake are shown as Figure 2. When aftershock relative magnitude were over 0.67, frequency distributions were sharply monotonic decrease. When aftershock relative magnitude were over 0.73, aftershock frequency tends to 1. The frequency was not less than 4 when aftershock relative magnitude over 0.65. In order to obtain more effective earthquake records, it is necessary to select single strongest aftershock record data over 0.65, and statistical time should long enough [9].

**Magnitude Spatial Distribution of After Shocks**

Magnitude spatial recorded distribution of Wenchuan earthquake and Fukushima earthquake are shown as Figure 3. Although there were no obvious coincident between main shock epicenter and aftershock’s, aftershocks epicenter should be properly controlled for making full use of the seismic intensity zoning map.
To simplify the calculation method, the data deviation of epicenter latitude and longitude between main shock and aftershocks were be controlled within $0.2^\circ$ [9], and 68 groups records of main shocks and their aftershock have been selected.
AFTERSHOCK QUANTIFICATION

Aftershock Magnitude Model

Magnitude distribution are shown as Figure 4. Using least square method, the regression relation is shown in equation (1):

\[ M_a = 0.12M_m + 1.24 \]  

(1)

In type: \( M_m \) for main shock magnitude, \( M_a \) for aftershock magnitude.

Aftershock Epicenter Intensity Model

Epicenter intensity distribution are shown as Figure 5. According to least square method, the equation between main shock and aftershock epicenter intensity is shown as follows:

\[ I_a = 0.35I_m + 1.476 \]  

(2)

In type: \( I_m \) for main shock epicenter intensity, \( I_a \) for aftershock epicenter intensity.

![Figure 4. Magnitude relationship.](image1)

![Figure 5. Epicenter intensity relationship.](image2)

Simplified Method of After Shock Calculation

Earthquake intensity attenuation model can be expressed as follows [10]:

\[ I = A + BM + C \log(R + R_s) \]  

(3)

In type: \( R \) As the epicenter distance ( km ) , \( A B C R_s \). For the regression coefficients.

Ignore epicenter difference of main shock and aftershock, earthquake intensity attenuation model can be represented as follows:
\[ I_a = /A12I_m + /366A + 1./A B + /366 C 1g(R + R) \]

Calculated aftershock epicenter intensity are shown as Figure 6. Compared with china code, it can be found: When \( R=0 \text{km} \), calculated values are 0.6~0.8 degree higher. When \( R=20 \text{km} \), calculated values are coincide. When \( R=40\text{km}~\text{to}~100\text{km} \), calculated values are small. When main shock epicenter intensity is 9 degrees, and epicenter distance is more than 100km, aftershock intensity did not exceed 6 degrees, the influence of aftershocks can be ignored. Therefore, it is adaptable to suppose that epicenter distance equal 20km.

**CONCLUSIONS**

1. It is feasible to consider only single strongest aftershock.
2. Aftershock epicenter intensity can be calculated by adjusting its main shock intensity.

**REFERENCES**