

Study on Loss Ratio of Urban Building Damages

Chen Hongfu and Sun Baitao

Institute of Engineering Mechanics, China Earthquake Administration, Heilongjiang Harbin, 150080

ABSTRACT:

At present, with the economic development and improvement of living standards of the people, the proportion of the building decoration expenses in the engineering cost is increased significantly, it is necessary to consider appropriately house decoration losses in earthquake damage loss assessment. "Loss Ratio" is a very key parameter in earthquake damage loss assessment. So, in this paper, based on expert questionnaire and earthquake experience, building decoration loss ratio of different cities are presented, which offers the basis for establishing China earthquake damage loss assessment model and enable earthquake disaster loss assessment more refined and improved in our country.

KEYWORDS:

Loss assessment; Loss ratio of decoration damage; Expertise; Weight coefficient

1.RESEARCH STATUS QUO OF EARTHQUAKE DAMAGE LOSS ASSESSMENT

That earthquake damage loss assessment works date from the Urumqi earthquake in 1964 in our country, including two stages^[1]:

Before 1988, earthquake damage loss assessment mainly relied on the report of the local government department. Because scientific standard had not been set up yet at that time and earthquake loss assessment had no available standard to follow, it caused the local government department to adopt the simple method to count the losses reported by disaster victims, even the minority disaster victims still exaggerate the disaster situation and losses in order to obtain the national disaster relief funds. Therefore the final assessment result is far away with actual earthquake damage loss.

As Datong-Yanggao earthquake in 1989 (Ms6.1), for providing basis for distributing post-earthquake relief funds and reconstruction loans by the Government and World Bank, State Seismological Bureau (China Earthquake Administration) began to adopt uniform standard to assess earthquake damage loss. As a beginning, State Seismological Bureau had further made the loss assessment work standardized and constituted «Work Guidance for earthquake damage investigation and loss assessment and appendix (detailed regulations to earthquake damage loss assessment in 1990, which is used for guiding earthquake damage loss assessment. Based on the Yunnan Lijiang earthquake, Neimenggu Baotou earthquake and so on many big, middle earthquake's practice, the problems in the assessment have been discussed and perfected. (the regulation for earthquake damage loss assessment (Tryout) is revised and made in 1997, which is used in all country. In 1999, by absorbing loss assessment experience in Xinjiang Jiashi consequent earthquake, «supplementary regulation of earthquake damage loss assessment » is issued. In 2005, based on previous practical experience, some experts of institute of engineering mechanics (IEM), China earthquake administration such as Yuan Yifan have made the national standard (Post-earthquake field works the fourth part: assessment of direct loss) (GB/T18204.4-2005), which made revisions for many key problems in assessment, such as " Loss Ratio of house damage"(increase approximately 5%), considering economic development. Since this standard is issued and implemented, it plays an enormous role in all previous loss assessment, and provides important basis for provided reliable basis for national relief organization and homeland rehabilitation.



No matter that comparing with other natural disasters (Such as floods) and the result of foreign earthquake damage loss assessment, the earthquake damage loss assessment value of our country is relatively on the low side. The technological route of earthquake damage loss assessment is scientific in our country; just the integrity of assessment projects need be further refined and improved. With nearly 20 years of economic development and people's improved living standards the proportion of the building decoration expenses in the engineering cost is increased greatly. So, based on summarizing assessment, a set of urban building earthquake damage loss assessment method is set up^[2]. In this paper, we have a discussion on relevant content of key parameter "loss ratio" in decoration loss assessment.

2.EARTHQUAKE DAMAGE LOSS ASSESSMENT MODEL

Earthquake loss analysis is to predict earthquake loss of this area that might suffer in future (earthquake damage prediction) according to earthquake risk and social environment of an area, which offers a basis for making and lightening the earthquake disaster measure, or assesses earthquake loss based on post- earthquake once happened or relevant parameter of earthquake taken place (earthquake loss assessment), and offers basis for rescuing promptly. Earthquake loss is showed four quantities by Seismologist^[1]in recent years: Earthquake danger, anti-seismic ability, loss ratio, and social wealth.

