Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SSS025-12 Room: 301A Time: May 25 15:00-15:15

The Relation between Building Damage and Characteristics of Strong Ground Motion

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1. Introduction
During the 2008 Wenchuan earthquake, catastrophic building damages happened in the vicinity of the source fault zone. According to investigation reports of building damages, there were seen some regions with collapse ratios (CRs) of more than 90%, some regions with CRs of 10% to 90 %, also other regions with CRs of less than 10%. Such diversities of building damages should be due to following two factors, one is vulnerability of buildings, the other is characteristic of strong ground motions. In our study, we discussed the causes of diversities of building damages based on the relation between building damages and characteristics of strong ground motions. Building damages due to landslides and ground failures were excluded in our discussion.
2. Relation between building damage and characteristics of strong ground motions
If PGA and PGV become more than 200gal and 15cm/s respectively, CRs exceed 10%. Besides, a linear relationship between CRs and 5% damped pseudo-acceleration (PSA) of strong ground motions according to different CRs is also made clear. If PSAs exceed more than 500gal and dominant periods of strong ground motions range from 0.2s to 0.9s, CRs become more than 10%.
3. Relation between CRs and seismic intensity degrees of China
In most of disastrous areas, buildings are designed as seismic fortification intensity VII following the Code for seismic design of buildings (GB 50011-2001). Mean damage indexes of regions with seismic fortification intensity VII are greater than 0.10. Because the meaning of CR is close to the meaning of mean damage index of a region, CRs in regions with mean damage indexes of more than 0.10 can be regarded as more than 10%. Therefore, in our study CR of 10% is regarded as the standard value in the damaged regions. According to the code, buildings should sustain strong ground motions with seismic intensities at least one degree greater than seismic fortification intensities, so buildings designed as level VII should not be destroyed under seismic intensity VIII. But many buildings, at least 10% of the total buildings in the design region can not sustain PGA (178gal~353gal) and PGV (19cm/s~35cm/s) of seismic intensity of VIII. On the other hand, Chinese seismic intensity scales are generally estimated according to damaged degrees of buildings including non seismic fortification designed ones. This kind of buildings should be one of reasons why CRs in regions with seismic fortification intensity of VII become more than 10%.
4. Vulnerability of typical buildings
Vulnerability of buildings should be another reason for high CRs. In order to make clear the vulnerability of typical buildings, we choose two 5-floor brick-concrete buildings, one is moderately damaged in Dujiangyan city (DJY) and the other is seriously damaged in Hanwang town of Mianzhu city (MZH). The moderately damaged building is strengthened in NS direction after earthquake. Natural periods and damping ratios of the strengthened building are, 0.22s and 0.26s, 3.24% and 1.99% in the NS and EW direction, respectively. The natural periods and damping ratios of the seriously damaged building in MZH are, 0.33s and 0.34s, 3.69% and 4.37% in the NS and EW direction, respectively. The natural period in the strengthened direction of building in DJY is almost the same with design value which equal to the total height (13.5m) multiplied by 0.017 that is 0.23s. Natural periods of the building in MZH are elongated to more

than 0.3s after earthquake. The design damping ratio is always determined as 5%, but measured values are smaller than it. The causes of CRs exceeding 10% in regions with design seismic intensity of VII should be existence of non-fortification designed buildings and reduction of earthquake resistant capability of buildings.

Keywords: 2008 Wenchuan earthquake, damage of buildings, characteristics of strong ground motion, PGA, PGV, collapse ratio