Earthquake loss=Earthquake risk*anti-seismic ability*Loss ratio*social wealth (1)

Where:

Earthquake risk: possibility of happening earthquake. Earthquake risk is provided through earthquake danger analysis or historical earthquake statistics, such as earthquake intensity, response spectrum or acceleration time history. It may be deterministic, and can be probability too.

Anti-seismic ability: vulnerability too. Here includes the anti-seismic ability of the project, social system, government department and people's reaction ability to earthquake, etc. Generally, it is expressed by using earthquake damage matrix or damage probability matrix.

Loss ratio: the ratio between loss under given damage grade and the replacement price of project facilities. It is different under different destroy grade.

Social wealth: It means value of RMB converted in the house, project facility, apparatus and goods built by the need of country, collective and individual because of production, life and social life, etc. Because the social property is increasing with the lapse of time constantly, social wealth is the dynamic function changing over time.

Formula (1) is a common expression formula which calculates earthquake disaster losses, and also suitable for building decoration losses assessment. It must be point out that earthquake risk is the earthquake happened while assessing earthquake losses; Anti-seismic ability is reflected by earthquake damage matrix(Vulnerability matrix), and got by sample on post-earthquake, which is one of the most important and tedious works of earthquake loss assessment; Loss ratio is the one of every assessment object under different damage grade, and is got by the experience statistical analysis; Social wealth refers to mainly total value of every assessment target, and mainly relies on sampling live or the local department supplement.

3.LOSS RATIO OF HOUSE DECORATION DAMAGE

According to the house construction budget estimation and consulting the construction department, loss ratio of our country is confirmed in the 1980s; For example, we enumerated the typical medium-sized destruction form first, then investigated the measure repaired and spend, compared with total fabrication cost, and got loss ratio at last. With economic development, there is all improvement in the value of the house and



repair expenses, lose ratio should be appropriately adjusted (Li Shuzhen (1996)^[1], Yin Zhiqian (2004)^[3] and national standard (GB 18208.4-2005)^[4]). When the house destruction intensity is different, the building losses are different too. The loss size is influenced by the repairing complexity. For this reason, house decoration damage grade is defined at first, and the corresponding relation of decoration and structure destroy grade is analyzed according to the real earthquake; Then, using expert consult and live investigation, the experience value of house decoration damage loss ratio is got through weighted average.

3.1 Division standard of house decoration damage grade

At home, house earthquake damage loss evaluation by using division destroy grade method began with the Urumqi earthquake in 1964 first, and went through numerous earthquakes hereafter and practiced repeatedly, the division standards of five grades were basically confirmed until Haicheng earthquake in 1975. For evaluating decoration loss size, based on summering a lot of earthquake damage experience at home and abroad, in line with the rule of "damage degree of supporting member is main, and the repairing degree and expense size are considered", damage grade division of house decoration is defined (see table 1), so as to make the use of assessment easy. Table 2 shows corresponding relation of structure and decoration damage grade.

It should be noted that: the damage grade division between structural part and decoration part distinguishes. Decoration part is weight to structural part. The situation is often met, such as decoration part presents crack, after removing decoration, the structural component has no crack; The real earthquake shows: for the fragile structure (masonry structure), the state of decoration damage corresponds to better with the structure, and for the flexible structure (steel reinforced concrete, steel construction, etc.), decoration damage is greater, even under the state of intact or slight, it has some to drop.

	None	Slight	Moderate	Extensive	Complete				
Serial number	D1	D2	D3	D4	D5				
decoration	Basically harmless, fit up and can see the Crack individually	The veneer appears in the macroscopic crack; A piece of not glass breaks to pieces and falls, repair and can use normally a little on the glass curtain wall the macroscopic crack; A piece of not glass breaks to pieces and falls, repair and can use normally a little on the glass curtain wall the veneer has obvious cracks and out of shape, the part drops; The glass curtain wall supporting part is out of shape and relatively old, a few glass breaks to pieces and falls		Out of shape seriously, produce many cracks, the majority drop	Brokenness and coming off of the large area				
	Table 2 Corresponding relation between house structure damage grade division and decoration								
	None	Slight	Moderate	Extensive	Complete				
Structure	Most bearing components are intact, the specific unbearable component is destroyed slightly, repairing can go on and use	The specific bearing component presents and can see the crack, the unbearable component has obvious cracks, do not need or repair and can continue using a little	Most bearing components appear in the slight crack, there are obvious cracks partly, the specific unbearable component is destroyed seriously, need general repair	Most bearing components are destroyed seriously, or there is part that collapses, need overhauling, the specific house repairs the difficulty	Most bearing components are destroyed seriously, the structure is on the brink of collapsing or destroying, it is possible not to repair yet				
decoration	D1, D2	D2, D3	D3, D4, D5	D4, D5	D5				

Table 1 Division standard of house decoration damage grade

3.2 Questionnaire investigation

For providing loss ratio proper range of house decoration damage, the way of expert consults is adopted imitating ATC- 13 method (Delphi method)^[5]. The questionnaire is designed by the panel of expert during the



beginning course of project, and is revised and supplemented repeatedly to form the formal draft of questionnaire; Then, the questionnaire is released to the earthquake engineering expert and decoration company in the country through the form of the mail or field investigation, and invite he (she) to investigate measure and expense of reparation under damage grade ruled in table 1,table 2, compared with total replacement cost, the loss ratio of house decoration damage is provided under different damage grade; Do statistic by weight coefficients finally, and considering building budget estimation, the last result is received .

The influence of experts' experience level and professional knowledge background on loss ratio estimation is obvious. So, accorrding to its professional title and the experience level of this content, weight coefficient is confirmed as following (see table 3). The greater weight coefficient is, the greater to represent its function on the estimation result is.

Serial number	Experience level	Weight coefficient	
1	The person who is advanced and the above professional title and familiar with of this content	9-10	
2	The person who is advanced and the above professional title and to person who is relatively	7.0	
	familiar with of this content	/-8	
2	And advanced and the above professional title owes the person who is familiar with to this	5-6	
3	content		
4	Intermediate professional title and to person who is familiar with of this content	6-7	
5	Intermediate and the following professional title and to person who is relatively familiar with	57	
3	of this content	J-1	
6	And intermediate and the following professional title owe the person who is familiar with to	Under 5	
0	this content	Under 5	

Table 3 Expertise weight coefficient

In the end, the answering paper of 28 experts are collected, they contain lots of experts of authoritative research institutions and universities in the earthquake engineering fields both at home and abroad. Then, advanced and the above professional title person accounts for 82%, the professional title under the intermediate person accounts for 18%. The representative answered test paper among them are chosen and given certain weight coefficient separately, followed by a statistical analysis and the final result. Letbe y_{ijk} is the estimation of loss ratio k given by expert i under damage grade j level; ω_{ijk} is corresponding weight coefficient, whose value relies on expert experience and expertise. Average value is \overline{Y}_{kj} estimated low, medium, high of loss ratio (k=1,2,3) as damage grade is j, corresponding Covariance S_{kj}^2 and variation coefficient V_{kj} is obtained:

$$S_{kj}^{2} = \sum_{i} \omega_{ijk} \left(y_{ijk} - \overline{Y}_{kj} \right) / \sum_{i} \omega_{ijk}$$
$$\overline{Y}_{kj} = \sum_{i} \omega_{ijk} y_{ijk} / \sum_{i} \omega_{ijk}$$
$$V_{kj} = S_{kj} / \overline{Y}_{kj}$$

Correspondent to various structural type houses, under various damage grade, these calculation are repeated. Except loss ratio statistical calculation, the standard deviation of mean value and experience level should be calculated. The first column is a variable in the form, and the second column is expert count. Correspondent to every variable of the first column, mean value, standard deviation, greatest and the minimum, variance of mean and variation coefficient, etc are given with percentage (see Table 4, 5). For example, 12 experts answered multi-story masonry buildings under "None". Its average experience level is 7.545 from graduation of 0 to 10, and the maximum and minimum of experience level reported is 9 and 6 respectively, corresponding standard deviation, variance and variation coefficient are 1.368, 1.871% and 0.181%, respectively.



Answers of all experts are drawn to figure (See Figs. 1,2) ,but the contribution of experts' answers whose experience level is low to the calculation average value and standard deviation is insignificant; In the paper, those answers of dissociating from a standard deviation range are considered to go against accepted conventions.

Table 4 the statistics summary of the decoration loss ratio questionnaire answer of multi-story maso	onry
buildings (%)	

variable	The expert counts	Mean value	Standard deviation	Minimum	Maximum	Variance	Change coefficient	
None								
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181	
DF-L	12	0.361	1.508	0.000	5.000	2.274	4.177	
DF-M	12	2.440	1.619	0.000	5.000	2.621	0.664	
DF-H	12	5.241	3.560	0.000	10.000	12.674	0.679	
			:	Slight				
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181	
DF-L	12	6.145	3.725	0.000	11.000	13.876	0.606	
DF-M	12	12.320	4.917	5.000	21.000	24.177	0.399	
DF-H	12	18.490	7.103	10.000	30.000	50.453	0.384	
			Μ	oderate				
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181	
DF-L	12	19.490	7.103	11.000	31.000	50.453	0.364	
DF-M	12	33.450	7.023	26.000	46.000	49.323	0.210	
DF-H	12	47.410	8.448	40.000	60.000	71.369	0.178	
			Ех	tensive				
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181	
DF-L	12	48.410	8.448	41.000	61.000	71.369	0.175	
DF-M	12	66.800	7.991	56.000	81.000	63.856	0.120	
DF-H	12	85.180	11.930	70.000	100.000	142.325	0.140	
Destroy								
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181	
DF-L	12	85.920	11.540	71.000	100.000	133.172	0.134	
DF-M	12	92.960	5.771	86.000	100.000	33.304	0.062	
DF-H	12	100.000	0.000	100.000	100.000	0.000	0.000	

The variable in the form: EXP - Expertise level; DF-L - Loss ratio lowest estimation; DF-H - Loss ratio highest estimation; DF-M - Loss ratio estimation medium.

 Table 5 the statistics summary of the decoration loss ratio questionnaire answer of Multi-Storey Reinforced

 Concrete building (%)

variable	The expert counts	Mean value	Standard deviation	Minimum	Maximum	Variance	Change coefficient
None							
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181
DF-L	12	0.360	1.508	0.000	5.000	2.274	4.189
DF-M	12	2.542	1.800	0.000	5.000	3.240	0.708
DF-H	12	5.446	3.584	0.000	10.000	12.845	0.658
slight							
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181



DF-L	12	6.240	4.180	0.000	11.000	17.472	0.670		
DF-M	12	12.789	7.162	3.000	26.000	51.294	0.560		
DF-H	12	19.337	10.596	5.000	40.000	112.275	0.548		
Moderate									
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181		
DF-L	12	20.300	10.600	6.000	41.000	112.360	0.522		
DF-M	12	34.900	11.800	41.000	88.000	139.240	0.338		
DF-H	12	49.500	14.200	50.000	100.000	201.640	0.287		
			E	xtensive					
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181		
DF-L	12	50.500	14.200	31.000	81.000	201.640	0.281		
DF-M	12	67.600	12.900	41.000	88.000	166.410	0.191		
DF-H	12	84.800	15.100	50.000	100.000	228.010	0.178		
			С	omplete					
EXP	12	7.545	1.368	6.000	9.000	1.871	0.181		
DF-L	12	85.494	14.824	51.000	100.000	219.751	0.173		
DF-M	12	92.747	7.412	76.000	100.000	54.938	0.080		
DF-H	12	100.000	0.000	100.000	100.000	0.000	0.000		

The variable in the form: EXP - Expertise level; DF-L - Loss ratio lowest estimation; DF-H - Loss ratio highest estimation; DF-M - Loss ratio estimation medium.



Fig. 1 Means of the questionnaire answer and standard deviation range of multi-story masonry buildings loss ratio (interval lower limit)



Fig. 2 Means of the questionnaire answer and standard deviation range of Multi-Storey Reinforced Concrete building loss ratio (interval upper limit)

3.3 The final value

Loss ratio has nothing to do with earthquake intensity, and different from damage grade. For providing loss ratio proper range of house decoration damage, through the way of questionnaire investigation, the questionnaire is released to the earthquake engineering experts and decoration companies in the country, and who are invited to investigate measure and expense of reparation under damage grade ruled in table 1,table 2, compared with total replacement cost, the loss ratio estimation of house decoration damage is provided under different damage grade; Do weighted statistic finally, and considering building budget estimation, the last result is received (see table 6).

The value of loss ratio is an important link in loss assessment, especially for heavy earthquake, damage range and building area is large, total losses have greater changes when the value of loss ratio has little changes. Decoration damage loss ratio advisedly fetches medium generally, medium-decoration fetches the number value under medium-high grade decoration fetches the number value upper medium.



Table 6 Loss ratio of house decoration damage (%)								
House type	Destroy grade							
House type	None	slight	moderate	Extensive	Complete			
Storey Reinforced Concrete building	2-10	11-25	26-60	61-90	91-100			
story masonry building	0-5	6-19	20-47	48-85	86-100			

In Figs. 3 and 4, loss ratio of house decoration damage put forward in this paper, "Li Shuzhen, 1996" [1], "YI Zairian, 2004"^[3], and the proposing value of house damage loss ratio provided in "disaster direct loss assessment norm, 2005^[4], are contrasted. Comparison shows that loss ratio of house decoration damage in different damage grade takes greater than one of main structure, which accords with phenomenon of actual earthquake damage. According to the disaster areas' replacement experience in recent years, when lots of components of building decoration in medium damage grade, the building is already inclined to remove and rebuild, and whose material can be very low in the utilization ratio. Therefore, loss ratio of decoration damage herein is much greater than loss ratio of main structure when above moderate damage grade.



Fig. 3 damage loss ratio comparison of multi-story masonry building(interval lower limit)



Fig. 4 damage loss ratio comparison of multi- Storey Reinforced Concrete building (interval upper limit)

4.CONCLUSIONS

After the destructive earthquake takes place, the fast and accurate earthquake disaster loss assessment is significant for government department, public organization and international community inside and outside the disaster area to implement emergency relief, earthquake relief and recovery rebuilt after earthquake. During the last ten years, numerous earthquake damage loss assessment were carried on every year, some practical problems in practice of assessing was found and put forward each time constantly. In every assessment, some practical problem are found and provided, which makes the earthquake damage loss assessment of our country improve constantly. As to the economic developed large and middle scale city, decoration proportion is very high in many buildings; even decoration expenses of some buildings have exceeded the fabrication cost of the main structure. It becomes very essential to increase decoration loss assessment in the house losses. Because of this, house decoration loss assessment method suitable for the large and middle scale city has been proposed ^[2]. The building decoration damage grade is defined at first, and the corresponding relation of decoration and structure damage grade is analyzed according to the real earthquake; then, using expert consult and live investigation, the experience value of house decoration damage loss ratio is got through weighted average. We look forward that the existing earthquake damage loss assessment method of our country expecting can be improved and perfected.

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